MANUAL OF GUIDELINES AND STANDARDS

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PART III STATION MODERNIZATION PROGRAM  (Discontinued)
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GENERAL INTRODUCTION

The Massachusetts Bay Transportation Authority has found it both necessary and possible to concentrate attention on the complex needs of people. Programs to improve service must now include a new emphasis on the quality of the transportation experience. In effect, transportation engineering has been joined by human engineering and environmental design.

This manual provides a framework for the continued coordination of all those elements in the system that affect human comfort.

Many of the criteria involved are common to all environments, such as the control of light, noise, humidity, temperature, wind, and odors, or the need for orderliness, through clear and easy circulation and clean appearance. Other criteria that are more specific to the transportation environment are such needs as safety, traffic handling capability, spatial variety, consistently available information, and orientation.

The most important single criterion that has guided the preparation of this manual is the need for orientation. The rider must not only be physically comfortable, he must also know in the fullest sense where he is and where he is going.

Since to the layman a public transportation system is to a large extent an invisible skeleton of the city and metropolitan region, the comprehension of that structure generates an awareness and appreciation of the city itself, and an appreciation of travel through it.

There are many aspects to achieving this orientation. Circulation at all points must be direct and open. Spaces should relate visually to their surrounding environment, either through direct openings to adjacent spaces and structures, or in the case of platforms, by graphic reflection through photographic murals.

Above all, the need for orientation places great emphasis on maps and a consistent system of identification and directional signing. Graphics then emerges as a major factor in the design of each environment, a factor that must be given high priority in the early design phases of each project.

It is hoped that all participants in all programs will familiarize themselves with the entire manual, so that the implications of each decision can be understood in a system-wide context.

The standards and guidelines presented here are not inflexible rules. They are a framework for meaningful development and variety, and offer no restriction to the capacity of each participant to evolve better solutions to old or new problems.

As new solutions are developed and approved, revised and additional pages for the manual will be issued to all participants.
INTRODUCTION

Part VIII of the Manual provides the designer with a brief discussion of: the rail transit noise environment, suggested noise criteria, and possible approaches to noise abatement in stations and along the right-of-way. The primary purpose is to make the designer sufficiently aware of the scope of the problems and their possible solutions, to insure that proper attention and resources are devoted to this area in the design process.

Rail transit noise affects three groups of receivers (persons subjected to noise): persons waiting in stations, persons along the right-of-way, and persons on the trains. This volume will deal primarily with those aspects of noise environment and control which affect the various receivers, which lie within the province of the station and facility designer.

This section supersedes the entire ACOUSTICS Section of the original issue of the Manual of Guidelines and Standards.
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<tr>
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<tr>
<td>E. Bibliography</td>
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</tr>
</tbody>
</table>
A. The Rail Transit Noise Environment

The subject of noise and means of controlling it are covered in considerable depth in text books and technical reports in the field of acoustics. The purpose of this section is to give the designer some basic background in acoustics as applied to rail transit noise problems. There are many popular misconceptions about noise and its control, and hopefully some of these may be disposed of.

1) Noise and How It Is Measured

- Noise, which really means a disagreeable sound, consists of rapid fluctuations of pressure, which travel outward from the source through the atmosphere, to a location where they are detected by the ear.

- Noise, or pressure fluctuations, are created by a vibrating object, such as a violin string or a moving railroad car wheel.

- Noise is measured in decibels, giving an indication of the sound pressure level, on a logarithmic scale. This is done because of the wide range of sound pressure levels.
• The frequency of the pressure fluctuations determines the pitch of the sound with higher frequencies corresponding to higher pitch sounds.

• As the ear responds differently to varying frequencies, measuring devices called sound level meters can be compensated for this electronically to give the "loudness level" or "noise level" in decibels in the A scale, normally expressed as dBA. This is a reasonable approximation of loudness of a sound as heard by the average person, and will be used throughout this report, except where otherwise noted.

• A change in noise level must be at least 5 dB to be definitely perceptible to the average person.

• A change in noise level to 10 dB is equivalent to an apparent doubling, or reduction by one-half, of a sound.

• A very low noise level, such as a soft whisper at a distance of 5 feet is 34 dBA, an average residential area at night has a noise level of 40 to 45 dBA, while inside a factory, punch presses may create a noise level of over 110 dBA. Normal conversation is at a level of 60 dBA.
2) **The Characteristics of Rail Transit Noise**

Rail transit noise must be discussed from the standpoint of its:

- Sources, Paths and Receivers
- Loudness or "Sound Power"
- Frequency Content

All of these must be considered by the designer in order to define the problems and develop their solutions.

a) **Sources, Paths, and Receivers:**

**Sources:**

Rail transit noise and vibration is greatest by a number of primary sources, with the most dominant one originating at the interface between wheel and rail. Other sources of noise radiation are equipment installed on vehicles or the wayside. The primary sources are as follows:

- Wheel-on-rail noise which includes that caused by:
  - Rolling
  - Side slippage of the wheel across the railhead
  - Wheel slippage across and along the railhead on curves
  - Wheel flange bearing on the restraining rail and side of the running rail
  - Impact at built-in irregularities such as rail joints, switch and crossing frogs
Impact at rail defects such as rail corrugation, burns, or cracks

Impact at wheel defects such as flats and spalling

Current Collector noise which includes that caused by:

- Sliding of the collector over the 3rd rail or overhead trolley
- Impact at irregularities such as ramps at rail ends and joints

Vehicle-mounted equipment noise which includes that caused by:

- Traction motors (windage and bearings)
- Gears
- Brake shoes bearing on wheel treads, discs or rail surface
- Air compressors
- Motor-generator or alternator sets
- Air Conditioning condensor and ventilating fans and refrigerant compressors
- Fluorescent light ballast
- Doors (operator noise plus bangs and rattles)
- Couplings, and Pantograph Gates (rattles)
- Brake valve air venting
- Ventilation ducts, inlets, outlets, and louvers
- Vehicle slip-stream
Structure borne paths which include:

- Vehicle suspension system
- Auxiliary equipment suspension system (on vehicles)
- Vehicle structure
- Track and station supporting structure

Ground borne vibration path

Certain paths for the transmission of noise and vibration may in turn become radiators of audible noise. These secondary radiators include:

- Vehicle walls and ceilings
- Bridges and viaducts
- Station structures
- Adjacent building structures

Receivers:

The receivers of rail transit noise and vibration include:

- System users and employees on trains and in or around stations
- Wayside community

These receivers may be effected by noise and vibration in a number of ways:
Wayside equipment noise which includes that caused by:

- Ventilating fans
- Ventilating shafts (moving air noise and train noise)
- Substation transformers (60 Hz hum)
- Substation rotary converters
- Pumps and ejectors
- Switch machines
- Fare collection equipment
- Escalators
- Air conditioning equipment

Other sources including people, motor vehicles, buses, airplanes, etc., which affect the acoustical environment of the transit system user

Paths and Secondary Radiators:

The paths between source and receiver include the following:

- Airborne paths which include:
  - Directly radiated sound
  - Reflected sound
  - Reverberation in tunnels
  - Reverberation in stations
  - Reverberation in vehicles
• Psychological effects including annoyance and interference with conversation, rest, and work performance
• Physiological effects including discomfort, temporary or permanent hearing loss, and other general effects on health
• Economic effects such as decreased property values or interference with commercial activities

These effects in combination can help create an image of the rail transit system which discourages its ridership and community acceptance.

b) **Loudness or "Sound Power of Noise":**

Investigation of the acoustical environment normally begins with measurements of the loudness of the sounds, or "sound power" (sound pressure level). Some typical noise levels and characteristics of transportation noise are described below.

- Comparison of average peak noise levels generated by modern transportation vehicles, measured at a distance of 50' (from center of vehicle), out of doors at ear level, with speeds of 35 to 50 mph, are as follows:
  - Automobiles in traffic: 70 to 80 dBA
  - Two Car MBTA Rapid Transit Train on surface track with welded rail: 81 to 91 dBA
  - Diesel Bus: 80 to 88 dBA
Heavy Truck

   Diesel Locomotive

   Passenger and Freight trains excl. locomotive

- The effect of speed on noise generated by rapid transit trains running in the normal range of operating speeds (above 35 mph) is as follows:
  Increase of speed by 25% increases noise by 3.5 dB
  Increase of speed by 50% increases noise by 5 dB
  Increase of speed by 100% increases noise by 9 dB

- The number of cars in a train makes slight difference in the apparent loudness - at 50 ft. from the tracks and a speed of 45 to 50 mph doubling from 2 to 4 cars increases the noise by 2 dB. One also hears the noise for a slightly longer time.

- Doubling the distance from the train will reduce the noise level by 3 dB for distances less than 1/3 the train length, and by 6 dB for distances greater than 1/3 the train length.

Wayside noise levels measured by DOT Transportation Systems Center (TSC) at various residential areas along surface and elevated sections of "T" rapid transit lines at distances from 50 to 100 feet from the line are as follows:
(1) Blue Line 84 to 89 dBA
(2) Orange Line 88 to 100 dBA
(3) Red Line 80 to 92 dBA

The range of noise level at wayside at 50 ft. was found to be 80 to 95 dBA, in stations 80 to 95 dBA, and in the cars 70 to 95 dBA. These are judged to be typical of rail rapid transit systems in the U.S.

Noise levels measured by TSC on the Red Line South Shore Extension near Tenean Street on April 1972 were as follows:

<table>
<thead>
<tr>
<th>Train Length</th>
<th>Speed</th>
<th>Peak RMS Noise Level in dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at 25 ft.</td>
<td>at 50 ft.</td>
</tr>
<tr>
<td>Range:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 car</td>
<td>47.4 to 51.3</td>
<td>74 to 100</td>
</tr>
<tr>
<td>Average:</td>
<td>49.9</td>
<td>89.5</td>
</tr>
<tr>
<td>Range:</td>
<td>4 car</td>
<td>48.6 to 56.4</td>
</tr>
<tr>
<td>Average:</td>
<td>4 car</td>
<td>50.1</td>
</tr>
</tbody>
</table>

These measurements were made on welded rail on concrete ties. Due to excessive wheel flats and wheel spalling they are at least 5 dB higher than would be expected with this type of equipment and roadbed. (Installation of a modern wheel-truing machine in the new South Bay shop will cause a major improvement in this area.)

c) Frequency Content of Noise:

The loudness or level of noise as expressed by the A-weighted level does not give sufficient information to the designer when
methods of noise abatement are under detailed study. It is necessary to consider the frequency content of the sound. Normally these are plotted by one-third octave band center frequencies. Typical wayside noise spectra for the South Shore Line measurements are shown on Figure 1 and 2.

When dealing with specific problems such as wheel-squeal, frequency analysis is particularly important. Measurements made at Government Center subway station are shown on Figure 3. Note the very intense peaks at the high end of the scale.

The designer may require analysis of this type, as well as other more extensive measurements and analyses of noise and vibration to solve the problems of individual location.
Wayside Noise Spectra at 25, 50, and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound - Ser. Nos. 1503, 1506, 1611, 1110 at 49.7 mph.
WHEEL-SQUEAL NOISE CONTAINING A HIGH-FREQUENCY COMPONENT
MEASURED IN GOVERNMENT CENTER STATION

WHEEL SQUEAL

ONE-THIRD OCTAVE BAND CENTER FREQUENCY (Hz)
3) **Noise at Stations**

Noise level on station platforms varies with the type and condition of equipment and roadbed, maximum speed of trains entering and leaving the station, to what degree the station is enclosed (subway station versus un-roofed surface station), the nature of the enclosing surfaces, and the configuration of the track geometry approaching and within the station.

The preliminary report "Rapid Transit Noise Assessment and Abatement/Cost Requirements" by U. S. DOT Transportation Systems Center (TSC) of March 1973 covers a measurement program done on MBTA rail rapid transit lines. It describes station noise as follows:

"In the absence of any train, waiting patrons hear ambient noise due to station machinery and, if the station is above ground, from traffic and aircraft. As a train arrives the awaiting patrons hear low frequency noise. Usually the noise level reaches a peak in about six to eight seconds and drops rapidly during the next several seconds to a rough noise plateau as the train stops. Frequently, the mechanical tread-braking produces a short screech prior to the stop. In the worst cases, the following effects then occur in rapid succession: (1) Door slam; (2) Brake air release hiss; (3) auxiliary equipment such as ventilation and motor-generators produce a steady noise. As the train departs another sequence of door slam and brake hiss noises..."
occur followed by the low frequency rumble of the departing train." This sequence of events is shown on Figure 4.

A comparison of subway station platform noise levels for various rail transit systems is shown below:

<table>
<thead>
<tr>
<th>Car Type</th>
<th>Passby Speed and Conditions</th>
<th>Noise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>BART</td>
<td>0 mph</td>
<td>63-64 dBA</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Entering &amp; Leaving</td>
<td>70-75</td>
</tr>
<tr>
<td>TTC</td>
<td>Entering &amp; Leaving -</td>
<td>85-91</td>
</tr>
<tr>
<td></td>
<td>No acoustical treatment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>With acoustical treatment</td>
<td>70-80</td>
</tr>
<tr>
<td>PATCO Lindenwold</td>
<td>Entering &amp; Leaving -</td>
<td>79-89</td>
</tr>
<tr>
<td></td>
<td>No acoustical treatment</td>
<td></td>
</tr>
<tr>
<td>Paris Metro New</td>
<td>20 mph</td>
<td>75-82</td>
</tr>
<tr>
<td>Steel Wheel</td>
<td>40</td>
<td>89-91</td>
</tr>
<tr>
<td></td>
<td>Entering &amp; Leaving</td>
<td>80-86</td>
</tr>
<tr>
<td>Paris Metro Rubber</td>
<td>20 mph</td>
<td>73</td>
</tr>
<tr>
<td>Tire</td>
<td>40</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Entering &amp; Leaving</td>
<td>80-85</td>
</tr>
<tr>
<td>Paris RER</td>
<td>Entering &amp; Leaving</td>
<td>70-80</td>
</tr>
<tr>
<td>CTA</td>
<td>Tunnel Stations with</td>
<td>103-110</td>
</tr>
<tr>
<td></td>
<td>Concrete Trackbed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subway Stations with</td>
<td>90-95</td>
</tr>
<tr>
<td></td>
<td>Ballast &amp; Tie Track</td>
<td></td>
</tr>
<tr>
<td>MBTA - high</td>
<td>Entering &amp; Leaving</td>
<td>84-93</td>
</tr>
<tr>
<td>platform lines</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sample Time History of Station Platform Noise Levels (dBA)
The TSC measurement program in Boston included platform noise level measurements in eighteen of the forty-four stations of the three rapid transit lines. In some cases continuous recordings were made and in others a series of rapid hand held meter readings were obtained. The microphone or meter was placed about ten feet back from the platform edge at a typical waiting location. The average of the arriving and departing peaks in the A-weighted sound levels was chosen as a simple measure of the severity of noise in stations.

Based on the measurements, noise levels were estimated for all the remaining stations on these lines. Measured and estimated values are shown below:

<table>
<thead>
<tr>
<th>Station</th>
<th>Type</th>
<th>Avg. of Entering &amp; Leaving peaks (dBA)</th>
<th>Ambient Level (dBA)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bowdoin</td>
<td>Subway</td>
<td>90</td>
<td>55</td>
<td>Measured</td>
</tr>
<tr>
<td>2. Govt. Center</td>
<td>Subway</td>
<td>89</td>
<td>62</td>
<td>Measured</td>
</tr>
<tr>
<td>3. State</td>
<td>Subway</td>
<td>90</td>
<td>55</td>
<td>Measured</td>
</tr>
<tr>
<td>4. Aquarium</td>
<td>Subway</td>
<td>85</td>
<td>45</td>
<td>Measured</td>
</tr>
<tr>
<td>5. Maverick</td>
<td>Subway</td>
<td>88</td>
<td>53</td>
<td>Measured</td>
</tr>
<tr>
<td>6. Airport</td>
<td>Surface</td>
<td>90</td>
<td>58</td>
<td>Measured</td>
</tr>
<tr>
<td>7. Wood Island</td>
<td>Surface</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>8. Orient Hghts.</td>
<td>Surface</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>Station</td>
<td>Type</td>
<td>Avg. of Entering &amp; Leaving peaks (dBA)</td>
<td>Ambient Level (dBA)</td>
<td>Comments</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------</td>
<td>---------------------------------------</td>
<td>---------------------</td>
<td>------------</td>
</tr>
<tr>
<td>9. Suffolk Downs</td>
<td>Surface</td>
<td>92</td>
<td>54</td>
<td>Measured</td>
</tr>
<tr>
<td>11. Revere Beach</td>
<td>Surface</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>12. Wonderland</td>
<td>Surface</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td><strong>b) Orange Line</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Everett</td>
<td>Surface</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>2. Sullivan</td>
<td>Elevated</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>3. Thompson</td>
<td>Elevated</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>4. City Square</td>
<td>Elevated</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>5. North Sta.</td>
<td>Elevated</td>
<td>87</td>
<td>66</td>
<td>Measured</td>
</tr>
<tr>
<td>6. Haymarket</td>
<td>Subway</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>7. State</td>
<td>Subway</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>8. Washington</td>
<td>Subway</td>
<td>84</td>
<td>60</td>
<td>Measured</td>
</tr>
<tr>
<td>9. Essex</td>
<td>Subway</td>
<td>87</td>
<td>55</td>
<td>Measured</td>
</tr>
<tr>
<td>10. Dover</td>
<td>Elevated</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>11. Northampton</td>
<td>Elevated</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>12. Dudley</td>
<td>Elevated</td>
<td>80</td>
<td>64</td>
<td>Measured</td>
</tr>
<tr>
<td>13. Egleston</td>
<td>Elevated</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>14. Green</td>
<td>Elevated</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>15. Forest Hills</td>
<td>Elevated</td>
<td>78-82</td>
<td>-</td>
<td>Estimated</td>
</tr>
</tbody>
</table>
**c) Red Line**

<table>
<thead>
<tr>
<th>Station</th>
<th>Type</th>
<th>Avg. of Entering &amp; Leaving peaks (dBA)</th>
<th>Ambient Level (dBA)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Harvard</td>
<td>Subway</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>2. Central</td>
<td>Subway</td>
<td>93-97</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>3. Kendall</td>
<td>Subway</td>
<td>93</td>
<td>55</td>
<td>Measured</td>
</tr>
<tr>
<td>4. Charles</td>
<td>Elevated</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>5. Park</td>
<td>Subway</td>
<td>89</td>
<td>62</td>
<td>Measured</td>
</tr>
<tr>
<td>7. South Sta.</td>
<td>Subway</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>8. Broadway</td>
<td>Subway</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>9. Andrew</td>
<td>Subway</td>
<td>90</td>
<td>62</td>
<td>Measured</td>
</tr>
<tr>
<td>10. Columbia</td>
<td>Surface</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>11. Savin Hill</td>
<td>Surface</td>
<td>85</td>
<td>72</td>
<td>Measured</td>
</tr>
<tr>
<td>12. Fields Corner</td>
<td>Surface</td>
<td>83</td>
<td>50</td>
<td>Measured</td>
</tr>
<tr>
<td>13. Shawmut</td>
<td>Subway</td>
<td>88-92</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>15. North Quincy</td>
<td>Surface</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>16. Wollaston</td>
<td>Surface</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
<tr>
<td>17. Quincy Ctr.</td>
<td>Subway</td>
<td>83-87</td>
<td>-</td>
<td>Estimated</td>
</tr>
</tbody>
</table>

The noise level for MBTA high platform subway stations was measured or estimated within a range of 84 to 93 dBA, surface stations 78 to 92 dBA, and elevated stations 78 to 87 dBA.
A study by Bolt Beranek and Newman "The Acoustical Treatment of Stations to Alleviate Wheel-Squeal Noise" of October 1970 included measurements at 3 Green Line subway stations where small radius curves created extreme noise levels:

1. Government Center: 93-105 dBA Entering Southbound
   97-109 dBA Leaking Southbound
2. Park Street: 95-114 Entering Southbound
3. Boylston: (curve) 93-105 Entering Northbound
   95-98 Leaking Westbound

Noise levels in areas of stations other than platforms will vary with the distance from the tracks, and the shape and composition of openings, passageways, or barriers between the tracks and the area in question. The designers should have measurements made at locations where noise problems are apparent. At locations in the station where personnel are on duty, such as collector's booths adjacent to subway platforms, a health hazard due to excessive noise may be possible. Preliminary study by TSC has indicated that the present facilities lie within present OSHA criteria, but in some cases the margin is small.

Noise levels in bus terminal areas of enclosed stations, such as Fields Corner or Ashmont, may reach 80 to 85 dBA. Generally the bus noise is less of a problem at stations than the train noise.
Exterior noise levels at surface or elevated stations will depend on the location of tracks with respect to the receivers, and the physical design of the structure supporting and/or enclosing the station.

Noise levels adjacent to platforms at open surface stations, such as North Quincy, is similar to levels on the platform, except that the sound will be attenuated with increasing distance from the track. Noise adjacent to station approaches is similar to that on line sections of the same geometric configuration for speeds in the area of 30 to 50 mph (the higher speed being further from the station). At stations with sharply curved track approaches, wheel squeal can be expected, which can cause annoyance to station users or neighbors.

Along subway sections vent shafts occur, often in the vicinity of stations. Depending on their configuration and location with respect to wayside receivers, vent shafts may create problems. Therefore acoustical studies of modernized or new subway stations should include consideration of vent shafts.

B. Noise Criteria for Modernization and New Design

The purpose of these criteria is to establish guidelines for good practice for the designers of new facilities. These
criteria are based on the "Guidelines and Principles for Design of Rapid Transit Facilities" by the Institute for Rapid Transit, draft of June 1972.

Because of the built-in characteristics of existing facilities and equipment, it is not practical to expect that modernized stations and structures will be able to meet these standards. The designer for modernization projects should consider these criteria as a desirable "ideal" goal while in the process of seeking means of making a significant improvement over the existing noise environment.

The IRT guideline criteria are not intended to be, nor are they to be confused with, noise abatement controls of the type enacted or proposed by various communities or public agencies.

1) Types of Noise Criteria

There are two principle types of noise criteria which are based on some measure of human response to noise. They are:

- **Criteria Based On Ambient Noise Levels.** This type of criterion uses limits based on the difference between the noise in question and the prevailing ambient noise. Criteria based on ambient noise levels are often used to set objectives for remedial design in existing systems. They are generally applicable in problems relating to the system impact on the community.
Ambient noise levels in the community have been rising rapidly in recent years. Criteria based on ambient levels should be reviewed periodically to determine whether or not the ambient will have any significant effect on the public.

**Absolute Limit Criteria.** These criteria use absolute limits related to measurable physical quantities. They usually deal with hearing damage and protection, speech communication or interference with other tasks and subjective reactions such as annoyance and are used in ensuring an acceptable acoustical environment for passengers and employees of the system.

The use of absolute criteria in design problems relating to system impact on the community should be considered carefully. There is a wide variation in public reaction that can occur even at the same noise levels.

Factors which may affect public reaction to noise, besides the fact that a noise is new and higher than existing ambient level, include high socio-economic status, property ownership, duration and frequency of noise, previous community exposure, nature of the community and its previous success with complaints.
However, the primary objective in good transit design should therefore be to reduce annoyance rather than simply reduce complaints.

4) Rail Transit Noise and Vibration Criteria for New Design

The following assumptions are made in stating the criteria herein:

- Noise, or sound pressure levels, are measured with a sound level meter which meets the Type 2 requirements of American National Standard (ANS) S1.4-1971, Specification for Sound Level Meters.

- All noise levels are in decibels referred to 0.0002 microbar. (0.002 bar)

- The "slow" meter response is assumed for all noise level measurements except those involving measurements of moving and transient sources such as exterior train noise, train noise from vent shafts and car door operation. The latter sources should be measured using "fast" meter response.
# RAIL TRANSIT NOISE AND VIBRATION CRITERIA FOR NEW DESIGN

## a) TRANSIT VEHICLES, NOISE AND VIBRATIONS

### Vehicle Interior Noise Levels (Empty car)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>In open (ties and ballast) at maximum speed</td>
<td>68 dBA</td>
</tr>
<tr>
<td>In open (concrete trackbed) at maximum speed</td>
<td>72 dBA</td>
</tr>
<tr>
<td>In tunnels at maximum speed</td>
<td>78 dBA</td>
</tr>
<tr>
<td>All auxiliaries operating, car stationary</td>
<td>65 dBA</td>
</tr>
<tr>
<td>One auxiliary system operating, car stationary</td>
<td>60 dBA</td>
</tr>
<tr>
<td>Door operation</td>
<td>65 dBA</td>
</tr>
</tbody>
</table>

### Vehicle Exterior Noise Levels (50 ft. from T & B Track)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car stationary, auxiliaries operating</td>
<td>60 dBA</td>
</tr>
<tr>
<td>Two-car train at max. speed (70 mph)</td>
<td>83 dBA</td>
</tr>
</tbody>
</table>

### Vehicle Equipment Noise Levels (15 ft. from car)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propulsion system at equivalent to max. speed</td>
<td>90 dBA</td>
</tr>
<tr>
<td>Car stationary, auxiliaries operating</td>
<td>65 dBA</td>
</tr>
<tr>
<td>Decrease in criteria for presence of pure tones</td>
<td>3 dBA</td>
</tr>
</tbody>
</table>

### Vibration Levels

Measurements taken on car interior surfaces unless noted. Displacements measured peak-to-peak. Velocity and acceleration are:
<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum amplitude</td>
<td>0.10 in.</td>
</tr>
<tr>
<td>Maximum acceleration, up to 10 Hz.</td>
<td>0.01 g.</td>
</tr>
<tr>
<td>Maximum velocity, 1&quot; Hz. and over</td>
<td>0.03 in/sec.</td>
</tr>
<tr>
<td>Maximum amplitude on detached traction</td>
<td></td>
</tr>
<tr>
<td>motors</td>
<td>0.0015 in.</td>
</tr>
</tbody>
</table>

b) STATION NOISE

- Underground Station Noise Levels

  - Platform level, trains entering and leaving 80 dBA
  - Platform level, trains passing through 85 dBA
  - Platform level, trains stationary 67 dBA
  - Maximum train room reverberation time 1.6 to 2 sec.
  - Platform level, only station ventilation system operating 55 dBA
  - In station attendants booths 45 dBA

- Surface or Elevated Station Noise Levels (Interior)

  - Platform level, trains entering and leaving 70-75 dBA

3) Criteria for Community Exposure to Rail Transit Noise and Vibration

The criteria for vehicle exterior noise levels of 85 dBA included in section 2 above represent the maximum noise level permitted at a distance of 50 feet from a train at speed on modern
track. It is necessary, however, that the designer consider the
noise and vibration generated by trains, fixed equipment, and
by motor vehicles at terminals, as felt by the actual receivers
along the wayside.

a) **Airborne Noise**

Community noise levels may be considered in five general
categories according to ambient sound levels at night:

<table>
<thead>
<tr>
<th>Area Category</th>
<th>Area Descriptions</th>
<th>Ambient Noise Levels at Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quiet urban residential, open space park, suburban residential or recreational area. No nearby highways or boulevards.</td>
<td>35-40 dBA</td>
</tr>
<tr>
<td>2</td>
<td>Average urban residential, quiet apartments and hotels, open space, suburban residential, or occupied outdoor area near busy streets.</td>
<td>40-45 dBA</td>
</tr>
<tr>
<td>3</td>
<td>Busy urban residential, average semi-residential/commercial areas</td>
<td>45-55 dBA</td>
</tr>
<tr>
<td>4</td>
<td>Commercial areas with office buildings, retail stores, etc., with daytime occupancy only. Open space parks, suburban areas near highways or high speed boulevards, distant residential buildings.</td>
<td>Over 55 dBA</td>
</tr>
<tr>
<td>5</td>
<td>Industrial or Highway Corridors with either residential or commercial areas adjacent.</td>
<td>Over 60 dBA</td>
</tr>
</tbody>
</table>
Airborne noise from above-ground train operations should be considered in relation to the nature of the adjacent community. In view of the transient nature of train operational noise, community acceptance should be expected provided that noise levels do not exceed the following criteria:

**NOISE CRITERIA FOR TRAIN OPERATIONS**

<table>
<thead>
<tr>
<th>Area Category</th>
<th>Transit Noise Level Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quiet residential</td>
<td>70 dBA</td>
</tr>
<tr>
<td>2. Average residential</td>
<td>75 dBA</td>
</tr>
<tr>
<td>3. Busy residential/semi-commercial</td>
<td>80 dBA</td>
</tr>
<tr>
<td>4. Commercial/open</td>
<td>85 dBA</td>
</tr>
<tr>
<td>5. Industrial and Highway Corridor</td>
<td>85-90 dBA</td>
</tr>
</tbody>
</table>

These criteria are referenced to a point 50 feet from track centre line. In cases where buildings or occupied areas are further from the transit line, the criteria may be referenced to the building or area being considered.

It is obvious that to meet these criteria, or more stringent criteria which may be necessary when the right-of-way is close to special uses such as schools, theatres, etc., the designer must provide further means of reducing wayside noise, as will be discussed in the section on noise abatement measures.

Airborne noise from wayside transit facilities such as vent shafts and substations, should meet the below listed criteria. Note that in the case of vent shafts the transient
criteria apply to the sound created by passing trains, and in the case of fan shafts, pumping stations, and substations, the steady state criteria apply. Transient noises are acceptable at higher levels than steady-state noises particularly when the latter contain pure tones.

**CRITERIA FOR NOISE FROM WAYSIDE TRANSIT FACILITIES**

<table>
<thead>
<tr>
<th>Area Category</th>
<th>Noise Level Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transient</td>
</tr>
<tr>
<td>1. Quiet residential</td>
<td>45 dBA</td>
</tr>
<tr>
<td>2. Average residential</td>
<td>50 dBA</td>
</tr>
<tr>
<td>3. Busy residential, semi-commercial</td>
<td>55 dBA</td>
</tr>
<tr>
<td>4. Commercial/open</td>
<td>60 dBA</td>
</tr>
</tbody>
</table>

b) **Groundborne Noise and Vibration**

Vibration levels from modern transit cars and track are below the threshold of perception in most circumstances. However, these levels are still sufficient to generate a low frequency rumbling noise which can signal the passage of a train. This noise level is frequently of sufficient loudness to create a significant intrusion or annoyance.

The principal noise sources in modern buildings are the air conditioning and ventilating systems and background noises transmitted into the building from street traffic. Noise and vibration from these sources will often exceed those generated by transit operations.
The most critical locations where noise could create intrusion are sleeping rooms and auditoriums. Since sleeping rooms are most common and found in various classes of residences, interior noise criteria relating to these areas should be considered in the same area categories as airborne noise from wayside transit equipment.

For three categories of residential area the background noise in sleeping spaces is generally different, and the allowable noise level can be greater in the noisier areas. The table below indicates the range of levels for transient noise generated by mechanical vibration of the building structures, which should be acceptable to the community if not exceeded. It would be unreasonable in most cases to design for a noise level that is undetectable by occupants. The low level transient noises generated by groundborne vibrations from passing trains must be made unobtrusive but not necessarily undetectable.

**NOISE CRITERIA FOR INTERIOR SLEEPING AREAS**

<table>
<thead>
<tr>
<th>Area Category</th>
<th>Building Type And Sleeping Space Description</th>
<th>Groundborne Noise Level Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quiet residential</td>
<td>Private residences Apartments</td>
<td>25 to 30 dBA 30 to 35 dBA</td>
</tr>
<tr>
<td>2. Average residential</td>
<td>Private residences Apartments Hotels</td>
<td>30 to 35 dBA 35 to 40 dBA 40 to 45 dBA</td>
</tr>
<tr>
<td>3. Busy residential</td>
<td>Private residences Apartments Hotels</td>
<td>35 to 40 dBA 40 to 45 dBA 40 to 45 dBA</td>
</tr>
</tbody>
</table>
The table below presents generally acceptable noise levels in occupied spaces of various types of buildings. This Table is not intended to be all inclusive but may be a convenient general guide to the designer.

**MISCELLANEOUS ROOM NOISE CRITERIA**

<table>
<thead>
<tr>
<th>Type of Building or Room</th>
<th>Groundborne Noise Level Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditoriums or Concert Halls</td>
<td>25-30 dBA</td>
</tr>
<tr>
<td>Churches and Theaters</td>
<td>30-35 dBA</td>
</tr>
<tr>
<td>Music Rooms and TV Studios</td>
<td>30-35 dBA</td>
</tr>
<tr>
<td>Hospital Sleeping Rooms</td>
<td>35-40 dBA</td>
</tr>
<tr>
<td>Courtrooms</td>
<td>35-40 dBA</td>
</tr>
<tr>
<td>Schools</td>
<td>35-40 dBA</td>
</tr>
<tr>
<td>University Buildings</td>
<td>35-40 dBA</td>
</tr>
<tr>
<td>Offices</td>
<td>40-45 dBA</td>
</tr>
<tr>
<td>Commercial Buildings</td>
<td>45-50 dBA</td>
</tr>
</tbody>
</table>

Noise caused by the vibrations which meets the design criteria listed above will not be inaudible in all cases, however, the level will be sufficiently low that no significant intrusion or annoyance should occur. In most cases, there will be noise from street traffic, other occupants of a building, or other sources, which will create intrusion that is greater in level than the noise from transit trains passing by in adjacent tunnels.
C. Suggested Methods for Noise and Vibration Abatement

The designer is expected to explore a number of methods of noise and vibration control. Analysis of the noise problem at particular locations may require a combination of several solutions, some of which may be incorporated in the station or facility construction or modernization project, while others may be made a part of other improvement or maintenance projects carried out by Authority forces or outside contractors. The definition of project responsibility for specific noise abatement measures will be made by the Authority at the conclusion of the preliminary design phase.

The designer should consider the prevailing acoustic environment and the noise and vibration criteria when deciding how improvement can best be attained. In some situations, the retention of an Acoustical Consultant may be necessary. Materials and methods not described herein may be proposed, and will be approved by the Authority provided they meet acceptable standards of safety, durability, maintainability, appearance, and economy.

There are several principal means of abating rail transit noise:

- The most effective way of lessening rail transit noise is in the reduction of sound at its source. This can be achieved through:
(1) Basic design of the cars themselves in order to reduce noise creating movement.

(2) Resilient mounting of track and welding of rails

(3) A continuing program of wheel truing and other car maintenance procedures

- A second method of noise control is isolation, whereby barriers are introduced between the sound source and the receiver.

- A third method is absorption of the sound within a space.

- A fourth method is damping of resonant surfaces.

The first method involves design of cars which is beyond the scope of station and structure designers. The question of track design is covered extensively in the literature and will be only briefly reviewed here. Should noise measurements at particular sites indicate car or track related problems, these should be discussed in the consultant's report. The other methods of noise control will be covered in greater detail as they may be applied by the station or structure designer.

1. Noise and Vibration Reduction at the Source – Track Design

   Measures for noise and vibration reduction as applied to track concern rail joints, rail support and rail lubrication.
a) Rail Joints

Rail joints can create noise levels as high as 8 or 10 dB above the normal rolling noise. Welding of joints eliminates this problem though the grinding of the joint must be carefully done to be an effective noise reduction measure.

On lines with older signal systems insulated joints are necessary (Green, Orange and Blue lines) at the ends of track circuits. Normally these occur near the ends of stations. Lines with modern cab signal systems such as the Red Line do not require insulated joints except at interlockings.

"Frozen joints" created by glued or Huck bolted joint bars with no space left between rail ends do not substantially reduce noise compared with a normal bolted joint.

b) Rail Support

The conventional form of track construction on MBTA lines consists of rail resting on tie plates and secured to wooden ties with cut or screw spikes. In some cases thin pads are placed under the tie plate to reduce tie wear. Surface track on the South Shore Line has the rails attached to concrete ties with spring clips, with an elastomeric pad between rail and tie for vibration and electrical isolation.
Conventional construction has the disadvantage of producing rattles or impact sounds when the rail is not tightly fastened to the tie. On the other hand, the wood ties have some capacity to attenuate vibration, compared with concrete ties.

At bridges on the South Shore Line, the rails are clamped directly to the concrete deck with rubber pads between rail and deck and between rail and the hold-down clamps. Because of the configuration of the fastener and resonance of the bridge deck and supporting beams, the noise level on these bridges is up to 12 dB higher than on concrete tie and ballast surface track.

The design of earlier generation of track fasteners such as used on the South Shore bridges and on other systems, requires that the under-rail pad be preloaded by the bolts which clamp down the rail. Thus a portion of the resiliency of the pad is lost. More recent fasteners such as the "Landis Fasteners" used on BART permit the rail to float by clamping the rail to a steel plate forming the top layer of a rubber sandwich. The steel plate at the bottom of the sandwich is then attached to the bridge deck. This system on BART results in noise levels on bridges only 4 dB higher than tie and ballast surface track.

In MBTA subways wood tie and ballast construction is normal, however the ballast below the ties is only 6 to 8" deep, and is fouled with years accumulation of subway dirt. This reduces the
effectiveness of ballast as a vibration isolator. At specific locations it may be necessary to support the rail on the ties with resilient fasteners to achieve a significant reduction in structure borne noise and vibration.

A new method of rail support in subways now being installed in certain sections of the Washington Metro is the "floating slab". It consists of a continuous reinforced concrete slab mounted on resilient pads free of the tunnel invert and walls. The rails are held in place by resilient fasteners such as those used on BART. Preliminary tests indicate a 10 to 15 dB reduction in vibration intensity in the lower middle frequency band. Metro will use this system where the subway passes under or close to noise or vibration sensitive structures.

c) Rail Lubrication

Wheel-squeal at short curves can be reduced in intensity and duration or even eliminated by use of lubricating devices. Grease type lubricators apply to one or both faces of the wheel flanges as they approach a curve. The wheel carries the lubricant along the curve, depositing it along the edge of the running and restraining rails. A problem with these devices is that excessive amounts of lubricant can accumulate on the running surface of the rail, interfering with normal braking of trains.
Another type of lubricator sprays water, or water with a small amount of lubricant in suspension, on the wheel and rail at the start of a curve. Trial of this method on the MBTA indicated that the water dried off at about the end of the curve so that interference with normal braking was minimal. This method cannot be used on outdoor locations during the winter months.

2. **Noise Reduction by Isolation**

The placement of barriers between the noise source and the receiver are a very effective means of reducing noise.

a) **Wayside Barriers**

Barriers along surface rail lines or solid-deck viaducts can reduce noise levels from 6 to 12 dBA. Maximum effectiveness can be gained by eliminating openings which would allow sound to bypass the barrier, and by placing sound absorbing material on the face of the barrier. The barrier should be close to the source, and extend to car floor level.

Barriers may be constructed of concrete, masonry, earth, or light weight wood or metal panels. Normally mass is required to stop transmission of sound but in the case of the light-weight panels, the sound absorbing material against a solid backing can trap some of the sound on its way through. As barriers will reflect sound it may be necessary to apply sound absorbing material to wall surfaces across the track from a barrier.
(Sound absorption treatment is discussed in detail in part 3 of this section.)

A very effective barrier results from depressing track in an open cut with walls or slopes. Depending upon the location of the receivers, barrier walls at the top of slope may be required. Figure 5 shows noise reductions expected by various wayside barriers.
ELEVATED, 4' ACOUSTIC BARRIER

ELEVATED, NO ABATEMENT

DEPRESSED, 6' ACOUSTIC BARRIER

DEPRESSED, NO ABATEMENT

AT GRADE, 6' ACOUSTIC BARRIER

AT GRADE, NO ABATEMENT

PEAK NOISE CONTOURS

Figure 5

ACOUSTICS VIII

41
b) Barriers in Stations

At certain stations it may be possible to utilize noise barriers. At Park Street and Boylston Stations, where some of the most acute problems occur there are opportunities for this treatment. Stations with staggered platforms expose persons on one platform to noise from trains at speed on the track in the opposite direction. Because of the nature of an enclosed station where sound is reflected by walls and ceilings, etc., and thus reaches the receiver by many paths, barrier design in the subway requires more analysis than that required by a wayside installation. This is discussed in the following paragraphs taken from Bolt Beranek & Newman Inc. Report 2052 made for the MBTA in 1970:

The effectiveness of acoustic barriers depends on whether the listener is in the direct or reverberant sound field. The direct sound field is close to the sound source where the SPL owing to sound transmitted directly from the source to the listener is greater than the SPL owing to multiple reflections of sound. Conversely, the reverberant field describes the region farther from the source where reflected sound waves dominate. For the stations we studied, the reverberant field begins approximately 10 ft. from the train wheels.
Barriers reduce direct-field noise levels by "shielding" the listener from the sound waves. The sound which the listener actually hears is diffracted or "bent" over the top of the barrier. However, sound will also be transmitted through barriers and may be significant if the barriers are too flimsy. For the reverberant field, the barrier is effective only in absorbing a portion of the sound power radiated by the source. For example, a barrier must absorb 90% of the sound power to reduce the reverberant field by 10 dB. Thus, to reduce reverberant field levels significantly, barriers, along with acoustical treatment along other paths from the source, must cover a substantial portion of the area through which sound can be radiated.

The BB&N study considered the possibility of using barriers in low platform stations such as Government Center, where gaps would be left to provide access to the trains. It was found however, that the intermittent sound level produced by train wheels passing the barrier gaps would be more annoying to the receiver than the situation with no barrier at all.

Barriers should be placed as close to the source as possible. On curves there must be sufficient space allowed for overhang of the car ends outside of curves, and car center inside of curves, plus an allowance for car roll. Safety niches for personnel must also be provided approximately 20' on center if refuge space is not available immediately across the track from the barrier.
To be effective in reducing reverberant field levels, absorptive barriers must be used on both sides of the vehicle; or if there is a wall next to one side, it should be treated with an absorptive material. It is essential to line the barrier with an absorptive material in order to dissipate acoustic energy. The thickness of the material should be equal to approximately 1/4 of the wavelength of sound to be attenuated.

The sound power radiated beyond the barrier will be approximately proportional to the ratio of the angle subtended by the gap between the barrier and car to the total angle (approximately 90°) from which the sound is radiated to one side of the car. Thus the noise reduction is given by

\[ \Delta L = 10 \log \left[ \frac{\pi/2}{\tan^{-1}(a/h)} \right] \]

where \( h \) is the barrier height. From Eq. (1) we find that a 10-dB reverberant-field reduction requires that \( h \geq 7a \).

Barriers attenuate radiation to the direct field principally by diffraction rather than absorption. The excess attenuation \( A_e \) along a line perpendicular to the top edge of the barrier is given approximately by

\[ A_e \approx 10 \log \left( \frac{fh^2}{ca} \right) + 10 \]
where \( h \) is the barrier height, \( f \) the frequency, and \( c \) the speed of sound in air. Equation 2 is valid for values of \( A_e \) up to approximately 20 dB. Values in excess of the 20 dB predicted by Eq. 2 should be reduced to 20 dB. Furthermore, Eq. 2 is based on the assumption that the sound source is at the same height as the base of the barrier. This is not entirely valid since sound is probably radiated from the entire wheel surface. Hence, Eq. 2 is an upper bound to the direct-field noise reduction provided by a barrier.

The direct-field and reverberant-field reductions in sound pressure level are shown in the Figure 6 for three stations of interest. We find that the maximum values of direct-field attenuation vary between approximately 15 and 20 dB. In the reverberant field (farther from the train) the noise reduction is less, ranging from an estimated 4.2 to 10 dB. The comment "with full wall lining" applies to those sections of the track that are bounded by a full height wall. The desired sound reduction requires that these walls be lined with an absorptive treatment like the barrier treatment shown in Figure 7.

Barriers should generally be constructed as illustrated in Figure 7. The essential features are a rigid wall lined with a sound-absorbing material which faces the noise-producing wheels. The construction details are unimportant, provided they meet the following criteria:
# BARRIER EFFECTIVENESS AT THREE MBTA STATIONS.

<table>
<thead>
<tr>
<th>Location</th>
<th>Track Radius (ft)</th>
<th>Barrier Clearance at Truck Center</th>
<th>Direct Field maximum value of $A_e$ at 10 ft for 3-ft barrier</th>
<th>Reverb Field</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inner $A_{ib}$</td>
<td>Outer $A_{ob}$</td>
<td>800 Hz</td>
<td>2850 Hz</td>
</tr>
<tr>
<td>Park Street</td>
<td>45</td>
<td>2.1</td>
<td>2.0</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>82</td>
<td>1.4</td>
<td></td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>1.2</td>
<td>1.2</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Government Center</td>
<td>100</td>
<td>1.2</td>
<td></td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>0.9</td>
<td></td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Boylston Street</td>
<td>85</td>
<td>1.4</td>
<td>1.4</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>1.3</td>
<td>1.3</td>
<td>16</td>
<td>20</td>
</tr>
</tbody>
</table>

*A full height wall between the curved portions of the tracks extending into the station approximately 50 - 100 ft beyond the curves would be very effective in reducing noise levels owing to outbound trains. The lower 3 ft of the wall should be lined with absorptive material similar to that used in barrier construction, not only to reduce station noise but also to reduce sound reflected back toward the cars.*
RIGID WALL
(e.g., CONCRETE, 2 IN. THICK)

GLASS FIBER BLANKET
IN THIN MYLAR BAGS

PERFORATED METAL FACING
(GREATER THAN 50% OPEN AREA)

SCHEMATIC DIAGRAM OF BARRIER CONSTRUCTION
1) The wall should be sufficiently massive to attenuate the sound passing through it by a greater amount than the attenuation of sound passing over the top. For example, a 2 - 4 in. concrete wall would be adequate.

2) The absorptive coefficient of the material should be greater than 0.8 over the frequency range of interest (800 - 5000 Hz). This can be accomplished with a 4-in. thick Fiberglas blanket.

3) The porous material must not be allowed to become clogged with dirt. Enclosing the blanket with very thin Mylar bags is probably the best current procedure.

4) The absorptive layer should be protected from damage. This can be done by covering it with perforated sheet-metal with an open area of 50% or more.

3. Noise Reduction by Absorption
   a) Station Treatment

   As seen in the discussion of barriers, it is necessary to utilize sound absorbing materials on barriers, and in subways on walls associated with barriers. Additional improvement in the noise level at stations can be achieved by treating ceilings and walls with sound absorbing material.
In typical interior architectural spaces where the length, width, and height of the space do not vary from each other by a factor of more than two or three to one, the sound level drops off as one moves away from the source until the "reverberant field" of the room is reached. From this point, increasing the distance from the sources does not result in a further decrease in the sound level. The addition of sound-absorbing treatment in such a space will result in a reduction of the sound level in the reverberant field of the room, although it will have no affect on the sound level in the near field of the source. If the original room consists of hard, sound-reflecting surfaces (e.g., concrete), the addition of substantial amounts of sound-absorbing treatment can result in reductions in the reverberant sound level of as much as 15 decibels.

Acoustically, subway stations represent a type of space much different from the normal interior architectural space described in the paragraph above. This station may be considered as a "two-dimensional room". The width of the station is from four to ten times the height, and the length of the station is approximately 20 times the height. In this type of space, the sound level drops as one moves away from the source of sound much as it does in the near field of the sound source in a normal "diffuse" room. Instead of leveling off, as it does when one
reaches the reverberant field in a normal diffuse room, the level continues to drop with distance so that the farther one moves from the sound source, the lower the sound level will be. In its present condition, with all surfaces hard and sound-reflecting, the following reductions in sound level may be expected as one moves away from a sound source:

Table I

<table>
<thead>
<tr>
<th>Change in Distance From Source</th>
<th>Reduction in Sound Level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ft - 6 ft</td>
<td>5</td>
</tr>
<tr>
<td>6 ft - 12 ft</td>
<td>4</td>
</tr>
<tr>
<td>12 ft - 24 ft</td>
<td>3</td>
</tr>
<tr>
<td>Beyond 24 ft</td>
<td>3 dB per doubling of distance</td>
</tr>
</tbody>
</table>

Reductions in sound level shown in the table above may be added together to find the total drop-off. For example, if one moves from 3 ft to 24 ft from the sound source, the total sound reduction will be the sum of 5 + 4 + 3, or 12 dB. The table is somewhat simplified and ignores the wall reflections which would influence the results, particularly for locations close to wall surfaces. It is not felt, however, that these differences would have any significant affect on final conclusions relating to sound-absorbing treatment within the station.
The sound field within the station can be influenced by the addition of a highly efficient absorbing treatment to the entire ceiling of the station. For example, suspended perforated metal pans with glass fiber batts above or a porous, washable ceramic acoustic tile would be desirable. This type of treatment would result in greater attenuation of sound as one moves away from the sound source. The following conditions might be expected if the entire ceiling in the station consisted of a very efficient sound-absorbing material.

Table II

REDUCTION OF SOUND WITH DISTANCE IN A STATION WITH A SOUND-ABSORBING CEILING

<table>
<thead>
<tr>
<th>Change in Distance From Source</th>
<th>Reduction in Sound Level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ft - 6 ft</td>
<td>5</td>
</tr>
<tr>
<td>6 ft - 12 ft</td>
<td>5</td>
</tr>
<tr>
<td>Beyond 12 ft</td>
<td>5 dB per doubling of distance</td>
</tr>
</tbody>
</table>

Using the information presented in Tables I and II, the noise reduction due to addition of a sound-absorbing ceiling may be calculated as a function of distance from the sound source. The following table presents this information.
Table III

<table>
<thead>
<tr>
<th>Distance from Source</th>
<th>Noise Reduction (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 ft</td>
<td>0</td>
</tr>
<tr>
<td>12 ft</td>
<td>1</td>
</tr>
<tr>
<td>24 ft</td>
<td>3</td>
</tr>
<tr>
<td>50 ft</td>
<td>5</td>
</tr>
<tr>
<td>100 ft</td>
<td>7</td>
</tr>
<tr>
<td>200 ft</td>
<td>9</td>
</tr>
<tr>
<td>400 ft</td>
<td>11</td>
</tr>
</tbody>
</table>

Preliminary study of Park St. Station by BB&N indicated that significant reductions in noise level of 7 to 11 dB were possible over much of the station. In certain frequency ranges where wheel-squeal peaks occur, reductions as high as 15 dB are possible. As stations such as Government Center, where curve tracks run through the station, little reduction immediately adjacent to the track is possible, but at locations further from the track would get 5 to 10 dB reductions.

The result of extensive sound absorbing treatment in subway stations would be greater than a simple reduction in overall noise levels. The effect of sound-absorbing treatment in any noisy environment is usually to make the space "feel" quieter than it actually is by minimizing the persistence (reverberation) of sound in the space and making the sound seem to come from its...
actual source and not from everywhere. Ideally, efficient sound-absorbing treatment should be applied to the enclosing surfaces of a given station to the maximum possible extent. For practical reasons, considering durability, ease of maintenance, etc., the areas available for sound-absorbing treatment are limited to the ceiling surfaces and, in some cases, the lower wall areas adjacent to the tracks (i.e., side pit areas). The reduction in reverberant noise levels in a typical station may be approximated by the relationship:

\[
NR = 10 \log_{10} \frac{S_2}{S_1}
\]

where: \( NR \) is the noise reduction in decibels

- \( S_2 \) is the calculated total absorption in sabins after treatment (sq. ft. of absorbing area x its sound absorbing coefficient)

- \( S_1 \) is the calculated absorption in sabins without treatment

The following factors should be observed in the selection and use of sound-absorbing materials to reduce noise levels:

- Sound-absorbing materials should be located insofar as possible to avoid large areas of opposing hard, sound-reflective surfaces.
Sound-absorbing efficiency of materials generally increases with increasing thickness. Materials spaced away or suspended from a hard backup surface (i.e., Mounting #7 as defined by the Acoustical Materials Association) will provide increased low frequency absorption over the same material applied directly to a hard backup surface (Mounting #1).

Materials placed in strips, or patches (2-4 ft wide) with hard areas between often provide as much absorption as continuous areas of the materials due to diffraction and edge effects.

Materials with relatively large fissures or perforations on the surface are least effected by future painting from the standpoint of sound-absorbing efficiency.

Treatments using glass fibre baths should have the bath contained in Mylar bags to prevent clogging of pores by dirt.

Care should be taken to avoid build-up of dirt on top of suspended ceiling panels. Such panels should also be designed to prevent their being blown out by air currents or over-pressures caused by passing trains.

Materials should not create a fire hazard.
Absorbent materials not enclosed by bags, such as spray-on types, should be washable.

Materials should be selected which are colored, or can be painted to minimize discoloration by dirt near the track bed, and minimize loss of light when used at or near the ceiling.

Easily damaged materials should not be used on surfaces where they may be reached by the public to eliminate vandalism.

Recommended specifications to cover sound absorption for sound absorbing materials suitable for ceiling and wall applications are as follows:

The sound absorption performance for the materials shall be verified by a test report from an independent acoustical laboratory. The test shall be conducted in accordance with Recommended Method of Test ASTM C-423-60T.

For suspended sound-absorbing materials the sound absorption coefficients shall meet or exceed the following values:

<table>
<thead>
<tr>
<th>Frequency, cps</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption coefficient</td>
<td>0.2</td>
<td>0.4</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
For surface-applied materials the sound absorption coefficients shall meet or exceed the following values:

<table>
<thead>
<tr>
<th>Frequency, cps</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption coefficient</td>
<td>0.2</td>
<td>0.4</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

b) Tunnel Treatment

The tunnel areas outside of stations may be treated with sound absorbing materials. In this case appearance of the material and susceptibility to vandalism is not a problem. However certain materials, such as glass fibre bats in plastic bags, would have to be protected by a durable mesh or screen to prevent accidental damage by workers in the tunnels.

The material is normally applied to the lower 5' or 6' of the tunnel walls. This treatment can result in noise reduction in the vicinity of 5 dB.

4. Damping of Resonant Surfaces

Secondary radiation from structural members of viaducts, or wall or ceiling surfaces in stations can add to the noise level created by passing trains. Some of these problems can be avoided by initial choice of material. For instance, a precast concrete bridge structure will be less resonant than a similar structure in steel.
Application of a viscoelastic material to surfaces of beams or panels works by reducing the height of resonance peaks. Thus this treatment can reduce identifiable tones making the sound more acceptable. The material is effective on large uninterrupted radiating surfaces, such as thin plate girders, but would be useless on small members of a steel truss.

The materials should be very stiff, nearly that of the surface they are being applied to. They may be applied as a single layer, or as a sandwich, with the viscoelastic material being covered by a metal constraining sheet.

5. Other Methods of Noise and Vibration Abatement

It may be necessary to treat the building or structure on the receiving-end of rail transit generated noise, rather than, or in addition to, treatment of the transit facility. In the case of structure or ground borne noise or vibration, a building or space within a building may be floated on resilient pads to isolate it from such disturbances. This could apply particularly to air rights buildings.

Experience in London has shown that elastomeric pads can be considerably more effective than the traditional lead-asbestos pads used in the U.S. They were used in new structures immediately over transit tracks in open cut, and in buildings near deep "tube" lines lying in London Blue Clay which was a good transmitter of vibration at certain frequencies.
Airborne noise may be reduced at the receiver by use of double glazing. This may require installation of air conditioning which has the additional effect of raising the ambient noise level and making the intermittent train sounds less noticeable.

In extreme cases, it may be more cost effective to acquire properties suffering from an acute transit noise problem, rather than the noise generator or receiver.
1. **System Requirements**

Unless determined otherwise by the Director, every station shall have a paging and announcing system for the dissemination of schedule changes, arrival and departure calls, and emergency announcements. The system need not attempt to overpower the noise of trains, but must provide intelligible information for auditors at platform level, when trains are not in motion. In the highly reverberant environment of station, this will mean a relatively large number of low power speakers fairly closely spaced.

Microphone positions are required in all collection and token booths, and in all starters rooms. Each position will have a monitor loudspeaker. Amplifier equipment should be located in a central equipment room, preferably an electric or other room which will not normally be accessible to unqualified personnel. Equipment confined to a small space must be adequately ventilated. In every station there should be a conduit running to the tunnel electric duct bank to permit future connection to a more general system.
2. **Consultant's Report**

One matter that has been discussed, is the possibility of installing loudspeaker systems in the stations to transmit announcements and, if desired, playing background music. Such a system can only be satisfactory in a station that has been treated with sound-absorbing material to make it reasonably "non-reverberant." Our preliminary studies indicate that it is unrealistic to attempt to design a loudspeaker installation that would override the noise of subway trains entering the station, but there is no reason why the system cannot override the average rush hour condition when trains are not actually moving.

The following performance objective should be considered in the design of a system to be used in the subway stations. The loudspeaker system should provide:

a) Satisfactory levels of amplified sound, with respect to ambient noise levels expected during both quiet and peak activity periods. The system would not be expected to override excessive levels during an actual train passage.

b) Frequency band width of reproduced signals with minimum reverberation and echo effects caused by sound reflection from the station boundaries.

c) Simplicity of system operation and control.

Our preliminary studies indicate that the only type of sound system that makes sense in a subway station is the type generally used in the better airport terminals; a distribution system of loudspeakers located in the ceiling. Each loudspeaker covers only a limited floor area and sends sound down on top of the "audience." It does not spray energy all over the walls and other distant surfaces. The loudspeakers would be spaced to give uniform coverage and in most cases, would have an on center spacing approximately equal to the ceiling height. Only by a carefully controlled, continuous distribution of sound can we hope to achieve fairly uniform levels throughout the station, at the same time giving high quality reproduction of announcements and music.
In general, the sound system design must be considered as a part of the overall design of the acoustical environment; not as a separate element to be designed independently. The poor results observed in the numerous transportation terminals around the country attest to the folly of this course. We urge that sound system design be included as part of the total architectural modification program of existing stations as well as in the design of new ones for the MBTA.

Bolt, Beranek and Newman, Inc.
Draft Report 30 June 1965
3. **System Specification**

The Sound System should be consistent with

SPECIFICATIONS FOR LOCALLY AND REMOTELY CONTROLLED
PUBLIC ADDRESS SYSTEMS FOR PASSENGER STATIONS
METROPOLITAN BOSTON AREA - MASSACHUSETTS
MBTA CONTRACT NO. SM-500 (R)
OCTOBER, 1972

Available from MBTA Power and Signal Section
BIBLIOGRAPHY - Noise Studies

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B  RD 106 Track Fastenings, 16 pages with charts and illustrations.

C  RD 107 Noise and Vibration Theories, 32 pages with illustrations
    and charts.


E  RD 109 Noise and Vibration Control, 13 pages of text only.

F  RD 110 Summary consisting of 14 pages and Bibliography.

12. NOISE LEVEL MEASUREMENTS ON THE UMTA MARK I DIAGNOSTIC CAR
    (R42 MODEL) Rickley, E. J., Quinn, R., Byrnon, G., Transportation
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MASSACHUSETTS
BAY
TRANSPORTATION
AUTHORITY
GUIDELINES AND STANDARDS
PART IX
SERVICE FACILITIES
REVISED 1977
GENERAL INTRODUCTION

The Massachusetts Bay Transportation Authority has found it both necessary and possible to concentrate attention on the complex needs of people. Programs to improve service must now include a new emphasis on the quality of the transportation experience. In effect, transportation engineering has been joined by human engineering and environmental design.

This manual provides a framework for the continued coordination of all those elements in the system that affect human comfort.

Many of the criteria involved are common to all environments, such as the control of light, noise, humidity, temperature, wind, and odors, or the need for orderliness, through clear and easy circulation and clean appearance. Other criteria that are more specific to the transportation environment are such needs as safety, traffic handling capability, spatial variety, consistently available information, and orientation.

The most important single criterion that has guided the preparation of this manual is the need for orientation. The rider must not only be physically comfortable, he must also know in the fullest sense where he is and where he is going.

Since to the layman a public transportation system is to a large extent an invisible skeleton of the city and metropolitan region, the comprehension of that structure generates an awareness and appreciation of the city itself, and an appreciation of travel through it.

There are many aspects to achieving this orientation. Circulation at all points must be direct and open. Spaces should relate visually to their surrounding environment, either through direct openings to adjacent spaces and structures, or in the case of platforms, by graphic reflection through photographic murals.

Above all, the need for orientation places great emphasis on maps and a consistent system of identification and directional signing. Graphics then emerges as a major factor in the design of each environment, a factor that must be given high priority in the early design phases of each project.

It is hoped that all participants in all programs will familiarize themselves with the entire manual, so that the implications of each decision can be understood in a system-wide context.

The standards and guidelines presented here are not inflexible rules. They are a framework for meaningful development and variety, and offer no restriction to the capacity of each participant to evolve better solutions to old or new problems.

As new solutions are developed and approved, revised and additional pages for the manual will be issued to all participants.
Part IX of the Manual describes the functional requirements for the non-public work areas of the station, and the design requirements and treatment of the public toilets. It further sets down existing and proposed Authority policy with regard to station drainage, water supply and fire protection, heating, ventilation, communication systems, and electrical systems.

Refer to Part VI: Lighting for lighting standards, to Part VIII: Acoustics for the sound system, and to Part XI-C for heating and ventilating requirements.
PART IX SERVICE FACILITIES

A. Public & Staff Toilets
B. Safe Rooms
C. Starters/Inspectors Rooms
D. Porters Room
E. Electrical Room
F. Lamp Storage Room
G. Signal Equipment Room
H. Communication Equipment Room
I. Third-Rail Disconnect
J. Sewage Ejectors & Pump Rooms
K. Train & Yard Crew Lobbies
L. Miscellaneous Rooms & Equipment
M. Mechanical/Electrical Systems
   1. Water Supply
   2. Dry Standpipe System
   3. Train Approach Indicator
   4. Miscellaneous Electrical
   5. Communication & Alarm Systems
   6. T.V. Surveillance System
1. General

Separate toilet facilities will be provided for the public and the staff. The public facilities must be accessible and useable by the physically handicapped.

Public toilets are located in the primary station lobby, preferably in the paid area, with doors within direct view of the collector's booth.

Staff toilets are located in each lobby, and at major bus terminals (where buses layover) adjacent to the busway. They are also provided at platform or track level at rail terminals, usually in conjunction with road and yard crew lobbies, and at traction power substations.

Mens and womens facilities are provided in all cases, except in traction power substations where a single room is sufficient.

2. Number of Fixtures

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Water-closet</th>
<th>Urinal</th>
<th>Lavatory</th>
<th>Handicapped Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Men's</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>yes</td>
</tr>
<tr>
<td>Public Women's</td>
<td>2</td>
<td>1</td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Staff Men's- Sta. Lobby</td>
<td>1</td>
<td>1</td>
<td></td>
<td>no</td>
</tr>
<tr>
<td>Staff Women's-Sta. Lobby</td>
<td>1</td>
<td>1</td>
<td></td>
<td>no</td>
</tr>
<tr>
<td>Staff Men's-Bus Terminals</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>no</td>
</tr>
<tr>
<td>Staff Women's-Bus Terminals</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>no</td>
</tr>
</tbody>
</table>

Staff toilets at rail terminals will be slightly larger than at bus terminals, depending on number of personnel assigned to the location.

DESIGN STANDARDS
3. Finishes and Equipment

Finishes and equipment shall generally be the most rugged, impervious, easily cleaned and chemically resistant obtainable, consistent with reasonable standards of economy and appearance. Where new floor surfacing is installed, a waterproof membrane shall be included.

Doors shall have either a louver, or be undercut. They shall have automatic closers, pushplates and kickplates, and a deadlock only.

Toilet partitions, with stainless steel doors, and urinal screens should be provided, constructed of glazed masonry, glazed tile, or stainless steel, well supported against lateral force. Porcelain enamel is insufficiently resistant to marking for use in toilet partitions.

Each toilet room shall have a plate glass, stainless steel-framed mirror, sized to fit the available opening, and preferably located away from the lavatory. Each women's toilet shall have a stainless steel shelf, mounted below the mirror at 3'-4" height above the floor.

Each toilet room shall have an electric hand dryer, recessed wall mounted type, (World Dryer Co., Model RA, or approved equal), with the nozzle fixed downward.

Soap is not provided. Toilet paper is supplied by the Authority, who will install the toilet paper holder.
4. Plumbing

Plumbing for new and modernized toilets shall be in accordance with the Boston Plumbing Code.

Each new toilet room, and, if possible, each modernized toilet room, shall have a floor drain. Supply valves shall be concealed from public access. Valves and cleanouts must be easily reached either from service areas behind the wall, or through vandal proof access panels from the toilet rooms themselves.

Acceptable fixtures shall be equal to the following. As no hot water will be provided, the lavatory shall have the hot water faucet opening blanked off. Substantial wall carriers should be provided for all fixtures.

- water closet: American Standard Instanto F-2515
- urinal: American Standard Washbrook F-6505
- lavatory: American Standard Prismere F-5515-1

5. Ventilation - See Part. XI-C

6. Lighting

Toilets will typically be lighted by a wall mounted fixture extending from wall to wall over the plumbing fixtures. Other lighting should be provided as required, with the intent that every part of the room be highly illuminated. Emergency lighting is required.

7. Heating - See Part. XI-C
1. General:

Every fare collection layout requires the use of two safes, one for cash deposits by the collectors, and one for the temporary storage of fare boxes. The former safe is always located in the primary collection booth; presently the latter safe is sometimes left freestanding close to the fare collection equipment and sometimes put in a safe room. The Authority intends that all new and modernized stations have safe rooms.

2. Collection Procedure:

(1) A special crew visits each station early in the morning, and leaves with the first collector of packet of change, and if used, sufficient tokens for the day.

(2) There are several shifts of collectors. As each leaves his post he turns over to his relief only the amount of change which he was originally given, sealing the excess cash in a bag and depositing it, with a report form, in the collection booth safe. The last collector bags and seals all the cash, and deposits them in the safe.

(3) At closing time, and as may be necessary during the day, the starter removes loaded fare boxes from the turnstiles and locks them in the safe room safe. He finds the safe unlocked, and having shut the boxes within the safe, cannot again unlock it. Therefore another safe must be used for each successive change of fare boxes.

(4) The special crew in the morning brings empty fare boxes, as well as new change. It collects the loaded fare boxes from the safe room safe, and the cash from the collection booth safe and returns them to the central accounting office.

3. Size of Safe Room:

A desirable minimum safe room size is 75 square feet, proportioned to permit 90° swing of the safe door; however, existing conditions may dictate less. In any case the Authority will establish the number and sizes of safes to be accommodated. The Authority uses a number of different sizes of safes. The number of safes required is equal to the number of times the fareboxes are changed during the day. Safe room safes are primarily for storage of tokens; however in some cases they also are used for cash and will require an ADT connection. The safe room should also accommodate at least one change of fare boxes, which can be placed atop the safe. Fare boxes are 9" x 9" x 18" high.

DESIGN STANDARDS
4. Location of Safe Room:

Safe rooms should be located as close to the fare collection equipment as possible, and should not open into collection booths. They should open onto the paid area. Doors should have a lock, and must be sized to permit entrance of the safe. The Authority will provide cylinders for the safe room door locks. Some means of ventilation should be provided, by undercutting the door, or, if a louvre is used, it should be barred on the inside. Both normal and emergency lighting should be provided. See Part XI-C for heating and ventilating requirements.
1. Starter/Inspectors Room at Way Stations:

The starter or inspector is normally assigned to supervise more than one station. He uses the starters room only to fill out reports and make telephone calls. Ideally each station should have a starters room at platform level, centrally located, on each platform. Failing this, surface car stations can make do with a room on one platform and provision for cross-over between platforms. If there is a crossover at the station, the starters room should be located at the end of the platform adjacent to the crossover.

The room need only be large enough to accommodate one man, at a stand up counter, or approximately 25 sq.ft. Equipment includes the stand up counter, a microphone jack and monitor loudspeaker for the paging and announcing system, and a telephone connected to the central MBTA switchboard. The door should have a lock, and either an undercut or a louver. In small starters rooms, used for no other purpose, the door should have a glass view panel. Both normal and emergency lighting should be provided. In special cases, other station control equipment, such as alarms and switches, can be located in the starters room. See Part XI-C for heating and ventilating requirements.

2. Inspectors Room at Terminal Stations:

This facility may be occupied full time, serving as an office for direction of train and yard personnel assigned to the terminal. It should have an area of 100-150 sq.ft. Equipment is similar to that of the starters/inspectors room at way stations. Windows overlooking the platform or track area should be provided. The room is normally located adjacent to the train crew lobby at the end of the station platform closest to the train storage or turnback tracks. See Part XI-C for heating and ventilating requirements.

DESIGN STANDARDS
3. Bus Starters Room:

This facility may be occupied full time, or during rush hours, and serves as a control center for bus operations at stations where bus routes terminate. It should have an area of 50-100 sq.ft. Equipment is similar to that of the starters room at way stations. Windows overlooking the busway and bus passenger waiting areas should be provided. The starters room should be located near the center of the busway, and if possible, adjacent to the train station lobby or entry so that the starter can provide assistance to waiting bus patrons, as well as overseeing the operation of the buses. The bus drivers toilet rooms may be located adjacent to the bus starters room, but should not be entered via the starters room. See Part XI-C for heating and ventilating requirements.
1. A porters room should be provided on each train platform and fare collection lobby. In stations with extensive covered busways or lengthy enclosed passageways or concourses, additional porters rooms may be required.

2. Porters rooms are 75 to 100 square feet in area. They should have a service sink, hot and cold water, a floor drain, shelving for janitors supplies, and racks for hanging mops and brooms. Space for storage of a floor cleaning machine (approx. 2'x3') and for storage of filled trash bags is required. Wall and floor finishes should be resistant to water and strong cleansers. The door should have a lock and either an undercut or a louver. Only normal lighting need be provided. See Part XI-C for heating and ventilating requirements.
1. Electrical rooms should be provided where required to contain station electrical equipment, such as AC and DC panels, switchgear, and entrance equipment. These rooms should be sized and located by the station electrical designer and architect. A lamp storage room, see Part IX Fl, may be adjacent to an electrical room.

2. Electrical rooms vary considerable in size. The smallest is a panel room of 50 sq. ft. and the largest is a station unit substation with a maximum area of 2000 sq. ft. The larger facilities are provided at stations having a large lighting or power load such as a major parking facility, or many escalators, ventilation fans etc.

3. Extreme care must be taken that seepage of water does not occur into electrical rooms. Doors should have locks and be sized to accommodate the passage of equipment. All doors should have louvers. All electrical rooms must have both normal and emergency lighting. See Part XI-C for heating and ventilating requirements.

DESIGN STANDARDS
1. A lamp storage room should be provided in each station, preferably adjacent to the main electrical room in the station. It should not be entered via the electrical room.

2. This room should have an area of approximately 100 sq. ft. It should have shelving and racks to accommodate the various sizes and types of lamps used in the station, as well as a step ladder. It must have both normal and emergency lighting. See Part XI-C for heating and ventilating requirements.

DESIGN STANDARDS
1. A signal equipment room should be provided at each station. It is located at track or platform level near the end of the platform. Usually it is outside of the platform area, though it may be located within the platform area if necessary. If there is an interlocking (crossover or junction) near the station the signal equipment room should be located at the end of the station closest to the interlocking. Conduit and ducts will lead the signal and related cables from the room to the right of way.

2. A signal equipment room at a way station is typically 300 sq. ft. (min. of 10' x 30'), and at an interlocking 500 sq.ft. (min. of 10' x 50'). The precise size is determined by the signal designer. At subway stations, it is constructed in place, but at outdoor stations it may be provided in the form of one or more prefabricated, prewired bungalows. A communication equipment room may be located adjacent to the signal equipment room, see Part IX H1.

3. The signal equipment racks are normally set up in rows running across the short dimension of the room. Aisles between racks are 5' wide, racks are 4' deep, and made up of units 2'-6" wide. At interlockings a local control board is provided in a separate fenced-off area. It should be possible to enter this area from outside without going into the remaining part of the signal equipment room.

4. Extreme care must be taken that seepage of water does not occur into signal equipment rooms. Doors should have locks and be sized to accommodate the passage of equipment. All signal equipment rooms must have both normal and emergency lighting. See Part XI-C for heating and ventilating requirements.

DESIGN STANDARDS
1. A communication equipment room should be provided at each station. It houses the equipment for the station public address system, closed circuit TV, the train radio system, fire or emergency detection, alarm and radio systems, and other systems used within, or tied-into the station. If possible, it should be located adjacent to the signal equipment room, but should not be entered from the latter.

2. A communication equipment room is typically 100 sq.ft. in area. The precise size is determined by the signal/communications designer. Space should be left for future equipment and system installations.

3. Extreme care must be taken that seepage of water does not occur into communication, equipment rooms. Doors should have locks and be sized to accommodate the passage of equipment. All communication equipment rooms must have both normal and emergency lighting. See Part XI-C for heating and ventilating requirements.

DESIGN STANDARDS
1. A third-rail disconnect switch or "B-Switch" should be provided for each track at the leaving end of the station platform. Thus it is located to be easily accessible to the motorman of a train on each track. It consists of a simple manually operated knife-switch which is used to disconnect the power feeding a segment of the third-rail through the station platform area, in emergency situations.

2. The switch is enclosed by a fibre-glass reinforced plastic box with hinged doors. It occupies an alcove 4' wide by 7' high by 2'-0" deep. Cables from the third rail are fed to the bottom of the box via large conduits. The box may be on the platform or just beyond the end of the platform, at the same level as the platform. There must be at least 4' clear between the face of the box and any fixed vertical obstruction opposite the box, to allow sufficient room for opening or closing the switch. The switch box may be exposed, or if on the platform, may be behind doors. The area in front of the switch should be lighted. No heating of the switch box or room is required, but doors if used, should be undercut.

3. Other traction power switches may be located near the station, sometimes adjacent to the "B-Switch". The number and location is determined by the traction power designer. The "B-Switch" and other switches may be grouped at the platform end with other service rooms, but the "B-Switch" should be easy to find in emergencies. If not visible from the platform a sign giving the switch number should be provided.

DESIGN STANDARDS
1. Sewage ejectors are required at locations where the sanitary drainage from the station must be raised to a higher level to feed into the city sanitary sewers. Pumps of various types are used to remove storm, water, seepage, and other water brought into the station or tunnel by the cars (rain or snow melt), from station washing, or from fire fighting, at all stations lower than the city or other storm drainage systems.

2. Typically the rooms are 75 to 150 sq. ft. in area. The room should be sized to provide adequate space for maintaining or replacing the equipment. Doors should have locks and should be sized to permit removal of equipment. Both normal and emergency lighting are required. See Part XI-C for heating and ventilating requirements.

DESIGN STANDARDS
1. Train Crew Lobby:

A train crew lobby is provided at any rail terminal where trains are stored. It is placed at the end of the platform closest to the storage tracks and may be at platform or track level. It usually will adjoin a large inspectors room located at the platform end. The size of the lobby depends on the personnel assigned to it, which will be specified by the Authority.

The train crew lobby must accommodate the following:

- A lunch room with tables, benches, kitchenette, space for 3 vending machines, and 50 sq. ft. of bulletin board

- A men's locker room with one locker per person, benches, and 1 shower stall.

- A men's toilet room with at least 1 urinal, 2 wc's, and 2 lavatories.

- A women's locker room with one locker per person per shift, benches, and 1 shower stall.

- A women's toilet room with at least 1 wc and 2 lavatories.

- A porters/utility room

It is desirable that the men's and women's locker rooms are designed so that by moving partitions and furnishings the size of the two rooms could be easily altered to adapt to a change in the ratio of men to women employees. Initially provide women's lockers equal to 10% of the number required for men.

2. Yard Crew Lobby

A yard crew lobby is provided at any rail terminal where trains are stored. It may adjoin the train crew, lobby, oriented toward the storage tracks, and preferably at track grade. If the storage yard is some distance from the station, the yard crew lobby may be located closer to the throat of the storage yard, than to the station. The yard crew lobby is much smaller than the train crew lobby. The number of employees will be specified by the Authority.

DESIGN STANDARDS
The yard crew lobby must accommodate the following:

- An office for the yardmaster of 100 sq.ft.
- A lunch room with tables, benches, kitchenette, space for 1 vending machine, and 20 sq.ft. of bulletin board.
- Separate mens and womens locker rooms and toilet rooms similar to the train crew facilities except smaller. Toilet rooms would have only 1 of each type of fixture.
- A porters/utility room.

For heating and ventilating requirements for train and yard crew lobbies see Part XI-C. Finishes, lighting, and furnishings should be extremely durable, and easily cleaned.

At some locations it may be possible to consolidate the train crew and yard crew lobbies in a single facility. Common lunch rooms and toilet rooms are permitted. Separate train and yard crew locker rooms are required.

3. Walkways & Platforms at Storage or Turnback Tracks:

Paved, lighted walkways will be provided to connect the train and yard crew lobbies with the storage yard. Location of walkways must be coordinated with track and 3rd rail layouts to minimize the number of gaps in the 3rd rail.

Raised platforms at least 3' wide between tracks, and 2' wide if adjacent to a wall, will be provided at the storage tracks, as directed by the Authority. Steps to the ground are provided as required.
1. Storage Rooms:

Storage rooms may be provided at or near station lobbies, at train platforms, at busways, or within parking garage structures. Size, location, and requirement for utilities, heating, and ventilating will be specified by the Authority. Typically one room of 100 to 200 sq.ft. is provided at terminal stations.

2. Sand Boxes:

At outdoor train and bus platforms, and at other extensive walkway or roadway locations where ice conditions could exist, sandboxes should be provided. They should be 5'-6" long x 2'-6" wide x 3'-0" high, of concrete construction with a hinged steel top. They may be built-in in combination with other platform service rooms or furnishings, or as free-standing precast units.

3. Emergency Exits:

See Part IV-E Components

4. Platform/Track Access Stairs

Stairs to connect platform and track levels will be provided at each end of a platform. Min. clear width is 2'-0", minimum tread 9½", maximum riser 7½". If it is not possible to use a stair meeting these criteria, a 2'-0" wide ships ladder, and in the worst case a 2'-0" wide vertical ladder with maximum tread spacing of 1'-0" may be used.

5. Vent Shaft & Fan Rooms:

1. Water supply is from city mains, with meter located in a service area. Water is required at toilets, porters' rooms, drinking fountains located in starters and employees' locker rooms, and at some concessions. Hose bibbs should be located throughout the station at approximately 100 foot spacing, so that most areas can be reached with 50 feet of hose. When possible, the hose bibbs should be located in service areas such as porters rooms, but not in electrical, signal or communication rooms.

2. Hose bibbs shall be of frost-proof, vandal-proof design. Heat trace all water and drain lines subjected to below freezing temperatures.
All subway tunnels and stations will be equipped with a dry standpipe system to aid the fire departments in fighting subway fires. The system consists of connections at street level which are fed by pumpers, vertical pipes dropping down to the subway level, horizontal runs through tunnels and stations, and hose connections at frequent intervals within the subway. The system must meet the following criteria.

a. Pipe:

Schedule 40 black iron grooved ends for victaulic or equal fittings. Mains shall be maximum 6 inch nominal size.

b. Fittings:

Victaulic or equal except that terminals shall be two, 2½" nominal size valved hose connections threaded to drop from main. Street level connection for pumper service shall be per Fire Department standard.

c. Location:

The two, 2½" valued hose connections shall occur every 100 ft. for each track unless access between tracks is provided at a minimum of 100 ft. intervals. The same spacing for outlets shall apply to stations. Street level connections shall be provided at stations and vent shafts. Street level connection shall be reasonably accessible to Fire Department equipment.

d. Identification:

Pipe shall be painted red. Street level connections shall be identified by signs.

e. Interference:

A minimum 6 inch clearance shall be maintained between the train dynamic envelope and any part of the dry standpipe fire.
A set of signal lights will be provided at busways to indicate that a train is approaching the station. It should be located to be visible to all drivers of buses waiting at the station, and to the bus starter. It is part of the Signal System and usually lights-up when a train enters the previous station, thus is 2 to 3 minutes from the station where the busway is located. It is most useful in the off-peak hours when bus service is infrequent, as it allows a bus to be held several minutes beyond its scheduled leaving time so that passengers from the next train can make a bus connection.

TRAIN APPROACH INDICATOR
1. For cleaning and maintenance equipment, vandal-proof 110V AC convenience outlets (equal to Arrow Hart 5797) are required at platforms, spaced about 50 feet on center. Actual spacing and mounting height will be determined by the elevations of the particular station. At mezzanines, a similar convenience outlet should be wall-mounted at each collection booth.

2. In new and modernized stations underfloor electric ducts should be installed, beneath the bank of turnstiles and to other likely locations of future automatic fare collection equipment. These ducts can be used at present to feed collection booths and fare boxes, and should be installed in groups of three, one duct each for AC, DC and signal wiring. Each of the three ducts should be connected by conduit to the nearest electrical room. A large junction box should be located at the termination of the duct system in each collection booth.

MISCELLANEOUS ELECTRICAL

2. An ADT Alarm is required on the safe in most primary collection booths. It is not required on the safe in the safe room. This alarm is connected via the telephone line to the ADT Central Office.

3. All collection booths and all starters' rooms shall have telephones, connected to the central MBTA switchboard.

4. A starter's call bell system shall be installed, actuated by push button at any collection booth. The bell should be located at a central point in the station, and elsewhere as may be required in a particular station.

5. The opening of an emergency exit shall actuate an alarm located in the primary collection booth, and in the starter's room.

6. Public telephones may be installed in fare collection lobbies (normally in the free area), at station entry areas, at busways and at kiss and ride areas. Wall or post mounted units of vandal resistant design will be used.

7. Fire alarm boxes will be located at fare collection lobbies, train and bus platforms, and parking garages, as required by the fire department of each municipality.

8. Smoke and fire detection systems will be installed in all concession areas, rooms housing electrical equipment and other spaces as directed by the Authority. They will be connected with the Authority operations control center, and may be tied into the municipal fire alarm system as determined by the fire department.

COMMUNICATION AND ALARM SYSTEMS
1. A television surveillance system will be provided for at each station. It will include cameras at appropriate locations and a conduit system connecting the camera location and the primary collection booth with the station communications room. Additional conduit will lead from the communications room to the tunnel or wayside cable system to provide a connector with monitors at the operations control center. Cameras should be located to provide surveillance of platforms, passageways and other public areas which can not be observed directly by the collector. Additional monitors may be located at the collectors booth or other locations in the station which are manned during normal operating hours.

2. The station designer is responsible for planning the camera locations and the conduit system conduit and junction boxes will be installed by the station electrical contract. Design and installation of the TV equipment will be done under separate contracts for an entire route or group of stations and will provide a complete system of station equipment wayside connecting cables and monitoring system at the operations control center.
MANUAL OF GUIDELINES AND STANDARDS

PART I GUIDELINES AND PRINCIPLES
PART II STATION RECONNAISSANCE
PART III STATION MODERNIZATION PROGRAM
PART IV COMPONENTS
PART V GRAPHICS
PART VI LIGHTING
PART VII MATERIALS
PART VIII ACOUSTICS
PART IX SERVICE FACILITIES
PART X SITE PLANNING AND NEW STATIONS
PART XI VENTILATION
Part X of the Manual describes environmental and functional criteria for new rapid transit stations. New stations will occur either at the surface or underground. Existing underground stations have been discussed in detail in the previous nine parts which also contain material pertinent to surface stations. "Surface" applies to stations located below, at or above the normal grade level of the site which are largely open to the outside.

The following other parts of the Manual give information necessary for an understanding of Part X.

Part I Guidelines and Principles
A. Circulation
B. Openness (Platform Openness)
   (Openness to Neighborhood)
   (Daylight to Platform)
D. Platform Elements (Required Car Clearances)
   (Sightlines)
E. Defined Spaces
F. Platform Walls (Side and End Walls)
H. Advertising and Graphics (Advertising Location-)
   (Sign Locations)
   (Map Space)

Part III Station Modernization Program

Part IV Components
B. Fare Collection - Standard Fare Layout
C. Station Furnishings

Part V Graphics
A. Authority Symbol and Name
B. Color Coding
C. Lettering
D. Maps
F. Station Entering Signs
G. Station Exiting Signs
H. Platform Photomurals
I. Miscellaneous Signs
K. Bus Stop Signs
L. Revenue Advertising

Part VI Lighting
A. Lighting Design
B. Fixture Types

INTRODUCTION
PART X - Site Planning and New Stations

A. Site Selection
1. General
2. Sites in Structures
3. Expressway Sites
4. Level and Sloping Sites
5. Dense and Open Sites
6. Underground Sites

B. Site Analysis and Design
1. Climatic Conditions
2. Planting
2.1 Landscape References
3. Surface Treatment
4. Exterior Lighting
4.1 Exterior Lighting Fixture Types

C. Station Access Facilities
1. General
2. Pedestrian
3. Bus Facilities: General
3.1 Bus Facilities: General
3.2 Bus Facilities: On Street
3.3 Bus Facilities: Off Street - General
3.4 Bus Facilities: Off Street - Inline Flow
3.5 Bus Facilities: Off Street - Island Flow
3.6 Bus Facilities: Off Street - Compressed Flow
3.7 Bus Facilities: Long Island Platforms
3.8 Bus Facilities: Off Street - Short Island Platforms
3.9 Bus Facilities: Off Street - Random Loading
3.10 Bus Facilities: Off Street - Cross Platform Transfer
3.11 Bus Facilities: Off Street - Platform Dimensional Criteria
3.12 Bus Facilities: Roadway Details
3.13 Bus Facilities: Off Street - Turning Street
3.14 Bus Facilities: Driver Accommodations
3.15 Bus Facilities: Bus Dimensions
4. Park & Ride Facilities - General
4.1 Park & Ride Facilities - Access & Control
4.2 Park & Ride Facilities - Layouts
4.3 Park & Ride Facilities - Lot Layout & Landscaping
4.4 Park & Ride Facilities - Garages
5. Kiss & Ride and Taxi Facilities
5.1 Kiss & Ride - Typical Layouts
6. Electrical Facilities
7. Concessions and Shops
D. Station Lobbies and Platforms

1. Lobby to Platform Relationships
   1.1 Station Cross-Sections
2. Typical Station Circulation
   2.1 Typical Station Circulation - Vertical
   2.2 Vertical Circulation
3. Platform Types - Two Track
   3.1 Platform Types - Three Track
4. Platform Access
5. Platform Design Criteria
   5.1 Platform Dimensions
6. Railroad Shuttle Transfer
Certain objectives have been established for the location of transit extensions. These objectives are the result of regional studies conducted jointly by the Authority and various state and local agencies. These objectives are as follows:

1. Routes that complement major highways, renewal or other public works.
2. Routes that promote economic development and stabilization of individual communities.
3. Routes that reach into a large and active transit market.
4. Routes that replace costly, lowspeed, or inconvenient local systems.

The station site location and general configuration will be determined by the Authority. The basic street and track alignments will be furnished to the station architects.
A transit station may be part of a larger urban development incorporating commercial, housing and light industrial uses.

The Authority cannot build structures for commercial purposes, but may sell air rights to other public agencies or private developers. Structures developed in coordination with stations provide the following advantages:

1. A total integration of the transportation system within the physical structure of the community.

2. An increase in Authority revenues by development of traffic generating activities at or near stations. Examples of these activities are high density residential or commercial development.

3. An indirect increase in Authority revenues by creation of safe and pleasant surroundings for the stations.

4. An improvement of Authority operations by providing new facilities which might not be available by other means, such as weather protected busways or storage yards.

5. The provision of space for special uses such as low rent housing, housing for the elderly, or public facilities, in communities where land for such uses is in short supply.

6. Through the sale of air rights or excess property, the receipt of funds which may be applied to further capital improvements of stations and facilities.

Because of the extreme urgency of completing some parts of the expansion program, it will not always be possible to arrange for air rights development to occur simultaneously with station construction. The station structure and site should be developed with enough flexibility to permit air rights development at a later date.

SITES IN STRUCTURES
The interconnection of the highway system and the mass transit system is necessary for a balanced transportation system. The location of transit stations at these interconnecting points provides a further reinforcement of both systems.

The rapid transit routes incorporated in the Authority Master Plan connect with the expressway and critical highway network in two ways. The first is a right angle intersection of expressway and transit line. An example of this type is the Riverside line's connection to Route 128. Here the highway becomes a major feeder to the transit station. The second is a transit line paralleling the highway. An example of this type is the Southwest Corridor. Here the expressway will feed the transit at the rail terminal and one or two other locations, but the arterial roadways crossing the joint transit corridors will feed both modes at many points.

An expressway location presents special problems. The majority of people will arrive by automobile or bus. The driver will be traveling at high speed and must be signaled of the approaching entrance to the transit station.

Station elements may be placed directly beneath elevated sections or above depressed sections of the expressway. Such locations require strong visual elements to compete with the scale of the expressway and the speeding traffic. Elements that span the roadway or project vertically beside or between the roadways can provide these focal points.

The station may also be located adjacent to the expressway where it is more visible. This scheme simplifies parking and approach roads, but requires more land.

The exit lanes from the expressway to the station should be located on the approach side of the station, with the station visible from the point of exit. Sight lines to the station may be improved by curves or slopes in the roadway.

Bibliography:

Appleyard, Lynch & Meyer, View from the Road, MIT Press, Cambridge, 1963
While level sites are best suited for intense activity, activity alone will not insure the success of a level site. A suburban station on a level site may become an island in a sea of vehicles.

Planting, manmade landforms, changes in surface texture, and the station structure can be utilized to define spaces, direct and orient circulation, and provide variety.

Sloping sites may be utilized to divide parking into small units, separate pedestrian levels from vehicles, screen unwanted views, define spaces, and increase the visibility of the station from the surrounding area.

The topography of each site will determine the organization of the plan. The location of circulation, the use of an area, the position of the buildings, and its visual aspects, will be influenced by the topography.

The following general scale of slopes should be followed for particular uses:

- Slopes under 1% do not drain well
- Slopes of 1% to 4% are desirable for intense activity
- Slopes of 4% to 10% are suitable for informal movement and activity
- Slopes over 8% are unfavorable for roads.

To provide level areas for parking, the sloping portions may be graded and the level areas developed in steps down the site. The slopes between these parking plateaus are then available for major planting such as trees. Areas of grass should be avoided unless maintained by local park departments. Brick, stone, concrete, etc. may be used where surface texture is desired. If plant material is desired for ground cover it should be a type that needs little attention. Landscaping should be kept simple and used in large enough areas to have impact.
Surface stations located in densely populated areas may be required to use smaller sites. Parking, if it is provided, will be based on site design limitations. If the area surrounding the site is architecturally noteworthy, the station should be suppressed so as to be sympathetic with these surroundings. Building set backs, existing height limitations, and the types of materials should relate to the local area.

In vast open areas or areas of little visual significance, the transit stations may be a strong visual element and a focal point for the whole neighborhood.
New underground stations should be light and airy. This can be accomplished by wide simply shaped platforms and high interior spaces. Daylight should be brought into underground stations by penetrating the surface. The new North Station, on the Orange Line, shown above, indicates one solution: sky lights to the street, allowing daylight to wash the side walls of the space.

Mezzanines or entrance lobbies at grade should wherever possible provide orienting views of the platform space. In the example shown above, a mezzanine fare collection lobby is located as a wide bridge within the platform space, providing pleasant views and awareness of platforms and trains below.

UNDERGROUND SITES
Waiting passengers should be given protection from prevailing winds and sun angles. Panels may be erected as wind guards. These panels will also provide necessary surface for upper and lower name bands, maps, orientation photomurals, and revenue advertising. For precise standard locations of these graphic elements, see Sections I, III, V.

CLIMATIC CONDITIONS
Existing trees should be preserved when possible. Trees and other plant material may be used to screen undesirable views, divide large parking areas into smaller units, or suggest a flow of exterior space.

Planting when used as surface texture and color should be limited to those types requiring minimum maintenance. Whenever planting is used it should be used in large enough areas or numbers to make an impact.
For further information refer to the following books:


Army Corps of Engineers, *Planting and Maintenance of Trees*, EM 1110

Fanlatan, D., *Shaping Tomorrow's Landscape*, Amsterdam, 1964


Urban Land Institute, *Community Builders' Handbook*, pages 152-153

Surface textures other than grass should be used extensively. A change of surface texture may be used to denote pedestrian paths at crosswalks and within parking areas. Vast areas of asphalt or concrete should be relieved by introducing strips or areas of contrasting material. Concrete and asphalt may be used together. Loose crushed stone or gravel should not be used in areas accessible to the public. Where a hard surface is not desired, wood chip mulch may be used alone, or in combination with planting.
The type of lighting and the light intensity will be determined by the function of the area.

Lighting for the pedestrian should be in scale to the human figure. Rows of lights may be used to indicate direction or define paths. Lighting in parking areas should be of a quality and intensity, preferably high pressure sodium, to impart a sense of safety. Self-parking areas and paths require one footcandle of illumination. Large parking areas should be 2-3 foot candles.

Direction and information signs may be brightly backlit for contrast. Surface illuminated sign boards need fifty foot-candles on dark surfaces. Backlit signs should be used whenever possible as they are more easily seen at night than surface illuminated signs. Care in placement, color selection, and intensity of light will be necessary to avoid washing out colors and graphics.

Light fixtures should be as vandal resistant as possible, with polycarbonate or high impact acrylic diffusers, particularly those which might be within reach of pedestrians.

Poles should be heavy gauge, extremely rigid, with hand hole and fixed base.

All wiring for exterior lighting fixtures should be buried in plastic coated rigid steel conduit. Overhead wiring will not be permitted.

For large areas, parking, train and bus storage, etc., serious consideration should be given to high mast lighting to minimize number of poles and luminaires. High mast installations should be of type that permits lowering of the luminaire assembly to ground level for servicing.

Maximum mounting height of fixed luminaires shall be forty (40) feet to permit servicing by bucket truck, where truck access is available.

Ease of maintenance of all fixtures is of prime concern.

EXTerior LIGHTING
HIGH MAST LIGHTING (LARGE AREAS)

LIGHT TO INDICATE DIRECTION

14' + 25' - 30'

LIGHT TO INDICATE DIRECTION

40' MAXIMUM

HIGH INTENSITY HIGH LEVEL

EXTERIOR LIGHTING FIXTURE TYPES
The amount of traffic and the mode of arrival will shape each site and station in a different way. Each mode has its own characteristics and needs which are fully described below. The modes are: pedestrian, bus, auto drop-off ("kiss and ride"), park and ride, and in several locations, railroad shuttle. Some stations must accommodate all of these modes; others only one or two.

As one progresses along a transit route outward from downtown, the emphasis of the major mode of access to stations shifts from pedestrian to automobile.

Typically, several modes feed a station - priority in terms of convenience of access to the station lobby should be 1) Pedestrian, 2) Bus, 3) Kiss and Ride, and 4) Park and Ride. At individual stations the order of priority may be modified to conform to the forecasts of the activity for a particular station.

Estimates of traffic by mode of arrival, and schematics of traffic flow patterns, are furnished by Planning.
Absolute segregation of pedestrian from vehicular circulation is not required, nor is it necessarily desirable except in high volume areas. The pedestrian values travel time and convenience over almost anything else, and will not use grade separation structures unless they are very convenient. Major pedestrian-vehicle conflicts should be avoided wherever possible, but must not unduly inconvenience the users. Walkways which are too isolated from other circulation can create problems in surveillance and policing during off-peak hours. Crosswalks should be well marked with stripes or by a change of materials. The safety of pedestrians must be assured where vehicles share the accessway.

If possible, pedestrian overpasses or underpasses should be used where one end can be at or near grade. This minimizes the successive up and down movements, allows better surveillance, gives the pedestrian a sense of orientation, and is generally more pleasant.

Pedestrian way—specific details:

- Minimum width of unobstructed sidewalks: 5'
- Minimum width of pedestrian crosswalks: 7'
- Minimum width of pedestrian bridge: 8'
- Minimum width of pedestrian tunnel: 10'
- Maximum slope of pedestrian ramp: 1:12
- Preferred slope of 1:15

Roadways over 4 lanes in width require a pedestrian refuge area at least 4' wide

- Minimum headroom for short distances preferred minimum: 7'6''

PEDESTRIAN
The present fare collection policy of the Authority allows free entry to buses at rapid transit terminals, the passenger pays as he leaves the bus outbound. Inbound to a rapid transit terminal, he pays as he enters the bus and exits free at the terminal. This system minimizes loading and unloading times at the terminals where time and space may be critical. A separate additional fare collection is made in the station lobby for the rapid transit ride.

Bus routes may operate through or adjacent to a station, or terminate at a station. Bus loading facilities at a transit station may be on-street or off-street. Either type of route can be served by either type facility, though through routes can often be better served by on-street stops.

Generally, when traffic volume at a single stop for terminating buses (with space for 2 buses) exceeds 12 per peak hour, off-street bus loops should be provided. The required number of berths will be determined by the Authority.

There is no typical bus terminal layout. The amount of bus traffic, possible points of street access, configuration of available site, and topographic relationships will dictate the layout of bus facilities in a different way for every transit station.

BUS FACILITIES—GENERAL
As the bus to train transfer is a breakpoint in a journey, it involves penalties in travel time and inconvenience. Thus, everything within reason should be done to make the transfer quick and easy. Unless otherwise specified, buses should have prime access to the station entry lobbies, taking priority over other vehicular access modes. All bus stops must be designed for right-hand loading. The pedestrian route from bus to train should be direct and involve a minimum of stair climbing. Liberal use should be made of shelters. Bus terminal areas should be well ventilated, illuminated, and designed for easy surveillance. The terminals must be planned to permit easy bus-to-bus as well as bus-to-train transfer. Conflicts with other access modes should be minimized.

The passengers movement and wait in the station should be as pleasant as possible. Benches, wind screens, and platform heating will increase passenger comfort.
An advantage of on-street bus stops at transit stations is that in some instances they can offer shorter overall travel time for the rider. Site considerations or traffic conditions could make it difficult to provide convenient off-street bus loops that would get the passenger to the station faster than he could walk from an on-street stop. Both solutions should be studied and the most convenient recommended.

At on-street bus stops, a pull-out lane at least 10' but preferably 12' in width, and long enough for at least 2 buses, should be provided, where possible.

Bus routes terminating at a station may stop in the street at the station and go beyond the station to turn around a block or public square. It is preferred, however, to provide turn around space for the buses on the transit station property.
At stations of low traffic volume, those with less than 12 terminating buses per peak hour, buses may share parking area roadways with the kiss-and-ride and park-and-ride traffic. For volumes greater than 12 per peak hour, buses should use special lanes or roadways for unloading, waiting, and loading. Thus, conflicts between buses and automobiles using parking and kiss-and-ride may be avoided. All busways should be designed to permit a bus to pass a standing bus (see dimensions below). Buses should never be required to back-up in the station area.

The ideal bus station should be laid out so that terminating buses may: 1) unload, without delay, 2) pass through a holding area, where they can wait if their loading berth is occupied, and proceed to a loading berth for normal layover and boarding. Unloading bus passengers should have short, direct access to the station lobby. There should be a loading berth for each major bus route, though heavily used routes may need two berths, while very light routes can double-up at a single berth. A loading berth should be able to serve approximately 10 to 12 buses per hour. Only where bus volume is relatively light, or where buses run through the station, can they unload and load at the same stopping point, though extra length for "bunching" should be provided.

The advantage of allowing buses to layover at the loading berth is that passengers may wait in the bus.

BUS FACILITIES: OFF STREET - GENERAL
The layout shown above permits direct pedestrian access to the lobby without use of stairs or escalators.

As the time spent at the unloading area is relatively short, one unloading berth can serve 3 or 4 loading berths. Unloading buses can stop bumper to bumper. Shortcuts for empty buses to go directly from the unloading area to the outside to return to a garage, or from the outside directly to the loading area, are a desirable but not mandatory extra feature. Loading areas should be designed to permit a loaded bus to pull out of a berth and pass other standing buses.

The ideal bus flow pattern shown can result in an excessively long station if many routes must be handled. Thus, it can be advantageous to compress the flow pattern by various means, as shown on the following pages.

BUS FACILITIES: OFF STREET - IN-LINE FLOW
In the schemes above, buses go clockwise around an island with unloading on one long side, storage at one end and loading on the other long side. This scheme works well when access to the lobby is via pedestrian underpass or overpass. A split level variation of this pattern is also possible. The example shown has the advantage of reducing the need for stair climbing as buses can unload on the upper level with direct lobby access, and load on the lower level reached from the lobby via a down stairway.

BUS FACILITIES: OFF STREET - ISLAND FLOW
Other methods of compressing the length of a bus facility are shown above. In some examples, it is necessary to slightly increase the empty bus mileage for those buses which cannot go directly from the unloading to the loading area as they must loop through the hold area. Also, at-grade crossing of the busway is necessary for some cases. This is not serious as long as proper sight distance and warning signs are provided. The advantage of these schemes is the saving of space and reduction of walking distance.
With the above scheme, the number of loading berths may be reduced by having buses layover in the hold area and stop in the loading berths just long enough to load. More routes can double up at a single berth this way.
When space does not permit use of long in-line loading areas, a more compact arrangement, utilizing small island platforms, may be used. This system, however, leads to uncontrolled pedestrian crossings over a large part of the busway, and hence increased danger and possible movement delay.
The scheme above involves intensive use of loading berths by many routes in a random manner. It requires a large platform for waiting passengers, an audio/visual system, and a traffic controller for identifying buses. This scheme offers short walking distances, but is more hectic for the rider due to the constant milling about on the platform. Buses may layover in the hold area in this scheme.

BUS FACILITIES: OFF STREET - RANDOM LOADING
Bus terminals with cross-platform transfer are found at a number of locations on the "T" system today. Though convenient for bus to train transfers, this layout as shown above, is generally inconvenient for all walk-in, kiss-and-ride, and park-and-ride passengers. As this system requires side platforms, two fare collection lobbies at platform level are required, except at rail terminals. This layout takes considerable length, as grade separations between buses and trains are needed at each end of the station, and also makes an inbound-outbound option difficult for loading or unloading passengers. In addition, it is too wide to fit into expressway medians or on rights-of-way shared with railroads.
Minimum vertical clearance at busways should be 13'-6". Obstructions on the platform should be at least 6' from the platform edge. Shelter should be provided for unloading and loading areas. Benches should be furnished at loading areas. At heavy traffic stations continuous canopies should cover the bus platforms and connect with the lobby. At lighter traffic stations or stops, small free standing shelters should be used. Benches, maps, windbreaks, and at least one sheltered and heated space should be provided at bus loading areas at each station. See Parts I and IV for similar furnishings used on train platforms.
Single lane busways should be avoided unless they are short and there are alternate paths available. The minimum width of a 2-lane roadway for moving buses is 20', and where buses stop, 24'. As is shown on the turn radius diagram, a turning bus sweeps a considerably larger area than a bus on a tangent path. If pedestrian traffic is adjacent to the outside of a tightly curving bus loop, a protective fence or stripe should be used to allow space for overhang of the front outer corner of the bus. Buses should not load or unload in the midst of a short radius loop or curve as they cannot get up to the curb, and waiting passengers cannot predict the path of the bus.
The minimum turning radius for the largest Authority buses is shown above. For ease of operation, larger dimensions than the minimum should be provided. Other data on geometric design of roadways, corners, median dividers, etc, can be found in "A Policy on Arterial Highways in Urban Areas", by American Association of State Highway Officials, Washington, D.C. 1957.
Separate service facilities for bus drivers may be furnished at heavy volume stations. They include a toilet and washroom of 100 to 150 sq. ft., a lunch and locker room of 200 to 300 sq. ft., and a starter's office of 100 to 150 sq. ft. Access to operators' toilet, locker rooms, etc., should not be via the starter's room. These facilities should be at a location which is convenient to the bus loading area and surveillance. The starter's room is normally near the leaving end of the busway. They may be incorporated in the station lobby, but should be outside the fare collection line. At lighter volume stations the bus driver's facilities would be joined with those provided for station personnel.
Principal dimensions and features of the largest buses now operated by the Authority are shown above. (G.M. "New Look" etc.)

BUS DIMENSIONS

SITE PLANNING & NEW STATIONS

STATION ACCESS FACILITIES
Park and ride requirements for each station are spelled-out by Planning. As a general rule, parking will be supplied at all stations outside of the high density central area. The amount of parking space at a particular station depends upon the traffic potential, the ability of the street system to feed the station, and availability of reasonably priced land. Generally, more parking space is needed at stations in the outer low density suburban areas where walk-in and feeder bus traffic is of minor importance.

The policy of the Authority at existing lots is to have pay parking, requiring a means of controlling entry to the parking area. Aside from producing revenue, pay parking helps limit use of the lot by non-transit riders, and through use of selective pricing, helps get maximum utilization of all lots along a transit route and to control use of areas within a lot, such as reserving space near the lobby for mid-day riders. At the present, station lots are operated by a concessionaire, with an attendant collecting the parking fee as cars enter the lot and must be flexible enough to allow the control to be at either entry or exit.
From 30% to 60% of the cars parked at a station over 24 hours may arrive in the AM peak hour, depending on circumstances of the station location.

There may be surges within the peak hour with as many as one-third of the cars arriving or leaving in the peak 15 minutes. Entry and exit facilities should be dimensioned to handle this traffic. The capacity in cars per hour for an attendant or a mechanical toll collection device is 400 to 500 per hour, depending on the fee being collected. A pass system would be somewhat faster. Specific parking demand forecasts and other design criteria for each location are furnished by The Authority.

Parking lot exits may be shared with the other access modes. Several exits may be used as long as gates and signs are provided to prevent illegal entry, where lots handle pay parking. Exits should be planned so that cars waiting to enter the street do not foul other station traffic.

Street access to parking areas should be designed in keeping with good traffic engineering and geometric design practice. Street improvements, including signalization, widening, and construction of access roads or ramps, can be made when necessary.

The ability to have paid parking must be designed into all new Park and Ride facilities, though installation of control devices may not be made initially. Roadways and control points should be located so that cars waiting to pay will not block either public street access or internal access routes to kiss-and-ride and bus terminal areas. The roadway at the control point should have at least two 10 ft. lanes, with at least six feet width at each shoulder for attendant's booths and automatic toll collection equipment. Storage space should be allowed for waiting cars, so that adjacent facilities will not be blocked.

A single entry control for Park and Ride lot where a fee is collected is usually preferred. The entry from the street may be shared with kiss-and-ride and bus traffic. Site considerations and traffic demand may require several entries in particular cases. It may be necessary to divide the parking into several individual lots each with its own control. This layout should only be used when there is no other solution.
Circulation within the parking bays should be one way, with a counter-clockwise pattern preferred. Entries to bays and the roadway system should be well signed. Bays should be aimed toward the station entry so that pedestrians flow along the bays to the station. Crosswalks at busways should be marked.

Ninety degree parking is preferred with angle parking used only where space is restricted. The preferred dimensions for right-angle parking bays are shown above.

With a 65' bay width the stalls may be reduced to 8.5', or the stalls may be held at 9' and the aisle width reduced to 62' in tight situations. Minimum inside turning radius for cars is 20' with outside 30'. Other details of right angle and angle parking may be found in various handbooks.
Parallel curb parking may be used in Kiss-and-Ride areas and in other left-over spaces. Stalls should be 9' wide and 22' long.

For preliminary planning purposes, assume 350 sq. ft. per parking space, which gives 125 cars per acre. This allows for stalls, aisles, and general circulation within the lot.

Curbs or barriers between stalls and bays should not be used, because they make efficient snow removal impossible. However, ends of bays may be defined with raised curbs. Where pedestrian flows through a lot are more concentrated, as in the case of pedestrian access way from outside the station, curb protected pedestrian ways should be provided, with allowance made for snow removal.

To break-up the scale of large lots, they should be sub-divided into sections. Changes in level, protected walkways, access roadways and landscaping may be used for this purpose. In general, where landscape elements are used they should be massed rather than scattered thinly throughout the lot. This yields a better visual effect, and easier snow removal and maintenance.

Landscaped barriers at least 10' wide should separate the parking area from adjacent streets. Special cases, particularly in residential areas, may require greater width. Vertical screens or fences may be needed to protect the privacy of neighboring parcels. Landscape spaces and materials must be designed with snow removal, minimum maintenance cost, and the vandalism threat constantly in mind.

Grassed areas require constant care and should be avoided if possible. For variety, various paving materials such as brick, stone, or concrete textures may be used. (See Part X-B3)

Lighting in general is discussed under environmental criteria in this section. Wires, wood poles, and other unsightly devices will not be permitted.
Parking garages will be used at a few specific locations where the parking demand exceeds the supply possible with surface parking alone. Garages, like lots, will have provision for entry control, and will be self-parking. Space criteria for stalls and aisles is similar to that of lots. Preferred grade of ramps is 5% with 10% as absolute maximum. Overall design should be in keeping with good self-parking garage planning practice. Pedestrian circulation within the garage should be designed to connect directly with the station lobby. Special controls to limit the use of the garage by non-transit riders other than at the entry may be necessary.

For further information refer to the following books:

Baker and Funaro, Parking, Reinhold, New York, 1958


Facilities should be made available for “kiss-and-ride” and taxi passengers at all non-downtown stations. Unless otherwise specified, these facilities should rank second in access priority after buses. Space needs vary with time of day. Relatively little space is needed in the mornings for auto drop off, but in the evening rush more space for waiting cars is required. Both on and off-street “kiss-and-ride” facilities are possible.

On-Street Facilities:

Traffic patterns on adjacent streets and site considerations may dictate the placement of “kiss-and-ride” space on the street. Where possible a pull-out lane, similar to that shown for on-street bus terminals, should be provided. A free-standing shelter should be furnished at such locations if specified by the Authority. These areas should have easy pedestrian access to the station, and be placed so that waiting cars will not block bus or parking lot access ways.

Off-Street Facilities:

Off-street “kiss-and-ride” facilities should be used wherever space permits, and usually are provided at suburban type stations. The roadway for “kiss-and-ride” may be shared with buses at light traffic stations. The “kiss-and-ride” facility should be located so that it will not interfere with buses or other traffic. Pedestrian access to the station may cross busways at properly marked crosswalks, where bus traffic is not excessive. See parking lot geometry above for parking space criteria.

As park and ride lots may have controlled entrance or exit, the “kiss-and-ride” roadway must be placed so that cars may enter and leave without going through the parking lot control.

Parking space for 20 to 60 waiting cars is generally necessary though specific requirements will be given for each station. This space can be used for mid-day parking if properly controlled by parking lot personnel or meters. As an alternative, part of the park and ride lot may be used for waiting cars during the evening rush period, when the parking lot is not controlled.

Parking spaces within the kiss-and-ride area are normally laid out with a row of 60° diagonal spaces on one side of an aisle, and parallel curb spaces on the other. (See sketches)

KISS-AND-RISE AND TAXI FACILITIES
Curve radii and roadway widths should be sufficient to permit operation of buses in the kiss-and-ride area if required.

KISS & RIDE - TYPICAL LAYOUTS
This section discusses briefly some of the other facilities or activities which must be accommodated within or adjacent to the station site. Specific details will be furnished by Planning or by the engineering department or consultant responsible for the particular item in question.

Power Substations:

Power substations are often associated with passenger stations. The preferred design of substations occupies a space approximately 50' x 70'. This is a rectangular box with a split level interior layout. The transformer bay occupies a lower level, at grade, along one long side, and has open side walls fenced or with grilles for ventilation. The building must have truck access along the transformer bay. Other layouts involving open air switchgear and transformers are possible. These however, occupy more space, and are less suitable for residential or commercially developed neighborhoods. The substations should be located away from prime space in the vicinity of the station lobby and bus terminal areas. Architecturally, they should be compatible with the passenger station and be visually friendly to their surrounding neighbors. In specific cases it may be possible to build the substation into a parking structure, or some other part of the station structure. Exterior design of substations should be developed in coordination with the station architects.

Relay Rooms, Signal Towers:

These facilities may be built into the station or platform structures, or be free-standing (see Service Facilities, Part IX). Built-in facilities are preferred for economy and to minimize the clutter at stations. Specific information is supplied by the engineering department and consultants responsible for train control, signals, and communications. These spaces or structures must be integrated into the total design by the station architect.
Space should be made available wherever possible in heavily used new stations for concessions and shops. These facilities not only produce revenue; they also perform a public service and contribute substantially to the lively character of the stations as "places" integrated with their community.

Newsstands should be built-in to station lobbies, so as to minimize improvised cluttering from stands that are added after construction.

Other concessions such as small coffee shops, flower shops, bakeries, book shops and small clothing shops may be possible at the busier stations. These may occupy space or cubage that can be built at little extra cost over that needed for transportation purposes.

To be successful, space for concessions must be along the primary circulation routes (never in a cul-de-sac) but they must in no way interfere with the pedestrian flow that is passing by them.

CONCESSIONS AND SHOPS
Station lobbies are located under, at, or over the platform level. Minimum vertical distance between platform and lobby is about 13' for a lobby over the tracks, and 14.5' for a lobby under the tracks, assuming minimum depth of structure. Where railroad freight tracks are parallel to, and at the same grade as, the transit line, a lobby over the tracks will have to be somewhat higher. Precise clearance for railroad facilities is spelled-out by the Authority.

In general, lobby facilities should not be at platform level. Fare collection facilities on an island platform require excessive platform width, and once installed are difficult to expand in case of an increase in traffic. At a side platform station, fare collection on the platform requires inefficient duplication of fare collection equipment, and manpower. Such a station layout may be convenient in one direction of travel, but often extremely inconvenient in the opposite direction. As a rule, stations and station lobbies should be laid out so that the station can be controlled by a minimum of one person. Stations with lobbies located at both ends may be designed so that a major lobby is open at all times, and a minor lobby is open part time as an entry and full or part time as an exit.

LOBBY/PLATFORM RELATIONSHIPS
STATION CROSS-SECTIONS

Island Platform

Stair → Lobby

Train → Platform

Lobby over tracks in cut

Lobby over tracks at grade

Lobby under tracks at grade

Lobby under tracks above grade

Side Platform

STATION LOBBIES AND PLATFORMS

SITE PLANNING & NEW STATIONS
Lobby Layout

Details of lobby layout, fare collection, vertical circulation, signage, graphics, and service facilities are found in Parts IV, V, and IX of the Manual. Capacity requirements for design of lobbies and circulation are furnished by the Planning Department.

For preliminary layout purposes refer to the following excerpts from Part IV, "Components".

Design Capacity of coin or token turnstiles, and exit gates: 40 persons/min.

Turnstile Dimensions: 4' deep x 2'-4" wide (automated gate 3' wide).

Exit Gate: 5'-6" diameter.

Minimum queue space on each side of the turnstile bank:
   a) Suburban Station: 15'
   b) Downtown Station: 20'

Total minimum depth of fare collection area excluding stair run-off and through circulation paths:
   a) Suburban Station: 34'
   b) Downtown Station: 44'

Width of fare collection area depends on traffic.

Note that stations outside of the central area must be designed for collection of fares for persons entering and leaving the station. Allowance should be made at all stations for eventual uses of change machines, and ticket machines which could be incorporated in a future automated fare collection system.

**TYPICAL STATION CIRCULATION**
The long-range goal of the Authority is to provide sufficient escalators at each station so that there will be available to any passenger at least one path between vehicle and surface, or from vehicle to vehicle at transfer points, where all upward movements of over ten feet are mechanized, provided average daily volume at such points is at least 1000 potential passengers.

Wherever a continuous downward movement exceeds 25 feet, the use of a down escalator should be considered, especially if such escalator would lend itself to reverse operation when traffic flow peaks in the opposite direction.

The term "escalator" as used here, may also apply to "moving ramps" or "moving sidewalks" where appropriate. Moving sidewalks should also be considered in cases of long horizontal transfers with heavy traffic.

All new stations should be designed to meet the above goals as nearly as possible, consistent with the funds available, even if actual installation of the escalator is deferred to a later date.

Summary of Planning Standards for Vertical Circulation

1) Stairways:

Maximum Capacity: 20 persons/foot-width/minute, (or 36.5 persons per minute for each single lane 1' - 10" in width.)
Design capacity: 15 persons/foot-width/minute.

Minimum Width: 6' which allows for later installation of escalators and stairs - wider than 8' requires a center handrail.

Approximate Length: 1.73 x rise (for 30 stair used in conjunction with escalators) plus landings @ 4.5' for straight stairs with a rise of 8' (15 risers) or over. Landing for return stair should equal width of stair.

Minimum Run-off: (clear space) at ends of stair or escalator:
   a) To a solid obstruction: width x 1.7
   b) To edge of queue space: 10'
   c) To another stair or escalator: 30'
Note: Run-off for stair and escalator in same well is the combined width x 1.7.
2) **Ramps:**

Design Capacity: Minimum width and run-off same as stairs.

Maximum Slope: 1:12, preferred 1:15.

3) **Level Passageways:**

Design Capacity: Range from 20 to 25 persons/foot-width/minimum.

Minimum Width: 10', preferred 12'

4) **Escalator:**

Maximum Capacity: 135 persons/minute for a 4' tread width and speed of 120'/minute (32'' escalators not to be used in new work). For design capacity, use 100 persons/minute.

Width: 6' clear shaftway opening.

Approximate Length: $1.73 \times \text{rise} + 15'$ (30° slope plus level transition at ends). See manufacturers catalogues for precise dimensions.

Minimum Run-off (clear space at ends):

a) To a solid obstruction: 15'

b) To edge of queue space: 10'

c) To another escalator or stair: 30'

Note: Moving sidewalks have similar characteristics except that maximum slope is 15° (1:3.46)

Minimum headroom requirements for all pedestrian passageways, stairs, etc. is 7'-6" for short distances (under beams, etc.), preferred minimum 8' to 10'. For greater detail, see Section IV. Components.

5) **Elevators:**

May be required at selected locations for use of handicapped, and in multi-story parking garages

Minimum cab size: 4' x 4' clear

**VERTICAL CIRCULATION**
Stations on two-track lines are of two types: island platform and side platform. Island platforms are preferred because they offer more efficient use of platform space, furnishings, and vertical circulation. Traffic flow at the typical station, outside of downtown, is very peaked -- A.M. inbound, P.M. outbound. Island platforms result in a more efficient lobby layout with a cleaner straight-through circulation path than is possible with side platforms. The passenger need not make his decision as to train direction until he reaches the platform instead of in the lobby where space is more restricted and other activities, such as fare collection, must occur.

However, in certain areas physical conditions at or near the station site will have a strong constraint upon the track alignment and require the use of side platforms. In special cases, of a particularly heavy interchange movement, a side platform layout could be required to permit easy cross-platform transfer to buses. Platform configurations are specified by the Authority.

**PLATFORM TYPES: TWO-TRACK**
Stations on three-track lines are of two general types: double island and side platform. The double island type is preferred as it offers the greatest flexibility for operation. Trains on any track can stop at the station if necessary and any track may be used as the express track. As in the case of two-track routes, side platforms may be necessary at certain locations. An advantage here of side platforms is that less overall width is needed than for a double island layout.
Variation of platform access points along a route

Platforms may be center loaded or end loaded - at one or both ends. End loading requires less platform width and offers more straightforward circulation than center loading, while the latter shortens walking distance on the platforms. As people who enter a station to await a train will tend to cluster in the vicinity of the platform access point, it is necessary to vary the points of access from station to station along a route. One station should be center loaded, another at the inbound end, another at the outbound end and perhaps another double end loaded. Loading at the third or quarter points is also possible. Thus, boarding passengers will be distributed more or less uniformly along the length of a train as it proceeds along its route.

The approximate location of platform access points are normally specified by the Authority.
Platforms should be on tangent tracks, and on grades of \( \frac{1}{2}\% \) or less, if possible. When curves are necessary, the radius should be at least 4000'-5000'; and platform faces should be convex curves. Concave curved platforms should be avoided because they make it difficult for train guards to have clear sightlines along the train when closing doors. Platforms may be tapered at the ends with long radius convex curves to permit maximum width at the access point while permitting the tracks to reach normal spacing within a reasonable distance from the station.

Minimum headroom requirements is 15' from top of rail to any structure over the tracks, though a lower ceiling over the platform is permissible with 9'-6" from platform to ceiling as minimum. (This allows 1'-0" depth for continuous lighting fixture located above the platform edge.) The edge of the dropped ceiling should be set back at least 2'-2" from the platform edge.

Other details of platform widths, lengths and clearances are found in Manual Parts I and IV.
Minimum Platform Dimensions:

- Track to Edge of Platform
- Red 5'
- Orange 4'-7"
- Blue 4'-6-1/8"

ISLAND- END LOADED
- 16' min.
- 8' min.
- 22' min.
- Min. 2'-2" Wall to Platform Edge

ISLAND-CENTER LOADED
- 16' min.
- 23' min.
- 7'

SIDE-END LOADED
- 12' min.
- Min. 2'-2" Wall to Platform Edge

SIDE-CENTER LOADED
- Red 440'
- Orange 410'
- Blue & Green 300'
- No Columns 13' with columns
- Red: 14'-4" + Col.
- or Blue & Green
- 13'-6" + Col.

Note: All clearances to be checked with the Authority and/or track geometry consultants.

PLATFORM DIMENSIONS
Railroad shuttle service connecting with several rapid transit stations is currently under study. Preliminary design of these particular stations must allow for this kind of service. What facilities are actually built will depend upon the outcome of these studies.

Ideally the station should be planned to permit future conversion of the railroad facilities to electrified rapid transit, with through service to downtown. If possible, cross-platform transfer should be planned. A possible layout for such a terminal is shown above.
MANUAL OF GUIDELINES AND STANDARDS

PART I GUIDELINES AND PRINCIPLES
PART II STATION RECONNAISSANCE (Discontinued)
PART III STATION MODERNIZATION PROGRAM (Discontinued)
PART IV COMPONENTS
PART V GRAPHICS
PART VI LIGHTING
PART VII MATERIALS
PART VIII ACOUSTICS
PART IX SERVICE FACILITIES
PART X SITE PLANNING AND NEW STATIONS
PART XI VENTILATION
GENERAL INTRODUCTION

The Massachusetts Bay Transportation Authority has found it both necessary and possible to concentrate attention on the complex needs of people. Programs to improve service must now include a new emphasis on the quality of the transportation experience. In effect, transportation engineering has been joined by human engineering and environmental design.

This manual provides a framework for the continued coordination of all those elements in the system that affect human comfort.

Many of the criteria involved are common to all environments, such as the control of light, noise, humidity, temperature, wind, and odors, or the need for orderliness, through clear and easy circulation and clean appearance. Other criteria that are more specific to the transportation environment are such needs as safety, traffic handling capability, spatial variety, consistently available information, and orientation.

The most important single criterion that has guided the preparation of this manual is the need for orientation. The rider must not only be physically comfortable, he must also know in the fullest sense where he is and where he is going.

Since to the layman a public transportation system is to a large extent an invisible skeleton of the city and metropolitan region, the comprehension of that structure generates an awareness and appreciation of the city itself, and an appreciation of travel through it.

There are many aspects to achieving this orientation. Circulation at all points must be direct and open. Spaces should relate visually to their surrounding environment, either through direct openings to adjacent spaces and structures, or in the case of platforms, by graphic reflection through photographic murals.

Above all, the need for orientation places great emphasis on maps and a consistent system of identification and directional signing. Graphics then emerge as a major factor in the design of each environment, a factor that must be given high priority in the early design phases of each project.

It is hoped that all participants in all programs will familiarize themselves with the entire manual, so that the implications of each decision can be understood in a system-wide context.

The standards and guidelines presented here are not inflexible rules. They are a framework for meaningful development and variety, and offer no restriction to the capacity of each participant to evolve better solutions to old or new problems.

As new solutions are developed and approved, revised and additional pages for the manual will be issued to all participants.
PART XI - VENTILATION

A. Ventilation Standards for Stations

1. General Information
   Method of Ventilation

2. Special Heat Sources in a Subway Station
   Special Requirement
   Normal Ventilation of a Typical Subway Station

3. Normal Ventilation in a Station Inside of Which Diesel Powered Buses Operate

4. Emergency Ventilation Controls

B. Subway Environmental Design Handbook

1. Outline of Handbook

C. Detailed Criteria
   (Revision of 1977)
PART XI SERVICE FACILITIES

A. Ventilation Standard for Stations

B. Subway Environmental Design Handbook

C. Heating, Ventilating, Air Conditioning Requirements For Station Areas

1. Lobby and Fare Collection (Below Grade)
   Collector's Booths

2. Porter's Room
   Safe Room
   Electric Closet

3. Public Toilets
   Employee Toilets

4. Lamp Storage
   Head Houses
   Mechanical Rooms
   Mechanical Rooms (Above Grade)

5. Storage Room
   Bus Starter's Room
   Passenger Waiting Enclosed (Above Grade)

6. Passenger Waiting Open Windbreak Type
   Train Platform
   Inspector's Room

7. Signal Bungalow or Rooms
   Train Crew Lobby or Yard Crew Lobby
   Substations, Rectifier Rooms, Switchgear Rooms

8. Parking Garage
   Toll Collection
   Garage Operator's Office

9-10. General HVAC Guidelines For Buildings
A. VENTILATION STANDARD FOR STATIONS

The primary requirement of a station ventilation system shall be to provide a safe environment for the Authority's passengers. It shall have the capability in an emergency to exhaust smoke fumes, etc.

A secondary requirement of a station ventilation system shall be making the environment within the station, under normal operating conditions, conform to certain standards for the comfort of our passengers and employees.

1. General Information

a. The rapid transit trains operating between Quincy and Harvard Station are air conditioned.

b. All new rapid transit and light rail (similar to streetcars) will be air conditioned.

c. Existing cars will not be air conditioned.

d. Existing stations will not be air conditioned.

e. Previous to this time, normal subway and station ventilation has been accomplished by the "piston action" of the trains. The rolling stock push the air in the subway ahead of it to the next vent shaft emergency exit connection to the adjacent subway or station. When the train passes an exit for the air, it draws air along after it.

f. Electric motor driven fans are provided at various locations in the transit system for emergency ventilation. While not decided at this time, the Authority may order the operation of certain of the fans at night to bring cool air into the subway to cool the subway walls and lower the general subway temperature.

2. Method of Ventilation

a. In general, ventilating air will be drawn or pushed into the station from the subway.

b. Air will be exhausted from the station to the outside.
c. The consultant shall evaluate the effect of the existing vents, emergency exits and any new ventilation under study by others or being installed.

3. **Special Heat Sources in a Subway Station**

In addition to the normal heat in a subway station, lights, etc., a major source of BTU's is the trains. The braking and accelerating of a train, the heat output of the auxiliaries and heat of the sun on the cars while running outside the tunnel add many BTU's to the station.

4. **Special Requirements**

Realizing the limitations of the existing subway stations, it is still desired that the consultant design a system that will limit the amount of dirt laden air from entering the station. Any duct work carrying air from the subway to other parts of the station will be equipped with easily serviced filters in the line. Unless the filters are easily serviced using hand carried tools, they will soon become overloaded and useless.

5. **Normal Ventilation of a Typical Subway Station**

a. Any individual rooms in a station shall have a system with the capabilities as listed below:

- **Cable Rooms and Pits**: Natural ventilation to suit heat load
- **Electrical Operating Equipment Rooms**
  - **Control Rooms**: 8 changes of air per hour (even outside air must be filtered)
- **Maintenance and other Personal Rooms except Toilets**: 8 changes of air per hour
- **Toilets**: 10 changes of air per hour
- **Battery Rooms**: 15 changes per hour

The consultant shall balance the cost of using filtered subway air including special controls such as remote controlled louvers necessary in case of fires in the subway against the cost or providing an outside air supply.
b. The station ventilating equipment shall be capable of maintaining the ambient temperature in the station within 5° of the outside air when the temperature is 91° F and 10° F when the outside air is 60° F. Further, the system shall have the capability of supplying 7.5 cubic feet of fresh air per minute for each passenger in the station complex.

6. Normal Ventilation in a Station Inside of Which Diesel Powered Buses Operate

The consultant shall research the existing state of the art of diesel fume removal. In general, an attempt will be made to have an exhaust grille located 5' forward of the left rear of a bus in its normal berthing position. Where there are two bus lanes, an intake air grille shall be located opposite the exhaust grille.

The normal flow of exhaust from a diesel bus when accelerating is estimated to be 500 SCFM. Unless the state of the art research shows that this figure is improper, the consultant shall provide an exhaust capacity of 12 x 500 or 6000 SCFM per berthing position. The velocity through the grille will be at least 1000 feet per minute and not greater than 1200 feet per minute. Where there are two lanes, the intake grille will have a capacity of 5000 SCFM.

The consultant shall make a comparison of the most economical system considering the number of buses berthed during the rush hour and the number at other times. During the rush hour, all systems could be operated; at other times fans could be shut down.

Proper consideration shall be given to the exterior ends of the intake and exhaust systems so that there will not be any "short circuiting". The air drawn in shall be as uncontaminated as possible and the vitiated air shall be properly discharged.

Further, special care shall be taken so that any air fouled by diesel fumes is not blown into the subway.

Normally, if vehicles enter and leave a station, it is open enough so that additional ventilation beyond the above is not required. In any case, Section 5 above must be satisfied either with mechanical fans or natural ventilation.
7. **Emergency Ventilation**

The ventilation system shall have the capability of exhausting the air in the station complex 15 times per hour. The emergency ventilation system shall include station fans and may include fans located in the subway between stations.

Where possible, provision shall be included to close off, by dampers, individual rooms to accomplish the above.

8. **Controls**

Fan controls for normal operation shall be located at a convenient place in the station.

Emergency controls for station ventilating equipment shall be located both in the station and at the Dewey Control Center. Controls for ventilating equipment located in the subway shall be located on the adjacent subway platform and the Dewey Control Center.

Controls shall be able to reverse fan motors.

Each control area will be equipped with indicating lights to show the operating status of the equipment.
This technical report, Project No. DC-06-0010, funded by UMTA, has been prepared for planners, operators, and others involved with underground rapid transit systems who are not necessarily concerned specifically with environmental control but who require guidelines for this decision-making process in the overall system design. The following is a brief outline that illustrates areas covered.

It is hoped that if more specific information is needed the "Handbook" will be referred to.

Part I. Digest

Section 1.1 Past Practices and Concepts
Section 1.2 Contemporary Environmental Control Concepts
Section 1.3 The Design Process
Section 1.4 Comparison of Alternatives

Part II. Human Environmental Criteria

Section 2.1 Temperature and Humidity
Section 2.2 Air Quality
Section 2.3 Air Velocity and Rapid Pressure Changes
Section 2.4 Emergency

Part III. Subway Environmental Evaluations and Design Strategies

Section 3.1 Design Strategies to Achieve Air Temperature Criteria
Section 3.2 Air Velocity Control
Section 3.3 Air Quality Control
Section 3.4 Air Pressure Control
Section 3.5 Environmental Control for Emergencies
Section 3.6 Strategies for Multiple Criteria

Part IV. Application of Equipment and Structures for Environmental Control

Section 4.1 Environmental Control Systems
Section 4.2 Environmental Control Equipment
Section 4.3 Vehicle Air Conditioning
There are also a number of Appendices that detail research reports, scale models, survey results, bibliography and statistical information on eleven Canadian and United States subway systems relative to environmental control. Furthermore, there is a Volume II of the "Handbook" that contains detailed computer programs and other aids to the designer.
HEATING, VENTILATING, AIR CONDITIONING REQUIREMENTS
FOR STATION AREAS

The following criteria supplement the information shown on pages 1 through B1.1 issued in 1974. In case of conflict, these new criteria will apply:

1. LOBBY AND FARE COLLECTION (Below Grade)

   Temperature: No control. Provide exterior finishes and equipment capable of withstanding temperature variations ranging from $0^\circ$ F to $105^\circ$ F.

   Humidity: No control.

   Ventilation: Provide sufficient outside air in summer months to carry heat gain with a maximum differential of $10^\circ$ F. All ventilation shall be mechanical. Turn on summer ventilation by thermostat set at $80^\circ$ F inside temperature. Design for residual velocities of 50 FPM.

   Odor: No control.

   Dust: Throw away filters with indication of pressure drop across filter.

2. COLLECTOR'S BOOTHs

   Temperature: Maintain $70^\circ$ F minimum in winter months. Maintain $78^\circ$ F maximum in summer months. Consider using water-cooled condensers below grade if practical and air cooled condensers above grade if good ventilation is available. Energy source to be electricity.

   Humidity: No control.

   Ventilation: Provide 20 to 25 CPM local outside air. Maximum residual air velocity in occupied area to be 50 FPM. All ventilation shall be mechanical and run when booth is occupied.
3. PORTER'S ROOM


Humidity: No control.

Ventilation: Provide 1/3 CFM local air per square foot of floor area. 100 CFM minimum. Maintain small negative pressure in room. Exhaust to outside. Mechanical ventilation on-off switch.

Odor: Negative room pressure.

Dust: No control.

4. SAFE ROOM

Temperature: Same as 3.

Humidity: Install dewpoint control to prevent wall condensation in intermediate seasons. Humidistat and two thermostats.

Ventilation: Provide 1/3 CFM per square foot floor area, local air. 100 CFM minimum. Maintain small negative pressure in room. Mechanical ventilation. On-off switch.

Odor: No control.

Dust: No control.

5. ELECTRIC CLOSET

Temperature: Same as 3.

Humidity: Same as 4.

Ventilation: Provide 1/3 CFM per square foot floor space local air 100 CFM minimum. Main-
Ventilation: Maintain small positive pressure in room. Mechanical ventilation. On-off switch.

Odor: No control.

Dust: Provide 30 to 35 percent efficiency filter based on ASHRE 52-68 test. Maximum velocity through filter 200 FPM. Initial pressure drop 12 inches water guage. Provide indication of filter pressure drop. Change filter when pressure drop reaches 7 inches water guage.

6. PUBLIC TOILETS

Temperature: Maintain 45°F minimum in winter months. No control in summer months. Locate to minimize heating requirement. Electric heat. Thermostat. Adequate to heat ventilation air.

Humidity: No control.

Ventilation: Provide 40 CFM for each toilet and 40 CFM for each urinal, but not less than 50 CFM in any single toilet. Use local air and exhaust to outside. Maintain small negative pressure in room. Mechanical ventilation. On-off with light switch.

Odor: Negative room pressure.

Dust: No control.

7. EMPLOYEE TOILETS

Temperature: Maintain 70°F minimum in winter time. Electric heat. Thermostat. Capacity adequate to heat ventilation air.

Humidity: No control.

Ventilation: Same as 6.

Odor: Negative room pressure.

Dust: No control.
8. LAMP STORAGE

Temperature: Same as 3.
Humidity: Same as 4.
Ventilation: Provide 1/3 CFM per square foot floor space local 100 CFM minimum. Maintain small negative pressure in room. Mechanical ventilation. Off-off switch.
Odor: Negative room pressure.
Dust: No control.

9. HEAD HOUSES

Temperature: Maintain heated entrance to control ice.
Humidity: No control.
Ventilation: None.
Odor: No control.
Dust: No control.

10. MECHANICAL ROOMS (Underground)

Temperature: Same as 3.
Humidity: Same as 4.
Ventilation: Same as 5.
Odor: No control.
Dust: Same as 5.

11. MECHANICAL ROOMS ABOVE GRADE

Temperature: Same as 3.
Humidity: Same as 4.
Ventilation: Provide mechanical ventilation capable of carrying heat gain in summer with a 100°F differential. Provide 1/3 CFM per square foot in winter or 100
Ventilation (cont'd.)
CFM minimum. Outside air if practical. Maintain small positive pressure in room. Automatic control.

Odor: No control.
Dust: Same as 5.

12. STORAGE ROOM

Temperature: No control.
Humidity: No control.
Ventilation: Provide 1/3 CFM per square foot of floor area minimum 100 CFM local air exhaust to outside. On-off switch. Maintain small negative pressure in room. Mechanical ventilation.

Odor: Negative pressure.
Dust: No control.

13. BUS STARTER'S ROOM

Temperature: Same as 2.
Humidity: Same as 2.
Ventilation: Same as 2.
Odor: Same as 2.
Dust: Same as 2.

14. PASSENGER WAITING ENCLOSED ABOVE GRADE

Temperature: Maintain 45°F minimum in winter. Electric heat. Thermostat control.
Humidity: No control.
Ventilation: Same as 1.
Odor: Same as 1.
Dust: Same as 1.
### 15. PASSENGER WAITING OPEN WINDBREAK TYPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Provide radiant heat, electric, thermostat control.</td>
</tr>
<tr>
<td>Humidity</td>
<td>No control.</td>
</tr>
<tr>
<td>Ventilation</td>
<td>No control.</td>
</tr>
<tr>
<td>Odor</td>
<td>No control.</td>
</tr>
<tr>
<td>Dust</td>
<td>No control.</td>
</tr>
</tbody>
</table>

### 16. TRAIN PLATFORM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Same as 1.</td>
</tr>
<tr>
<td>Humidity</td>
<td>No control.</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Provide exhaust system and supply air system capable of removing 60 percent of heat released from train dynamic braking grids while in station. Supply air and exhaust air quantities shall be directed over the platform to provide some air movement on the platform for people standing there. Automatically shut down supply air when outside air temperatures would be uncomfortable across platform. Continue to run exhaust system until heat is needed on platform at which time exhaust system shall be shut down. Exhaust system shall be part of emergency ventilation for station and shall be arranged for eventual remote control. Fans shall be capable of handling 300°F cases for at least one hour. Direct driven, single speed.</td>
</tr>
<tr>
<td>Odor</td>
<td>No control.</td>
</tr>
<tr>
<td>Dust</td>
<td>Same as 1.</td>
</tr>
</tbody>
</table>

### 17. INSPECTOR'S ROOM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Same as 2.</td>
</tr>
<tr>
<td>Humidity</td>
<td>Same as 2.</td>
</tr>
</tbody>
</table>
Ventilation: Same as 2.

Odor: Same as 2.

Dust: Same as 2.

18. SIGNAL BUNGALOW OR ROOMS

Temperature: Maintain 78° F maximum in summer and 70° F minimum in winter. Electric resistance heat, direct expansion air cooling. Consider air cooled condensers, well ventilated above grade or below grade if practical. Water cooled condensers can be considered using city water and run to drain if three tons or smaller.

Humidity: 50 percent maximum in summer and intermediate seasons use electric reheat. No control below 50 percent.

Ventilation: Provide sufficient local outside air to maintain small positive pressure in room.

Odor: No control.

Dust: Same as 5.

19. TRAIN CREW LOBBY AND YARD CREW LOBBY

Temperature: Same as 2.

Humidity: Same as 2.

Ventilation: Provide 15 CFM per occupant as an average occupancy basis of local outside air where practical. Maintain small positive pressure in space.

Odor: No control.

Dust: Throw away filters with remote indication of pressure drop across filters.

20. SUBSTATIONS, RECTIFIER ROOMS, SWITCHGEAR ROOMS

Temperature: Maintain, minimum 45° F in winter time.
Humidity: Same as 4.

Ventilation: Provide sufficient mechanical ventilation to carry design day heat gain with a 10°F rise. Operate ventilation system automatically when inside temperature rises above 90°F.

Odor: No control.

Dust: Same as 5.

21. PARKING GARAGE

   Temperature: No control.
   Humidity: No control.
   Ventilation: Provide sufficient ventilation to keep CO within safe limits. Operate mechanical ventilation if required by a CO monitoring system. Provide sound treatment on fan to limit noise level to that of surrounding area.

   Odor: No control.
   Dust: No control.

22. TOLL COLLECTION

   Same as 2.

23. GARAGE OPERATOR'S OFFICE

   Same as 19.
1. Buildings with more than 25 tons of refrigeration shall use multiple compressor package water chillers installed in interior mechanical rooms with remote air cooled condensers.

2. Buildings with less than 25 tons of refrigeration shall use direct expansion package-type equipment with remote air cooled condensers. Small room-type equipment may be used for offices and other small room areas where comfort, zoning, and economy are better served by this type of equipment.

3. All air conditioned buildings shall be zoned for comfortable and economical operation.

4. Buildings shall use hot water heating systems. Buildings with a chilled water cooling system shall use a four-pipe heating and cooling system. The heating requirement of wall and window shall be carried by a perimeter heating system. Roof and outside air heating requirement shall be carried by air handling equipment. Outside air tempering coils shall be equipped with separate run-around pumps, and the circulating fluid shall be glycol water solution.

5. Heat gains shall be calculated in accordance with storage system developed by Carrier Corp. Humidity control in comfort air conditioned areas shall be a function of a 50°F temperature swing above thermostat setting during the duration of the design outside temperature. Process humidity control shall be accomplished by refrigeration with reheat where necessary.

6. 10 CFM of outside air shall be supplied for every individual in the building in addition to exhaust required for toilets, etc. Outside air shall be controlled relative to building occupancy and shall be shut down when the building is unoccupied and shall be reduced under partial occupancy conditions. Enough outside air shall be supplied to maintain a small positive pressure in the building. All outside air shall be filtered and return air shall be filtered. Pressure drop across filters shall be remotely indicated at thermostat control locations. Instructions relative to filter maintenance shall be posted at the remote pressure drop readout.
7. **Conference room air conditioning systems shall be completely independent of building air conditioning systems.** Outside air in the amount of 30 CFM per chair shall be supplied. The heat gain shall be calculated on an instantaneous load basis. Conference room air conditioning shall be shut down when the room is not in use, and its unoccupied load shall be assumed by the zone it is located in.

8. **All control systems shall be simple in nature.** On-off control shall be employed everywhere possible. Conditions in occupied areas shall not be controlled by turning fans on and off. Electric controls are preferred, rather than electronic or pneumatic controls.

9. **Heat trace all water and drain lines subjected to below freezing temperatures**
FOURTH DRAFT

FIRE PROTECTION AND LIFE SAFETY PROGRAM
FOR THE
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

ARTICLE 1 - INTRODUCTION

The purpose of this document is to present the fire protection and life safety criteria for the design, construction and operation of the fixed guideway rapid transit system of the Massachusetts Bay Transportation Authority, hereinafter referred to as the MBTA, to provide a safe environment for the MBTA passengers, employees, property and equipment as well as the general public.

SECTION 100.0 SCOPE

This document describes the fire protection systems and life safety requirements for all new construction of rapid transit stations, tunnels and aerial structures.

It is divided as follows:

ARTICLE 1 - INTRODUCTION
ARTICLE 2 - FIRE ALARM AND WARNING SYSTEM
ARTICLE 3 - COMMUNICATIONS
ARTICLE 4 - VENTILATION
ARTICLE 5 - ELECTRICAL
ARTICLE 6 - CONSTRUCTION
ARTICLE 7 - MEANS OF EGRESS
ARTICLE 8 - FIRE FIGHTING FACILITIES
ARTICLE 9 - EMERGENCY PROCEDURES, INSTRUCTIONS AND EQUIPMENT
100.1 RAPID TRANSIT FACILITIES: All structures or parts thereof shall be classified in the rapid transit facilities group which are used or designed as rapid transit stations, including underground and above ground stations, tunnels, aerial structures, power plants and/or substations.

100.1.1 Included in this group are commuter rail stations which are in common with rapid transit facilities.

100.1.2 Excluded from this group are surface streetcar (light rail) stops and commuter rail stations with open platform areas which provide unlimited egress to adjacent open areas such as lawns, parking lots, roadways, and median strips. Also excluded are parking garages which are in common with rapid transit facilities.

SECTION 101.0 ADMINISTRATION AND ENFORCEMENT

101.1 BASIC CODE: All of the provisions of the Commonwealth of Massachusetts State Building Code, hereinafter referred to as the Basic Code, shall apply unless otherwise specifically modified herein.

101.1.1 Other Codes: All of the provisions of the Rules and Regulations of the Architectural Barriers Board and other applicable Massachusetts Rules and Regulations and General Laws shall apply.

101.2 JURISDICTION: All of the administration and enforcement of the Basic Code and of this rapid transit facilities code shall be under the jurisdiction of the Department of
Public Safety of the Commonwealth of Massachusetts, the State Building Code Commission and other applicable state agencies and local fire departments.

101.3 SPECIAL PROCEDURES: Required signatures of authorized MBTA officials must be obtained before plans and specifications may be issued for construction.

101.4 UPDATING: This document shall be updated as necessary to incorporate changes indicated by new technology, operating experience and improvements in the state-of-the-art of rapid transit transportation systems. Reference to the Basic Code shall include the latest amendments and shall refer to the latest edition.

SECTION 102.0 DEFINITIONS

The terms defined herein are in addition to those included in Section 201.0 (General Definitions) of the Basic Code.

Aerial Structure: Any system structure which carries transit tracks and spans above land or water surfaces. Also called an elevated structure.

Ancillary Spaces: The non-public areas or spaces of the stations which contain operating, maintenance or support equipment and functions.

Central Control: The location where train control or train supervision is accomplished for the entire rapid transit system; the system command center.
Communications Systems: Those elements and their interconnections which permit voice, data or video interchange of information between system functions which are separated by distance.

Contact Rail: A rail mounted on insulators alongside the running rail which provides traction power for train operation. Also called the third rail.

Station: A place designated for the purpose of loading and unloading transit passengers.

Station, Above Ground: A station in which the tracks and platform are either located on an aerial structure or rest directly on grade.

Station, Depressed: A station in which the trainway and platform areas are below the level of the adjacent finished grade.

Station, Underground: A station in which the major portions of the structure, including the tracks and platforms, are located below the finished grade and are totally enclosed. Also called a subway station.

Transit Car, Rail Rapid: An electrically propelled passenger carrying rail vehicle characterized by high acceleration and braking rates for frequent stops, and fast loading and unloading.

Tunnel: A totally enclosed trainway section which exceeds six hundred (600) feet in length.
ARTICLE 2 - FIRE ALARM AND WARNING SYSTEM

SECTION 200.0 SCOPE

The provisions of this article shall control the design and installation of the fire alarm and warning systems for all new construction of rapid transit facilities.

200.1 GENERAL: Rapid transit stations shall be equipped with fire alarm devices and be protected by a local system connected to a city or town master box with contacts and a connection to a data gathering panel in the station central instrument room for transmission of the alarm signal to Central Control. (See Article 12 of the Basic Code.)

SECTION 201.0 FIRE ALARM ANNUNCIATOR PANEL

Rapid transit stations shall be provided with a fire alarm annunciator panel, located at a suitable location approved by the local fire department. The main fire alarm panel shall announce by audible alarm the activation of any fire detector or pull station. The annunciator panel shall visually display the fire zone in which the initiating alarm device is located.

201.1 FIRE MANAGEMENT PANEL (FMP): Rapid transit subway stations shall be provided with a Fire Management Panel (FMP). The FMP shall be located at a suitable location approved by the local fire department. The FMP is designed to function as a fire command post in an emergency. It shall have means to tie into the public address system to provide fire department communications with passengers for specific directions in case of fire or emergency (See Section 207.0). A direct connection to the rapid
transit dispatcher shall also be provided for train control or power shut-off.

SECTION 202.0 FIRE ALARM DEVICES

Fire alarm devices shall be installed as follows:

a) Electrical Rooms - smoke detectors with alarm indication.

b) Central Instrument Rooms (CIR), Emergency Control Rooms (ECR), and Communications Rooms - smoke detectors with alarm indication and an automatic halon extinguishing system.

c) Mezzanine, concession areas, corridors, mechanical and toilet rooms, porter's rooms, and rooms used infrequently - rate of rise heat detectors.

d) Pull stations shall be provided at station entrances, platform areas, and at the fare collection area. Pull stations shall comply with NFPA 72B, Article 310. All locations shall be approved by the local fire department having jurisdiction.

e) Combination light and horn units located in public areas shall time out and silence the horn unit after two or three minutes. All visual alarm devices shall remain "ON" until the system is reset.

SECTION 203.0 SYSTEM TYPE

The fire detection and alarm system shall be supervised electrically. Trouble indication shall be located at the primary collector's booth and at Central Control.

The system shall have an approved secondary source of power.
SECTION 204.0 MUNICIPAL CONNECTION

A direct tie shall be provided from the rapid transit station master box to the local fire department headquarters in accordance with NFPA 72B.

SECTION 205.0 TRANSIT SYSTEM CONNECTION

A direct tie to Central Control shall be provided via a Data Gathering Panel.

SECTION 206.0 FIRE DEPARTMENT RADIO

Each rapid transit station shall be equipped with a base radio station connected to the local fire department headquarters for use by the fire department during emergencies as described in Article 3 - Communications.

SECTION 207.0 PUBLIC ADDRESS SYSTEM

Each rapid transit station shall be equipped with a public address system to provide communication with passengers in the event of a fire or emergency as described in Article 3 - Communications.
ARTICLE 3 - COMMUNICATIONS

SECTION 300.0 SCOPE

The provisions of this article shall control the design and installation of the communications systems for all new construction of rapid transit facilities.

300.1 GENERAL: The rapid transit system of the MBTA requires radio and wire subsystems for emergency use.

SECTION 301.0 RADIO SUBSYSTEMS

Radio subsystems for operational control, MBTA police, and local fire departments shall have the capability to cover all of the rapid transit stations and trainways, including above ground, subways and storage yards, with radio frequency signals. Radio coverage in the underground section for the above systems will be accomplished using a slotted coaxial cable (lossy line).

301.1 FIRE DEPARTMENT RADIO: Each local fire department along the route of the rapid transit system requires separate, though similar, tunnel coverage within its respective city or town limits using portable receivers. These fire departments will require base stations.

301.2 MBTA POLICE RADIO: The MBTA Police Department requires a full subway trainway and station coverage channel using portable transceivers and necessary base stations.
SECTION 302.0 WIRE SUBSYSTEMS

All land line channels shall be carried on physical telephone cable pairs. The treatment and termination of these pairs, including the use of carrier channels, and the installation of the cable and its terminal equipment shall conform to general practices and the MBTA Standards.

SECTION 303.0 PUBLIC ADDRESS

The MBTA Rapid Transit Dispatcher located at Central Control shall be provided with a system to address passengers directly, when necessary, and there shall be provided a voice grade, DC signal, zero dbm channel for each individual transit station public address destination.

303.1 STATION REQUIREMENTS: For purposes of rapid transit station operation, each station shall require a public address system in accordance with MBTA standards.

SECTION 304.0 PRIVATE AUTOMATIC EXCHANGE (PAX) TELEPHONES

There shall be provided common battery off-premise local stations connected to the existing line switching machine located at the MBTA Central Control. These locals shall include PAX telephone instruments at specific locations.

304.1 STATION TELEPHONES: For purposes of rapid transit operation, PAX telephone stations shall be installed in the starter's room at each station. The telephone sets in these locations shall be key sets that will accommodate an individual PAX line, an emergency telephone connection, and access to
each of the station public address zones in the station

SECTION 305.0 EMERGENCY TELEPHONES IN TUNNELS

The MBTA shall require emergency telephone sets installed at a maximum interval of one thousand (1,000) feet along each subway trainway. Locations shall include cross passages, vent shafts, turnouts and cross-overs, and platform ends. The telephone instrument at each location shall include the handset, subset, enclosure with instructions for use, visible identifier code, and blue light locator.

305.1 INSTALLATION: The emergency telephone circuit shall provide for common battery operation without outward signaling, but with automatic signaling to Central Control when "off-hook".

305.1.1 Emergency telephone channels shall be provided between Central Control and each rapid transit station. These channels shall be extended, but not in the inter-stations cable, from each station in all trainways through the line sections toward both adjacent stations. Alternate emergency telephone stations in each trainway shall be connected to alternate emergency telephone circuits (the dual cable plan extensions within each trainway). Telephone set connections to the same channel shall be multiple with common access to supervisory at Central Control.

305.1.2 Each local emergency telephone station shall require a connection also to a PAX line.

SECTION 306.0 DATA CHANNELS

Channels shall be provided to accommodate several data trans-
mission systems.

306.1 SIGNAL SYSTEM: The signal system shall include a supervisory data transmission system.

306.1.1 Two voice grade, duplex channels, without signaling, shall connect master terminals at Central Control with remote terminals in the Central Instrument Room (CIR) in each rapid transit station.

306.1.2 There shall be provided a dedicated channel to each rapid transit station with access to standby channels in the event of failure in any link of the normal channel.

306.1.3 The signaling supervisory digital data transmission system shall communicate controls and indications for remote operation of the signal system, the ventilation system, the sump pumps and various alarms from the field to the support facility monitor at Central Control.

306.2 POWER SYSTEM: The power system shall include a supervisory and telemetry data transmission system, using a separate complement of master and remote terminals.

306.2.1 A voice grade, duplex channel, without signaling, shall connect master terminals located at Central Control with remote terminals in the Central Instrument Room (CIR) in each rapid transit station.

306.2.2 There shall be provided a dedicated channel to each station with access to standby channels in the event of failure.
in any link of the normal channel.

306.3 FIRE AND INTRUSION SYSTEM: The fire and intrusion system shall be a separate data transmission system which includes a central processor that buffers and decodes data from the field.

306.3.1 A voice grade, duplex channel, without signaling, shall connect a master terminal located at Central Control with remote fire and intrusion terminals located in each rapid transit station.

306.3.2 There shall be provided a dedicated channel to each station with access to standby channels in the event of failure in any link of the normal channel.

SECTION 307.0 CLOSED CIRCUIT TELEVISION

Empty conduit systems shall be provided for future equipment.

SECTION 308.0 MBTA POLICE TALK BACK SPEAKERS

On each rapid transit platform, there shall be MBTA police talk back speakers in a box convenient for passenger use.

SECTION 309.0 COMMUNICATIONS ROOM

There shall be a communications room in each rapid transit station located at the platform level separate from, but close to, the Central Instrument Room. Each communications room will contain both the system and the local rapid transit
station communications equipment, cabling and accessories.

309.1 MECHANICAL REQUIREMENTS: See Section 403.2 of this code.
ARTICLE 4 - VENTILATION

SECTION 400.0 SCOPE

The provisions of this article shall control the design and construction of the ventilation systems for all new construction of rapid transit stations and tunnels.

400.1 GENERAL: The objectives to be achieved by the ventilation systems in the rapid transit stations and tunnels are as follows:

a) To provide and maintain egress routes from the stations and tunnels reasonably clear of smoke and heat in the event of an emergency.

b) To provide a sufficient current of air which would indicate to individuals the direction of egress.

c) To remove smoke in order to assist passengers, employees and fire fighters.

Underground rapid transit stations and tunnels shall be ventilated by using the action of the moving trains, called piston action, or, if required, by power-driven fan systems or by a combination of both methods. As a minimum, the following mechanical ventilation systems shall be provided:

a) Underplatform exhaust and platform supply systems.

b) Intermediate tunnel fan shaft ventilation systems

All stations shall provide ventilation in ancillary areas as indicated in a later section of this article.

SECTION 401.0 CODES AND STANDARDS

Except as modified hereunder mechanical installations and
materials shall conform to the applicable sections of the latest editions of the following codes and standards:

a) National Fire Protection Association  
b) Massachusetts State Building Code  
c) ASHRAE Guide  
d) Massachusetts Bay Transportation Authority Standards  
e) American National Standards Institute  
f) OSHA

SECTION 402.0 CONTROLS

The controls for normal operation of heating, ventilating and air conditioning (HVAC) equipment shall be as simple as practical and consistent with energy conservation. (See Article 20 of the Basic Code.) In addition, the controls of the ventilation equipment available for use in emergencies shall meet the requirements of both the MBTA and the local fire departments.

SECTION 403.0 UNDERGROUND STATIONS

In this section, heating, ventilating and air conditioning will be considered together. The HVAC systems for the underground (subway) stations shall provide a suitable environment for passengers, operating personnel and employees in any concession area.

403.1 BASIC REQUIREMENTS: When control of heat in underground stations is indicated, the temperature shall be limited to seventeen (17) degrees Fahrenheit above the outside ambient
or a maximum of one hundred five (105) degrees Fahrenheit. Short peaks of higher temperature may be allowed. The temperature limitations shall be achieved by train induced air flow through ventilation shafts, platform supply and underplatform exhaust systems and intermediate tunnel vent shaft and fan ventilation systems.

403.1.1 Station ventilation systems shall be designed to aid in maintaining egress routes clear of heat and smoke in the event of an emergency. The ventilation system shall have the capability of sweeping with fresh air the open stairways and escalators available to passengers to enable them to be used as emergency egress exitways. Adjustable openings, if required, may be provided in certain locations in the station complex to enable this system to function effectively.

403.1.2 Any heating added to the stations shall be by means of electricity.

403.2 ANCILLARY SPACES: In all rooms or areas, the heating, ventilating and air conditioning requirements of the Basic Code shall be met, except as follows or as may be required by the MBTA:

a) Battery rooms shall be equipped with a mechanical fan which will exhaust air from a location near the ceiling. The fan shall be adequate to provide ventilation that will limit the hydrogen concentration to no more than three (3) percent at the maximum charge rate. Provision shall be made to maintain a minimum temperature of forty (40) degrees Fahrenheit.
b) Emergency generator rooms shall have provisions to supply one hundred (100) percent of the required air from the outside when the generating unit is in operation and to exhaust directly to the outside atmosphere.

c) Communications rooms shall have positive, clean air pressurization, and temperature and humidity control. A loss of positive pressure, momentary or steady-state, shall cause an alarm to annunciate the loss at Central Control.

403.3 UNDERPLATFORM VENTILATION: At high platform subway stations, excess heat shall be exhausted to the outside by means of an underplatform ventilation system. The system shall be capable of removing a minimum of one hundred twenty-five (125) cubic feet of air per minute (CFM) per linear foot of station platform edge at trackside through adjustable openings located under the overhang of the platform. Unfiltered make-up air of an equal or greater volume, drawn from an outside source, shall be supplied by means of reversible fans located within the station complex.

403.4 ENCLOSED EMERGENCY EXIT STAIRWAYS: An enclosed emergency exit stairway from a platform which is located at an elevation greater than thirty (30) feet below the level of the exit to the outside or is located under another station platform or tunnel shall be required to be made smokeproof.

403.4.1 These enclosed emergency exit stairways shall be made smokeproof by providing a mechanical exhaust or supply/exhaust system which will supply outside air of sufficient capacity so as to prevent the intrusion of smoke or remove intruding smoke before such smoke can travel further than one-half flight of
stairs up the exit stairway. Supply air shall be introduced far enough above entry level to ensure a flow of smoke-free air into the faces of persons exiting from the platform and/or mezzanine levels. The specific system proposed shall be reviewed with the MBTA and the MOPS prior to incorporation into the design of a station.

403.4.2 The emergency exit stairway ventilation system shall have adequate controls and switches for either manual or automatic activation of the system or both as local conditions indicate.

403.4.3 The standby power required in Section 618.9.4 of the Basic Code may be provided by the dual feeder system complex as described in Article 5 of this document.

SECTION 404.0 ABOVE GROUND STATIONS

In this section, heating, ventilating and air conditioning will be considered together. The HVAC systems for the above ground (depressed, surface and aerial) stations shall provide a suitable environment for passengers, operating personnel and employees in any concession area.

404.1 ANCILLARY SPACES: See Section 403.2 of this article.

SECTION 405.0 TUNNELS

405.1 BASIC REQUIREMENTS: Fans capable of producing a velocity of five hundred (500) feet per minute (FPM) in any of the adjacent segments of a tunnel (stations and tunnel expansions excepted) shall be provided. This velocity will supply fresh air to persons evacuating from the tunnel on foot and will indicate the direction of safety.
405.1.1 At the interface of the supply and exhaust air between the tunnel structures and the outside air, the velocity of the air due to either the piston action of the moving trains or the mechanical ventilation systems shall be limited as follows:

a) In areas accessible to the public, gratings installed at an angle less than forty-five (45) degrees to the horizontal and located from ground level up to within three (3) feet above ground level - 500 FPM.

b) In areas accessible to the public, louvers or gratings installed at an angle greater than forty-five (45) degrees above the horizontal with the bottom edge less than eight (8) feet above the contiguous ground level - 500 FPM.

c) In locations contiguous to areas accessible to the public, louvers and gratings installed at an angle of forty-five (45) degrees or less above the horizontal with the bottom edge three (3) feet or higher above the contiguous ground level - 1,000 FPM.

d) In areas accessible to the public, louvers and gratings installed at an angle greater than forty-five (45) degrees above the horizontal with the bottom edge eight (8) feet or higher above the contiguous ground level - 1,000 FPM.

e) Other louvers and gratings have no restrictions.

f) In an emergency, the limits of the velocities through the openings listed above in this section shall not apply.

405.2 FAN EQUIPMENT: The entire fan assembly of blades, bearings, vanes, motors, wiring, housing, etc. shall withstand and operate
in a three hundred (300) degrees Fahrenheit temperature for a minimum period of one (1) hour.

405.3 NOISE CONTROL: Excess noise and vibration associated with the tunnel ventilation system shall be attenuated to meet the latest requirements of all applicable codes and standards.

SECTION 406.0 INTERNAL COMBUSTION TRACTION POWER EQUIPMENT

In stations and tunnels in which internal combustion traction power equipment operates (such as diesel-electric locomotives or rail cars) special ventilation shall be provided, if required, to reduce any contamination to a safe level according to the latest applicable codes and standards.
ARTICLE 5 - ELECTRICAL

SECTION 500.0 SCOPE

The provisions of this article shall control the design and installation of the electrical systems for all new construction of rapid transit stations and tunnels.

500.1 GENERAL: The rapid transit system electrical loads are served with either alternating current (AC) or direct current (DC). AC power serves the station and auxiliary loads. DC power provides the energy to drive the motors on the transit vehicles using a third rail or overhead wire system for the supply and the running rails for the return.

SECTION 501.0 CODES AND STANDARDS

Electrical installations and materials shall conform to the applicable sections of the latest editions of the following codes and standards:

a) National Fire Protection Association
b) Massachusetts Electrical Code 527 CMR 12.00
c) National Safety Code
d) Association of American Railroads
e) Association of Edison Illuminating Companies
f) Institute of Electrical and Electronic Engineers
g) Insulated Power Cable Engineers Association
h) Massachusetts Bay Transportation Authority Standards
i) American National Standards Institute

SECTION 502.0 STATION POWER

AC power is distributed from a double ended unit substation
which serves electrical loads for lighting, escalators, elevators, heating and ventilation equipment, pumps, communications and signal equipment.

502.1 UNIT SUBSTATIONS: Unit substations are served from available utility company electrical systems or available MBTA power sources.

SECTION 503.0 STATION EMERGENCY POWER

503.1 GENERATOR: An engine generator set shall be the main source of power during failure of the normal power supply to the transit station. The engine generator shall be of sufficient capacity and rated for continuous standby service for the station auxiliary loads, signal and communications equipment, and emergency lighting, and shall have the provision for automatic starting when the normal power supply fails.

503.1.1 Noise pollution level requirements of applicable codes shall govern the operation of the emergency generator unit.

SECTION 504.0 STATION EMERGENCY LIGHTING

504.1 BATTERY INVERTER UNITS: In addition to the emergency generating unit, battery inverter units shall be provided to automatically maintain station emergency lighting units during the time interval when the normal utility power fails and the emergency generator unit starts and is able to serve the emergency lighting load. The batteries for the inverter
system shall be rated for a minimum of one and one-half (1½) hours of operation.

505.0 TRACTION POWER

DC power is provided by means of 1,000 volt feeders from the traction substation DC switchgear.

505.1 TRACTION POWER SYSTEM: The traction power system shall include the primary AC switchgear, rectifying transformers, rectifier units and the output network including DC switchgear, 1,000 volt class positive feeders, contact rails or overhead wires, trackside switches and all accessories.

SECTION 506.0 EMERGENCY SWITCHES

Switches shall be installed that will de-energize traction power circuits in an emergency.

506.1 "B" SWITCH: A manually operated, normally closed disconnect switch (called a "B" switch) shall control the traction power for the pit rail in the transit station. These switches shall be located in each station at the departing end (the motorman's position) of every station platform for each track.

506.1.1 New "B" or "BJ" switch design applications may have these switches in parallel-series at each end of the station platform.

506.2 "J" SWITCH: At every transit station, the contact rails (pit rails) shall be sectioned by normally open dis-
connect switches (called "J" switches). "J" switch applications will vary according to electrical design requirements peculiar to individual passenger stations.

SECTION 507.0 SIGNAL POWER

Power shall be provided especially for signaling and communications at each rapid transit station, or yard, where signaling and communications equipment will be located.

507.1 MODE: Mode of signal power, Normal, Standby or Emergency-Generator, shall be relayed to Central Control over the supervisory system.

507.2 COMMUNICATIONS EQUIPMENT STANDBY POWER. At both the MBTA and the fire department radio base stations, the power supply system shall include a twenty-four (24) hour standby battery and ancillary equipment to operate the base station radio equipment only, in the event of complete failure of the utility system and the standby engine generator.

SECTION 508.0 STATION LIGHTING

General illumination for the normal lighting system shall be served from the AC station electrical distribution system.
508.1 ILLUMINATION LEVELS: Levels of illumination shall conform to Table 5-1 below in accordance with the lighting provisions of Article 20 of the Basic Code.

**TABLE 5 - 1 GENERAL ILLUMINATION LEVELS**

<table>
<thead>
<tr>
<th>AREAS</th>
<th>FOOTCANDLES - MAINTAINED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative Staff Areas, Starter's Room, Fare Collection Booth, Communications Room, Central Instrument Room and Equipment Rooms</td>
<td>30</td>
</tr>
<tr>
<td>Bus Parking</td>
<td>3</td>
</tr>
<tr>
<td>Bus Loading Zone</td>
<td>10</td>
</tr>
<tr>
<td>Concession Area</td>
<td>30</td>
</tr>
<tr>
<td>Emergency Lighting at Station Platforms, Places of Egress, Stairways and Exits</td>
<td>4</td>
</tr>
<tr>
<td>Entrance Lobbies</td>
<td>30</td>
</tr>
<tr>
<td>Mechanical and Electrical Spaces</td>
<td>20</td>
</tr>
<tr>
<td>Outdoor Entrances to Escalators and Stairways</td>
<td>10</td>
</tr>
<tr>
<td>Outdoor Plazas</td>
<td>5</td>
</tr>
<tr>
<td>Pedestrian Tunnels and Passageways, Mezzanine Areas</td>
<td>40</td>
</tr>
<tr>
<td>Pedestrian Walkways</td>
<td>5</td>
</tr>
<tr>
<td>Stairways and Entrances</td>
<td>25</td>
</tr>
<tr>
<td>Station Platforms</td>
<td>20</td>
</tr>
<tr>
<td>Storage Rooms, Porter's Rooms</td>
<td>15</td>
</tr>
<tr>
<td>Toilets</td>
<td>30</td>
</tr>
<tr>
<td>Trackways and Tunnels (emergency and normal)</td>
<td>1.5</td>
</tr>
<tr>
<td>Waiting Areas:</td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td>30</td>
</tr>
<tr>
<td>Exterior</td>
<td>15</td>
</tr>
<tr>
<td>Vending Area</td>
<td>40</td>
</tr>
</tbody>
</table>

Note 1 All footcandle levels shall be computed on a horizontal plane at the finished floor.

Note 2 Other areas not listed shall conform to the requirements of the Basic Code.
508.2 LIGHTING POWER LIMITS FOR RAPID TRANSIT SYSTEMS: The maximum power limit for interior and exterior illumination systems associated with underground and above ground rapid transit stations shall be as required in the Basic Code.

SECTION 509.0 TUNNEL LIGHTING

509.1 LIGHTING FIXTURES: Tunnels shall be illuminated with 480 volt AC fluorescent weatherproof fixtures, individually fused. Successive fixtures along the trackway shall be connected to alternate 480 volt three phase distribution lines.

509.1.1 The source of one distribution line shall be the secondary switchgear in the unit substation at the rapid transit station at one end of the line section. The source of the other distribution line shall be the secondary switchgear in the unit substation at the rapid transit station at the other end of the line section.

509.1.2 Lighting fixtures shall be mounted parallel to the trackway and spaced no more than forty (40) feet on center.

509.1.3 The entrance to an emergency exit, including cross passages, shall be indicated by one vertically mounted fluorescent lighting fixture.

509.2 WIRING: Insulated conductors on racks mounted on the tunnel walls shall be the wiring arrangement for the tunnel lighting.

SECTION 510.0 LIGHTING CONTROL: Adequate accessible switches and circuits shall be provided to promote energy conservation.
ARTICLE 6 - CONSTRUCTION

SECTION 600.0

The provisions of this article shall control the design and construction of all new rapid transit stations, tunnels and aerial structures and all new construction in existing rapid transit facilities.

600.1 GENERAL: Except as otherwise specified herein, all new rapid transit facilities shall conform to the requirements of the Basic Code for Type 1 (Fireproof) construction; Type 2 (noncombustible) construction or combinations of Type 1 and Type 2 construction.

SECTION 601.0 UNDERGROUND STATIONS

Building construction for the basic structural elements such as columns, bearing walls, beams and slabs over trainways for subway stations shall conform to the requirements for Type IB (fireproof) construction of the Basic Code.

601.1 ANCILLARY SPACES: See Section 603.0 of this Article.

601.2 STAIRS AND ESCALATORS: Stairs and escalators used regularly by passengers need not be enclosed, even though they may serve as emergency exit routes. (See Elevator and Escalator Regulations 524 CMR 3.00-11.00 and Elevator, Dumbwaiter, Escalator and Moving Walk Regulations.)

601.3 INTERIOR FINISH AND SPECIAL MATERIALS AND TRIM: All interior finish and acoustical and insulation materials used within the station shall be noncombustible or Class I with a smoke development rating not to exceed 50, as measured by ASTM E84.
602.0 ABOVE GROUND STATIONS

Building construction for the basic structural elements such as columns, bearing walls, beams and slabs over trainways for depressed (below-grade), surface (at-grade) and aerial (above-grade) stations shall be of noncombustible types of construction complying with the requirements of the Basic Code.

602.1 EXCEPTIONS: Where the platform or concourse exceeds the area limits of Table 305 of the Basic Code for the use group A-3 (assembly) and has only a roof above it, the walls and roof supporting structure may be:

a) Of one (1) hour protected construction of noncombustible materials when roof construction is less than twenty (20) feet above the platform or the platform or concourse is enclosed.

b) Of unprotected construction of noncombustible materials when the roof construction is more than twenty (20) feet above the platform and the station or concourse is open.

c) For a platform area to be considered "open" not less than twenty-five (25) percent of those enclosing walls which are parallel to the trackway shall be open with openings substantially uniformly distributed along both walls, except that platform areas not exceeding 600 feet in length with open ends shall be considered open.

d) For a concourse area to be considered "open", not less than three of its four enclosing walls shall have substantially uniformly spaced openings equal to not
less than twenty-five (25) percent of the total area of all of the enclosing walls. In no instance shall any of the three exterior walls be less than twenty-five (25) percent open.

602.1.1 For a platform or concourse area to be considered "open" in a depressed station where none of its enclosing walls contain any openings, the roof area above the enclosed trainways and platform or concourse shall have substantially uniformly spaced openings equal to not less than twenty-five (25) percent of the roof area. Automatic or operable roof vents complying with NFPA204 may be used to provide the required minimum opening percentage.

602.1.2 Aerial trainways and open platforms may be of unprotected construction of noncombustible materials unless located over combustible buildings, areas used for storage of highly combustible materials or other known hazardous locations.

602.2 ANCILLARY SPACES: See Section 603.0 of this Article.

602.3 STAIRS AND ESCALATORS: Stairs and escalators used regularly by passengers need not be enclosed, even though they may serve as emergency exit routes.

SECTION 603.0 ANCILLARY SPACES

In all stations, ratings of fire separations shall be maintained between occupancies as required by the Basic Code, except as follows:

a) All traction power substations shall be of three (3) hour fireresistive construction.
b) Switchgear and electrical control rooms, auxiliary electrical rooms and associated battery rooms shall be of two (2) hour fireresistive construction.

c) Central Instrument Rooms, train control rooms and associated battery rooms shall be of two (2) hour fireresistive construction.

d) Trash and storage rooms shall be of two (2) hour fireresistive construction.

e) Enclosed concession and retail spaces shall be of two (2) hour fireresistive construction.

1. Exception: Freestanding booths and kiosks shall be of noncombustible construction

f) There shall be a two (2) hour fireresistive separation between the ancillary (non-public) areas and the public areas.

1. Exception: Agent's and information booths shall be of noncombustible construction.

g) Emergency exit passageway walls through the ancillary areas and the shafts, including the exit stairs, shall be of two (2) hour fireresistive construction.

h) All openings in fireresistive separations shall be enclosed with approved labeled protective assemblies as required in the Basic Code.

i) There shall be a three (3) hour fireresistive separation between all system public areas and all non-system (private) occupancies. All openings from system public areas to all non-system occupancies (i.e., private entrances) shall be protected with Class A, three (3) hour fire door assemblies. These doors shall be normally closed by positive means or operation
of the closures shall be by automatic means activated by products of combustion (such as ionization type) detectors and fusible links, or by fusible links only where a separate smoke barrier is provided.

SECTION 604.0 ALTERATIONS AND REPAIRS

When existing stations are altered or repaired, the full requirements of this rapid transit facilities code need not apply, except as provided in Section 106.0 of Article 1 and Article 22 of the Basic Code. However, all new work shall be made to conform to the requirements of this code.

SECTION 605.0 UNDERGROUND TUNNELS

605.1 CUT-AND-COVER: When tunnels are to be constructed by the cut-and-cover method, perimeter walls and related construction shall be of noncombustible construction.

605.2 DECK STRUCTURES: Construction of all continuous deck structures over the transit stations and trainways shall be of totally noncombustible materials. Where unusual conditions or excessive fire loads exist, construction conforming to Type 1 or Type 2 construction of the Basic Code or combinations of Type 1 and Type 2 shall be used.

605.3 TUNNELING: When line structures are to be constructed by mine tunneling methods, unprotected steel or cast-iron liners, reinforced concrete liners, shotcrete or the equivalent shall be used. Rock tunnels may utilize steel bents with a concrete liner if a lining is required. Walkways designated for evacuation of passengers shall be of non-
combustible construction.

605.4 UNDERWATER TUBES: Noncombustible construction as defined by Table 214 of the Basic Code shall be used as applicable. Ancillary areas within tubes shall be separated from trackway areas by fire separations as required by Section 603.0 Ancillary Areas.

606.0 BRIDGE STRUCTURES

606.1 FIRE PROTECTION: Where an existing or new bridge structure is located within a deck structure in a station area only noncombustible materials may be used. Consideration shall be given to the use of fire resistive construction where conditions indicate excessive build up of heat from serious fire conditions, or total inaccessibility for fire fighting exists and the bridge structure is considered to be in an unventable location.

SECTION 607.0 OTHER CONSTRUCTION

607.1 SHAFT TERMINATIONS: To limit the entrance of a hazardous liquid, there shall be no grates for fan or vent shafts or other openings terminating in vehicular travelways except as specified below in Section 607.1.2.

607.1.1 Vent and fan shafts and other openings may terminate in median strips of divided travelways or in sidewalks designed to accept such openings, or in open space areas, provided that the grade level of the median strip or sidewalk, or open space, is higher than the level of the adjacent vehicular travelway and separated by a minimum six (6) inch high concrete or stone curb.
607.1.2 Where conditions of construction are such that it is impossible to avoid locating the gratings or other openings in a vehicular travelway, gratings may be permitted in a vehicular travelway provided that a drainage trough is installed to immediately intercept the flow of any liquids onto the grating area.

Further an interceptor shall be installed at the bottom of the vertical shaft to intercept any liquids spilled directly onto the gratings. The trough will connect into the local surface drainage system and the interceptor shall drain through a gasoline trap into the subway drainage system.
ARTICLE 7 - MEANS OF EGRESS

SECTION 700.0 SCOPE

The provisions of this article shall control the design, construction, and arrangement of building elements required to insure safe means of egress from all new rapid transit stations, tunnels and aerial structures.

700.1 GENERAL: This article includes all new rapid transit stations and trainways whether they be located entirely or in any part underground or above ground. Every station or trainway section, or area thereof of such size, occupancy, and arrangement that the reasonable safety of numbers of occupants may be endangered by the blocking of any single means of egress due to fire or smoke shall have at least two means of egress from the affected area remote from each other, so arranged as to minimize any possibility that both may be blocked by any one fire or other emergency conditions. (See Article 6 of the Basic Code and NFPA 101.)

SECTION 701.0 STATION EXITING

701.1 OCCUPANCY: The primary purpose of a rapid transit station is for the use of rapid transit patrons who would normally stay in a station structure for a period of time no longer than that necessary to wait for and enter upon a departing rapid transit vehicle, or to depart from an arriving rapid transit vehicle.

701.1.1 Occupancy shall also include MBTA employees whose work assignments require their presence in the station structures and persons employed in any concession area.
701.2 OCCUPANCY LOAD: The occupancy load for a rapid transit station shall be established based on the net usable area of the station platform, deducting the space occupied by structural elements, stairs, escalators, elevators, concession and service spaces, furnishings and the eighteen (18) inch wide platform edge safety stripe.

701.2.1 An occupancy load of one (1) person per seven (7) square feet of net usable area of the station platform shall be used to calculate the passenger loading for any platform which serves a rapid transit line.

701.2.2 An occupancy load of one (1) person per two (2) linear feet of station platform edge at trackside shall be used to calculate the passenger loading for any platform which serves only a commuter and/or an intercity railroad.

701.2.3 Any uncovered portion of a station platform need not be included in the calculation of the occupancy load of a station, and may be considered an area of safety when clearly designated.

701.3 TRAVEL DISTANCE: The maximum travel distance from any point on the platform to an exit, to an area of safety, or to an area of refuge, shall not exceed three hundred (300) feet, including any length of travel on a stair or escalator.

701.3.1 An area of safety is defined as an open space of Type 1 or Type 2 construction with ceilings over twenty (20) feet high with adequate natural or mechanical ventilation. It shall be clearly designated as an area of safety in case of fire.
Directional signs indicating the direction to the area of safety shall be provided where the direction of travel to reach the area of safety is not immediately apparent.

701.3.2 An area of refuge is defined as a sprinklered area along an exit path protected on all sides by two (2) hour rated walls, and one and one-half (1½) hour Class B doors. It shall be clearly designated as an area of refuge in case of fire. Directional signs indicating the direction to the area of refuge shall be provided where the direction of travel to reach the area of refuge is not immediately apparent. Provisions shall be made for smoke control.

701.3.3 At a station where the trainway is open at or near the end of the station platform, including depressed, surface and aerial stations, said open trainway may be considered as an area of safety, provided that such use will take place only under the guidance and control of authorized MBTA personnel or by other authorized personnel as warranted under an emergency situation, and that it shall first be positively established that the contact rail traction power circuits have been de-energized. At the ends of this platform, forty-four (44) inch wide gates and stairs shall lead to the trainway.

701.3.4 Any area of safety or any area of refuge, as defined in Sections 701.2.3, 701.3.1 and 701.3.2 of this Article, may be considered as providing safety for one (1) person per seven (7) square feet of net usable area.
701.4 UNIT OF EXIT WIDTH (UEW): Means of egress shall be measured in units of width of twenty-two (22) inches. Fractions of a unit shall not be counted except that twelve (12) inches added to one (1) or more full units shall be counted as one-half (~) a unit of exit width. (See Section 608.1 of the Basic Code.) Width shall be measured in the clear at the narrowest point except that individual handrails may project three and one-half (3½) inches into the required width. Stringers may also project one and one-half (1½) inches into the required width. (See Section 616.0 of the Basic Code.) Exception: See Section 701.9 of this Article.

701.5 DESIGN CAPACITY ALLOWANCE: The exiting capacity per unit of exit width of a stair or escalator or ramp of over four (4) percent slope shall be limited to seventy-five (75) persons. The capacity per UEW of level or horizontal exits including doors and gates, or ramps of four (4) percent slope or less shall be limited to one hundred (100) persons. The capacity per UEW of a turnstile shall be limited to fifty (50) persons.

701.6 MINIMUM HORIZONTAL EXITWAY WIDTHS: Exitway corridors and ramps of four (4) percent slope or less shall be a minimum of sixty-six (66) inches wide.

701.6.1 All ramps required as a means of egress for the handicapped shall comply with the requirements of the Rules and Regulations of the Architectural Barriers Board.

701.7 MINIMUM VERTICAL EXITWAY WIDTHS: Exitways shall be provided from the station platform to grade level with no
reduction in exit width unless specifically excepted by the state inspector.

701.7.1 Exit doors shall be class B, one and one-half (1½) hour labeled assembly forty-four (44) inches wide equipped with panic hardware in accordance with Section 612.5 of the Basic Code. (This door width is required to accommodate stretchers and a fully equipped fireman using breathing apparatus.)

701.7.2 Exit stairs shall be a minimum of sixty-six inches wide, excluding those leading to the trainway. The stairway shall be designed in accordance with Section 616.0 of the Basic Code.

701.7.3 Exit ramps of over four (4) percent slope shall be a minimum of sixty-six (66) inches wide.

701.7.4 Escalators shall be considered as conforming exit stairs for the purpose of exit capacity calculations. A thirty-two (32) inch wide escalator shall count as one (1) UEW and a forty-eight (48) inch wide escalator shall count as two (2) UEW. In the event of an emergency, incoming escalators shall be stopped by the station attendant.

701.7.5 Elevators throughout all stations shall not be considered a means of egress in determining the exitway capacity. They shall be equipped with controls which will offer special provisions for operation by the fire department including selective stopping and override capability. To prevent entrapment in an elevator during a fire, each elevator shall be equipped with an intercom
connected to the primary collector's booth. This "call for aid" system shall be served by the emergency power system if normal power fails.

NOTE: 701.8 ESCALATORS (SEE PAGE 7-6A) NEXT PAGE

701.8.5 Escalators may be operated at any speed approved by ANSI A17.1.

701.9 FARE COLLECTION GATES: The following design features shall be provided to permit ample exits if an emergency should occur:

a) Fare aisles shall assume an emergency exit mode in the event of a power failure, or by activation of a manual or remote control.

b) At least one gate-type exit thirty-eight (38) inches high and forty-four (44) inches wide which swings in both directions shall be provided at each fare collection array.

c) A turnstile fare collection gate of minimum eighteen (18) inch aisle and maximum thirty-six (36) inch height of the turnstile bar which when deactivated will free wheel in the exit direction may be considered as an emergency exit and shall count as one-half (½) a horizontal UEW.

701.10 GATES AND DOORS: Gates and doors that are used to protect a station and are necessary for use as an emergency egress shall be able to be opened either by remote control from a location that is continuously attended while the station is open or by panic hardware which will activate any latches or locks.
701.8 ESCALATORS: All of the provisions of Section 620.0 of the Basic Code shall apply except the vertical travel height of escalators in transit stations may exceed the limits given in Section 620.7.3 providing additional safety features are included. The number of flat steps at the upper landings shall be increased according to the vertical rise of the escalators. Escalators up to a twenty (20) foot rise shall have a minimum of one and three-fourths (1-3/4) flat steps, those with a rise over twenty (20) feet shall have a minimum of two (2) flat steps.

701.8.1 Landing and floor plates exposed to the outdoor environment shall be covered with an approved slip-resistant material.

701.8.2 Understep lighting near comb-plates or other means of illuminating the comb-plates shall be provided.

701.8.3 Upthrust switches shall be provided at the upper and lower radii.

701.8.4 A flashing light and horn located in the collector's booth shall indicate that an escalator has stopped because of the activation of a safety device or other unusual condition. Also located in the collector's booth shall be an emergency stop button so that the station attendant can stop any escalator in the event of an emergency. If roll down grilles or doors are installed at escalator head houses, interlocks must be provided so that escalators cannot operate if grilles or doors are closed, to prevent the pile up of passengers against grilles or doors.
SECTION 702.0 TUNNEL EXITING

702.1 OCCUPANCY: It is anticipated that MBTA passengers will enter upon the tunnel trainways (subways) only in the event it becomes necessary to evacuate a disabled train. Such evacuation will take place only under the guidance and control of authorized MBTA personnel or by other authorized personnel as warranted under an emergency situation. In all cases, however, it shall first be positively established that the contact rail traction power circuits have been de-energized by MBTA personnel or by other authorized personnel.

702.2 EXITWAY DETAILS: Exitways shall be provided from tunnels to a point of safety. In a tunnel, a point of safety shall be defined as any one of the following:

a) an enclosed fire exit that exits to a public way or safe location outside the tunnel structure,

b) an at-grade point beyond any enclosing structure,

c) or other passage that affords adequate protection from smoke and fire for a passenger.

702.2.1 Along one wall of each tunnel a safety walk with a minimum width of twenty-four (24) inches shall be constructed a maximum of twelve (12) inches above the top of the adjacent running rail. The function of the safety walk is to enable passengers to detrain and walk to the nearest station, emergency stairway or other area of safety.
A continuous handrail shall be wall mounted forty-two (42) inches above the safety walk. In tunnels with safety niches, the handrail shall be interrupted for the width of the niche. The handrail shall not project more than three and one-half (3½) inches from the wall on which it is mounted and shall be designed to withstand an applied load of two hundred (200) pounds in any direction at any point. All handrails shall be returned to walls at each end of the handrail. The handgrip portion of a handrail shall not be less than one and one-quarter (1¼) inches nor more than two (2) inches in outside diameter and shall be basically round or oval in cross-section, and shall have a smooth surface with no sharp corners. Clearance between a wall and its wall handrail shall be one and one-half (1½) inches.

702.2.2 Emergency exit stairways shall be provided throughout the tunnels, spaced so that the maximum distance between emergency exits shall never be greater than twenty-five hundred (2500) feet. The stairways shall be designed in accordance with Section 616.0 of the Basic Code. The stairways shall be enclosed and shall lead directly to the outdoors, or to a safe refuge area.

702.2.3 Where trainways are divided by minimum two (2) hour rated firewalls, or trainways are in twin bores, such an arrangement shall be deemed to afford adequate protection for the passengers via cross passages between the trainways.
and may therefore be utilized in lieu of exit stairways to the surface, or in the event that a ventilation system does not provide a sufficient stream of fresh air to protect the passengers in a path of egress, provided that:

a) Cross passages are no further than six hundred (600) feet apart and a minimum of seventy-two (72) inches wide.

b) Cross passages have at each end a set of Class B labeled assembly double egress doors. Both doors of each set shall be not less than thirty-six (36) inches wide and each door shall swing in the opposite direction from its mate.

c) Cross passages will contain an emergency telephone, and portable fire extinguishers as directed by the local fire department.

d) A system of positive ventilation satisfying air velocity criteria of this code is maintained in the uncontaminated trainway.

e) A ventilation system for the contaminated tunnel is capable of removing smoke from the vicinity of the passengers.

f) A suitable means of evacuating passengers in the uncontaminated trainway, for protecting passengers from oncoming traffic, and for evacuating passengers to a nearby station or other emergency exit is provided.

702.2.4 Doors to all tunnel exit access points shall swing in the direction of exit travel and shall be Class B, one
and one-half (1½) hour labeled assembly forty-four (44) inch wide doors equipped with panic hardware in accordance with Section 612.5 of the Basic Code.

702.2.5 Exit hatches at exit discharge points shall be protected by covers and shall be latched with UL listed panic hardware. Each separate leaf, if more than one, shall be independently operated so that with minimal effort the leaf can be released and opened. Hatch covers shall be capable of being opened from the outside by authorized personnel. The areas into which the hatches exit shall be designed to minimize obstruction of the hatches and maintain safe egress by approved guard rails if practical. The hatch areas shall be maintained obstruction free.

SECTION 703.0 SURFACE EXITING

703.1 OCCUPANCY: It is anticipated that MBTA passengers will enter upon the surface (at-grade) and depressed (below-grade) trainways only in the event it becomes necessary to evacuate a disabled train or evacuate a station platform. Such evacuation will take place under the guidance and control of authorized MBTA or other authorized personnel as warranted under an emergency situation. In all cases, however, it shall first be positively established that the contact rail traction power circuits have been de-energized by MBTA personnel or other authorized personnel.
703.2 EMERGENCY ACCESS AND EGRESS: Access gates, which are usable by the fire department for entering the trainway for emergency purposes, shall be provided in the security fences adjacent to the trainway. These gates shall also be used as emergency egress for passengers.

703.2.1 The gates shall generally be spaced at intervals not to exceed twenty-five hundred (2500) feet with a gate as close as practical to the portals to permit easy access to tunnels.

703.2.2 The gates shall be a minimum of forty-four (44) inches wide and shall be of the hinged or sliding type, and secured with a standard MBTA lock.

703.2.3 At the location of each gate in a depressed (below-grade) trainway, an unenclosed exit stairway to grade, a minimum of forty-four (44) inches wide, shall be provided.

SECTION 704.0 AERIAL EXITING

704.1 OCCUPANCY: It is anticipated that MBTA passengers will enter upon the aerial (above-grade) trainways only in the event it becomes necessary to evacuate a disabled train or evacuate a station platform. Such evacuation will take place under the guidance and control of authorized MBTA personnel or by other authorized personnel as warranted under an emergency situation. In all cases, however, it shall first
be positively established that the contact rail traction
power circuits have been de-energized by MBTA personnel
or other authorized personnel.

704.2 EMERGENCY ACCESS: Access to the aerial trainway
shall be from the rapid transit station or by mobile ladder
equipment from roadways adjacent to the trainway. If no
adjacent or crossing roadways are available, access ways at
intervals not to exceed twenty-five hundred (2500) feet
shall be required.

704.2.1 If security fences are used along the trainway,
gates shall be required as described in Section 703.2 of
this code. Fences should not be in close proximity to the
contact rail and/or overhead power and should be grounded
at each post and to the fence mesh.

704.3 EMERGENCY EGRESS: There shall be a walkway or other
suitable means for passengers to evacuate a train at any
point along the trainway to either proceed to the nearest
station or point of egress or wait for an evacuation train
to arrive.

SECTION 705.0 SIGNING AND GRAPHICS

The signing and graphics within the rapid transit stations
and trainways shall clearly mark exit routes. (See Section
623.0 of the Basic Code.)
705.1 STATIONS: Illuminated emergency exit signs and directional signs shall be placed within the rapid transit stations at emergency passageways and stairs and over all doors to emergency stairways. (See Section 624.0 of the Basic Code.)

705.1.1 Principal passenger station entrances and exits that are clearly visible are not required to have illuminated exit signs and/or directional signs.

705.2 TUNNELS: Illuminated emergency exit signs shall be placed at all emergency cross passages and over all doors to emergency stairways. Graphics shall be provided to clearly identify the location of each emergency exit.

705.3 SURFACE AND AERIAL TRAINWAYS: Emergency access and egress gates shall be equipped with an emergency exit light. Graphics shall be provided to clearly identify the location of each exit.
ARTICLE 8 - FIRE FIGHTING FACILITIES

SECTION 800.0 SCOPE

The provisions of this article shall control the design, construction and installation of fire fighting facilities for all new rapid transit stations and tunnels.

800.1 GENERAL: Rapid transit stations and tunnels shall be equipped with fire fighting facilities and equipment to limit the spread of fire and to assist in the fighting of a fire in any of these structures.

SECTION 801.0 UNDERGROUND AND ABOVE GROUND STATIONS

All stations, including subway, depressed, surface and aerial structures shall be equipped with various fire fighting facilities.

801.1 STANDPIPE SYSTEM: A dry standpipe system shall be installed at each station platform. The station standpipe system shall not be connected to tunnel standpipe system. Separate street connections shall be provided for each independent system.

801.1.1 Two (2) two and one-half (2½) inch accessible stand pipe valves shall be spaced at one hundred (100) feet intervals.

801.1.2 A street-level connection shall be provided to fill the standpipe system and shall be as required by the local fire department.
801.1.3 All connection points, both fill and draw-off, shall be equipped with threads that conform to the standards of the local fire department.

801.2 PLATFORM HOSE SYSTEM: A first aid fire fighting system with threads that conform to the standards of the local fire department shall be installed at each platform at all stations if required by the local fire department. It may use the domestic water system as a supply source and shall include one and one-half (1½) inch hoses of sufficient length to cover the entire station platform.

801.3 SPRINKLER SYSTEM: A sprinkler line, heat traced if necessary, with sprinkler heads located as directed by the local fire department shall be installed in all enclosed concession areas. The domestic water system may be used as the supply source if no more than twenty (20) sprinkler heads are installed. (See Section 1205.0 of the Basic Code.)

801.3.1 A water flow alarm valve with the alarm connected to the fire alarm supervisory panel and to Central Control shall be installed in the sprinkler line.

801.4 HALON SYSTEM: Central Instrument Rooms (CIR), Emergency Control Rooms (ECR) and communications rooms shall be provided with an automatic halon extinguishing system.

801.5 FIRE EXTINGUISHERS: Portable fire extinguishers shall be provided in electric rooms, CIR, communications rooms, starter's rooms and main collector's booths and as directed by the local fire department.
SECTION 802.0 TUNNELS

802.1 STANDPIPE SYSTEM: A dry standpipe system shall be installed in all tunnels and shall meet the provisions listed earlier in Section 801.1.

802.2 FIRE EXTINGUISHERS: Portable fire extinguishers shall be provided as directed by the local fire department.
ARTICLE 9 - EMERGENCY PROCEDURES, INSTRUCTIONS AND EQUIPMENT

SECTION 900.0 SCOPE

The provisions of this article shall require the formulation and implementation of emergency procedures, instructions, and equipment for the rapid transit system of the MBTA.

900.1 GENERAL: The Massachusetts Bay Transportation Authority (MBTA) shall provide various items of emergency equipment and shall develop and distribute operating procedures and/or instructions to provide guidance for its personnel in the event of an emergency.

900.2 ENDORSEMENT: The master set of emergency procedures and/or instructions and the lists of emergency equipment shall be reviewed and endorsed annually in the month of July by the chief operating officer, certifying that the equipment lists, procedures and/or instructions have been reviewed in light of current operating practices and procedures and are presently adequate. These items shall be subject to the review of the local fire department.

SECTION 901.0 EMERGENCY PROCEDURES

The emergency procedures shall address the following situations for both the subway and open areas of the rapid transit system:

a) Fire or suspected fire:
   1. In the right-of-way
   2. In rooms or areas of the right-of-way
3. In passenger areas of stations.
4. In ancillary areas of stations.
5. Under a train.
6. In a train.
b) Injured or sick individuals:
1. In normal passenger areas of stations.
2. In ancillary areas of stations.
3. On the right-of-way.
4. Under a train.
5. In a train.
c) Derailment.
d) Bomb threat.
e) Robbery.
f) Civil disturbance or riot.
g) Natural disasters such as floods, earthquakes, windstorms and snowstorms.
h) Power failure.
i) Volatile liquid entering the subway of various locations.

SECTION 902.0 EMERGENCY INSTRUCTIONS

The instructions shall include check lists for materials to be available at various locations in the rapid transit system. These lists shall include procedures for the checking and replacing of materials.

The instructions shall contain detailed procedural methods for reporting various emergencies.

The instructions shall include rules for both Central Control and employees of the rapid transit system to follow in handling certain emergency situations and principles to follow in other cases.
SECTION 903.0 EMERGENCY EQUIPMENT

Throughout the rapid transit system, various items of equipment shall be provided to extinguish small fires or to limit the spread of large fires and to assist in the evacuation of passengers in the event an emergency occurs.

Equipment items to be provided shall be determined by the MBTA and may include special ladders for evacuating passengers from trains, third rail testers and covers, stretchers, fire extinguishers and pails of sand.

The emergency procedures and/or instructions for use of this equipment shall be provided by the MBTA as indicated earlier in this section.
Reference Documents Applicable to MBTA Fire Protection and Life Safety Program

**ACI 318-1977**
Building Code Requirements for Reinforced Concrete (American Concrete Institute)

**AISC - 1969**
Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings (American Institute of Steel Construction)

**NFPA 72 B-1974**
Auxiliary Signaling Systems (National Fire Protection Association)

**NFPA 101-1976**
Code for Safety to Life from Fire in Buildings and Structures (National Fire Protection Association)

**NFPA 220-1975**
Standard on Types of Building Construction (National Fire Protection Association)

**521 CMR 3.00**
Rules and Regulations of the Architectural Barriers Board (Massachusetts Department of Public Safety)

**524 CMR 3.00-11.00**
Elevator and Escalator Regulations

**524 CMR 15.00-33.00**
Elevator, Dumbwaiter, Escalator and Moving Walk Regulations

**527 CMR 12.00**
Massachusetts Electrical Code (Mass. Department of Public Safety)

**780 CMR 18.00**
The Commonwealth of Massachusetts State Building Code
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