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Research Article

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Numerical Investigation on Smoke Management in Underground Road Tunnels

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Abstract After the appearance of the Corona virus, it has become beyond a reasonable doubt that human health and safety are risks and epidemics and maintain its security in the first place and the value of scientific research is the most important thing now. In this research paper, I refer to the seriousness of smoke in tunnels, especially car tunnels and what results from them as a result of accidents or cars burning inside Tunnels and how to get rid of smoke so that it does not affect human safety and how to reduce the negative effects of the fire so that people can escape and this paper deals with ventilation and smoke management after a fire occurs in several ways.

Keywords road tunnel, FDS, smoke management, curtain, visibility

Nomenclature

c_p	constant pressure specific heat (kJ/(kg K))	$\dot{q}'''$	heat release rate per unit volume (kW/m^3)
D	diffusion coefficient (m^2/s)	T	temperature (K)
D^*	characteristic fire diameter (–)	T_0	temperature of ambient (K)
d	droplet diameter (μm)	t	time (s)
d_m	median droplet diameter (μm)	u	velocity vector (m/s)
f	external force vector (excluding gravity) (kg/s^2/m)	Y_l	mass fraction of lth species (–)
g	acceleration of gravity (m/s^2)	ρ	density (kg/m^3)
h	enthalpy (kJ)	ρ_0	dencity of ambient (kg/m^3)
k	thermal conductivity (W/m/K)	τ	viscous stress tensor (kg/s^2/m)
$\dot{m}'''$	production rate of lth species per unit volume (kg/s/m^3)	γ	empirical constants (–)
Q	heat release rate from fire (kW)	σ	empirical constants (–)
q_r	radiative heat flux vector (kW/m^2)		

1. Introduction

Building [1] tunnels as a result of increased traffic and the construction of the transport network are used in most regions; smoke, which causes reduced visibility, coughing and fatality, is the major concern in the entire fire of tunnels which threatens the lives of people living in the tunnels as about 70% of the accidents are caused by inhalation. Knowing that SMOKE MANAGEMENT will not be fire prone but is a tenancy advantage that provides the potential of recovery and fire protection for citizens to function and to maximize the time of recoveries without significant damages. The airflow mechanism is built to prevent the build- of temperatures above a reasonable range because vehicles are free to collect within the tunnels. Without a fire alarm, smoke reduction must be tackled to allow the main road tunnel to flee quickly.

Longitudinal [2] ventilation systems are usually installed in modern tunnels in the largest cities in Far East, including Mainland China, Hong Kong and Taiwan.In major towns there are numerous tunnels, several of which have a horizontal angle. Yet the flow of smoke in tilted tunnels is not completely compromised. The ventilation system for other tunnels was designed on the basis of supposed smoke motion patterns without experimental evidence. A scaling method was used in a tilted tunnel configuration to test the smoke movement pattern. Deceptive acrylic plastics were manufactured in a 2 m length 1/50-tunnel configuration with a horizontal tilt adjustable. A small 0.097 kW for propanol container fire was used as a heat source in conjunction with burning smoke pellets. An upward fan has been designed for longitudinal airflow. In the case of different airflow speeds a transformer was used to track or to adjust fan speed.

This paper [3] presents research on the passage of smoke in a tilted fire tunnel with longitudinal ventilation. First study of the mathematical equations of fires on the smoke sheet. Computational Fluid Dynamics (CFD) numerical simulations have been performed. Modeling studies on physical levels have been conducted for the critical velocity to avoid reverse layering at 0 ° ,3 ° ,6 ° and 9 ° horizons in either a tunnel-mode configuration. The standardized heat release rate Q is an important factor, and Q is 0.12. The above work tends to focus on Q″ less than 0,1 while the relation among critical speed and heat release rate has been determined. Several of the observations in the literature mentioned above are close to the results. With a thermal release rate of 1/3, non-dimensional critical longitudinal value was found to be differed for the avoidance of back-layering. Critical speeds are higher than values needed for horizontal tunnels to prevent back lay in the inclined tunnels. However, based on experimental and numerical results, a valid theoretical model for critical speed in a tilted tunnel is proposed.

Currently, only few regulators [4] with competence recommend that water flow is required for adequate dilute system activity in tunnels. The amount of water needed for a car fire to be correctly suppressed and the threshold at which systems fail to be successful is scarce. This paper seeks to bridge the void in the awareness of tunnel fire suppression; a series of full-scale car fire tests were performed to investigate the efficacy of flood sprinkler systems. The tests were conducted by putting one car under a dilution bucket; the car was set on fire and the car's burning behavior was thoroughly tested. Temperatures were measured inside, round and above the car and infrasound camera images were used to obtain the heights of the flames. Two types of car fire removal via the flood system were obtained from this study: incremental and instantaneous. A relation is made between the fire heat release rate and the water flow needed for the water system. It has also been found that a 6.6 mm / min water flow decreases temperature for a large variety of fire sizes in the immediate area of the vehicle.

In recent [5] decades the use of these tunnels to lower traffic jamming was especially an important research and design issue for car tunnel smoke management. Only small fires can seriously endanger life, property and the environment in these tunnels. As a result, further efficient fire safety methods are further implemented in order to reduce fire risks and enhance security. Large studies have shown that more than 70 percent of deaths in these common incidents are caused by smoke migration. CFD standards is used to try out new ventilation systems and to test the efficiency of protection measures across a variety of fire scenarios. This research explores the propagation of smoke and temperature through a vehicle tunnel following a steady diesel fire experiment. A transient three-dimensional CFD method is used in this study, simulating soot move as a single-phase gas combination while simulating a k omega turbulent formula for the real fire experiment reported by the Al-Azhar tunnel literature. In Oct 2001 the experiments is carried out shortly before the tunnel was opened for general use through vehicles to assess the ventilation system to control burn-generated smoke. Comprehensive soot concentration, temperature and longitudinal velocity contour distributions are provided at different real times counted from the beginning of fire and at different air ventilation levels to ensure smoke stratification in the early stages of fire for evacuation. Mathematical international are reached between both the predictions and an experimental study previously disclosed. The thesis can be viewed an analytical method which might help to develop smoke management systems effectively as well as to improve the range of ventilation systems in general and vehicle tunnels in specific

Smoking [6] behaviors, caused by explosions, were addressed by computational simulations in inclined tunnels at various slopes and the average upstream temperatures were precisely oriented around the centerline of the tunnel. The analysis of the experiment indicate that the maximum longitudinal centerline temperature exists in the downstream fire source area instead of just above the fire source. During the almost constant condition, two common behaviors were found: the upstream interface of smoke layers is nearly parallel to the horizontally floor whereas the downstream interface of smoke layers is parallel to both the tilted tunnel floor. Due to the fact that the vortexes occur and vary very drastically from downward maximum temperature spread, the peak temperature at the peak of the ceiling stays about steady near fire sources and slowly falls with a that distance to the fire source. Therefore, the tunnel pent, heat release rate as well as the average upstream temperature are taken into consideration by using aspect analyzes to establish an analytical correlation. The relationships suggest that as the distance from the fire source increases, the maximum temperature of the dimensionless upstream decreases and the dimensionless heat discharge rate is proportional to 0.56 electricity.

2.FDS

FDS [7] is a realistic means of modeling a fire-induced system as it numerically solves a variety of Navier-Stokes thermal flow equations. A description of the definition, validations and a bibliography of related documentation and information is accessible on the http:/fire.nist.gov / fds/. The DNS model and the LES (large Eddy simulation) principle are present here. The LES model, typically used for smoke flow analysis induced by fire, is chosen. The equations rule

Conservation of mass:

$$\frac{\partial \rho}{\partial t} + \nabla . \rho U = \dot{m}_b'''$$

Conservation of species:

$$\frac{\partial}{\partial t} . (\rho Y_\alpha) + \nabla . \rho Y_\alpha U = \nabla . \rho D_\alpha \nabla Y_\alpha + \dot{m}_\alpha''' + \dot{m}_{b,\alpha}'''$$

Conservation of momentum:

$$\frac{\partial}{\partial t}(\rho U) + \nabla . \rho U U + \nabla p = \rho g + f_b + \nabla . \tau_{ij}$$

Conservation of energy:

$$\frac{\partial}{\partial t}(\rho h_s) + \nabla . \rho h_s U = \frac{Dp}{Dt} + \dot{q}''' - \dot{q}_b''' - \nabla . \dot{q}'' + \varepsilon$$

3.Validation

Since the vehicle tunnel fire, large-scale laboratory work is daunting. The FDS test method is performed by Tiannian Zhou [8] on a wide tube. In FDS (edition 2019), fire calculation of 1 Megawatts is being used to assess the soot intensity of vehicle fires in the pipe. The experimental variables at a site applied in Tunnel in Zunyi, Guizou, China were the average rooftop temperature, time and volume of carbon monoxide. The total range is 600 m of same path tunnel, including a curved 295 m section and a normal 305 m part. a The diameter of road tunnel is 14 m, the mean depth 7 m to minimize measurements, the same field is selected for testing and fire is positioned 200 m is the lane as in figure 1.

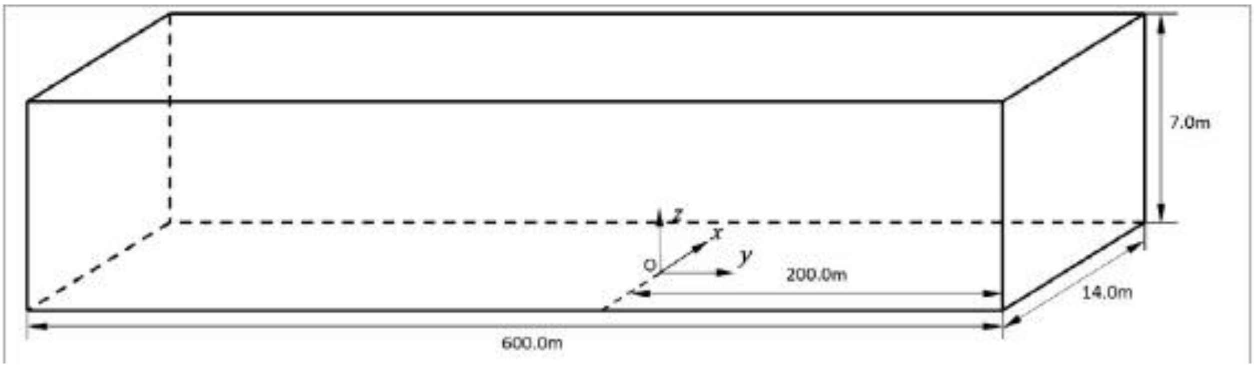

Figure 1: Schematic diagram of the tunnel

It is rising with increasing distance from fire due to high ceiling temperature validity. The simulation should forecast the pattern of ceiling temperature adequately. It is noted as in figure 2.

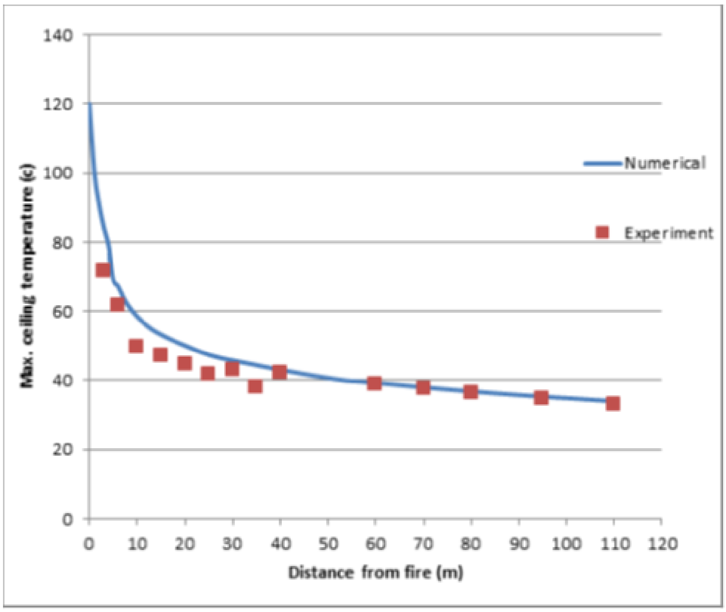

Figure 2: Comparison between experimental and numerical simulaion

4. Results & Discussion

The design road tunnel is made up of a rectangular 10 meters (W) X 5 m (H) cross section and 600 m in length. A comparison between three case for oil tanker its heat release rate 70 MW by increase the number exhaust fans 2 ,3 and 4 the flow rate 140 m3/s for each one and using solid curtain as in figure 3 , figure 4 and figure 5 .

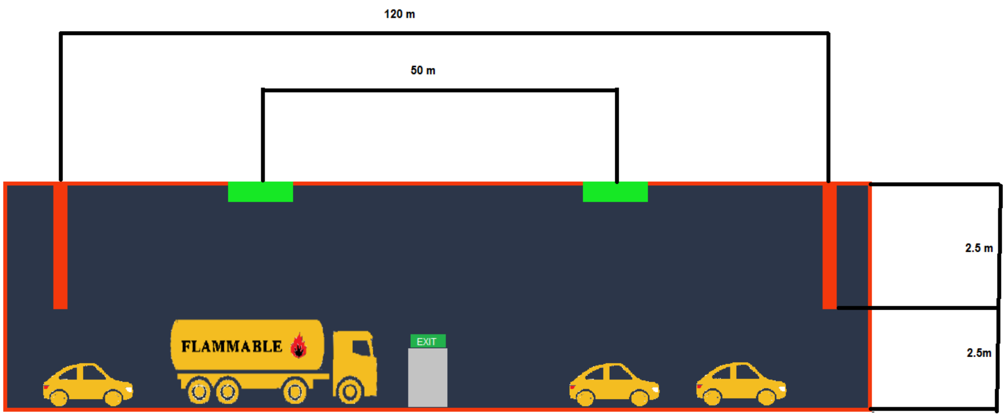

Figure 3: Schematic diagram section of the tunnel with 2 exhaust fans and solid curtain

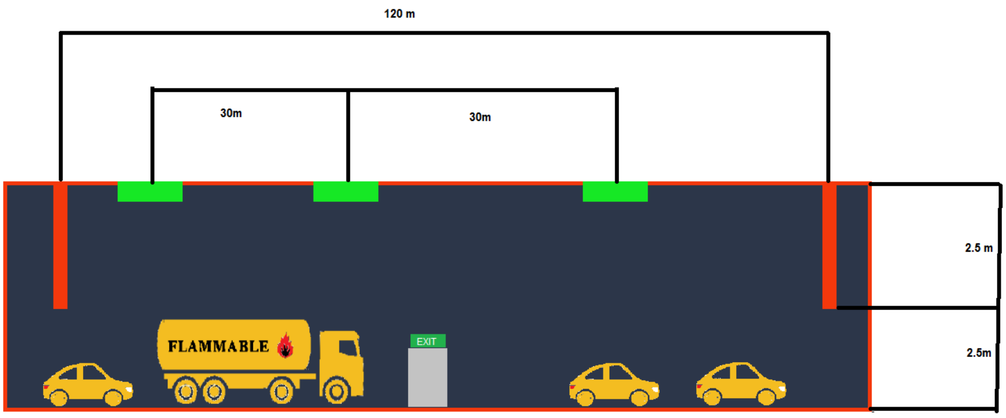

Figure 4: Schematic diagram section of the tunnel with 3 exhaust fans and solid curtain

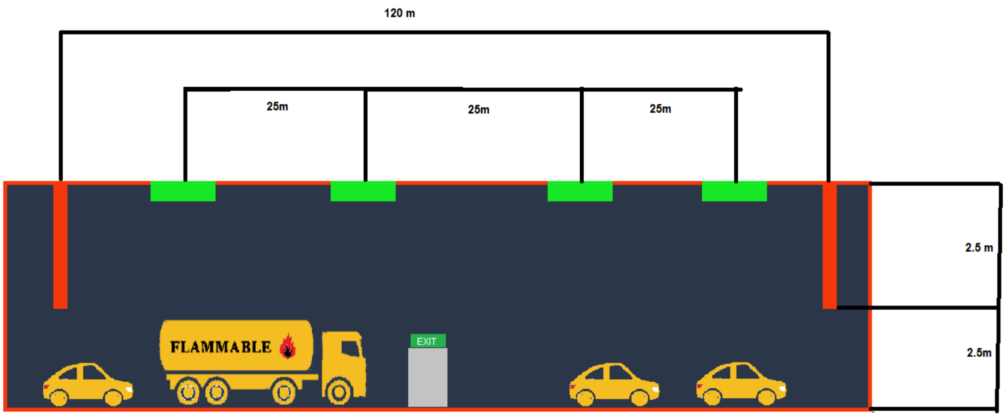

Figure 5: Schematic diagram section of the tunnel with 4 exhaust fans and solid curtain

4.1. Smoke spread

The comparison after 300 second show that the smoke is confirmed between the curtains and the 3rd case is the best as in figure 6.

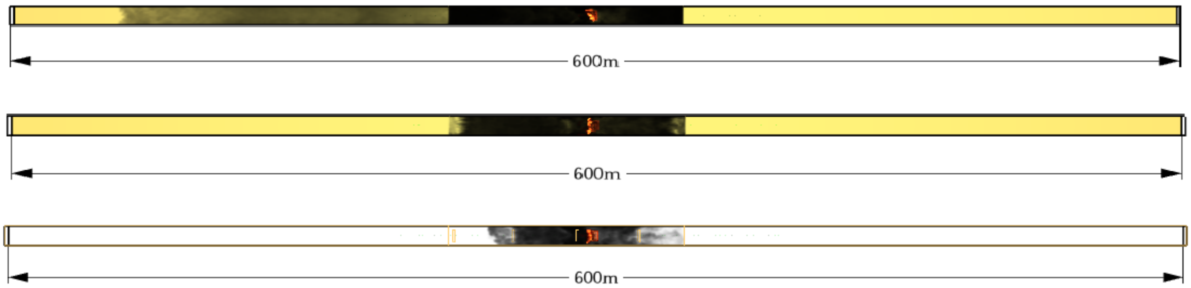

Figure 6: Comparison smoke spread in tunnel at 300 sec. by using 2,3 and 4 exhaust fans and solid curtain

4.2. Visibility distrusting

The comparison after 300 second at 1.8 m show that the visibility of the 3rd case is the best as in figure 7.

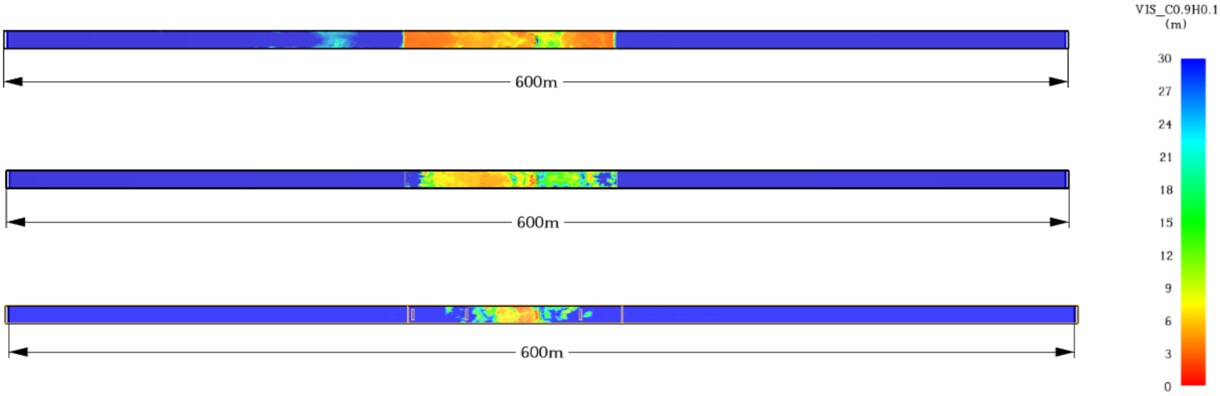

Figure 7: Comparison Visibility distrusting in tunnel at 300 sec. by using 2,3 and 4 exhaust fans and solid curtain at 1.8m

4.3. Temperature distribution

The comparison after 300 second at 1.8 m show that the temperature in the 3rd case is in the acceptable range.

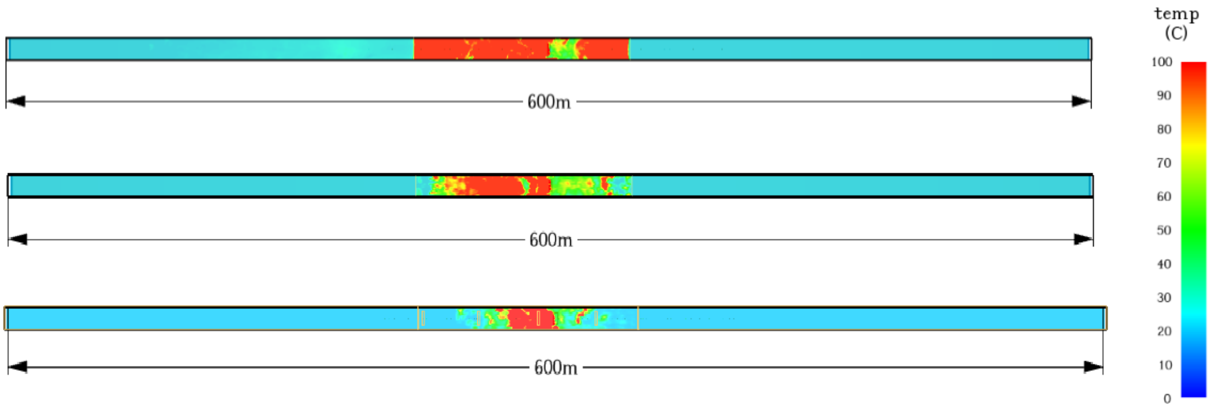

Figure 8: Comparison Temperature distribution in tunnel at 300 sec. by using 2,3 and 4 exhaust fans and solid curtain at 1.8m

4.4. CO concentration

The comparison after 300 second at 1.8m show that the CO concentration is in the acceptable range as in figure 9.

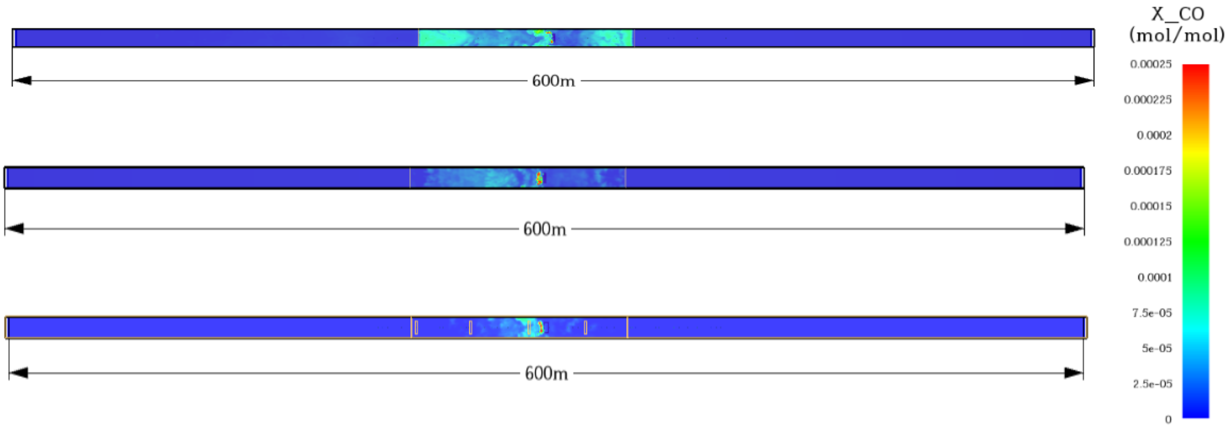

Figure 9: Comparison CO concentration in tunnel at 300 sec. by using 2,3 and 4 exhaust fans and solid curtain at 1.8m

5. Conclusion

Based upon findings obtained during the previous analysis by using the numerical test, the following assumptions can be expressed: -• FDS is a useful tool which can simulate smoke spreading and other results.

The present paper examined and understood the significance of smoke management in overall as well as the requirements for smoke management in the design of vehicle tunnels.

As the Solid Curtain as a smoke barrier with a transverse ventilation device increases the output of the smoke extraction method by 70 MW and has a significant effect on the production of human smoke mining and environmental conditions.

Acknowledgment

With the name of GOD, I started this research paper hoping that it accelerates the wheel of progress in this field. I would like to express my sincere appreciation and infinite thanks to my family, I cannot express; in words; the support of my family. Their insight and wisdom have been invaluable.

Last, but not least, I dedicate this paper to my home country, Egypt.

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