DESIGN DIRECTIVE

To: Distribution

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Chief Engineer

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RE: Fire Load Design Criteria

This design directive is intended to provide guidance on the MBTA's approach, preferences, and requirements for the determination of fire load design criteria for all MBTA station and tunnel improvement, renewal, and expansion projects as well as for all right-of-way overbuild projects by the MBTA or by third parties (collectively referred to herein as "Projects").

In the event that conditions warrant deviation from this directive, a design waiver signed by the Chief Engineer and department owning the scope of work will be required of the Project.

Design consultants shall design to standards as prescribed by code. MBTA Standards shall apply only where code does not address a topic or the MBTA requires a standard above and beyond code. The more stringent shall always apply.

OBJECTIVE

To ensure that all Projects are designed using acceptable fire load design criteria in order to achieve the MBTA's priorities to:

1. Maximize safety of MBTA passengers, personnel, and the general public.
2. Protect MBTA assets and surrounding infrastructure.
3. Sustain operational performance.
4. Maintain serviceability.

Design of fire protection is critical to life-safety as well as the functionality and longevity of the transportation system. The establishment of Project fire load design criteria and the ensuing design development of systems to accommodate this criteria shall be a coordinated effort with the MBTA's Office of the Chief Engineer (OCE), Authority having Jurisdiction (AHJ), and local fire departments.

CODES, STANDARDS, AND POLICIES

- 780 CMR – Massachusetts State Building Code
- NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems
- NFPA 502 – Standard for Road Tunnels, Bridges and Other Limited Access Highways
- Overbuild of Amtrak Right-of-Way Design Policy (attached)

DESIGN PRINCIPLES

1. All Projects shall consider design for fire scenarios. Design criteria for each Project shall be developed by the Engineer of Record (EOR) and be incorporated into a basis of design report for review and approval by the OCE, AHJ, and local fire department. The report shall define the following at a minimum:
    a. Project description
    b. Operations narrative
    c. Design fire scenarios including: heat release rate curves, smoke release rates, and time-temperature curves
    d. Time of tenability – Considering ignition time, reporting time, evacuation time, and response time
    e. Tenable environment – Including smoke obscuration levels, heat effects, carbon dioxide levels, air velocities, and noise levels
    f. Methods of analysis
    g. Assumptions
2. Designers shall consider vehicle, electrical, trash, arson and other potential fire types depending on the Project design and intended use. When designing for trash fire scenarios, a minimum peak heat release rate of 3.4 MBtu/hr (1 MW) shall be used. When designing for vehicle fire scenarios, the following minimum peak heat release rates for MBTA vehicles shall be used:

	Mbtu/hr	MW
Green Line Rail Car	45	13.2
Blue Line Rail Car	80	23.4
Red Line Rail Car	80	23.4
Orange Line Rail Car	60	17.5
Silver Line Bus	68	20
Commuter Rail Coach	106.2	31
Commuter Rail Locomotive	Analysis by EOR Required	
Non-revenue Vehicles	Analysis by EOR Required	

In environments where multiple vehicle types or transportation modes are present, the greater heat release rate shall be used. In environments where non-MBTA vehicles may be present, peak heat release rates consistent with those vehicles' fire scenarios shall be used. The designer shall consider fire spread from car to car within a single train and/or from train to train depending on track center spacing and other variables.

3. Suitable modeling shall be used to analyze conditions within fire scenario environments.
    a. For tunnel environments, the FTA's Subway Environment Simulation (SES) program shall be used.
    b. For station and overbuild environments, a computational fluid dynamic (CFD) program capable of simulating these more complex structure types shall be used.
4. Ventilation systems shall designed and equipped to:
    a. Provide a tenable environment along the path of egress for the required time of tenability.
    b. Provide sufficient airflow rate to maintain critical velocity and avoid backlayering for a minimum of 1 hour but not less than the time of tenability.
    c. Reach full operational mode in 180 seconds.
    d. Accommodate for the presence of additional trains between ventilation shafts based on peak-hour operations.
    e. Operate on an uninterruptable power supply.
5. Structural design shall provide sufficient fire resistance to:
    a. Provide safe egress for occupants.
    b. Avoid loss of structural stability and material integrity indefinitely.
    c. Protect first responders by minimizing the risk of explosive concrete spalling.
    d. Minimize socio-economic impact following a design fire scenario by reducing the need to perform lengthy repairs ensuring that normal operations can be restored as rapidly as possible.
6. Final fire protection design documents shall be submitted by the EOR to the OCE, AHJ, and local fire departments for review and approval.

SCOPE AND NATURE

The development of property resulting in a closed or partially enclosed overbuild structure over tracks, shall include design features to ensure adequate ventilation, illumination, emergency egress and fire protection to provide a safe environment for Amtrak employees and customers during normal and emergency operations. The developer shall make all accommodations to the above grade structure, and shall be responsible for the design, construction and maintenance of the systems described below.

This document provides fire-life safety and diesel emissions design criteria for Amtrak enclosed station platforms, built-over tunnels, and tunnels. It is recognized that there may be more than one acceptable solution and Amtrak is prepared to review any scientific analysis that accomplishes the stated function and cooperate with the developer to achieve a maintainable and effective overbuild system.

SPECIAL REFERENCE

American Railway Engineering and Maintenance-of-Way Association, AREMA Manual for Railway Engineering, Chapter 6, Buildings and Support Facilities

American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE Handbook HVAC Applications, Chapter 13, Enclosed Vehicular Facilities

Illuminating Engineering Society of North America, Lighting Handbook, Chapter 11

National Fire Protection Association, NFPA 92B, Standard for Smoke Management Systems in Mall, Atria, and Large Spaces.

National Fire Protection Association, NFPA 101, Code for Safety to Life from Fire in Buildings and Structures

National Fire Protection Association, NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems

National Fire Protection Association, NFPA 502, Recommended Practice on Fire Protection for Limited Access Highways, Tunnels, Bridges, Elevated Roadways and Air Right Structures

U.S. Department of Labor, 29 CFR 1910, OSHA Safety and Health Standards

Van Nostrand Reinhold, Tunnel Engineering Handbook, Chapter 19, Tunnel Ventilation

Schirmer Engineering Corporation, "Life Safety Study and Computer Modeling Analysis for New York City Railroad Tunnels and Penn Station.

United States Department of Transportation, Subway Environmental Design Handbook. Volume II, "Subway Environment Simulation Computer Program, SES Version 4.1, Part I User's Manual".

SPECIAL MATERIALS

Not applicable.

PROCEDURE

Ventilation

DEFINITIONS

A station is defined as a place for the purpose of loading and unloading passengers, including patron service areas and ancillary spaces associated with the same structure. An enclosed station platform is constructed in such a manner that it is not open to or substantially restricted to the atmosphere and smoke, and heat are not allowed to easily disperse directly into the atmosphere.

For example, the following existing and proposed structures are enclosed stations:

- Pennsylvania and Moynihan Stations at approximate milepost 0 from 9th Avenue to 7th Avenue in New York City, NY.
- Providence Station at approximate milepost 185 in Providence, RI.
- Back Bay Station at approximate milepost 227 within Back Bay Tunnel in Boston, MA.
- 30th Street Station at milepost 88.5(original) in Philadelphia, PA.
- Chicago Union Station from Madison Street to Congress Street in Chicago, IL.

A built-over tunnel is an enclosed trainway having two or more tracks. Built-over tunnels may

be adjacent to a station, below an enclosing or covering structure, or a covered entry to a Yard and not having any separation between the tracks. Trains usually stop in built-over tunnels for five minutes or less during normal operations. Trains usually stop in built-over tunnels for 20 minutes or less during non-routine, non emergency (congested operations).

For example, the following Amtrak structures are built-over tunnels:

- Overbuilds (Brookfield and Schulweis) of Moynihan Station approach from 9th Avenue to 10th Avenue at approximate milepost W0.7 in New York City, NY.
- Overbuild of Pennsylvania Station approaches from 7th Avenue to the portal in the vicinity of 6th Avenue at approximate milepost E0.5.
- Various contiguous and non-contiguous overbuilds along the Empire Connector from milepost 0.97 to milepost 5.28 in New York City, NY.
- Overbuild for Providence Place Mall development adjacent to Providence Station in Providence, RI.
- Back Bay Tunnel Overbuild from milepost 226.9 to 227.5 in Boston, MA.
- Overbuild north of Union Station from Madison Street to Randolph Street in Chicago, IL.
- Overbuild south of Union Station from Congress Street to Polk Street in Chicago, IL.

A tunnel is an enclosed trainway having one or two tracks, not including stations or built-over tunnels. Trains usually stop in tunnels for five minutes or less during normal operations. Trains usually stop in tunnels for 30 minutes or less during non-routine, non emergency (congested operations).

For example, the following Amtrak structures are tunnels:

- North River Tunnels under the Hudson River from 10th Avenue at approximate milepost W0.7 in New York City, NY to Bergen Portal at approximate milepost W3.0 in North Bergen Township, Hudson County, NJ.
- East River Tunnels under the East River from the portal in the vicinity of 6th Avenue at approximate milepost E0.5 the Long Island City Portal at approximate milepost E2.5 in New York City, NY.
- Empire Connector North Access Tunnel from approximate milepost 0.41 (10th Avenue Portal) to approximate milepost 0.71 in New York City, NY.
- New Haven Tunnels between approximate mileposts 76.4 and 76.7 in New Haven, CT.
- Three B&P Tunnels from North Avenue Portal at approximate milepost 95.9 to Gilmor Street Portal at approximate milepost 97.5 in Baltimore, MD.
- Union Tunnel from Bond Street Portal at approximate milepost 94.6 to Greenmount Avenue Portal at approximate milepost 95.2 in Baltimore, MD.
- First Street Tunnel from First Street Portal at approximate milepost 134.8 to South Capital Street Portal at approximate milepost 137.0 on Washington, DC.

CITY OF NEW YORK

Any overbuild project in the City of New York, if already not constructed, shall be considered an Enclosed Station Platform or a Built-Over Tunnel as defined herein and regardless of actual length shall require mechanical ventilation, lighting, fire protection and at least one means of egress away from track level.

Plans must be submitted to the City of New York Bureau of Fire Prevention and Public Transportation Safety Unit for review and approval.

ENCLOSED STATION PLATFORMS and BUILT-OVER TUNNELS

Station public-area fire-life safety facilities shall be as per the latest edition of NFPA 130. Station non-public area (ancillary spaces) fire-life safety facilities shall be designed as per local codes.

Built-over tunnel fire-life safety facilities shall be as per the latest edition of NFPA 130, except that emergency egress facilities shall be sufficient for all those that can self-rescue to exit within 30 minutes.

Built-over non-public area (ancillary spaces) fire-life safety facilities shall be designed as per local codes.

Stations shall be designed to provide a tenable environment as per the latest edition of NFPA 130 Annex B for a period of 30 minutes.

Built-over tunnels shall be designed to provide a tenable environment as per the latest edition of NFPA 130 Annex B for a period of 60 minutes.

Station ventilation systems shall be designed for train fires, platform fires and wayside fires. Tunnel ventilation systems may be used for the ventilation of stations and built-over tunnels and vice versa.

A platform or wayside fire may involve trash, maintenance materials or other combustibles. The fire heat release rate for a platform fire shall be one megawatt (MW) (3.412 million British Thermal Units per hour [MBtu/hr]). The fuel burn rate shall be 0.0254 kg/s (0.0556 lbs/s). The combustion products release rate shall be 0.3624 kg/s (0.7992 lbs/s). The opaque products release rate shall be 0.0042 kg/s (0.0092 lbs/s). (Note: this data is written to three or four-decimal place accuracy to assist the comparison of simulation outputs by different engineers. This does not imply the accuracy of the data).

The platform or wayside fire growth rate shall be “fast” as defined by NFPA 92 (Reference 2). A fast fire growth rate is parabolic at 46.892 w/s² (160 Btu/hr - sec²) and reaches 1 MW (3.412 MBtu/hr) in approximately 150 seconds.

A train fire is a fire beginning in one car of a train and spreading to other cars in the same train and to other trains that are in the station. The following train fire heat and fire smoke release rates shall be used in the ventilation analysis for enclosed stations and built-over tunnels having two or more tracks not separated by a platform.

TIME	HEAT RELEASE RATE	HEAT RELEASE RATE
Seconds	MW	MBtu/hr
0	0	0
180	5	17.060
600	5	17.060
780	10	34.120
1200	10	34.120
1560	52	177.476
> 1560	52	177.476

The fuel burn rate shall be 0.0254 kg/(s-MW)[0.0164 lbs/(s-MBtu/hr)].

The combustion products release rate shall be 0.3624 kg/(s-MW) [0.2342 lbs/(s-MBtu/hr)].

The opaque products release rate shall be 0.0042 kg/(s-MW)(0.0269 lbs/[s-MBtu/hr]).

The following train fire heat and fire smoke release rates shall be used in the ventilation analysis for enclosed stations and built-over tunnels having one track, or two tracks separated by a platform.

TIME	HEAT RELEASE RATE	HEAT RELEASE RATE
Seconds	MW	MBtu/hr
0	0	0
180	5	17.060
600	5	17.060
780	10	34.120
1200	10	34.120
1380	31	106.200
> 1380	31	106.200

The fuel burn rate shall be 0.0254 kg/(s-MW)(0.0164 lbs/[s-MBtu/hr]).

The combustion products release rate shall be 0.3624 kg/(s-MW) (0.2342 lbs/[s-MBtu/hr]).

The opaque products release rate shall be 0.0042 kg/(s-MW)(0.0269 lbs/[s-MBtu/hr]).

The emergency ventilation analysis shall be done using publicly available computational fluid dynamics (CFD) software such as FLUENT, CFX, Star-CD. Certain geometries may be analyzed either by using the CFD Package FDS or by not using CFD at all. Amtrak may approve the use of FDS or the waiver of CFD after the engineer submits a request documenting the appropriateness of the recommended change.

The design philosophy of an enclosed station or built-over tunnel ventilation system shall be to maintain a tenable environment in the path of evacuation for the time periods specified above. Note the ventilation system may mechanical or non- mechanical (natural or buoyancy driven).

Design for Diesel emissions shall be as per Chapter 13 of the ASHRAE HVAC Applications Handbook. The design criteria shall be 5 ppm of nitrogen dioxide at an elevation of 14 feet above the top of rail. The ventilation systems shall be energized when the NO2 concentration at this elevation reaches 3 ppm. In the event that normal operations train idling is no greater than ten train-minutes per hour, no analysis need be made. Instead, it shall be assumed that the emergency ventilation systems can be operated in such a manner as to purge diesel emissions from the station or built-over tunnel when the 3 ppm concentration is reached.

TUNNELS

Tunnel fire-life safety facilities shall be as per the latest edition of NFPA 130. Tunnel non-public area (ancillary spaces) fire-life safety facilities shall be designed as per local codes. Trains usually stop in tunnels for 20 minutes or less during non-routine, non emergency (congested operations).

The fire heat release rate used to design the tunnel ventilation system shall be 31.12 MW (106.2 MBtu/hr). The fuel burn rate shall be 0.7898 kg/s (1.7417 lbs/s). The combustion products release rate shall be 11.2788 kg/s (24.8667 lbs/s). The opaque products release rate shall be 0.1295 kg/s (0.2853 lbs/s).

The design philosophy of the tunnel ventilation system will be the control of the direction of smoke movement (i.e., the prevention of backlayering).

The analysis shall be done using the latest publicly available version of the Subway Environment Simulation (SES) computer program.

VENTILATION EQUIPMENT

Ventilation equipment shall be as per NFPA 130 or local codes, whichever is the most stringent. The words “for a minimum of one hour” in the Ventilation Chapter of NFPA 130 shall be replaced by “for one hour, or for the anticipated evacuation time plus 30 minutes, whichever is greater”.

Illumination

Lighting shall be provided. Illumination levels of track and walking surfaces shall not be less than 2 foot-candles. Exit lights, essential signs and emergency lights shall be included in an emergency lighting system powered by a standby power system. Unless specific color rendition is required, High-Pressure Sodium (HPS) fixtures should be used for general illumination.

Egress

At least one emergency exit stairway shall be provided, and additional exits if required spaced so the distance to an emergency exit shall not exceed 1250 feet. The stairway shall lead directly to outdoors or to a safe refuge area. Signs shall indicate direction and distance to nearest exit. Egress points shall be illuminated. Emergency telephones shall be provided if deemed necessary by the authority having jurisdiction.

Fire Protection

A dry fire standpipe system, minimum 4 inch, shall be provided when the length of the overbuild exceeds the maximum length of fire hose (permitted by the local authority having jurisdiction) minus the distance from the portal to the nearest hydrant or approved water source.

Local Authorities Review and Approval

Plans must be submitted to local building code and fire prevention officials for review and approval.

REPORTING

Not Applicable.

RESPONSIBILITY

Designers of overbuild structures.

- Comply with standards and procedures.

Supervisors of Designers

- Ensure compliance with standards and procedures.

Chief Engineer, Structures

- Ensure compliance.