Committee Comment No. 17-NFPA 130-2015 [Sections H.3, H.4, H.5]
H.3 Fire Profiles.
As per 7.2.1(2), critical velocity is the criterion for determining the required tunnel airflow and hence the ventilation system fan capacities required for tunnel fire incidents. The most commonly used software is the Subway Environment Simulation (SES) computer program [1]. The peak fire heat release rate is the primary fire input.

Tenability in stations is usually predicted by computational fluid dynamics (CFD) programs. The design fire profile is an input to the CFD programs, which predict temperatures, visibilities, and carbon monoxide concentrations as a function of the three-dimensional location in the station and the time since the initiation of the fire. Any combustible materials that could contribute to the fire load at the incident site should also be evaluated.

Several references provided a reasonably good overview of a number of methodologies for predicting design fire profiles [2][3][4]. More recent methodologies include, but are not limited to, the following:

**CFD Modeling of Fire Profiles with Cone Calorimeter Tests of Train Materials.** This methodology includes cone-calorimeter tests of train materials and computer modeling of fire growth and decay for a fire that originated in a train's interior in the presence of accelerants. Several CFD programs have been used in predicting fire profiles for transit and rail projects in the United States since 2005. The CFD programs are validated for their intended use and predict pre- and post-flashover fire profiles. When selecting a computer program, it is important to select the program that best fits the need of the problem rather than to select the program based on availability. The following conditions should be considered when building a CFD model for predicting fire profiles: 1) quantity and properties of accelerants; 2) fire characteristic of car interior materials measured according to ASTM E1354; 3) layout of the car interiors, including seating layouts, orientations, and dimensions; 4) bags and luggage carried by passengers; 5) overall thermal transmission value for vehicle body; 6) openings, including windows and doors; 7) oxygen levels; and 8) mechanical and natural ventilation.

**Full-Scale Fire Tests.** A handful of full-scale train fire tests have yielded data to estimate the fire profiles. The 1995 EUREKA project [5] showed that an intercity train reached a peak fire heat release rate of 12 MW in 25 minutes, while a Metro train car reached a peak fire heat release rate of 35 MW in 5 minutes. A Baku Metro train fire (Azerbaijan, 1995) was estimated to reach 100 MW in about 30-45 minutes, and in 2002 a Frankfurt Metro fire model reached 5.6 MW in 30 minutes [3]. The fire profile studies focused on accidental fires such as debris or transient car loadings becoming ignited or mechanical failure causing the train car itself to ignite.

More recent full-scale fire tests have focused on fires where a deliberate attempt was made to ignite and flashover the train car. The full-scale fire tests in Sweden [6] used a commuter train and found that the maximum fire heat release rate of 76.7 MW was achieved in 12.7 minutes in one of the tests, and the corresponding value for another test with the train walls and ceiling covered by aluminum was 77.4 MW and occurred 117.9 minutes after ignition. The general shape of the two fire curves are almost the same. Other full-scale fire tests in Canada used a subway car, which reached a maximum FHRR of 52.5 MW in 2.3 minutes, and a railway car, which reached a peak FHRR of 32 MW in 18 minutes [7]. A fourth test was performed in Australia, where a passenger rail car reached a maximum FHRR of 13 MW in 2.3 minutes [8].

Modern trains that are fire hardened have not been readily tested. Research such as that described above has been on older model trains where the degree of fire hardening has not been quantified. Initiating fires in order used to combust the trains have been disproportionately large in consideration of the ignition source. Typically found on a train and have been conspicuously located in the worst-case location in order to combust the train. The above results in a premature growth to the combustible lining materials on the train than would ordinarily be present from ignition sources; this yields extremely large fires that overcome the fire hardening characteristics and result in very large peak heat release rates. Consideration should also be given to ventilation conditions, different types of lining materials, especially at the ceilings, and the interconnection of train cars. Additionally, the ventilation conditions represented in the testing are potentially characteristic of tunnels, but not necessarily characteristic of stations.

Research on fire hardened materials on vehicles [9, 10, 11] indicates that the source of the initiating fire is a key parameter in the likelihood of fire growth and spread. Specifically, it was found that localized ignition sources such as small flames, small burning items, or electrical failures were unlikely to result in sustained combustion of the train given the limited propensity of the ignition source to overcome the limited burning characteristics of the fire hardened materials. Larger sustained ignition sources between 50 kW and 500 kW, which are unlikely to be normally present on a train, could result in increased fire growth and development on order up to 2.6 MW as found experimentally [10] and 7 MW as found theoretically with forced ventilation at low velocity [9].

The research did not support fire growth and development leading to flashover on a train but rather a localized burning of the vehicle interior. The same research aligned with the research where larger initiating fire were present coupled with higher air velocities.
Therefore, in understanding the fire behaviour on a train, the acceptable risk associated with the ignition source requires consideration in the determination of the appropriate design fire. The research supports guidance as follows:

1. Large sustained initiating fires not normally present on a train have been found to be necessary to overcome the fire hardening characteristics of the train materials. Therefore, quantifying the likelihood of a large train fire requires a risk quantification as to the extremity of the initiating event.

2. In applications with large sustained ignition sources and far-field ventilation induced flows of less than 2 m/s, fire development on trains was found to be limited to between 2.5 and 7 MW.

3. In applications with large sustained ignition sources and far-field ventilation greater than 2 m/s, there is an increased likelihood of fire spread from the origin source leading to full vehicle involvement ranging between 45 MW [9] and 52.5 [7].

Determination of the design fire size used as the basis of design requires a more holistic risk consideration relative to the objectives of the key stakeholders [12, 13]. The process should consider a probabilistic (quantitative or qualitative) approach in defining what is deemed credible by the key stakeholders and the level of risk to be adopted in the design of the system.

H.4 Impacts on Ventilation System Design.

The train fire profile has a major impact on the station and tunnel ventilation design. The design fire scenarios and fire profiles should be determined based on the perceived threats. In response to increased awareness that transit and passenger rail systems are potential terrorist targets, some systems are designed for significant incendiary fires and others are not. The decision could be based on cost, the inferred risk, or a formal threat and vulnerability assessment.
**H.5 References.**

The following references are cited in this annex:


13. APTA RP-PS-005-00 Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment, Approved November 1, 2000, edited 3-22-04.

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**Committee Statement**

**Committee Statement:** The committee recognizes that these are critical issues that need further study.