X. Jin, R. Huo and W.K. Chow, "Experimental Studies on 'Bare Cabin' Fires", Journal of Applied Fire Science, Vol. 23, No. 3, p. 269-281 (2013-2014).

Experimental Studies on 'Bare Cabin' Fires

Jin Xuhui and Huo Ran
State Key Laboratory of Fire Science
University of Science and Technology of China
Hefei, Anhui, China

and

W.K. Chow
Research Centre for Fire Engineering
Department of Building Services Engineering
The Hong Kong Polytechnic University
Hong Kong, China

February, 2013

Abstract

The cabin fire protection concept was widely used in the retail areas of many public transport terminals in Southeast Asia since 1990. Fire environment in a 'bare cabin' was studied experimentally in a big burning hall. The objectives are to understand the possible fire environment in such design for providing useful data in deciding suitable fire services installations.

A cabin of length 4 m, width 4 m and height 3 m was constructed with limited ventilation supplies adjusted by the door size. Pool fires with heat release rate up to 1 MW were considered. Eight of the tests carried out will be reported in this paper.

1. Introduction

The “cabin” concept (1) has been used widely for fire safety protection in many big halls in Southeast Asia including Hong Kong including many terminal buildings (e.g. 2,3). Generally speaking, the ‘cabin’ concept is a good design to protect the areas of high fire load in big halls and allow better space allocation. However, fire services provisions, at least a workable sprinkler system and a smoke management system, must be installed and designed properly under agreed design fires. There are concerns (4,5) on whether the sprinkler system can control fires at low values such as 2 MW in the retail areas.

Because of the cabin roof that confines heat and smoke, flashover would occur if the sprinkler and smoke extraction systems fail to work. Also, smoke would come out of the ‘open’ design if the smoke extraction system does not work properly. Note that the objective of installing a sprinkler system is to control the fire at a certain value, not to extinguish it completely. In case of the sprinkler and smoke management system fail to work, a fire in a cabin, defined as a ‘bare cabin’ fire, would become a big burning object with large air entrainment rate to give very high smoke production rate. Smoke would then spread quickly to its adjacent areas. These were pointed out in theoretical studies on analyzing flashover criteria (6) for a cabin fire (7), smoke filling process in an atrium, and smoke extraction system performance (8) and others (3). However, experimental data are absent in the literature for fires of high heat release rate to demonstrate the real physical picture of a ‘bare cabin’ fire.

Preliminary experimental studies of ‘bare cabin’ fires were carried out in a burning hall, the Fire Test Atrium, at the State Key Laboratory of Fire Science, University of Science and

Technology of China (USTC). Experimental data for understanding cabin fires in an atrium were obtained through full-scale burning tests (9,10). The target is to provide useful information for the building operation team and also the design engineers for assessing this fire safety design for the atrium. In this paper, only fire in a cabin itself, i.e. bare cabin, was studied. Consequences of such a fire for the atrium were reported separately (11-13).

2. Experimental Design

For a cabin with high fire load and adequate ventilation, flashover would occur quickly to give a fully-developed fire (e.g. 14,15). There are difficulties in designing flashover experiments, since the study would destroy the testing facility. However, it is necessary to carry out such studies (16). By referring to different experiments and flashover studies reported in the literature such as the crib fire experiments in a room (17), flashover fire experiments in a full-scale testing facility (18), and smoke filling process experiments in an atrium (9,10), and taking into account the requirements of a 'bare cabin' fire, a cabin similar to a retail shop in a terminal hall was built with a photograph shown in FIG. 1a. The geometry is of length 4 m, width 4 m and height 3 m as illustrated in FIG. 1b. The roof and the walls were made of sandwich fireproof plasterboard, with overall thickness of 7 cm.

Ventilation can be provided by a door and also adjustable vents:

- The door was designed with adjustable size.
- There are four vents of 18 cm high at the bottom of the cabin. Area of those vents can be changed.
- Window located in the wall opposite to the door can also be taken as a vent if necessary.

There are four steel wheels installed at each corner of the cabin for moving to different places of the atrium. For the experiments described in this paper, the cabin was located at the centre of a burning hall of length 22 m, width 12 m and height 27 m.

Diesel with heat of combustion 46000 $kJkg^{-1}$ was used as the burning fuel in the experiments.

Diesel is difficult to ignite but would produce large quantities of smoke so that visual inspection of the smoke filling process can be carried out easily. A small amount of gasoline was added for easier ignition. Three pool fires labeled as PC1, PC2 and PS1 were:

- PC1: A circular pool fire of 0.59 m diameter
- PC2: A circular pool fire of 0.975 m diameter
- PS1: A square pool fire of size 1 m by 1 m

A total of eight pools were made and put together to give bigger fires. The heat release rate Q was calculated from the transient mass loss rate $\dot{m}$, the combustion efficiency α and the heat of combustion ΔH:

$$Q = \alpha \dot{m} \Delta H \qquad \ldots (1)$$

The maximum heat release rate of a single pool was 1.5 MW.

3. Experiments

The following were measured in a 'bare cabin' fire:

- Mass loss of fuel:

  Mass of fuel was measured by a six-fulcrum electronic balance with output converted to channel voltage signal. The maximum weight was 50 kg and the precision was 0.1 kg. The balance was lagged with thermal insulating materials. The pool was supported by fireproof fibre glass in the pool boards to keep each fulcrum equally weighted.

- Temperature distributions inside the cabin:

  Horizontal and vertical distributions of temperatures in the cabin were measured using thermocouples. There were three racks of thermocouples in the cabin as shown in FIG. 2:

  - Rack I:

    There were 10 T-type thermocouples distributed vertically with intervals of 5, 20, 20, 20, 20, 20, 20, 30, 30 cm from the cabin roof. They were placed at 35 cm from the north wall, and 30 cm from the west wall.
  - Rack II:

    Similar to Rack I with 10 T-type thermocouples, placed at 90 cm from the south wall.
  - Rack III:

    There were 9 K-type thermocouples mounted in the east wall, and arranged as a T-shape with five thermocouples placed horizontally and four placed vertically. The top five thermocouples labeled as 1 to 5 were put at 40 cm horizontal intervals from each other, and 5 cm down the ceiling from south to north. The middle four thermocouples labelled as 6 to 9 were arranged with the same vertical intervals which can measure temperature through a manual meter thermocouple.

- Heat flux:

  A heat flux meter was employed to measure heat flux at 30 cm above the ground. The heat flux was proportional to the voltage output with a coefficient of 18.85 $kWm^{-2}mV^{-1}$.

Video facilities were used to record and observe the burning processes. Detailed arrangement of the instrument is shown in FIG. 2.

4. Typical Experimental Results

Many tests were carried out and eight of them are reported in this paper. The ventilation conditions were changed by varying the area of the door and vent size at the bottom of the cabin. A summary of the tests is shown in TABLE 1 together with the door size. The ventilation conditions at the bottom vents were:

- East and west: Either open with height 0.18 m and area 0.72 m^2; or closed.
- South and north: Either open with height 0.18 m and area 0.54 m^2; or closed.

A typical burning test such as test 5 is shown pictorially in FIG. 3. There, the fire source was a PC2 circular pool of 97.5 cm diameter with 6.1 kg of diesel oil. The vent at the bottom of the cabin was closed, and the door vent was 58 cm high (excluding the bottom vent of 18 cm high). The west door of the big hall was fully open to supply adequate air for complete combustion. All other windows and natural vents of the hall were closed during the experiment.

Key results for the eight tests are summarized in TABLE 1. The ventilation condition, maximum heat release rate Q_{max}, flashover time using various temperature criteria, maximum mean temperature of the hot smoke layer in the cabin T_g, and flashover time using heat flux criteria are shown.

Horizontal and vertical temperature distributions of the hot smoke layer for test 4 are shown in FIGS. 4a and b. Temperature did not vary much in the horizontal direction, while varied quite a lot in the vertical direction. The transient average temperature of the hot smoke layer at 5 cm away from the ceiling for test 4 is shown in FIG. 5. The temperature increased significantly at about 200 s. A maximum temperature of 660°C was recorded 20 s after that, which indicated the occurrence of flashover.

5. Observations

The following were observed:

- By comparing Q_{max} and T_g in test 4 with other experiments, the larger the heat release rate, the higher the temperature of the hot smoke layer in the cabin.

- Ventilation conditions affected flashover significantly. Under the same condition of pool size and fuel mass, flashover occurred in test 5 with a maximum temperature of 558°C; but flashover did not occur in test 2 and the maximum gas temperature T_g was only 415°C. Note that the conditions of the bottom vents were the same for the two tests. However, the door area was 0.93 m^2 for test 5 and 2.35 m^2 for test 2.

- Smoke temperatures in the cabin would be affected by the ventilation conditions. Higher maximum T_g of 662°C was found in test 4, where all the bottom vents were open, and the door area was 1.63 m^2. If the number and area of the ventilation openings increased, smoke temperature would be lowered. For test 2 with all the bottom vents open and a door area of 2.35 m^2, maximum T_g was 415°C. While in test 5 with all the bottom vents open and a door area of 0.93 m^2, maximum T_g was 558°C. Therefore, higher heat release rate is required for flashover.

- From tests 7 and 8 with all the bottom vents closed, smoke layer temperature increased as the ventilation factor of the door $A_v\sqrt{H_v}$ increased. For test 7, $A_v\sqrt{H_v}$ was

$0.71\,m^{5/2}$ and maximum T_g was 531°C. But for test 8, $A_v\sqrt{H_v}$ was 0.98 $m^{5/2}$ and maximum T_g was 536°C.

- Test 3 was performed with water added to the pool fire. Adding water to the pool would affect the burning process significantly. Comparing test 3 with test 4, the heat release rate of the former case was much lower than that of the latter case with water added. The effect of adding water on the heat release rate is still unknown.

- It is observed from experiments that the burning rate increased suddenly for the eight tests. A possible explanation is due to the thermal radiation from the hot smoke layer to the pool fire. As a result, flashover occurred. However, this was not indicated by the smoke layer temperature in other tests. This suggested that using only the smoke temperature criterion (550°C or 600°C) to determine flashover may not be sufficient.

6. Analysis

The minimum heat release rate for flashover Q_{max} was found to be correlated with the ventilation factor (e.g. 14,16,19). This can be used to check with the results measured in this study. However, there are several openings for tests 1 to 6.

The total ventilation factor ($A_T \sqrt{H_T}$) of equivalent height H_T, width W_T and area A_T (= $H_T W_T$) for each test calculated by assuming that the proportionality constant relating air flow rates and ventilation factor are the same for all openings. If the i^{th} opening is of width W_i, height H_i, area A_i and ventilation factor $A_i \sqrt{H_i}$, then for N openings, the total ventilation factor $A_T \sqrt{H_T}$ is:

$$A_T \sqrt{H_T} = \sum_{i=1}^{N} A_i \sqrt{H_i} \qquad \ldots (2)$$

Values of flashover heat release rate Q_{Thomas} calculated by the equation proposed by Thomas (14), but included as a computer program in the fire engineering design tool FIREWIND (20), are shown in TABLE 1 as well.

7. Conclusion

Preliminary experiments on bare cabin fires were carried out. It is observed that flashover occurs easily by burning a very small amount of diesel. Note that many 'open cabins' are constructed for retailing in public transport terminals in the Far East. Igniting the huge amount of combustibles stored might lead to very big fires.

The following are suggested to be studied for assessing fire safety of those cabin designs:

- To study the relationship between the fire heat release rate, smoke layer temperature and the ventilation factor.
- To study the smoke filling process due to a cabin fire in an atrium, and compare it with the smoke filling process of a fire in an atrium.
- To study the effects of sprinklers, natural ventilation and forced ventilation on cabin fire and smoke filling process in an atrium.

Appropriate fire services installations can then be decided to control the design fire to a more realistic high value. Most of these items are being studied as doctoral degree projects and reported (21,22).

8. Additional Comments

The paper was published as a journal paper (23). With the practice of publisher, preprint is allowed to upload at a website. There are further studies on this topic (24,27-34,38,39-40,42-43).

Additional fire services installations such as long throw sprinklers are installed, see (25-26,36-37,45). Fire safety management is a key part in providing safety, see (35,39,41,44,46-51).

Acknowledgement

This project is supported by the National 973 project "Fire Dynamics and Fundamentals of Fire Safety" under Subgroup 4 "Smoke Movement and Toxic Harmful Gases Transfer in Fire" with number 2100CB409604, People's Republic of China.

References

1. M. Law, Fire and smoke models – Their use on the design of some large buildings, *ASHRAE Transactions*, *96:1*, pp. 963-971, 1990.
2. W.K. Chow, On the 'cabin' fire safety design concept in the new Hong Kong airport terminal building, *Journal of Fire Sciences*, *15:4*, pp. 404-423, 1997.
3. J.C. Jones, Flashover in enclosure fires, *International Fire Protection*, *22*, pp. 84-87, 2005. http://www.ifpmag.com/
4. W.C. Yan and M.C. Luo, Fire safety design for 2008 Olympic Halls, *Fire and Disaster Prevention*, p. 70, 2007 - In Chinese.
5. W.K. Chow, A note on cabin fire design for protecting large halls, Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, February 2012, Available at: http://www.bse.polyu.edu.hk/researchCentre/Fire_Engineering/Hot_Issues.html
6. W.K. Chow, Study on the flashover criteria for compartmental fire, *Journal of Fire Sciences*, *15:2*, pp. 95-107, 1997.
7. W.K. Chow, A preliminary study on the fire protection aspects of the new airport terminal building, *Journal of Applied Fire Science*, *6:4*, pp. 327-338, 1997.
8. W.K. Chow and Q. Kui, Time to flashover for fires in a 'bare cabin' with smoke extraction system, *Architectural Science Review*, 44:2, pp. 115-125, 2001.
9. Y. Li, R. Huo, E Cui and W.K. Chow, Experimental study on smoke filling in atrium with large fire, *Proceedings of 99 International Symposium on City Fire Safety*, Huangshan, China, 1999.

10. L. Yi, W.K. Chow, R. Huo, N.K. Fong, Y.Z. Li, C.W. Leung, C.L. Shi, W.Y. Hung and H.B. Wang, Full-scale burning tests on mechanical smoke exhaust in large atrium, *ASHRAE Transactions*, 110:2, pp. 267-273, 2004.
11. R. Huo, X.H. Jin, W.K. Chow and N.K. Fong, Experimental studies on natural smoke filling in atrium due to a shop fire, *Building and Environment*, 40:9, pp. 1185-1193, 2005.
12. C.L. Shi, Y.Z. Li, R. Huo, B. Yao, W.K. Chow and N.K. Fong, Mechanical smoke exhaust for small retail shop fires, *Proceedings of the 2004 ASME International Mechanical Engineering Congress (IMECE04)* held at Anaheim, California, Anaheim Hilton, USA, 13-20 November 2004, Paper IMECE2004-59301, 2004.
13. C.L. Shi, Y.Z. Li, R. Huo, B. Yao, W.K. Chow and N.K. Fong, Mechanical smoke exhaust for small retailing shop fires, *International Journal of Thermal Sciences*, *44:2*, pp. 477-490, 2005.
14. P.H. Thomas, Testing products and materials for their contributions to flashover in rooms, *Fire and Materials*, 5:3, pp. 103-111, 1981.
15. R.D. Peacock, P.A. Reneke, R.W. Bukowski and V. Babrauskas, Defining flashover for fire hazard calculations, *Fire Safety Journal*, *32*, pp. 331-345, 1999.
16. W.K. Chow, Gaowan Zou, Hui Dong and Ye Gao, Necessity of carrying out full-scale burning tests for post-flashover retail shop fires, *International Journal on Engineering Performance-Based Fire Codes*, 5:1, pp. 20-27, 2003.
17. J.G. Quintiere and B.J. McCaffrey, NBSIR 80-2054, *The Burning of Wood and Plastic Cribs in an Enclosure*, *Vol. I, Final Report*, 1980.
18. M. Luo and V. Beck, Flashover fires in a full scale building: Prediction and experiment, *Proceedings of the Seventh International Fire Science and Engineering Conference*, pp. 361-370, Cambridge, England, 1996.

19. R. Huo, X.H. Jin, C.L. Shi and W.K. Chow, On the equations for flashover fire in small compartments, *International Journal on Engineering Performance-Based Fire Codes, 3:4*, pp. 158-165, 2001.

20. FIREWIND version 3.5, Fire Modelling and Computing, Sydney, Australia, 2000.

21. C.L. Shi, Study on enclosure fire growth and smoke movement in large space buildings, PhD thesis, University of Science and Technology of China, Hefei, Anhui, China, 2005.

22. L. Yi, Study on the fire smoke's flow and management in an atrium, PhD thesis, University of Science and Technology of China, Hefei, Anhui, China, 2005.

23. X. Jin, R. Huo and W.K. Chow, Experimental Studies on 'Bare Cabin' Fires, *Journal of Applied Fire Science*, *23:3*, pp. 269-281, 2013-2014.

24. N. Cai and W.K. Chow, Numerical studies on heat release rate in a room fire burning wood and liquid fuel, *Building Simulation - An International Journal, 7:5*, pp. 511-524, 2014.

25. K.P. Cheung and W.K. Chow, Concerns on installing long-throw sprinklers in tall halls, *International Journal on Engineering Performance-Based Fire Codes*, *11:1*, pp. 1-3, 2012.
https://www.academia.edu/79730325/Concerns_on_installing_long_throw_sprinklers_in_tall_halls

26. W.K. Chow, Necessity of in-depth evaluation of long-throw sprinkler installation at tall atria storing high amounts of combustibles, *International Journal on Engineering Performance-Based Fire Codes, 11:1*, pp. 4-10, 2012.
https://www.academia.edu/79730390/Necessity_of_in_depth_evaluation_of_long_throw_sprinkler_ins tallation_at_tall_atria_storing_high_amounts_of_combustibles

27. W.K. Chow, Fire safety provisions for large halls in the Far East, Invited talk - Beijing University of Technology, Beijing, China, 24-25 April 2014, Beijing, China, 2014.

28. Y.H. You, Y.Z. Li, R. Huo, S.C. Li, X.Q. Sun, H.B. Wang and W.K. Chow, Experimental studies on open type cabin fire, *Journal of Applied Fire Science, 24:3*, pp. 253-272, 2014-2015.

29. W.K. Chow, A discussion on possible fire hazards of airport terminals, *Journal of Architectural Engineering Technology, 4:1*, 1000136, 2015.

30. Y.H. Xi, W.K. Chow and J. Mao, Aerodynamics simulation on density jump in a long corridor fire, *Tunnelling and Underground Space Technology, 50*, pp. 23-31, 2015.

31. L. Yi, Y.Z. Li, R. Huo and W.K. Chow, Numerical simulation on mass flow across the smoke layer interface in a room fire under mechanical extraction, 2nd European Symposium of Fire Safety Science, 16-18 June 2015, EUC Center, Nicosia, Cyprus, 2015.

32. W.K. Chow, Fire hazards of crowded airport terminals, 1st International Symposium on Sustainable Aviation, 31 May to 3 June 2015, Istanbul, Turkey, 2015, also published in *International Journal of Sustainable Aviation, 2:4*, pp. 327-337, 2016.

33. L. Miao and C.L. Chow, Numerical Studies on a Window Plume Ejecting Out of a Room Fire to an Internal Building Void, 2016 International Symposium on Safety Science and Technology, 17-19 October 2016, Kunming, Yunnan Province, China, 2016.

34. Wilson Y.K. Woo, M.C. Chan and W.K. Chow, Physical characteristics of residential sprinklers water spray, Proceedings of the 7th International Conference on Energy and Environment of Residential Buildings,20-24 November 2016, Brisbane, Australia, 10 pages, 2016.

35. Y. Huo, C.H. Cheng, T.K. Yue and W.K. Chow, Fire safety management on staircase allocations for evacuation in a tall building, CONFAB 2017, 10-12 Sep 2017, Brunel University, London, UK, 2017.

36. D.F. Szeto, N.K. Fong and W.K. Chow, A study on thermal sensitivity of sprinkler heads for residential buildings, Fire Safety 2017 International Conference on Research and Advanced Technology in Fire Safety, 20-21 Oct 2017, Santander, Spain, 2017.

37. S.L. Lin, W.K. Chow, Y.K. Woo, D.F. Szeto and C.H. Su, Effect of heat collector plate on thermal sensitivity of sprinkler heads in large terminal halls,*Journal of Building Engineering, 25*, 100787, 2019.

38. T.Y. Yeung and W.K. Chow, Study of positive pressure ventilation in room fires using a small-scale model, *Heat Transfer Research, 50:3*, pp. 243-261, 2019.

39. W.C. Fan, Some thinking behind public safety science, 2019 International Conference on Urban Public Safety and Emergency Rescue, Invited talk, Changzhou, China, 24-26 May, 2019.

40. K.M. Wong, W.K. Chow, Anthony C.H. Cheng, Vincent Y. Wan and C.L. Chow, A study on positive pressure ventilator in room fires using small scale model, SFPE 19 Annual Conference & Expo, 13-15 October 2019, Phoenix, Arizona, 2019.

41. W.K. Chow, Fire safety strategy for large halls in airport, China Public Safety Conference 2020, 1 November 2020, Beijing, China, 2020.

42. M. Ivanov, W. Peng, Q. Wang and W.K. Chow, Sustainable smoke extraction system for atrium: A numerical study, *Sustainability - Special issue Fire Safety in Green and Sustainable Buildings, 13:13*, 7406, 2021.

43. Y.H. Xi, X. Dong and W.K. Chow, Numerical simulation on temperature in wood crib fires, *Thermal Sciences, 25:4, Part A*, pp. 2621-2636, 2021.

44. M. Ivanov, W.K. Chow, T.K. Yue, H.L. Tsang and W. Peng, Upgrading of fire safety requirement for tall buildings in Bulgaria and proposal of implementing firesafety management under facility management, *Facilities, 40:5-6*, pp. 385-393, 2022.

45. W.K. Chow, Concerns on Installing Long-throw Sprinkler in Tall Atria, RCFE web, 17 Jan 2012, Academia, 18 Jan 2022, https://www.academia.edu/68590908/Hot_Issues_in_Fire_Engineering_January_2012_Concerns_on_Installing_Long_throw_Sprinkler_in_Tall_Atria

46. M. Ivanov and W.K. Chow, Importance of Safety Management and Safety Culture for Storage with Explosion Risk: Lesson Learnt from the Beirut Disaster, engrXiv, posted 25 May 2022, https://engrxiv.org/preprint/view/2229

47. The Standard, Bosses could be fined HK$10M, jailed two years for safety breaches as latest bill passes, 19 April 2023.

48. South China Morning Post, Beijing district official apologises after hospital fire kills 29 people, injures dozens, 19 April 2023.

49. South China Morning Post, '2 arrested' after concrete canopy attached to 57-year-old building collapses, injuring Hong Kong driver, 2 July 2023.

50. Dimsumdaily Hong Kong, Canopy roof collapse on Mong Kok Road injures driver and damages vehicle, 2 men arrested, 2 July 2023.

51. The Standard, 'Rain of concrete' falls off 57-year-old building in Mong Kok again, 5 July 2023.

BCab20131e

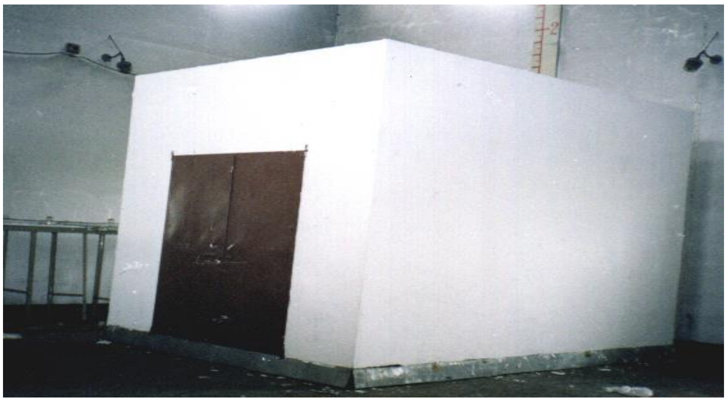
Record:
A482UL22-1a (opened 24 July 2023, open from BCab20131e.doc)
A482UL22-1b (opened 9 Aug 2023)
A482UL22-1c (opened 11 Aug 2023)

TABLE 1: Summary of the eight tests

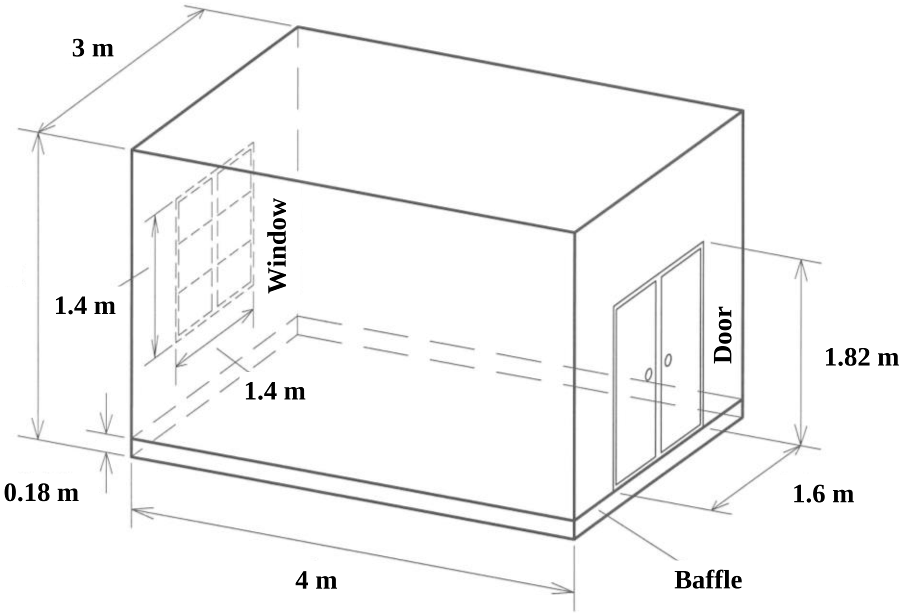
Tests	Pool type	Fuel mass (kg)	Hall temp (°C)	Burning time (s)	Ventilation conditions of bottom vents of the cabin				Door			Q_{max} /MW	Time to flashover t_g (s)			Max temperature T_g (°C)	Time for radiation heat flux to 20 kW/m^2	Q_{Thomas} /MW
					East	South	West	North	Av $/m^2$	Hv /m	$Av\sqrt{Hv}$ $/ m^{5/2}$		500°C	550°C	600°C			
Test 1	PC2	6.2	18	240	Open	Open	Open	Open	1.63	1.02	1.65	1.20	202	UM	UM	521	106.5	1.5
Test 2	PC2	6.2	14	300	Open	Open	Open	Open	2.35	1.47	2.85	0.98	NA	UM	UM	415	NA	2.0
Test 3	PS1	6.2	15	420	Open	Open	Open	Open	1.63	1.02	1.65	0.92	123	UM	UM	527	-	1.5
Test 4	PC2	6.2	15	315	Open	Open	Open	Open	1.63	1.02	1.65	1.42	205	209	212	662	-	1.5
Test 5	PC2	6.1	14	325	Open	Open	Open	Open	0.93	0.58	0.71	1.27	220	229	UM	558	-	1.2
Test 6	PC2	6.1	14	310	Closed	Closed	Open	Closed	0.93	0.58	0.71	1.32	208	214	248	612	-	0.9
Test 7	PC2	6.6	14	358	Closed	Closed	Closed	Closed	0.93	0.58	0.71	1.11	245	UM	UM	531	NA	0.8
Test 8	PC2	4.4	14	240	Closed	Closed	Closed	Closed	1.15	0.72	0.98	1.04	137	UM	UM	536	NA	0.9

Keys:

- T_g was the average temperature of hot smoke layer by taking the average values measured in the thermocouple Rack III.
- Q_{max} was calculated from maximum values of $\dot{m}$ and α of 0.8.
- NA: Flashover criteria were not satisfied.
- UM: Unnecessary to measure.



(a) Picture



(b) Geometry

Fig. 1: The cabin

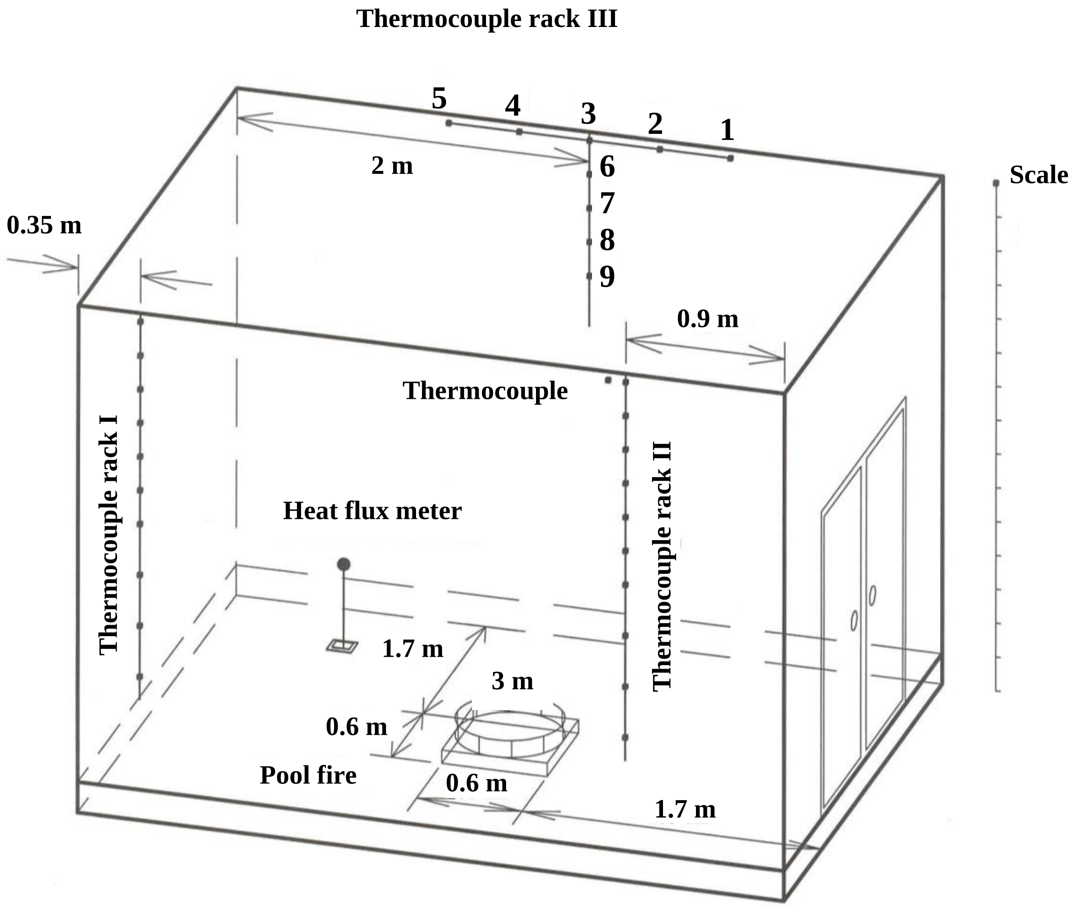


Fig. 2: Instrumentation

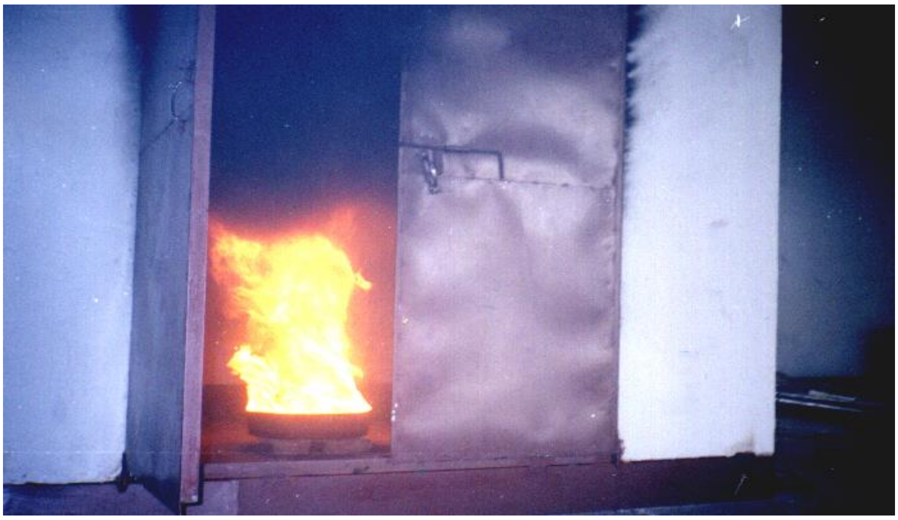
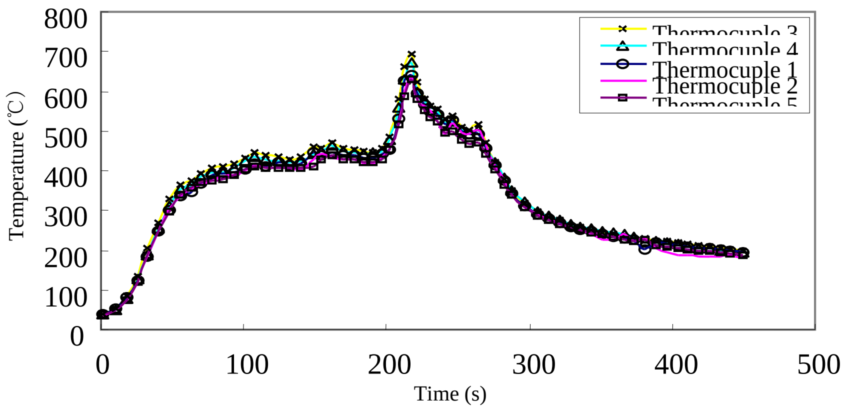
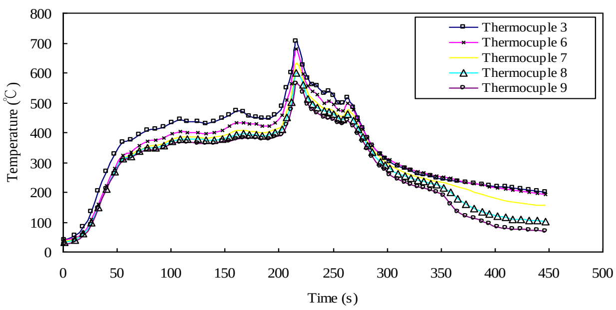


Fig. 3: A typical cabin fire test 5



(a) Horizontal distribution



(b) Vertical distribution

Fig. 4: Smoke temperature measured by thermocouple rack III for test 4

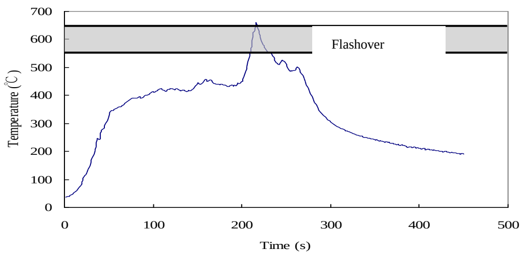


Fig. 5: Average smoke temperature at 5 cm below the ceiling for test 4

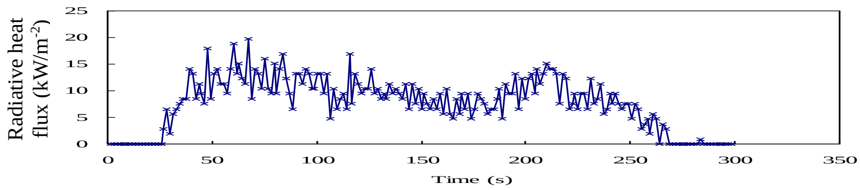


Fig. 6: Radiant heat flux at the fire source for test 2