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The Memorial Tunnel Fire Ventilation Test Program: Program Objectives

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ABSTRACT

This paper traces the evolution of the concept for the Memorial Tunnel Fire Ventilation Test Program conducted in West Virginia during the period 1989-1995. It clearly identifies the objectives set forth for the program by the technical evaluation committee (TEC) representing ASHRAE Technical Committee 5.9

INTRODUCTION

This program was an effort initiated by and guided throughout its implementation by ASHRAE Technical Committee 5.9, Enclosed Vehicular Facilities. Prior to stating the objectives of the program, it would be helpful to briefly relate the background and underlying need as perceived by the technical committee members.

Background

Although there has been an increasing focus on life safety during fire emergencies by all elements of our society, there is presently no definite and universally accepted consensus regarding the design and operation of life safety systems for road tunnel fire emergencies. There are, in fact, various approaches in use and, in some instances, controversy among design engineers, road tunnel system operators, and fire fighters regarding some issues —especially the application of the ventilation system in an emergency.

Most modern road tunnels are equipped with closed-circuit television (CCTV), fire alarm pull boxes, temperature-activated fire detection devices, and emergency telephones to alert tunnel operators to a potential fire or fire-related problem. In addition, most road tunnels have ventilation systems that could generally be utilized in a smoke management mode, as well as fire standpipe systems for suppression. A few tunnels have been equipped with foam and/or water sprinkler systems, particularly where hazardous materials are allowed. However, only a few relevant, but limited, design standards applicable to the above systems for road tunnels exist in the United States today.

The standards that have been applied to design existing facilities have been based upon theoretical analyses, empirical values, individual judgment, and/or experience—not drawn from comprehensive testing. As a result, with specific reference to ventilation and sprinkler systems, a number of opinions prevail regarding the capabilities of various types of systems.

In addressing the minimum ventilation rate for smoke and heat management, ASHRAE (1995) indicates that it is current practice to utilize an exhaust rate of at least 100 cubic feet per minute per lane foot (cfm/lf) of tunnel. Prior to this action by ASHRAE, the ventilation requirements to maintain acceptable environmental conditions during normal tunnel operation exceeded 100 cfm/lf. As vehicle emission controls were phased in, the corresponding ventilation requirements for normal operation diminished substantially, eventually falling below 100 cfm/lf. As a result, concern developed regarding the adequacy of the ventilation system capacity during a fire emergency—hence the ASHRAE notation. The effectiveness of this minimum ventilation rate had, however, until the conducting of the MTFVTP, not been validated under actual fire conditions. Further, the ASHRAE recommendation did not address additional specifics regarding airflow velocities, type of ventilation system, and appropriate modes of operation in an emergency.

Incidents involving injuries and fatalities in road tunnels have been relatively few when compared to highway fatalities. The Permanent International Association of Road Congresses (PIARC 1991) reported that 19 deaths and 75 injuries have been recorded in the history of operating road tunnels. However, with increasing utilization of tunnels, especially in urban areas, and the tendency to route hazardous cargo through these tunnels as an alternative to urban streets and the potential for a large number of casualties in one incident, the issue deserves more significant technical analysis and resolution.

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Prior tests concerned with the application of ventilation systems to life safety were limited regarding either fire size and/or type of ventilation system or configuration. The basic question remained—would ventilation improve life safety in an emergency and, if so, how should each particular system be operated? Other related questions also needed to be answered, including the following.

- Would central ventilation fans overheat and fail?
- Would jet fans employed in longitudinal ventilation overheat and fail?
- If airflow was longitudinal would a blow-torch effect result (as reported in one prior test)?
- How would smoke stratification be affected by operation of a ventilation system?
- How effective is smoke extraction?
- How is a foam sprinkler system affected by longitudinal airflow?

In the early 1980s, Philip Egilsrud, in a meeting of ASHRAE Technical Committee 5.9, recommended a potential program to develop definitive data to support emergency ventilation design and operating concepts. The committee approved the recommendation for a full-scale fire ventilation test program and proceeded to seek support for the conduct of such a program. Subsequently, the need for supporting data was also shared by the Federal Highway Administration (FHWA) and the Massachusetts Highway Department (MHD), which were in the process of having preliminary designs prepared for an extensive road tunnel construction program in Boston known as the Central Artery/Tunnel (CA/T) project.

When TC 5.9 became aware that the Memorial Tunnel near Charleston, West Virginia, had been supplanted by new highway construction, efforts were undertaken at a meeting with representatives of several federal agencies of the U.S. Department of Transportation to solicit support for a full-scale test program. Early in 1989, the FHWA and the MHD requested the preparation of a scope of work for a comprehensive fire ventilation test program in the abandoned Memorial Tunnel. The effort was undertaken by a subcommittee of TC 5.9, the technical evaluation committee (TEC), and resulted in what is termed the "Phase I Report" (B/PB 1995).

The scope of work in the Phase I Report included the following:

- test facility assessment and recommended modifications,
- designation of types of ventilation systems to be tested, and
- specific test run matrices for each type of ventilation system configuration.

OBJECTIVES

In view of the above concerns and questions, the objectives of the Memorial Tunnel Fire Ventilation Test Program were established as follows.

- For each type and configuration of a ventilation system, obtain a comprehensive database regarding temperature and smoke movement under various fire sizes and airflow quantities. The data should be in absolute values and time-related values.
- Put the database into a practical format to facilitate analysis.
- Summarize the generalized relative effectiveness of the various ventilation system configurations tested.

Members of ASHRAE Technical Committee 5.9 believe that the program achieved its objectives.

CONCLUSIONS

Companion papers in this symposium will highlight the test program procedures and results. In general, basic road tunnel ventilation system configurations at various airflow capacities were tested under fires having heat release rates ranging from 10 MW to 100 MW. Data were collected from 98 full-scale fire ventilation tests. This database has been reduced to diagrammatic and pictorial form. The analysis and findings contained in the comprehensive test report were solely derived from the test program database. There was no attempt to evaluate maintainability, reliability, or durability of components or systems utilized in the test program.

It is anticipated that the test report will be of particular interest, not only to design engineers of tunnel ventilation fire life safety systems, but also to tunnel owners and operators, firefighting organizations, academicians, and scientists.

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