第10卷第3期 火 灾 科 学 Vol. 10, No. 3
2001年7月 FIRE SAFETY SCIENCE Jul. 2001
文章编号: 1004-5309(2001)03-0184-09

Fire Safety Provisions Observed in Three Airport Terminals by Touring Around

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Abstract: Fire safety provisions in the terminal buildings of three airports are observed by touring around the areas accessible to the public. The three airports are the old Kai Tak Airport in Hong Kong, the Sydney Airport and the Melbourne Airport in Australia. The general passive building design and active fire protection systems are noted. The geometry and products sold at the shops in the retailing areas were recorded with the fire load density estimated. The activation times of three types of sprinkler heads were predicted by using the fire engineering calculator FIRECALC.

Key words: Fire safety; Airport; FIRECALC

1 Introduction

An expensive new airport was built in the Hong Kong Special Administrative Region (HKSAR) with an investment of over billions of dollars, and so a high level of fire safety in the terminal building is expected[1~2]. Before the opening of this new airport, an accidental fire happened in April 1998. After its opening on 6 July 1998, the operation of the airport was unpleasant in the first few days. All these made the new authority very concerned about the operation of the airport including the provision of fire safety.

Before these incidents happened, a tour was made at the old Kai Tak Airport to observe the fire safety provisions. This would be good to see what should be provided in a local airport. Fire safety was seriously considered in Australia[3]. The Sydney Airport and the Melbourne Airport were toured as their fire safety features might be similar to those in the new airport.

The fire safety aspects at the Kai Tak Airport, the Sydney Airport and the Melbourne Airport observed by touring the three sites are reported in this paper. The general passive building design and active fire protection (known as fire services installations in Hong Kong[4]) observed were outlined. Fire safety in the retailing areas was assessed. A fire is likely to start in these areas because of the large amount of combustibles stored. The dimensions and business nature of the shops, combustible materials stored and the fire safety design in those three airport terminal buildings were surveyed. The activation times of sprinkler heads were calculated by the fire protection engineering tool FIRECALC[5].

2 Key Geometrical Parameters of the Three Airports

By touring at the three airports, the shapes and dimensions of the areas accessible to the general public were estimated. What can be observed by a passenger was

收稿日期: 2001-03-13; 修改日期: 2001-05-10

recorded without disturbing the normal operation of the terminals. All of the three airport terminal buildings are divided into similar functional areas as shown from figures 1 to 6:

° Departure level;

° Arrival level;

° Baggage hall.

Note that there are restricted areas where passengers cannot enter. For example, the departure level is divided into the departure concourse area and the departure restricted area. Further, the departure level is usually located at the second floor and with varying ceiling heights.

Key dimensional features of the Kai Tak International Airport are:

° Height of the departure concourse area: 3.7 m;

° Height of the departure restricted area: 3 m;

° Dimension of the departure restricted area: 65 m by 640 m;

° Height of the arrival level: 3 m;

° Height of the baggage hall: 3 m;

° Dimension of the baggage hall: 137 m by 227 m;

° Baggage belt size: 48 m by 15 m.

Dimensional features of the Sydney International Airport are :

° Height of the departure concourse area: 4.5 m, but 2.5 m near the entrance; and 7.5 m at some places;

° Dimension of the departure concourse area: 297 m by 137 m;

° Height of the departure restricted area: 3 m;

° Dimension of the departure restricted area: 260.5 m by 228 m;

° Height of the arrival level: 3 m;

° Height of the baggage hall: 6.5 m;

° Dimension of the baggage hall 1: 89.5 m by 42.5 m;

° Dimension of the baggage hall 2: 42.5 m by 76 m.

Dimensional features of the Melbourne International Airport are :

° Height of the departure concourse area: 4.5 m, but 3.5 m at the domestic terminal;

° Dimension of the departure concourse area: 95 m by 99 m;

° Height of the departure restricted area: 3 m;

° Dimension of the departure restricted area:

° Height of the arrival level: 4.2 m;

° Height of the baggage hall: 5.5 m;

° Dimension of the baggage hall: 135 m by 120 m;

° Baggage belt size: 68 m by 8.5 m.

The geometrical shapes of the three airport terminal buildings are different but the following characteristics are similar:

° Typical building materials are used in the terminal buildings.

° Arrival level is at the ground floor.

° The luggage hall is at the arrival level with large compartment volume of height up to 6 m.

° Departure level is at the second floor with ceiling height varied in different zones.

° The height of all areas in the restricted region is not higher than 3 m.

° Different compartments are separated by a fire resistance wall.

° The size of retailing shops and the products sold can be categorized into different groups.

° Sprinklers are installed in the retailing shops.

° Combustibles in the retailing shops include paper, cotton, silk, alcohol and foodstuffs.

3 Fire Safety Provisions Observed at the Kai Tak Airport

Because of the simple geometry of the terminal building, the evacuation routes can be located easily. Exits were found at the departure restricted area. The separation distance between adjacent exits was within 50 m. All retailing shops were divided into different compartments with smoke detectors. However, the compartment wall was made of plywood which would support rapid flame spreading.

The following fire services installations were observed :

° Break—glass alarm systems, fire hydrants and hose reels were found.

° Smoke detectors were installed with a spacing of 8 m apart in the whole terminal building covering the Departure Level, Arrival Level and the retailing shops.

° Sprinkler heads were found in the waiting zones of the Arrival Hall, Baggage Reclaim Hall, and the concourse area of the Departure Level. No sprinkler heads were observed in the restricted area of the Arrival Level.

° Fire hydrants, hose reels and break — glass alarms were found near the exits in the concourse area and the restricted area of the Departure Level. Also, they were found in the waiting zones of the Arrival Level.

° Public announcing system was installed and would be operated when the manual fire alarm system was activated.

° Carbon dioxide extinguishing agents would be discharged into the Departure concourse area in case of fire. The system was controlled manually and would operate after evacuating all the people.

4 Fire Safety Provisions Observed at the Sydney Airport

All the restaurants and fast food shops are located in a designated area. A fire can be easily observed by the people whenever it happens. The evacuation routes are easy to identify. Exits were spaced a certain distance apart with a portable fire extinguisher placed near to it.

The cabin concept[6~7] was used with the retailing shops divided into different compartments. In each compartment, sprinklers and smoke detectors were installed. The compartment wall is supposed to have adequate fire resistance period. The following fire services installations are observed:

° Smoke detectors were installed at a separation distance of about 8 m in the whole terminal building, at the Departure Level, the Arrival Level, retailing shops and the luggage reclaim area.

° Sprinkler systems were provided in the whole building, especially in the retailing shops.

° Fire hydrants, hose reels, break—glass alarms were found near the exits and entrances of different zones.

° Public announcing system was installed, and it would be operated when the manual fire alarm system is being activated.

° Nozzles for discharging carbon dioxide were not found.

5 Fire Safety Provisions Observed at the Melbourne Airport

Exits were located at a certain distance from each other. Again, a portable fire extinguisher was placed near each exit. An evacuation plan was shown near the exits and entrances of different zones. All the restaurants and fast food shops are located at one confined space, so if a fire occurs, it is easily observable by the people.

All retailing shops are divided into different compartments. Sprinklers and smoke detectors were installed in each compartment. Also, the compartment wall should have adequate fire resistance period, so that would be similar to a 'cabin design'[6~7].

All the counters at the Arrival Level are of open design. Therefore, they can be considered as open cabins. Only smoke detectors were installed. The top of the counter is 2 m high. Sprinklers were installed at the mezzanine level, and in the areas outside the shops.

The following fire services installations are observed:

° Smoke detectors were separated 8 m apart. They were installed throughout the whole terminal building covering the Departure Level, Arrival Level, retailing shops and the luggage reclaim area.

° Sprinklers were installed in the whole terminal building, and more are to be added at the luggage reclaim area of the domestic terminal. Holes for piping were drilled through the wall to a size suitable for installing sprinklers.

° Fire hydrants, hose reels and break — glass alarms were found near the exits.

° Manually operated public announcing system was installed.

° Nozzles for discharging gas protection agents such as carbon dioxide were not found.

6 Retailing Shops and Restaurants

The dimensions of shops and products sold in the retailing areas of the three airports are summarized in Tables 1 to 3.

A diversity of retailing shops are found selling fashions and clothes, leather products, silk products, cosmetic products, jewels, perfumes, books and toys, electrical appliances, audio and visual appliances, wine and cigarettes. There are also restaurants, cafes, and shops selling food but without cooking facilities there.

Book shops are expected to have a higher fire load density since the books, magazines, journals, novels, stationery, and plastic folders are all combustibles. Besides, the fire load density is also high in the storerooms.

Fashion shops would have a high content of organic substances since synthetic materials are widely used in clothings. Even if the clothings are made of natural materials such as silk, they are usually packed in plastic bags. Further, restaurants having cooking facilities might have accidental fires.

Tab. 1 Retailing shops and restaurants at the Kai Tak Airport

Number	Products	Width / m	Length / m	Height / m
1	Cosmetics, wine & cigarettes	23	16	3
2	Cosmetics, wine & cigarettes	22	13.5	3
3	Cosmetics, wine & cigarettes	25	13.5	3
4	Books	22	16	3
5	Books	15	6.5	3
6	Restaurants: Food services	30	25.5	3
7	Restaurants: Food services	35.5	35	3

Tab. 2 Retailing shops at the Sydney Airport

Number	Products	Width / m	Length / m	Height / m
1	Clothes	5.5	6.5	3.5
2	Clothes	8	9.5	4.5
3	Clothes	6.5	9.5	4.5
4	Clothes	13	9.5	4.5
5	Clothes	12	9.5	4.5
6	CD records	8	4	3.5
7	Film developing	8.5	6.5	3.5
8	Souvenirs	12.5	5.5	3.5
9	Cosmetics	6.5	8.5	4.5
10	Clothes and shoes	11	9.5	3.5
11	Books	19	14	3.5
12	Food services	25	109	3.5

Tab. 3 Retailing shops and restaurants at the Melbourne Airport

Shop number	Products	Width / m	Length / m	Height / m
1	Fashion accessories: ear rings, necklace	7.5	7.5	4.5
2	Clothes & shoes	5.5	13	4.5
3	Clothes & shoes	5.5	13	4.5
4	Film developing	5.5	16	4.5
5	Fashion accessories: Leather products	5.5	18	4.5
6	Books	17.5	12	4.5
7	Clothes	5.5	10	4.5
8	Clothes	5.5	10	4.5
9	Cosmetics	5.5	10	4.5
10	Sunglasses	7.5	7.5	4.5
11	Fashion accessories: Ties	5.5	1.5	4.5
12	Flowers	4	3	4.5
13	Drugs	10	8	4.5
14	Souvenirs	20.5	13	4.5
15	Jewels	15	5	4.5
16	Food shop	11	5	4.5
17	Food shop	16	6.5	4.5
18	Cosmetics, wine & cigarettes	19	13	4.5
19	Postal service	7.5	4	4.5
20	Restaurant: Food services	27	26	4.5
21	Restaurant: Food services	17.5	22.5	4.5
22	Restaurant: Food services	11	13.5	4.5

7 Discussions

Two parameters are important for fire safety: occupancy level and fire load density. In this paper, only the Arrival Level, the Departure Level and the retailing shops in the airport terminals which are accessible to the general public are discussed.

The arrival hall, departure concourse area, and baggage hall are the places having higher fire load density. A rough estimation on the fire load density can be made by observing the combustibles while touring around.

At the Arrival Level, only the baggage reclaim area and the custom counters are accessible. It is found that there are not too many shops because passengers usually buy things while leaving, not arriving at the place. There might be a duty free kiosk before passing through the Custom counters. Flower shops, convenience stalls, car hiring counters, candy and gift shops might be found. Probable fire scenarios at the Arrival Level are to have a fire start at the duty free kiosk by burning some combustibles; or a fire in the baggage hall by burning some luggage while circulating at the baggage belt. This might support rapid spreading of fire.

There are retailing shops, restaurants and check—in counters located at the non—restricted areas of the Departure Level. Combustibles such as clothes, food, books and magazines are observed in the retailing shops. Passengers would walk around before boarding the plane. The occupancy level would then be quite high. In addition, restaurants, duty free shops and retailing shops are found in the restricted area. Therefore, the fire safety issues must be considered carefully.

A fire is likely to start in a restaurant or a retailing shop at the Departure Level. Combustible materials in those places can be identified to calculate the fire load density. Goods stored in most of the retailing shops are similar to those in a shopping mall. The retailing areas normally have more combustibles than other places of the terminal building. As those areas are accessible to the general public, a high occupancy level was observed. Special considerations on fire safety must be given to places with high fire load density and high occupancy level.

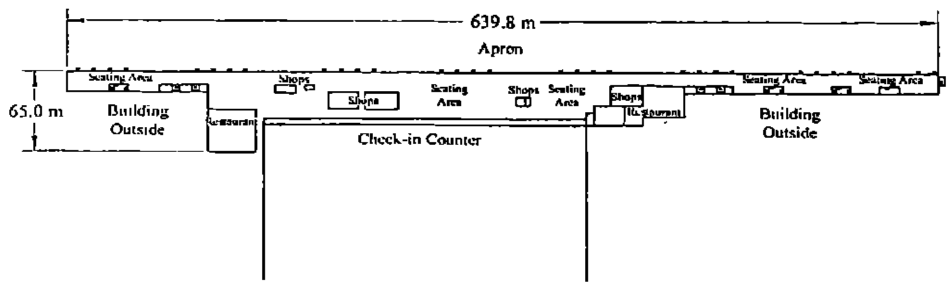

Fig. 1 Kai Tak Airport: Departure Level

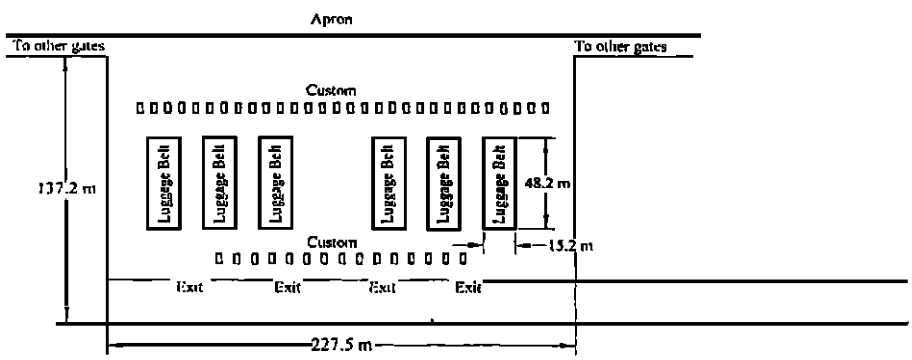

Fig. 2 Kai Tak Airport: Arrival Level

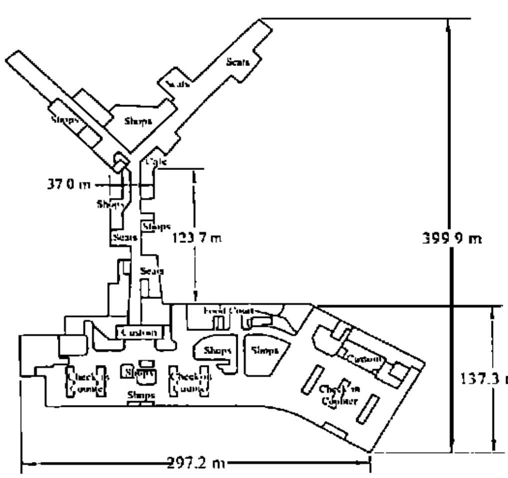

Fig. 3 Sydney Airport: Departure Level

8 Activation Times of Sprinkler Heads

Sprinkler heads were found at different heights above the floor in the three airports. It is important to study their thermal sensitivity. The fire engineering calculator FIRECALC[5] was used to calculate the activation times of sprinkler heads.

Three types of sprinkler heads with different response time indices (RTI) were considered:

- Fast response sprinkler head: 50 $m^{1/2}s^{1/2}$.
- Commercial sprinkler head: 100 $m^{1/2}s^{1/2}$.
- Normal sprinkler heat: 200 $m^{1/2}s^{1/2}$.

The ceiling heights were varied from 2.5 m to 7.5 m. All the four NFPA[8] slow (S), medium (M), fast (F) and ultra—fast (U) t^2—fires were considered. This gives a total number of 120 (3 × 4 × 10) simulations. The ambient temperature was taken as 23 ℃ and the activation temperature of the sprinkler heads was 68 ℃.

The activation times of the sprinkler heads calculated from FIRECALC are shown in Table 4. It is found that all sprinkler heads can be activated under these conditions. Longer activation time is expected for spaces with higher ceilings under a slow t^2—fire.

Tab. 4 Sprinkler activation time

Ceiling height / m	Activation time / s											
	RTI = 50 $m^{1/2}s^{1/2}$				RTI = 100 $m^{1/2}s^{1/2}$				RTI = 200 $m^{1/2}s^{1/2}$			
	S	M	F	U	S	M	F	U	S	M	F	U
2.5	97	82	50	28	127	102	63	37	173	126	79	49
3	141	100	59	34	173	120	73	44	223	146	90	56
3.5	199	117	68	40	223	136	82	50	260	165	102	64
3.7	217	123	71	42	237	143	86	52	275	173	106	67
4	236	133	76	45	257	153	91	56	296	186	113	71
4.2	249	139	79	47	270	160	95	58	311	194	118	74
4.5	267	149	84	50	290	171	101	62	333	207	125	78
5.5	336	185	102	60	363	210	121	73	412	246	147	91
6.5	422	226	122	70	444	248	141	84	487	286	170	104
7.5	494	264	141	80	518	287	160	96	564	328	191	117

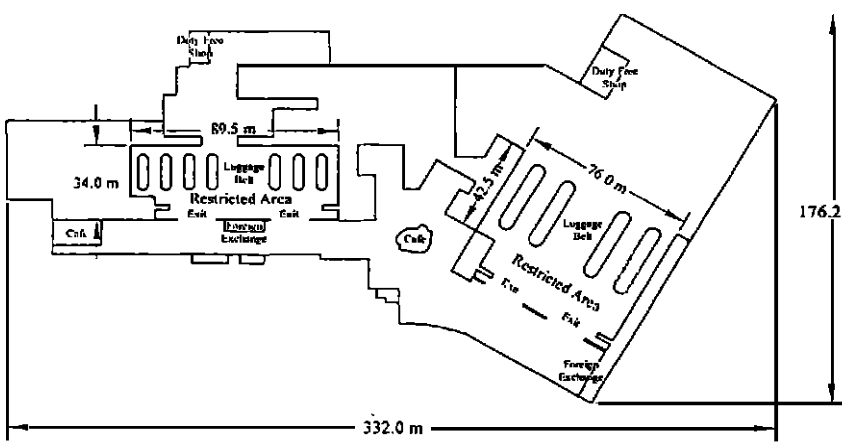

Fig. 4 Sydney Airport: Arrival Level

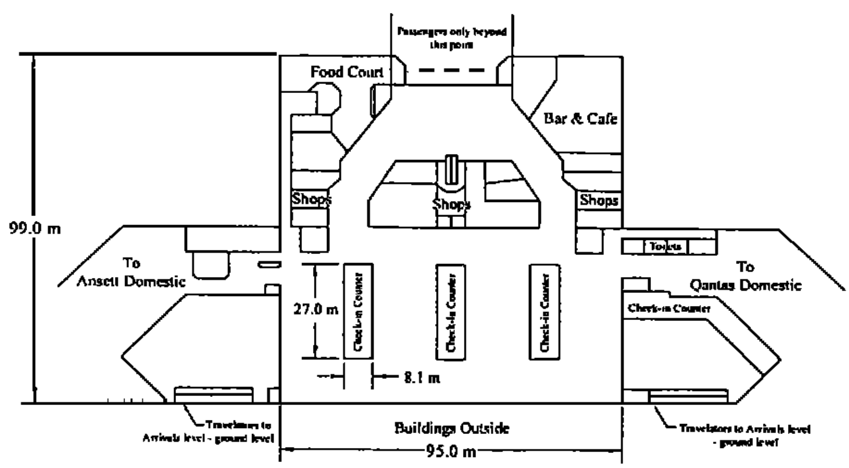

Fig. 5 Melbourne Airport: Departure Level

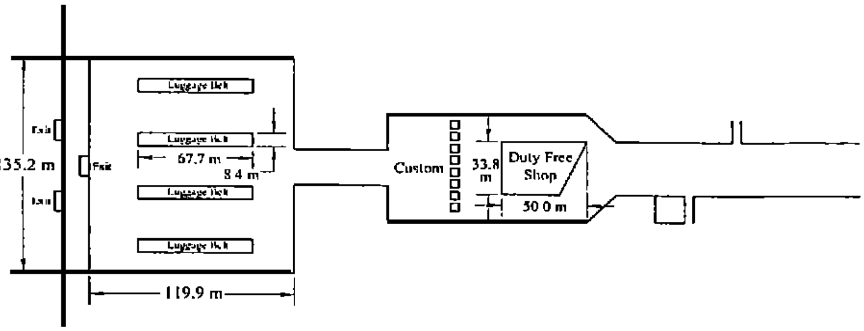

Fig. 6 Melbourne Airport : Arrival Level

9 Conclusion

Fire safety aspects in three airport terminal buildings were surveyed and reported. Basically, the terminal buildings are divided into different zones with variable fire load density. Different fire safety provisions for each zone should be considered. The activation times of sprinkler heads were assessed by FIRECALC.

Observations from such a tour are useful in determining what should be installed in a new airport terminal. Preliminary recommendations are :

° Adequate passive building design should be provided such as a good evacuation design, adequate fire resistance period for building elements and the use of non—combustible building materials.

° Active fire protection systems should be provided, especially in the luggage hall.

° The retailing areas should be watched carefully. The cabin design[6~7] is a good proposal, but the interaction of sprinkler system with the smoke control system should be watched. There are some points of concern as reported in the literature[9~10].

° Fire safety management[11] should be worked out carefully.

The ' cabin concept' is used in both the Sydney Airport and the Melbourne Airport. The retailing shops are the main concerns when considering the fire aspects. The cabin concept was not used in the old Kai Tak Airport because the ceiling height was not high. However, the concept was used in the new Chek Lap Kok airport terminal. The shops are kept at a certain separation distance so that the radiative heat flux due to a shop with a flashover fire would not affect the nearby shops. Sprinkler and smoke extraction systems are installed in each cabin.

Most of the luggage are combustibles and might be ignited easily. Hand baggage should be considered as movable (or live) fire loads. The new Chek Lap Kok airport [1] has a baggage hall of area 46, 000 m^2, space volume 400, 000 m^3 and maximum height 10 m. It is obvious that the fire loads, in particular the live fire loads, might be high at this area. In fact, a ' luggage belt fire' happened on 5 March 1998 at the Departure Hall of the Kai Tak Airport. That was believed to be started from the belt motor. Large quantity of smoke was given out. Because of good safety management, passengers were evacuated in time with only several flights delayed.

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三个机场候机厅的火灾安全分区评述

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摘要:通过参观机场对公众开放的区域,对三个机场侯机厅的火灾安全分区进行了评述。这三个机场是:香港的旧启德机场、澳大利亚的悉尼机场和墨尔本机场。指出了一般的被动建筑设计和积极的火灾防护系统。按照估计的火灾载荷密度对零售区域商店的形状和商品进行了记录。利用消防工程计算程序FIRECALC对三种水喷头的启动时间进行了预测。

关键词:火灾安全;机场;FIRECALC

中图分类号:TU248.6 文献标识码:A

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香港新机场侯机厅的基本几何结构特点及其火灾安全分区的简短回顾

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摘要:描述了香港新机场侯机厅的基本几何结构特点。在没有扰乱机场的正常运作的情况下,对侯机厅的火灾安全分区进行了实地考查。对候机厅内的零售店发生轰燃所需的最小热释放速率进行了调查。

关键词:几何特点;机场;火灾安全

中图分类号:TU248.6 文献标识码:A