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SHOULD SMOKE MANAGEMENT SYSTEM BE PROVIDED IN KARAOKE ESTABLISHMENTS?

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ABSTRACT

Smoke management system is proposed for life safety in karaoke establishments. Arguments are supported by simulating different scenarios with a two-layer zone model. A typical room-corridor structure of a karaoke establishment is selected. Different ventilation arrangements are considered. With careful design such as adequate extraction rates, smoke layer in the corridor can be kept at high levels for easier evacuation, even under a bad scenario of closing the corridor door. Further analysis with full-scale burning tests is strongly recommended to convince the industry before implementing such tight regulations.

1. INTRODUCTION

Consequent to an arson fire in 1997 [e.g. 1], public concern on fire safety aspects in karaokes has been raised. The government is trying to set up new license systems [e.g. 2,3] for karaoke establishments with fire safety to be a key component for issuing a license. However, smoke management system (SMS) [e.g. 4], a key factor providing fire safety, is not explicitly spelled out. In fact, smoke was identified to be the major factor in providing life safety. Note that plastic materials are used widely without tight regulations on restricting using only those treated with fire retardants. This point will be addressed later.

The special features of karaokes are that there are a large number of small karaoke boxes and long corridors [e.g. 5]. Even a small fire in a karaoke box would give out large quantity of smoke, which would fill up the corridor, and then spread to other areas. If flashover occurs in a certain box, even flame might spread out. Incomplete combustion would give high carbon monoxide level and toxic combustion products in different areas. Fire services installations other than smoke control systems provided in karaokes might not be able to ensure life safety as demonstrated in that arson fire [e.g. 1]. SMS is essential for life safety, and should be provided to ensure total fire safety. The system should be designed with consideration to the integration with other active fire potection systems, passive building design features such as means of escape, and mechanical ventilation and air-conditioning (MVAC) system. As corridors are the main escape routes [5] for people in the karaoke establishments, SMS in corridor should be considered carefully.

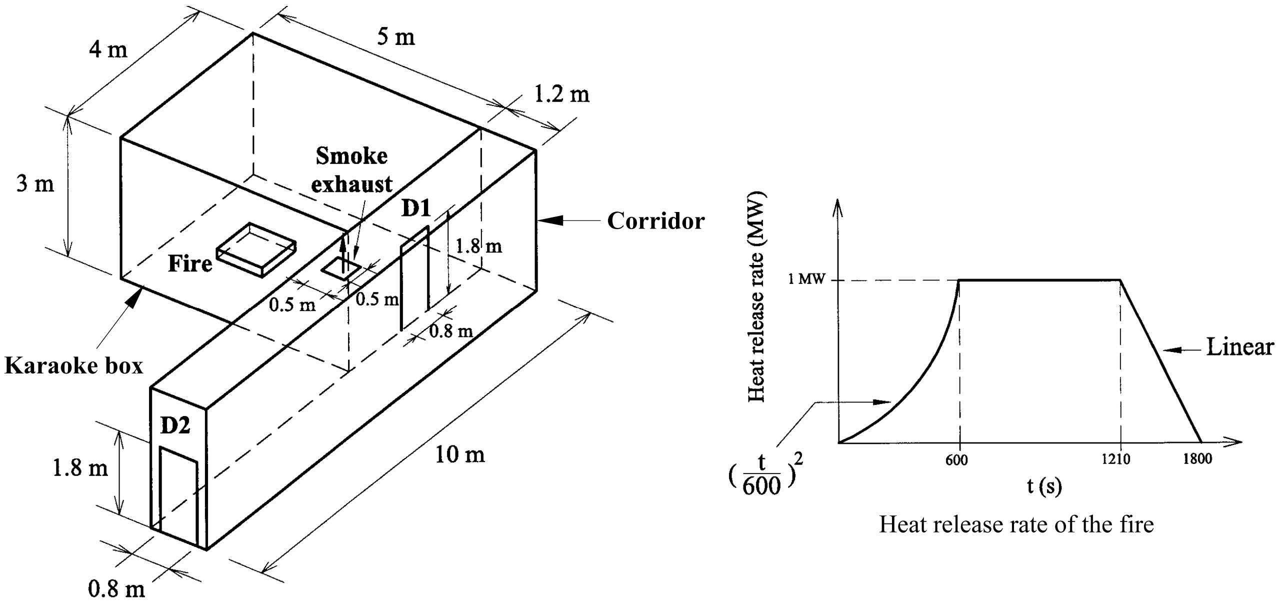
In this paper, preliminary analysis on the smoke control system is reported. The two-layer zone model CFAST version 4.01 [6] is used as the simulation tool to support the proposal. Smoke filling process in karaoke corridor is simulated with different ventilation arrangements. This will give a better fire environment for faster evacuation. Further, fire safety management [e.g. 7,8] should be enhanced so that the total evacuation time is short enough.

2. EXAMPLE SIMULATIONS

The room-corridor structure of a typical karaoke as shown in Fig 1 is considered. The karaoke box is of length 5 m, width 4 m and height 3 m. A door D1 of width 0.8 m and height 1.8 m is linked to the corridor of width 1.2 m and ceiling height 3 m. A section of length 10 m of the corridor is considered. There is a door D2 of width 0.8 m and height 1.8 m opened to the outside ambient.

A fire is taken in the karaoke box. The heat release rate Q of the design fire follows a NFPA slow-t^2 fire initially, but with cut-off value of 1 MW, then starts to decrease linearly from 1 MW at 1,200 s to 0 MW at 1,800 s. The two-layer zone model CFAST 4.01 was used as the simulator.

Mechanical smoke extraction system is suggested to be provided in the corridor for removing smoke, or at least, keeping it at higher levels, for evacuation. The duct is 0.5 m by 0.5 m, and the number of air changes per hour (ACH) is taken with respect to the corridor volume, i.e. 36 m^3. A fan curve with operating pressures up to 300 Pa was selected and operated as the fire started.



Heat release rate of the fire

Fig. 1: Geometry of karaoke room-corridor structure

Three sets of scenarios are considered in this paper:

- S1 : Doors D1 and D2 opened

  The following scenarios were considered to see how smoke would fill up the karaoke box and the corridor, and the effects of the extraction rates of the mechanical systems.

  - S1a : No smoke control.
  - S1b : Extraction rate of 10 ACH.
  - S1c : Extraction rate of 100 ACH.

- S2 : Doors D1 closed and D2 opened

  These scenarios were considered to see how smoke would fill up the karaoke and the corridor by closing the door of the karaoke box. Effects of varying the extraction rates of the mechanical systems on the corridor are also studied. Although door D1 is closed, a gap of 5 cm was assumed. Effectively, there is a vent door of width 0.8 m and height 5 cm above the floor level. However, door D2 is opened.

  - S2a : No smoke control.
  - S2b : Extraction rate of 10 ACH.
  - S2c : Extraction rate of 100 ACH.

- S3 : Doors D1 opened and D2 closed

  These scenarios were conducted to see how smoke would fill up the karaoke and the corridor by opening door D1 of the karaoke box, and closing door D2 linking the corridor to outside. Again, effects of varying the extraction rates on the smoke environment in the corridor are also studied. Although door D2 is closed, a gap of 5 cm was assumed. Effectively, there is a vent door of width 0.8 m and height 5 cm above the floor level. All the smoke from the karaoke box coming out would fill up the corridor. Whether the extraction system is effective or not can be observed from the simulation results.

  - S3a : No smoke control.
  - S3b : Extraction rate of 10 ACH.
  - S3c : Extraction rate of 100 ACH.

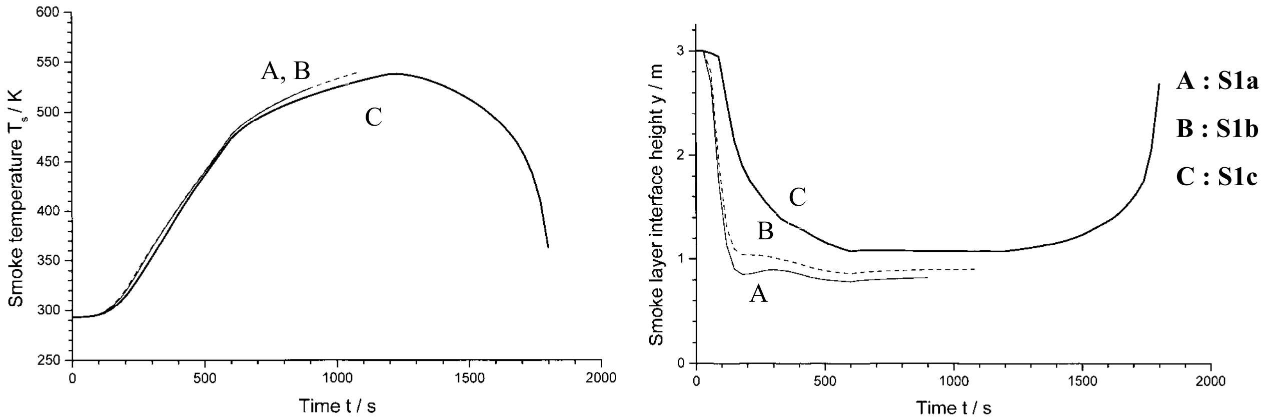
Note the fan would be operated once the fire started. Effect of fan operation time is not studied as the karaoke is relatively small. Further, the objective of the numerical experiments is to illustrate the importance of providing SMS.

3. RESULTS AND DISCUSSIONS

Results on the smoke temperature and smoke layer interface height in the corridor for the three sets of scenarios are shown in Figs. 2 to 4. The following are observed:

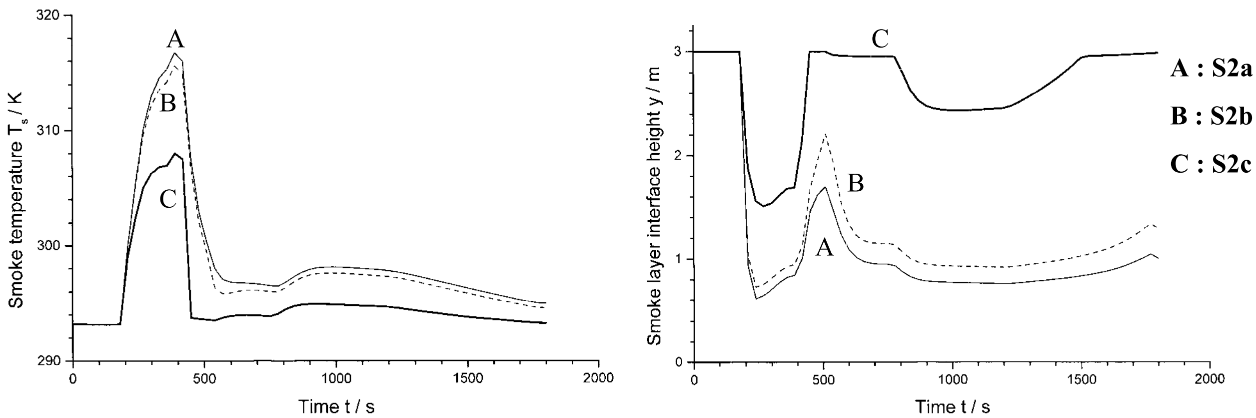
For both doors D1 and D2 opened in S1 scenarios, simulations for scenarios S1a and S1b stopped at about 1150 s where flashover occurred in the karaoke box. However, when the extraction rate is high at 100 ACH, hot smoke was extracted from the corridor and so even the temperature in the karaoke box reduced. Smoke layer at the corridor can be kept at relatively higher level for all S1a, S1b and S1c, due to the high opening height of D2 of 1.8 m.

With extraction rate of 100 ACH, smoke layer in the corridor can be kept above 1 m.



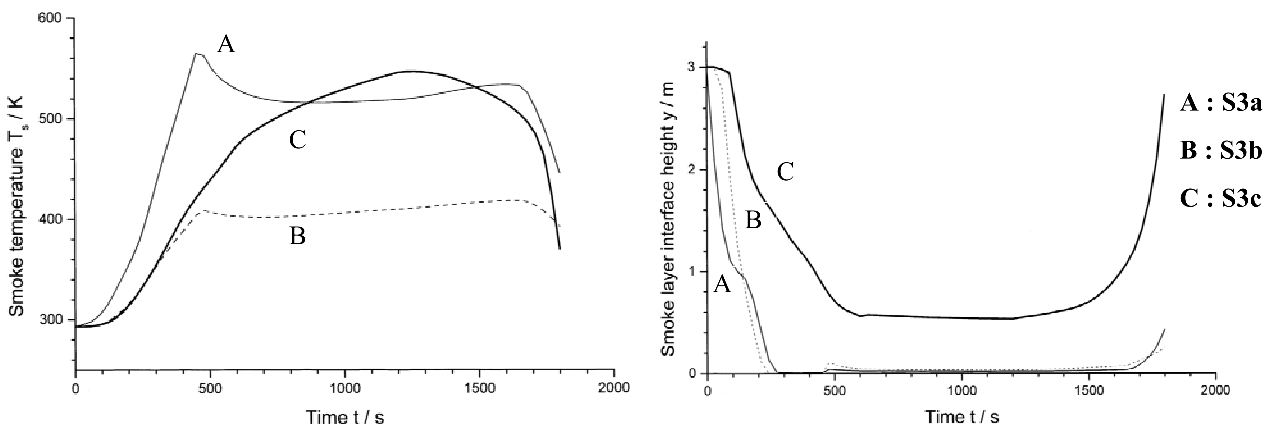
(a) Smoke temperature (b) Smoke layer interface height

Fig. 2: Scenario S1



(a) Smoke temperature (b) Smoke layer interface height

Fig. 3: Scenario S2



(a) Smoke temperature (b) Smoke layer interface height

Fig. 4: Scenario S3

For closing the door D1 and opening the door D2 in S2 scenarios, smoke temperature at the corridor is not too high, below 318 K even without smoke control system. However, the smoke layer interface height might fall to 0.6 m above the floor if there is no smoke extraction, or just extraction rate of 10 ACH. But with high extraction rate of 100 ACH, smoke layer at the corridor can be kept above 1.5 m.

For opening the door D1 to let smoke flow out of the karaoke box, but closing the door D2 to prevent smoke flowing out to the ambient in S3 scenarios, smoke temperature at the corridor might be higher than 560 K without smoke control system. The smoke layer interface height in the corridor might fall to the floor level if there is no smoke extraction, or just extraction rate of 10 ACH. But with high extraction rate of 100 ACH, smoke layer at the corridor can be kept above 0.5 m, demonstrating the importance of the smoke control system. However, the smoke temperature might be higher as the smoke layer thickness is relatively thinner for scenario S3c.

4. RECOMMENDATIONS

It is obvious that SMS should be provided in the corridor of karaoke establishments. Doing this will give better protection on life safety, which is the first fire safety objective. The extraction rates should be high enough to ensure smoke can be kept at higher levels. However, it cannot be excessively high and make-up air should be provided. Simulations with a two-layer zone model will give data for initial assessment, not detailed information on the air flow pattern as provided by Computational Fluid Dynamics (CFD) [9]. Therefore, further analysis with other techniques such as CFD should be considered. More importantly, full-scale burning tests [10] should be carried out for system evaluation.

Fire safety management should be worked out carefully. Poor management failed to ensure evacuation with occupants staying inside as reviewed by Malhotra [7]. This was demonstrated by losing lives in the big fires occurred before. A fire safety plan should be prepared with the following components:

- Maintenance plan for proper keeping of fire safety provisions, both passive building design and active fire protection system.
- Staff training plan for karaoke staff.
- Fire action plan with well-defined actions to take in case of accidents.

Two modes of operation were proposed for local karaokes [e.g. 11]:

- Normal mode of operation including:
  - Maintenance plan
  - Staff training plan

- Emergency mode of operation:
  - Fire action plan

It is important to include the operation of SMS in the fire action plan for a karaoke. In this way, a better fire environment with smoke layer kept at higher level will be provided for faster evacuation.

There are lots of criticisms [e.g. 8] on saying that fire safety plan is just a manual kept in the safe. Nobody would care about taking the appropriate action. This is similar to a ‘peacock feather’ (孔雀翎) as said before. The government should consider implementing inspection schemes to ensure that fire safety management is carried out properly. Such management elements should be updated whenever there are building alternations or new fire safety technology developed. It is better to designate a single government department to ensure that fire safety management is properly implemented.

5. CONCLUSION

It is not yet clear that putting fire safety provisions suggested for karaokes [1,2,12] is demonstrated by in-depth investigational work. Therefore, fire safety is not guaranteed even by including all the requirements. Note that if fire systems are not designed and operated properly, adverse effects like producing a large volume of hot steam in a sprinkler fire might happen.

Flame spreading over partition walls and surface linings have not yet been specified, as lots of partition walls built five years ago are timber-based [13]. Smoke management system should be installed in the karaoke corridors as demonstrated by the above preliminary study. This is even more important than providing fire resistance construction [2,3] in the karaoke boxes. That passive design is possibly for assessing the behaviour of the construction element under a ‘standard fire’, with time scale of 0.5 hour, 1 hour, 2 hours and 4 hours. SMS would assist evacuation, dealing with time scale of several minutes.

Full-scale burning tests [10,12] should be performed in collaboration with government departments and perhaps, the service industry, to support the argument. Bearing in mind that public safety should be considered carefully, not just based on some preliminary calculations as shown in this paper. Conducting systematic experimental studies is a necessity, no excuse in talking about the cost.

ACKNOWLEDGEMENT

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