COMBUSTION PROPERTIES OF THE CIVIL AIRCRAFT INTERIOR MATERIALS AND PRODUCTS

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Abstract

The FAA(Federal Aviation Administration) specified fireworthiness requirements and test methods, compiled in FAR(Federal Aviation Regulation) Part 25 Appendix F 1-5, are described and listed in Table 1-3.
Several hundred of specimens were collected from aircrafts Y7, Y8, Y10, Z9, B707, MD-82, etc., and their flammability, smoke, toxicity and LOI(Limited Oxygen Index) were examined, according to FAA revised test methods. Typical data are listed in Table 4-11.
The drafting of HB 5875-85, HB 5469-91, HB 5470-91 publications on fire safety and assembling suitable Bunsen burners for other laboratories were also mentioned.
Wishes to cooperate with other reserach organizations in fire safety field at home or abroad sincerely expressed.

Keywords: combustion properties, aircraft materials, fire safety.

Introduction

The fire safety for civil aircraft is obviously very important. The work has begun on researches of cabin fire safety since 1970. Mostly based on the U.S.FAR 25. It followed the FAR 25 Appendix F revised methods on 1986-1990. Different tests were done on various materials from Y7, Y8, Y10, Z9 B707, MD-82, etc., for comparison. The objective was to improve the fire safety level of aircraft design in material selection. To cooperate sincerely with other laboratories and to establish a more ideal lab. in aircraft interior materials field are hoped.

FAA revised FAR 25 Appendix F

FAA revised FAR 25 Appendix F very often. The criteria of cabin materials and related test methods therefrom are quoted as in table 1-3[1].

All of these achievments have obtained from a full-scale testing with a modified surplus C-133 is as shown Fig.1[1].
The FAA researchers used it to simulate a lot of real fire postcrashes and obtained data. According to these sources the FAA revised FAR 25 App. F to F1-F5.

Table 1 Requirements of cabin materials

FAR25	Interiors	App.F1	App.F2	App.F3	App.F4	App.F5
25.853	(a)Materials(including finishes or decorative surface)	+				
	(b)Seat cushions	+	+			
	(c)Ceiling wall panels partitions out surfaces of galleys large cabinets stowage	+			+	+
25.855	(c)Ceiling and sidewall of Class C,D compartments			+		
	(d)All other materials of cargo or baggage compartment	+				

Table 2 Criteria and test methods of cabin materials

Test item	Criteria					
Flammability App.F1	Exting. time s	Burn length mm	Drip exting. s	Burn rate mm/min	Flame penetrtn.	Glow time s
60s vertical	15	152	3			
12s vertical	15	203	5			
45° inclined	15				None	10
60° inclined	15	152				
15s horizontal				64		
15s horizontal				102		
Flammability of seat cushion App.F2	At least 3 sets of seat bottom and seat back cushion specimens. At least 2/3 of the total number of specimen sets tested, the burn length from the burner must not reach the side of the cushion opposite the burner. The burner length must not exceed 17 in. At least sets tested must not exceed 10 percent weight loss.					
Flame penetration resistance of cargo liners App.F3	At least 3 specimens. There must be no flame penetration of any specimens within 5 min. after application of the flame source. The peak temperature measured at 4 in. above the upper surface of the horizontal test sample must not exceed 400° F.					
Heat release rate App.F4	The total positive heat release over the first 2 min. of exposure for each of the three or more samples tested must be averaged. The peak heat release rate for each of the samples must be averaged. The average total heat release must not exceed 65 kw.min/m². The average peak heat release rate must not exceed 65 kw/m².					
Specific optical density of smoke. App. F5	The optical smoke density(Ds) must not exceed 200 within 4 min.					

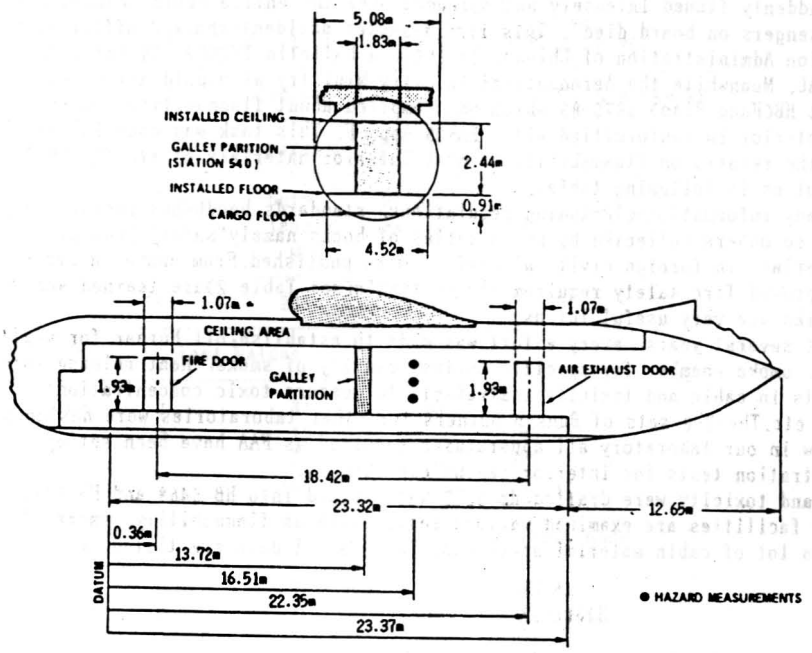

FIGURE 1. SCHEMATIC OF C-133

The new FAA fire requirements issued and came into effect as Table 3.

Table 3 New FAA fire test requirements

Item	Compliance date	FAR 25 item	Aircraft impact
Seat cushion fire blocking layers	26,11,1987	25.853 App. F2	All
Cargo liners	16,6,1986	25.855 App. F3	New certification
Low heat/ smoke release panels	20,8,1990	25.853 App. F4,5	production & major refurbishment

Work on research of fire safety

From early 1970's according to western airworthiness regulations (including FAR 25, BCAR*, ICAO** etc.), A trunk aircraft, Y10, was successfully designed and produced in China. The cabin materials of Y10 were selected by designers according to our research results.

* British Civil Aviation Regulation
** International Civil Aviation Organization

At 24, Dec, 1982 an aircraft, IL-18, flew from Xi'an to Guangzhou Bai-Yun airport, in flight a cigarette fell on carpet, when the aircraft landed on the ground, after the doors were opened, the small fire suddenly flamed intensely and spreaded over the entire cabin, caused a flashover. More than ten passengers on board died[1]. This fire disaster accident shocked officials of CAAC (Civil Aviation Administration of China). In 1983, a bulletin TY2500-009 based on FAR25 App.F. was issued by CAAC. Meanwhile the Aeronautical Industry Ministry also paid attention to this problem,[4] and the first HB(Hang Biao) 5875-85 which was compiled about flammability requirements and test methods of interior in conformitied with FAR25 App. F. This task was done in 1984. Through the experiments, the results on flammability of most interior materials of Y7, Y8, Y10, Z9, B707, MD-82, etc., were got as in following tables.

Up to now, many informations(including regulations, standards, handbooks, research reports and conferences and so on)are collected by us. A series of books namely"safety regulation and standard of interior materials in foreign civil aircraft"[5] were published. From above informations the FAA's new improved fire safety requirements in 1980's(see Table 2)are learned and studied in our lab. Their works are very useful for us.

Over the past several years, every effort was made to establish: oil burner for seat cushions and cargo liners, smoke chamber for specific optical density of smoke, heat release rate for large surface panels in cabin and toxicity instruments to measure toxic concentrations of CO, HCL, HF, HCN, SO_2, NO_x etc. The 7-8 sets of Bunsen burners for other laboratories were designed and produced. Now in our laboratory all apparatuses required as FAA have been set up so that all of FAA's demonstration tests for interior cabins can conduct.

HB of smoke and toxicity were drafted, HB 5875 was revised into HB 5469 and HB 5470. Using our laboratoty's facilities are examined various tests, such as flammability, smoke density, LOI, and toxicity on a lot of cabin material specimens. The typical data are listed in Table 4-11[6].

Table 4 Vertical test (60s ignition) HB 5469-91, HB 5470-91

Test temperature≥ 843℃ Specimen conditioning 21±3℃, 50%±5% RH

	Test requirements (Max. Avg.)			
Item	Exting. time s	Burn length mm	Drip exting. s	Remark
	15	152	3	
Specimems	Test values			
Melamine laminate	0	85	No	Y10
Wall panel	0	117	No	MD-82
Wall panel	0	69	No	Y7
Glass felt	0	127	No	B707
Sidewall panel	0	82	No	Y7
Nomex honeycomb core	0	44	No	China made

Table 5 Vertical test (12s ignition) HB 5469-91, HB 5470-91

Test temperature≥ 843℃ Specimen conditioning 21±3℃, 50%±5% RH

Item	Exting. time s	Burn length mm	Drip exting. s	Remark
	Test requirements (Max. Avg.)			
	15	203	5	
Specimems	Test values			
Nonflame fabric	0	31	No	Y7
Carpet	0	10	2	MD-82
Wall carpet	1	71	No	Y7
Covering fiber	0	166	No	MD-82
Fire blocking layer	0	12	No	Italy made
Decorative panel of lavatory	2	70	No	MD-82
Aramid/PBI felt	0	10	0	XT48466K
Fire-resistant cotton fabric	0	127	0	China made
Air duct	4	76	0	MD-82
Polysulfone fabric	0	52	0	China made

Table 6 Horizontal test (15s ignition) HB 5469-91, HB 5470-91

Test temperature≥ 843℃ Specimen conditioning 21±3℃, 50%±5% RH

Item	Burn rate mm/min	Remark
	Test requirement	
	102	
Specimems	Test values	
Cotton-linen fiber	102	Y8
Extrude silicone rubber	102	Y10
Rubber sheet	102	Dolphin
Rubber sheet	102	Z9
PMMA	0	Japan made
PMMA	0	China made
Safety belt	0	Y8, Z9
Extrude plastic strip	0	Y7

Table 7 45° inclined test (30s Ignition) HB 5469-91,HB 5470-91

Test temperature≥ 843℃ Specimen conditioning 21±3℃, 50%±5% RH

Item	Test requirements (Max. Avg.) Exting. time s	Flame penetrin.	Glow time s	Remark
	15	No	10	
Specimems	Test values			
Floor panel	3.5	No	0	Y7
Covering for cargo floor	0	No	0	Y7
Glass fiber felt(insulation)	0	No	0	MD-82

Table 8 60° inclined test (30s ignition) HB 5469-91,HB5470-91

Test temperature≥ 954℃ Specimen conditioning 21±3℃, 50%±5% RH

Item	Test requirements (Max. Avg.) Exting. time s	Burn length mm	Drip exting. s	Remark
	30	76	3	
Specimems	Test values			
Polyimind wire	0	33	No	China made
Polytetrafluor-ethylene(PTFE)	0	30	No	China made
AF-250	0	26	No	China made
AF-550	0	30	No	China made

Look forword

Over the past more than ten years,much reseach work on cabin materials have been completed. Now development research will be contiuned in our special laboratory. With reform and open policy exchange and cooperate with domestic and abroad organizations will be increased so that our academic and technical level in this field may upgrade. If there is capability and financial support, the full-scale articles intereseing in developing estimated and simulated our own fire postcrash accidents as establishing data base. This is of great significance to survivability and can provide a best way to evaculate from damaged burning aircraft. Also it is used to develop new safety standard and to select better materials for cabin. It is believed that to catch up and go along with top fire safety of foriegn aircraft would be hoped in near future.

Conclusions

1. Realizing the importance of fire safety in civil aviation, we studied many documents about fire regulations, and compiled in books for publication. Testing experiments on cabin materials collected from different aircrafts to check with regulations published. Most of the data shown met the requirements of regulation.

2. Utilizing the apparatuses and equipments in our laboratory, combustion properties of interior materials for aircraft or ship, building could be certificate.
3. Devoting in developing our laboratory in this special field, and to cooperate with others were hoped.

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Table 9 Specific optical density of smoke (Nonflame) ASTM F 814, HB xxxx

Specimen conditioning 21±3℃, 50%±5% RH			
	Test requirements		
Item	Ds/90s	Ds/240s	Remark
		200	
Specimems	Test values		
Glass fabric felt	66	98.8	B707
Covering for cargo floor	261.5	288.1	Y7
Wall panel	12.5	33.6	MD-82
Air duct(Silicone glass fabric)	1.51	2.9	MD-82
Fire-resistant fabric	17.5	16.3	China made
Upholstery fabric	25.3	56.8	China made
PVC wire	9.2	77.8	China made
Phenolic fabric	16.3	27.6	China made
Silk fabric	16.1	25.3	China made
Carpet	31.5	58.4	MD-82
Aluminized fabric (Insulation)	0	0	MD-82
Aluminized fabric	3.71	3.23	China made
Fire-resistant laminate		172	China made
Wool/Upholstery		52	China made
AF-250 wire		6.39	China made

Table 10 Limited oxygen index (LOI) GB 2406-80

Specimens	LOI	Remark
Polyester-silk	35.5	
Silk fabric	32	
Polyester(Dacron, thick)	27.5	All of these materials are made in China except last item.
Polyester(Dacron, thin)	29.5	
Polyurethane foam (Rigid)	23.5	
Polysurfone with aluminium foil	34.5	
PTFE-fabric	27	
Wool	31.5-32.5	
Phenolic fabric	32	
Aramid/PBI felt (XD192.26R)	40	

Table 11 Toxicity of cabin materials BSS 7239, ATS 1000.001, HB xxxx

	Toxicity, ppm(Max.)						
	Test requirements						
Item	CO	HCL	HF	HCN	SO_x	NOx	Remark
	3500	150	100	150	100	100	
Specimens	Test values						
Carpet	159	55	1	109	13	22	Y7
Leather	650	1092	43	9	8	8	Y12
Glassfabric/ phenolic	233	128	23	3		11	China made
Polyvac-TXT with film	339	850	129	0.3		4	Polyplastex
	(167)	(37.5)	(38)	(2.45)		(4.2)	Polyplastex
Polyvac-3000 with film	429	425	66	0.7		3	Polyplastex
	(75)		(25)	(2)		(5)	polyplastex

Note: The data in parentheses without film are samples provided by Polyplastex Co.

References

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