MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

The attached Specifications are required for any construction and/or related activities on, over, under, within or adjacent to railroad property owned or controlled by the Massachusetts Bay Transportation Authority. They are intended to provide general guidelines and safeguards. Attachment "A" of Construction Guidelines and Procedures contains a summary of MBTA Railroad Operations Specifications which may be required. It is the responsibility of the Contractor to obtain all the necessary specifications for each project.

MAY 1994

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

GUIDELINES AND PROCEDURES

FOR CONSTRUCTION ON

MBTA RAILROAD PROPERTY

APRIL 2001

SECTION 1. SCOPE

1.01 These specifications provide general safeguards to railroad property owned or controlled by the Massachusetts Bay Transportation Authority and to railroad operations upon that property during the performance of construction and/or related activities on, over, under, within or adjacent to the railroad property. They are intended as guidelines and do not represent all legal requirements which are or may be associated with construction and/or related activities. The MBTA reserves the right to require additional information and clarification and to make unilateral changes to these specifications at any time, at its sole discretion.

SECTION 2. DEFINITIONS

MBTA Massachusetts Bay Transportation Authority

TRA Transit Realty Associates, LLC, Designated Representative of MBTA Real Estate

RAILROAD COMPANY

The particular reference for the purpose of these specifications is the railroad company which maintains and/or operates or has trackage rights on the subject MBTA Railroad Property, including, but not limited to:

- Massachusetts Bay Transportation Authority ("MBTA")
- Providence and Worcester Railroad ("P&W7
- Massachusetts Bay Commuter Railroad (“MBCR”)
- National Railroad Passenger Corporation ("Amtrak")
- CSX Transportation ("CSX")
- Pam Am Railways, The Boston and Maine Corporation, The Springfield Terminal Railway Company, its affiliates, successors and assigns ("Pan Am”)
- Bay Colony Railroad Corporation ("Bay Colony")

MBTA RAILROAD PROPERTY

All railroad rights of way and adjacent owned and/or controlled by the MBTA.

OWNER

The individual, utility, government, or corporation having title to the structure to be constructed upon, over or adjacent to railroad property owned or controlled by the MBTA.

UTILITY

Public or private communication, water, sewer, electric, gas and petroleum companies or other entity governed by the Massachusetts Department of Public Utilities.

GOVERNMENT

Federal, State, Town, City, County and other forms of government.

CORPORATION

Any firm duly incorporated under laws of a state government.

INDIVIDUAL

Any party not defined by "Owner, Utility, Government or Corporation".

CONTRACTOR

The individual, partnership, firm, corporation or any combination thereof, or joint venture, contracting with a Utility. Government, Firm, Company, Corporation or Individual for work to be done on, over, under, within or adjacent to MBTA Railroad Property.

OWNER OR ITS CONTRACTOR

As used in these specifications, does not affect the responsibilities of either party for work conducted on, over, under, within or adjacent to MBTA Railroad Property.

SECTION 3. SUBMITTALS

3.01 INITIAL CONTACT

A. The MBTA owns the majority of the railroad lines in eastern Massachusetts. Many of these railroad lines are operated for passenger service, using a Railroad Company as an operating and maintaining contractor. Some of the railroad lines are used for freight-only service, operated and maintained by other Railroad Company(s). In most instances, both passenger and freight service are operated over the same railroad lines.

B. All of the MBTA railroad lines are maintained by a designated Railroad Company(s), excepting rapid transit and light rail lines. The maintaining Railroad Company(s) has rights and responsibilities, in addition to the MBTA's property owner's rights.

C. To obtain further information concerning License Agreements, Easements, Licenses for Entry, and performance of construction related activities which affect MBTA Railroad Property, a written request may be forwarded to:

License Administrator

Transit Realty Associates, LLC
77 Franklin Street, 9th Floor
Boston, MA 02110

or you may access the website at www.transitrealty.com.

The License Administrator is also the contact person for information concerning rapid transit and light rail lines.

SECTION 4. PLANS AND SPECIFICATIONS

4.01 SCOPE: It is the intent of the MBTA to eliminate or minimize any risk involved with construction or related activities on, over, under, within or adjacent to MBTA Railroad Property. Therefore, MBTA approval and frequently one or more Railroad Company(s) approval of construction plans and specifications for all phases of a proposed project affecting MBTA Railroad Property is required.

4.02 GENERAL: The applicant must provide six (6) sets of plans and specifications to the License Administrator. These plans and specifications must meet the approval of the Railroad Company(s) and the MBTA prior to the start of construction. These plans are to be prepared in sizes as small as possible and are to be folded to an 81/2 inch by 11 inch size (folded dimensions) with a 1-1/2 inch margin on the left side and a 1 inch margin on the top and submitted electronically.

A. After folding, the title block and other identification of the plans shall be visible at the lower right corner, without the necessity of unfolding. Each plan shall bear an individually identifying number and an original date, together with subsequent revision dates, clearly identified on the plan.

B. All plans are to be individually folded or rolled and where more than one plan is involved, they shall be assembled into complete sets before submission to the MBTA.

4.03 PLANS: The plans are to show all the work which may affect MBTA Railroad Property, and contain a location map and plan view of the project, with appropriate cross sections and sufficient details. The proposed construction or related activities must be (orated with respect to top of rail (vertical) and center line of track (horizontal). The plan must also include railroad stationing, property lines and subsurface soil conditions. The subsurface information is to be in the form of boring logs with the borings located on the plan view. The plans must be stamped by a Professional Engineer registered in the state of Massachusetts. (The purchase of railroad valuation plans may be arranged by contacting MBTA Engineering offices at 222-6179).

4.04 SPECIFICATIONS: The specifications summarized on Attachment "A" attached hereto are the Standard Specifications of the MBTA Railroad Operations

Department and apply to all types of construction work affecting MBTA Railroad Property.

A. In addition to “Maintenance and Protection of Railroad Traffic" and "Insurance Specifications" which are required for all work on, over, under, within or adjacent to MBTA Railroad Property, certain other Specifications contained in Attachment "A" shall be incorporated into construction/engineering submittals when deemed necessary by the MBTA and/or Railroad Company(s). (The purchase of additional specifications may be arranged by contacting MBTA offices at 222-3448 or visiting TRA website at www.transitrealty.com).

SECTION 5. SUBMISSION REVIEW

5.01 An initial submission of six (6) sets of plans and specifications for MBTA review must be forwarded to the License Administrator, along with a completed MBTA Application for Entry (Attachment "E"). The submission will be circulated for review and comment to MBTA departments which may be impacted by the proposed project. If approved by the MBTA, the Railroad Company(s) will review.

5.02 The applicant is advised that the MBTA's initial review process requires a minimum forty-five (45) day period, prior to the Railroad Company(s) involvement, and additional processing time may be required for specific documents (See Section 9).

SECTION 6. INSPECTIONS/PAYMENTS

6.01 The MBTA may inspect all projects affecting MBTA Railroad Property at least twice, at the applicant's sole expense. The actual number of MBTA inspections will depend on the size and complexity of the project.

6.02 The MBTA may utilize Railroad Company inspectors and flagmen for daily inspection and protection of rail traffic during the term of the construction period or related activities. The Owner or Contractor will be responsible for advance payment of all associated fees.

6.03 Advance payments to the MBTA for construction/engineering review of plans and specifications by MBTA staff must be submitted when initial contact is made with the License Administrator. Payments shall be in the form of check or money order, made payable to the Massachusetts Bay Transportation Authority.

6.04 Advance payments covering the services for Railroad Company(s) construction/engineering review of plans and specifications, or services of an inspector or flagman, will be paid directly to the Railroad Company(s). The MBTA will advise when such services are required, and the Railroad Company(s) will advise of the amount of the required advance payment.

SECTION 7. EXAMINATION OF PLANS OR PROPERTY

7.01 The Contractor/Applicant shall have no claim for any differences between MBTA valuation plans and the actual conditions encountered in the field.

SECTION 8. INSURANCE AND INDEMNIFICATION

8.0I Prior to entry upon MBTA Railroad Property, insurance will be provided to and approved by the MBTA and affected Railroad Company(s), as outlined in “Insurance Specifications."

8.02 Additionally, all MBTA Licenses and Letters of Authorization contain a clause for Indemnifying MBTA and the Railroad Company(s) from and against any and all liabilities, losses, damages, costs, expenses, causes of action, suits, claims, demands and/or judgments of any nature whatsoever that may be imposed upon or incurred by or asserted against the MBTA or the Railroad Company(s).

SECTION 9. LEGAL DOCUMENTS FOR TEMPORARY AND PERMANENT INSTALLATIONS

9.01 The nature of entry upon or installation within MBTA Railroad Property will determine the authorizing document to be issued. Listed below are brief descriptions of MBTA documents:

A. **License for Entry**: Authorizes short-term entry for purposes of survey, Inspection, test borings, access, etc. One time administrative/ engineering/legal review and access fees.

B. **License Agreement**: Authorizes installations, subject to termination clause, if Applicant chooses not to pursue an Easement. One time administrative/engineering/legal review fee as well as annual rental fee.

C. **Easement**: Authorizes permanent installations in form suitable for recording at Registry Deeds. All easements are non-exclusive and subject to relocation at the Owner's expense, for Mass transportation purposes:

1. Easements must receive MBTA Board of Directors approval, which involves considerable time. Once approved by the Board of Directors and upon payment in full to the MBTA, a License for Construction is issued. Upon final inspection and acceptance of the installation by the MBTA the Easement document is issued.

2. Permanent Subsurface Easement widths are limited to a maximum three-foot distance on either side of the occupation.

3. a) A one-time administrative/engineering/legal review fee, in addition to value of easement, as established by independent appraisal conducted at the Applicant's expense.

b) If easement size is minimal, as determined by the MBTA, a fixed fee, encompassing administrative/engineering/legal review fee.

D. **Letter of Authorization**: Authorizes installations and construction activities in association with Master License Agreements. One-time administrative/engineering/legal review as well as access and/or annual fees.

ATTACHMENT "A"

SUMMARY OF MBTA RAILROAD OPERATIONS SPECIFICATIONS

I. GUIDELINES AND PROCEDURES FOR CONSTRUCTION ON MBTA RAILROAD PROPERTY

This general specification outlines the immediate design requirements and methodology for progressing construction activities on MBTA Railroad Property.

II. MAINTENANCE AND PROTECTION OF RAILROAD TRAFFIC

This specification will be included in ALL work requirements on MBTA Railroad Property, and covers rules, requirements, and protective services or any construction-related activity on MBTA Railroad Property. Supplemental specifications are listed below.

III. INSURANCE SPECIFICATIONS

This specification details required insurance coverages and limits of the MBTA and Railroad Company(s).

IV. PIPELINE OCCUPANCY SPECIFICATIONS

This specification details requirements for all pipeline borings/jackings and open cuts on or adjacent to MBTA Railroad Property, as well as requirements for plan submittals.

V. SPECIFICATIONS FOR WIRE CONDUIT AND CABLE OCCUPATIONS

This specification details requirements for clearances and installations of parallel and overhead crossings on MBTA Railroad Property, as well as requirements for plan submittals.

VI. BRIDGE ERECTION DEMOLITION AND HOISTING OPERATIONS

This specification details plan preparation for demolition and/or hoisting and erection of structures on and over MBTA Railroad Property.

VII. TEMPORARY SHEETING AND SHORING

This specification details requirements for plan preparation and calculations necessary for sheeting and shoring for construction on or adjacent to MBTA Railroad Property.

VIII. BLASTING SPECIFICATIONS

This specification outlines submittals, details and requirements for blasting on or adjacent to MBTA Railroad Property.

IX. TEMPORARY PROTECTION SHIELDS FOR DEMOLITION AND CONSTRUCTION

This specification outlines criteria for plan preparation related to protection of MBTA Railroad Property when work takes place on overhead structures.

X. INDUSTRIAL SIDE TRACK SPECIFICATIONS

This specification outlines minimal requirements for materials and installation submission for private railroad side tracks up to MBTA property line and/or clearance point. Other provisions, site-specific, may be required, including signal protection maintenance and protection of railroad traffic.

XI. RIGHT OF WAY FENCING SPECIFICATIONS

This specification details the requirements for the materials, construction and installation of standard right of way fence.

XII. TEST BORING SPECIFICATIONS

This specification outlines procedures and requirements for the performance of test borings on MBTA Railroad Property.

XIII. FIBER OPTIC CABLE SPECIFICATIONS

This specification details requirements for design and installation of fiber optic cables on MBTA Railroad Property; and is modified by site-specific requirements, including the construction methodology, location and type of fiber optic cables and protection conduits.

XIV. RAILROAD OPERATIONS BOOK OF STANDARD PLANS, TRACK AND ROADWAY, MW-I SPECIFICATIONS FOR CONSTRUCTION AND MAINTENANCE OF TRACK

Certain construction activities may require obtaining this comprehensive package if rail construction details and requirements are related to the track operation.

XV. COMMUTER RAIL DESIGN STANDARDS

ATTACHMENT "B"

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
APPLICATION FOR ENTRY UPON MBTA RAILROAD PROPERTY
$1,000.00 Administrative Fee must be submitted with Application

Date: _____

1. Name of Applicant: _____

2. Type of Entity (Partnership, Corporation, Proprietorship, Public Authority, etc.):

   _____

3. Mailing Address: _____

   Contact Information: Name, Tel #, Cell #, email _____

4. If incorporated, state of incorporation: _____

5. Proposed license term commencement date: _____

6. Proposed license term: _____

7. Agents for applicant for service of notice or process: _____

   _____

8. If applicant is self-insured, please provide limits of self-insurance and attach copies of authorizing legislation or certification thereof:

9. If applicant is authorized by public authority to enter into such license agreement, please provide:

   Motion, Resolution, or Ordinance No.: _____

   Date of Adoption: _____

   Adopted by: _____

10. Name and title of applicant's officer authorized to sign agreement: _____

    _____

    _____

Project Description

1. Brief description of construction (including types of pipes and other attachments or ancillary facilities to be installed on MBTA Railroad Property): _____

_____

_____

_____

_____

2. Brief description of purpose of entry and/or installation: _____

_____

_____

_____

_____

Space Requirements
[*To Be Provided*]

Technical Information

1. Is this occupancy within the limits of a public road? _____
   Attach copies of applicant's franchise to occupy such space.

2. If occupancy is under, over, through, or attached to undergrade or overhead bridge, who owns such bridge? _____

   _____

3. Type of occupancy (facility):
   a) Exact Length of MBTA Railroad Property to be burdened by occupancy: ____

      _____

   b) Width of excavation facility on MBTA Railroad Property:

      _____

   c) Number of manholes: _____

   A. Aerial or underground wire and cable:

      (1) Telephone and other communication cables:

      Number of cables: _____

      Number of pairs/cable: _____

      Are these composite coaxial cables? _____

      (2) Power Cables:

      Number of cables/size: _____

      Number of volts per conductor: _____

      Are these pipe-type cables consisting of one or more high voltage cables encased in steel pipe under inert oil pressure? _____

      (3) Fiber optic cables:

      Number of cables: _____

      Number of distribution cables: _____

      Number of transmission cables: _____

      Number of strands in each cable: _____

Number of repeater stations on MBTA Railroad Property: _____

Systems (check one):

Transmission _____

Distribution _____

Sensor _____

(4) Number of spare or unoccupied ducts to be installed: _____

B. Pipes and Sewers

(1) Circular line carrying no pressure:

Number of pipes: _____

Number of inches of inside nominal diameter per pipe: _____

(2) Circular lines under pressure and carrying non-flammable, non-explosive, or non-combustible supporting materials, except coal and slurry:

Number of pipes: _____

Number of inches of inside nominal diameter per pipe: _____

(3) Circular lines under pressure and carrying flammable, explosive, or combustible supporting material:

Number of pipes: _____

Number of inches of inside nominal diameter per pipe: _____

(4) Non-circular pipe: _____

(5) Will a pipe tunnel be constructed? _____

(6) Will pipe be supported by MBTA structures, bridges, etc.? _____

Explain: _____

_____

(7) Will pipe be attached to MBTA structures, bridges, etc.? _____

Explain: _____

_____

C. Ancillary Facilities

Number of wooden poles to be installed on MBTA Railroad Property:

_____

Other wooden supporting structures: _____

_____

Steel supporting structures: _____

Explain: _____

Number of braces, stub poles: _____

Number of guy wires anchored on MBTA Railroad Property: _____

Number of span guy wires crossing MBTA Railroad Property: _____

D. Attachments

(1) Attachment of aerial wires and cables to poles or other structures of MBTA used in wire line construction or support:

Number of wires attached to MBTA cross-arm: _____

Voltage of wire: _____

Number of wires attached to applicant's cross-arm or bracket: ___

Voltage of wire: _____

Number of cross-arms or brackets attached to MBTA poles: _____

(2) Attachment of aerial wires and cables to building or structures other than those used in wire line construction or support:

Number of wires or cables attached to MBTA's building or structures:

_____

(3) Attachment of cable terminals to poles, buildings, or structures including highway bridges, railroad bridges over highways, or other bridges of MBTA:

Number of cable terminals, loading coils, transformers, or like devices attached:

_____

Explain: _____

E. Guy wire crossings and overhanging cross-arms and power wires of pole lines

outside MBTA right-of-way.

Number of guy wires crossing MBTA Railroad property but not anchored thereon: _____

Number of cross-arms overhanging MBTA Railroad Property from poles located outside thereof: _____

Number of cross-arms on any poles: _____

It is hereby understood and agreed that the undersigned applicant will bear any and all costs associated with MBTA's preliminary and final engineering review in connection with this application. Any charges in excess of the initial advance payment will be billed directly to the address indicated in Item #3 above.

Agent: _____

For: _____
Name of Applicant

By: _____
(Title)

_____
(Date)

ATTACHMENT “C”

REFERENCED STANDARDS AND SPECIFICATIONS

A. Wherever standards or specifications issued by a recognized industry association or regulatory body are referenced in these Specifications, the reference shall be interpreted as incorporating the referenced standard or specification in total into these Specifications as applicable. In the event of a difference between referenced standard or specifications and these Specifications, the latter shall govern.

B. Technical Reference Abbreviations - References are made to recognized standards by use of the acronyms listed below. Addresses are included for convenience, and the accuracy of the addresses is not warranted:

AA	The Aluminum Association 900 19th Street NW Washington, DC 20006
AAR	The Association of American Railroads American Railroads Building 50 F Street NW Washington, DC 20001
AASHTO	American Association of State Highway and Transportation Officials 444 North Capitol Street NW Suite 249 Washington, DC 20001
ACGIH	American Conference of Governmental Industrial Hygienists 1330 Kemper Meadow Drive Cincinnati, OH 45240
ACI	American Concrete Institute P. O. Box 19150 Detroit, MI 48219
AFPA	American Forest and Paper Association 1111 19th Street, NW Suite 700

Washington, DC 20036

AIA American Insurance Association
1130 Connecticut Avenue NW
Washington, DC 20036

AISC American Institute of Steel Construction Inc.
1 East Wacker Drive
Suite 1300
Chicago, IL 60601

AISI American Iron and Steel Institute
1101 17th Street NW
Suite 1300
Washington, DC 20036-4700

AITC American Institute of Timber Construction
7012 South Revere Parkway
Suite 140
Englewood, CO 80112

ANSI American National Standards Institute
11 West 42nd Street
New York, NY 10036

APA American Plywood Association
P. O. Box 11700
Tacoma, WA 98411

APHA American Public Health Association
1015 15th Street NW
Washington, DC 20005

AREA American Railway Engineering Association
50 F Street NW
Washington, DC 20001

ASCE American Society of Civil Engineers
345 East 47th Street
New York, NY 10017

ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers
1791 Tullie Circle, NE
Atlanta, GA 30329

ASME	American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017
ASTM	American Society for Testing and Materials 1916 Race Street Philadelphia, PA 19103
AWPA	American Wood Preservers' Association P. O. Box 286 Woodstock, MD 21163-0286
AWS	American Welding Society 550 NW 42nd Avenue Miami, FL 33126
AWWA	American Water Works Association, Inc. 6666 W. Quincy Avenue Denver, CO 802350
CSI	Construction Specifications Institute 601 Madison Avenue Alexandria, VA 22314-1791
FHA	Federal Highway Administration 400 7th Street SW Washington, DC 20590
FRA	Federal Railroad Administration 403 7th Street SW Washington, DC 20590
ICBO	International Conference of Building Officials 5360 Workman Mill Road Whittler, CA 90601
IIA	Incinerator Institute of America 60 East 42nd Street New York, NY 10017

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

II

MAINTENANCE AND PROTECTION OF RAILROAD TRAFFIC

APRIL 2001

SECTION I. GENERAL

1.01 The contractor should note that these specifications govern proposed work that involves construction on, over, under, within or adjacent to MBTA Railroad Property. Requirements must be strictly observed whenever the tracks, structures, or properties of the MBTA are involved or affected.

1.02 If the tracks or other facilities of the MBTA are endangered, the Contractor shall immediately perform such work as directed by the Railroad Company(s), and upon failure of the Contractor to carry out such orders immediately, the Railroad Company(s) may take whatever steps are necessary to restore safe conditions. The cost and expense to the Railroad Company(s) and/or MBTA of restoring safe conditions or of any damage to the MBTA's trains, tracks, or other facilities caused by the Contractors' or subcontractors' operations, shall be at the sole expense of the Contractor and will be collected as appropriate. This cost shall be paid for by the Contractor and may be deducted from any monies due and that may become due to the Contractor.

1.03 Before entering upon MBTA Railroad Property:

A. The Owner or its Contractor shall be fully informed of all requirements of the MBTA pertaining to the specific project and shall conduct all his work accordingly. Any questions relating to the requirements of the MBTA should be directed to the Chief Engineering Officer of the MBTA or his authorized representative.

B. The Owner or its Contractor shall execute an MBTA License for Entry, and shall provide the MBTA and Railroad Company(s) with the information required in the "Insurance Specifications".

C. The Owner or its Contractor shall take note that if an excavation is to be made within a 2 to 1 slope line commencing 5.5 feet from the centerline of track, he shall submit the proposed method of soil stabilization for approval by the Chief Engineering Officer of the MBTA.

D. The Owner or its Contractor shall furnish detailed plans for falsework, bracing, sheeting, or other supports adjacent to the tracks for approval by the Chief Engineering Officer of the MBTA and the Railroad Company(s), and the work shall be performed in accordance with temporary “Sheeting and Shoring". All plans and calculations shall be stamped by a Registered Professional Engineer.

E. The Owner or its Contractor shall give written notice to the Chief Engineering Officer of the MBTA and the applicable Railroad Company(s) at least 21 days in advance of starting work or locating equipment at the site.

F. The Owner or its Contractor shall make all necessary arrangements with the

MBTA before entering upon MBTA Railroad Property.

1.04 After entering upon MBTA Railroad Property:

A. The Owner or its Contractor shall have, in his possession on the job site, the contract plans and specifications which bear the stamp of approval of the MBTA Chief Engineering Officer or Railroad Company(s). The Owner or its Contractor shall conduct all his work according to these plans and specifications.

B. All work shall be performed and completed in a manner fully satisfactory to the MBTA Chief Engineering Officer or authorized representative(s). Railroad Company(s) inspection of the work shall be conducted at any time and the Owner or its Contractor shall cooperate fully with the MBTA and Railroad Company(s) representatives.

C. All equipment used by the Owner or its Contractor on MBTA Railroad Property may be inspected by the Railroad Company(s) and shall not be used if considered unsatisfactory by the Railroad Company(s) representative. Equipment of the Owner or its Contractor to be used adjacent to tracks shall be in first class condition so as to positively prevent any failure that would cause delay in the operation of trains or damage to MBTA or railroad facilities. Equipment shall not be placed or put into operation adjacent to a track without first obtaining the permission of the Railroad Company(s).

D. Operators of such equipment must be properly licensed and may be examined by the Railroad Company(s) representative to determine their fitness. If it is determined that they are unfit to work, then the Owner or its Contractor shall remove them from MBTA Railroad Property.

E. If the Chief Engineering Officer of the MBTA deems it necessary, the Owner or its Contractor shall furnish and erect in close proximity to the site of the work a suitable, furnished shelter with lights, heat, telephone, etc., for use by Railroad Company(s) personnel providing services to the Owner's or Contractor’s work.

F. The Owner or its Contractor's work shall be performed in such manner that the tracks, train operations and appurtenances of the MBTA and the Railroad Company(s) will be safeguarded.

G. Open excavations shall be suitably planked and safeguarded when construction operations are not in progress.

H. Blasting will be permitted under or adjacent to tracks only after proof that blasting is required and all methods have been approved by the MBTA's

Chief Engineering Officer and the Railroad Company(s). All blasting operations must comply with the MBTA's "Blasting Specifications".

I. The Owner or its Contractor shall be fully responsible for all damages arising from their failure to comply with the requirements of these specifications. Failure to comply may result in their removal from MBTA Railroad Property, at the MBTA's sole discretion.

SECTION 2. RULES, REGULATIONS, ETC.

2.01 Railroad traffic shall be maintained at all times with safety and continuity, and the Contractor shall conduct all operations on, over, under, within or adjacent to MBTA Railroad Property within the rules, regulations, and requirements of the Railroad Company(s) and/or MBTA. The Contractor shall be responsible for acquainting himself with such requirements as the Railroad Company(s) and/or MBTA may demand.

2.02 The Contractor shall obtain verification of the time and schedule of track occupancy from the Railroad Company(s) before proceeding with any construction or demolition work on, over, under, within or adjacent to MBTA Railroad Property. The work shall not proceed until the plans and method of procedure have been approved by the Chief Engineering Officer of the MBTA or his authorized representative.

2.03 All work to be done on, over, under, within or adjacent to MBTA Railroad Property shall be performed by the Contractor in a manner satisfactory to the MBTA and the Railroad Company(s), and shall be performed at such times and in such manner, as to not interfere with the movement of trains or operations upon the tracks of the MBTA. The Contractor shall use all necessary care and precaution in order to avoid accidents, delay or interference with the MBTA's trains or other property.

2.04 The Contractor shall give written notice to the Railroad Company(s) at least twenty-one (21) days prior to the commencement of any work, or any portion of the work, by the Contractor or his subcontractors on, over, under, within or adjacent to MBTA Railroad Property, in order that necessary arrangements may be made by the Railroad Company(s) to protect railroad operations.

2.05 If deemed necessary by the Railroad Company(s), it may assign an inspector and/or engineer who will be placed on the work site during the time the Contractor or any subcontractor is performing work on, over, under, within or adjacent to MBTA Railroad Property. The cost and expense will be paid directly by the contracting party with an advance deposit to the Railroad Company(s), unless otherwise approved.

2.06 Before proceeding with any construction or demolition work, on, over, under, within or adjacent to the MBTA’s Railroad Property, a pre-construction meeting shall be held at which time the Contractor shall submit for approval of the MBTA and

Railroad Company(s), plans, computations, and a detailed description of the method for accomplishing the construction work, including methods of protecting railroad operations. Such approval shall not serve in any way to relieve the Contractor of complete responsibility for the adequacy and safety of the referenced methods.

2.07 During any demolition procedure, the Contractor must provide an approved shield to prohibit all debris from falling onto MBTA Railroad Property. A protective fence must be erected at both ends of the project to prohibit trespassers from entering MBTA Railroad Property.

2.08 Cranes, shovels, or any other equipment shall be considered to be fouling the track when located in such position that failure of same with or without load, brings the equipment within the fouling limit. The Contractor's employees and equipment will not be permitted to work near overhead wires or apparatus.

2.09 The Contractor shall conduct his work and handle his equipment and materials so that no part of any equipment should foul an operated track or wire line without the written permission of the Railroad Company(s). When it becomes necessary for the Contractor to foul any track, he must give the Railroad Company(s) written notice of his intentions twenty-one (21) days in advance, so that if approved, arrangements may be made for proper protection of the Railroad Company(s).

2.10 The Contractor's equipment shall not be placed or put into operation adjacent to tracks without first obtaining permission from the Railroad Company(s). Under no circumstances shall any equipment or materials be placed or stored within fifteen (15) feet from the centerline of the closest track.

2.11 Materials and equipment belonging to the Contractor shall not be stored on MBTA Railroad Property without first having obtained permission from the Railroad Company(s), and such permission will be on the condition that the MBTA and/or Railroad Company(s) will not be liable for damage to such materials and equipment from any cause. The Contractor shall keep the tracks adjacent to the site clear of all refuse and debris that may accumulate from construction operations, and shall leave the MBTA Railroad Property in the condition existing before construction commencement. Equipment repair, refueling or extended storage is prohibited on MBTA Railroad Property.

2.12 The Contractor shall consult the Railroad Company(s) in order to determine the type of protection required to insure safety and continuity of railroad operations. The railroad field engineer may assign track foremen, flagmen, signalmen or other employees deemed necessary for protective services by the Railroad Company(s), to insure the safety of trains and MBTA Railroad Property. The cost of same shall be paid directly by the contracting party with an advance deposit to the Railroad Company(s), unless otherwise approved.

2.13 The provision of such protective services, and other precautionary measures, shall not relieve the Contractor from liability for the cost of any and all damages caused by his operations.

2.14 The Railroad Company(s) will require protection during all periods when the Contractor is working on, over, under, within or adjacent to MBTA Railroad Property or as may be deemed necessary. When protection is required, the Contractor shall make the request in writing to the Railroad Company(s) at least twenty-one (21) days before such protection is required.

2.15 The Contractor shall not bill the Railroad Company(s) or MBTA for any work which he may perform, unless the Railroad Company(s) or MBTA authorizes the said work in writing. This work must be to the benefit of the MBTA or Railroad Company(s).

2. I6 The Contractor, subcontractor and respective employees who will come within the limits of the MBTA Railroad Property, must first attend the Railroad Company(s) Safety Orientation Class. They are required to comply with the Railroad Company(s) Safety Requirements throughout the entire construction period. All costs associated with compliance of the Railroad Company(s) Safety Requirements will be at the sole expense of the Contractor and subcontractors.

A. The Contractor for the project must appoint a qualified person who will be designated as a Safety Representative. He must be approved by the Railroad Company(s) Safety Representative. The Contractor's designee will be responsible to give Safety Orientation to the Contractor's/subcontractor's employees who will come onto the MBTA's Railroad Property for short periods of time after the initial Safety Orientation Class has been given by the Railroad Company(s). The Contractor's designee will keep the Railroad Company(s) Safety Representative informed of the temporary employees who received Safety Orientation. The Railroad Company(s) Safety Orientation Class will be repeated when employee turnover or groups of Contractor's and subcontractor’s employees are such that another Railroad Company(s) Safety Orientation Class is justified.

B. Contractors will follow established safety procedures and remain 15 feet or more from the centerline of the closest track. When it becomes necessary for Contractors to encroach on this 15 foot limitation, the proper fouling procedures will be arranged with the Railroad Company(s).

C. Contractors will establish the 15 foot foul line by installing stakes and taping off the area prior to beginning work.

2.17 Upon completion of the work, the Contractor shall remove from the MBTA Railroad Property, all machinery, equipment, surplus materials. falsework, rubbish, temporary buildings and other property of the Contractor, or any subcontractor, and

shall leave MBTA Railroad Property in a condition satisfactory to the MBTA and Railroad Company(s). Failure to comply will result in Railroad Company(s) forces restoring MBTA Railroad Property at the Contractor's expense.

2. I8 The Contractor will pay the Railroad Company(s) directly, for all protective services unless otherwise approved. The services are performed to insure safe operation of trains when construction work would, in the Railroad Company(s) opinion, be a hazard.

SECTION 3. DEFINITION OF HAZARD

3.01 Protection Services will be required whenever the Contractor is performing work on, over, under, within or adjacent to MBTA Railroad Property. This will include excavating, sheeting, shoring, erection, removal of forms, handling material, using equipment which by swinging or by failure could foul the track, and when any other type of work being performed, in the opinion of the Railroad Company(s), requires such service.

3.02 Railroad operations will be considered subject to hazard when explosives are used in the vicinity of MBTA Railroad Property during the driving or pulling of sheeting for footings adjacent to a track, when erecting structural steel across or adjacent to a track, when operations involve swinging booms or chutes that could in any way come closer than 5 feet to the center line of a track or wire line. None of these or similar operations, shall be carried on without Railroad Company(s) protective services personnel on site.

3.03 A signal line or communication line shall be considered fouled and subject to hazard when any object is brought closer than ten (10) feet to any wire or cable. An electrical supply line shall be considered fouled and subject to hazard when any object is brought closer than ten (10) feet to any wire of the line.

3.04 As excavation approaches pipes, conduits, or other underground structures on or adjacent to MBTA Railroad Property, digging by machinery shall be discontinued and the excavation shall continue by means of hand tools. All existing pipes, poles, wires, fences, property line markers, and other structures, which the MBTA and/or Railroad Company(s) decides must be preserved in place, shall be carefully protected from damage by the Contractor or its Owner. Should such items be damaged, they shall be restored by the Railroad Company(s), at the Owner’s or Contractor's sole expense to the original condition prior to construction commencement. If any excavation is taken beyond the work limit indicated on the approved plans or prescribed herein, the Owner or its Contractor shall backfill and compact to the satisfaction of the Railroad Company(s) at his own expense.

SECTION 4. BACKFILL

4.01 Backfilling

A. All backfill material adjacent to any Railroad Company(s) facility shall be approved by the Railroad Company(s). Backfill material shall be free from hard lumps and clods larger than 3 inches in diameter, and free from large rocks or stumps. Uniformly fine material shall be placed next to any pipe liable to dent or break.

B. All backfill material shall be compacted at or near optimum moisture content, in layers not exceeding 6 inches in compacted thickness by pneumatic tampers, vibrator compactors, or other approved means to the base of the railroad subgrade. Material shall be compacted to not less than 95 percent of AASHTO T 99, Method C. The Contractor will be required to supply to the job site, ballast stone (AREA #4) to be installed by the Railroad Company(s).

4.02 Certification

The Owner or its Contractor shall provide testing, through the use of a testing lab or Professional Engineer, to insure that the inplace density of the backfill meets or exceeds the requirements of Section 4.01(B). Written certification of the tests shall be given to the Railroad Company(s) immediately upon completion of the test.

4.03 Alternate

In the case of an open cut crossing of the MBTA Railroad Property, the Owner or its Contractor may backfill with concrete having a three-day compressive strength of 1000 psi to the base of the track subgrade. This may be used in lieu of providing the certification of proper compaction when using gravel backfill. The Owner or its Contractor will be required to supply to the job site, ballast stone (AREA #4) to be installed by the Railroad Company(s).

SECTION 5. CLEARANCES

5.01 Staging falsework or forms shall at all times be maintained with a minimum vertical clearance of 226" above top of he high rail and a minimum horizontal clearance of 15' from the center line of track.

SECTION 6. PROTECTION SERVICES

6.01 The MBTA shall require railroad inspection and may require railroad flagging. Prior to the start of any work on MBTA Railroad Properly, the Owner or its Contractor shall submit a deposit to the amount required by the Railroad Company(s). If Railroad Company(s) expenses are greater than the amount of deposit, the Owner or its Contractor shall reimburse the Railroad Company(s) for the balance when billed, and, if the Railroad Company(s) expenses are less than the amount of deposit, the Railroad Company(s) will refund the balance to the Owner or its Contractor. The Railroad Company(s) reserves the right to request additional deposits as project work progresses.

6.02 If the MBTA or Railroad Company(s) determines that flagmen are necessary, the number required shall be on duty at the site during the hours of hazard described under Section 3. No work shall be performed if flagmen are required but are not on duty.

6.03 It shall be the responsibility of the Owner or its Contractor to keep the MBTA and Railroad Company(s) informed at all times when the Owner or its Contractor shall be working on, over, under, within or adjacent to MBTA Railroad Property and creating the hazards described under Section 3. Failure of the Owner or its Contractor to give the MBTA and Railroad Company(s) suitable advance notice of hazardous operation shall result in the shut down of the work by the Railroad Company(s), until such time as sufficient number of flagmen are on duty at the site. If this becomes a repeat occurrence, the Contractor will be removed from the project.

6.04 The Railroad Company(s) will make its best effort to provide protective services personnel. Should the situation arise where such personnel are not available, Contractor operations must cease. The Railroad Company(s) is not liable for any monetary claims incurred during the absence of protective services personnel.

SECTION 7. INSPECTION

7.01 If deemed necessary by the Chief Engineering Officer of the MBTA, the MBTA will furnish and assign an engineer(s) for inspection and the Railroad Company(s) will furnish an appropriate inspector for general inspection purposes or for general protection of MBTA Railroad Property and operations during construction. All protection services will be at the expense of the Owner or its Contractor.

SECTION 8. EXTRA-CONTRACT SERVICES

8.01 Temporary and permanent changes of tracks and all railroad utilities made necessary by the work of the Contractor, will be made by the MBTA or Railroad Company(s) at the expense of the Owner or its Contractor.

8.02 All other changes made or services furnished by the Railroad Company(s), at the request of the Owner or its Contractor, will be at the Owner's or its Contractor's expense.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

III

INSURANCE SPECIFICATIONS

The insurance outlined in these Specifications is required of the Owner or Contractor, and shall be provided by or in behalf of all subcontractors performing any portion of the work. The Owner or Contractor shall be responsible for any modifications, deviations or omissions of the required insurance as it applies to subcontractors.

All insurance policies, unless otherwise specified under Railroad Protective Liability Insurance, are to be written either on an occurrence basis or, if a claims-made form, applicable renewals must have a date retroactive to the construction start date and shall be maintained in force for one year following the acceptance of the work by the MBTA or its duly authorized representative.

With the exception of Railroad Protective Liability Insurance, all insurance policies must name the MBTA as an additional insured as its interest appears and waive any rights of subrogation against the MBTA.

Certificates of Insurance evidencing (1) either the claims-made or occurrence form coverage, (2) work description/location, (3) Owner or Contractor's corporate name, and (4) individual, company, government agency or municipality for which the work is being performed, are to be furnished to the MBTA prior to work commencement, and within fifteen (15) days of expiration of the insurance coverage, when applicable.

All policies must contain a minimum thirty (30) day written notice of cancellation clause, and provide that the Insurance Company shall notify the Owner, Contractor, MBTA and Railroad Company(s), via registered mail, of any cancellation, change or expiration of the policy.

Original Insurance Certificate(s) shall be received and approved by the MBTA before the Owner or Contractor will be allowed entry upon MBTA Railroad Property. Certificates, including any required endorsements, shall be furnished to the MBTA, c/o Risk Manager, Office of the Treasurer-Controller, Ten Park Plaza, Room 8450, Boston, MA 02116, and shall provide stated coverage and a provision that Notice of Accident (occurrence) and Notice of Claim shall be given to the Insurance Company as soon as practicable after notice to the insured(s).

Original Insurance Binders reflecting Railroad Protective Insurance shall be received and approved by the MBTA and the appropriate Railroad Company(s) prior to entry upon MBTA Railroad Property. Mailing addresses for transmittal of original Insurance Binders to the named insured Railroad Company(s) are contained on Page Four of these Specifications.

The Owner or Contractor shall indemnify, defend and save harmless the MBTA and the appropriate Railroad Company(s) from and against any and all liabilities, losses (including losses of revenue), claims, costs, damages and expenses (including reasonable attorney's fees and expenses) that may be asserted against or incurred by the MBTA and the Railroad Company(s) arising from or as a result of the Owner or Contractor's work, or its use of adjacent land. Said indemnification shall include claims, whether covered by

insurance or not, including, but not limited to Workers Compensation and similar insurance.

The Owner or Contractor shall maintain, during the life of the contract, from company(s} authorized to do business in the Commonwealth of Massachusetts and satisfactory to the MBTA:

A. **COMMERCIAL GENERAL LIABILITY INSURANCE** for personal injury, bodily injury and property damage in an amount not less than $1,000,000 per occurrence and $3,000,000 in the aggregate covering all work performed on over or adjacent to MBTA Railroad Property (the “work"), including:

1. All operations;

2. Contractual liability;

3. Coverage for the so-called "X, C, U" hazards, i.e., collapse of building, blasting, and damage to underground property;

4. Asbestos abatement, when applicable.

B. **AUTOMOBILE LIABILITY INSURANCE** including the use of all vehicles owned, non-owned, leased and hired, in an amount not less than $2,000,000 combined single limit covering all the work.

C. **WORKER'S COMPENSATION INSURANCE** including Employees, Liability Insurance, as provided by Massachusetts General Laws, Chapter 152, as amended, covering all the work.

D. **UMBRELLA LIABILITY COVERAGE** in an amount not less than $5,000,000 per occurrence covering all the work.

E. **HAZARDOUS MATERIALS INSURANCE** if the work involves hazardous materials, the following coverage is required:

1. **Pollution Liability insurance** for sudden and gradual occurrences in an amount not less than $1,000,000 per occurrence and $5,000,000 in the aggregate arising out of the work, including but not limited to all hazardous materials identified in the contract.

2. When applicable, the Owner or Contractor shall designate the disposal site and furnish a Certificate of Insurance from the Disposal Facility for Environmental Impairment Liability Insurance for (a) sudden and accidental occurrences in an amount not less than $3,000,000 per occurrence and $6,000,000 in the aggregate and (b) non-sudden occurrences in an amount not less than $5,000,000 per occurrence and $10,000,000 in the aggregate.

3. Certificates of insurance shall clearly state the hazardous materials exposure work being performed.

F. RAILROAD PROTECTIVE LIABILITY INSURANCE is specifically designed for insuring Railroads, and is purchased by the Owner or Contractor in the name of the MBTA and the Railroad Company(s). **The Railroad Company(s) is the named insured on the policy**. Railroad Protective Liability Insurance is required for y work performed within fifty (50) feet from center line of the nearest railroad track; it is not a substitute for any types of insurance outlined in these Specifications. Required limits are:

Bodily injury: not less than $5,000,000 for all damages arising out of bodily injuries to or death of one person, and subject to that limit for each person, a total limit of $10,000,000 for all damages arising out of bodily injury to or death of two or more persons in any one accident;

Property Damage: not less than $5,000,000 or all damages arising out of injury to or destruction of MBTA property in any one accident, and subject to that limit per accident, a total of $10,000,000 in the aggregate for all damages arising out of injury to or destruction of MBTA property.

Questions regarding insurance should be directed to MBTA License Administrator at (617) 482-2525.

Questions regarding train counts and train speeds should be directed to the appropriate Railroad Company(s) listed on Page Four.

PROOF OF INSURANCE
MAILING ADDRESSES:

MBTA	Risk Manager c/o Treasurer-Controller 10 Park Plaza Boston, MA 02116 cc: MBTA Real Estate Management
National Railroad Passenger Corporation (Amtrak)	Boston Division Office c/o Division Engineer 32 Cobble Hill Road Somerville, MA 02143
Consolidated Rail Corporation	Chief Engineer Design and Construction 2201 Market Street - 11C P. O. Box 41411 Philadelphia, PA 19101 (215) 209-3874/Denise Boyle
Bay Colony Railroad Corporation	General Manager 4 Freight House Road East Wareham, MA 02571
Boston and Maine Corporation and Springfield Terminal Railway Co.	Chief Engineer 402 Amherst Street Suite 300 Nashua, NH 03063-1287
Providence and Worcester Railroad Company	P. O. Box 1188 Worcester, MA O1601

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

IV

PIPELINE OCCUPANCY SPECIFICATIONS

INDEX

SECTION I. GENERAL REQUIREMENTS

1.01 DESCRIPTION OF WORK AND LOCATION

These specifications apply to the design and construction of pipelines carrying flammable and non-flammable substances and to casings over 4-inches in diameter containing wires and cables, under, across or along MBTA Railroad Property, facilities and tracks.

1.02 LICENSE TO ENTER RAILROAD PROPERTY

A. Entry upon MBTA Railroad Property for the purpose of conducting surveys, field inspections, obtaining soil information, or any other purpose associated with the design and engineering of the proposed occupancy, will be authorized by an MBTA License for Entry (See "Guidelines and Procedures for Construction on MBTA Railroad Property").

B. Issuance of the License does not constitute authority to proceed with the actual construction.

1.03 WORK ON RAILROAD PROPERTY

A. The safety and continuity of train operations shall be the first priority. The Applicant shall arrange the work so that the trains will be protected and safeguarded at all times. Whenever the work may affect the safety and movement of trains, the method, sequence and time schedule of performing such work shall be submitted to the MBTA's Chief Engineering Officer or his authorized representative for approval.

B. The Applicant waives all claims against the Railroad Company(s) and/or the MBTA for delays or any interference occasioned by railroad traffic or railroad maintenance.

C. All Applicant-designed temporary construction on MBTA Railroad Property, shall be designed in accordance with the appropriate railroad criteria and all construction performed on, over, under, within or adjacent to MBTA Railroad Property will he subject to the inspection and approval of the Railroad Company(s) and/or MBTA.

D. A minimum of fourteen (14) days advance written notice shall be given to the Railroad Company(s) prior to construction related activities.

E. The Railroad Company(s) will furnish such qualified flagmen, signalmen or protection men as may be required to insure complete protection of train operations and railroad facilities. The need for this type of service will be determined by the Railroad Company(s) on the basis of railroad regulations

and the Applicant's approved construction schedule. No work shall proceed without proper protection on the site.

F. All expenses incurred in connection with protection of railroad facilities by Railroad Company(s) employees will be borne by the Applicant. Billings for such service or expense, including labor, materials and equipment will be made directly to the Applicant for payment.

G. During construction, railroad traffic shall be maintained at all times without interruption, except when approved in advance, in writing, by the Chief Engineering Officer or his authorized representative.

H. All construction operations shall be conducted so as not to interfere with, interrupt, or endanger the operation of trains, nor damage, destroy, or endanger the integrity of railroad facilities. All work on or near MBTA Railroad Property shall be conducted in accordance with the Railroad safety rules and regulations. The Applicant shall secure and comply with the Railroad safety rules and shall give written acknowledgment to the Railroad Company(s) that they have been received, read, and understood by the Applicant and his employees. Construction operations will be subject to Railroad Company(s) inspection at any and all times.

I. All cranes, lifts, or other equipment that will be operated in the vicinity of the MBTA's electrification and power transmission facilities shall be electrically grounded as directed by the Railroad Company(s).

J. At all times when the work is progressing, a field supervisor for the work with no less than twelve (12) months experience in the operation of the equipment being used shall be present. Certification of the above must be submitted to the Railroad Company(s).

K. Whenever equipment or personnel are working closer than fifteen (15) feet to the centerline of an adjacent track, that track shall be considered as being obstructed. Insofar as possible, all construction operations shall be conducted no less than this distance. Construction operations closer than fifteen (15) feet to the centerline of a track shall be conducted only with the permission of, and as directed by, a qualified Railroad Company(s) employee present at the work site.

L. Crossing of tracks at grade by equipment and personnel is prohibited except by prior arrangement with, and as directed by, the Chief Engineering Officer or his authorized representative.

M. All tunneling, jacking and boring operations within railroad influence lines will be done on a 24 hour per day basis to minimize Railroad exposure to construction hazards.

1.04 COORDINATION

The Applicant shall coordinate his work with his contractors, subcontractors, utility companies, governmental units, and any affected Railroad Company(s) with regard to site access, establishment and use of temporary facilities, work schedules, and other elements of the specified work which require interfacing with others.

1.05 LAYOUT OF WORK

The Applicant shall lay out his work true to lines and grades indicated on the drawings and shall be responsible for all measurements in connection therewith. The Applicant will be held responsible for the execution of the work to such lines and grades indicated on the approved construction drawings or such other lines and grades as may be directed or established by the Chief Engineering Officer or his authorized representative.

1.06 INDEMNIFICATION AND INSURANCE

See requirements in "Guidelines and Procedures for Construction on MBTA Railroad Property" and "Insurance Specifications."

1.07 SCIENTIFIC OR HISTORIC ARTIFACTS

The Applicant shall immediately notify the Chief Engineering Officer of the discovery of scientific or historical artifacts and shall protect same until identified and removed by the appropriate Authorities exercising jurisdiction.

1.08 RECORD DOCUMENTS

A. The Applicant shall furnish the Railroad Company(s) and the MBTA with one reproducible "As Built" copy of each approved Construction Drawing, marked to indicate all changes and deviations from same.

B. All project record documents shall be received and accepted by the MBTA and the Railroad Company(s) prior to final inspection.

SECTION 2. SUBMITTALS

2.01 APPLICATION FOR OCCUPANCY

The Applicant must agree, upon approval of the construction details by the Chief Engineering Officer, to execute the MBTA Pipeline Occupancy Agreement and pay any required fees and/or rentals outlined therein. Refer to "Guidelines and Procedures for Construction on MBTA Railroad Property" for application policy.

2.02 SUBMISSION OF CONSTRUCTION PLANS AND SPECIFICATIONS

A. Six (6) sets of plans and specifications for proposed pipeline occupations shall be submitted to the Director of Real Estate and meet the approval of the Railroad Company(s) and the MBTA prior to the start of construction. These plans are to be prepared in sizes as small as possible arid are to be folded to an 8-1/2 inch by 11-inch size (folded dimensions) with a 1-1/2 inch margin on the left side and a 1-inch margin on the top.

1. After folding, the title block and other identification of the plans shall be visible at the lower right corner, without the necessity of unfolding. Each plan shall bear an individually identifying number and an original date, together with subsequent revision dates, clearly identified on the plan.

2. All plans are to be individually folded or rolled and where more than one plan is involved, they shall be assembled into complete sets before submission to the MBTA.

B. Draw plans to scale and show the following (see attached Plates).

1. Plan view of proposed pipeline in relation to all railroad facilities.

2. Location of pipe (in feet) from nearest railroad milepost, centerline of a railroad bridge (giving bridge number), or centerline of an existing or former passenger station, or other fixed point. In all cases, the name of the City or Town and County in which the proposed facilities

are located must be shown.

3. Profile of ground on centerline of pipe from field survey showing relationship of pipe and casing to ground level, tracks and other facilities. For longitudinal occupations, the profile of adjacent track(s) must be shown.

4. All MBTA property lines. If pipeline is in a public highway, the limits of the right-of-way for the highway shall be clearly indicated with dimensions from centerline.

5. The angle of crossings in relation to centerline of tracks.

6. Location of valves or control stations of the pipeline.

7. "Pipe Crossing Data Sheet" completed and out on Plan.

C. The plan must be specific (both on MBTA Railroad Property and under tracks that are not on MBTA Railroad Properly) as to:

1. Method of installations.
2. Size and material of casing pipe.
3. Size and material of carrier pipe.

These items shall not have an alternative.

D. Once an application is approved by the Chief Engineering Officer or his authorized representative, proposed variances from the approved plans, specifications, method of construction, etc., will be resubmitted for approval.

E. Location and dimensions of jacking, boring, or tunneling pits shall be shown with details of their sheeting and shoring. If the bottom of the pit excavation nearest the adjacent track intersects a line from a point 5.5 feet horizontally from center line of adjacent track at the plane of the base of fall drawn on a slope of 2 horizontal to 1 vertical, submit design and details of the pit construction to the MBTA for approval complete with computations prepared by a Registered Professional Engineer. In any event, the face of the pit shall be no less than 25 feet from adjacent track, unless otherwise approved by the Chief Engineering Officer or his authorized representative. Pits shall be fenced, lighted, and otherwise protected as directed by the Railroad Company(s).

F. All plans and computations, including those submitted by contractors, must bear the seal of a Registered Professional Engineer.

G. Computations for all structures involving the support or protection of railroad

track, embankment and facilities must be prepared by and bear the seal of a Registered Professional Engineer and shall be submitted within the construction plans.

H. When computer calculations are included with design calculations, the following documentation shall be furnished:

1. A synopsis of the computer program(s) stating briefly required input, method of solution, approximations used, second order analysis incorporated, specifications or codes used, cases considered, output generated, extent of previous usage of certification of program(s) and program(s) author.

2. Identification by number, indexing and cross-referencing of all calculation sheets, including supplemental "long-hand" calculation sheets.

3. Fully identified, dimensioned, and annotated diagram of each member or structure being considered.

4. Clear identification and printing of all input and output values, including intermediate values if such values are necessary for orderly review.

5. Identification of the processing unit, input/output devices, storage requirements, etc., if such supplemental information is significant and necessary for evaluation of the submittal.

I. Specifications shall conform to Construction Specifications Institute (CIS) 16 Division, 3-part Section Format.

J. If other than American Railway Engineering Association (AREA), American Society for Testing and Materials (ASTM), or American National Standards Institute (ANSI) specifications are referred to for design, materials or workmanship on the construction plans and specifications for the work, then copies of the applicable sections of such other specifications referred to shall accompany the construction plans and specifications for the work.

SECTION 3. TEMPORARY FACILITIES AND CONTROLS

3.01 REQUIREMENTS OF REGULATORY AGENCIES

Applicant shall:

A. Obtain and pay all costs for required permits for installation and maintenance of temporary facilities and controls.

B. Comply with all applicable Federal, State and local codes, regulations and ordinances.

C. Comply with regulations and requirements of all utility or service companies from which temporary utilities or services are obtained, and pay all costs incurred therewith.

3.02 INSTALLATION AND COORDINATION - GENERAL

Applicant shall:

A. Install all temporary facilities and controls in a neat and orderly manner.

B. Make all temporary facilities structurally and functionally sound throughout.

C. Construct temporary facilities and controls to give continuous service and to provide safe working conditions.

1. Enforce conformance with applicable standards
2. Enforce safe practices.

D. Modify, extend or relocate temporary facilities and controls as work progress requires.

E. Locate temporary facilities and controls to avoid interference with, or hazards to:

1. Work or movement of railroad personnel or traffic.
2. Vehicular traffic.
3. General Public.
4. Work of other contracts.
5. Railroad Passengers.

F. Obtain easements as may be required across non-MBTA Railroad Property.

G. Provide materials for temporary facilities and controls for the purpose intended and shall not violate requirements of applicable codes and shall not

create unsafe conditions.

3.03 SANITARY FACILITIES

Prior to the start of work, the Applicant shall furnish necessary toilet conveniences, secluded from public observation. They shall be kept in a clean and sanitary condition and comply with the requirements and regulations of the area in which the work is performed.

3.04 LIGHT AND POWER

Applicant shall make his own arrangements for obtaining temporary light and power as required for the work, and shall maintain such temporary facilities in a proper and safe condition, including compliance with applicable codes.

3.05 TEMPORARY WATER

Applicant shall make his own arrangements for obtaining all temporary water service as required for the work.

3.06 TEMPORARY TRAFFIC CONTROLS

Applicant shall cooperate with the directives of the MBTA and/or Railroad Company(s) regarding vehicular traffic control and provide any temporary controls or devices required to eliminate or minimize congestion or obstruction of vehicular traffic caused by the work, including use of designated routes of ingress and egress from the work area.

3.07 TEMPORARY WORK AND STORAGE AREAS

A. The areas designated by the MBTA as the temporary parking, work and storage area(s) will be provided to the Applicant in accordance with the terms of the MBTA License Agreement.

B. All designated temporary parking, work and storage areas used by the Applicant shall be restored to their original condition prior to completion of the work, subject to inspection and approval of the MBTA and the Railroad Company(s).

3.08 POLLUTION ABATEMENT CONTROLS

Applicant shall:

A. Conduct operations in a manner to minimize pollution of the environment surrounding the area of work by every means possible. Specific controls shall be provided as follows:

1. Vehicles: All vehicles and material transport trucks leaving the site and entering paved public streets shall be cleaned of mud and dirt clinging to the body and wheels of the vehicle. Trucks arriving at or leaving the site with materials shall be loaded in a manner which will prevent dropping of materials or debris on the streets. Spills of materials in public areas shall be removed immediately at no cost to the MBTA or Railroad Company(s).

2. Waste Materials: No waste or erosion materials shall be allowed to enter natural or man-made water or sewage removal systems. Erosion materials from excavations, borrow areas or stockpiled fill shall be contained within the work area. The Applicant shall develop methods for control of waste and erosion which shall include such means as filtration, settlement and manual removal to satisfy the above requirements. Do not dispose of machinery lubricants, fuels, coolants and solvents on the site. If hazardous waste is encountered, the Applicant shall dispose of it in accordance with all federal, state and local codes. Verification of proper disposal must be provided, in writing, to the MBTA and the Railroad Company(s).

3. Burning: No burning of waste shall be allowed without prior written permission. In cases where permission is granted, burning shall be conducted in accordance with the regulations of :the appropriate jurisdictional agency.

4. Dust Control: The Applicant shall at all times control the generation of dust by his operations. Control of dust is mandatory and shall be accomplished by water sprinkling or by other methods approved by the MBTA or Railroad Company(s).

5. Noise Control: The Applicant shall take every action possible to minimize the noise caused by his operation. When required by agencies having jurisdiction, noise producing work shall be performed during less sensitive hours of the day or week as directed by the MBTA or Railroad Company(s) or as required by local ordinance.

6. Environmental: All local and state environmental laws will be strictly adhered to. All applications, permits. licenses, approvals, etc., will be the sole responsibility of the Applicant.

B. Submit a program for pollution control with applicable licenses and permits for all piping carrying non-potable liquids, gases or other pollutants.

3.09 PROTECTION OF PERSONS AND PROPERTY

A. Safety Requirements

1. The Applicant must adhere to the most stringent provisions of the applicable statutes and regulations of the political subdivision in which the work is being performed. The Applicant must also observe the Department of Labor-Occupational Safety, Health Administration provision, pertaining to the safe performance of the work, and further, the methods of performing the work must not involve undue danger to the personnel employed thereon, Railroad Company(s) employees, the public, or to public and private property. Should charges of violation of any of the above be issued to the Applicant in the course of the work, a copy of each charge shall immediately be forwarded to the Railroad Company(s). The Applicant shall pay all fines and penalties levied against him.

2. The Applicant shall erect and maintain, as required by existing conditions and progress of the work, all reasonable safeguards for safety and protection. This includes posting danger signs and other warnings against hazards, promulgating safety regulations and notifying owners and users of adjacent utilities.

B. Safety of Persons and Property - The Applicant shall take all reasonable precautions for the safety of, and shall provide all reasonable protection to prevent damage, injury or loss to:

1. All employees on the work site and all other persons who may be affected.

2. All materials and equipment, whether in storage on or off the site, under the care, custody or control of the Contractor or any of his subcontractors.

---3. Other property at the site or adjacent thereto, including walks, pavements, roadways, structures, and utilities not designated for removal, relocation or replacement in the course of construction. Any damage to such items shall be restored to original condition by the Applicant at no cost to the MBTA or Railroad Company(s).

C. First Aid

The Applicant shall maintain adequate first aid supplies at the site as prescribed by Federal, State or Local codes and regulations.

D. Use of Explosives

Non blasting methods are preferred. See "Blasting Specifications."

E. Site Security

The Applicant shall:

1. Maintain a secure work site protecting the MBTA and the Railroad Company(s) interests and property from claims arising from trespass, theft and vandalism.

2, Permit access to the work site only to employees, contractors and those persons having business related to the work.

3. Provide security measures as required to protect his or his subcontractor's tools, equipment and property from damage, theft or vandalism.

4. Assume all costs for any MBTA and/or local police details required by the work.

3.10 VERMIN CONTROL

A. Do not permit food scraps, lunch bags, food wrappers or other items which would attract rats or other vermin to be left lying around the site. Deposit such items in closed, rat-proof metal containers for disposal on a regular basis.

B. The Applicant must provide vermin control as required by the MBTA or Railroad Company(s).

3.11 RUBBISH AND DEBRIS REMOVAL

A. Rubbish and debris resulting from the work must be neatly piled in a single location and legally disposed of at least once a week. If rubbish or debris interferes with railroad activities, or creates a fire or safety hazard, it must be removed on a more frequent basis.

B. Volatile waste such as mineral spirits, oil, or paint thinner shall not be

disposed of in storm or sanitary drains, streams or waterways or any location upon the site.

SECTION 4. PIPELINE OCCUPANCY GENERAL CRITERIA

GENERAL:

4.01 METHOD OF INSTALLATION:

A In a public way:

1. No work shall be done without a Railroad Company(s) Inspector present.

2. Open cuts will not be allowed in or immediately adjacent to an at grade crossing. Sleeves will be installed by the jerking method, unless otherwise approved by the Chief Engineering Officer.

3. Jerking is the preferred method of installation in or immediately adjacent to an at grade crossing. The sleeve may be installed by the open cut method with the Applicant paying for the complete rebuilding of the crossing, pending approval of MBTA's Chief Engineering Officer. Approval will be given only under very unusual circumstances.

4. Jacking is the preferred method of installation in or immediately adjacent to an at grade crossing scheduled for rebuilding. The sleeve may be installed by the open cut method within seven (7) calendar days of the scheduled date of the crossing reconstruction. In the case of any open cut, strict adherence shall be made to the backfill specifications which provide the MBTA with written certification from a testing lab or Professional Engineer, that the backfill density requirements of the MBTA specifications have been met or exceeded.

B. Not within a Public Way:

The preferred method of crossing the railroad is by jacking of a pipe sleeve under the railroad. Only upon written request, will an alternate of open cut be given consideration. The engineering decision shall he based upon, but not limited to, the following: (1) track usage, (2) depth of cut, (3) soil conditions, (4) physical restraints. In the event an open cut is allowed, the following items shall be adhered to, and (5) any other circumstances which may necessitate an open cut.

1. The installation is to be a continuous operation and performed according to an MBTA approved schedule.

2. No work shall be done without a Railroad Company(s) Inspector present.

3. MBTA backfill specifications by the Owner or its Contractor.

4. The Owner or its Contractor may be required to provide a non-refundable lump sum payment for "after the fact maintenance." The determination of this amount is based on the individual situation. No work will be allowed until this payment is received. This payment is not to be confused with payments for plans and specification review, flagging, inspection, etc. (also required from the Owner or its Contractor before he enters upon MBTA property.)

4.02 GENERAL REQUIREMENTS

A. Pipelines under or across MBTA tracks on rights-of-way shall be encased in a larger pipe or conduit called the casing pipe as indicated in Plate II.

B. Casing pipe will be required for all pipelines carrying oil, gas, petroleum products, or other flammable, highly volatile substances which, from their nature or pressure, might cause damage if escaping on or near MBTA Railroad Property.

C. For non-pressure sewer or drainage crossings where the installation can be made without interference to railroad operations, the casing pipe may be omitted when the pipe strength is capable of withstanding railroad loading. This type of installation must be approved by the MBTA's Chief Engineering Officer.

D. The casing pipe shall be laid across the entire width of the right-of-way. Casing pipe shall extend beyond the right-of-way when the right-of-way line on either side of the tracks is less than the minimum length of casing specified in Section 6, Para. 6.01(E).

E. Pipelines laid longitudinally on railroad right-of-way shall be located in accordance with Plate III. If located within 25 feet of the centerline of any track or closer than 45 feet to nearest point of any bridge, building or other structure, the carrier pipe shall be encased.

F. Where practicable, pipelines shall be located to cross the tracks at approximate right angles, but preferably at not less than 45 degrees.

G. Pipelines shall not be placed within a culvert, under railroad bridges, or closer than 45 feet to any portion of a railroad bridge, building, or other structure, except in special cases, and then by special design, as approved by the Chief Engineering officer.

H. Pipelines carrying liquified petroleum gas shall, where practicable, cross the railroad where tracks are carried on embankment.

I. Any replacement or modification of an existing carrier pipe and/or casing shall be considered a new installation, subject to the requirements of these Specifications.

J. Where laws or orders of public authority prescribe a higher degree of protection than specified herein, the higher degree so prescribed shall be deemed a part of these Specifications.

K. Pipelines and casings shall be suitably insulated from underground conduits carrying electric wires on MBTA Railroad Property.

4.03 INSPECTION AND TESTING

For pipelines carrying flammable or hazardous materials, ANSI Codes B 31.8 and B 31.4, current at time of constructing the pipeline, shall govern the inspection and testing of the facility on MBTA Railroad Property, except that proof-testing of strength of carrier pipe shall be in accordance with the requirements of ANSI Code B 31.4, as applicable, for all pipelines carrying all liquified petroleum gas, natural or manufactured gas, and other flammable substances.

4.04 CATHODIC PROTECTION

A. Cathodic protection shall be applied to all pipelines and casings carrying flammable substances.

B. Where casing and/or carrier pipe is cathodically protected by other than anodes, the Chief Engineering Officer shall be notified and suitable testing shall be made. This testing shall be witnessed by the Railroad Company(s) to insure that other railroad structures and facilities are adequately protected from the cathodic current in accordance with the recommendations of Reports of Correlating Committee on Cathodic Protection, current issue by the National Association of Corrosion Engineers.

4.05 SOIL INVESTIGATIONS

A. Soil borings (or other soil investigations approved by the Railroad Company(s) will be performed to determine the nature of the underlying material for all pipe crossings under tracks. See Test Boring Specifications".

B. Borings shall be made on each side of the tracks, on the centerline of the pipe crossing, and as close to the tracks as practicable.

C. Soil borings shall be in accordance with the current issue of the American Railway Engineering Association Specifications, Chapter 1, Part 1, "Specifications for Test Borings". Soils shall be investigated by the split-spoon and/or thin-walled tube method and rock shall be investigated by the Boring method specified therein.

D. Soil boring logs shall clearly indicate all of the following:

1. Boring number as shown on boring location plan.
2. Elevation of ground at boring, using same datum as the pipeline construction plans.
3. Description or soil classification of soils and rock encountered.
4. Elevations or depth from surface for each change in strata.
5. Identification of where samples were taken and percentage of recovery.
6. Location of ground water at time of sampling and, if available, subsequent readings.
7. Natural dry density in lbs./sq. ft. for all strata.
8. Unconfined compressive strength in tons/sq. ft, for all strata.
9. Water content (percent). Liquid limit (percent) and plastic limit (percent).
10. Standard penetration in blows/ft.

E. The location of the carrier pipe and casing shall be superimposed on the boring logs before submission to the Chief Engineering Officer.

F. Soil investigation by auger, wash, or rotary drilling methods are not acceptable.

G. Soil boring logs shall be accompanied by a plan drawn to scale showing location of borings in relation to the tracks and the proposed pipe location, the elevation of around surface at each boring, and the elevation of the base of rail of the tracks.

4.06 GROUND STABILIZATION

Soil stabilization shall take place prior to the start of jacking. Stabilization shall be achieved by dewatering, grouting or a combination of both to maintain the stability of the face of the heading.

A. The Owner or its Contractor shall lower and maintain the ground water level a minimum of two (2) feet below the invert at all times during construction by well points, vacuum well points, or deep wells to prevent inflow of water and/or soil into the heading. Ground water observation wells shall be installed in the area to be dewatered to demonstrate that the dewatering requirements are being complied with.

B. The grouting contractor shall be a specialist in the field with a minimum of five (5) continuous years of successfully grouting soils. All granular soils (silty sands, sand or sand and gravel) shall be stabilized by injection of a cement or chemical grout from the ground surface or from the pipe heading. The stabilization shall extend as far as necessary outside the periphery of the casing pipe in order to maintain a stable face at the heading.

C. Railroad Company(s) forces will survey the crossing prior to, during and after construction. If it is necessary to align or surface the tracks as a result of construction, the Railroad Company(s) will perform the work at the expense of the Owner or the Owner's Contractor.

4.07 SUPPORT OF TRACKS

A. When jacking, boring, or tunneling, temporary track support structures will be installed. The track support structures will he provided by the Applicant and installed by the Railroad Company{s) at the Applicant's expense. The type of temporary track support structures shall be approved by the Railroad Company(s)'

B. All work involving rail, signals, ties and other track material will be performed by the Railroad Company{s) at the Applicant's expense.

C. The Applicant shall deliver the track support structures to a site approved by the Railroad Company(s). Provisions for unloading will be provided by the Applicant at no expense to the Railroad Company(s) and the Applicant will provide the necessary labor to handle the material for pre-installation inventory.

4.08 GEOTECH MONITORING

THE FOLLOWING SPECIFICATIONS ARE REQUIRED FOR ALL PIPE JACKING OPERATIONS.

A. Jacking will be on a continuous basis, 24 hours per day, 7 days per week.

B. The monitoring points will be set up one week before the jacking operation begins. The MBTA and Railroad Company(s) shall be notified. Elevation readings shall begin two days prior to the start of jacking and continue for a minimum of two weeks after the completion of the jacking operation. Initial readings immediately after any surfacing operations shall serve as new baseline figures. All future elevation readings shall be compared to the adjusted baseline. If the track deviates to a condition not acceptable to the MBTA or Railroad Company(s), corrections will be made at the proponent's expense.

C. Elevation readings will he taken from the top fall of each track.

D. Elevation readings will be taken every four hours or two times per shift, i.e., six times per day. The readings will be faxed to the MBTA and Railroad Company(s) on a daily basis and all information is to be presented in legible print. Additional readings may be required by the MBTA or Railroad Company(s).

E. Stations will be spaced at 15-1/2 foot intervals. The number of stations required will be determined by the depth of the pipe. There will be a minimum of two stations on either side of the centerline jacking. Additional stations may be required by the MBTA or Railroad Company(s),

F. Elevation readings must show the date, time, weather conditions and temperature. Each reading must also provide the following information: track number, compass direction, station number, base elevation (with date), static elevation, change in elevation (recorded in hundredths and in inches), dynamic reading and total deflection in inches. See sample sheet attached.

G. Station "0" will be located at the centerline of the pipe jacking with Stations 1 and being to the right and Stations -1 and -2 being to the left when standing in the gauge of the near track and looking at the receiving pit. In multiple track areas the stations as determined herein are to be carried across each track perpendicular to the near track.

H. Elevation readings taken from the top of the rail for static measurement and the dynamic readings shall be combined and the sum compared to the adjusted baseline. This reading will demonstrate the difference in elevation

caused by the jacking operation.

I. The MBTA requires that the truck be maintained at all times within established criteria for the specific track classification. At the completion of the project the requirement for tamping and realigning the tracks, caused by the settlement from the construction activity, remains with the proponent for the duration as specified by the MBTA in their initial review of the work plans. This tamping and track realignment will be performed by the MBTA or Railroad Company(s) at the sole expense of the proponent.

4.09 PIPELINES ON BRIDGES

A. Pipelines carrying flammable or non-flammable substances which by their nature might cause damage if escaping on or near railroad facilities or personnel, shall not be installed on bridges over railroad tracks or bridges carting railroad tracks.

B. The Chief Engineering Officer may approve such an installation when it is demonstrated that no practicable alternative is available.

C. When allowed by the Chief Engineering Officer, pipelines on bridges shall be located as to minimize the possibility of damage from vehicles, railroad equipment, vandalism and other external causes. Pipelines on bridges may be installed in a utility bay that is constructed between the girders of the bridge. The utility bay will be protected from the environment by a removable shield bolted to the girders. This will allow utility companies to comply with the Code of Federal Regulations for Periodic Inspection.

D. In the event of pipe relocation due to the reconstruction of a bridge, the installation of the new pipe must comply with the requirements in these Specifications.

4.10 BONDING AND GROUNDING OF PIPELINES IN ELECTRIFIED TERRITORY

A. Carrier pipe shall be enclosed in a metal casing that is isolated from carrier pipe by approved insulators having a dielectric value of not less than 25 k.v. that provide an air gap between carrier pipe and casing of not less than 2 inches.

B. Carrier pipe supporting hangers, mountings or cradles shall provide an insulation value of not less than 25 k.v. and an air gap of not less than 2 inches between casing and any portion of mounting assembly.

C. Any grounding or isolation methods used must have a minimum dielectric of 25,000 volts.

4.11 ABANDONED PIPELINES OR FACILITIES

A. For all pipeline occupations on the railroad right-of-way, the owner of the pipeline shall notify the MBTA, in writing, of the intention to abandon the pipeline. Upon abandonment the carrier pipe shall be removed and the casing shall be filled with cement grout, compacted sand or other material approved by the Chief Engineering Officer. If it is impractical to remove the carrier pipe, then the carrier must be filled along with the annular space between the casing and carrier.

B. Facilities other than pipelines will be removed or altered at abandonment to the satisfaction of the Chief Engineering Officer.

4.12 DRAINAGE

A. Occupancies shall be designed, and constructed, so that adequate and uninterrupted drainage of railroad right-of-way is maintained. If it becomes necessary to block a ditch, pipe or other drainage facility, the applicant shall install temporary pipes, ditches or other drainage facilities as required to maintain adequate drainage, as approved by the MBTA or Railroad Company(s). Upon completion of the work, the temporary drainage facilities shall be removed and the permanent facilities restored.

B. Water may not be pumped or disposed of onto railroad rights-of-way unless discharged into an existing drainage facility, providing discharge does not cause erosion or leave sediment.

C. When water runoff is disposed of onto MBTA Railroad Property, it must be demonstrated to the Railroad Company(s) that the existing drainage facility can accommodate the increased runoff. Drainage calculations stamped by a Registered Professional Engineer must accompany all requests to use railroad culverts or drainage ditches.

D. If in the estimation of the Chief Engineering Officer or his authorized representative, the railroad culvert or drainage ditch has to be cleaned in order to allow the increased flow to safely pass through the culvert, it must be cleaned at the expense of the applicant.

SECTION 5. CARRIER PIPE

GENERAL:

5.01 DESIGN CRITERIA

A. If the maximum allowable stress in the carrier pipe on either side of the occupancy of MBTA Railroad Property is less than specified herein, the

carrier pipe on MBTA Railroad Property shall be designed at the same stress as the adjacent carrier pipe.

B. Requirements for carrier pipe under railroad tracks shall apply for a minimum distance equal to that of the casing pipe.

C. Carrier pipes within a casing shall be designed for railroad live loads as if they were not encased.

D. All pipes, ditches and other structures carrying surface drainage on MBTA Railroad Property and/or crossing under railroad tracks shall be designed to carry the run-off from a one hundred (100) year storm. Computations indicating this design and suitable topographic plans, prepared by a Registered Professional Engineer, shall be submitted to the Chief Engineering Officer, or his authorized representative, for approval. If the drainage is to discharge into an existing drainage channel on railroad right-of-way and/or under railroad tracks, the computations should include the hydraulic analysis of any existing structures. Submitted with the computations should be formal approval of the proposed design by the appropriate governmental agency.

PRODUCTS:

5.02 GENERAL

A. All pipes shall be designed for the external and internal loads to which they will be subjected. The dead load of earth shall be considered 120 pounds per cubic foot. Railroad live loading shall be Cooper's E-8O with 50% added for impact. On railroad right-of-way or where railroad loading will be experienced, the following shall be the minimum requirements for carrier pipes:

1. Reinforced concrete pipe - ASTM Spec. C-76, Class V, Wall C.

2. Ductile Iron Pipe - For Culverts and Gravity Sewers - ASTM Spec, A-142 Extra Heavy.

5.03 OIL AND GAS PIPES

A. Pipelines carrying oil, liquified petroleum gas, natural or manufactured gas and other flammable products shall conform to the requirements of the current ANSI B 31.4, with Addenda, "Liquified Petroleum Transportation Piping Systems," ANSI B 31.8, "Gas Transmission and Distribution Piping Systems," and other applicable ANSI codes, except that the minimum allowable stresses for the design of steel pipe shall not exceed the following percentages of the specified minimum yield strength (multiplied by the

longitudinal joint factor) of the pipe as defined in the ANSI Codes:

1. Steel pipe within a casing under, across and longitudinally on MBTA Railroad Property. (The following percentages apply to hoop stress):

    a. Seventy-two percent for installation on oil pipelines.
    b. Fifty percent for pipelines carrying liquified petroleum gas and other flammable Iiquids with low flash point.
    c. Sixty percent for installations on gas pipelines.

2. Steel pipe without a casing laid longitudinally on MBTA Railroad Property. (The following percentages apply to hoop stress):

    a. Sixty percent for installations on oil pipelines.
    b. Forty percent for pipelines carrying liquified petroleum gas and other flammable Iiquids with low flash point.
    c. Forty percent for installations on gas pipelines.

B. Design computations showing compliance with the requirements of Paragraph 5.03(A) above, and prepared by a Registered Professional Engineer, shall accompany the application for occupancy.

5.04 CAST IRON PIPE: For water and other materials under pressure shall conform to the current ANSI specifications A-21 Series 21/45 Iron strength with plain end, compression type or mechanical joints. The strength to sustain external railroad and other loadings shall be computed in accordance with the current ANSI A-21.1 “Thickness Design of Cast Iron Pipe."

5.05 VITRIFIED CLAY PIPE: ASTM Spec C-700, Extra Strength.

5.06 CORRUGATED METAL PIPE: AREA Spec Chapter I, Part 4

5.07 ASBESTOS CEMENT PIPE (Non-pressure): ASTM Spec. C-428, C1. 5000 Min. Pressure: AWWA Spec. C400, C1. 150 Min.

5.08 OTHER: Other miscellaneous piping not specified above shall be submitted to approval by the Chief Engineering Officer.

5.09 SHUT-OFF VALVE

A. Provide accessible emergency shut-off valves at each side of the railroad within distances and at locations as directed by the Chief Engineering Officer.

B. Where pipelines are provided with automatic control stations and within distances approved by the Chief Engineering Officer, no additional valves will be required.

5.I0 SIGNS

A. Prominently identify all pipelines at rights-of-way by durable, weatherproof signs located over the centerline of the pipe. Mark pipelines at under crossings on both sides of track. Signs shall display the following:

1. Name and address of pipeline Owner.
2. Contents of Pipe.
3. Pressure in Pipe.
4. Depth below grade at point of sign.
5. Emergency telephone in event of pipe rupture.
6. Railroad File Number.

B. For pipelines running Iongitudinally on MBTA Railroad Property, place signs over the pipe (or offset and appropriately mark) at all changes in direction the pipeline. Locate signs so that when standing at one sign, the next adjacent marker in either direction is visible. In no event shall pipeline identification signs be placed more than 500 feet apart, unless otherwise directed by the Chief Engineering Officer.

C. Submit details of signs (materials, size, methods of support, etc.) to the Chief Engineering Officer for approval.

EXECUTION:

5.11 INSTALLATION:

A. Install carrier pipes in accordance with approved Construction Drawings, requirements of this specification, and all applicable codes and ordinances.

B. Install carrier pipes with sufficient slack so they are not in tension.

SECTION 6. CASING PIPE

GENERAL:

6.01 DESIGN CRITERIA

A. Casing pipe and joints shall be of metal and of leakproof construction.

B. Casing pipe shall be designed for the earth and/or other pressures present, and for railroad live load. The dead load of earth shall be considered 120 pounds per cubic foot. Railroad Live load shall be Cooper E-80 with 50g added for impact.

C. The inside diameter of the casing pipe shall be such as to allow the carrier pipe to be removed subsequently without disturbing the casing or the roadbed. For carrier pipe less than six (6) inches in diameter, the inside diameter of the casing pipe shall be at least two (2) inches greater than the largest outside diameter of the carrier pipe joints or couplings. For carrier pipe six (6) inches and over in diameter, the inside diameter of the carrier pipe shall be at least four (4) inches greater than the largest outside diameter of the carrier pipe joints or couplings.

D. For flexible casing pipe, a minimum vertical deflection of 3 percent of its diameter, plus 1/2 inch, shall be provided so that no loads from the roadbed, track, traffic or casing pipe itself are transmitted to the carrier pipe. When insulators are used on the carrier pipe, the inside diameter of the flexible casing pipe shall be at least two (2) inches greater than the outside diameter of the carrier pipe for pipe less than eight (8) inches in diameter; at least 3-1/4 inches greater for pipe 8 to 16 inches in diameter, and at least 4-1/2 inches greater for pipe 18 inches and over in diameter. In no event shall the casing pipe diameter be greater than is necessary to permit the insertion of the carrier pipe.

E. Casing pipe under railroad tracks and across MBTA Railroad Property shall extend the Greater of the following distances, measured at right angles to centerline of track:

1. Across the entire width of MBTA Railroad Property.
2. Two (2) feet beyond ditch line.
3. Three (3) feet beyond toe of slope.
4. A minimum distance of 25 feet each side from centerline of outside track when casing is sealed al both ends.
5. A minimum distance of 45 feet from centerline of outside track when casing is open at both ends.

F. If additional tracks are constructed in the future, the casing shall be extended at the expense of the Applicant.

G. Table of Live Loads

LIVE LOADS, INCLUDING IMPACT, FOR VARIOUS HEIGHTS OF COVER FOR COOPER E- 80

COVER(FT)	LOAD(PSF)	COVER(FT)	LOAD(PSF)	COVER(FT)	LOAD(PSF)
2	3800	1O	1100	20	300
5	2400	12	800	30	100
8	1600	15	600		

6.02 PROTECTION AT ENDS OF CASING

A. Casings for carriers of flammable substances shall be sealed to the outside of the carrier pipe. Details of seals shall be shown on the plans.

B. Casings for carriers of non-flammable substances shall have both ends of the casing blocked in such a way as to prevent the entrance of foreign material, but allowing leakage to pass in the event of a carrier break.

C. Where ends of casing are at or above ground surface and above high water level, they may be left open, provided drainage is afforded in such a manner that leakage will be conducted away from railroad tracks and structures.

6.03 VENTS

A. Sealed casings for flammable substances shall be properly vented. Vent pipes shall be of sufficient diameter, but in no case less than two (2) inches in diameter, and shall be attached near each end of the casing and project through the ground surface at right-of-way lines or not less than 45 feet (measured at right angles from centerline of nearest track).

B. Vent pipes shall extend at least four (4) feet above the ground surface. Top of vent pipe shall have a down-turned elbow, properly screened, or a relief valve. Vents in locations subject to high water shall be extended above the maximum elevation of high water and shall be supported and protected in a manner approved by the Chief Engineering Officer.

C. Vent pipes shall be at least four (4) feet from the closest aerial electric wires.

D. When the pipeline is in a public highway, street-type vents shall be installed.

PRODUCTS:

6.04 STEEL PIPE

The minimum yield strength for steel pipe will be 35,000psi. Smooth wall pipes with a nominal diameter greater than 70 inches require special approval by the Chief Engineering Officer. See Plate V, "Table of Minimal Wall Thickness for Steel Casing Pipe."

6.05 CAST IRON PIPE

May be used for a casing, provided the method of installation is by open trench. Cast iron pipe shall conform to ASTM Specification A-142, Extra Heavy. The pipe shall be of the mechanical joint type or plain end type with compression type couplings.

6.06 CORRUGATED METAL PIPE AND CORRUGATED STRUCTURAL PLATE PIPE

May be used for casing only when emplaced by the open-cut method. Jacking or boring through railroad embankment is not permitted. Pipe shall be bituminous coated and shall conform to AREA Specifications Chapter 1, Part 4.

6.07 REINFORCED CONCRETE PIPE

Shall conform to ASTM Specification C 76, Class V, Wall C. It shall be used only in the open cut and jacking methods of installation. If concrete pipe is to be jacked into place, grout holes tapped for at least 1-1/2 inch pipe spaced at approximately 8 feet around the circumference and approximately 4 feet longitudinally shall be cast into the pipe at manufacture. Immediately upon completion of jacking operations, the installation shall be pressure grouted.

6.08 TUNNEL LINER PLATES

Shall be four flange and otherwise conform to American Railway Engineering Association Specifications Chapter 1, Part 4. In no event shall the liner plate thickness be less than 0.1046 inches. Tunnel liner plates are to be used only to maintain a tunneled opening until the carrier pipe is installed. After installation the annular space between the carrier and liner must be filled with 1:6 cement grout or lined with 6 inches of concrete, reinforced with 6x6-6/6 wire mesh for tunnels up to 108 inches in diameter. Required thickness of lining for larger tunnels will be determined by span and structural analysis. Manufacturer's Shop Detail plans and manufactures computations showing the ability of the tunnel liner plates to resist the jacking stresses shall be submitted to the Chief Engineering Officer for approval.

EXECUTION:

6.09 DEPTH OF INSTALLATION:

A. Casing pipe under railroad tracks and across MBTA Railroad Property shall be at least 6-1/2 feet from top of rail to top of casing at its closest point. Under secondary or industrial tracks this distance will be at least 5-1/2 feet. On other portions of MBTA Railroad Property where casing is not directly beneath any track, the depth from ground surface or from bottom of ditches to top of casing shall be at least four (4) feet, unless otherwise specified herein.

B. Pipelines laid longitudinally on MBTA Railroad Property 50 feet or less from

centerline of track, shall be buried not less than five (5) feet from ground surface to top of pipe. This applies to all pipelines carrying oil, gas, petroleum products, or other flammable or highly volatile substances under pressure, and all non-flammable substances which by their nature or presence in the judgment of the Chief Engineering Officer may be hazardous to life or property. For pipelines carrying water, sewage and non-flammable substances, the distance from surface of ground to top of pipe shall not be less than four (4) feet.

C. Pipelines located within the line of track live load influence (as shown on Plates II and Ill) are subject to railroad loading and require a casing or are to be of special design approved by the Chief Engineering Officer. All longitudinal occupation locations must be approved by the Chief Engineering Officer.

D. The minimum cover shall be at least three (3) feet when pipeline is laid more than 50 feet from center line of track.

E. Pipelines installed under or adjacent to any overhead structure must be a minimum of 29 feet from the bottom of the structure to the top of the casing. Such installations must comply with the above requirements.

6.10 METHOD OF INSTALLATION

A. The Owner or its Contractor shall submit to the Chief Engineering Officer, data and information demonstrating that he or his subcontractor has had successful previous experience in jacking, or using the proposed method of installation, in similar situations.

B. Before any work is begun within the limits of jacking, the Owner or its Contractor shall have assembled all tools, materials, and equipment which will be required. When the Owner or its Contractor has started the jacking operation, he will proceed in a continuous operation without stopping. This will minimize the tendency of the material to freeze around the pipe.

C. A jacking shield shall be used and jacked ahead of the casing pipe. The excavation within the jacking pipe should not advance beyond the head of the pipe shield. If the stability at the face needs to be maintained from raveling or running soil, suitable temporary bulkheads, struts, and bracing shall be required. After completion of the sleeve installation the annular space around it shall he completely grouted with cement grout under pressure.

D. Casing pipe ends shall he beveled with a single V-groove toe field welding. Pipe joints shall be butt welded and shall be a full penetration on the outside circumference of the pipe. The single V-groove butt weld shall conform to the latest A.W.S. Welding Code. All joints of the easing pipe shall be butt

welded, by a certified welder, prior to being subject to the jacking operation.

Alternate method: The casing pipe may be jacked without being butt welded through the use of a continuous 1/2"x12" interior collar plate. The collar plate shall be welded completely upon completion of the jacking operation. All welding shall conform to the latest A.W.S. Welding Code, and shall be performed by a certified welder.

6.11 CONSTRUCTION:

A. The casing pipe shall be constructed so as to prevent leakage of any substance from the casing throughout its length, except where the ends are left open, or through vent pipes when the ends are sealed. The casing shall be installed so as to prevent the formation of a waterway under the railroad, shall have an even bearing throughout its length, and shall slope to one end (except for longitudinal occupancy).

B. Casing pipes shall be installed by the following methods:

1. Jacking

a. This method shall be in accordance with the most current edition of the American Railway Engineering Association Specifications, “jacking Culvert Pipe Through Fills." This operation shall be conducted without handmining ahead of the pipe and without the use of any type of boring, auguring, or drilling equipment.
b. Bracing and backstops shall be designed and jacks of sufficient rating used so that the jacking will be continuous.

2. Drilling

This method employs the use of an oil field type rock roller bit or a plate bit made up of individual roger cutter units which is welded to the pipe casing being installed and which is turned as it is advanced. The pipe is turned for its entire length from the drilling machine to the ground being drilled. A high density slurry is injected through a small supply line to the head which acts as a cutter lubricant. This slurry is injected at the rear of the cutter units to prevent any jetting action ahead of the pipe. The drilling machine runs on a set of steel rails and is advanced (thus advancing the pipe) by a set of hydraulic jacks. The method is the same whether earth or rock is being drilled. Any other drilling methods shall be submitted to the Chief Engineering Officer for approval.

3. Tunneling

Tunneling operations shall be conducted as approved by the Railroad Company(s). Care shall be exercised in trimming the surface of the excavated section in order that the steel liner plates fit snugly against the undisturbed material. Excavation shall not be advanced ahead of the previously installed liner plates any more than is necessary for the installation of the succeeding liner plate. The vertical face of the excavation shall be supported as necessary to prevent sloughing. At any interruption of the tunneling operation, the heading shall be completely bulkheaded. Tunneling shall be conducted continuously, on a 24 hour basis until the tunnel liners extend at least one foot beyond the railroad line of influence.

b. When tunneling, tight breasting must be maintained around the entire face. On any shutdowns (under or beyond railroad influence line, see Plate II), the entire face will be fully breasted and packed with hay.

c. The tail void shall be filled with pea stone (or other approved material) simultaneously with each advancement of the shield.

d. An ample supply of hay and/or sandbags must be kept at the site to fill any voids caused by the removal of large stones or other obstructions extending outside the shield.

e. A uniform mixture of 1:6 cement grout shall be placed under pressure behind the liner plates, in addition to the previously placed pea stone. Grout holes, tapped for at least 1-1/2 inch pipe and spaced 3 feet around the tunnel liner, shall be placed in every other ring. Grouting shall start at the lowest dole and proceed upwards. A threaded plug shall be installed in each grout hole as the grunting is completed at that hole.

f. Grouting shall be kept as close to the heading as possible, using grout stops behind the liner plates. if necessary, grouting shall proceed as directed by the Railroad Company(s), but in no event shall more than six lineal feet of tunnel be progressed beyond the grouting.

4. Tunneling Shields

a. All pipes 70 inches and larger in diameter shall be emplaced with the use of a tunneling shield, unless otherwise approved by the Chief Engineering Officer. Pipes of smaller diameter may also require a shield when, at the sole discretion of the

Chief Engineering Officer, soil, or other conditions indicate its need.

b. The shield shall be of steel construction, designed to support railroad track loading as specified in Paragraph 6.01 B herein, in addition to other loadings it must sustain. The advancing face shall be provided with a hood, extending no less than 20 inches beyond the face and extending around no less than the upper 240 degrees of the total circumference. Installations made with linear plates shall be provided with a full 360 degree shield. It shall be of sufficient length to permit the installation of at least one complete ring of liner plates within the shield before it is advanced for the installation of the next ring of liner plates, It shall conform to and not exceed the outside dimensions of the pipe being emplaced by more than one inch at any point in the periphery.

c. The shield must be adequately braced and provided with necessary appurtenances for completely bulkheading the face with horizontal breastboards, and arrange so that the excavation can be benched as may be necessary. Excavation shall not be advanced beyond the edge of the hood, unless otherwise approved by the Railroad Company(s).

d. Manufacturer's Shop Detail plans and computations showing the ability of the tunnel liner plates to resist the jacking stresses shall be submitted to the Chief Engineering Officer for approval.

e. For jacking reinforced concrete pipe, the shield shall be fabricated as a special section of reinforced concrete pipe with the steel cutting edge, hood, breasting attachments, etc., cast into the pipe. The wall thickness and reinforcing shall be designed for the jacking stresses.

f. Grout holes tapped for no less than 1-1/2 inch pipe, spaced at approximately 3 foot centers around the circumference of the shield (or the aforementioned special reinforced concrete section) and no more than 4 foot centers longitudinally shall be provided.

g. Detail plans sufficient to determine the adequacy of the shield, accompanied with design calculations prepared by a Registered Professional Engineer, shall be submitted to the Chief Engineering Officer for approval and no work shall proceed until such approval is obtained.

5. Boring

a. This method consists of pushing the pipe into the fill with a boring auger rotating within the pipe to remove the spoil. When augers, or similar devices, are used for pipe emplacement, the front of the pipe shall be provided with mechanical arrangements or devices that will positively prevent the auger and cutting head from leading the pipe so that there will be no unsupported excavation ahead of the pipe. The auger and cutting head arrangement shall be removable from within the pipe in the event an obstruction is encountered. The over-cut by the cutting head shall not exceed the outside diameter of the pipe by more than one-half inch. The face of the cutting head shall be arranged to provide reasonable obstruction to the free flow of soft or poor material.

b. Plans and descriptions of the auger stop arrangement to be used shall be submitted to the Chief Engineering Officer for approval, and no work shall proceed until such approval is obtained and the arrangement is inspected in the field by the Railroad Company(s).

c. The use of water or other Iiquids to facilitate casing emplacement and/or spoil removal is prohibited.

d. Any method which employs simultaneous boring and jacking or drilling and jacking for pipes over 8 inches in diameter which does not have the above approved arrangement WILL NOT BE PERMITTED. For pipes 8 inches and less in diameter, auguring or boring without this arrangement may be considered for use only as approved by the Chief Engineering Officer.

C. If an obstruction is encountered during the installation which stops the forward action of the pipe, and it becomes evident that it is impossible to advance the pipe, operations will cease and the pipe shall be abandoned in place and filled completely with grout, in accordance with Section 4, Paragraph 4.10.

D. Bored or jacked installations shall have a bored hole essentially the same as the outside diameter of the pipe plus the thickness of the protective coating. If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipe (plus coating) by more than 1 inch, grouting or other methods approved by the Railroad Company(s) shall be employed to fill such voids.

E. Pressure grouting or freezing of the soils before or during jacking, boring, or tunneling may be required at the direction of the Railroad Company(s) to stabilize the soils, control water, prevent loss of material and prevent settlement or displacement of the embankment and/or tracks. Grout shall be cement, chemical or other special injection material selected to accomplish the necessary stabilization.

F. The materials to be used and the method of injection shall be prepared by a Registered Professional Engineer (Geotechnical), or by an experienced and qualified company specializing in this work and submitted for approval to the Railroad Company(s) before the start of work. Proof of experience and competency shall accompany the submission.

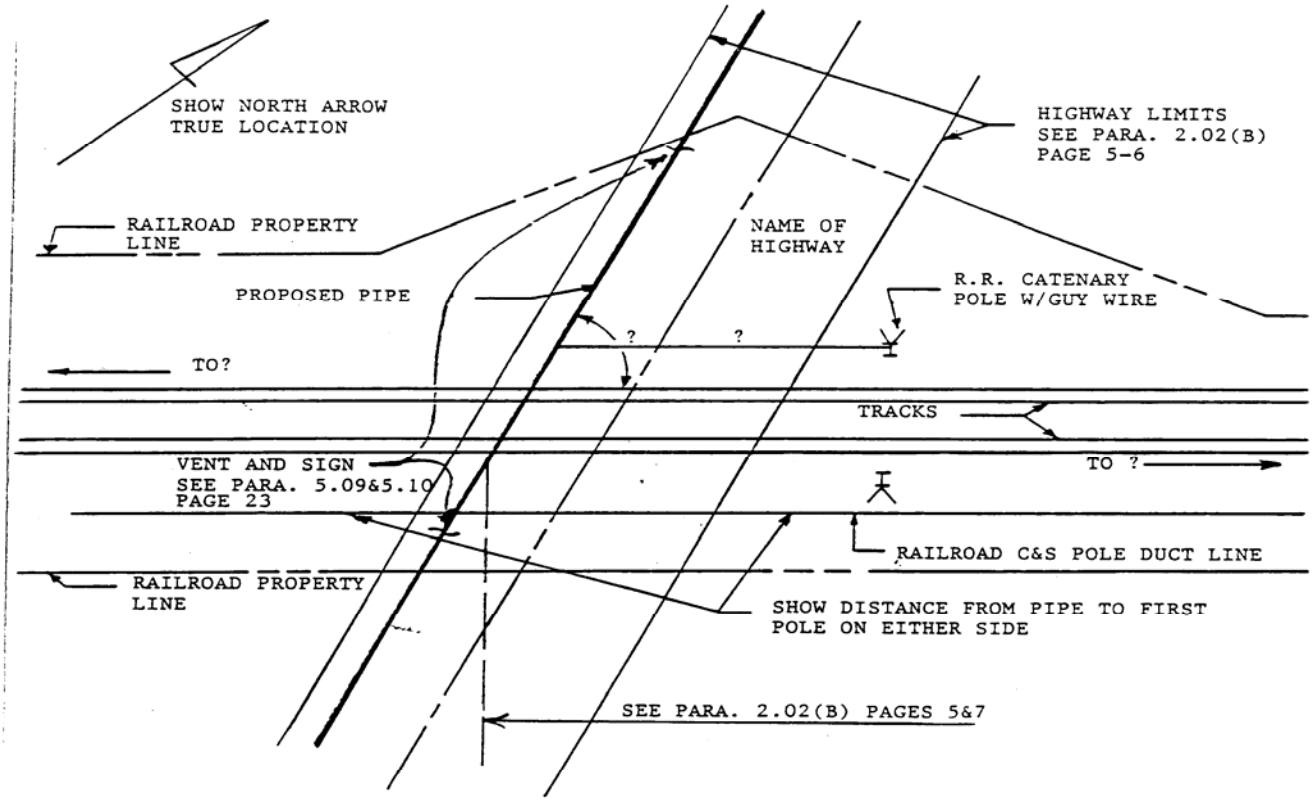
G. When water is expected to be encountered, pumps of sufficient capacity shall be provided and maintained at the site, and continually attended on a 24-hour basis, until in the sole judgment of the Railroad Company(s), their operation can be safely halted. When dewatering, close observation shall be maintained to detect any settlement or displacernent of railroad embankment, tracks, and facilities.

H. Proposed methods of dewatering must be submitted to the Railroad Company(s) for approval prior to implementation. The discharge from the dewatering operations in the vicinity of the railroad shall be carefully monitored. If in the opinion of the Railroad Company(s), there is an excessive loss of fine soil particles at any time during the dewatering process, the dewatering will be halted immediately. The dewatering operation cannot resume until the unsatisfactory condition is remedied to the satisfaction of the Railroad Company(s).

PLATE I

PIPE CROSSING

INFORMATION TO BE SHOWN ON PLAN SECTION OF DRAWING



(SCALE OF DRAWING TO BE SHOWN)

NOTE:

IF MANHOLES ARE PLACED ON MBTA RAILROAD PROPERTY, DETAILS OF SAME, WITH CLEARANCES TO THE CENTERLINE OF THE NEAREST TRACK ARE TO BE SHOWN ON THE DRAWINGS.

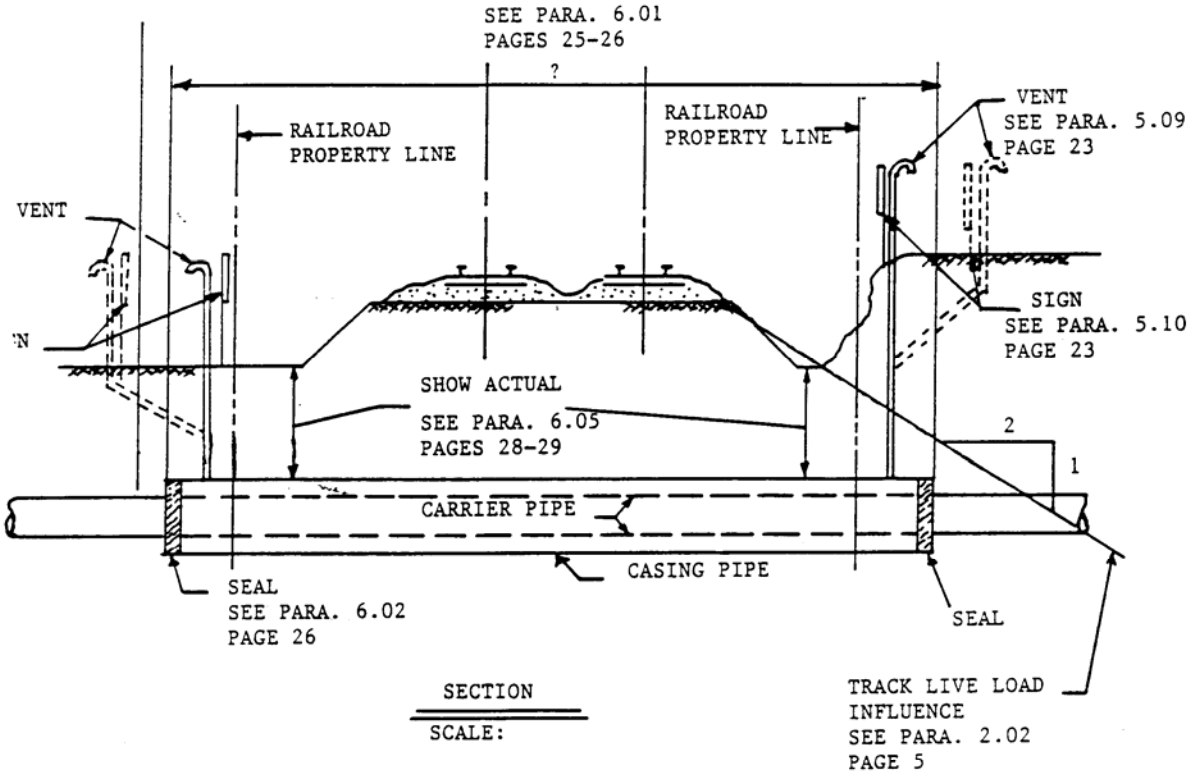
IF THE PROPOSED PIPE IS TO SERVE A NEW DEVELOPMENT, A MAP SHOWING THE AREA IN RELATION TO ESTABLISHED AREAS AND ROADS IS TO BE SENT WITH THE REQUEST.

THE PROPOSED PIPE IS NOT WHOLLY WITHIN HIGHWAY LIMITS, THE SAME INFORMATION IS REQUIRED AS SHOWN ON THIS PLATE.

PLATE II

PIPE CROSSING

INFORMATION TO BE SHOWN ON PROFILE SECTION OF DRAWING

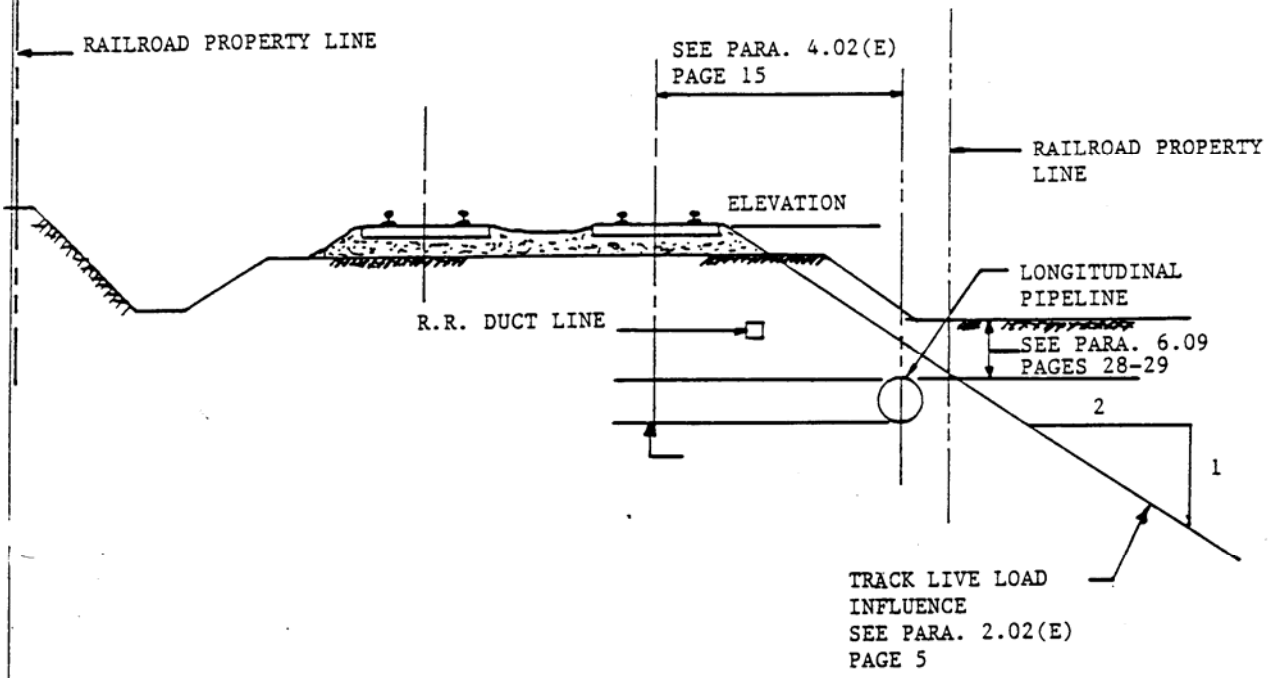


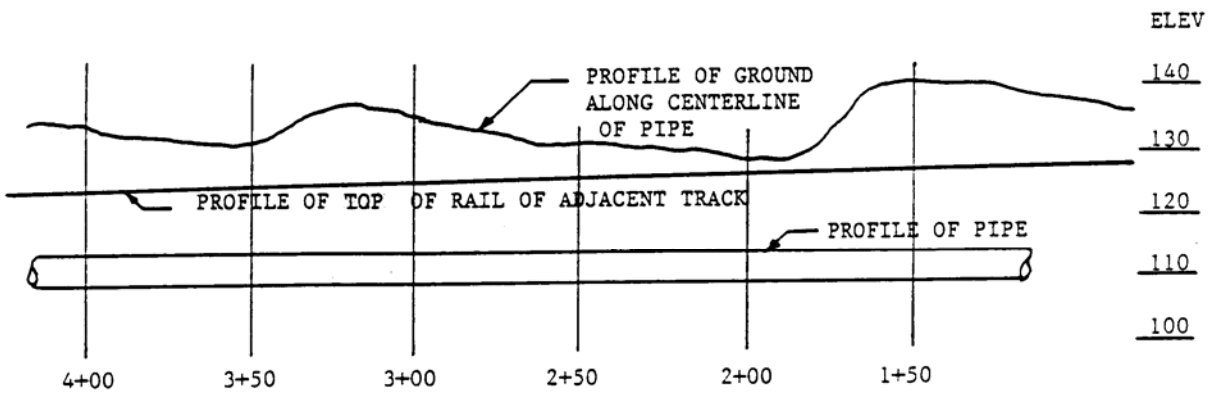
SECTION

SCALE:

PLATE III

LONGITUDINAL OCCUPANCY





STATIONING

PROFILE - SEE PARA. 2.02
PAGES 5-7

SCALE - HOR:
VER:

PLATE IV

PIPE CROSSING DATA SHEET

In addition to plan and profile of crossing, drawings submitted for the Railroad Company(s) approval shall contain the following information:

	Pipe Date	
	Carrier Pipe	Casing Pipe
Contents To Be Handled	_____	_____
Normal Operating Pressure	_____	_____
Normal Size of Pipe	_____	_____
O.S. Diameter	_____	_____
I.S. Diameter	_____	_____
Wall Thickness	_____	_____
Weight Per Foot	_____	_____
Material	_____	_____
Process of Manufacture	_____	_____
Specification	_____	_____
Grade or Class	_____	_____
Test Pressure	_____	_____
Type of Joint	_____	_____
Type of Coating	_____	_____
Details of Cathodic Protection	_____	_____
Details of Seal or Protection at Ends of Casing	_____	_____
Method of Installation	_____	_____
Character of Subsurface Material At the Crossing Location	_____	_____
Approximate Ground Water Level	_____	_____
Source of Information on Sub-surface conditions (Test Pits, Borings or Other)	_____	_____

NOTE: Any soil investigation made on MBTA Railroad Property or adjacent to tracks shall be carried on under the supervision of the Railroad Company(s).

PLATE V

TABLE OF MINIMUM WALL THICKNESS FOR STEEL CASING PIPE

(FOR INFORMATION ONLY)

PROTECTED WALL THICKNESS

PIPE SIZE (INCHES)	WALL THICKNESS (PROTECTED)
10	0.375
12	0.375
14	0.375
16	0.375
18	0.375
20	0.375
22	0.375
24	0.375
26	0.375
28	0.406
30	0.469
32	0.501
34	0.532
36	0.532
38	0.569
40	0.569
42	0.569
44	0.594
46	0.688
48	0.688
50	0.688
52	0.813
54	0.813
56	0.876
58	0.876
60	0.876
62	0.876
64	0.876
66	0.876
68	0.876
70	0.906

NOTE: FOR UNPROTECTED PIPE 26" AND UNDER ADD 0.032" TO PROTECTED WALL THICKNESS. FOR UNPROTECTED PIPE 28" AND OVER ADD 0.063" TO PROTECTED WALL THICKNESS.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

V

SPECIFICATIONS FOR WIRE CONDUIT AND CABLE OCCUPATIONS

SECTION 1. SCOPE

1.01 These specifications apply to the design of electric transmission wires and cables (power and communication) which are to be located over, under. across or upon property, facilities, and tracks owned by the MBTA.

SECTION 2. LICENSE TO ENTER MBTA RAILROAD PROPERTY

2.01 Individuals, corporations. or municipalities desiring wire or cable occupations must agree, upon approval of the construction details by the Chief Engineering Officer, to execute an appropriate occupational agreement and pay any required fees and/or rentals outlined therein.

2.02 Application for an occupancy shall be submitted in writing to:

Director of Real Estate
MBTA, 10 Park Plaza
Boston, Massachusetts 02116

See "Guidelines and Procedures for Construction on MBTA Railroad Property."

2.03 All applications shall be accompanied with six (6) copies of all construction plans, specifications and computations concerning the proposed occupancy.

SECTION 3. APPROVAL OF PLANS

3.01 Entry upon MBTA Railroad Property for the purpose of conducting surveys, field inspections, obtaining soil information, or any other purpose associated with the design and engineering of the proposed occupancy, will be permitted only with a proper entry permit prepared by the MBTA Real Estate Department. The issuance of such a permit does not constitute authority to proceed with the actual construction. Construction cannot begin until the proper insurance certificate is received and a formal agreement is executed by the MBTA and permission is received by the Railroad Company(s).

302 Plans shall be drawn to scale and show the following: (See attached plates I - VI)

A. Plan view of crossing or occupation in relation to all Railroad Company(s) facilities. (See Plate 1)

B. Location of wire or cane (in feet) from nearest railroad mile post, center line of a railroad bridge (giving bridge number), or center line of a passenger station. In all cases, the name of the County and City or Town in which the proposed facilities are located must be shown.

C. Profile of ground on center line of pole or tower line, showing

clearances between top of rail and bottom of sag, as well as clearances from bottom wire or cable to top wire or cable of the MBTA's transmission, signal and communication lines and catenary. If none of these facilities are in existence at the point of crossing, the plan should so indicate. Actual under-clearances are to be shown. (See Plate V for the required clearances).

D. Show all known property lines. If wires, cables or conduits are within public highway limits, such limits should be clearly indicated with dimensions from center line.

E. The plan must be specific as to:

1. Base diameter, height, class and bury of poles. Poles shall be set no closer than 13'6" from face of pole to center line of nearest track. When necessary, however, each location will be analyzed to consider speed, traffic, access, etc.

2. Number, size and material of power wires, as well as number of pairs in communication cables.

3. Nominal voltage of line, type of current and frequency.

4. Number, location, size and material of anchors and all guying for poles and arms.

NOTE: Double cross-arms are required on poles adjacent to track. Any tower designs must be accompanied by engineering computations and data.

SECTION 4. CONSTRUCTION REQUIREMENTS

4.01 Power and communication lines shall be constructed in accordance with "Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines, National Electrical Safety Code Handbook, Part 2" (current issue), with the following exceptions:

A. Item 3 (c), page 2.

B. Casing pipes to contain power or communication wires or cables having an outside diameter of over four (4) inches shall be constructed in accordance with the current issue of MBTA Railroad Operations "Pipeline Occupancy Specifications".

SECTION 5. LONGITUDINAL OCCUPATIONS

5.01 Wires and cables running Iongitudinally along railroad right-of-way shall be constructed as close to MBTA property lines as possible in accordance with Plate III. For electrical power lines and cables with voltages of 34,500 or over and communication canes containing over 180 pairs, the following information must be submitted in addition to the detail of the pole top configuration as called for on Plate IV of these specifications:

A. Voltage of circuit(s) or number of pairs.
B. Phase of electrical circuit(s).
C. Number of electrical circuits.
D. Size (AWG or CM) and material of wires and cables.

5.02 Any facilities overhanging MBTA Railroad Property must have approval of the MBTA and appropriate rental charges will be applied.

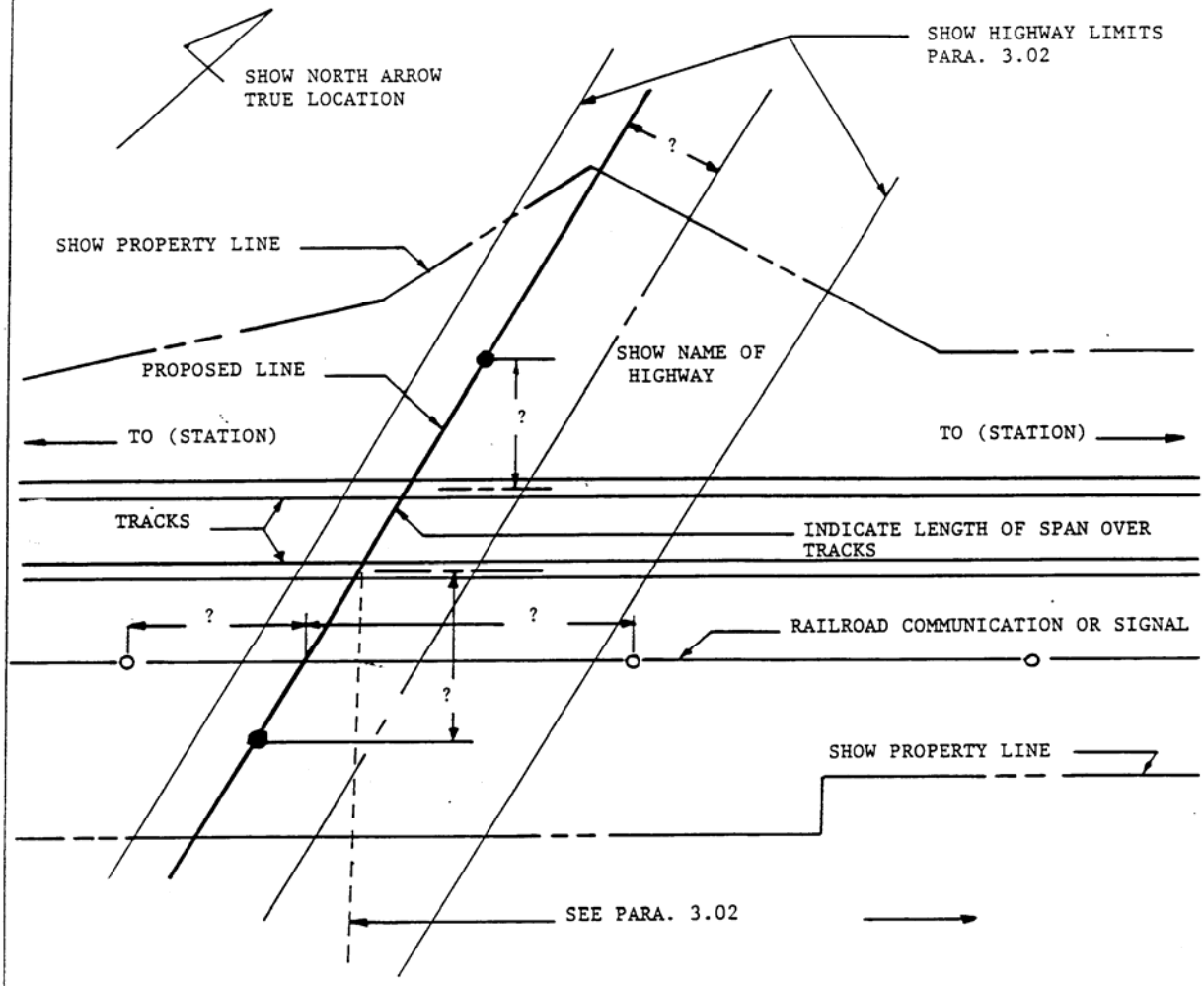
SECTION 6. INDUCTIVE INTERFERENCE

6.01 On agreements covering longitudinal occupations, provisions will be included that the applicant will provide appropriate remedies, at his own expense, to correct any inductive interference with MBTA facilities.

PLATE I

PLAN VIEW

INFORMATION TO BE SHOWN ON PLAN SECTION OF DRAWINGS
WHEN FACILITY IS A CROSSING



SCALE OF DRAWING TO BE SHOWN

NOTE:

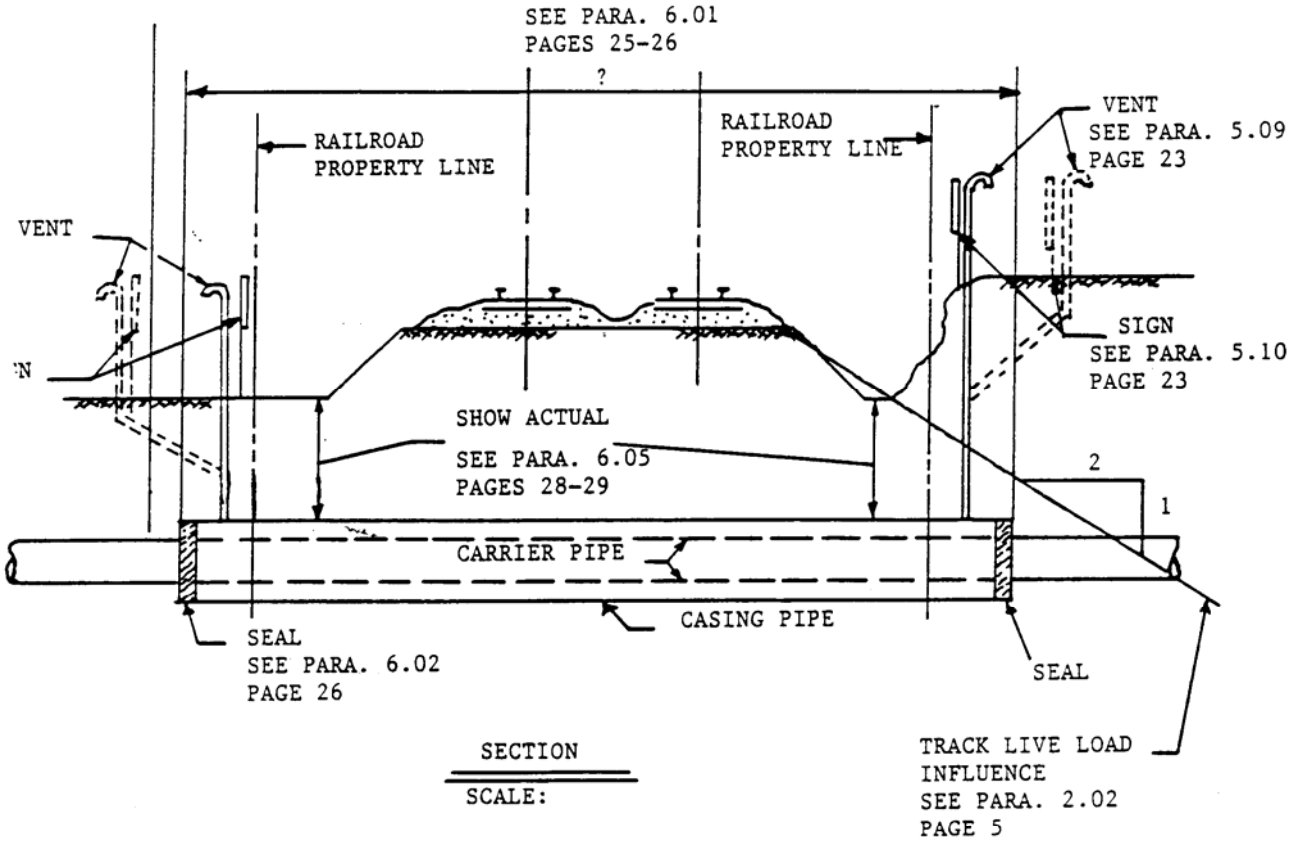
IF THE PROPOSED LINE IS TO SERVE A NEW DEVELOPMENT, A MAP SHOWING THE AREA IN RELATION TO ESTABLISHED AREAS AND ROADS IS TO BE SENT WITH THE REQUEST.

IF THE PROPOSED LINE IS NOT WHOLLY (OR PARTIALLY) WITHIN HIGHWAY LIMITS, THE SAME INFORMATION IS REQUIRED AS SHOWN ON THIS PLATE.

PLATE II

PIPE CROSSING

INFORMATION TO BE SHOWN ON PROFILE SECTION OF DRAWING



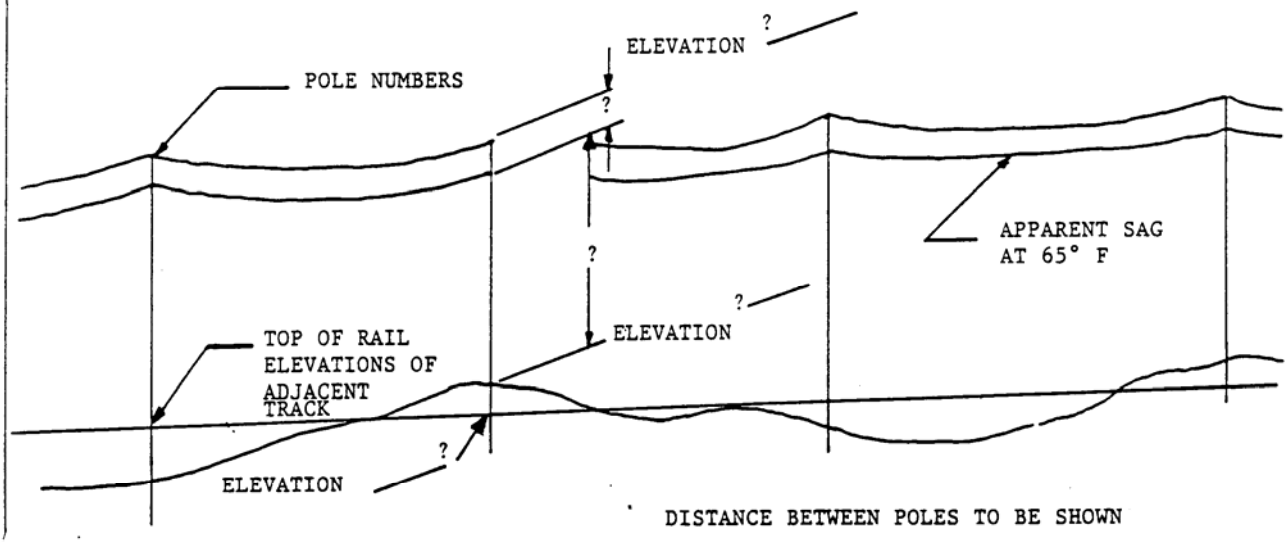
SECTION

SCALE:

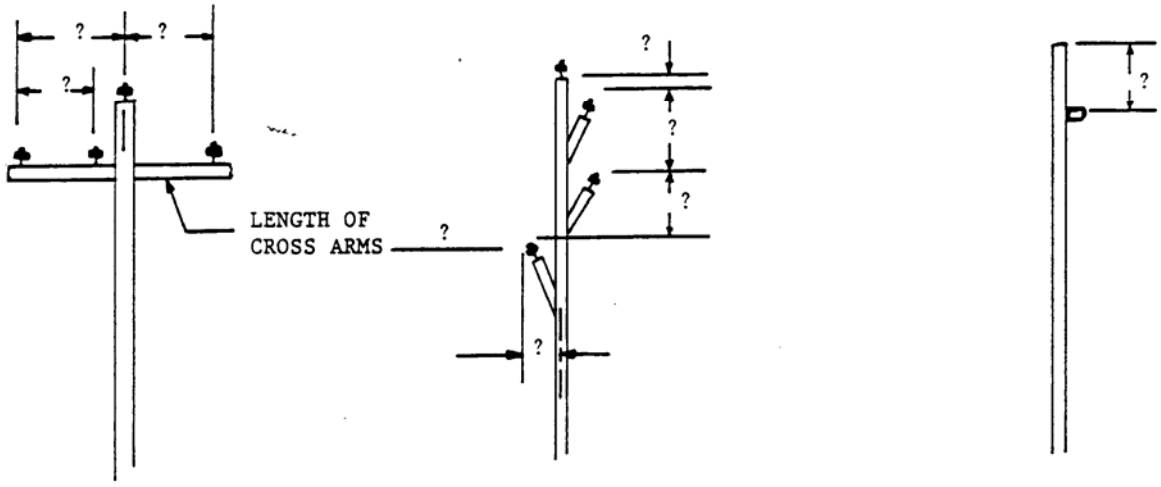
PLATE III

PROFILE VIEW

INFORMATION TO BE SHOWN ON PROFILE SECTION OF DRAWINGS
IN CASES OF LONGITUDINAL OCCUPATIONS



DISTANCE BETWEEN POLES TO BE SHOWN



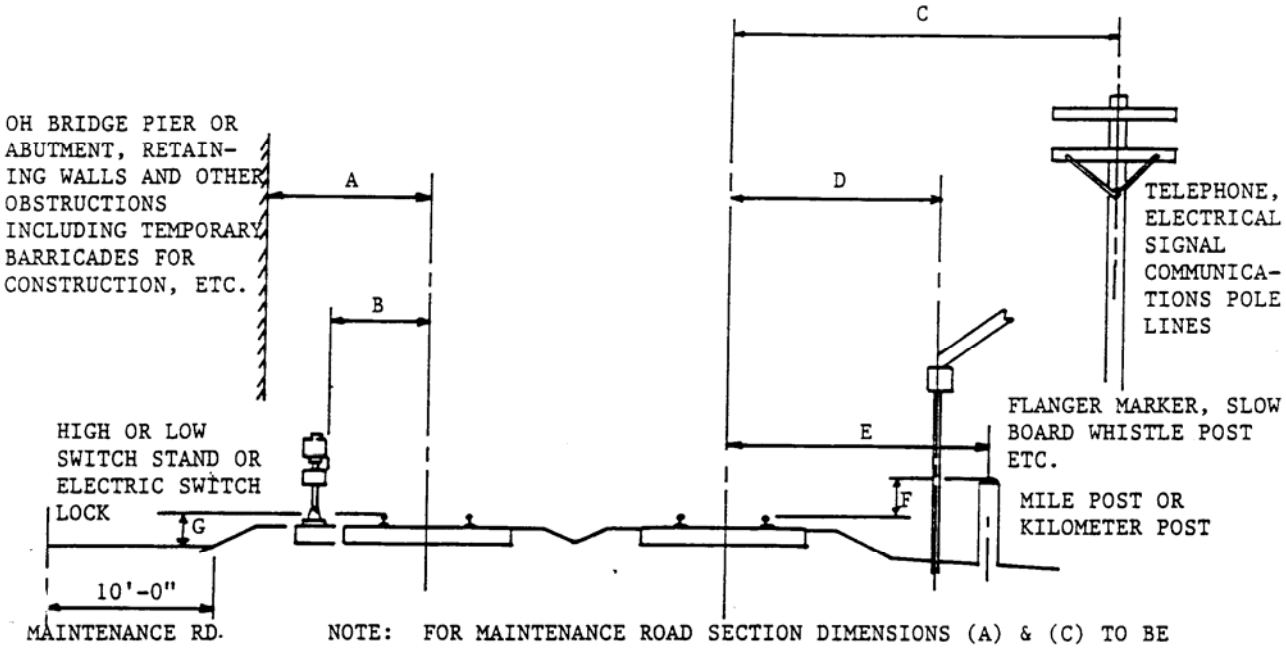
POLE TOP CONFIGURATION TO BE SHOWN SIMILAR TO SAMPLES ABOVE

NOTE: IF POWER LINE CROSSES ANY TRACK, THEN INFORMATION SHOWN ON PLATE II IS ALSO REQUIRED.

PLATE IV

STANDARD SIDE CLEARANCES - TANGENT TRACK

(FOR OBSTRUCTIONS OTHER THAN PASSENGER STATIONS)



NOTE: FOR MAINTENANCE ROAD SECTION DIMENSIONS (A) & (C) TO BE INCREASED ACCORDINGLY - DIMENSIONS (D) & (E) MAY BE REDUCED TO 8'-6" CLEARANCE.

DIMENSION	DESCRIPTION	
A	GENERAL MINIMUM SIDE CLEARANCE	8'-6"
	OVERHEAD BRIDGE PIERS & ABUTMENT, RETAINING WALLS & OTHER EXISTING STRUCTURES	8'-6"
B	LOW SWITCH STANDS (3'-0" MAX HEIGHT)	6'-6"
	HIGH SWITCH STANDS (OVER 3'-0" HEIGHT)	9'-0"
	ELECTRIC SWITCH LOCKS	6'-6"
C	POLE LINES - TELEPHONE, ELECTRIC, SIGNAL COMMUNICATIONS (MIN)	13'-6"
D	CENTERLINE WHISTLE POSTS, FLANGER MARKERS, SLOW OR SPEED BOARDS AND OTHRE WAYSIDE SIGNS	12'-0"
	AUTOMATIC HIGHWAY CROSSING PROTECTION (MIN)	8'-6"
	AUTOMATIC HIGHWAY CROSSING PROTECTION (DESIRED)	15'-0"
E	MILE POSTS - HORIZONTAL	13'-6"
F	MILE POSTS - VERTICAL	7'-0"
G	DEPRESSION OF MAINTENANCE ROAD	

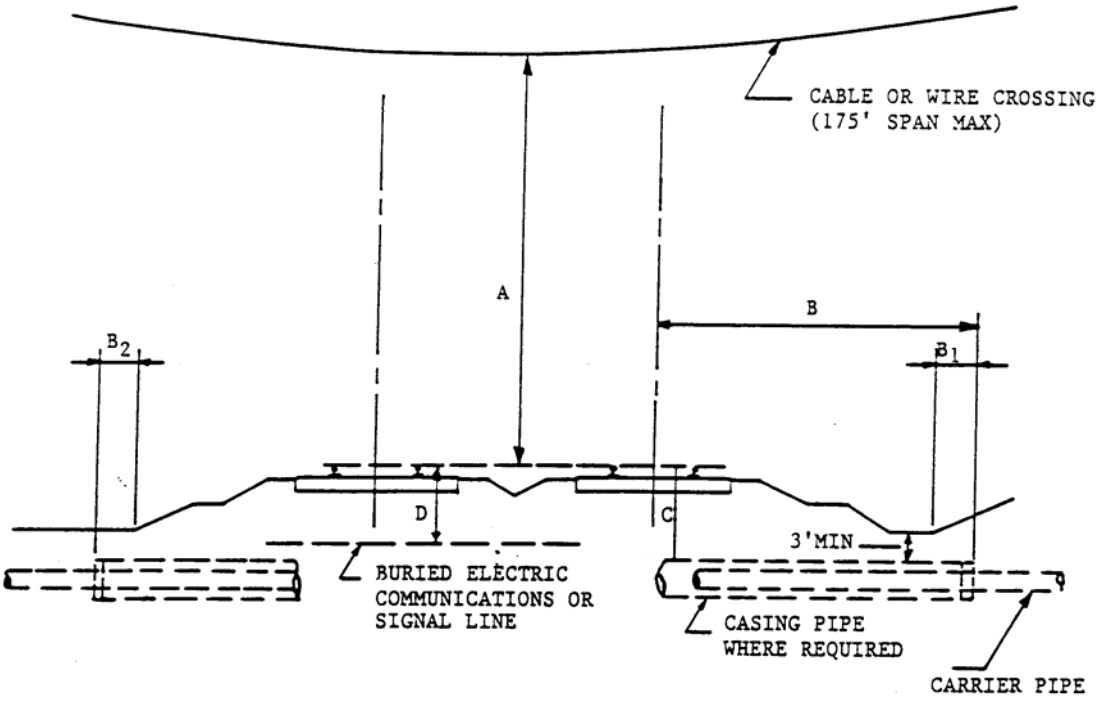
PLATE V

VOLTAGE	OVERHEAD CLEARANCE (Top of Rail to Bottom of Sag)	
0 - 750	27'0"	At 120°F Ambient Temperature
750 - 15,000	28'0"	
15,000 - 50,000	30'0"	
69,000	30'8"	
115,000	32'2"	
138,000	33'0"	
345,000	39'10"	
500,000	45'0"	
745,000	53'2"	
765,000	53'10"	
Other than power lines	27'0"	

(Calculation is 30'0" + 0.4" per 1,000 volts over 50,000 volts)

CLEARANCES FOR OVERHEAD AND BURIED UTILITY CROSSINGS

PLATE VI



DIMENSION	DESCRIPTION		
A	POWER LINES 0 TO 750V	27'-0"	At 120°F Ambient Temperature
	POWER LINES 750V to 15,000V	28'-0"	
	POWER LINES 15 to 50KV	30'-0"	
	OTHER THAN POWER LINES	27'-0"	
B	SEALED ENDED CASINGS	25'-0"	
	OPEN ENDED CASINGS	45'-0"	
B_1	END CASING DEYOND DITCH	2'-0"	
B_2	END CASING BEYOND SLOPE	3'-0"	
C	CASING PIPE	4'-6"	
	CARRIER PIPE WITHOUT CASING	6'-6"	
D	BURIED ELECTRIC LINES	6'-6"	
	RAILROAD SIGNAL LINES (220V)	2'-6"	
	COMMUNICATIONS LINES	3'-6"	

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

VI

BRIDGE ERECTION, DEMOLITION AND HOISTING OPERATIONS

Submittals for bridge erection, demolition, or other hoisting operations shall be prepared and stamped by a Registered Professional Engineer and must include the following:

1. Plan view showing locations of crane or cranes, operating radii, with delivery or disposal locations shown.

2. Crane rating sheets showing cranes to be adequate for 150% of the lift. Crane and boom nomenclature is to be indicated.

3. Plans and computations showing weight of picks.

4. Location plan showing obstructions, indicating that the proposed swing is possible.

5. Data sheet listing type and size of slings or other connecting equipment. Include copies of catalog cuts or information sheets of specialized equipment. The method of attachment must be detailed on the erection plan. All lifting components must be adequate for 150% of the lift.

6. A complete procedure indicating the order of lifts and any repositioning or re-hitching of the crane or cranes.

7. Plans detailing temporary support of any components or intermediate stages.

8. A time schedule (by hour and day) of the various stages, as well as a schedule for the entire lifting procedure.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

VII

TEMPORARY SHEETING AND SHORING

The following items are to be included in the design and construction procedures for all permanent and temporary facilities on, over, under, within or adjacent to MBTA Railroad Property:

1. Footings for all piers, columns, walls or other facilities shall be located and designed so that any temporary sheeting and shoring for support of adjacent track or tracks during construction will not be closer than toe of ballast slope. (See dimensions in the MBTA's Book of Standard Plans, #1000 and #1002 for tangent and curved track). Sheeting will be required when excavation is inside of a line which extends horizontally from 5.5 feet off center line of adjacent track, then on a 2 (horizontal) to 1 (vertical) slope. This is known as the zone of influence.

2. Where physical condition of design impose insurmountable restrictions requiring the placing of sheeting closer than specified above, the matter must be submitted to the Chief Engineering Officer for approval of any modifications.

3. When support of track or tracks is necessary during construction of above mentioned facilities, interlocking steel sheeting adequately braced and designed to carry E-80 live load plus 50% impact is required. Soldier piles and lagging will be permitted for supporting adjacent track or tracks only when required penetration of steel sheet piling cannot be obtained or when in the opinion of the Chief Engineering Officer, or his authorized representative, steel sheet piling would be impracticable to place.

4. Exploratory trenches, three (3) feet deep and fifteen (15) inches wide in the form of an "H" with outside dimensions matching the outside of sheeting dimensions are to be hand dug, prior to placing and driving steel sheeting, in areas where railroad underground installations are known to exist. These trenches are for exploratory purposes only and are to be backfilled and compacted immediately. This work must be done in the presence of a railroad inspector.

5. Absolute use of track is required white driving sheeting adjacent to any track. Procedure for arranging the use of track shall be through the Railroad Company(s) representative on the project.

6. Cavities adjacent to sheet piling, created by driving of sheet piling, shall be filled with sand and any disturbed ballast must be restored and tamped immediately as required by the Railroad Company(s).

7. Sheet piling shall be cut off at top of tie during construction. After construction and backfilling has been completed, the piling within twelve (12) feet from centerline of track will be cut off 24" below bottom of tie or 24" below finished grade, whichever is greater. Sheeting, used as a form on a permanent structure, will be cut as directed by the Railroad Company(s).

8. The excavation adjacent to the track shall be covered and protected by handrails and barricades, warning lights shall be provided by the Contractor as directed by the Railroad Company(s).

9. Graded backfill material shall be compacted at near optimum moisture content, in layers not exceeding 6 inches in compacted thickness, by pneumatic tampers, vibrator compactors, or other approved means to the base of the railroad subgrade. Material in the vicinity of sheet pile shall be compacted to not less than 95 percent of AASHTO T 99, Method C. The Contractor will be required to supply, to the job site, ballast stone as prescribed herein to be installed by the Railroad Company(s).

10. The Contractor is to advise the Railroad Company(s) of the time schedule of each operation and obtain approval of the Railroad Company(s) for all work to be performed adjacent to MBTA tracks so that it may be properly supervised by railroad personnel.

11. AII drawings for temporary sheeting and shoring shall be prepared and stamped by a Registered Professional Engineer and shall be accompanied by complete design computations when submitted for approval.

12. Particular care shall be taken to avoid erosion or filling of the Railroad Company(s) drainage facilities. Erosion and sediment control in the vicinity of the railroad shall be as approved by the Chief Engineering Officer. Correction of disrupted Railroad Company(s) drainage facilities shall be at the Contractor's sole expense.

MBTA REQUIREMENTS FOR GEOTECH MONITORING

THE FOLLOWING SPECIFICATIONS ARE REQUIRED FOR ALL PILE DRIVING/EXCAVATING OPERATIONS:

1. Pile driving will be on a continuous basis for each pile driven. Once a pile is started, it will be driven or cut off at an elevation not to exceed the plane across the top of the rails of any track within 8'-6" plus 2" for each degree of curvature from centerline of track to the closest edge of the edge or excavation.

2. The monitoring points will be set up one week before the pile driving or excavation operations begin. The MBTA and the Railroad Company(s) shall he notified. Elevation readings to establish the initial baseline reading shall begin two days prior to the start of driving. Readings shall be for a minimum of two weeks after the completion of the driving or backfilling of the excavation, whichever is longer. Initial readings immediately after any surfacing operations shall serve as new baseline figures. All future elevation readings shall be compared to the adjusted baseline. If the track deviates to a condition acceptable to the MBTA or Railroad Company(s), corrections will be made at the proponent's expense.

3. Elevation readings will be taken from the top of each rail of each track within the "zone of influence" the excavation. See Section 1, Page 1 of this specification.

4. Elevation readings will be taken once per eight hour shift. The readings will be faxed to the MBTA Railroad Company(s) on a daily basis and all information is to be presented in legible print. During excavation within the sheet pile protected area, the top of rail elevations shall be checked every hour. Additional readings may be required by the MBTA or Railroad Company(s).

5. Stations shall be spaced at 15-1/2 foot intervals. The number distractions required will be determiner the length of the excavation parallel to the tracks. There will be four additional stations on each end of the pile driving/excavation operation along the track. Extra stations may be required by the MBTA or Railroad Company.

6. Elevation readings must show the date, time, weather conditions and temperature. Each reading must also provide the following information: track number, compass direction, station number, base elevation (with date), static elevation, change in elevation (recorded in hundredths and in inches), dynamic reading and total deflection in inches. See sample sheet attached.

7. Station "0" will be located at the centerline of the project with Stations 1, 2. 3, etc., being to the right and Stations -1, -2, -3, etc., being to the left when standing on the near track and looking at the work. In multiple track areas the stations as determined herein are to be carried across each track located within any part of the zone of influence. See Plate I.

8. At each monitoring station a dynamic loud measurement will also be taken. The dynamic load measurement device will consist of a wooden stake placed firmly in the ballast and in initially in contact with the bottom of the rail. The loaded measurement is the resultant gap between the bottom of the rail and the top of the stake caused by the deflection of the rail under the load of a passing train. Based on field observations of the excavation, and at the option of the MBTA or railroad company(s), this requirement may be reduced.

9. Elevation readings taken from the top of rail for static measurement and the dynamic reading shall be combined and the sum compared to the adjusted baseline. This reading will demonstrate the difference in elevation caused by the excavation.

10. The MBTA requires that the track be maintained at all times within established criteria for the specific track classification. At the completion of the project the requirement for tamping and realigning the tracks, caused by the settlement from the construction activity, remains with the proponent for the duration as specified by the MBTA in their initial review of the work plans. This tamping and track realignment will be performed by the MBTA or railroad company(s) at the sole expense of the proponent.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

VIII

BLASTING SPECIFICATIONS

Blasting on, over, under, within or adjacent to MBTA Railroad Property will be permitted only in special cases where it is demonstrated to the MBTA's Chief Engineering Officer that there is no practicable alternative to perform the work.

In such cases when blasting is permitted, the Contractor must submit a detailed blasting program to the MBTA and Railroad Company(s) for approval prior to the commencement of any work. The blasting program must contain the following information:

a. Site plan with location of nearest MBTA structure.
b. Plan of each blast showing hole spacing and delay pattern.
c. Diameter and depth of each hole.
d. Amount of explosives per hole.
e. Total pounds of explosives per day.
f. Total amount of explosives per blast.
g. Type of non-electric delays to be used.
h. Amount of stemming in each hole.
i. Type of explosive to be used.
j. Soil and rock profile in blast zone.
k. Scaled distance to the nearest MBTA facility.
l. Type and location of seismograph to be used.
m. Size of blasting mats to be used.
n. Safety precautions to be followed.

The following general requirements are to be adhered to:

a. Obtain the services of a qualified vibration and blasting consultant to monitor the blasting.
b. Use a non-electric detonation system whenever possible. If electric caps are used, a check must be made for stray currents, induced current and radio frequency energy to insure that this hazardous extraneous electricity is at an acceptable safe level.
c. Provide an open face for maximum relief of burden.
d. Limit the maximum peak particle velocity to 1 inch per second. Depending on existing conditions, this may be modified to 2 inches per second.
e. Maintain an initial scale distance of 60 ft. per 1-1/2 lbs. After initial blasting, scale distance may be modified to a minimum of 50 ft per 1-1/2 lbs., if conditions permit.

Scale distance -- $\frac{\text{Distance from blast to structure (in feet)}}{\text{Weight of explosives per delay (in pounds)}}$

The contractor shall provide for a pro-blast and post blast survey, including photographs. An inspection of all nearby MBTA facilities shall be made to determine any changes that may occur due to blasting operations.

The contractor shall coordinate all blasting with the MBTA and Railroad Company(s) in advance to determine when the charges may be set. The contractor is advised that the MBTA and Railroad Company(s) use two way radios for train control. The radios operate in the 160 Mhz area. These radios cannot be turned off at any time.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

IX

TEMPORARY PROTECTION SHIELDS FOR DEMOLITION AND CONSTRUCTION

The Railroad Company(s) will determine when and where protection shields are required. The designated construction of temporary protection shields must adhere to the following specifications:

1. The construction of temporary protection shields will be designed to prevent any dust, debris. concrete, formwork, paint, or tools from falling on MBTA Railroad Property below.

2. The temporary protection shields shall be erected prior to the start of work. The Railroad Company(s) will determine whether or not sufficient protection has been provided to perform the work over any particular area.

3. The temporary protection shields shall remain in place until all work over the railroad has been completed and shall be removed only when ordered by the Railroad Company(s).

4. To minimize the inconvenience to the users of any properties below and adjacent to the project, the Contractor will be required to complete the actual erection and removal of the temporary shields within time limits acceptable to the Railroad Company(s).

5. The erected temporary protection shields shall not infringe on any existing minimum vertical clearance.

6. The Contractor will be required to obtain the approval of the Railroad Company(s) before commencing any work beneath the shield. In certain areas, depending on the nature of the work, the Railroad Company(s) may require a specific method of protection.

7. The horizontal shield shall he designed to carry a live load of 100 pounds per square foot and a single concentrated load of 2,000 pounds located to produce maximum stress. The vertical shield shall be designed to carry a wide load of 30 pounds per square foot.

8. Prior to the start of construction, the Contractor will be required to submit the details of the temporary protection shield to the Railroad Company(s), who will review and approve the details only as to the methods of erection and as to whether or not the proposed installation will provide the level of protection required at the various locations. It is the Contractor's responsibility to design these protections so that they are in conformance with all existing laws, regulations and specifications that govern this type of work. Shield plans must include a material list and shall be designed by a Registered Professional Engineer. The drawings and calculations must bear his seal when they are submitted to the Railroad Company(s).

9. If during the actual construction, the Railroad Company(s) deems that the

shield is not providing the desired level of protection or that the Contractor has failed to properly maintain the shield, all work at the affected location shall cease until corrective measures acceptable to the Railroad Company(s) are instituted.

10. All temporary shields will be constructed using new material.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

X

INDUSTRIAL SIDE TRACK SPECIFICATIONS

SECTION 1. GENERAL

1.01 All railroad track construction shall be performed under competent supervision of personnel experienced in railroad construction and shall conform to the standards of the MBTA. The MBTA and Railroad Company(s) will inspect and approve all side tracks prior to being put in service. This specification will be used for side tracks directly on or within 15 feet of the MBTA property line. Any construction outside of the MBTA property line will be in compliance with the standards of the serving freight railroad.

SECTION 2. MATERIALS

2.01 MATERIAL

Rails, ties, switches, frogs, etc. will conform with the standards of the MBTA for various types of turnouts and track installations thereby insuring replacement availability.

2.02 RAIL

The rails shall be 100# ASCE Section or of a heavier rail section in common use, new or relay. Relay rails shall not have more than 1/4" top wear measured vertically along center line of rail and not more than 3/8" side wear measured horizontally 3/4" below the normal top of rail. Rails shall be free from kinks, excessive rust and excessive head flow. Rails having line or surface bends that cannot be spiked will be rejected. Rail shall be free of internal defects. Rail used on the limits of MBTA Railroad Property shall be equal in weight and in section to the attached main line.

2.03 CROSS TIES

Cross ties shall conform to MBTA specifications, minimum size will be 7" x 8" x 8'6" and shall be treated with creosote in accordance with MBTA specifications. Relay ties may be approved after inspection by the MBTA and Railroad Company(s) prior to installation.

2.04 SWITCH TIMBER

Switch timber shall be new hardwood and conform to MBTA specifications 7" x 9" and of lengths required by MBTA standard turnout bill of materials. All timber shall be creosote treated as specified for cross ties. Relay timber as above.

2.05 TIE PLATES

Tie plates shall be new or relay at least 7-1/2" x 10-3/4", 1/2" thick, double shoulder and should be canted. Tie plates must conform to MBTA specifications. Damaged plates or plates showing more than 25% reduction in section due to corrosion or wear will be rejected.

2.06 JOINT BARS

Joint bars shall be new or relay, 100% toeless, 24" long or equal and conform to MBTA specifications. Relay bars must be free from appreciable wear. Joint bars shall have a minimum of four holes and the holes are to fit the punchings of the rail. Holes to have a clearance of 1/16". Joint bars that cannot be drawn up to give a tight fit will be rejected. No fewer than 4 bolts per joint will he allowed.

2.07 BOLTS, NUTS AND WASHERS

Bolts and nuts shall be new and of a size to fit the rail punchings. They shall conform to AREA specifications for low carbon steel track bolts and nuts. Washers shall be new spring type of appropriate size and shall conform to MBTA specifications.

2.08 TRACK SPIKES

Track spikes shall be 6" long, 5/8" square with an oval head and conform to MBTA specifications for soft steel track spikes. Tangent track will have at least 2 rail holding spikes per tie plate and all curves over 3” will have 3 spikes per tie plate.

2.09 BALLAST

Ballast shall conform to MBTA Material Specification 9248.

2.10 BUMPING POSTS

Bumping posts will be Hayes type, Durable "D" or equal, unless otherwise specified, and will conform to MBTA Material Specification 9206.

2.11 DERAIL

Type and quality of derail will be specified for each individual side track requirement. Derail will be connected into the railroad signal system. This will be performed by the Railroad Company(s) at the Owner's expense. Two pairs of insulated joints will be installed at a location to be determined by the MBTA. Side tracks with a descending grade toward the main track will require a split switch type derail.

SECTION 3. INSTALLATION

3.01 The track will be properly installed with a standard gauge of 4'8-1/2" except on sharp curves. In cases of sharp curves, gauge will be specified by the MBTA or the Railroad Company(s).

3.02 Ballast will be installed on top of subgrade for a depth of at least 6" below the bottom of tie and brought up to the top of the tie at the center and slope off to 1" below top of tie at the ends. It will then extend 1' beyond the end of the tie at that height, at which point it will slope off at a rate of 2:1 to the sub-ballast.

3.03 Cross ties will be placed not more than 24" on center on tangent track and 19 ½ " on center on curved track. When relay rails are used the unworn side will be placed on the gauge side. Tie plates will be installed on each cross tie. The center of the joint should he installed so as to be suspended by two ties.

3.04 It will be the responsibility of the builder of that portion of track designated as "property line to end" to connect to that portion of track designated as "clearance to property line" and provide the necessary joints or compromise joints with bolts as the weights of rail would dictate.

SECTION 4. BONDING

4.01 Where track bonding is necessary, it will be performed by the Railroad Company(s) in accordance with MBTA standards.

SECTION 5. APPROVAL

5.01 Plans for track installation must be approved by the MBTA and Railroad Company(s) before the design of the facility to receive rail service is finalized.

SECTION 6. CURVATURE OF TRACK

6.01 The recommended curvature shall be exceed 8^{o} or less. The maximum allowable degree of curve is not to exceed 12^{o} 30', unless approved by the Chief Engineering Officer.

SECTION 7. GRADE OF TRACK

7.01 The maximum allowable grade for all tracks shall not exceed 1.5% descending towards mainline or 3% descending from mainline using 100 foot vertical curves.

SECTION 8. ELEVATION

Super elevation shall not exceed 1 inch.

SECTION 9. SUBGRADE

9.01 Subgrade will be prepared to a grade 18" - 20" below the proposed top of rail and shall be of a material that is compacted to 95% and provides for adequate drainage.

SECTION 10. ACCEPTANCE

10.01 Before track is placed into service to receive cars, it will be inspected and approved by a qualified track inspector from the MBTA, the Railroad Company, and the freight carrier.

10.02 No exceptions to these specifications are authorized without the written approval of the Chief Engineering Officer.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

XI

RIGHT OF WAY FENCING SPECIFICATIONS

SECTION 1. GENERAL

1.01 DESCRIPTION

This section specifies the furnishing and installing of new Type I galvanized steel or Type II aluminum coated steel chain link fence. Right of way fence will be 6', 8' or 10’ as required by site specific conditions.

1.02 SUBMITTALS

Shop Drawings

1. Include cross sectional dimension of posts, braces, rails, fittings, accessories and gate frames, design of gates, and details of gate hardware.

2. Include a layout drawing showing the spacing of posts and location of all gates, abrupt changes in grade, and all corner, gate, anchor, end and pull posts.

SECTION 2. PRODUCTS

2.01 MATERIALS

A. General

1. Steel pipe dimensions and weights: ASTM A-53, Schedule 40 (except the hydrostatic testing requirement is waived). Dimensions specified are outside diameter (O.D.).

2. Provide post with accepted semi-steel or pressed steel tops, so designed as to fit securely over post and carry top rail or spring tension wire; the base of post top fitting shall fit over the outside of post and shall exclude moisture from post. All fittings and accessories shall be hot dipped galvanized in accordance with ASTM A-53.

B. Line Post: For all post heights, unless otherwise noted, Schedule 40, 2.375” O.D. pipe weighing 3.65 lbs./ft ASTM A-53 with a 2 oz. hot dipped galvanized coating shall be used.

C. Gate post: Furnish post to support single gate leaf, or one leaf of a double gate installation, for the following gate widths:

Leaf Width	Gate Post	Sch. 40
up to 6'	2.875" O.D.	5.79 lb./ft
6' to 12’	4.000" O.D.	9.11 lb./ft
12' to 18'	6.625" O,D.	18.97 lb./ft
18' to 32'	8.625" O.D.	28.55 lb./ft

D. End, Corner and Intermediate Posts

For all post heights, unless otherwise noted, Schedule 40, 2.875" O.D. pipe weighing 5.79 lbs./ft. ASTM A-53 with a 2 oz. hot dipped galvanized coating shall be used.

E. Top rail and Spring Tension Wire

1. Top Rail

a. Schedule 40, 1.66" O.D, pipe weighing 2.27 Ibs./ft. ASTM A-53 with a 2 oz. hot dipped galvanized coating.

b. Couplings and expansion sleeves: Outside sleeve type, minimum six inches long.

2. Spring tension wire: shall be marcelled (spiraled or crimped) #7 gauge (.177 inches) plus or minus 0.005 inches in diameter. ASTM A-824. 1.2 oz zinc per sq. ft.

F. Braces and Tension Rods

1. Compression braces: Same type and size as top rail.

2. Tension rods: 3/8" round rods with drop forged turnbuckles or other approved type of adjustment.

G. Fence Fabric

1. Type I galvanized steel ASTM A-392 Class 2 coating 2 oz.

a. Typical-2" diamond mesh 6 gauge (192") 2 oz.

b. Hot dipped galvanizing after weaving.

2. Type II aluminum coated steel ASTM A-491 size 2. 3/8" mesh.

3. Selvages: All types

a. Fabric shall be knuckled at both selvages.

b. Fabric over 60 inches high: knuckled at one selvage and twisted and barbed at the other.

H. Fabric Bands, Brace Bands and Stretcher Bars

1. Fabric Bands: 12 gauge pressed steel 7/8 inch wide.

2. Brace Bands: 11 gauge pressed steel 1 inch wide.

3. Stretcher Bars: 3/I6" x 3/4" galvanized steel.

I. Tie wire and miscellaneous Items

1. Tie Wire: Galvanized steel 6 gauge (.192") for post and rails.

2. Hog rings: Galvanized steel 6 gauge (.192") for spring tension wire.

3. Rail and Truss Cups: Galvanized semi-steel or pressed steel.

J. Barbed Wire and Extension Arms

1. Barbed Wire; ASTM AI21, 12-1/2 gauge, 4-point round barbs, Class 3 coating.

2. Extension Arms: Projecting at an angle of approximately 45 degrees, fitted with clips or other means of attaching three strands of barbed wire, the top outside wire approximately 12 inches from the fence line and the other wires spaced uniformly between the top outside wire and the fence fabric.

K. Gates

1. General: Furnish gates complete with necessary hinges, latches, and drop bar locking devices; corners shall be welded or fastened and reinforced with suitable fittings.

2. All gates fabricated from 1.90" O.D. Schedule 40 pipe weighing 2.72 lbs./ft with a 2 oz hot dipped galvanized coating.

L. Concrete: Class 2500 psi concrete consisting of aggregate passing the No. 8 sieve.

SECTION 3. EXECUTION

3.01 INSTALLATION

A. Place terminal post at each end, corner, gate post, pull post (minimum 500'), or any change in grade or direction greater than 30 degrees.

B. Line posts shall be spaced on a maximum of 10 foot centers. In determining the post spacing, measure parallel to slope of finished grade. All posts to be set plumb and in line. Post spacing on radius as follows:

200'- 500' radius 8' O.C.
100’ - 200' radius 6’ 0.C.
less than100’ radius 5' O.C.

C. When fencing is installed on the top of concrete structures, use galvanized sleeve and grout posts or install with suitable galvanized flange casing and galvanized anchor bolts. Set all other posts permanently in concrete.

D. Excavate post hole footings at least 12" in diameter for line post and I6" for terminal and gate posts up to 4" O.D. Larger gate posts require 18" diameter footings. All footings excavated to a depB1 of 42" with a minimum post embedment of 36". Crown top of concrete to shed water and allow to cure not less than 72 hours before proceeding with further work on the post.

E. Brace end, corner pull, and gate posts to the nearest line post with diagonal or horizontal brace rails used as compression chambers, and with truss rods with turnbuckles used as tension members. Brace line posts horizontally and truss in both directions as required, at approved intervals.

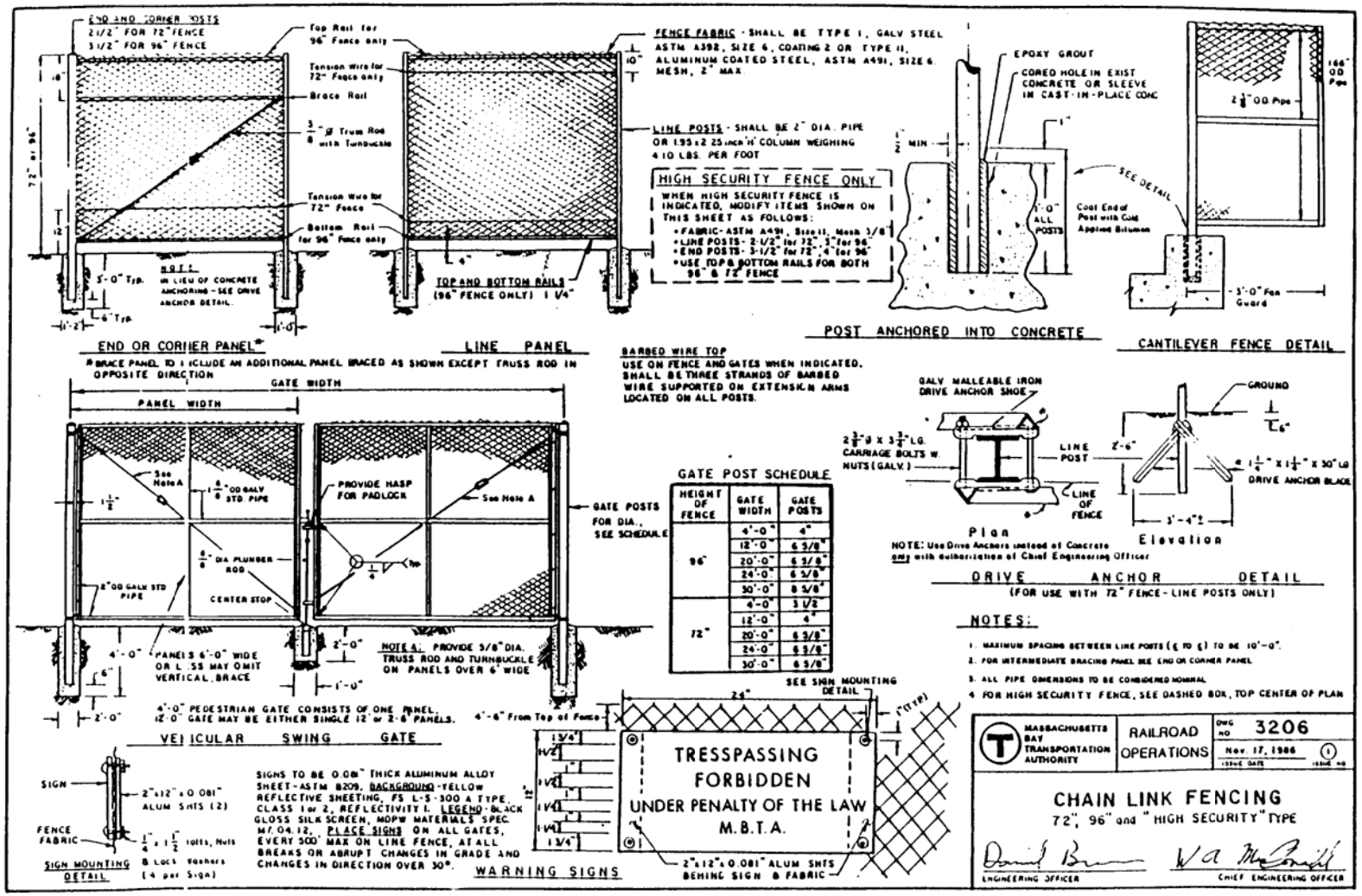
F. Install fabric on post side which best secures MBTA's Railroad Property. Pull fabric taut and tie to all line posts, rails, braces and spring tension wire spacing all ties at 12" intervals. Use hook shaped steel ties confined to the diameter of the pipe to which it is attached, clasping pipe and fabric firmly with both ends twisted at least 2 turns.

G. Barbed wire and tension wire must be taut and properly secured with brace bands at each terminal and gate post.

H. Electric Ground: Where a power line carrying more than 600 volts passes over fence, install ground rod at the nearest point directly below each point of crossing. Ground all substation fences and gates and perform other electrical grounding as indicated.

3.02 TOUCH-UP AND REPAIR WORK

Remove and replace fencing which is improperly located or is not true to line, grade and plumb within tolerances as indicated.


END AND CORNER POSTS
2 1/2" FOR 72" FENCE
3 1/2" FOR 96" FENCE
Top Rail for 96" Fence only
Tension Wire for 72" Fence only
Brace Rail
3/8" ø Truss Rod with Turnbuckle
Tension Wire for 72" Fence
Bottom Rail for 96" Fence only
72" or 96"
12"
10"
5'-0" Typ.
6" Typ.
1'-2"
1'-0"
NOTE
IN LIEU OF CONCRETE ANCHORING - SEE DRIVE ANCHOR DETAIL.
4"
TOP AND BOTTOM RAILS (96" FENCE ONLY) 1 1/4"
FENCE FABRIC - SHALL BE TYPE I, GALV STEEL ASTM A392, SIZE 6, COATING 2 OR TYPE II, ALUMINUM COATED STEEL, ASTM A491, SIZE 6 MESH, 2" MAX
LINE POSTS - SHALL BE 2" DIA. PIPE OR 1.95 x 2.25 inch 'H' COLUMN WEIGHING 4.10 LBS. PER FOOT
HIGH SECURITY FENCE ONLY
WHEN HIGH SECURITY FENCE IS INDICATED, MODIFY ITEMS SHOWN ON THIS SHEET AS FOLLOWS:
• FABRIC - ASTM A491, Size II, Mesh 1/8"
• LINE POSTS - 2-1/2" for 72", 3" for 96"
• END POSTS - 3-1/2" for 72", 4" for 96"
• USE TOP & BOTTOM RAILS FOR BOTH 96" & 72" FENCE
EPOXY GROUT
CORED HOLE IN EXIST CONCRETE OR SLEEVE IN CAST-IN-PLACE CONC
1/2" MIN
1"
1'-0" ALL POSTS
SEE DETAIL
Coat End of Post with Coal Applied Bitumen
2 1/2" OD Pipe
166" OD Pipe
3'-0" Fan Guard
POST ANCHORED INTO CONCRETE
CANTILEVER FENCE DETAIL
END OR CORNER PANEL*
LINE PANEL
* BRACE PANEL TO INCLUDE AN ADDITIONAL PANEL BRACED AS SHOWN EXCEPT TRUSS ROD IN OPPOSITE DIRECTION
GATE WIDTH
PANEL WIDTH
See Note A
1 1/2"
1 5/8" OD GALV STD PIPE
PROVIDE HASP FOR PADLOCK
See Note A
GATE POSTS FOR DIA., SEE SCHEDULE
3/8" DIA PLUMBER ROD
2" OD GALV STD PIPE
CENTER STOP
4'-0"
2'-0"
6"
1'-0"
2'-0"
PANELS 6'-0" WIDE OR LESS MAY OMIT VERTICAL BRACE
NOTE A: PROVIDE 5/8" DIA. TRUSS ROD AND TURNBUCKLE ON PANELS OVER 6' WIDE
4'-0" PEDESTRIAN GATE CONSISTS OF ONE PANEL. 12'-0" GATE MAY BE EITHER SINGLE 12' or 2-6' PANELS.
BARBED WIRE TOP
USE ON FENCE AND GATES WHEN INDICATED. SHALL BE THREE STRANDS OF BARBED WIRE SUPPORTED ON EXTENSION ARMS LOCATED ON ALL POSTS.
GATE POST SCHEDULE
HEIGHT OF FENCE | GATE WIDTH | GATE POSTS
96" | 4'-0" | 4"
96" | 12'-0" | 6 5/8"
96" | 20'-0" | 6 5/8"
96" | 24'-0" | 6 5/8"
96" | 30'-0" | 8 5/8"
72" | 4'-0" | 3 1/2"
72" | 12'-0" | 4"
72" | 20'-0" | 6 5/8"
72" | 24'-0" | 6 5/8"
72" | 30'-0" | 6 5/8"
GALV MALLEABLE IRON DRIVE ANCHOR SHOE
2 1/2" Ø x 3 1/2" LG. CARRIAGE BOLTS W NUTS (GALV.)
LINE POST
LINE OF FENCE
Plan
GROUND
2'-6"
1 1/2" x 1 1/2" x 30" LG DRIVE ANCHOR BLADE
3'-4" ±
Elevation
NOTE: Use Drive Anchors instead of Concrete only with authorization of Chief Engineering Officer
DRIVE ANCHOR DETAIL
(FOR USE WITH 72" FENCE - LINE POSTS ONLY)
NOTES:
1. MAXIMUM SPACING BETWEEN LINE POSTS (℄ TO ℄) TO BE 10'-0".
2. FOR INTERMEDIATE BRACING PANEL SEE END OR CORNER PANEL
3. ALL PIPE DIMENSIONS TO BE CONSIDERED NOMINAL
4. FOR HIGH SECURITY FENCE, SEE DASHED BOX, TOP CENTER OF PLAN
VEHICULAR SWING GATE
SIGN
2"x12"x0.081" ALUM SHTS (2)
FENCE FABRIC
1/4" x 1 1/2" Bolts, Nuts & Lock Washers (4 per Sign)
SIGN MOUNTING DETAIL
SIGNS TO BE 0.081" THICK ALUMINUM ALLOY SHEET - ASTM B209, BACKGROUND - YELLOW REFLECTIVE SHEETING, FS L-S-300 A TYPE, CLASS 1 or 2, REFLECTIVITY I. LEGEND - BLACK GLOSS SILK SCREEN, MDPW MATERIALS SPEC. M7.04.12. PLACE SIGNS ON ALL GATES, EVERY 300' MAX ON LINE FENCE, AT ALL BREAKS OR ABRUPT CHANGES IN GRADE AND CHANGES IN DIRECTION OVER 30°.
WARNING SIGNS
SEE SIGN MOUNTING DETAIL
24"
4'-6" From Top of Fence
1'-0" (TYP.)
1 3/4"
1 1/2"
1"
1"
1"
1 3/4"
TRESSPASSING FORBIDDEN UNDER PENALTY OF THE LAW M.B.T.A.
2"x12"x0.081" ALUM SHTS BEHIND SIGN & FABRIC
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
RAILROAD OPERATIONS
DWG NO 3206
Nov. 17, 1986
ISSUE DATE
ISSUE NO 1
CHAIN LINK FENCING
72", 96" and "HIGH SECURITY" TYPE
ENGINEERING OFFICER
CHIEF ENGINEERING OFFICER

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

XII

TEST BORINGS SPECIFICATIONS

SECTION 1. GENERAL

All borings on MBTA Railroad Property are to be performed according to the following requirements:

1.01 Work on MBTA Railroad Property must be performed with a Railroad Company(s) inspector and/or flagman present.

1.02 Where access can only be gained by crossing the tracks, a temporary crossing must be used. This crossing shall adhere to the following:

A. The location and material must be approved in advance by the Chief Engineering Officer or Railroad Company(s).

B. The crossing will be constructed by Railroad Company(s) forces at the Contractor's expense.

C. The crossing must be protected at all times when not in use. Access will be prohibited through the use of right-of-way gates which will be constructed by Railroad Company(s) forces at the contractor's expense.

D. No crossing of the track shall be made without a railroad flagman and/or inspector present.

E. The crossing of tracks shall be kept to a minimum.

1.03 Boring locations, including positioning of the boring rig, shall be kept at least 8'6" from the center line of track.

1.04 All borings must be cased to insure adequate return (of mud and water) and to avoid undermining of the track.

1.05 All holes shall be backfilled with cement grout to fill the voids and protect against an artesian condition.

106 The location of all utilities owned or private, shall be located and suitably marked by the Railroad Company(s) and/or the private owner at the Contractor’s expense to avoid damage to the utility and/or track structure.

1.07 Prior to entry upon the MBTA Railroad Property, all necessary contracts, insurance policies and financial obligations shall be provided in a form acceptable to the Railroad Company(s).

1.08 Work within the operating right-of-way that has potential to foul the tracks, shall be restricted to periods of non-peak passenger operations.

1.09 While performing the work, full cooperation with the inspector and flagman is

essential. The work will be terminated immediately if the safety of all traffic and personnel is jeopardized in any way.

SECTION 2. TESTING

2.01 Soil borings shall be in accordance with the current issue of the American Railway Engineering Association Specifications, Chapter 1, Part 1, "Specifications for Test Borings". Soils shall be investigated by the split-spoon and/or thin-walled tube method and rock shall be investigated by the Coring method specified therein.

2.02 Soil boring logs shall clearly indicate all of the following:

1. Boring number as shown on boring location plan.
2. Elevation of ground at boring.
3. Description or soil classification of soils and rock encountered.
4. Elevations or depth from surface for each change in strata.
5. Identification of where samples were taken and percentage of recovery.
6. Location of ground water at time of sampling and, if available, subsequent readings.
7. Natural dry density in lbs./sq. ft. for all strata.
8. Unconfined compressive strength in tons/sq. ft. for all strata.
9. Water content (percent). Liquid Emit (percent) and plastic emit (percent).
10. Standard penetration in blows/ft.

2.03 Soil boring logs shall be accompanied by a plan drawn to scale showing location of borings in relation to the tracks, the elevation of ground surface at each boring, and the elevation of the top of rail of the tracks.

2.04 Soil investigation by auger, wash, or rotary drilling methods are not acceptable.

2.05 Borings shall be taken no more than two (2) feet from the field stake which marks the boring location. The stake should not be disturbed during boring operations. Lost stakes shall be reinstalled.

2.06 Unless a boring hole is actively being worked, it shall be securely covered or otherwise protected until permanently filled. When work at each boring hole is completed, the hole shall be properly filled.

2.07 Access to the boring locations must be approved by the Railroad Company(s). When possible, access shall be from public roads. Licenses for Entry, Insurance and Flag Protection must be obtained by the Contractor in accordance with all applicable MBTA Specifications.

2.08 Boring operations shall be confined to each boring location to the extent possible.

The contractor shall take necessary precautions to prevent damage to structures and facilities. The site shall be restored to a condition satisfactory to the Railroad Company(s).

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS DIRECTORATE

XIII

FIBER OPTIC CABLE SPECIFICATIONS

SECTION 1. GENERAL

1.01 The purpose of the following standards is to provide basic information about the MBTA's requirements with respect to the design and construction of fiber optic cables on MBTA Railroad Property to fiber optic cable companies and their contractors.

1.02 All work performed on or affecting MBTA Railroad Property must be designed and constructed in accordance with the Commuter Rail Design Standards (Vol. I and II), MBTA Book of Standards, Railroad Operation Specifications and the following standards. Additional job specific requirements will be contained in the MBTA's Fiber Optic License Agreement and can be obtained by contacting:

Director of Real Estate
Ten Park Plaza
Boston, MA 02116

The Chief Engineering Officer or his designated representative will be responsible for the approval of all work. No modifications, changes or deletions will be made without his approval.

SECTION 2. PROJECT REVIEW AND COORDINATION

2.01 All plans and specifications shall be reviewed and approved by the MBTA and Railroad Company(s) prior to construction. The MBTA must approve the construction schedule and sufficient Railroad Company(s) personnel must be available before work begins.

2.02 If another fiber optic cable company has previous or exclusive rights along the proposed route, the alignment and cable location must be approved in accordance with existing agreements.

2.03 The fiber optic cable companies must coordinate the construction with others to minimize the disruptions to the MBTA railroad operations.

SECTION 3. CONDUCT OF WORK

3.01 In order to minimize the manpower requirements of the Railroad Company(s) and afford better control, supervision, and protection, the contractor will conduct his work sequentially and minimize the number of crews and their proximity. Crews should be confined geographically to an area that can be covered easily by a minimum number of Railroad Company(s) personnel. This can be accomplished by a block method of construction. A construction block will be used and is a 1-4 mile segment of right of way in which up to 3 fiber optic cable installation crews can work. The crews can work within the

construction block, but cannot work outside of it. The construction block must move as a unit along the right of way. The crews cannot work two blocks concurrently.

SECTION 4. CONSTRUCTION SCHEDULE

4.01 The fiber optic company or its contractor will submit a schedule of work to the MBTA for approval. The schedule will be based on methods of construction acceptable to the MBTA and Railroad Company(s). No work shall begin prior to approval by the MBTA.

4.02 Any changes or modifications to the schedule proposed by the fiber optic company or its contractor must be submitted to and approved by the MBTA prior to implementation. The MBTA, however, may be required to change or modify the construction schedule on account of its operations, maintenance requirements, or manpower shortages. In this event, the MBTA will give the fiber optic cable company as much advance notice as possible.

4.03 Construction schedules will be reviewed and updated every two (2) weeks or as required.

SECTION 5. ESTIMATE OF EXPENSES

5.01 An estimate of anticipated expenses will be provided based on durations provided by the fiber optic cable company or his contractor and construction schedules approved by the Railroad Company(s). Any changes in the schedule will cause the estimate to be revised. The fiber optic cable company or his contractor will be responsible for all of the costs incurred by the MBTA and Railroad Company(s) in support of the construction activities. This includes design review, engineering support, administration and supervision.

SECTION 6. BILLING

6.01 The fiber optic cable company or its contractor will be required to pay for railroad protective services in advance of costs incurred.

TABLE OF CONTENTS

SECTION I - TRACK AND ROADWAY

A. Background

The Commuter Rail Design Standards are a two-volume series that establish design objectives, guidelines, and criteria for commuter rail track and roadway, communications systems, signal systems and stations. Originally developed in 1976 as part of the Commuter Rail Improvement Program, this two-volume series expanded the Massachusetts Bay Transportation Authority's earlier series of design standards manuals for the rapid transit system--the Manual of Guidelines and Standards--to the area of commuter rail. This document contains extensive revisions and additions to the 1976 edition.

B. Purpose of the Manual

The purpose of this Manual is to provide guidance to the Authority and it's design consultants in commuter rail design and construction work. Due to the constant evolution of products and accumulation of practical experience it is neither practical or necessary to rigidly "standardize" all elements of the commuter rail system. The approach of this Manual is to recommend standardization of design criteria, but of components and material only when it is economically justified or is required for legal or technical reasons.

While the need for total system standardization is not a practical priority, it is a priority that future improvements satisfy all safety requirements and regulations regardless of methods or material used. The designer should also aim to achieve economy of design based on the past accumulation of prior experience with commuter rail improvements as well as consistency with the character and quality of the system's design.

This Manual is an important tool toward achieving the general goals of safety, economy, and consistency. In general, these standards establish three levels of guidance in the design of system improvements--design objectives, design guidelines, and design criteria and details. The design objectives are a very general form of guidance, broadly outlining the desired results of a component or facility.

Design guidelines are a more specific form of guidance. They describe the level of performance a facility should achieve; in general terms, where it should be located; what types of user or other needs it should satisfy; standard dimensions and clearances to be achieved; and where appropriate, several approaches to meeting the guidelines. In short, guidelines represent a planning and programming level of guidance.

The most detailed guidance provided in the Manual is categorized as design criteria and details. These criteria and details may describe specific construction methods or materials which the Authority requires the designer to use in specific circumstances. An example is the use of full depth rubber rubber crossing panels at most grade crossings. More often, however, the criteria describe specific materials or methods of construction simply because they have been successfully used in previous commuter rail facilities and are likely to be applicable and successful on future projects.

Within Section I of the Manual, Design Objectives and Guidelines are contained in one separate chapter. In Section II, Design Objectives and Guidelines are addressed in each chapter.

C. Organization of the Manual

The revised Manual is organized into two loose leaf volumes:

Volume 1. Section I - Track and Roadway. Section II - Stations and Parking
Volume 2. Signal & Communications

The two volume Manual is organized in a loose-leaf format for the reasons of flexibility and convenience. The passage of time and experience will require continuous modifications of the design guidelines and criteria presented in the Manual. The loose-leaf format provides the flexibility needed to insert new pages and delete outdated material. In addition, the format simplifies the process of copying pages or sections of the Manual as needed to guide future design work.

D. Revisions

The revision number and date of issue are noted in the revision box. When revisions are made, the entire chapter and a new table of contents is issued. By consulting the current table of contents, it is possible to determine if the chapters in the Manual are the latest revision. Any designer working on projects for Railroad Operations should check with the Authority to confirm that they are using the most recent revision before proceeding.

E. Other Applicable Documents

In addition to the Design Standards Manual, there are three other documents which supplement the Track and Roadway, Section I of the Manual. The first two are essential for designers to have and use with this document.

- Book of Standard Plans - Track and Roadway
- Railroad Operations - Commuter Rail - Material Specifications
- MW-1 Manual - Maintenance of Way Manual

A. Design Objectives

The objective of the Design Standards Manual for Track and Roadway shall be to provide a safe, efficient, and reliable fixed plant for the operation of the Massachusetts Bay Transportation Authority (MBTA) commuter rail services as well as through and local freight service over MBTA rights-of-way.

The use of these design standards is required for new installations or when general renewal or replacement of track and roadway materials is to be undertaken. Requirements for maintenance of existing track and roadway elements are contained in the Authority's separate MW-1 (Maintenance-of-Way) Manual. The separate Book of Standard Plans - Track and Roadway shall be considered as an extension of this section of the manual and plans contained therein are cited in this document as appropriate. Material Specifications for track and roadway material are contained in the document titled Railroad Operations - Commuter Rail Material Specifications which are also cited in this document as appropriate.

Track and roadway design and installation practices not specifically addressed in this Manual shall be in accordance with the current American Railway Engineering Association (AREA) Manual of Recommended Practice and Portfolio of Trackwork Plans.

All designers/consultants preparing plans and specifications for any project for MBTA Railroad Operation's facilities shall be required to use this document and the separate Book of Standard Plans as a basis for design. Exceptions are the Northeast Corridor between Boston and the Rhode Island state line where the requirements of Amtrak will be followed and any work on the Worcester Line west of Framingham Station where the requirements of Conrail will be followed.

It is recognized that field conditions and special situations often occur and present circumstances that cannot be addressed in the Manual. In these instances, it is the designer's responsibility to bring this to the attention of the Authority and direction will be given by the Chief Engineering Officer, Railroad Operations for that specific instance. In all cases, issues of safety shall be the primary concern.

B. Design Guidelines

The MBTA commuter rail system extends over portions of three former Class I railroads. Each had its own standards for track and roadway materials, designs, and practices. Since acquiring these properties in the 1970's, changes and improvements have eliminated many of the differences but some still exist.

For all new installations of track and roadway and major rehabilitation projects, the design standards specified herein and related documents noted in Chapter 1, Part E, shall apply in the interest of uniformity of design and maintenance.

Track and roadway components which are renewed shall adhere to current MBTA Standard Plans and Material Specifications.

The following specific design guidelines and policies are basic to all track and roadway engineering design:

1. Safety - The primary purpose of all engineering design shall be to provide for the safe operation of trains and elimination of hazards to personnel and equipment. Application of standard design to all situations is rarely possible. The designer is responsible to recognize when deviation from standards will be necessary and call it to the attention of Railroad Operations. The designer and Railroad Operations will work together to arrive at a satisfactory solution with safety the primary concern.

2. Reliability - The design and choice of component materials shall be in accordance with MBTA Railroad Operations Standards, deviating only when specifically allowed by the Chief Engineering Officer, Railroad Operations.

3. Design Speed - Maximum design speed for commuter rail shall be 70 mph and 100 mph where directed. However, the design for 70 MPH should not preclude a future increase to 79 mph[1]. The present exception is the Northeast Corridor/Shore Line Main Line which will be up to 150 mph. Existing permanent operating speed restrictions shall be maintained unless a change is sanctioned by the Authority. Station areas are to be designed for maximum authorized speed of track in abutting territory to facilitate operation of express trains.

4. Clearances - Minimum horizontal and vertical clearances shall conform to those shown on Standard Plans 1012 to 1019. In general, new design shall provide 14'-0" track centers and 8'-6" side clearance with appropriate compensation for curvature. In no case shall new design provide less than 13'-0" track centers. Vertical clearances will be on a site specific basis. (See Chapter 6)

   For continuous adjacent structures greater than 100 feet in length, measured along the track base line and closer than 8'-6" to centerline of track, safety niches shall be provided. Such restricted clearance will require a variance from the Department of Public Utilities (DPU). Chapter 6 contains additional information on clearances.

5. Load Capacity - Track and roadway shall be designed to accommodate heavy freight train traffic. Track bridges and other structures shall be designed for Cooper E-80 loadings as prescribed in the AREA Manual.

6. Grade Separation and Grade Crossings - In general, new grade separation structures shall be provided wherever possible to eliminate crossings at grade. Existing and future public and private grade crossings shall

[1] 79 MPH is the maximum speed allowed by Federal Railroad Administration (FRA) without cab signals.

be protected with flashers and gates approved by the Massachusetts Department of Public Utilities. Private crossings used less than two crossings of track(s) per week may instead use crossbucks and a locked right-of-way gate. Key for gate to be given to property owner and an agreement signed by owner that gate shall be kept locked except when they are in actual use of crossing.

7. New Grade Crossings - No new public grade crossings, auto or pedestrian, of main tracks shall be permitted without the permission of the Director of Railroad Operations, the local community, the County Commissioners and approval of the warning system by the Massachusetts Department of Public Utilities.

No new private grade crossings shall be permitted without the expressed consent of the Director of Railroad Operations and subject to an agreement signed by the General Manager of the MBTA.

A. Horizontal and Vertical Survey Control Requirements

Unless otherwise directed by the Chief Engineering Officer, Railroad Operations, the horizontal control used to establish rectangular coordinates for track geometry shall be based on the Massachusetts Plane Coordinate System, Mainland Zone. Horizontal control points and supporting survey shall meet U.S. Coast and Geodetic Survey second order specifications for accuracy with Class I requirements (1 part in 50,000) for projects encompassing more than 5 miles. Class II requirements (1 part in 20,000) will be adequate for projects less than 5 miles in length.

Vertical control shall be based on U.S. Coast and Geodetic Survey Mean Sea Level Datum, 1929 General Assessment. All vertical control points or benchmarks shall meet U.S. Coast and Geodetic Survey Second order Class II Specifications for accuracy. On small projects (less than 1 mile in length), third order requirements may be used.

B. Design Speeds

■ Design Speed	-	70* mph (100 mph where directed)[1] (*Do not preclude future increase to 79 mph)
■ Minimum Design Speed	-	Maximum speed allowed by local conditions
■ Station Pass-By Speed	-	Maximum authorized speed for territory[2]
■ Terminals, Terminal Approach Tracks and Servicing Areas[3]	- -	20 mph desirable 15 mph absolute minimum

C. Track Geometrics

1. General

The horizontal alignment of tracks shall consist of a series of tangents connected with circular and compound curves with appropriate spirals. Vertical alignment shall consist of tangent grades connected by parabolic vertical curves as required by these criteria.

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[1] On certain routes, such as Northeast Corridor and others where station spacing, geometry, etc. permit - design for up to 150 mph as directed.

[2] Up to 2-3/4" unbalanced elevation permitted in stations to achieve maximum speed so as to minimize actual elevation in station.

[3] Terminal areas include: Major stub end terminals, servicing areas, train storage yards and immediate approaches thereto.

2. Tangent Lengths - Horizontal

a. Mainline

Minimum desirable tangent lengths between reverse curves and/or spirals shall be 100 feet. In very limited areas where design speeds are 50 mph or less, tangents of lessor distance may be permitted with permission of Chief Engineering Officer, Commuter Rail and if spirals are long enough to provide less than a one half inch change in reverse cross level over 62 feet. Short tangents between curves in same direction (broken back curves) should be avoided by compounding to a flatter curve or using a connecting spiral.

b. Yards

In terminals and yard areas where design speed is 20 mph or less, tangent length may be reduced to 65 feet (the approximate truck spacing of an 85' long car) and, within yards only, when space is very limited and with permission of Chief Engineering Officer, the following table may be used:

Degree of Reverse Curves	Minimum Recommended Tangent Length (Feet)
Less than 7° - 8°	20
8° - 9°	25
9° - 10°	30
10° - 11°	40
11° - 12°	50
12° - 13°*	60

*Curves this sharp normally not permitted.

TABLE 3.1

C. Turnouts and Crossovers

The use of "back to back" turnouts of the same hand which results in a reverse curve, is prohibited unless a tangent length of at least 65 feet measured from PS to PS of the turnouts is added. Maintaining this dimension is especially critical with No. 8 & 10 turnouts. In yards and other low speed areas, the criteria indicated in Table 3.1 above may be used with permission. A No. 10 turnout has an equivalent radius of about 8° and a No. 8 about 12°-30'. It should be noted that a No. 8 crossover in track centers less than 14'=0" will not meet the criteria in the above table. No. 8 crossovers should therefor be avoided and used only with permission of the Chief Engineering Officer where absolutely necessary.

3. Curve Length

The minimum curve length (not counting connecting spirals) shall be 100 feet. In compound curves, each curve segment of differing radius should be at least 100 feet long.

4. Horizontal Geometry

a. Curve Definition

Curves shall be defined by chord definition and specified by degree. Arc definition shall not be used.

$$R=\frac{50}{Sin\ D/2} \quad or \quad Sin\ D/2 = \frac{50}{R} \quad or \quad D=2\ Sin^{-1}\frac{50}{R}$$

Formula 3.1

b. Maximum Curvature

The maximum degree of curvature allowed on main tracks is a function of design speed and the amount of superelevation - both actual elevation and unbalanced. Figure 3.1 illustrates the maximum curvature for a given design speed using both the preferred 1.5" as well as the maximum 2.75" unbalanced elevation combined with the maximum allowable 6" actual elevation. (See C.4.e. following for a discussion of superelevation)

Figure 3.1 based on following formulae from AREA:

$$E_a + E_u = 0.0007\ DV^2$$

(See 4.e following for derivation of this formula) Formula 3.2

$$V = \sqrt{\frac{E_a+E_u}{0.0007D}}$$

Formula 3.3

or

$$D=\frac{E_a+E_u}{0.0007\ V^2}$$

Formula 3.4

V = Velocity in mph
D = Degree of Curvature
Ea = Actual Superelevation in inches
Eu = Unbalanced elevation in inches

Figure 3.1 following uses the maximum allowable 6 inches actual elevation (E_a)

Design Speed - MPH	Max. Curve with 1.5" Eu	Max. Curve with 2.75" Eu
40	6°-42'	7°-49'
50	4°-17'	5°-00'
60	2°-59'	3°-28'
70	2°-11'	2°-33'
80 (79)	1°-43'	2°-00'
100	1°-04'	1°-15'

Figure 3.1

NOTE: Figure 3.1 will be modified if the FRA increases the currently mandated 3 inches maximum E_u to a higher value.

Within station platforms, the maximum curvature shall be limited to as flat a curve as possible. On platforms on the inside of curves, the curvature shall not exceed 4°-00' to control gap from door to platform edge.

Within yards and terminals, sharper curves are allowed. Due to rolling stock restrictions, maintenance considerations and historical experience, the preferred maximum curvature on any track regularly used by 85 foot long passenger equipment is 11°-00'. Any curvature in excess of 12°-00' should be avoided as operation above that radius has been found to be unreliable.

c. Design Considerations

Curvature, superelevation, spiral lengths and design speeds are all interrelated. The goal in design is to combine those elements in a way that provides a comfortable and safe operating speed for the predominant traffic. When designing a new or upgraded segment of railroad, the designer should avoid a curve by curve approach, blindly applying the criteria to each curve to achieve maximum possible speed. This may result in a curve with superelevation sufficient for 79 mph bracketed by curves limited to 50 mph. Because trains take a very long distance to change velocity, especially above 35-40 mph, trains will run the 79 mph potential curve at 50 mph. This will result in passengers sensing an inward lean on the curve and cause excessive wear on the inside rail.

The most restrictive curve in a given section of railroad sets the speed for that section. The designer should investigate various means by which the restrictive curve may be modified to increase the speed to that of adjacent lesser restrictions. The cost and other factors should be assessed with Railroad

Operations to determine what level of modifications could be justified or appropriate for each such location.

Signal aspects approaching interlockings may also be a factor in determining the line speed for a section of railroad. The designer should be aware of the locations of interlockings and inquire whether or not they will limit the maximum authorized speed for most trains in the approach area of the interlocking.

Often there are jurisdictional and safety issues that affect the design speed rather than civil restrictions based on geometry. An example would be a hazardous grade crossing which has a speed restriction imposed by the DPU.

Train performance calculation programs are a useful tool in analyzing line segments to determine what the practical maximum speed will be. By factoring in civil and jurisdictional restrictions and reviewing the results, it is possible to develop an overall design that will match the actual speed of most trains.

d. Concentric Curves in Multiple Tracks

In multiple track territory, when tracks follow the same general alignment, the tracks shall be concentric in curves. Track centers must be widened 2 inches per degree for curvature to maintain the equivalent tangent track center. The preferred method of increasing track centers is to lengthen the spirals of the inside track to a length where the spiral offset distance (p) relative to the outside track spiral (p) distance is increased by an amount equal to the required track center increase. The equivalent tangent track center is the nominal tangent track center for the route segment. When redesigning curves, strive to provide equivalent 14'-0" tangent track centers wherever possible, but in no case less than 13'-0".

e. Superelevation

Superelevation is expressed in terms of inches that the outside rail is raised above the level of the inside or low rail. Profile grade is always based on the low rail as superelevation is achieved by raising the outside rail relative to the inside rail.

There are three components to superelevation as used in railway design. It is essential that the use and relationship of these three components is understood.

$$E_e = E_a + E_u$$

(See following page for explanation of terms).

Ee = Equilibrium Elevation
Ea = Actual Elevation
Eu = Unbalanced Elevation

Equilibrium Elevation (Ee) is the amount of elevation required on a given curve at a given velocity for centrifical force to be in equilibrium. That is, the resultant of the overturning force caused by the angular acceleration is directed perpendicular to the centerline of the elevated or "banked" track. When a train traverses the curve at the equilibrium speed, passengers will feel no sideways force and there is no tendency for the inside wheels to lift and the carbody to roll. (Figure 3.2)

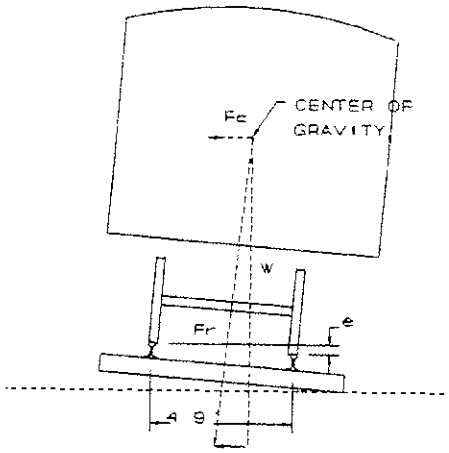


Figure 3.2

$$F_c = Wv^2/gR$$

Where:
Fc = Centrifical Force
W = Weight of car in lbs.
v = Speed in feet per second
g = Acceleration due to gravity (32.16 ft/sec/sec)
R = Radius of curve in feet
Fr = Resultant force of Fc & W directed perpendicular to elevated track
e = Equilibrium superelevation in inches

The formula derived from the proceeding used to determine equilibrium elevation on most passenger equipment is:

$$Ee = 0.000686\ DV^2 \text{ (usually rounded to)}$$
$$Ee = 0.0007\ DV^2$$
Or
$$Ee = 4.01V^2/R$$

Formula 3.5

Where:
- Ee = Equilibrium elevation in inches
- D = Degree of curve
- V = Velocity in mph
- R = Radius in feet

Unbalanced Elevation (Eu) is an equivalent amount of centrifical force which is not directed perpendicular into the track structure. A more descriptive term is cant deficiency. It has been found that a certain amount of deficiency in the elevation required for equilibrium is both safe and comfortable. For many years, the Federal Railroad Administration (FRA) has mandated that unbalanced elevation (cant deficiency) used in design and setting speed be limited to 3 inches for conventional passenger equipment. The MBTA currently uses a more conservative value for the amount of unbalanced (deficiency) elevation allowed, using 1.5 inches as the preferred limit and allowing up to 2.75 inches as a maximum. This provides improved passenger comfort, better compatibility with freight operations and a margin below the FRA mandated 3 inch maximum. Currently the 3 inch maximum Eu criteria is under review by FRA and an unbalanced elevation of 4 inches or more may be allowed in the future which would still provide a high level of safety and passenger comfort on well maintained track.

Actual Elevation (Ea) is the actual superelevation in track, limited to 6 inches. Based on the preceeding, the actual elevation required for a given curve is calculated as:

$$Ea = Ee - Eu$$
or,
$$Ea = 0.0007\ DV^2 - Eu$$

Formula 3.6

Where:
- Ea = Actual Superelevation in inches
- D = Degree of Curvature
- V = Velocity in mph
- Eu = Unbalanced elevation in inches. (1.5 inches preferred, 2.75" max).

Minimum and Maximum Superelevation

Minimum Ea shall be 1 inch. Maximum Ea shall be 6 inches except it is desirable to limit Ea to 4 inches on routes where through freights operate and where trains are likely to stop or operate below the design speed on a regular basis. Within stations it is

desirable to limit Ea to 3 inches and use 2.75 inches Eu to allow express operation at maximum authorized speed.

Superelevation shall be developed uniformly through the length of transition spirals. Where spirals are not present or are of insufficient length, such deficiencies should be corrected as track is reconstructed. Running out of superelevation on tangents and curves is not permissable on medium to high speed routes and will be done only with permission of the Chief Engineering Officer. Proper spiral length is determined as discussed in the following sub-section.

Although calculated to the hundreth of an inch, actual superelevation in track is normally expressed and set in practice to the nearest one eight or one quarter inch.

f. Spirals

Spirals shall be used to connect all mainline curves to tangents. However, for practical considerations, spirals may be omitted when the required spiral length divided by the curve radius in feet is less than 0.01. Spirals shall also be used to connect compound curves whenever there is any change in Ea (actual elevation) or a change in Eu (unbalanced elevation) of 1/2 inch or more between the compound curves.

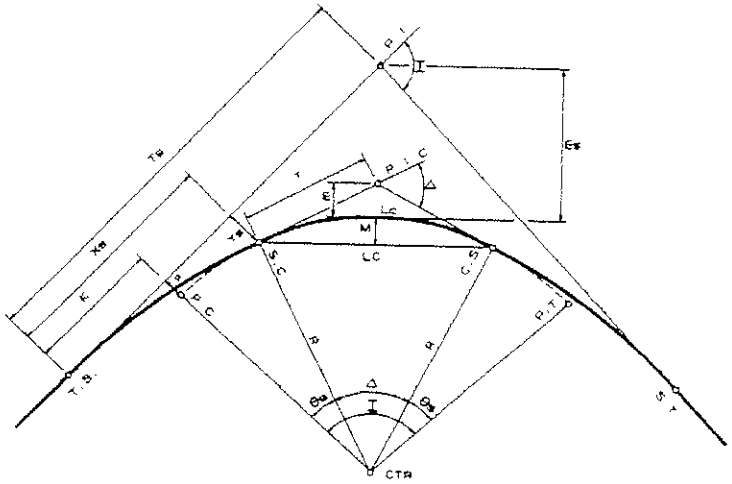
Spirals shall be a cubic parabola based on the so called "ten chord spiral" as shown in Figure 3.4. This is based on chord definition and is consistent with chord definition used with circular curves. The so called "Barnet Spiral", which is based on arc definition, will produce slightly different values.

Spirals shall increase in curvature directly with their length. Superelevation shall be increased uniformly over the length of the spiral reaching full Ea for the curve at the SC (spiral to curve point). The basic design data for spirals and curves is shown on Figures 3.3, 3.4 & 3.5.

In designing spirals and curves, determining the length of spiral (Ls) is a key element. There are three items that need consideration when determining the length of spiral:

1. The rate of run-in and run-out of the superelevation expressed in terms of inches per second, which affects passenger comfort.

2. The slope of the superelevated rail relative to the low rail. This results in a change in cross level between the two trucks of a car and should not exceed a 1 inch difference to prevent undue "racking" or torsional twisting of the car frame. This results in a tendency to lift the inside wheels of the lead truck. *Continued on Page 3.12*



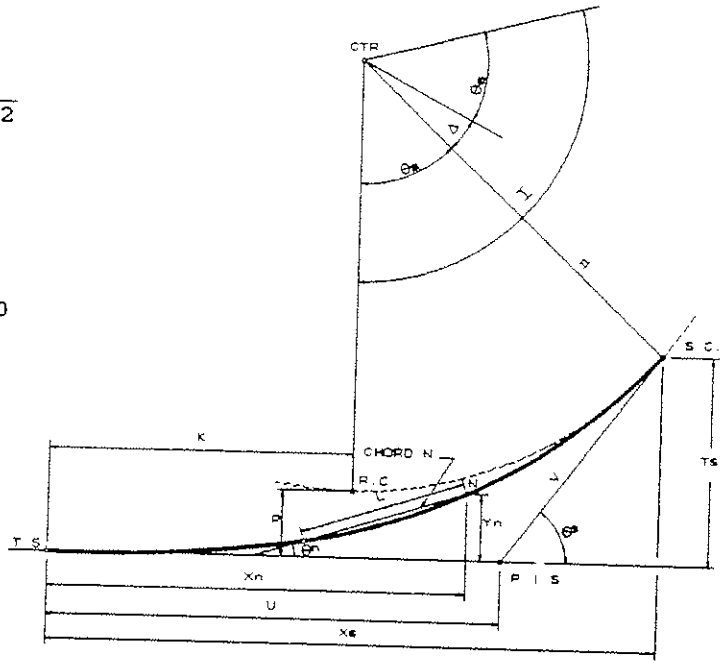
DEFINITIONS
Also See Figure 3.4

C.S.	CURVE SPIRAL, THE POINT OF CHANGE IN ALIGNMENT FROM CURVE TO SPIRAL
CTR	CENTER OF CIRCULAR CURVE
D_c	DEGREE OF CURVE DEFINED BY THE 100 FT. CHORD DEFINITION
E	EXTERNAL DISTANCE FROM MIDPOINT OF CIRCULAR CURVE FROM P.I.C
E_s	EXTERNAL DISTANCE FROM CURVE TO P.I.
I	ANGLE OF INTERSECTION OF MAIN TANGENTS AT P.I.
K	DISTANCE ALONG MAIN TANGENT FROM T.S. (OR S.T.) TO OFFSET P.C.
L	THE LENGTH OF EACH EQUAL CHORD
L_c	LENGTH OF CIRCULAR CURVE BETWEEN S.C. AND C.S. MEASURED ALONG 100 FT. CHORDS.
LC	CHORD LENGTH OF CIRCULAR CURVE FROM S.C. TO C.S.
L_s	THE LENGTH OF SPIRAL FROM T.S. TO S.C. (OR C.S. TO S.T.) AS MEASURED ON TEN CONSECUTIVE EQUAL CHORDS.
M	MID-ORDINATE DISTANCE OF CIRCULAR CURVE.
n	A NUMBER BETWEEN 1 AND 10 USED TO IDENTIFY CHORDS.
P	OFFSET FROM P.C. (OR P.T.) TO MAIN TANGENT.
P.C.	POINT OF CURVE, THE POINT OF CHANGE IN ALIGNMENT FROM TANGENT TO CIRCULAR CURVE, ON SPIRALLED CURVES THIS POINT IS OFFSET A DISTANCE P FROM THE MAIN TANGENT.
P.I.	POINT OF INTERSECTION OF MAIN TANGENTS.
P.I.C	POINT OF INTERSECTION OF LINES TANGENT AT S.C. AND C.S.
P.I.S.	POINT OF INTERSECTION OF MAIN TANGENT AND LINE TANGENT AT S.C. (OR C.S.)
P.T.	POINT OF TANGENCY, THE POINT OF CHANGE IN ALIGNMENT FROM CIRCULAR CURVE TO TANGENT, ON SPIRALLED CURVES THIS POINT IS OFFSET A DISTANCE P FROM THE MAIN TANGENT.
R	RADIUS OF CIRCULAR CURVE.
S.C.	SPIRAL CURVE, THE POINT OF CHANGE IN ALIGNMENT FROM SPIRAL TO CURVE.
S.T.	SPIRAL TANGENT, THE POINT OF CHANGE IN ALIGNMENT FROM SPIRAL TO TANGENT
T	DISTANCE FROM SC OR CS TO P.I.C. IN SPIRALED CURVE OR TANGENT FROM PC OR PT TO PI IN A SIMPLE CURVE
T.S.	TANGENT SPIRAL, THE POINT OF CHANGE IN ALIGNMENT FROM TANGENT TO SPIRAL.
T_s	LONG TANGENT, DISTANCE FROM P.I. TO T.S. (OR P.I. TO S.T.)
U	LONG TANGENT OF SPIRAL. DISTANCE FROM P.I.S. TO T.S. (OR P.I.S. TO S.T.)
V	SHORT TANGENT OF SPIRAL, DISTANCE FROM P.I.S. TO C.S. (OR P.I.S. TO S.C.)
Xn	DISTANCE ALONG A MAIN TANGENT FROM T.S. (OR S.T.) TO OFFSET CHORD POINT N.
X_s	DISTANCE ALONG MAIN TANGENT TO PERPENDICULAR OFFSET TO S.C. (OR C.S.)
Yn	OFFSET FROM CHORD POINT N TO MAIN TANGENT
Y_s	PERPENDICULAR OFFSET FROM MAIN TANGENT TO C.S. (OR S.C.)
Θ_n	CHORD ANGLE, THE ANGLE BETWEEN THE MAIN TANGENT AND CHORD N.
Θ_s	SPIRAL ANGLE, CENTRAL ANGLE OF SPIRAL.
Δ	ANGLE OF INTERSECTION OF TANGENTS OF CIRCULAR CURVE ONLY

MAIN TANGENTS - THOSE LINES TANGENT TO ALIGNMENT AT T.S. AND S.T. WHICH INTERSECT AT P.I.

CURVE WITH SPIRALS AND DEFINITIONS
FIGURE 3.3

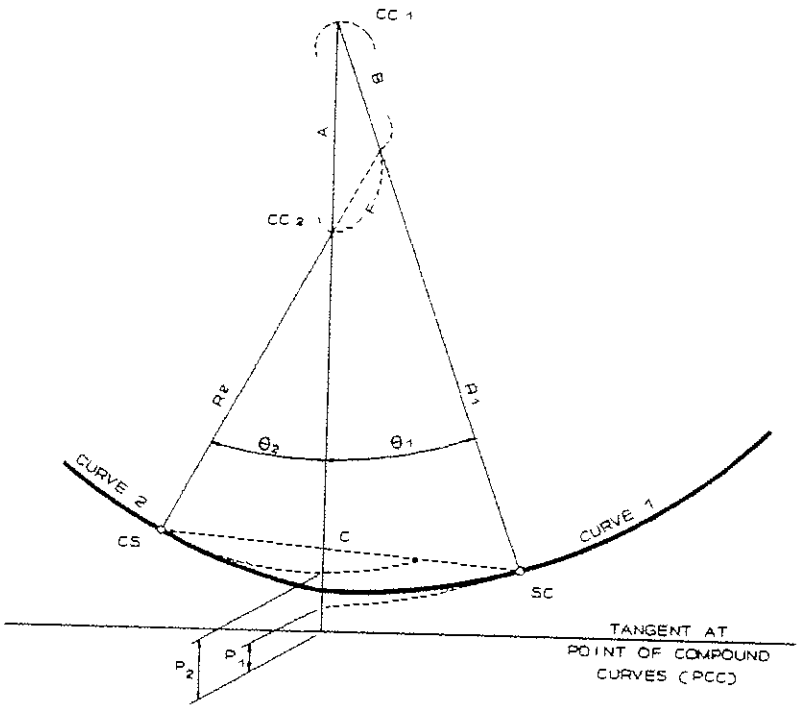
1. $D_c = 2\ ARCSIN\ \frac{50}{R}\quad R = \frac{50}{SIN\ D/2}$
2. $\Theta_s = \frac{L_s\ D_c}{200}$
3. $L = \frac{L_s}{10}$
4. $\Theta_n = \frac{3n^2-3n+1}{300}\ \Theta_s \quad n=1,\ldots 10$
5. $X_n = L \sum_{n=1}^{N} COS\ \Theta_n \quad n=1,\ldots 10$
6. $Y_n = L \sum_{n=1}^{N} SIN\ \Theta_n \quad n=1,\ldots 10$
7. $X_s = X_{10}$
8. $Y_s = Y_{10}$
9. $P = Y_s - R(1-COS\ \Theta_s)$
10. $K = X_s - R\ SIN\ \Theta_s$
11. $U = X_s - \frac{Y_s}{TAN\ \Theta_s}$
12. $V = \frac{Y_s}{SIN\ \Theta_s}$
13. $\Delta = I-2\Theta_s$ *(WHEN BOTH SPIRALS ARE OF EQUAL LENGTH)*
14. $T = R\ TAN\frac{\Delta}{2}$
15. $L_c = 100\ \frac{\Delta}{D_c}$
16. $E = R\left(\frac{1}{COS\frac{\Delta}{2}} - 1\right)$
17. $LC = 2R\ SIN\frac{\Delta}{2}$
18. $M = R\left(1-COS\frac{\Delta}{2}\right)$
19. $T_s = K+(R+P)\ TAN\ \frac{I}{2}$ *(WHEN BOTH SPIRALS ARE OF EQUAL LENGTH)*
20. $E_s = \frac{T_s - K}{SIN\frac{I}{2}} - R$ *(WHEN BOTH SPIRALS ARE OF EQUAL LENGTH)*



NOTES:

1. Spiral criteria shown is for spirals between tangents and curves
2. For definitions, see Figure 3.3

SPIRAL AND RELATED FORMULAE
FIGURE 3.4



$$\Theta_1 = \frac{Dc_1 \times L_S}{200}$$

$$\Theta_2 = \frac{Dc_2 \times L_S}{200}$$

$$A = (R_1 - R_2) - (P_2 - P_1)$$

$$B = A \, SIN \, \Theta_2 / SIN \, (\Theta_1 + \Theta_2)$$

$$F = A \, SIN \, \Theta_1 / SIN \, (\Theta_1 + \Theta_2)$$

$$C^2 = (R_1 - B)^2 + (R_2 + F)^2 - 2(R_1 - B)(R_2 + F) \, COS(\Theta_1 + \Theta_2)$$

K = *RATE OF CHANGE IN DEGREE OF CURVE*

$$K = \frac{100 \, (Dc_2 - Dc_1)}{LS}$$

$$P_n = Y_s - R(1 - COS\Theta_n)$$

COMPOUNDING SPIRAL
FIGURE 3.5

3. Lateral acceleration increase and decrease induced by the onset and then release of centrifical force caused by unbalanced superelevation when entering and leaving curves should be kept to low values for comfort. This acceleration rate is generally accepted to be 0.03 g/sec.

The first item (rate of superelevation run-in) is generally recommended to be 1-1/4 inches/sec for speeds up to 60 mph, 1-1/6 inches/sec from 60 to 80 mph and 1-1/8 inches/sec from 80 to 100+ mph. This can be expressed as:

Ls=1.17 Ea V (1-1/4"/sec)
Ls=1.26 Ea V (1-1/6"/sec)
Ls=1.30 Ea V (1-1/8"/sec)

The second item is a function of the truck spacing of an 85 foot long car. That dimension is typically 59'-6" for an 85' long car, however 62' is the figure used.

Ls=62 Ea

It has been normal practice to express elevation run-in in terms of inches per 31 foot chord (the usual stringlining interval). A run-in of 1/2 inch per 31' is typically used up to 50 mph and 3/8 inch per 31' from 50 to 80 mph and 1/4 inch per 31' from 80 to 100+ mph.

The following rates provide an expedient way of satisfying the first two items:

Ls=62 Ea Up to 50 mph
Ls=83 Ea 51 to 80 mph
Ls=124 Ea 81 to 110 mph

The third element - lateral acceleration increase - is expressed by the formula:

Ls=1.63 EuV (produces a lateral acceleration of 0.03g/sec)

In "tight" situations a shorter spiral is permitted:

Ls=1.22 EuV (produces a lateral acceleration of 0.04g/sec)

Summarizing: the minimum spiral length should be determined by using the longer result of the two following criteria:

1. $Ls=62EaV \leq 50$ mph
   $Ls=83Ea\ 50 < V \geq 80$ mph
   $Ls=124Ea\ 80 < V \geq 110$ mph — Formula 3.7

2. Ls=1.63 EuV (whenever possible)
   Ls=1.22 EuV (in "tight" situations) — Formula 3.8

The minimum length of spiral shall be 100 feet in mainline track. A spiral of 62 feet is permitted in secondary track as a curve easement and when superelevation is not over one inch.

g. Gauge Widening in Curves

The MBTA does not normally widen track gauge in curves on commuter rail. However, in certain instances it may be beneficial to consider widening gauge 1/8" per degree of curve in excess of 10 degrees up to a maximum of 4'-9 1/8". This should be discussed with Railroad Operations on a site specific basis.

5. Vertical Alignment

a. General

Railroads are very sensitive to gradient due to very low power to weight ratios and frictional limitations imposed by the adhesion of steel to steel. For these reasons, as well as general safety and economy, grades must be kept to a minimum. Vertical curves connecting changes in gradient must be gradual, long enough to prevent coupler slack action run-in and run-out in long freight trains from generating forces great enough to break the couplers and separate the train or buckle the train. Passenger trains are normally not subject to slack-action problems. Operating at high speed, vertical curves need only to be long enough to prevent passenger discomfort caused by relatively small vertical g forces. However, good design dictates that more conservative values be used that will fit the available space, especially if through freight service is operated.

b. Maximum Grade

• Maximum Grade[4]	0.70% Preferred Max. 1.50% Absolute Max.
• Maximum Grade at Stations or any locations where trains may stop on a regular basis	0.50% Preferred Max. 0.75% Absolute Max.
• Maximum Grade at Maintenance Facilities & Unattended Storage Yards	0.00% Preferred Max. 0.25% Absolute Max.[5]

The ruling or maximum grades on a section of railroad must be compensated for the increased resistance caused by curvature by

[4]Under very special conditions a grade up to 3.00% is permissible with permission of the Chief Engineering Officer

[5]If steeper grades are required - derails and other protection from rolling should be considered.

reducing the grade through the curve by 0.04 percent per degree of curvature.

c. Minimum Length of Constant Grade

Frequent changes in gradient are to be avoided. Eliminate grade changes wherever physically and economically possible.

Minimum Length of Tangent Grade	200 Feet
Absolute Min. Length of Tangent Grade	75 Feet

d. Vertical Curve Length

The only generally recognized criteria used by railroads for 100 years in determining the length and corresponding rate of change of a vertical curve is in the AREA, Manual Chapter 5, Part 3, Section 13 which gives the required rate of change as 0.05 feet per 100' station in sags and 0.10 feet per station in summits. Up to twice that rate is possible in track of "lesser importance". This criteria is currently under review by AREA Committee 5 and it appears that a considerable reduction in the required vertical curve length recommended by AREA is forthcoming.

Experience has shown that application of the current AREA criteria in the MBTA's Commuter Rail Territory will often require vertical curves far too long to fit either existing or new conditions. The current AREA criteria's very low rate of grade change is to control the "accordion effect" that occurs in long freight trains which generally have about one foot of slack between each car. This slack is needed to start heavy trains as it would be impossible to start the entire train all at once. This slack creates adverse train handling conditions and high buffing and draft forces on undulating profiles with short vertical curves. These forces can contribute to breaking a train apart or buckling the cars. Considering only passenger equipment, which has little slack between cars and fewer units than a long freight, much shorter vertical curves would not affect train buffing and draft forces, the primary concern being passenger comfort. Even very slight gravitational ("g") forces in a vertical plane produce a "queasy" feeling in many passengers.

The following criteria is suggested in determining the minimum length of vertical curve in main track. This criteria is more conservative than the revised AREA criteria currently under consideration.

$$L=0.05\ (G_1-G_2)V^2$$

Formula 3.9

Where:

L	=	Length of vertical curve in feet.
G_1-G_2	=	Net or algebraic difference of the grade change in percent.
V	=	Velocity in mph.

AREA criteria currently under consideration:

$$L = 0.036\ (G_1-G_2)V^2$$

The rate of change in grade per 100 feet is the way the "sharpness" of vertical curves are usually expressed.

$$r=\frac{G_1-G_2}{L}x100$$

Formula 3.10

Where:

r=rate of change in %/100'

Following is a summary of various vertical curve criteria:

Current AREA Criteria — Rate of Change %/100'

(Double rates if necessary)

0.05% Sags
0.10% Summits

Northeast Corridor (Amtrak) criteria - 1970's

0.30%
Summits & Sags

"Suggested" MBTA criteria:

$$r = \frac{2000}{V^2}$$

Formula 3.11

(r not to exceed 0.80%/100')

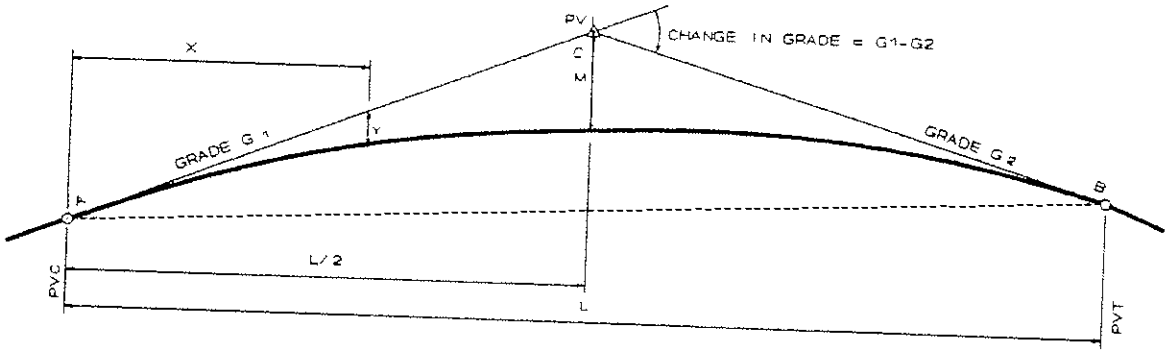
AREA Revision Under Consideration

$$r = \frac{2800}{V^2}$$

Formula 3.12

(r not to exceed 1.12%/100')

Unless otherwise directed, use Formulae 3.9 and 3.11, limiting rate of change to 0.80% per 100 feet. (Also see part "g" following).



Vertical Curves

Figure 3.6

Vertical curves shall be parabolic and have the following mathematical characteristics:

$$M = \frac{L/100\ (G_1 - G_2)}{8}$$

Formula 3.13

$$Y = \left(\frac{X}{L/2}\right)^2 x\ M$$

X cannot exceed L/2. Leftside of curve, use point A as origin for X. Right side of curve, use point B as origin for X.

Formula 3.14

$$L = \frac{G_1 - G_2}{r} x\ 100$$

Formula 3.15

$$\textit{Elevation of V.C. at any point} = \left(\frac{r}{2}\right)\frac{x^2}{100} + G_1\,\frac{x}{100} + \textit{PVC Elev.}$$

Formula 3.16

Where:

M = Mid ordinate of vertical curve at PVI
Y = Offset from tangent to vertical curve at any point on curve in feet
X = Any distance from PVC in feet
L = Length of vertical curve in feet
G_1 = Grade at PVC, in %
G_2 = Grade at PVT, in %
r = Rate of change in grade in %/100'

e. Vertical Curves Within Turnouts

It is good practice to avoid vertical curves in turnouts. When this is not possible, vertical curves may be introduced through turnouts with the following restrictions:

1. Keep vertical curves flat enough so that calculated vertical mid ordinate through the entire length of frog is 1/32 inch or less.

   This results in the following maximum permissible rates of change: Halve these rates in summit curves in switch area of turnout. This is in deference to concern that the switch points be forced upward - even slightly.

		Sag. Curves	Summit Curves
No. 8 T.O.	-	0.50%/Sta.	0.25%/Sta.
No. 10 T.O.	-	0.35%/Sta.	0.18%/Sta.
No. 15 T.O.	-	0.25%/Sta.	0.13%/Sta.
No. 20 T.O.	-	0.15%/Sta.	0.08%/Sta.

2. In yards or low speed areas where higher rates of change and shorter vertical curves may be necessary, vertical curves may be confined to the closure area of the turnout, the area between the switch and frog.

f. Minimum Length of Vertical Curve

Vertical curves shall not be less than 100 feet long on main lines. Curves with a calculated mid-ordinate less than 1/4 inch (0.021 feet) are too inconsequential to lay out in the field and maintain. Such vertical curves should be avoided by either lengthening the curve or using a vertical angle point when the algebraic difference of the grades is 0.10% or less.

Within yards and low speed areas such as servicing areas and

approaches to stub end terminals, vertical curves may be shorter than 100 feet and have rates of change in excess of 0.80%/100 feet, but never so short as to produce a vertical curve sharper than an equivalent radius[6] of 4,000 feet as determined by the formula:

$$Equivalent\ Radius^{6} = \frac{L}{G_1 - G_2} \times 100$$

Formula 3.17

Where:

L	=	Length of vertical curve in feet
G_1-G_2	=	Difference in connected grades in percent

g. Combined Horizontal and Vertical Curvature

Another consideration in the design of both horizontal and vertical curves is the combined effect of "g" forces resulting when both horizontal and vertical curves are combined. The horizontal forces are discussed in Section 4 of this chapter and are related to lateral acceleration forces developed through the spiral and centrifical force from cant deficiency. Generally, the combined effect is not significant except when one or the other or both are at or near their maximum allowable value. In either case, the following check should be made and the design adjusted as required.

- In locations where horizontal curves are the controlling factor the rate of change of grade (r) which may be allowed to act concurrently shall be determined by the following formula:

$$r = \frac{2000}{V^2}(1-0.33Eu)(1-0.018Ee)$$

Formula 3.18

Where:

r	=	Rate of change of grade in percent/100' Station.
v	=	Velocity in mph.
Eu	=	Unbalanced Elevation of Horizontal Curve
Ee	=	Calculated Elevation for Equilibrium.
D	=	Curvature in Degrees

- In locations where vertical curves are the controlling

[6]Note that "equivalent radius" formula calculates a circular curve, not parabolic as an actual vertical curve is. Parabolic curve is flatter on both ends and somewhat sharper opposite the PVI than equivalent radius curve. Formula 3.17 provides an expedient way of determining relative sharpness of vertical curves.

factor, the unbalanced superelevation Eu allowed to act concurrently shall be determined by the following formula:

$$Eu = (3.00)\left(1-\frac{rv^2}{2000(1-0.0000126\,V^2D)}\right)$$

Formula 3.19

Note: If a negative number is produced by above formula, either V or r must be reduced until a positive number is obtained.

This combined effect is not an issue with current AREA vertical curve criteria. Whenever the "suggested" criteria or "currently under consideration" AREA criteria is used, the combined horizontal/vertical effect should be investigated, and adjusted accordingly per above formulae.

A. General

All track materials and special trackwork shall conform to the current MBTA "BOOK OF STANDARD PLANS - TRACK AND ROADWAY" and the "MATERIAL SPECIFICATIONS" which are referenced as appropriate.

All new installations or track renewals shall be with resilient fasteners on either timber or concrete ties as directed by the Chief Engineering Officer.

Ballasted track construction will be used at all locations except on bridges, viaducts, subways and tunnels, where direct fixation track construction may be used when directed by the Chief Engineering Officer.

New open deck bridges shall not be permitted except on a temporary basis. Existing open deck bridges shall be rebuilt to ballasted deck or direct fixation wherever possible.

Main track subgrade shall be designed to the dimensional requirements of Standard Plans 1000 and 1002 and as defined in Chapter 5 of this Manual.

B. Rail

Reference Material Specifications No. 9233 & 9236.
Reference Standard Plans - 1300 & 1302.

The standard MBTA rail section for new construction is 132 RE continuous welded rail. 115 RE CWR may be used in certain applications only when directed by the Chief Engineering Officer. Suitable, available fit relay rail sections, either CWR or bolted, may be used when replacing secondary tracks as and when approved by Railroad Operations.

Standard control cooled rail shall be used on all main line track with curves up to and including 2°-00'. Fully heat treated rail shall be used on all main line curves where curvature is in excess of 2°-00'. Carry heat treated rail through spirals and through tangents between adjacent curves over 2°-00' wherever the tangent is less than 300 feet long.

Fully heat treated rail shall not be used in curves outside of main lines, unless specifically directed.

Fully heat treated rail shall be used within all turnouts and other special trackwork units.

All rail shall be weldable by either electric flash-butt or thermite process.

C. Timber Cross Ties

Reference Standard Plans - 1100, 1104, 1106 and 1108
Reference Material Specification - 9209

Transition ties shall be used in areas of changing track modulus as shown on Standard Plan 1108.

Timber cross ties shall be spaced at 19-1/2 inches except use 18 inches within grade crossings. Within full depth rubber crossings, 9'-0" long ties shall be used.

Material specifications, seasoning and other requirements to be as specified in No. 9209.

D. Concrete Ties

Reference Standard Plan - 1120

Concrete tie are increasingly being used on the MBTA system. Use on a specific route/project shall be determined by the Chief Engineering Officer. Standard tie spacing for concrete ties is 24".

E. Subballast

Reference Standard Plans - 1000 & 1002
Reference Material Specification - 9251

Subballast shall be used on all new track construction or major reconstruction when the underlying material is not clean, free draining, well graded, granular material. The typical section shown on the standard plans should be considered adequate only for fair to moderately good subgrade conditions. If there is a history or direct evidence of difficulty in maintaining good surface and line at an existing track location or, if on new location, test borings indicate any condition other than good, granular material; the designer should recommend measures to provide adequate support for the track structure, including a change from the 8 inch depth of sub-ballast shown on the typical sections. Additional discussion of subgrade treatments is found in Chapter 5, Roadway Criteria.

F. Ballast

Reference Standard Plan - 1000 & 1002
Reference Material Specification - 9248

Crushed stone ballast per the referenced material specification shall be used on all trackwork. 12 inches depth under bottom of tie is the mainline standard. Ballasted deck bridges should also have 12 inches of ballast under the tie with 8 inches minimum when conditions warrant and when approved by the Chief Engineering Officer.

Maintenance of adequate ballast shoulders of 18" beyond the end of tie and good ballast compaction is essential to track stability and to control track buckling. All projects involving track reconstruction or realignment of track must provide construction specifications and phasing plans which both enforce and enable the proper preparation and compaction of the ballast section prior to opening track to service.

G. Tie Plates

Reference Standard Plans 1220, 1222, 1224 & 1225
Reference Material Specifications - 9269 & 9272

Tie Plates shall be used on all tracks regardless of use.

The MBTA standard for new timber tie track construction is resilient fastener plates with lock spikes. Within turnouts - either with tropical hardwood or treated oak - plates shall be fastened with screw spikes.

Cut spike tie plates shall not be used on new construction or track renewal projects unless specifically directed by the Chief Engineering Officer.

H. Spiking

Reference Standard Plans - 1104 & 1230
Reference Material Specifications - 9274 & 9275

Spiking patterns within standard timber and ballasted track construction shall be as per Standard Plan 1104. Within turnouts, screw spikes shall be used throughout as follows:

Gage Plates	-	6 screw spikes per plate
Shoulder Slide Plates	-	4 screw spikes per plate
Adjustable Brace Slide Plates	-	4 screw spikes per plate
Heel Plates	-	4 screw spikes per plate
Frog Tie Plates/Self Aligning Shoulder Plates	-	4 screw spikes per tie per plate.
All Standard Plates within Turnout	-	2 screw spikes per plate
Guard Rail	-	4 screw spikes per plate
	-	4 screw spikes per tie per guard plus 2 drive screw spikes per rail seat.

Holes for lock spikes shall be pre-drilled 9/16" dia. x 6" deep and 11/16" dia. x 6" deep for screw spikes. Holes not used, shall be plugged with treated or cedar tie plugs. Within turnouts using tropical hardwoods, pre-drill spike holes at gauge side of both switch points to allow spiking switch out of service with a cut spike. Plug such holes with cork tie plugs.

I. Rail Anchoring

Reference Standard Plan - 1232
Reference Material Specifications - 9239 & 9242

Anchoring patterns shown on Plan 1232 are for cut spike fastened tracks only. Track using the standard resilient fasteners does not require additional anchoring unless specified by the Chief Engineering Officer.

J. Resilient Fasteners

Reference Material Specification - 9245

Resilient fasteners and matching tie plates shall be used on all new installations and track renewal projects. In addtion to the standard plate used on timber ties and rag stem inserts, tie pads and insulators used on concrete ties, there are other systems to be considered in certain applications. These applications include direct fixation slabs and possibly open deck bridges. Impact attenuating, composite tie plates with provision for holding the rial with the standard resilient fastener are a system to be considered where appropriate.

K. Special Trackwork

Reference Standard Plans 2000 to 2499
Reference Standard Specifications - 9278, 9281, 9284 & 9287

Unless otherwise directed, use "floating heel block" design turnouts as detailed on the Standard Plans.

No. 20 turnouts shall be used for mainline crossovers and junctions of diverging mainlines wherever there is sufficient room. Allowable design speed for the Standard No. 20 turnout is 45 mph through the curved side of turnout. No. 20 equilateral turnouts may be used at ends of double track and such locations where they may be used to advantage. Allowable design speed through both legs of a No. 20 equilateral turnout is 65 mph (2.75 inches unbalanced elev.). With authorization of the Chief Engineering Officer, a speed of 70 mph may be used (3 inches unbalanced elev.).

No. 15 turnouts shall be used for mainline crossovers where there is insufficient room for No. 20's or where the design speed is limited to 30 mph or less because of other civil restrictions. No. 15 turnouts shall also be used to connect secondary lines and primary yard leads to the main line. Allowable design speed for the standard No. 15 turnout is 30 mph through the curved side of the turnout. No. 15 equilateral turnouts may be used where feasible. Allowable design speed through both legs of a number 15 equilateral is 50 mph (2.75 inches unbalanced elev.)

No. 10 turnouts shall be used for all sidetrack connections to the main line and all yard leads and yard tracks wherever possible. The No. 10 turnout is the preferred minimum size turnout for any commuter rail application. The maximum allowable design speed through the curved side of the standard No. 10 turnout is 20 mph, however, 15 mph is the preferred maximum for safety and maintenance considerations.

No. 8 turnouts shall be used only within yards and servicing facilities, only when it is physically impractical to fit No. 10's and only with permission of the Chief Engineering Officer. The maximum allowable design speed through the curved side of the Standard No. 8 turnout is 15 mph, however, 10 mph is the preferred maximum for safety and maintenance considerations.

Turnouts shall have 5 inch hot mix asphalt underlayment installed per MBTA Standard Plan No. 1030 and as indicated in Chapter 6, Section A4.

L. Switch Stands

Reference Standard Plans - 3020, 3023 & 3030
Reference Material Specification - 9257

Manual switch stands on mainline turnouts shall be intermediate height-model Racor 17D or New Century 50-B with operating rod sufficient to provide required side clearance and mounted on 16'-0" long headblock timbers. Electric lock is required on any installation in signal territory. Racor moded 17D or New Century 50-B shall also be used in yards where there is sufficient room for the 16'-0" headblocks.

Low stands - Racor model 36D or New Century Model 50A - shall only be used in yards and terminals where there is limited side clearance. Do not use in main track without specific authorization of the Chief Engineering Officer.

The Racor Style 22 is a "run through" type mechanism allowing automatic operation of trailing point movements through either leg of the turnout regardless of switch position. Use only in yards and servicing areas as directed by the Chief Engineering Officer.

All switch stands shall be furnished with the MBTA Standard Red/Green switch stand target unless specifically directed otherwise.

M. Bumping Posts

Reference Standard Plan - 3010
Reference Standard Specification - 9206

A steel, model "WA" bumping post per referenced standards shall be installed on all stub end tracks subject to operation (either revenue or non-revenue) by commuter rail equipment. Tracks used only for dead storage or work equipment storage may have other types of bunters. End of line stub end terminals will have energy absorbing impact attenuators capable of disapating energy equivalent to a nine car & one locomotive consist travelling at 10 mph. This requirement may be waived by the Chief Engineering Officer at locations where there is insufficient room and/or there are no buildings or structures in the path of a train which overshoots the end of track.

N. Emergency Guard Rails

Reference Standard Plans - 3060 & 3062
Reference Material Specification - None

1. Bridges

Guard rails (double rail) shall be used on all through girder and through truss bridges regardless of the span length and on any bridge when the structure length between abutment backwalls is over 40 feet.

Resiliently fastened guard rail as detailed on Standard Plan 3062 shall be used on all ballasted deck bridges and approaches and ballasted approaches to open deck bridges to aid in removal and reinstallation during surfacing operations.

The 39'-0" end approach section shall be lengthened at design speeds in excess of 60 mph as follows:

Length of guard rail end approach = 0.74V

V = design speed in mph.

2. Other hazardous locations

Single rail guard rails and/or crash walls may be used at such other locations where a derailment would cause significant structural damage to adjacent, vulnerable structures or to the railroad's equipment. Examples where such installations may be considered include:

a. Adjacent to steep drop-offs to water or where derailment would cause significant damage from the length of potential fall.

b. Adjacent to near-by high voltage structures.

c. Adjacent to any supporting column of an overhead bridge or structure which if struck by a train would very likely cause catastrophic failure of the structure. A crash wall may be appropriate in such cases. See Section "N" below.

O. **Crash Walls**

When tracks are immediately adjacent to supports for bridges, buildings and air rights development over the right-of-way, consideration must be given to protecting supporting structures from impact of a train in event of derailment.

The impact design loading for crash walls shall be as follows:

- Train weight, 1,666,000 lbs consisting of locomotive at 280,000 lbs and nine coaches-fully loaded at 154,000 lbs each.
- The angle of attack (measured from tangent to the track) shall be ten degrees.
- The impact speed shall be authorized track speed at the location plus a 50 percent safety factor.
- Place piers and abutments at such an angle that a square hit is not possible. Provide "wing" or angled section to deflect train away from blunt ends.

Refer to AREA Manual Chapter 8 for additional considerations with respect to crash walls.

P. Derails

Reference Standard Plans - 3000, 3004, 3006 & 3007
Reference Material Specifications - 9215

Split switch derails shall be used on all side tracks which connect to the main line with a descending grade.

Where less positive protection is required, sliding block derails may be used as directed by the Chief Engineering Officer.

Hinged block type derails shall be used only on engine house ready and storage tracks when power operated derails and interlocked blue flag protection is not available.

Derails used to protect main lines in signal territory must include circuit controllers, insulated joints and connections to signal system. If necessary, provide for sign installation - "Siding not to be used to clear main line".

A. SUBGRADE

1. General

The trackbed cross section will be designed to the dimensional requirements of Standard Plans 1000 & 1002. The minimum subgrade cross slope should be 1/4 inch per foot to facilitate the removal of water from under the track structure. Final subgrade elevation in either cuts or fills shall be set to allow placement of design trackbed section at design profile grade. The section shown on the Standard Plans will be used only when existing subgrade conditions are satisfactory. Design of trackbed section in poor subgrades and design of additional measures to provide a stable and maintainable track structure shall be responsibility of the designer.

At existing track locations, when track renewal is planned, the designer must investigate the following to determine the need for additional subgrade preparation.

a. Inspect track structure and note any areas with obvious problems such as muddy, fouled or pumping track, poor surface and alignment, wet conditions, instability in slopes supporting or above the trackbed, gullying or potential washouts, ditches and pipes filled or partially filled with silt or clay and trees or other vegetation which could undermine track bed if dislodged.

b. Interview maintenance personnel to determine any locations that are difficult to maintain or have a known history of stability or drainage problems.

c. Recommend and observe cross track test pits at any locations suspected of poor subgrade conditions.

d. Recommend and observe a soils boring program as required for any locations where a major subgrade problem is suspected.

At new track alignment locations, test borings, test pits or other suitable means should be included as a part of the design process to determine the nature and depth of soil strata that will be supporting and draining the track bed.

Hot mix asphalt underlayment shall be installed under all new turnouts and grade crossings per Standard Plans. Composition of mix shall be as indicated in Part 4 of this heading of "Subgrade".

2. Fill Sections

New fill foundations must be explored and then designed to prevent failure of the subsoil or excessive settlement. The exploration program should be developed and carried out as detailed in the AREA Manual - Chapter 1, Part 1.1. Use of sand or wick drains and

surcharging may be necessary to consolidate compressive soils prior to final construction.

When widening existing fills, benching the existing slope and placing new fill in compacted lifts not over two to three feet in depth must be detailed in the plans and specifications. Simply dumping material down the slope is not permissible except for shallow fills (less than 5 feet high) or when dumping stone rip-rap for erosion control. Existing culverts, including equalizing culverts, should be investigated, protected or extended as necessary prior to widening fill sections.

3. Cut Sections

Cut sections pose particular problems related to drainage and soil stability. Within existing cuts it is imperative that the side ditches be cleaned, enlarged and lowered to a depth not less than four foot six inches below top of rail. Ditches should also be graded to drain. Where ditches of sufficient depth and cross section are not possible, underdrains and closed drainage systems must be provided.

Visually inspect all cut slopes for signs of instability and excessive moisture which could lead to instability. If widening of cut slopes is indicated, investigate stability of slope and recommend construction methods and materials necessary to maintain slope stability. Top of cuts must be inspected for water retention or ponding areas caused by low points, beaver dams, etc. and methods to remove water away from the cut detailed.

The track bed within existing cuts often is composed of non-granular material which fouls ballast quickly and does not allow water to drain. This condition should be remedied as much as possible during track renewal projects. Excavation of unsuitable material, additional underdrains, placement of hot mix asphalt underlayment, geotextiles, are some of the methods that may be considered in various combinations to improve roadbed stability and lower the cost of maintenance.

4. Hot Mix Asphalt Underlayment

Hot mix asphalt underlayment (HMA) shall be installed as subgrade under roadway crossings and turnouts as shown on Standard Plans 1030, 3100, 3106 and 3108. HMA may also be installed under normal track where subgrade conditions are poor.

The recommended job mix formula for HMA underlayment shall be as specified in MBTA Standard Specification 02513, Table 02513-c supplemented by the following table:

Standard Sieves	Underlayment Mix (HMA)
2"	
1-1/2"	100
1"	90 - 100
3/4"	
1/2"	56 - 80
3/8"	
No. 4	29 - 59
8	19 - 45
16	
30	
50	5 - 17
100	
200	1 - 7
Bitumen	3 - 9

Table 5.1

HMA mix shall be installed in one course using sufficient material to provide a compacted mat 5 inches thick.

B. DRAINAGE

1. General

Drainage in stations and landscapped areas is also discussed in Section II, Chapter 6, Landscapping.

Good drainage and it's maintenance are absolutely essential to the safe and economical operation of a railroad. Safety is of paramount concern and certain drainage related problems can result in failure of either the roadbed or structures. During the design of both new facilities and reconstruction of existing, it is essential that close attention be paid to roadbed drainage, cross culverts and structures over water courses.

In designing for removal of surface and groundwater from the trackbed section, the following general conditions shall apply:

- Existing drainage patterns shall be maintained wherever possible.
- To the maximum extent possible, surface and subsurface drainage of the roadbed should be handled by a system of gravity - flowing longitudinal ditches that feed into catch basins, transverse ditches or streams. Ditches should be designed to handle anticipated flows without silting or scouring.
- Low points in ditches should be avoided but when required, positive means of removal of water must be supplied at the low points. Those means may include tieing into municipal storm

sewer systems by use of catch basins, leaching basins or groundwater recharge ponds (if permitted by subsurface geology and local ordinances), transverse ditches, culverts and natural or artificial watercourses.

- When absolutely necessary, where gravity outfalls are impractical, pumps may be considered to ensure positive drainage. In such instances, the design flow shall include an allowance for groundwater infiltration as appropriate.

- Drainage systems that discharge to an existing wetland or are within 100 feet of a wetland must comply with the rules and regulations of the Wetlands Protection Act and local bylaws. The local conservation commission must be contacted and informed of project details and probable wetland impacts. The commissions issue "Orders of Conditions" which should be incorporated into the design. Conservation commissions may also require an EIR or EIS.

- Drainage systems connecting to an existing storm drain must also comply with the Wetlands Protection Act if it discharges to a wetland. Approval is also required from the drainage system owner. The owner should be contacted early in the design process to determine their specific requirements.

2. Mainline Trackbed Drainage Criteria

   a. Do not drain subgrade from one track across or towards an adjacent track. The area occupied by each track should drain to its own ditch or subdrain.

   b. Do not drain areas from beyond the track bed through the track structure. Typically, a ditch or subdrain should lie between the track and the adjacent ground area to intercept fines from an adjacent slope which would foul the ballast.

   c. At locations where there will be a future track, crown the subgrade on the centerline between the tracks. Where practical, keep the ditch or subdrain on the field side of the future track clear of the future track so it doesn't have to be changed later.

   d. Typical drainage pattern for double track roadbed section is from a crown between the tracks to a ditch or subdrain on the field side of the tracks. When double track is between walls a single subdrain may be located between the tracks. "Walls" may include a retained cut or a retained fill where the walls are too close to the tracks to allow ditches or subdrains.

   e. Typical drainage pattern for single track is a crown line on the centerline of the track to ditches or subdrains on each side. When a single track is between walls, the ditch or subdrain may

be located on one side and the subgrade sloped in one direction to the ditch or underdrain.

f. At side platform stations, the platform should drain away from the track. A subdrain should be placed between the track and the platform to drain half of the track bed, and any water from platform canopies or areas behind the platform that are not handled by other site drainage. If there is a wall on the opposite side of the track from the platform, the entire track area should drain to the subdrain lying between the track and platform.

g. At island platforms, the platform should drain into the track area to avoid ponding at the center of the platform. Subdrains should be placed between track and platform so that track drainage is handled the same way as at a side platform station.

3. Design Considerations

a. Design Storm Computation

1. Rational Equation:

Design flows for local drainage shall be computed by the Rational Equation:

$$Q = CIA \qquad \text{Formula 5.1}$$

where:

Q = Runoff quantity, in cfs
C = Coefficient of Runoff
I = Rainfall intensity, inches/hour
A = Drainage area, in acres

2. Design Frequency:

The track drainage system including all open track bed areas exposed to direct precipitation shall be designed to accommodate the peak flows produced by the 50 year rainfall event. All runoff shall be fully contained within the drainage system, no surcharge will be allowed for undepressed catch basins and the capacity of all pipes, ditches, etc. shall equal or exceed the 50 year runoff. In addition, the storm drainage system shall be designed to maintain a maximum water level 18" below top of tie during the 100 year rainfall event.

The drainage systems for non mainline track areas such as parking lots, station accessways and layover facilities shall be designed to accommodate flows produced by a 10-year storm unless otherwise specified by regulatory authorities. The capacity of the receiving storm-drain system shall be investigated to determine if there is adequate capacity to comply with this requirement.

3. Time of Concentration:

The minimum time of concentration used shall be 5 minutes.

Time of Concentration shall be determined by the equation:

$$Tc = (0.0078\ K\ L^{0.77})/S^{0.385}$$ [1] Formula 5.2

Where:

Tc = Time of Concentration, minutes
L = Maximum length of Travel from most remote point in drainage basin to outlet, feet
S = Average slope (feet/foot) = H/L
H = Difference in elevation between most remote point and drainage outlet
K = 1.0 for natural basins with well defined channels, for overland flow on bare earth, and for mowed grass roadway channels.
K = 2.0 for overland flow over grass surfaces
K = 0.4 for overland flow, concrete or asphalt surfaces
K = 0.2 for concrete channel

For areas with abrupt changes in topography or surface, the calculation shall be done for each segment and the total time of concentration shall be arrived at by adding the computed values for each segment.

4. Rainfall Intensity:

Rainfall intensity shall be obtained for specific design storm frequencies and times of concentration by using the Rainfall intensity-Duration-Frequency Curve for Boston, Massachusetts, as found in Technical Paper No. 25 of the U.S. Department of Commerce, Weather Bureau, December, 1966 on Rainfall Intensity-Duration-Frequency Curves.

[1] This equation is based on a study by Z.P. Kirpich (1940)

5. Coefficient of Runoff:

Values of runoff coefficient for use in the Rational equation (Q = CIA) shall be as defined in ASCE Manual No. 37, Design and Construction of Sanitary and Storm Sewers or Table 1 on Page 53 of Design of Roadside Drainage Channels, Hydraulic Design Series No. 4, U.S. Department of Commerce, Bureau of Public Roads, May, 1965.

b. Ditches

1. Geometric Requirements:

Ditches shall be of trapezoidal section, with a minimum depth of 18 inches and a minimum bottom width of 2 feet. They shall have a minimum gradient of 0.25% and a maximum design velocity of 2 feet/second for unlined channels. Water levels in ditches at design flow rates shall be at least 3 feet below the top of rail.

2. Flow Computation:

Drainage velocities and capacities shall be computed by use of Manning's Equation:

$$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Formula 5.3

where:

V = Velocity, ft/sec
n = Manning's Coefficient of Roughness
R = Hydraulic Radius, feet
= area/wetted perimeter
S = Slope, feet/foot

Manning's "n" values shall be determined from ASCE Manual No. 37 or Table 2, Page 53-54 of Design of Roadside Drainage Channels, Hydraulic Design Series No. 4, U.S. Department of Commerce, Bureau of Public Roads, May, 1965.

3. Gutter Flows and Inlets

Where curbing is proposed along roadways, gutter flows and gutter inlets shall be designed in accordance with the U.S. DOT - Federal Highway Administration Hydraulic Engineering Circular No. 12, Drainage of Highway Pavements, March, 1984. At least 10' of the travel way shall be free of gutter flows.

c. STORM DRAINS

1. Material, Cover and Structural Requirements:

Either reinforced concrete or asphalt-coated corrugated metal pipes shall be used. Minimum diameter pipe size shall be 12 inches. Culverts shall have a minimum diameter of 18 inches.

Pipes under railroad tracks shall be designed for Cooper E80 loading and shall have a minimum cover of 2 feet from bottom of tie to top of pipe.

Pipes under highways, parking lots and driveways shall be designed for H20 loading. They shall have a minimum cover of 1 foot from top of pavement to top of pipe.

2. Flow:

Manning's Equation, as defined in the ditch section and as shown below, shall be used.

$$Q = \frac{0.463 D^{\frac{8}{3}} S^{\frac{1}{2}}}{n}$$

Formula 5.4

Where:

full capacity

S = Pipe slope feet/foot)
Q = Flow (cubic feet per second)
n = Manning's roughness coefficient (Feet $^{1/6}$)
D = Pipe diameter (feet)

Pipes shall be designed for uniform flow, with a preferred velocity in the range of 3 to 9 feet per second. Maximum headwater for culverts shall be 1-1/2 times the pipe diameter. At design flows, water shall not back up at the pipe entrance to an elevation higher than six inches below top of railroad subgrade or roadway pavement.

No pipe shall be designed with a size smaller than the next pipe upstream.

3. Manholes:

Manholes shall be installed at all pipe junctions and grade or alignment change points. Maximum pipe length between manholes shall be 300 feet.

4. Catch Basins:

Catch basins shall be installed at all ground or pavement surface low points and all grades not drained by ditches or other means. The maximum interval between catch basins shall be 300 feet.

Catch basins shall have a 30 inch deep sump and a cast iron hood, frame and grate. Bicycle safe grates shall be used in station access roads, parking lots, and other areas where bicycle traffic is possible. Design of catch basins, cover and general arrangement must be done in a way to allow cleanout of sump with a clam shell bucket.

If leaching catch basins are used, they shall have a minimum of 12 inches of 2 inch diameter crushed stone placed around the outside. Their design shall be based on "perc" test data taken at the basin site. The design leaching capacity of the basin shall be increased to allow for partial blockage by debris and fine sediment.

d. Perforated Pipe Drains

Where ditches are not permitted by space, where additional flow capacity is needed, or where required to reduce underground hydrostatic pressure, perforated pipe drains shall be used. The pipes shall be perforated bituminous coated galvanized corrugated metal or perforated PVC. Minimum size shall be eight inch diameter in grade crossing installations and 12 inch diameter when used in place of ditches.

Where perforated pipes are used only as underdrains to reduce underground hydrostatic pressure and control groundwater elevation, the perforations shall face down. Where perforated pipes are being used to carry water with groundwater control a secondary requirement, the pipe shall be laid with perforations up. Use of perforated pipes to carry water shall be limited to the upper runs of a drainage system and checked to ascertain that they will not be subject to surcharging. Separate carrier pipes, for storm drainage shall be used in combination with perforated pipe underdrains in most cases.

Filters shall be used with all perforated pipe drains to prevent accumulation of sediment in the pipes. Filter material may consist of suitably graded crushed stone, synthetic filter material, or a combination thereof. The filter envelope shall extend a minimum of eight inches beyond the outside diameter of the pipe.

Perforated pipe drains shall discharge to a gravity drainage system or pump station. Care shall be taken to ensure that perforated pipe drains are not blocked by high water levels at

the outlet. Relatively impervious materials such as loam or topsoil shall not be installed vertically above these pipe drains.

MHWA design gas traps or oil-water separators shall be provided in areas where runoff is subject to contamination with petroleum products and where required by regulatory authorities.

e. Recharge and Detention Ponds

1. Detention Ponds

Detention Ponds shall be designed when necessary to limit peak outflow from the design storm to an acceptable value. When these detention ponds discharge into a wetland a review by the local conservation commission is required. The detention ponds shall include provisions for removing sediment, if warranted. Each pond must be evaluated individually to determine if enough sediment will enter to justify a sedimentation basin.

Ponds shall be provided with an emergency overflow section to allow the safe discharge of water in excess of the design storm. Multiple outlets may be used when needed to accommodate maximum and minimum design storms. Required storage volume shall be determined using inflow and outflow hydrographs based on the Soil Conservation Service criteria or another approved method.

2. Recharge Basins

Recharge basins shall be designed with both a sedimentation basin section and a recharge basin section. The sedimentation basin shall be designed to remove all sediment that might plug the pores and reduce the basin's infiltration capacity.

The recharge basin section shall be designed to allow infiltration of the design storm within a reasonable period of time. The recharge basin capacity may be supplemented using recharge wells or trenches if necessary. The infiltration capacity shall be based on percolation field tests. Deep hole field tests shall be used to determine the depth to ground water and/or the location of impervious strata.

The combined storage capacity of the recharge and sedimentation basins shall be adequate to contain the runoff from the design storm. The basins shall have an emergency overflow to allow the safe discharge of water in excess of the design storm.

f. Sedimentation and Erosion Control

1. Grading

Cut and fill slopes shall be as flat as practical. Minimum slopes shall be adequate to provide positive drainage. Mowed lawns shall have a 1% minimum slope and unmowed lawns or areas with groundcover shall have a minimum slope of 2%. Maximum mowable slopes shall not exceed 3:1 horizontal to vertical with an unmowable maximum slope of 2:1. Slopes steeper than 2:1 will require geotextile, rock or other protection treatments. The tops and toes of all slopes shall be rounded.

Roadways and parking areas shall be graded in accordance with the station and parking section of the Manual contained in Volume II.

2. Diversion Channels:

Diversion channels shall be located at the top of all steep cut slopes where terrain rises away from the track centerline. They shall be designed in accordance with the requirements of this chapter. Diversion channels shall discharge to the storm drainage system or a natural water course. Diversion channel outlets shall be designed to minimize erosion. All discharges into existing wetlands or within 100 feet of such shall comply with the rules and regulations of the local conservation commission.

3. Grade Stabilization Structure:

When it is necessary to convey storm water from one level to another across a steep slope, a grade stabilization structure shall be used. It may be a lined chute, drop box culvert, pipe drop inlet, channel with check dams, or other suitable structure.

4. Vegetation and Revegetation:

Grading operations shall minimize disturbance of existing vegetation. The design shall allow staged construction whenever practical to minimize the exposure of bare earth and the resulting sedimentation. Erosion control matting shall be used when necessary to avoid erosion of slopes before new vegetation can become established.

Vegetation requirements shall be coordinated by a landscape architect with the MBTA and each respective municipality.

5. Local Requirements

Whenever work takes place in a wetland area or within the buffer zone, the local conservation commission must be contacted, a notice of intent filed if required, and any orders of conditions issued incorporated into the design. Conservation commissions typically will require control of sedimentation and erosion during construction. Appropriate measures such as silt fences, straw bale checks, staged construction, and revegetation requirements shall be incorporated into the design.

C. FENCING

1. General

Fencing is a critical element of the commuter rail physical plant. Fencing provides safety for the general public, protects passengers using our facilities and the operation of both the Authority's trains as well as the freight carriers. Fences perform various functions in a wide variety of locations. Selection of the proper size and type of fence as well as it's proper installation is important. No trespassing signs shall be attached to all gates and on fences, facing in both directions, at intervals not exceeding 200 feet and as detailed on Standard Plans.

2. Types of Fences

Reference Standard Plans - No. 3200, 3204, 3206 and 3208.

The primary fence type is chain link at heights of 48 inch, 72 inch, 96 inch and 120 inch. The three strand barbed wire top is an option on all chain link fence.

High Security Fence consists of a very dense, close-spaced, difficult to climb mesh fabric with closer post spacing.

At overhead bridges, special mounting details are required. Also, special fence details using posts and fabric that curve back over the bridge to prevent throwing objects, (anti-missile fencing) at trains may be necessary at high risk locations.

Gates may be single swing, double swing or sliding as appropriate for the location, size of opening and use. In all cases, the design of the gate and related hardware must be of the heaviest, most durable material available to provide reliable operation over the life of the installation.

Snow fences are usually a portable type installed seasonally by maintenance forces. Treated timber fences of permanent construction may be used for this purpose and/or as a view block in areas where snow

drifting is a regular problem and where a visually solid fence would not be objectional.

3. Uses of Fences

a. Right-of-Way Fence

Fencing along the Authority's right-of-way is used to prevent unauthorized entry as well as to define the property of the Authority and abutters. The size and exact type of fence to use at a specific location is a function of the existing and potential degree of trespassing at that location. The following is a general guideline arranged in ascending order of control of trespassing:

. Very rural-wooded	No fence
. Rural-fields or farmland	72" CLF
. Light Suburban	72" CLF
. Medium to Dense Suburban	72" CLF with B/W
. Urban	96" CLF with B/W
. Urban areas with severe trespassing problems	96" HS-CLF with B/W

B/W = Barbed wire top-3 strands
HS = High Security Type fence

Gates must be located at suitable sites and frequency to allow maintenance personnel access to the right-of-way. This is especially critical at interlockings.

At a specific location, where trespassing has been a problem, a short segment of a more restrictive fence may be installed than used in the balance of the installation.

b. On-Site Access Control

Fences may be used at stations and parking areas to control where and how people move about. This is generally for their safety but may also be a means of directing them to the areas intended. In most situations, 48 inch CLF is appropriate for this purpose. Intertrack Fence is a particular use of this type of fence and is detailed on Standard Plan No. 3204. Its installation details and lack of a top rail is unique to that use. (See Station Design Section of Manual also.)

c. Snow Fences

Reference Standard Plan - 3200

Drifting snow caused by prevailing winds from the direction of open areas and accumulation of snow in cuts can be a problem for maintenance forces and have adverse affects on train operations,

station platforms, parking areas and access roads. Installation of snow fences is usually seasonal using portable type fences. In certain instances, it may be appropriate to use a permanent fence such as the "Wood Open Board Fence" shown on Standard Plan 3200. Landscape plantings of evergreens may also be effective barriers to use on a permanent basis where fences may be inappropriate.

d. Overhead Bridges

Overhead bridges, both vehicular and pedestrian, pose problems related to debris being thrown and dropped on the right-of-way and trains. Anti-missile fencing may be used as a barrier in these locations with special curved posts and extra wide fabric utilized at locations where vandalism is prevalent. Fan guards or short cantilever fence sections may be helpful at the ends of fence on bridge approaches.

e. Fence Setback from Property Lines

In most cases, right-of-way fences shall be installed 12 inches from the actual property or ROW line and on Authority property. Where clearances are close and where directed, this dimension may be reduced to 6 inches.

D. RIGHT-OF-WAY SIGNS, POSTS AND MARKERS

Reference Standard Plans 3300 to 3399

1. General

Various signs, both informational and regulatory, are required around any railroad. During reconstruction or new installation of right-of-way facilities, replacement, reinstallation and furnishing new signs shall be considered an integral part of the project. Specific signs related to stations and parking facilities are not covered in this section. These signs are covered in Section II, Stations and Parking.

Right-of-Way signs generally fall into two categories - informational and regulatory. Informational signs include:

- Mileposts
- Close Clearance Warnings
- Yard Limits
- Flanger Warning Boards

Regulatory signs include:

- Speed Boards - Permanent and Temporary
- Whistle Posts

2. Lettering shall be Helvetica Medium with certain applications in condensed form. Exceptions to the above only with direction from the Chief Engineering Officer. Letters shall be black gloss silk screen conforming to Mass Highway Department (MHD) material spec. M7.04.12 or reflectorized press-on vinyl equal to black "Scotchal".

3. Background shall be reflectorized white paint meeting Federal Specification FSL-S-300 A type, Class 1 or 2, reflectivity 1 for mileposts and no trespassing signs.

   Other signs with colored background shall use an adhesive vinyl covering as follows:

   - Yellow - No. 2271 Yellow Scotchlite
   - Green - No. 2277 Green Scotchlite
   - Silver - No. 2870 Silver Scotchlite

4. Sign boards shall be made from 0.081 inch thick aluminum alloy 6061-T6. Mile posts shall have a 1/4 inch thick steel sign back behind each sign panel as per Standard Plan 3302. Other permanent signs shall also include a 1/4 inch thick steel sign back when scrap rail sections are used as a post. Steel board to be welded to base of rail along both edges.

   Aluminum sign boards shall be mounted to steel sign back with a minimum of four 5/16 inch x 1 inch bolts with lock nuts and washers, all cadmium plated.

   Steel sign backs shall be cleaned with a grease cutting solvent, primed and painted with two coats of white enamel prior to mounting sign boards.

5. Sign posts for free standing, permanent signs are preferred to be fabricated from used rail sections at least 112 lb section, free from bends, kinks or visible damage. Rails shall be cleaned with a grease cutting solvent, primed and painted with two coats of white enamel after welding on steel sign boards.

   Temporary signs or small (18 inch x 24 inch or less) signs may use steel "U" posts or square posts pre-drilled for mounting. Posts shall have 1/4 inch thick anchor plates attached per detail on Standard Plan 3306.

   Any sign post which could be struck by a motor vehicle shall include a break-away mounting.

6. Sign locations

   a. General - The designer shall coordinate required signage and location with Railroad Operations. In general, the following signs and markers are required.

b. Mileposts - Are located based on mileage from the primary terminal (North or South Station) and are located to the right of the outbound track with the mileage signs facing in both directions. Miles should be based on the original railroad stationing whenever possible.

If the existing mileposts are made of granite and are in good condition, they may be repainted (white) on top and lettering redone (black) and reused instead of the rail post mile marker.

c. Permanent speed boards shall be placed at every point where there is a change in the authorized speed and at least every two miles.

d. Yard limit signs shall be placed at yard limits facing both inward and outward tracks at locations where there are defined yard limits. Yard limit locations should be checked with Railroad Operations. Yard limits are normally defined by the carrier operating freight service, not by the Authority.

e. Whistle posts shall be located 1000 feet in advance of location for which locomotive whistle is to be sounded.

f. Ring post shall be at location where locomotive bell ringing is to commence and repeated every 1000 feet where prolonged ringing is required.

g. Crossing circuit sign shall be placed at start of grade crossing protection circuit. On bi-directional tracks (signalled for movement in either direction), signs shall be provided on both approaches to the crossing. When crossings are close together and the crossing circuits overlap, signs shall also include small letters to indicate the crossing number (in mileage from terminal) of the respective crossing. Signs shall be placed directly opposite the insulated joints concerned.

h. Stop posts shall be used to indicate a grade crossing for which no protection is provided or for a crossing where a full stop must be made before activating the protection. Sign shall be placed 25 feet in advance of the crossing or opposite the insulated joint.

Reference Standard Plans - 1012 to 1019

A. General

Providing and maintaining adequate horizontal and vertical clearance is a key element in the safe operation of a railroad. Existing clearances on many routes in the Authority's territory are sub-standard by today's requirements due to the age of the facilities. During reconstruction and renewal, improvements in clearance that can be achieved are a priority item.

To the extent possible, new facilities or major rehabilitation and reconstruction shall conform to current Commonwealth of Massachusetts Statutes for clearance within yard limits. These statutes require a 22'-6" vertical clearance above top of rail, 8'-6" to any side obstruction from centerline of track and 13'-0" track centers with suitable increases for curvature. Various exceptions to the above are noted on the referenced standard plans and discussed in more detail below.

B. Vertical Clearances

1. Background

Vertical clearance within yard limits is defined by state statute as 22'-6" above top of rail. Yard limits were or are defined by the freight carriers, not by the MBTA. Historically, the requirement for 22'-6" clearance is based on protecting personnel walking on top of a box car that typically was about 15'-6" high. This is now a prohibited practice, roof walks are no longer placed on cars and brake wheels have been moved from the top of cars to a height just above the coupler.

Today, freight carriers are very concerned with improving clearances so they can remain competitive and handle cars which are considerably taller than the 14' to 15-1/2' box car of previous times. Fully enclosed tri-level automobile carriers and double-stack containers (shipping containers stacked two high on special drop-well flat cars) require a clearance just under 21 feet.

The MBTA has an interest in providing sufficient clearance for future electrification. This will be practical if the 22'-6" dimension is used and would be possible for passenger operation and very limited freight operation with 18'-0" clearance.

2. Minimum Vertical Clearance

When and if 22'-6" is not possible, lesser clearance will be permissible. Standard Plan 1016 gives the minimum vertical clearance by route segment which will satisfy both the MBTA's and current freight carrier's requirements. These clearances are subject to frequent revision due to changing requirements of freight carriers. Designers must check with railroad operations before design is advanced.

The absolute minimum clearance that is required to clear equipment of the MBTA and allow for dynamic movement plus a nominal safety factor and minimal resurfacing raise is 16'-4". Any clearances between 16'-4" and those indicated on Standard Plan 1016 must be approved by the Chief Engineering Officer.

3. Compensation for Superelevation

If tracks are superelevated under an overhead structure, clearance must be increased to allow the required vertical clearance out to a point 7'-0" from centerline of track on a plane even with the top of rail of superelevated track. (See sketch on Standard Plan 1016).

Relative to the low rail, which is the profile grade line, the required increase is defined by the following formula:

Increased clearance in inches = 1.43 x Ea

Formula 6.1

Where:

Ea = Actual Superelevation in Inches

4. Compensation for Vertical Curves

When there are vertical curves at overhead obstructions, allowance must be made for the vertical mid-ordinate of a car up to 90 feet long.

$$Increased\ clearance = \frac{0.90 \times G_1 - G_2}{8}$$

Formula 6.2

Where:

G_1 = Grade at PVC in percent
G_2 = Grade at PVT in percent

C. Horizontal Clearances

1. Background

By state statute, horizontal clearance within yard limits is 8'-6" from centerline of track from a plane at the top of rail vertically upward to the vertical clearance restriction. Yard limits were or are defined by the freight carriers, not the MBTA. The reason for 8'-6" is to allow a brakeman riding the side of a car to clear any obstructions. 8'-6" also provides room for a train to clear someone standing along side. The exception to the above is switch stands and other individual obstructions necessary for the operation of the railroad which are less than 3'-0" above top of rail. The reasoning being that a man riding the side of a car will be over that height and because they are only

point obstructions, a pedestrian would not get trapped between it and a train.

Although 8'-6" side clearance is dictated only within yard limits, it is imperative that this clearance be maintained everywhere possible for safety. Where 8'-6" side clearance cannot be maintained, safety niches must be provided and warning signs posted. (See Part E following).

2. Allowable Exceptions to 8'-6" Side Clearance.

Due to operational and physical requirements, certain elements, under certain conditions may intrude into the 8'-6" tangent clearance envelope as follows:

a. Low switch stands and electric locks less than 3'-0" above top of rail may be 6'-6" from centerline.

b. Low passenger platforms (less than 8" above top of rail) may be 5'-1" from centerline.

c. High passenger platforms (4'-0" above top of rail) may be 5'-7" from centerline. On certain routes, a breakaway, foldup edge to allow 7'-3" for over-dimension freight movements shall be provided. (See Article 5, following). At major terminals with direct fixation track and no freight operation, 5'-4" may be used.

d. Intertrack fence at passenger stations may be 6'-0" from track centerline if fence is not more than 4'-0" high. (See Standard Plan 3204).

e. Top flange of through plate girder bridges less than 4'-0" above top of rail may be closer than 8'-6" as shown on Standard Plan 1017 and with the conditions indicated in the asterisk note (*) on that plan.

f. Dwarf signals outside of track to be 7'-6" from centerline. Dwarf signals between multiple tracks permitted only if not over 2'-0" above top of rail.

g. Platform canopies may be 7'-6" from centerline of track except on Framingham/Worcester Line, maintain 8'-6".

3. Side Clearance Increase for Superelevation

All side clearances must be increased on the inside or low side of curves to compensate for the inward lean of equipment. The formula used for this purpose is:

$$\textit{Increased side clearance in inches} = h/5 \times Ea$$

Formula 6.3