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A Review on Fire Safety

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ABSTRACT

Ventilation in tunnels is required for normal and emergency operation. During normal operation, its purpose is to provide a clean air environment and to maintain reasonable temperatures during congested conditions. During emergency operation, ventilation is needed to influence the flow of smoke and combustion products so as to create a safer environment for tunnel users to escape and for emergency services to intervene. This document presents a guide to tunnel ventilation systems and their operation during emergency conditions. The emergency ventilation system design requires the identification of the potential fire and smoke threat in terms of visibility, temperature and toxicity effects. The proper operation of a ventilation system plays a key role in tunnel safety. Foremost, the ventilation system needs to provide acceptable air quality for the safe passage of tunnel users. Further, it needs to provide tenable environment and to facilitate rescue conditions during a smoke or fire event. While accomplishing the first task (normal operation), i.e. providing sufficient fresh air, is relatively straightforward, dealing with the second issue is the subject of considerable debate since defining the best means to ventilate a tunnel during a fire emergency is not always clear.

Keywaords: Fire Safty, Robotic Arm

I. INTRODUCTION

It is important to have a basic understanding about how a fire occurs and behaves within a tunnel. Essentially, fire is a chemical reaction. A carbon-based material (fuel) mixes with oxygen (usually a component of air) and comes in contact with something hot enough to heat this mixture so that combustible vapors are produced. If these vapors dissipate, then nothing happens. However, if they come in contact with an ignition source--such as open flame--a fire results. Depending on the combustibility of the ignited fuel, the fire may start as a slow-growth scenario with a long smoldering period or it may grow rapidly with almost no smoldering time. In either instance, once visible flames appear, the fire's destructive forces increase exponentially.

The flaming stage of a fire will start with a rapid rise in heat levels, initially along the tunnel ceiling, and then throughout the entire space. During the first two to three minutes, ceiling temperatures can reach 1,000°C (1,800°F). Over the next few minutes, these temperatures will spread throughout the room as the ceiling's layer of hot gases migrates. Ultimately, this gas layer acts like an oven's broiler, superheating and igniting all combustibles in the room. At that point, the tunnel and all within it are completely destroyed.

II. LITERATURE REVIEW

E. Casale and others [1] conducted experimental study on TheAutomation of the ventilation response in the case of a fire in a tunnel has been concluded thatThe tests performed at the end of the works, preliminary to the opening of the tunnel to the traffic, have shown that the objectives are matched by the ventilation control procedures.

They also highlight the effectiveness of the automatic systems, that requires twice less time to control the longitudinal velocity objective than a trained operator. In real fire conditions, it is admitted, and shown that any operator may commit mistakes in the application of the procedures.

The integration of the automatic procedures in the central control system of the Mont Blanc tunnel relates to marginal costs in the renovation works. Most of the costs are actually due to the application of the recommendations.

Peter Sturm, Michael Beyer and Mehdi Rafiei[2] did a research on this and has come to the conclusion that Fire ventilation – i.e. the use of ventilation during a fire event – is an important operating mode in any tunnel ventilation system. It enables and improves self-rescue during the initial phase of an incident. Various guidelines have already been established at international and national levels to ensure that safety standards are met. The focus lies on the control of the air/smoke velocity in the near-field region of the fire. In most cases a 'low velocity' philosophy is the most appropriate one in order to enable self-rescue, even in the smoke-filled zone. In order to achieve this goal reliable measurement of the air/ smoke velocity and control procedures for the fans are required. In turn, this will more or less automatically call for periodic testing of sensors (their functionality and plausibility) and also for regular testing of fire ventilation systems, including detection, activation and fan control. However time frames available for maintenance and tests are increasingly being shortened, due to the increased requirements on road traffic infrastructure, even though the technical infrastructure now in place is much more complicated compared to that used in former years. Thus there is a risk that in one of those rare moments when the system is needed, failure of one component of the safety chain could result in the system not delivering the required result. Hence, either the systems have to be simplified, or more efforts have to be invested in maintaining and testing safety equipment.

Jonatan Gehandler[3] present a review paper and concluded that Road tunnel fire safety concerns high uncertainty and high-stake decisions. This means the decision process should include a wider group of stakeholders and include different types of knowledge, e.g. prior experience, safety engineering, decision theory, systems theory, social science and design scienceIt is argued that the decision process should not be separated from the design and safety evaluation. Instead decision theory should be used to structure and drive the process; to identify the basic objectives, alternative solutions and key uncertainties, and prioritize resources for analysis where they matter the most.An efficient pro-active safety measure would be to improve the safety culture of professional drivers and truck companies. Regulation ensuring proper maintenance, training and quality management may be necessary in a global competitive economy.

III. VENTILATION SYSTEMS AND THE OBJECTIVES FOR SMOKE CONTROL

Tunnel ventilation can be achieved by either natural or mechanical means. Natural systems rely on the piston effect of moving vehicles, external wind, and temperature and pressure differentials between the portals to produce airflow through the tunnel. Mechanical ventilation systems use fans to produce airflows and may use ducts and dampers to distribute this airflow. Regardless of mechanical ventilation equipment, naturally induced airflows are present in all tunnels to a varying extent.

Tunnel ventilation is based on the application of either dilution or removal of smoke. Dilution is usually an efficient method for normal operation, in which case the objective is to maintain air quality and visibility. It can increase tenability by reducing concentrations of toxic gases. During emergency operation, smoke management is ideally achieved by removal of air, for example by the extraction of air and smoke. Hence, vitiated air is replaced by clean or smoke-free air, which is either supplied mechanically or drawn in through the portals.

The general classification of a ventilation system is based on the direction of airflow. Longitudinal ventilation is in the direction of the tunnel axis; air may be introduced or removed from the tunnel at a limited number of points, such as portals or ventilation shafts, or ceiling-mounted jet fans may be used to produce the required airflow through the tunnel. In transverse and semi-transverse ventilation systems, which are generally more common in road tunnels, air movement is perpendicular to the tunnel axis in the plane of a cross-section.

IV. FIRE DETECTION

Fire detection systems will enable the initial identification of a fire event. They have different characteristics depending of their form, but may be generally classified as follows:

Automatic detecting sensors: Developed specifically for fire and smoke detection, these sensors put out an alarm signal as soon as an incident is triggered (e.g., heat detection, CCTV information, smoke detection).

Human triggering: Manual triggering of the alarm by the operator due to appropriate information from sources like CCTV (e.g., incident or smoke detection), emergency phone calls, signals from inside the tunnel (emergency buttons, fire extinguisher removal, doors opened, etc.) or from information from automatic detection systems if an operator response for validation is required.

Indirect (automatic) detection: This kind of detection would be the result of a logical interpretation and correlation process of signals coming from different sources (carbon monoxide and/or particles concentration, air velocity, traffic speed, etc.).

Detection is conducted based on exceeding threshold values for a prescribed duration. It is useful to include the rates of change of the measurements in the evaluation.

The detection of a fire is of paramount importance, since missing an event could mean the loss of time. This in turn implies that a certain number of false alarms have to be accepted. Nevertheless, generating too many false alarms could tire the operator with a similar result (canceling them out without paying much attention). The reliability of the fire detection system is therefore very important.

In this context it is important that different sections of the tunnel are identified unambiguously, so that users who report fires can accurately convey their location to the operator. Particularly when using smoke extraction, the location of the fire needs to be detected in order to incorporate the correct response with respect to ventilation control.

Normally, smoke detection is less accurate in determining the location of the fire than is a high-temperature alarm using a linear heat detector. Moreover, the reaction due to several independent fire detectors by one or more systems has to be considered. This concerns the detection of moving fire sources (moving trains on fire) as the location of the initial detection of the fire might not be the same as the location where the vehicle comes to a standstill (in particular information retrieved from CCTV and smoke detection).

Normally, the response has to be organized in a hierarchy such that particular signals have higher priorities in defining the fire scenario. For example, in a tunnel equipped with smoke detectors, linear heat detectors, CCTV, opacity meters, etc., a decision process should be formulated that gives the most reliable guidance with regard to fire location. This is particularly important in the case where smoke extraction is through the use of remotely controlled dampers.

V. OPERATIONAL STRATEGIES

5.1 Rail tunnels

Operational strategies are designed to complement other safety strategies, and in particular the approach to ventilation. Each transit agency should consider its own unique issues that may require different or other additional procedures. The following general guidelines are common in subway systems:

- If a fire is detected on a train, and the train is operational, then it should be sent to the next station if possible. Evacuation from the train is much easier at a station than in a tunnel. This also helps first responders in assisting with the evacuation and fighting the fire.
- Other trains in the immediate area should be stopped. The piston effect of trains in a tunnel dominates the effect of ventilation systems, and so it would be challenging to manage ventilation unless other nearby trains are stopped.
- The communication and command structure must be clear. If the train operator contacts a control center with details of an emergency, then operating procedures should be in place with regard to the strategy for smoke management, who operates fans, when to activate fans, and how to operate the fans (such as push-pull, station all exhaust, station push-pull, point extract system, etc.).
- The train operator should contact Control with relevant information about the emergency and action being taken with passengers.
- First responders such as fire and police departments should be called out for a response and notified of ongoing transit response.
- Following trains should not enter the same ventilation block as the incident train. This may seriously impair the ability of the ventilation system to control smoke in the desired manner. It also potentially exposes the passengers on those follow-on trains to the smoke from the fire. The prohibition of a second train in the same ventilation zone may be achieved with the design of the train control system.
- Adjacent tunnels should be kept available for a rescue train or a fire department access train in the event that the train is stranded in the tunnel. The rescue train can expedite evacuation of passengers and transport of first responders to the scene.
- The train operator, if able, should lead passengers to a safe refuge.
- Traction power should be de-energized on the involved track so that evacuees and first responders are not at risk.

5.2 Road tunnels

In road tunnels, generally similar concepts are employed. A major difference is that involving the concept of self-rescue. Road tunnel users are freer entities than those in a rail tunnel, and there is no immediate, local commander to give direction. It is particularly important, therefore, that the initial smoke strategy prolongs the time available for self-rescue, so that users can appraise the unfamiliar situation and surroundings and take appropriate action prior to the arrival of the emergency services.

Typical operational strategies for road tunnels include the following:.

- Notify rescue resources according to operational procedures.
- Give support to emergency services comprising information of the course of events, creation of access passages, and possible change of operational mode of technical systems in order to create the best conditions for the rescue operation.
- Handle the external information to media and the public according to a common information and media plan.
- Other tunnel operator interventions depend on the specific tunnels and their technical systems. Interventions could include the following:
- Activate necessary traffic control restrictions and cooperation with emergency services on site if other activities concerning traffic restrictions are required.

- Activate fire ventilation scenario in order to ensure safe self-rescue and a safe environment for the rescue services approaching the fire. Cooperate with the fire brigade in operating the ventilation system if changes are wanted.
- Give information and orders to users by using the public address system or the radio system on how to act in the tunnel.

VI. CONCLUSION

There is a great future for tunnel fire safety and security, but the knowledge base must increase apace with the growing number of new tunnels being constructed worldwide, and it is important to protect our complicated and fragile underground infrastructures. We hope this special issue will provide you with new information and enhanced expertise in our collective attempt to reduce the knowledge gap.

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