Cabin explosion and fire during landing roll at Hua-Lien, Taiwan, involving a MD-90-30 on August 24, 2000.

Micro-summary: **On MD-90 landing, combustible materials combined to create an explosion and fire.**

Event Date: **2000-08-24 at 0436 UTC**

Investigative Body: **Aviation Safety Council (ASC), Taiwan**

Investigative Body's Web Site: **http://www.asc.gov.tw/**

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Aviation Safety Council

Accident Investigation Report

ASC-AAR-00-11-001

UIA 873, B-17912

MD-90-30 cabin explosion and fire

during landing roll Hua-Lien, Taiwan

August 24th, 2000

Aviation Safety Council
16th Floor Fu-Hsing North Road
Taipei 105.Taiwan. R.O.C.

Executive Summary

At 12:36 on August 24 1999, local time (04:36 UTC), UNI AIR Flight No. 873 (serving Taipei - Hualien) had just landed and was rolling on Runway 21 at the Hualien Airport, when a explosion was heard in the front section of the passenger cabin, followed by smoke and then fire. The pilot immediately braked, brought the aircraft to a stop on the runway. Then, after lowering the passenger evacuation slides and initiating an emergency passenger evacuation, the pilot proceeded to call the tower for help. Upon receiving this call, fire squads at both the Hualien Airport and the Air Force Wing rushed to the scene to extinguish the fire. The fire was eventually put out at 13:45. While the upper part of the fuselage was completely destroyed, 90 passengers plus the crew of 6 was safely evacuated. Casualties included 14 seriously wounded passengers and another 14 that suffered minor injuries. Most of the wounded passengers suffered burns. Fragments produced by the explosion struck 1 passenger.

Immediately following the occurrence of the crash the Aviation Safety Council (hereafter referred to as the Council) established an “Accident Investigation Team” to head investigative operations based on Civil Aviation Regulation clause number eighty-four, and “Aviation Accident Investigation Standard Operating Procedures” that the Council issued on April 1st, 1999. The Accident Investigation Team includes Accredited Representative (AR) Mr. Alfred Dickinson of the U.S. National Transportation Safety Board (NTSB), serving as team leader. The other collaborating U.S. team members include Joseph Kolly, Joseph Sedor, Cynthia Keegan and Nancy McAtee also of the NTSB, Floyd Tony James, Edward Kittel and Patricia Lee Cahill of Federal Aviation Administration (FAA), as well as Joan Hamilton, Mick Conahan and Robert Barrett of the Boeing Company (BCAG).

Initial findings revealed that factors involved in the accident were not solely related to aviation safety. The local prosecutors in Hua-Lien decided to follow criminal investigative procedures and undertook their investigation at the same time as the Council's investigating team was proceeding its investigation of the accident. The collection of evidence on the part of the prosecutors was thorough, and testing of this evidence was complete and detailed. Analytical tests done of one item of evidence, a ruptured bleach bottle, has been of much benefit to the progress of the investigation. Items of evidence suspected of contributing to the explosion, a motorcycle battery as well as explosion remaining, were sent to the Chung Shan Institute of Science and Technology (CSIST) for simulation experiments. The results of these experiments confirm a leak in a plastic bottle containing gasoline resulted in the evaporation of gasoline fumes in the air, when the vapor concentration reaches the lower limit of explosion, the spark energy generated by the 12V motorcycle battery in instant short circuit would be capable of triggering explosion

Probable cause to the accident

A flammable liquid (gasoline) inside bleach and softener bottles and sealed with silicone was carried on board the aircraft. A combustible vapor formed as the leaking gasoline filled the stowage bin, and the impact of the landing aircraft created a short in a battery. The short ignited the gasoline vapor and created the explosion.

Contributing factors to the accident

1. The Civil Aeronautical Administration Organic Regulations and its operational bylaws fail to designate any entity as responsible for

hazardous materials.

2. The Aviation Police fail to properly recruit and train personnel, to include preparing training materials and evaluating training performance. Some new recruits were found to have not received any formal security check training, but instead were following instructions from senior inspectors. Consequently, new inspectors cannot be relied upon to identify hazardous materials.

3. The detectors and inspectors failed to detect the hazardous materials. The detectors used by the Aviation Police did not detect the banned motorcycle batteries, nor did security inspectors detect the liquid bleach, a banned corrosive substance.

Safety Recommendations

To: <u>UNI AIR</u>

1. Implementation of a standard evacuation procedure and training of flight attendants thereon. The procedure shall specify the positions of flight attendants for assisting evacuating passengers, directing passengers at the end of the sideway, conducting a check before leaving the aircraft, the assembly, evacuation, and check of unhurt passengers, which will be reported to the scene commander. (ASC-ASR-00-11-001)
2. Improved training for company emergency teams, with the aim to

increase coordination with the backup operations provided by the airport. (ASC-ASR-00-11-002).

3. The installation of an emergency starts system or easily accessible loudspeakers to improve the communications between the front and the rear section of the aircraft. (ASC-ASR-00-11-003).

To: <u>Civil Aeronautical Administration, Ministry of Transportation & Communications</u>

1. The Organic Regulations and the bylaws shall clearly designate an agency responsible for the control of hazardous materials. (ASC-ASR-00-11-004)

2. Stipulation of airport emergency plans with mandatory regulations for command, firefighting and paramedic efforts, so that airports may formulate their own operation procedures accordingly. (ASC-ASR-00-11-005)

3. Review of firefighting and paramedic resource allocation, to ensure that they can handle any emergency. (ASC-ASR-00-11-006)

4. The airports shall provide associated training and information to the backup agencies to ensure successful collaboration during emergencies. The training shall cover dangerous areas and destruction areas of different aircraft models, firefighting and rescue effort patterns in airports used by the military and the civil operations, substitute routes in case of emergency, firefighting water supply spots

and medical treatment zones among others. (ASC-ASR-00-11-007)

5. Review conducted of the authorities of joint command, firefighting, paramedic and security during aircraft crash and severe accident operations, emergency operation processes and on-site communication systems as referred to in the agreement for airports shared by the military and civil operations. Intensive joint drills should be conducted with participation of all agencies. (ASC-ASR-00-11-008)

6. Review of the organization of emergency teams and crewmember emergency structure of all airlines at all airports, to ensure that the organizations are capable of handling their tasks.

   (ASC-ASR-00-11-009)

To: The Aviation Police Bureau of the National Police Administration, Ministry of Interior Affairs

1. Clearly define management authority of hazardous materials with the Civil Aeronautical Administration under the Ministry of Transportation & Communications. (ASC- ASR-00-11-010)

2. Coordinate with the Civil Aeronautical Administration to compile the Hazardous Materials Handling Code of the International Air Transport Association and prepare relevant regulations for local industry. (ASC-ASR-00-11-011)

3. Upgrade security inspection equipment in airports to capably detect hazardous liquid contained in bottles and cans.
(ASC- ASR-00-11-012)

4. Establish recruitment plan, and conduct training and regular on-the-job training for security inspectors. Associate training materials with systems for evaluation of performance of the training.
(ASC- ASR-00-11-013)

5. Conduct a full-scale evaluation of security inspection capabilities of all airports. (ASC- ASR-00-11-014)

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Abbreviations

AMC	**Acceptable Means of Compliance**
AR	**Accredited Representative**
ASC	**Aviation Safety Council**
BCAG	**Boeing Commercial Airplane Group**
CIB/ FSD	**Criminal Investigation Bureau/ Forensic Science Division**
CVR	**Cockpit Voice Recorder**
EPR	**Engine Pressure Ratio**
EVAC	**Evacuation**
FAA	**Federal Aviation Administration**
FAR	**Federal Aviation Regulation**
FDR	**Flight Data Recorder**
FS	**Fuselage Station**
ICAO	**International Civil Aviation Organization**
JAR	**Joint Aviation Requirements**
L	**Longeron**
NTSB	**National Transportation Safety Board**
PA	**Passenger Address**
PSI	**Pounds per Square Inch**
PSU	**Passenger Service Unit**
UTC	**Universal Time Coordinate**

Chapter 1 Factual Information

1.1 History of the flight

At 12:36 on August 24 1999, local time [Note 1] (04:36 UTC), UNI AIR Flight No. 873 (serving Taipei - Hualien) had just landed and was rolling on Runway 21 at the Hualien Airport, when a explosion was heard in the front section of the passenger cabin, followed by smoke and then fire. The pilot immediately braked, brought the aircraft to a stop on the runway. Then, after lowering the passenger evacuation slides and initiating an emergency passenger evacuation, the pilot proceeded to call the tower for help. Upon receiving this call, fire squads at both the Hualien Airport and the Air Force Wing rushed to the scene to extinguish the fire. The fire was eventually put out at 13:45. While the upper part of the fuselage was completely destroyed, 90 passengers plus the crew of 6 was safely evacuated. Casualties included 14 seriously wounded passengers and another 14 that suffered minor injuries. Most of the wounded passengers suffered burns. Fragments produced by the explosion struck 1 passenger.

The aircraft in question was an MD-90-30, registration No. B-17912. The aircraft had taken off at Sungshan Airport in Taipei, at 12:16 PM on August 24, and reached a cruising altitude of 10,000 feet. According to the fight schedule, the flight time was to be a total of 30 minutes (1205~1235), with a mean flight time of 20 minutes. After taking off, the aircraft ascended and took Route B591. After 5 minutes, it was reported to have reached the cruising altitude of 10,000 feet. By 9 minutes (at 1225), Hualien Approach Station was contacted to guide the aircraft via

[Note 1] Unless otherwise specified, all times given in this report refer to local time in the form of HHMM: SS.

radar to make a 160° turn before descending to 6,000 feet. At 1230:50, the pilot advised the air controller had made visual contact, upon which the approach station controller issued airport clearance and proceeded to end radar guidance service. At 1236:06 the aircraft landed and the explosion was then heard at 1236:32. The aircraft stopped at approximately 6,300 feet from the end of Runway 21.

According to the Air Flight Service Station, "the aircraft did not report any irregularities at any point during the flight, from the moment of takeoff up until landing. The Cabin Voice Recorder (CVR) recorded every detail of the flight, starting with the backup, taxing and takeoff from the Sungshan Airport and its climb, cruising, descending, approach and landing, suggesting no irregularities, until the explosion.

1.1.1 Security check at the Taipei Sungshan Airport

Before the aircraft departed from Taipei Sungshan Airport, all carryon luggage passed through the inspection room, located on the East Side of the Taipei Airport. In the inspection room there are ***3 mono-scale X-ray scanning units***. The left-hand unit is used for male passengers; the left-hand model is used for female passengers, with the center one used as a standby unit. Each of the American-made EG&G System 8B X-ray scanners (Serial No. 920098-9200100) employs a metal detector. These machines have all been well maintained since the time they were purchased in January of 1992. . According to the service assignment chart at Security Check Squad at Aviation Police Taipei Branch, a total of 7 people had conducted security checks on the left side unit and 5 on the right side unit, plus a supervisor, the day the passengers boarded the UNI AIR flight (1100-1200). The security-check assignment includes boarding gate control, body search of both male and female passengers, and X-ray check. The security check squad changes shifts every 15 minutes, suggesting that every 15 minutes, 3 people would be by the left gate and 3 by the right one.

Interviews with the assigned security personnel, combined with information gathered from security camera footage, indicate that one passenger passed the checkpoint carrying a dark-violet travel bag, containing bleaching liquid. The bag also contained 1 can of insecticide, 3 portable gas cans, and 2 supermarket plastic bags. In one of the plastic bags there were 2 bottles of bleaching liquid, and in the other two bags a few cans of soft drinks. The videotape shows the security inspector taking out and checking the bottles of bleaching liquid. Both the strong smell and stains on the mouths of the bottles indicated that the bottles did in fact contain bleach. None of the bottles were opened before being let go. The X-ray scanner is incapable of detecting whether or not a bottle has been modified or of detecting what type of liquid it contains.

While passing through the X-ray machine, both the insecticide can and the security personnel reading the monitor detected the 3 portable gas cans. Because these items are clearly hazardous materials, which are prohibited from being carried onto an aircraft, the passenger agreed not to carry them on board and all 4 cans were withheld.

After passing through the security checkpoint, the aforementioned passenger asked another passenger (who was also a relative of the person in question) to carry the travel bag (the dark violet bag containing 2 bottles of bleaching liquid) on board an aircraft he himself did not go on to board. Rather, this first passenger boarded another flight, with a different destination. Once brought aboard the aircraft, the travel bag in question was placed in the left-side stowage bin directly above seat 8B. The passenger who had carried it onto the plane was seated in 8B.

Airlines must follow procedures outlined in "Guidelines for Inspecting Aircraft after cleaning". Namely, the airline shall be responsible for performing an aircraft cleaning check on an unspecified basis. Records of the cleaning checks show that no passenger belongings were found from the flight immediately preceding that of the passenger in question. (Appendix 1)

1.1.2 Testimony of witnesses

1. Testimony from crew members of other airlines

   When the accident occurred, there was a chartered aircraft of another airline waiting on the middle taxiway for UNI AIR 873 to land. Its passengers had already disembarked the aircraft in front of the Air Force Hangar, and the aircraft was in the process of being towed back to the commercial aircraft ramp at the Hualien Airport.

   Testimony from the crew members of that aircraft indicated that *after having just landed, the aircraft was rolling on the runway when an explosion was heard followed by thick smoke from an opening (the size of a human head) above the third window on the left side, with flames immediately following. Fire fighters rushed to the scene within 8 minutes and spent a total of 50 minutes to extinguish the fire. Ambulances were at the scene 30 minutes after the explosion.*

2. Testimony of the Air Force Follow Me car driver

At the moment of the accident, the driver was traveling at the entrance of the central access road guiding the chartered aircraft back to the civil airport ramp and it had not turned into the access road. The UNI AIR flight landed a little bit later at opening No. 4 and braking followed right after the landing. The explosion was created between the center opening and No. 2 opening and the aircraft stopped soon. The rupture is located at the ***UNI*** *insignia and it goes outward without producing smoke in the first moment. The evacuation slide raft was lowered immediately as I saw passengers leaving the aircraft from L4 first. Then fire sparked out from windows 3~5 on the left side near the bow, followed by thick smoke. The tail door was not open then. The fire engines arrived at the scene 5~10 minutes after the passengers had evacuated the aircraft. I then went to the scene with my coworkers driving the 343 car and we helped directing traffic next to the bow through Opening 2 on the runway. That was when the press and the volunteer fire engines were in and everything went out of control. Then 2 police cars were at the scene and there were only 3~4 policemen directing the traffic Others stood by the aircraft. After some 20 minutes, ambulances arrived.*

3. Testimony from on-duty personnel in the Air Force Wing Flight Control Room

Personnel were on duty in the flight control room watched the UNI AIR aircraft land near the No. 4 exit. Just when everything seemed to be fine, an explosion ripped off the top of the UNI insignia on the left side of the fuselage and, after some 30 seconds, thick smoke emerged from above the UNI AIR insignia. Then, the FOLLOW ME car arrived at the scene and the driver of the car contacted the tower via two-way walkie-talkie 118.1 to call for fire engines and ambulances. When the fire engines arrived, the passengers were already outside the aircraft and we could see a middle-aged aboriginal person with burns all over his body. The passengers *were not assembled together nor were they all accounted for. They were gathered around the aircraft. Later on, the passengers were guided back to the lawn. Two T6 fire engines first approached the bow of the aircraft from No. 2 opening and stopped 10~15 meters from the aircraft. The 2 fire engines*

were later brought to the left side of the aircraft and, by that time, one TN2 water tanker and a T6 vehicle were already on the left side of the aircraft. Then the ambulances approached from the bow, followed by the air wing commander's vehicle.

1.1.3 Parallel investigations

The district attorney and the board of Aviation Safety Council decided to proceed with an investigation of the accident both as a criminal act and as an aircraft accident, citing more than simply flight safety concerns suggested by a preliminary investigation of the accident. For a complete investigation to be attained one must use a hands-on approach and achieve close cooperation with all involved parties, not to mention the fluid exchange of test and laboratory information.

The police conducted a complete and detailed investigation of all relevant evidence gathered. Based on the evidence collected during site survey the investigators also sent suspected explosion-triggering parts to the Aviation Research Laboratory of Chungshan Institute of Science & Technology for testing for later analysis reference.

1.2 Injuries to persons

The accident caused 14 serious injuries (one severely injured passenger died on Day 47 after the accident). There were 14 other passengers that suffered minor injuries. There were no casualties among the flight crew or flight attendants. Table 1.2-1 outlines the casualties:

Table 1.2-1 Casualties

Injury	Flight crew	Flight attendant	Passenger	Total
Fatal	0	0	1	1
Serious	0	0	13	13
Minor	0	0	14	14
Unhurt	2	4	62	68
Total	2	4	90	96

1.3 Damage to aircraft

The upper part of the fuselage was totally destroyed (See 1.12 Aircraft wreckage and impacts). Several fragments from the explosion were found in the left-side engine. However, the main framework, the wings, the engines and the auxiliary power units remained intact.

1.4 Other damages

As the accident took place after the aircraft had already landed safely on the runway, there were no other damages.

1.5 Personnel information

1.5.1 Captain

Age: 41 (born on November 8, 1952)

Background: Transferred from military service

Co-pilot of HS-748: 827 hours

Captain of HS-748: 1977 hours

Captain of MD-90: 1205 hours

Total flight hours: 6532 hours (as of end of July 1999)

Assignments and activities in the 72 hours preceding the accident:

- August 21, no assignment;
- August 22, 4 flights between Taipei and Kaohsiung and 2 flights between Taipei and Chiayi, for a total service time of 8 hours 50 minutes and total flight time of 4 hours 48 minutes;
- August 23, 4 flights between Taipei and Makung, staying overnight in Tainan, for a total service time of 8 hours 10 minutes and total flight time of 3 hours;
- August 24, 1 flight from Tainan to Taipei, 2 flights between Taipei and Makung and 1 flight from Taipei to Hualien, for a total service time of 5 hours 45 minutes and a total flight time of 2 hours 50 minutes;

During his 3 days off duty, the captain performed his normally daily routine without incident.

1.5.2 Co-pilot

Age: 35 (born on December 25, 1964)

Background: EVA AIR trainee: 328 hours
Trainee co-pilot of B-767: 2 hours
Co-pilot of B-767: 216 hours
Co-pilot of B-747: 4525 hours
Co-pilot of MD-90: 96 hours
Total flight hours: 5167 hours (as of end of July 1999)

Assignments and activities in the 72 hours preceding the accident:

- August 21 and 22, 2 days off;
- August 23, 4 flights between Taipei and Makung, staying overnight in Tainan, for a total service time of 8 hours 10 minutes and total flight time of 3 hours;

- August 24, 1 flight from Tainan to Taipei, 2 flights between Taipei and Makung and 1 flight from Taipei to Hualien, for a total service time of 5 hours 45 minutes and a total flight time of 2 hours 50 minutes;

During his 3 days off duty, the co-pilot performed his normally daily routine without incident.

1.5.3 Flight attendants

The UNI AIR Flight 873 carried 4 flight attendants:

(1) When the accident occurred, the cabin chief (26 years old, female) was seated in the front-row flight-attendant seat (L1) by the entrance door. Her seat faces backward towards the passengers. The cabin chief has been a flight attendant for 4 years, of which 3 years were on an MD90. Her last annual on-duty training was conducted on November 24, 1998.

(2) The second flight attendant (24 years old, female) was seated in the front-row flight-attendant seat (L1') by the aisle. Her seat faces backward towards the passengers. This flight attendant has been serving for nearly 2 years. Her last annual on-duty training was conducted on November 12, 1998.

(3) The third flight attendant (25 years old, female) was seated by row 34 near the galley, in the front section of the aircraft (L4). This flight attendant has been serving for more than 2 years. Her last annual on-duty training was conducted on November 23 1998.

(4) The fourth flight attendant (23 years old, female) was seated by the aft exit door of the aircraft facing forward(C5). This flight attendant has been serving for more than 2 years. Her last annual on-duty training

was conducted on February 20, 1998. The C5 flight attendant had been suspended during the period 12/16/98 to 08/15/99 and was reinstated on 08/21/99, after undergoing the required training.

Fig. 1.5-1 shows the seat plan of the aircraft.

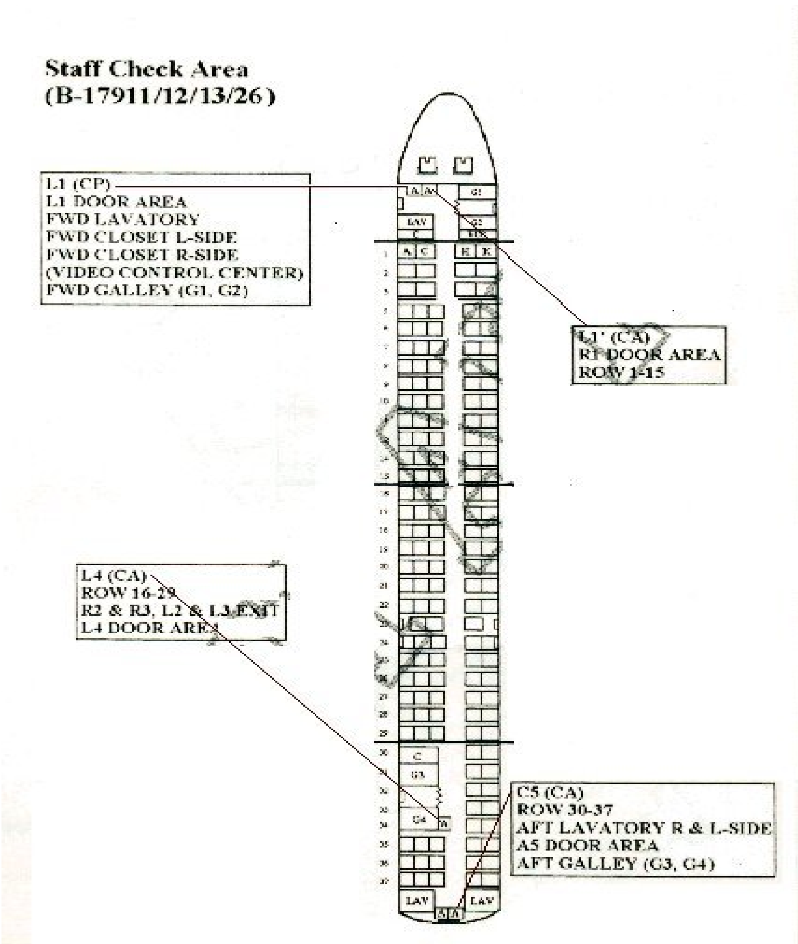


Fig. 1.5-1 Flight attendant seat plan

1.6 Aircraft information

1.6.1 Basic information

Model	: MD-90-30
Manufacturer	: Boeing (MDC)

Manufacture serial No.	:	53536
Registration No.	:	B-17912
Date of delivery	:	November 27 1996
Total fuselage time	:	4929 hours, 7736 Cycles
Date of Certificate of Airworthiness was granted	:	October 15 1999

1.6.2 Airworthiness and maintenance

The "Deferred Discrepancy Record " for the 30 days preceding the accident (from July 25 to August 23) shows 2 open items:

1) Left side power failure: L AC PWR FAULT, L GEN OFF transcript dated August 18 (released per Minimum Equipment Requirement 24-21-01 with report for extension).
2) R/H "NOSE LT" INOP IN DIM POSITION transcript dated August 23 (released per Minimum Equipment Requirement 33-41-01).

1.6.3 Performance and weight & balance

Subject to a maximum takeoff weight of 142,780 Lbs, the aircraft took off from the Sungshan Airport with a total weight of 140,705 Lbs. Its c.g. index range was logged at between 206.9 and 399.1, with a maximum landing weight of 141,700 Lbs.

Zero Fuel Weight :	106,918 Lbs
Total Fuel Weight :	18,700 Lbs
Total Weight :	125,618 Lbs
Estimated Taxi Fuel Weight To Be Deducted :	660 Lbs
Total Takeoff Weight :	124,958 Lbs

In-flight Fuel Consumption :	3,300 Lbs
Estimated Landing Weight :	121,658 Lbs

The Zero Fuel Weight and Estimated Landing Weight c.g. index were all within the allowable range.

1.7 Meteorological information

The weather on the day of the accident was fair and the aircraft landed with a "wind direction of 140°, wind speed of 6 nautical miles, visibility of 9999, scatter clouds at 1600, broken clouds at 4000 and 10,000, temperature of 32°C, dew point of 25, and altimeter setting to 1013 hps. The airfield was in set for visual approach and landing.

1.8 Aids to navigation

On the day of the accident, the air navigational aid and the air navigational facilities showed no abnormalities from the time off from Sungshan Airport through to the time of landing at Hualien Airport.

1.9 Communications

Frequency:	Taipei (Sungshan) departure clearance	- 121.2 KHz
	Taipei (Sungshan) ground control	- 121.9 KHz
	Taipei (Sungshan) tower control	- 118.1 KHz
	Taipei (Sungshan) radar control	- 119.6 KHz
	Hualien approach radar control	- 119.1 KHz
	Hualien tower control	- 119.7 KHz

The flight made its call to the Sungshan ground control at 1158:20 and was granted permission to depart. The aircraft pushed back from the terminal at 1210:25, once again after receiving permission from ground control. At 1212:50 it was given permission to taxi on runway 10. At 1214:10 changed to tower control and at 1215:20 the aircraft was instructed to hold on the runway. At 1216:10 the aircraft took off. At 1217:30 shifted to radar control, and instructed to climb to and maintain an altitude of 10,000 feet. At 1219:30 the aircraft requested permission to turn to 110° so as to avoid clouds. At 1220:00, it reported that it had avoided the clouds and was then permitted to fly directly toward WADER at 10,000 feet. At 1225:19, the aircraft contacted the Hualien approach radar, and at 1225:30 the aircraft was instructed turned to 160° and then descend to an altitude of 6,000 ft.

At 1230:50, the aircraft reported visual contact with the airport, whereat the aircraft was given permission for a visual approach on Runway 21. With the radar service ended, communications were switched to the tower. At 1237:40, the tower advised the approach radar control that, "UNI AIR is having trouble on the runway". At 1242:40, the tower responded to the request from the approach radar control, "the aircraft has a rupture and the fuselage is in smoke". See Appendix B for the transcript of the recording between the Hualien tower and the approach radar control.

1.10 Aerodrome information

The Hualien Airport is an airfield serving both military and commercial flights. The airport has only one runway 03/21 measuring 2,750 meters (9,075 feet) in length and 45 meters (148.5 feet) in width. The end of Runway 3 is 45 feet in elevation and Runway 21 is 52 feet in elevation. The maximum load is 23,000 kg (50,600 Lbs) per landing gear. The runway was operating normally at the time of the accident.

1.11 Flight recorders

1.11.1 Cockpit voice recorder

The cockpit voice recorder is used to record of data from cockpit microphones, the captain's microphone, the co-pilot's microphone, and the third crewmember's microphone. The surface of the recorder shows residual ashes, yet its structure was not damaged or burnt. The voice traffic for the entire flight of flight of UNI AIR 873 was recorded at good quality. After landing, the aircraft taxied on the runway and the explosion was heard at 1236:32. Two seconds later, at 1236:32, the cockpit voice recorder stopped recording. In the last two seconds of the recording, an explosion, followed by an echo, and an utterance of surprise from the co-pilot, can be heard. Appendix C shows a transcript of the entire recording, from the time of backing out to the time the recording ends.

1.11.2 Flight data recorder

Since the fire did not affect the flight data recorder, its structure remained intact and the recorder medium was completely recovered. After thorough reading of the data contained, a total of 140 flight operations and system status parameters were obtained. This data is outlined in Appendix D. The flight data covered the entire flight, with the last datum recorded at 12:36:32, the moment that the explosion was recorded on the cockpit voice recorder. However, the data recorded in the 4 beginning at 12:36:29 (1236:29 to 1236:32) were rated as Unsynchronized Frame [Note 2Note 2]. After undergoing manual processing. most of the data recorded in the last

Note 2 Unsynchronized Frame could not be converted into engineering agency data from L3 Comm. using the manufacturer's decoding software "ROSE" second was found to be unreliable. Appendix E shows the flight data from the last 61 seconds (providing only critical parameters, 1 to 10). Other parameters, such as the aircraft barometric altitude, the radar altitude, the air speed, the vertical acceleration, the nose gear landing signal, as well as the EPR of the two engines, are available in Appendix D.

1.12 Wreckage and impact information

The flames caused by the accident consumed most of the aircraft's interior decoration. Except the seats located in rows 5, 6, 7 and a few others in the tail section that were found intact, all of the seats were severely damaged (as was the fuselage skin and the upper system wiring).

Of the 4 holes found on the fuselage, 3 were located on the left side. One was located in the front section (a large opening of 337.82cm in length), another was between rows 5~7 (a longitudinally hole of 144.78cm in length that is ripped off along the rivet line), and the third was on the rear part of the aircraft (an opening of extended space measuring 1320.80cm in length). The one hole fused out on the right side of the fuselage was found between rows 7 and 9 and above the ***UNI AIR*** insignia. Fragments of the keel beam, over the 7th row on the left side, were found among the debris scattered about the end of the runway. (See Pictures 1.12-1 and 1.12-2)

Fig. 1.12-1 The damaged aircraft (left side)

Fig. 1.12-2 The damaged aircraft (right side)

1.12.1 Structure of the area in the vicinity of the explosion

The area of the explosion is found between frameworks FS408 and FS484 of the fuselage. A sectional view shows that the explosion covered the longitudinal beams 1 through L10 on the left side, right above the carryon luggage bin over rows 5, 6 and 7 on the left side, as shown in Fig. 1.12-3.

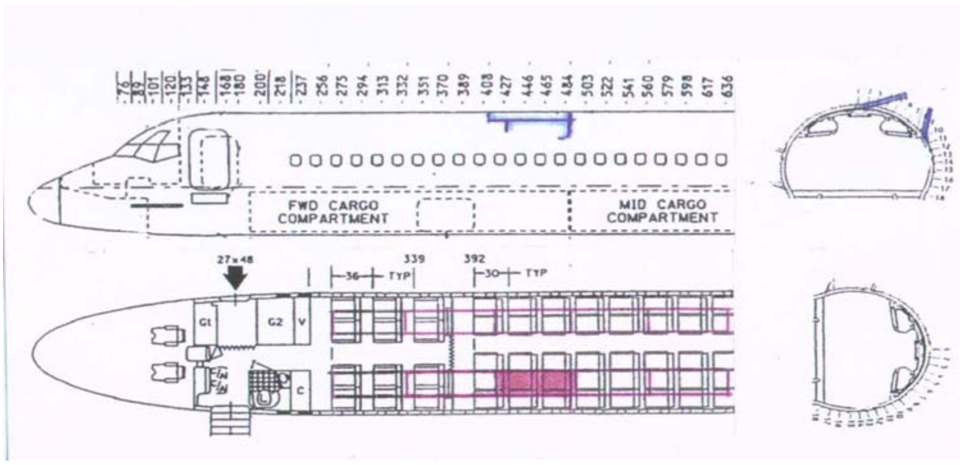


Fig. 1.12-3 Layout of the explosion area

An area of ripped-off skin, within the explosion area, demonstrates an opening along the rivet perforation. Both cracks pointed upwards from the rivet perforation line, and tend to aim towards the lower left side. Also, the crack located on the left framework FS.484 stretches from L6 to L10 (some 56.9cm) and the crack on the left framework FS.427 develops from L6 through L9 (approximately 40.7cm), A part of the skin along the rivet perforation and the mid-upper section shows missing paint (indicated by the arrow, in Picture 1.12-4). The structural drawing of the aircraft shows that the ripped-off skin is located above the overhead carryon, bin above rows 6~7.

Fig. 1.12-4 The ripped-off cover

All FS.408, FS.427, FS.446, FS.465 and FS.484 frameworks of the fuselage and the 8 sections of the keel beam ranging from L1 through L8 were severely damaged by the fire. The explosion ripped off the skin along the rivet perforation of section L6 of the keel beam, with extension toward the top and the side. Section L6 of the keel beam (FS.408 through Fs.484) broke off in the explosion. The lining cover of the inner structure in the vicinity of fuselage frameworks FS.408 and FS.427 was also torn off from L6 through L13, displaying the deformed skin and the bent section of the keel beam. Sections L4, L5 and L6 of the keel beam broke off at FS.408. (Picture 1.12-5)

Fig. 1.12-5 Ripped-off structural skin in the vicinity of the framework

1.12.2 Structure of the stowage bin and its damage

By comparing a picture of the damaged aircraft to an image of an undamaged aircraft of the exact same type (Fig. 1.12-6), we can deduce that the rupture is located in the stowage bin above rows 3~7 (there is no row 4). The stowage bin is constructed of reinforced fiberglass and measures 577.2cm in length, 57.4cm in width and 37.0cm in height. Its lugs are attached in suspension to the rack that stretches along the fuselage. Above it are electric wire clusters. The larger wires are for carrying a larger load for the galley. Two environmental control tubes can be seen along side the wires. The one of larger diameter is an air duct that provides exhaustion from the wall of the fuselage. The thinner one is for cold and feeds air from the gasper in the Passenger Service Unit (PSU), contained inside the bottom wall of the stowage bin. The entire stowage bin and its suspension system were destroyed by the explosion. Fig.

1.12-7 shows how the condition of the air duct as seen from the outside. There is a large burnt area from the bottom to the top.

Evidences gathered at the scene include the lower panels of the stowage bin, the PSU (gasper, reading light, chemical oxygen generator and oxygen masks). The chemical oxygen generators on the passenger cabin floor show burn marks on the outside, though they appear to be intact. At the scene, inspectors also found the power supply stabilizer with connectors that providing power to the reading lights. These items, wile destroyed by the fire, remain recognizable.

Fig. 1.12-6 Picture of the passenger cabin and stowage bin of an aircraft of identical model.

Fig. 1.12-7 Damaged air duct showing burns from the bottom to the top

1.12.3 Fire inside the aircraft

Ripped off by the explosion, the upper left area above rows 5, 6 and 7 shows the skin torn outward and the beams above rows 6 and 7 split off (Fig. 1.12-8). Both the beam and the bin rail broke, with components scattered about the runway (Fig. 1.12-9). The bin support and the tie rod above row 5 are twisted yet still attached to the aircraft (Fig. 1.12-10). The fire did not affect the bin lid, though the latch and the hinge were torn off (Fig. 1.12-11). The hinge for the bin support above row 6 still is still attached.

The effect of the fire on the condition of interior of the aircraft

<u>Right side of the aircraft [from FS253 (behind Galley 2) to FS1156 (in front of Galley 3)]</u>

The entire area from the back of the seat to the aircraft skin was completely destroyed by the fire. Except for rows 6, 7 and 8, all of the windows were destroyed. (Fig.1.12-12). In this same area, the fire consumed the interior material, from the sidewall through the air return in the lower part of the seats. After having been consumed by flames, the cabin partition panel was found on top of the doghouse. Aside from the carbon-fiber wire clusters on the back of the stowage bin, most of this area is now just ashes.

Fig. 1.12-8 Breaking point of the longitudinal beam

Fig. 1.12-9 Fragments of longitudinal beam and bin rail tie rod found on the runway (showing no burn signs)

Fig. 1.12-10 Bin support and the tie rod

Fig. 1.12-11 The bin lid latch

Fig. 1.12-12 FS253~FS1156

<u>Mid-section of the aircraft (From FS168 to FS1156)</u>

The ceiling of the mid-section including the fallen portion was full of ashes. The upper part of the life raft on the aisle floor showed slight burns, while the rest of it was severely damaged by the fire. The life raft was not used.

<u>Left side of aircraft [From FS187 to FS1156 (except FS386 to FS500 over rows 5, 6 and 7)]</u>

The burnt front panel, which supports of the rear of the lavatory, was found on the floor. The stainless steel washstand was completely destroyed by the fire, with only the washtub remaining recognizable. The seats and other materials in the sector were either scattered into debris or turned to ashes.

<u>Seats in rows 5, 6 and 7 on the left side of the aircraft</u>

There is one set of PSU above rows 5, 6 and 7 on the left side

Attached to the air conditioning duct, though it has been split into 2 pieces was found fallen on the seats in row 6 (Fig. 1.12-13). Another PSU was found on the seats in row 5, showing no visible smoke marks or burns.

The air conditioning duct of the sector remained recognizable, while the sidewall showed smoke marks. The seats in rows 5, 6 and 7 showed signs of smoke but were not burnt. The cabin partition panel remained firm in its original position.

From FS1156 to Aft Pressure Bulk

This section shows minor signs of smoke. The emergency exit has been melted away. The central ceiling, seats, stowage bins, tail stairs, galley, and the service area showed signs of smoke but were not burnt.

Emergency exit

The 3 emergency exits L1, R1 and L4 remained unaffected by either smoke or fire. The 3 overwing hatches on the right side, L1, L2 and R1, were found open. Only one hatch was found on the seats inside the aircraft, while 2 others were missing. The R3 overwing hatch was not open (Fig. 1.12-14).

Fig. 1.12-13　　Condition of the PSU

Emergency equipment

The labels on the equipment indicated that all the emergency equipment remains effective. The fire extinguisher located behind the rear of the co-pilot was found to have been used and was and discovered near the L1 door (Fig. 1.12-15). The fire extinguisher in the doghouse behind row 37 was not used and was found in the aisle near the passenger seat in front of the L4 exit. The emergency equipment in all other doghouses was found it its original position, and found to have not been used. A melted speaker was found on the floor, beneath its original position. The evacuation indication light was found on the floor burned beyond recognition.

Fig. 1.12-14 Overwing hatches on the left and right (R3 is not open)

Fig. 1.12-15 A used fire extinguisher

1.13 Medical and pathological information

Hospital records and interviews indicate that 1 passenger died on Day 47 after the accident. Thirteen were seriously wounded and 14 suffered minor injuries.

The deceased passenger had been seated in 7B. Death was found to have been was caused by the 2^{nd} and 3^{rd} degree burns sustained on over 45% of the passenger’s body, which resulted in poisonous blood eventually cardiopulmonary failure. The passenger died on day 47 after the accident.

The female passenger seated in 8H suffered a facial fracture, a head injury and a hemorrhage in her skull. Also, the 26-week-old fetus she was carrying at the time of the accident died. The passenger suffered shock and was found unconscious.

The passenger seated in 7C suffered second third degree burns over 25% of his body, as well as injuries from smoke inhalation.

The passenger seated in 7A suffered 2nd and 3rd degree burns over 21.55 of his body.

The 11 other passengers who suffered serious burns were seated in 6B, 6C, 7H, 7K, 8C, 8H, 8K, 9H, 9K, 10H and 10K.

The passenger seated in 11H-suffered injuries while evacuating the aircraft via the evacuation slide raft.

Except the passenger seated in 17A, who suffered smoke inhalation burns, all other 10 injured passengers were seated between row 5 and row 11. (Fig. 1.13-1)

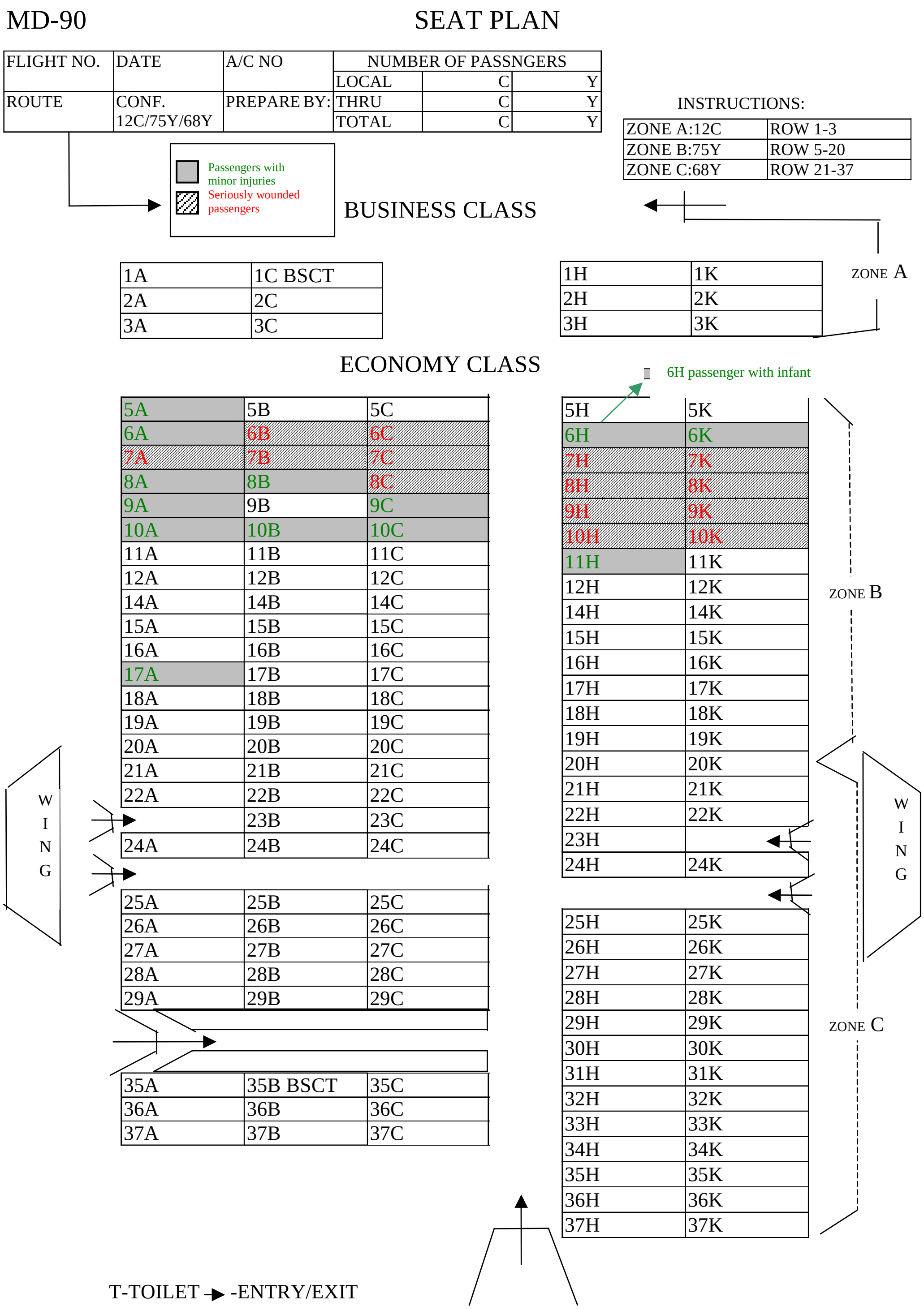


Fig. 1.13-1 Seat plan of the wounded passengers

1.14 Fire

The evidence gathered by the Forensic Division under the Criminal Investigation Bureau (hereinafter referred as CBI/FSD) at Hualien Airport is listed in the Checklist of Evidence in Attachment 1. Except evidence No's. 584 and 219, which are undergoing material identification and section analysis by the Chungshan Institute of Science & Technology, CIB/FSD is analyzing all other evidence. Appendix G shows the objects scattered on the runway.

1.14.1 Relevant evidence found at the scene

1. Evidence No. 584 is the battery found on the floor of the main cabin under the seat 5C. The broken housing shows burn signs. The trademark on the outside suggests that it is a GS-brand 12-volt battery for motorcycles as shown in Fig. 1.14-1, not equipment from the aircraft. The battery shown on the left side is the one found under seat 5C, which has barely visible metal conductors attached to both positive and the negative poles. The one to the right is an intact battery of the same type.
2. Evidence No. 219, which fell onto Section 3 of the runway, is a mono-core metal conductor and resembles the conductor of the positive and negative poles on the battery. (Fig. 1.14-2)
3. Evidence No. 219, found on the runway, and evidence No. 585, found on the floor under seat 7C of the main cabin, both belong to the upper part of the blue-colored bottle containing bleaching liquid. Soft and semi-transparent material is located on the inside of the bottle's neck and gasoline was detected on the inner wall (Fig. 1.14-3 and 1.14-4).

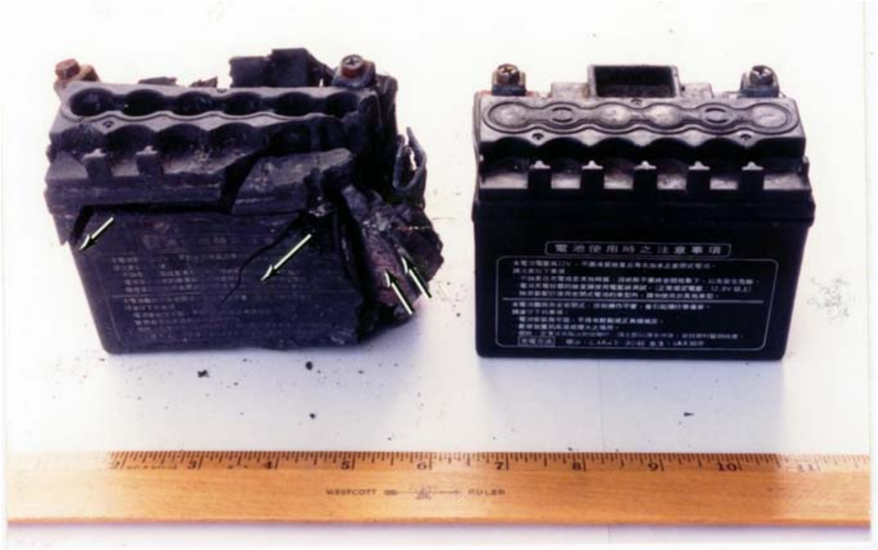


Fig. 1.14-1 On the left is the battery found under seat 5C.An intact battery of identical type is shown on the right.

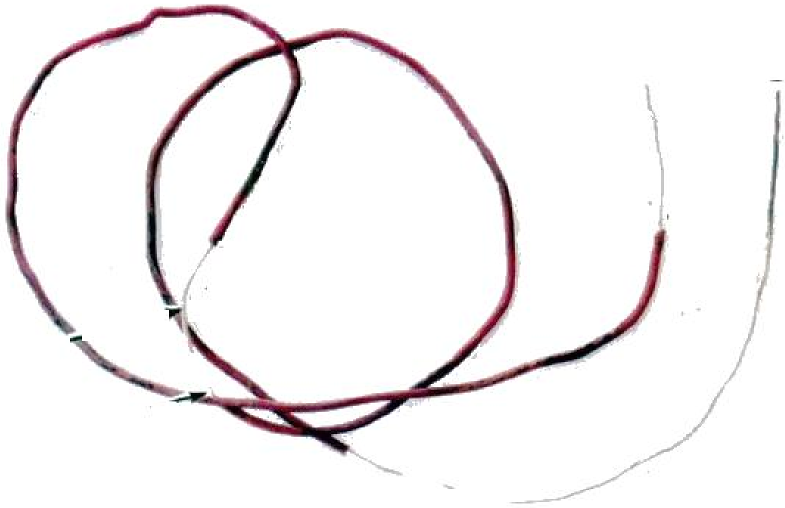


Fig. 1.14-2 The mono-core metal conductor of evidence No. 219

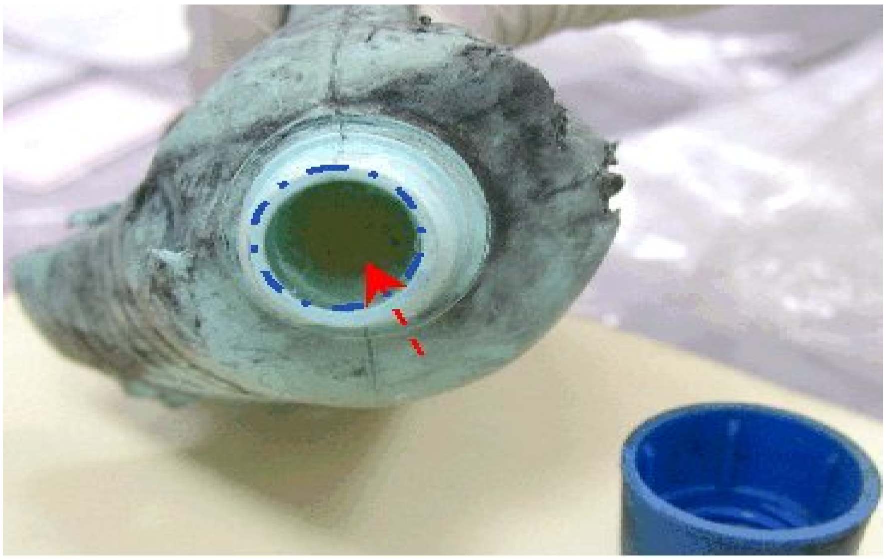


Fig. 1.14-3 A view from the mouth to the bottom of the bottle, semi-transparent material evident on the neck of evidence No. 210.

Fig. 1.14-4 A view from the fractured bottle opening, evidence No. 585 showing semi-transparent material.

1.15 Survival aspects

The aircraft has a seating capacity of 155 passengers, and the flight carried 90 passengers in 89 seats (the passenger seated in 6H held a 3-year-old child).

In the front section of the main cabin of the aircraft there are 2 exits (L1, R1) that were each equipped with an emergency slide raft. There are also 2 emergency exits (L2, L3, R2, R3) by rows 23 and 24 in the midsection of the fuselage and above the wing. Another emergency exit (L4) equipped with a slide raft is located between the two galleries on the left side of the rear section. The tail stair on the (A5) is located at the end of the aisle. The aircraft has a total of 8 emergency exits (as shown in Fig. 1.15-1). Instead of being inflated automatically when opened by the cabin chief, the slide raft at the emergency exit L1 was inflated manually and the slide raft R1 inflated automatically when passengers opened the emergency exit. Passengers opened the emergency exits at L2, L3 and R2. The slide raft at L4 inflated automatically when the flight attendants opened the exit. The co-pilot from the outside opened the tail stairway A5. The R3 emergency exit in the mid section above the right wing failed to open.

Statements given by several crewmembers suggest the following sequence of events during the evacuation: After the explosion, the captain brought the aircraft to an emergency stop and sent the EVAC, EVAC, EVAC signals over the main cabin PA system, contrary to the standard procedure of first turning off the engines. The co-pilot, carrying a flashlight and fire extinguisher, then rushed to extinguish the fire with the assistance of the L1 flight attendant. They simultaneously attempted to assist the passengers. Their effort was unsuccessful as thick smoke kept them from entering into the main cabin. The co-pilot then left the aircraft to try to enter from the tail stairway but was again turned back by the thick smoke. When the co-pilot tried to enter via the right wing, the passenger seated in 7H was at the R2 evacuation exit helping the passenger in 8H leave the aircraft. The co-pilot then helped the two seriously injured passengers off the aircraft from the rear edge of the wing. The captain, having completed the engine shutdown procedure, then attempted to visually confirm that the all passengers had left the main cabin. As his flashlight could not penetrate the thick smoke, he yelled to see if there was anybody still inside. Without hearing any reply, he then turned off the battery and left the aircraft from L1. The captain then provided assistance to the inured passengers alongside the aircraft.

As suggested by the main cabin passenger list and interviews, all passengers were seated in rows 1~28 after boarding the plane (the passenger first seated in 32K was later moved to 25K). The emergency evacuation procedure followed right after the aircraft stopped and all the 890 passengers, 4 flight attendants and 2 flight crewmembers evacuated from emergency exits L1, L2, L3, L4, R1 and R2. Flight attendants L1 and C5 indicate that the emergency lights at the emergency exits went off within 1 or 2 seconds after aircraft power went out. None of the interviewed witnesses noticed whether the emergency floor track lights in the main cabin were on.

Other flight attendants and passengers indicated that after a few passengers left the aircraft from the L1 emergency exit, the cabin chief was alongside the aircraft to help passengers deplane. The L1' flight attendant was in charge of the evacuation of passengers next to L1 and R1, and helped the co-pilot attempt to extinguish the fire before leaving the aircraft. The L4 and C5 flight attendants also tried to use fire extinguishers but passengers in their way prevented them. They returned to L4 to help passengers deplane but, when they received no response to their calls in the main cabin, they left the aircraft to provide assistance to injured passengers outside. After the entire crew left the aircraft, the two injured passengers 7H, 8H) were evacuated from the emergency exit R2 above the wing.

The flight attendants could not give the scene commander the total number of passengers as the passengers had dispersed. The airline counter provided the scene commander with the passenger list. At 1258, only 59 passengers were confirmed. Without knowing whether all passengers had been evacuated, Air Force personnel made two unsuccessful attempts to go inside the aircraft to look for more passengers. Only when the fire was almost extinguished could firefighters enter the cabin and confirm that no passengers were left behind.

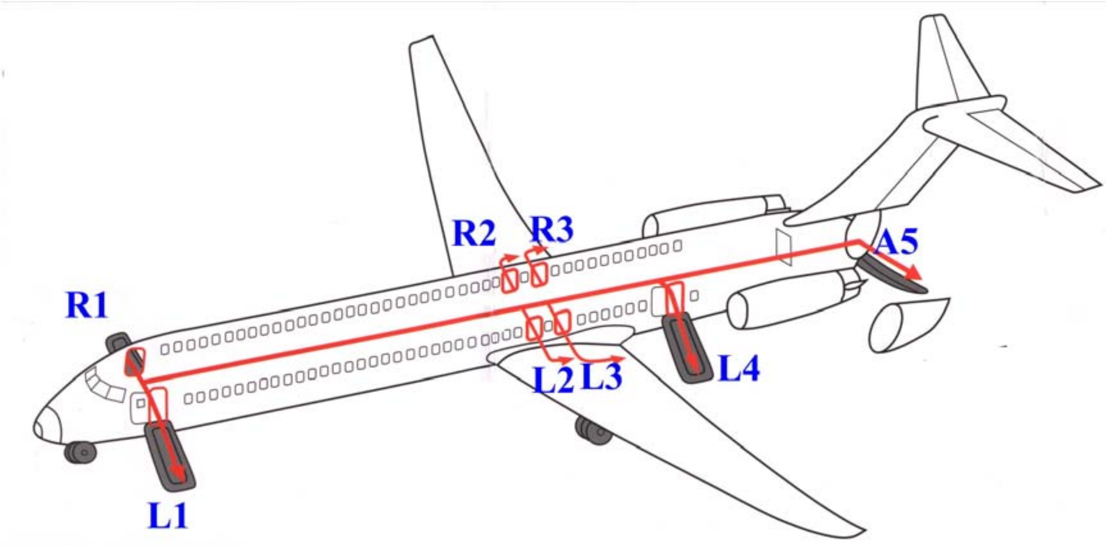


Fig. 1.15-1 Emergency exits in the main cabin

1.15.1 Evacuation and fire fighting effort recorded in CVR and the ATC tape recorder

The CVR was without power from the point two seconds after the explosion and it has no recording of the evacuation effort.

However, the ATC transcript between the tower and the aircraft indicates that the captain issued the Mayday! Mayday! Mayday! call right after the power went off.

Traffic between the tower and the aircraft:

Approach time	Speaker		Text
1237:20	Tower	:	UNI873, this is Tower
	UNI	:	Go ahead
	Tower	:	Do you have any problem? Please remain where you are.
1237:30	Tower	:	Fire engine! This is Tower

1237:45	UNI	: Mayday! Mayday! Mayday!
1238:30	Tower	: Fire engine! This is Tower
	Fire engine	: Go ahead
1238:40	Fire engine	: Fire engine copy, fire engine standby on the ramp.
1238:50	Tower	: Fire engine! You are at Opening 2.
	Fire engine	: Roger
1239:00	Tower	: Fire engine! Go to Opening 2, UNI flight is at Opening 2.
1239:10	Fire engine	: Fire engine Roger!
	Tower	: Fire engine! Enter into the runway through the central exit, UNI flight is standby at exit 2.
1239:20	Tower	: Standby for backup
1240:00	Tower	: Fire engine into runway
1240:30	Tower	: UNI873, this is tower
1241:20	Tower	: Fire engine get closer

1.15.2 Crewmember training and response to emergency

The four flight attendants had passed both basic training and the annual on-duty training.

The annual on-duty training record shows no grades for fire alarm, firefighting procedure, main cabin security check or hazardous materials.

Art. 66 of the Air Flight Operation Management Procedure stipulated by the Civil Aeronautical Administration Navigation in 1997 covers the annual on-duty training. The 1997 training provided by UNIAIR offered no depressurization training and in its 1998 training, there was no hazardous material training.

According to both the Flight Operations Manual and the Flight Crew Emergency Handbook, the crew has the following responsibilities in case of emergency:

Captain's responsibilities

1. To make the EVAC, EVAC, EVAC call using PA;
2. To take out the emergency kit;
3. When possible, to remain in the middle of the main cabin to direct the effort and verify with the cabin chief whether all passengers have evacuated the aircraft or if any assistance is needed;
4. To check if all passengers have been evacuated and provide assistance together with the cabin chief to evacuate the crewmembers;
5. To leave the aircraft and remain directing the effort at least 200 feet off the aircraft against the wind.

Co-pilot's responsibilities

1. To take out the emergency kit;
2. To evacuate the aircraft from the exit;
3. To supervise the evacuation effort outside the aircraft;
4. To provide assistance to passengers and evacuate to at least 200 feet from the aircraft against the wind.

The procedure given in Chapter 8 of the Flight Attendant Handbook (version of July 1 1999) states:

Unless in an imminent situation where human lives can be at stake, after an emergency landing, the flight attendants shall wait for captain's evacuation instructions. It is described in Emergency Evacuation Procedures 8-6-5 and 8-7-5 that two passengers shall be selected to slide off the slide raft from each emergency exit and then provide assistance to other passengers by the slide raft.

cabin chief : Before the captain gives the evacuation instruction, the cabin chief shall act on the captain's behalf and check the cockpit (or help the captain leave the aircraft should the latter be found disabled) or take necessary measures given as follows:

1. To make the EVAC, EVAC, EVAC call using PA;
2. To open the emergency door;
3. To evacuate the passengers from the aircraft immediately;
4. To check the cockpit before evacuating the aircraft and help the captain leave the aircraft should the latter be found disabled;
5. To leave the aircraft immediately after confirming that all passengers have been evacuated;
6. To leave the aircraft and remain directing the effort at least 200 feet off the aircraft against the wind.

<u>Flight attendant that opens the door</u>:

Before opening the door, to ask two volunteers to exit the aircraft first and then provide assistance to other passengers by the slide raft.

1. To open the emergency door;
2. To help passengers evacuate from the aircraft immediately;
3. To leave the aircraft immediately after confirming that all passengers have been evacuated;
4. To evacuate passengers to an area of at least 200 feet off the aircraft against the wind.

When everyone has been evacuated, the MD90 crewmembers shall:

1. Assemble the passengers in a safe place;
2. Confirm the number of passengers and crewmembers;
3. Proceed with first-aid;

4. Secure luggage and cargo;

5. Advise the local branch office;

6. Use ELT when necessary.

Layout of the emergency kit is given in Fig. 1.15-2

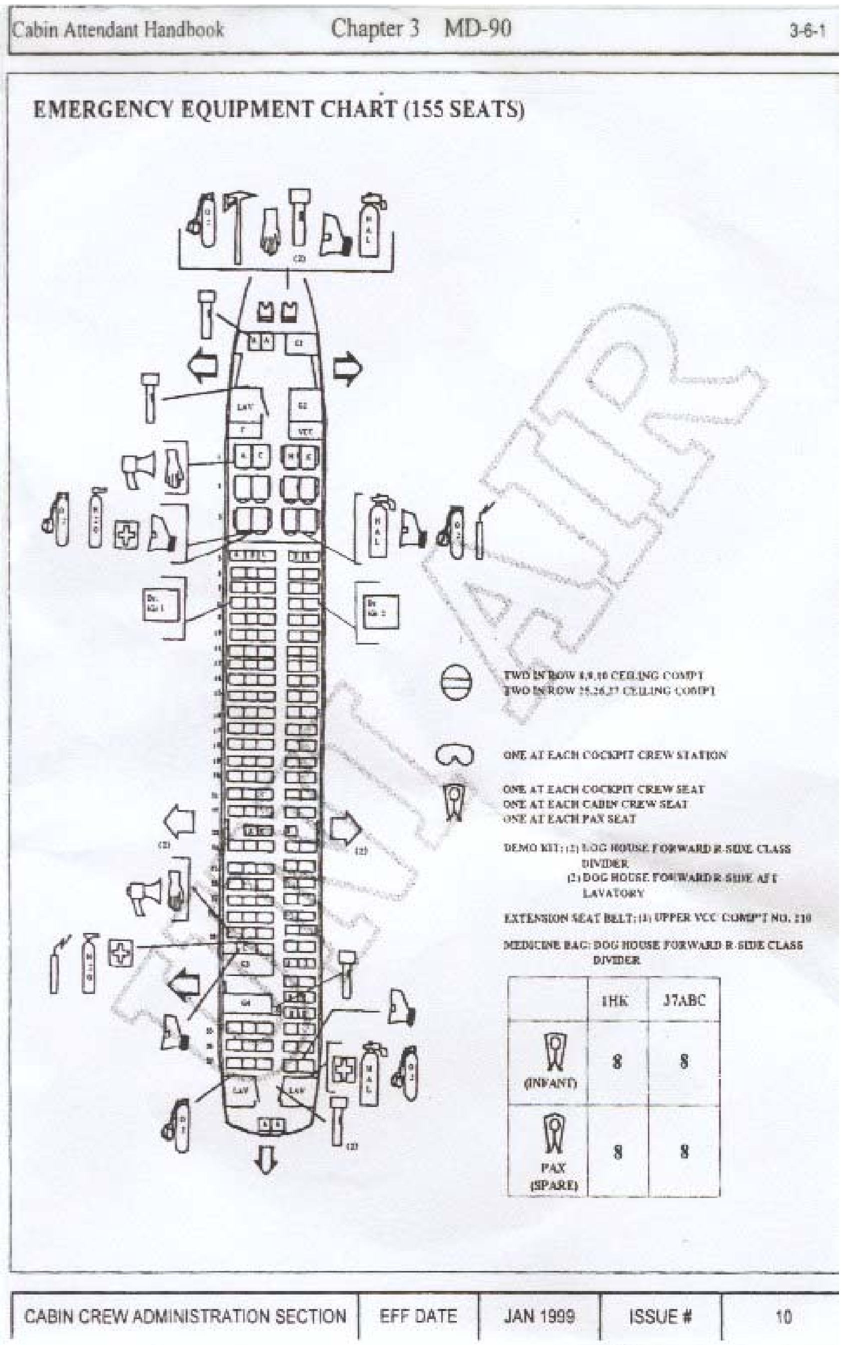


Fig. 1.15-2 Layout of the emergency kit

The following sequence of events following the explosion is based on interviews conducted with the aircraft's flight attendants.

(1) The cabin chief was seated in the seat assigned to flight attendants by Exit L1. When the aircraft was rolling on the runway after landing, the L1 flight attendant had just pressed the PA button to make an announcement when an explosion was heard. In less than 2 seconds, the passengers in the front rows of the main cabin rushed to the L1 and R1 exits and tried to open the doors. The cabin chief tried to stop the passengers from opening the door, as she had not received instructions from the captain for emergency evacuation nor had the aircraft had completely stopped. With the power off, the cabin chief could not contact the captain using the interphone, and so communicated via the broken ventilation opening linking the cockpit. While the cabin chief asked whether to proceed with the emergency evacuation of the passengers, the captain was heard calling EVAC, EVAC, EVAC. The aircraft then stopped and the emergency evacuation proceeded.

The cabin chief saw the dark and thick smoke and immediately opened the L1 door after the emergency evacuation instruction was given. The inflatable slide raft at L1 failed to automatically inflate [the cabin chief turned the slide raft to "Armed" when she was sure that the aircraft had stopped. When the L1 door was pushed open, the slide raft failed to open and properly inflate]. The slide raft was later inflated manually. After evacuating two or three passengers, the cabin chief first asked the L1' flight attendant to remain on board to help evacuate passengers and then left the aircraft to help evacuate the passengers by the slide raft.

According to the cabin chief, the emergency exit light above L1 was on until the power went off. After leaving the aircraft, she helped evacuate passengers using the slide raft on L1 and L4. As of that time the aft door was not yet open and she estimated that it took a little more than 1 minute to get all the passengers off the aircraft. She then provided assistance to the injured and attempted to count the passengers.

According to the cabin chief, the captain had summarized the journey, weather, and emergency procedure in the pre-flight briefing. The aircraft had served an earlier flight from Makung to Taipei. Upon arrival in Taipei, crewmembers conducted a cabin check and, following the cabin-check regulations, inspected the stowage bins. After taking off, both the luggage and the passengers were found in normal condition. The flight was smooth and the air conditioning system operated normally, with no odor detected before the explosion.

(2) The flight attendant L1' was seated in the flight attendant seat by the L1 door. After serving the last flight and checking the cabin to ensure that her assigned stowage bins were empty, the flight attendant L1' was standing between rows 7~8 to attend to boarding passengers. The cabin chief played the welcome speech and demonstration tape before checking the entire main cabin to confirm that safety belts were worn and stowage bins closed. The L1' attendant closed the bin without noticing any luggage under pressure.

Before the explosion, no one noticed any odor or irregularities; no equipment, to include the A/C, lights and hot water kettle, malfunctioned.

At the moment of the explosion, the L1' flight attendant was seated in her seat ready to make the post-landing announcement. Just as she pressed to PA to begin, she heard the explosion and felt hot air passing by her feet and buzzing in her ears. The power went off right after the explosion. Remaining in her seat, L1' flight attendant saw passengers filling the aisles as they rushed to the front section. They even tried to open the R1 door. While the power was off and the aircraft not fully stopped, flight attendant L1 (the cabin chief) heard the captain call EVAC. She then she opened the L1 door. As flight attendant L1' had lost her hearing and did not hear the emergency evacuation order, passengers opened the R1 door. The R1 slide raft then opened and inflated on its own.

The cabin chief then asked flight attendant L1' to remain on board to help evacuate the passengers and then left the aircraft. At this time, the co-pilot passed the cockpit fire extinguisher to flight attendant L1' to put off the fire. The flight attendant sprayed the cabin floor with the extinguisher. Meanwhile, the co-pilot, standing behind her and with a flashlight in hand, shouted to the main cabin to see if there was anybody left behind. When flight attendant L1' reached the business cabin with the fire extinguisher she could not breathe because of the thick smoke. The co-pilot then asked flight attendant L1' to take the flashlight while he used the fire extinguisher. There was no response to the co-pilot’s shouts as to whether anybody was left in the cabin. The co-pilot then asked the flight attendant L1' to leave the aircraft to help evacuate the passengers.

Once off the aircraft, flight attendant L1' helped to move the injured and assemble the mass of passengers. She then made a report to the cabin chief.

(3) When the aircraft landed, flight attendant L4 was seated in the crewmember seat in Row 34 and by the aisle of G4 and she said the aircraft was taxing smoothly after the landing until the tremendous explosion coming from the front section of the main cabin. She then

took the fire extinguisher in the doghouse located in row 37 and tried to put off the fire together with the flight attendant in the tail section. That was when the passengers were rushing to the back and flight attendants L4 and C5 could not go further when they reached the L4 exit. Some passengers tried to open the L4 door. When the aircraft stopped, the slide raft opened and inflated automatically. The flight attendants L4 and C5 helped evacuate the passengers and then shouted to check for anybody left behind. They left the aircraft after knowing for sure that there was nobody left behind.

Once off the aircraft, flight attendant L4 helped move the injured by the aircraft and assemble passengers, who were counted and the number was reported to the cabin chief.

(4) The C5 flight attendant was seated in her designated seat in the tail section. She said that the aircraft had a smooth flight and landing. She heard the explosion as the aircraft was rolling on the runway and rushed to the tail section with the fire extinguisher while stating that there was fire. Flight attendants L4 and C5 took the fire extinguisher from the doghouse and flight attendant L4 used it on the fire. At that point passengers were rushing back to row 30. After the aircraft stopped and the cabin was filling with thick smoke, the flight attendant opened the L4 door and the L4 slide raft inflated automatically. Flight attendants L4 and C5 helped guide the passengers off the aircraft and the L4 flight attendant assisted the blood-soaked passenger in 8H evacuate. Before leaving the aircraft, L4 and C5 flight attendants shouted into the main cabin to check for any remaining passengers but received no response. Once off the aircraft, they helped move the injured, assemble the passengers and reported the number of the passengers to the cabin chief.

This office interviewed a total of 13 injured passengers and sent a questionnaire on the evacuation effort (see Appendix H) to all the passengers. Of the 23 replies received, 22 indicated that they received no special care during evacuation. An 80-year-old passenger seated in row 11 suffered serious wounds while sliding without assistance down the slide raft. Four passengers said that flight attendant L4 assisted them during evacuation (See Appendix I).

1.15.3 Firefighting and control

Fire engines from the Hualien Airport, the Air Force's 401st Wing and police from both Hualien City and Hualien County responded at 1236 to the fire from the explosion on board aircraft B-17912. They put out the fire at 1345. (Please refer to Fig. 1.15-3 for the firefighting effort at the airport and Fig. 1.15-4 for the firefighting plane coordination pattern at Hualien Airport).

As a Class 7 IATA-rated airport, the firefighting squad at the Hualien Airport is subordinated to the airport and owns two large, high-performance fire engines (Protector 3000, of 3000 gallons, and Emergency One, of 3000 gallons), one backup fire engine (SHKOSHM-1500, of 1500 gallons) and a lighting vehicle. Each of the two fire engines dispatched that day had two people on board to conduct the first round mission.

Fig. 1.15-3 Firefighting effort in the airport

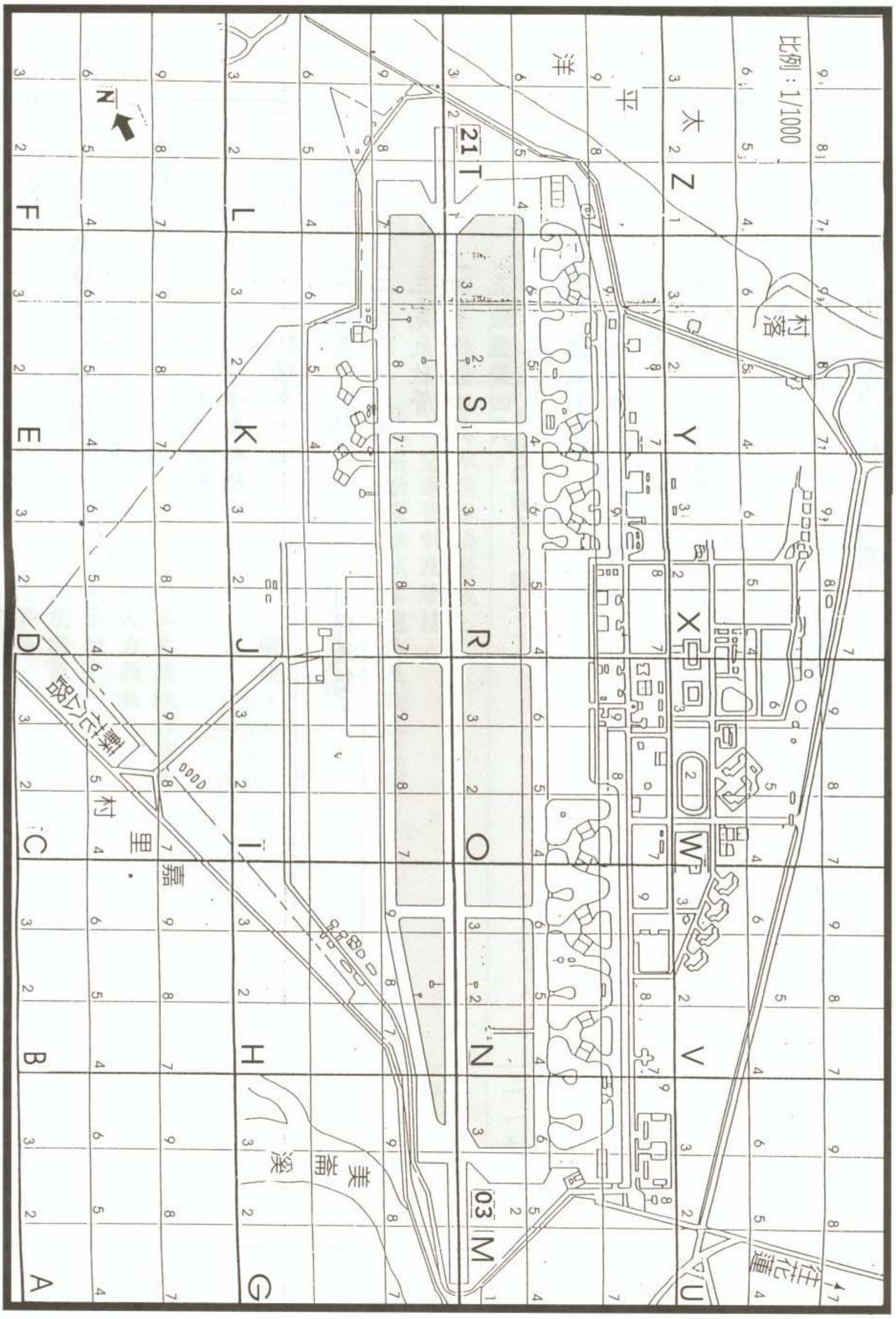


Fig. 1.15-4 Firefighting plane coordination pattern in the Hualien Airport

According to the station's Flight operations section records, the tower notified the station at 1237 and the fire squad was immediately notified.

Fire engines 1 and 2 were dispatched one minute apart, at 1238. As the fire engines were rushing to the scene, the control tower requested Engine No. 1 to take the No. 2 entrance and remain on the ramp at standby. Engine No. 1 did not follow the order but approached the scene from the center taxiway. At approximately 1239:30, fire engine No. 1 arrived at the accident scene to find that the passengers had been removed. Then an Air Force water tank truck arrived and positioned itself by the left wing of the aircraft. Fire engine No. 1 then began spraying foam from its turret-type spraying gun to the left-side skin of the aircraft from its position behind the left wing of the aircraft. Both the tower and the Air Force had asked the vehicle to move toward the bow. The No. 2 fire engine arrived at 1240 and stopped behind the right wing and provided assistance to the seriously injured passengers while spraying water to cool down the fuselage. At 1241, the tower and the Air Force ordered the No. 1 and No. 2 fire engines to move to the left side of the bow and the effort. Under the direction of the Air Force, the No. 2 fire engine aimed at the emergency exit above the left wing. At 1249, the No. 1 and No. 2 fire engines returned to the airport to refill. The No. 1 engine was ready at 1305 and returned to the left side of the aircraft. The No. 2 fire engine completed its refill at 1307 and returned the left side of the aircraft. From there it worked on the inside of the aircraft from the tail stairway to door L4 using its pressurized hose located in front of the vehicle. At that time, Air Force Wing personnel entered the aircraft from the tail stairway to search for more passengers. They were unsuccessful because of the thick smoke. At 1316 the No. 1 fire engine again returned to the airport to refill. Firefighters used the No. 3 fire engine to support the No. 2 fire engine on the right side of the tail. At 1326, firefighters and ground service personnel entered the cabin to check for people. Airport records state that the fire was put out at 1345. The No. 1 fire engine used only its turret while the No. 2 fire engine used hoses following its second refill.

According to firefighters from the Peipu team of the Hualien City Firefighting Squad, the Flight operations section at the airport telephoned at 1247 for ambulances. At 1255 the ambulance dispatched by the team asked for fire engines. The team dispatched one fire engine with 2 firefighters and 6 volunteer firefighters. At 1259 the Flight operations section asked for more fire engines and one water tanker was dispatched. When the first fire engine arrived at the scene, the passengers had been removed and the aircraft was on fire with the tail slide raft down. There were two military fire engines active at the scene, one in front of the bow and the other on the left side of the bow. One fire engine dispatched by the airport was on the right side of the tail and another one on the left side. The fire engine dispatched by the team then went to the left side of the aircraft, where the volunteer firefighters broke the windshield. At approximately 1320, the fire was under control and firefighters went inside the aircraft with hoses to put out the fire.

The statement given by Air Force Wing 401 indicated that the tower notified the fire squad at the air wing at 1237 by both the accident and regular administration telephone. The on-duty sergeant (Administration Office) then paged the fire squad for the fire engines. The No. 2 fire engine of the air wing arrived at the scene and parked at some 50 meters from the left side of the bow. The No. 4 engine arrived right after and parked at approximately 50 meters in front of the bow. Then the Air Force ambulance and the water tanker arrived and both parked on the left side in front of the bow. While the No. 2 engine was away for refill, the Air Force firefighters observed that the airport fire engines had arrived and had parked on the left side of the aircraft. (apparently the airport's No. 1 fire engine). The Air Force's No. 2 fire engine made four efforts on the left side of the bow and after refill, the No. 4 engine parked behind the airport's fire engine on the left side of the aircraft. At this time, the Chiashan Air Base No. 5 and No. 6 engines arrived and parked by the bow of the aircraft. Firefighters then went into the aircraft to spray with hoses. The four Air Force rescue people attempted to enter the aircraft to look for more passengers but were turned back by the flames.

The tower firefighting report made at the time of the accident states that at 1236 it made visual contact with UNI873 as it was rolling on the runway. At 5,500 feet it heard the explosion and saw smoke. The tower asked the pilot if the taking experienced any difficulty. Immediately as the aircraft stopped at 6,500 feet, the on-duty personnel in the tower pressed the airport accident alarm. The tower then alerted the Flight operations section using the exclusive telephone and issued a 118.1 radio call to the airport for fire engines. At 1236:50 the accident telephone and the alarm at Air Force Wing 401 sounded and all the rescue agencies responded. The fire squad at Air Force Wing 401 notified its On-Duty Room after the receiving the accident phone call from the tower and paged its personnel. The tower notified by phone the Flight operations section and the airport fire squad via the flight operations section. Upon receiving of the alert, the airport fire squad did not need to page anyone as it could respond immediately. The firefighters on the fire engines advised their co-workers using the alarm. At 1237:50, the captain issued the Mayday, Mayday, Mayday call.

The on-duty personnel in the Flight operations section indicate that at 1247 they alerted the Hualien City Fire Squad (119) and at approximately 1300, the tower asked them to call 119 again.

Records in the tower also show that at 1250 the scene commander (Chief of Staff of Air Force Wing 401) advised the tower to call the Aviation Police and Flight operations section and notify the Peipu Team for backup. Fire engines of the Peipu Team of the Hualien Fire Squad arrived at the scene at 1305. At 1322, fire engines from the Navy's Falcon Base joined the effort, and this version matches the narration of other witnesses. After a little more than 1 hour, the fire was put out at 1345. At first, fire engines were at parked at distant spots from the aircraft as turrets were used to spray foam mixed with water onto the skin.

Clause 6 of the firefighting backup agreement entered between Air Force Wing 401 and the Hualien Airport suggests that the military shall provide the base plane coordinate chart to the civil fire fighting agencies for reference so that firefighting personnel of both services can locate an accident in a timely fashion. The plane coordinate chart would allow all firefighters to determine wind direction and position of firefighters in case of an accident, so that the scene commanders can conduct successful communication with backup agencies both on and off the scene. Consequently, an updated plane coordinate chart (Fig. 1.15-4) shall be provided to firefighting and medical services in Hualian City and Hualien County, and agencies at the airport, Aviation Police and other rescue agencies. The military shall provide updated information on the chart to Flight operations section at the Airport, which shall then notify relevant rescue agencies. However, during the investigation this office found that the chart used by the firefighting team at the airport is different from the one used by the military firefighting agency.

At the Hualien Airport there are two sets of firefighting water supply systems, both fed by the same water reservoir. Interview data and records produced by the Flight operations section indicate that Vehicle 1 (carrying 3000 gallons of water) returned to the station for refill at 1249, taking until 1305 (15 minutes) to make a 75% refill. Vehicle 2 (carrying 3000 gallons of water) returned to the station for refill at 1249 and took until 1307 (17 minutes) to completely refill. Air Force Wing 401 has only one water supply system and the interview record suggests that it takes 5 minutes to refill a fire engine of 1500 gallons, though there were other vehicles in the line waiting for refill as well.

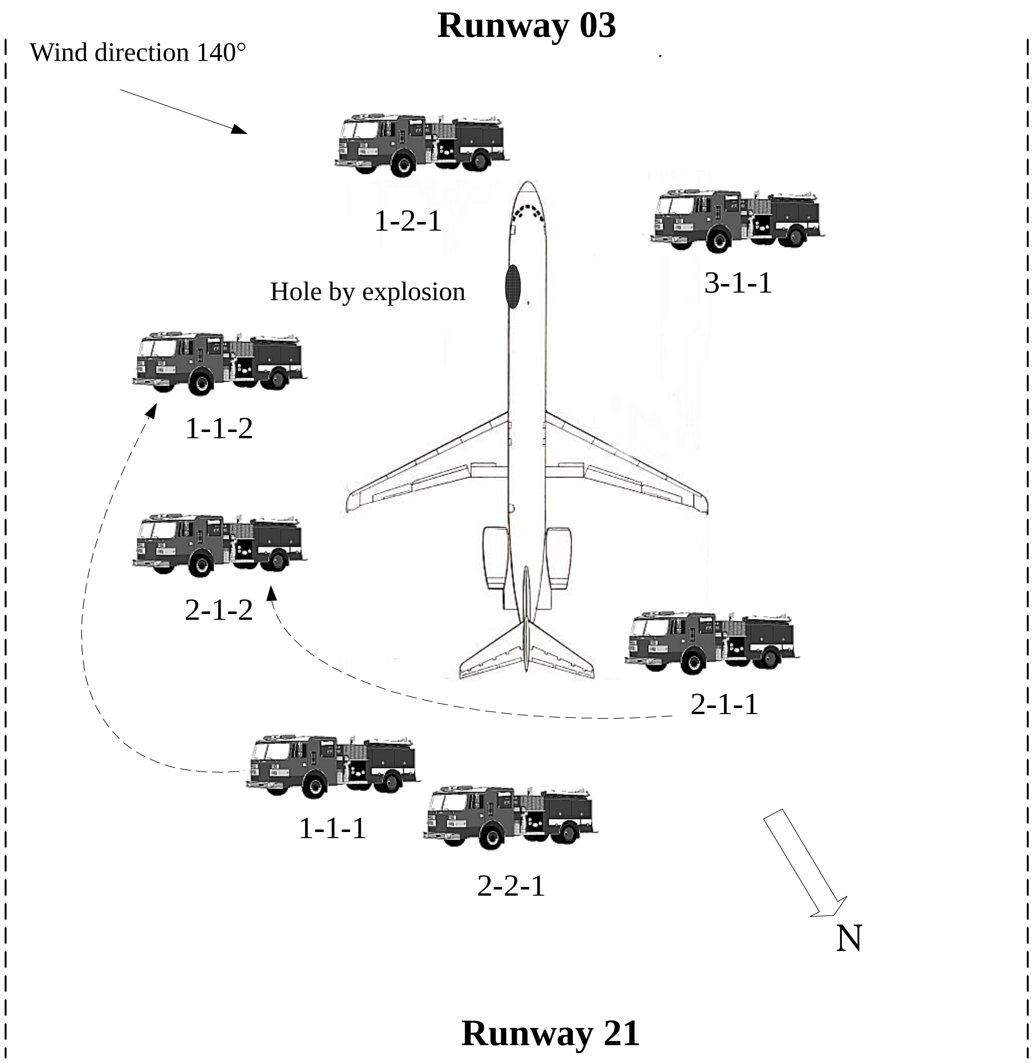
Both the ICAO Aircraft Service Manual Part I Rescue and the Firefighting, Appendix I “Aircraft Data for Rescue and Firefighting Personnel” indicates that hazardous areas inside an aircraft include fuel tanks, oil tanks, batteries, fuel heaters, hydraulic fluid tank, emergency exits, destruction sectors and fixed hydrogen cylinders. Investigations suggest that none of the firefighting squads at Air Force 401 Wing, the Chiashan Air Base, and Police Department in Hualien City, Hualien County or even the firefighting squad at Hualien Airport had been trained to identify the type of commercial aircraft in question.

Other interviews of security personnel at the scene suggest that many volunteer firefighters arrived at the airport shared by the military and civil agencies by car or motorcycle. It is indicated in Article 4 of the agreement on joint military-civilian firefighting backup and rescue efforts that, in case of a commercial aircraft accident at an airport shared by the military and civil agencies [Shuinan (Taichung), Chiayi, Tainan, Pingnan, Hualien, Makung and Shangyi], the Aviation Police shall be responsible for the security outside the airport and the military shall be responsible for both security at the scene and imposing traffic restrictions. The civil aviation personnel carrying out orders at the scene shall carry identification credential issued by the station or will not be allowed in. Security personnel shall keep out volunteer firefighters not carrying identification.

The version of events given by the Flight operations section at Hualien Airport and the firefighting squad at Air Force’s 401st Wing indicate that Flight operations section fire engines were positioned as in Fig. 1.15-5 and Air Force 401st Wing Firefighting Squad vehicles were positioned as in Fig. 1.15-6.

According to the Review Report on Rescue Waged by the Air Force during the Accident of B17912 UNI873 on August 24 (Appendix J) and information provided by Hualien Airport, we have the following statistics:

Fire Fighting Squad of Hualien Airport	8 persons	5 sorties
Fire Fighting Squad of Air Force 401 Wing	56 persons	9 sorties
Fire Fighting Squad of Chiashan Air Base	24 persons	9 sorties
Fire Fighting Squad of Hualien City/County	187 persons	9 sorties



1-1-1: First position of Vehicle 1 of Airport on the first round

1-1-2: Second position of Vehicle 1 of Airport on the first round

1-2-1: First position of Vehicle 1 of Airport on the second round

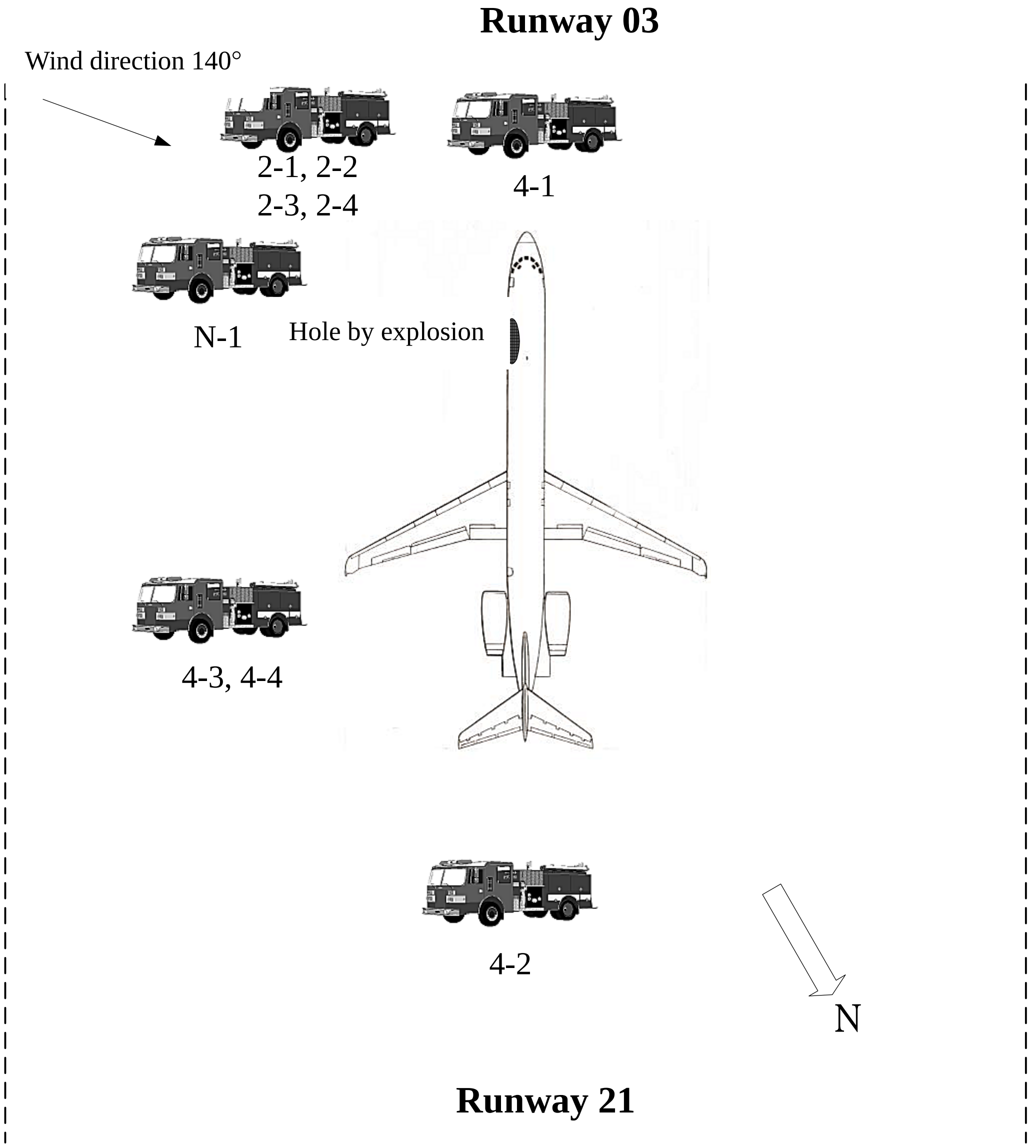
2-1-1: First position of Vehicle 2 of Airport on the first round

2-1-2: Second position of Vehicle 2 of Airport on the first round

2-2-1: First position of Vehicle 2 of Airport on the second round

3-1-1: First position of Vehicle 3 of Airport on the first round

Fig. 1.15-5 Allocation of fire engines of Hualien Airport for UNI873



2-1: Position Round 1 Vehicle 2 of Air Force 2-2: Position Round 2 Vehicle 2 of Air Force

2-3: Position Round 3 Vehicle 2 of Air Force 2-4: Position Round 4 Vehicle 2 of Air Force

4-1: Position Round 1 Vehicle 4 of Air Force 4-2: Position Round 2 Vehicle 4 of Air Force

4-3: Position Round 3 Vehicle 4 of Air Force 4-4: Position Round 4 Vehicle 4 of Air Force

N-1: Position of Round 1 of Water tanker of the Air Force

Fig. 1.15-6 Allocation of fire engines of the Air Force for UNI873

1.15.4 Emergency measures taken at the airport

The Commercial Aircraft Accidents Procedure Regulations (announced on November 16 1998), and the agreement entered between the Hualian Airport and the 401 Wing posted at the Hualien Air Base on firefighting and rescue support, state that the director of the airport or the proxy shall be responsible for accidents of commercial aircraft in the airport.

Rescue personnel and other witnesses at the scene state that Air Force 401st Wing personnel were in command that day. The scene commander (the chief of staff of the wing) indicated that upon notification they contacted the tower to verify the alert and then the commander of the wing was duly informed. Air Force personnel arrived at the scene at 1250~1255.

The flight controller of the wing that first arrived at the scene took charge of the initial phase. He was on duty in the control room at the moment of the accident. When he became aware of the accident, he took the Follow Me cart that was guiding a Far Eastern aircraft and drove it to the scene. He then contacted the tower using his radio handset and asked for fire engines, ambulances and buses. At the scene, the flight controller led the passengers back to the lawn. He then guided fire engines and ambulances. The flight controller relinquished command when the commander arrived.

According to the Commercial Aircraft Accidents Procedure Regulations at Hualien Airport, the director of the airport shall have overall command and the Chief of airport flight operations (or the airport flight operations first officer) shall be the scene commander. At the moment of the accident, the airport flight operations first officer was on the ramp, which is next to the Air Service on-duty room. When the tower informed the Airport flight operations information officer of the situation on Runway 03, the information officer took a Polaroid camera and drove to the scene in a firefighting squad patrol car. At the scene he asked the Hualien Airport UNI Director to arrange buses to take the passengers to the VIP room; it was there that the passengers were counted. Polaroid pictures were taken for record purposes.

According to the aforementioned operating procedure, the Airport flight operations section information personnel shall form the coordination team. For successful operations, the airport shall coordinate with all relevant agencies to dispatch fire engines and ambulances for the rescue effort. However, Air Service Station information personnel indicated that there are three types of telephones in the on-duty room for contact with the tower: a red one to notify accidents, a black one for regular use, and a third used as an extension line. The accident notification came via the extension line. Upon notification from the tower, fire squads 209 and 210 were notified at 1238. At 1240, the Airport Director of Internal Affairs was notified and was asked to notify the General Affairs director and the on-duty officer. At 1242, Aviation Police were asked to open the VIP room for injured passengers and to provide drinking water. At this point, the Information Director took over the telephone contact effort. At 1247, the director called 119 for backups with ambulances. At 1300 the tower requested that he call 119 again.

1.15.5 Medical care and the first-aid effort

Ambulances and office vehicles from the 401st Air Wing took 28 injured passengers to the hospital.

According to the air wing medical squad, passengers gathered by the front left wing and front right of the aircraft after evacuating from the aircraft. There were three people, including a doctor, in the ambulance that was standing by at the air wing fire squad. When they heard the alert, the ambulance moved immediately to transport the injured. The second ambulance arriving at the scene had an aviation doctor and a nurse and cared for the seriously wounded passengers. The third vehicle, belonging to the wing commander, followed the second ambulance and took the pregnant woman who had lost consciousness after the explosion to the hospital. The ambulance dispatched by the Hualien Police Department's Peipu Team carried five injured passengers to the hospital. The other passengers were carried to the hospital on board of Air Force vehicles. Ambulances and office vehicles of 401 Air Wing, ambulances of the 805 Air Force Hospital at Chiashan Air Base, ambulances of the Hualien City Fire Squad and that of other hospitals also took part in the effort. Uninjured passengers were sent to the airport VIP room.

Airport medical personnel state that they were on lunch break (1200~1300) when the accident took place and were never notified. They became aware of the accident when they saw the fire engines and patrol vehicles moving onto the field. When they checked with the Airport flight operations section, the Air Force ambulances had arrived at the scene and took the order of the lieutenant of the medical squad to take care of the passengers in the VIP room. They also helped register the passengers being sent to the hospital and note their status. (Note: Both the training provided to the medical team at the nursing room of the Airport flight operations section in the airport and the first-aid team assigned in the drill aim to provide care and calm to passengers.). The Air Force air control team sent the call for ambulances to the tower by radio and then the tower made additional radio calls. At 1243, the scene commander requested backups with ambulances from the 401st Air Wing and the Chiashan Air Base. The tower was also asked to request that the Aviation Police and the

Armed Forces Hualien Hospital send ambulances. Tower records state that ambulances from Chiashan Air Base and the 805 Air Force Hospital arrived at the airport at 1250 while the Air Service Station sent a 119 request for ambulances to the Hualien City Medical Network at 1247.

Security and traffic control personnel at the scene indicate that the ambulances from outside the airport arrived approximately 20-30 minutes after the accident.

Of sixteen injured passengers interviewed, 9 stated that they were carried to the hospital by ambulance and 7 by administrative vehicles.

The 28 injured passengers were sent to the Armed Forces Hualien Hospital and the Buddhist Tsuchi Hospital; both maintain a medical backup agreement with the Hualien Airport.

The resources employed by the medical first-aid system are given as follows:

5th Medical Squad of 401 Air Wing	31 people	7 ambulance trips
Hualien County/City Police Dept. Fire Squad	N/A	12 ambulance trips
Hualien Airport	7 persons	N/A

1.16 Tests and research

CIB/FSD test and analysis: After the accident, a total of 763 items were gathered from the cabin and runway, mainly skin fragments scattered from the explosion. (Attachment 1)

Report on Materials by the Chungshan Institute of Science and Technology: From the 763 fragments, we have found remains of a motorcycle battery (Evidence 584) and a piece of wire (Evidence 219) that are probably associated with the explosion. Both were sent to the Aircraft Materials Section, Aerospace Division at Chungshan Institute of Science and Technology for further tests. The motorcycle battery underwent a polarity acid liquid test. The electric wires taken from the positive and the negative lead of the battery and the one gathered on the runway were be subject to an electron microscope scanning (Attachment 2). The institute shall conduct additional tests to determine the cause of the explosion, to include the oil vapor concentration. (Attachment 3)

A simulated test of the explosion in the bin was conducted using a wooden box of identical capacity (1000 liters). A physical bin of identical construction to the original material yet of a reduced capacity (375 liters) was used for another test. The purpose of doing this was to compare the explosion and burn of the accident with the test. Pressure of the explosion was measured for estimation of the destruction to the structure. The institute conducted the test at an unknown firework test site in Southern Taiwan.

1.17 Organizational and management information

1.17.1 Emergency organization and management at the airport

1.17.1.1 Airport Flight Operations Section and the Airlines Accidents Procedure Organization

Article 5 of the Commercial Aircraft Accidents Regulations:

1. Section chief: The chief of the Airport flight operations (when the section chief is absent, the first officer shall be the proxy) shall be the scene commander.
2. Coordination team: the on-duty officer in the Flight operations section of the airport shall form this team.
3. Firefighting team: firefighting squads at the air base and the airport shall form the team.
4. Medical team: the first-aid teams of the airport and the airline of the accident aircraft shall form this team.
5. Security team: This shall be formed by the Aviation Police station.
6. Properties team: This shall be formed by the airline of the accident aircraft and the Aviation Police station.
7. Wreckage team: This shall be formed by the airline (or the agent) of the accident aircraft.

Further, the commercial aircraft accidents regulations of UNI AIR at Hualien Airport state that the aircraft accidents team consists of the General Commander, Coordination Team, Fire Fighting Team, medical Team, Rescue Team, Security Team, Reception Team and Properties Team. All teams shall become operational and ready to take orders from the scene commander.

1.17.1.2 Organization of the Fire Fighting Squad subordinated to the Flight Operations Section of Hualien Airport

Governed by the Airports Organic regulations of the Ministry of Transportation and Communications, Civil Aeronautical Administration, the fire fighting resources at the Hualien Airport shall include 1 captain, 2 supervisors, and 12~16 firefighters. However, the firefighting squad did not have a designated captain nor supervisor and the 9 firefighters operate on two shifts of 4 personnel, from 0700 to 2200.

1.17.2 The Aviation Police

[Organic regulations for the Aviation Police, National Police Administration, under the Ministry of the Interior]

Article 2: The Aviation Police, National Police Administration under the Ministry of the Interior (hereinafter referred to as This Office) has the following responsibilities:

1. To provide protection to the civil aviation industries and facilities;
2. To provide security protection to commercial aircraft in airports;
3. To conduct criminal investigation, security and associated restrictions in airport areas;
4. To conduct identification checks of passengers passing the state borders and handling foreign affairs;
5. To conduct security checks of luggage and other items carried by passengers and crewmembers boarding commercial aircraft of the Republic of China and other nations;
6. To provide security checks of cargo carried by commercial aircraft of the Republic of China and other nations;
7. To provide assistance in case of emergency and prevent disasters in airport areas;

8. To provide assistance in the implementation of the civil aviation law and other relevant affairs;
9. Other responsibilities as required by relevant laws.

To carry out civil aviation business, This Office shall be subject to the command and supervision of the Civil Aeronautical Administration under the Ministry of Transportation and Communications.

1.17.3 Civil Aeronautical Administration

Neither the Organic Regulations No. 8700124000 for the Civil Aeronautical Administration under the Ministry of Transportation & Communications, revised and announced on June 24 1998 by Hwatsong (1) Yi, nor the Operation Regulations for Civil Aeronautical Administration under the Ministry of Transportation & Communications No. 002112, revised on April 27 1996 by Jiaoren (85) of the Ministry of Transportation and Communications, fail to explicitly designate any authority responsible for the management of hazardous materials.

1.17.4 Commanding authority over commercial aircraft accidents as agreed by both the military and the civil aviation

According to the Civil Commercial Aircraft Accidents Regulations of the Hualien Airport, in the event of an accident, the airport's Chief of airport flight operations (when the section chief is absent, the first officer shall be the proxy) shall be the scene commander. As stated in Article 9 of the Firefighting and Rescue Backup Agreement entered between the Air Force 401 Wing at the Hualien Air Base and the Hualien Airport, the military shall take the command of the firefighting efforts involving military aircraft or buildings and the civil agency shall take the command at accident scenes involving civil aircraft or buildings. The agreement additionally states that civil authorities are in command of firefighting and rescue backup in accidents involving either military or commercial aircraft at airports shared by the military and civil agencies.

1.18 Other information

1.18.1 Regulations for management, inspection and operation of hazardous materials

[State Security Law]

Article 4 When deemed necessary, the police or the border security agency shall have the authority to check the following personnel, materials and transport means:

1. Departing or arriving passengers with their luggage;
2. Departing or arriving vessels, aircraft and the passengers or cargoes;
3. Vessels and aircraft traveling inside the Republic of China and their passengers and cargo.

Article 19 The inspection to be imposed on aircraft departing from or arriving at the Republic of China with passengers and materials shall be conducted as follows:

1. Aircraft: Cabin inspection.
2. Personnel, vehicles moving in and out of restricted areas at airports carrying materials shall bear certificates;
3. Passengers and crew: inspection with instrument or body search;
4. Carry-on luggage of passengers and crewmembers: The luggage shall be opened for inspection;
5. Check-in luggage: After check-in, if a passenger decides not to board the aircraft, the check-in luggage shall be removed before the aircraft

takes off. Otherwise a written guarantee shall be produced by the airline.

Article 21 The inspection to be imposed on aircraft with personnel and materials traveling in the Republic of China shall be conducted per Clause 1 of Article 19. When boarding the aircraft, the passengers shall be duly identified.

[Civil Aviation Law]

Article 43: Unless authorized by the Civil Aeronautical Administration, no aircraft shall carry weapons, ammunition, explosives, toxic gases, radioactive materials or other materials that would jeopardize air safety.

Airline personnel, aircraft staff and passengers shall not carry the aforementioned materials on board or use any communication devices that may interfere with airborne communications.

[Civil Air Transport Business Management Code]

Article 33 The Civil Air Transport industry shall abide by the Hazardous Materials Regulations stipulated by IATA when it comes to handling hazardous materials.

[Civil Air Transport Business Fixed-wing Aircraft Management Procedure]

Article 8 No aircraft is allowed to carry hazardous materials or explosives. Exceptions would only be allowed when authorized by the Civil Aeronautical Administration or when required by the operation of an aircraft or demanded by the safety of personnel on board or the hazardous materials are handled according to regulations stipulated by IATA.

[Taiwan Area Civil Airport Security Inspection Code] Revised by the Ministry of the Interior in 1998:

1. This code is prepared in pursuance of Art. 48 of the State Security

Regulations.

2. Unless otherwise stipulated, aircraft departing from or arriving at or traveling within the Republic of China with personnel and materials and personnel, vehicles and materials moving in and out of restricted areas in civil airports shall be inspected per this regulation.
3. The so-called restricted and banned materials referred in this regulation shall mean: (omitted)
4. Security check authority:

(1) National Police Administration under the Ministry of the Interior: Responsible for the planning and supervision of security inspections.

(2) Aviation Police: Responsible for the supervision of its subordinates in conducting security inspections.

(3) Aviation Police Taipei Office and Kaohsiung Office: Responsible for security inspections at the local airport with supervision on performance of security inspections conducted by the outlets.

5. Scope of security inspections:

(1) Cabin inspection of aircraft;

(2) Inspection of personnel, vehicles with materials and cargo moving in and out of restricted areas in airports;

(3) Passengers and crewmembers;

(4) Passengers in transit;

(5) Carry-on bags and check-in luggage;

(6) Cargo;

(7) In-bond cargo;

(8) Identification of passengers traveling on domestic flights.

Article 16 Inspection of aircraft traveling within Taiwan with personnel and materials shall be inspected in pursuance of the regulations given in this code. All passengers shall be duly identified when boarding the aircraft.

The Aviation Police is responsible to conduct security inspections in pursuance of the [Airports Security Inspection Handbook] published by the National Police Administration under the Ministry of the Interior on November 5 1993.

Further, the Aviation Police Security Inspection Instruments Function Requirements and Evaluation Report identifies:

5. Items that fail security inspections:

(1) to (4) (omitted)

(5) Hazardous materials:

Knives, bats, toy guns, electric appliances, stunt sticks, canned gas, sprayers, grease removers, fuel, lighters, volatile and inflammable substances, corrosive substances, acid and alkaline substances, batteries, unstable metal powders, liquors, banned radio materials, radio remote controls, magnetic items, banned radioactive substance and other hazardous materials.

When conducting checking of banned materials (Enhanced Security Inspection Scheme of Hang-ching-chien No. 147 of March 25 1998), the following shall be followed:

Cans

(1) First check for intact seals, if the seal is removed, then check if the can contains any hazardous material (inflammable, explosive, corrosive, magnetic or toxic substances.)

(2) If the seal is intact, then check if it is forged.

1.18.2 Cabin inspection of aircraft

Taiwan Area Civil Airport Security Inspection Code, Revised by the Ministry of the Interior in 1998;

In pursuance of the Aircraft Cabin Inspection Regulations, the Aviation

Police shall conduct inspections when necessary. The airline or the Aviation Police shall conduct inspections regularly. When the inspection is conducted by the airline, Aviation Police shall provide assistance and supervision.

1.18.3 Airlines security inspection regulations

[UNI AIR Cabin Inspection Regulations]

In pursuance of Nei-ching No. 8670623 of September 18, issued by the National Police Administration under the Ministry of the Interior, and Han-ching-chien No. 21415 issued by the Aviation Police on October 1 2000.

(3) Responsibilities of agencies in association with cabin inspection of aircraft departing from or arriving at the Republic of China or in domestic flights:

1) Engineering: To be responsible for the cockpit and electronic and hydraulic cabin.
2) Aviation: To be responsible for inspection of stowage bins above passenger seats, passenger seats, main cabin and tail galleries.
3) Services: To be responsible for lavatories by the cockpit, lavatories in the main cabin, front and mid cabin of MD-90, cargo compartments of DHC-8, DO-228 and BN-2 aircraft.

1.18.4 Emergency training for flight attendants

In Art. 66 of the Air Flight Management Procedure stipulated by the Civil Aeronautical Administration in 1997, on-duty training for flight attendants is regulated as follows:

Article 66 The aircraft operator shall produce and implement duly approved annual training programs, so that the flight attendants would be familiar with the following:

1. Capable of handling emergency situations or duties and assignments required for emergency evacuation.
2. Familiar with the use of emergency and survival equipment such as life vests, life raft, emergency exits, slide raft, portable fire extinguishers, oxygen gears and first-aid medical kit.
3. Aware of physical conditions during flights at over 10,000 feet in altitude without oxygen or when the cabin depressurizes.
4. Being aware of duties and assignments of other crewmembers in case of emergency.
5. Full knowledge of hazardous materials that might be carried on board and having receiving training on hazardous materials.

Chapter 2 Analysis

2.1 Aircraft explosion analysis

The analysis of the explosion of the aircraft involved in this investigation examines two areas: one is the destruction of the aircraft at the scene, on which the basis for the cause of the overall explosion is formed and, the other is the possible relationship between the causes and effects based on the evidence of the aircraft system as well as the position of the route. Finally, a physical test is conducted to further demonstrate the conclusions of the two analyses given above.

2.1.1 Analysis of the explosion

Both the direction of the broken skin and the breaking pattern of the screw of the stowage bin as evidenced in the comparison of the destruction at the scene and the gathered system data indicate that the entire skin was ripped open by the explosion created from inside the cabin. According to fracture mechanics, the L6 longeron suffers the largest and longest crack at the point of initial impact and then continues up to L3 along the rivet hole line and down to L9. (Below the longeron is the insulation lining and a number of electric wire pencils along the fuselage and under them go the stowage bin). The explosion could have developed in the following ways:

(1) The skin on both sides of the explosion point was ripped open along the rivet line. Although the cracks were of different lengths, the pattern was the same. The laboratory report conducted by the CIB shows no trace of explosion dynamite, suggesting that explosives could not have caused the explosion. The area of the damaged is not only extensive but also evenly distributed. Indicating that it was a gas explosion of medium pressure and lasting a longer length of time.

(2) According to witnesses on board they heard the explosion (some heard more than one explosion), then felt the pressure of the explosion. They believed that the explosion was first confined to a specific area but the pressure built up exceeds the maximum capacity, causing the explosion. Those who witnessed the explosion outside the aircraft recounted two versions: (Version 1) Air force personnel insist that they saw the aircraft skin rip open first and then thick smoke emerge from the hole. (Version 2) Pilots of the Far Eastern Air Transport Corp. allege that they saw thick smoke come out from the third window and then a few seconds later, the skin (from Window 11 through Window 14) rip open. This version does not match the fact that the fire at the scene of the explosion stopped at around Window 3. As the A/C duct in the neighborhood of the explosion shows burn marks running from top to bottom, this suggests that the explosion could not have been created from outside the bin.

(3) The ripped-open skin shows a visible mark of peeled paint in the center of the top section, possibly caused by the impact of fragments from the damaged part or objects in the bin that were forced out by the explosion. The mark has an irregular shape, 8 cm in diameter, and

can not be the result of an impact caused by any fragment such as a longeron, rivet or A/C duct, though it could have been made by objects in the bin. This suggests that the explosion could have occurred inside the bin, not in the small space between the bin and the airframe.

(4) Owing to the extended fire fighting effort, the upper fuselage was totally engulfed by the flame. The study conducted on the wreckage at the scene shows that it consists of aluminum alloy skin and that the ashes consists of the furbishing material of the aircraft and the main cabin components. The burnt axial bundle along the fuselage and the charred insulation material of the wiring bundle in the neighborhood of the explosion suggest that the wiring in the front and the rear section was exposed to different temperatures, indicating that there should be no other explosion or detonation point other than that of the suggested area.

2.1.2 Analysis of the detonation point and the detonation mechanism

The study of the wiring diagram and the exhibits left at the scene suggests three potential detonation mechanisms:

(1) Spark in the electric wiring or equipment on the aircraft: The wiring bundles in the neighborhood of the detonation point come in bundles that do not pass through the bin and PSU bundles. The first consists of 9315 (galley power supply), 9300 (CAT I bundle), 9301 (MAIN CABIN DC, CAT II), 9302 (MAIN CABIN NOISE SENSITIVE) and

9305 (APU GEN CONTROL) duly allocated longitudinally along the airframe. The latter is inside the bin and in connection with the PSU. Inside the bin there is a power supply stabilizer for the PSU lighting.

(2) Chemical oxygen generator: This is a closed recipient that contains oxygen-containing compounds and it is wrapped with a clad to keep it from contacting other system wiring. When in use, the trigger is pulled by the wire to decompose and release the oxygen chemically, forming an auto-sufficient oxygen system of high temperature.

(3) Spark in the battery in short circuit: The battery that was found under seat 5C and the mono-core metal wires were scattered on the runway (it is not a metal wire used on any aircraft). Microscope tests and further comparisons were conducted at the Aeronautical Research Dept. of the Chungshan Institute of Science and Technology on both the battery and the metal wire to indicate that the battery was damaged by alien forces and the remaining wire around the polarities and the scattered metal wires belong to one conductor. See Attachment 2 for the verification and the analysis report.

Accordingly, we could establish the cause of the explosion: the four wire bundles 9315, 9300, etc. are located between the outside of the bin and the skin of the fuselage. While the 9315 is of a 3-phase 115-Volt AC of higher voltage, the rest (of the) bundles have quite a low voltage and current load. With the objects in the bin scattering on the runway as result of the explosion and the skin showing peeled paint caused by impacts from heavy objects, we can assume that the explosion could not have taken place between the outside of the bin and the skin of the fuselage. In searching the lower portion of the wreckage of the bin, the upper portion was totally consumed by the fire, though the bottom (for PSU) remained intact. Had there been a fire triggered by the high temperature of the chemical oxygen generator, the substrate of the bin would have shown burn marks. At checking the oxygen generator gathered at the scene, there remained intact despite the fire; Since the oxygen generator is installed in the PSU, any burn or explosion would have drawn (the) attention of the passenger and the interior furbishing and the lower level of the bin would have been severely damaged, which is not what we saw at the scene. The light tube fragments and the sockets we gathered at the scene show no burn marks, allowing us to assume that objects contained inside the bin must have created the explosion.

As we have found a battery with broken metal conductors attached, we could assume that sparks created by the short circuit in the battery of (3) ignited the vapor. When the mixture of vaporized gasoline and air reaches a specific concentration, it ignites when heated and the inflammable gas then expands from the detonation point and the thermal impact of the gas molecule would parallel that of the flame. When the molecular thermal impact speed exceeds the minimum impact speed required, the flame would then explode. The bin in the explosion is twice the size of the others, providing the required room for an explosion of this nature.

2.1.3 Analysis of the leaking bleaching liquid bottle and the destruction test of the bin

Our assumption: The seepage test conducted on the bleaching liquid bottle containing gasoline that we found on the runway and under seat 7C in the main cabin by the Chungshan Institute of Science and Technology shows that although the bottle was sealed with silicon glue, after prolonged exposure to gasoline, leakage may have occurred in minimum concentrations that still would not invite any explosion. In order to reach the minimum concentration to ignite the liquid may have escaped due to accidental loosening of the cap, squeezed loose during handling, or the liquid simply leaking from the mouth of the bottle. Tests show that in a short period of time, gasoline contained in a bottle may evaporate into the air and ignite if significant concentrations have been built up. Reconstruction of the same environment of the bin in a closed vessel, having a bleaching liquid bottle containing gasoline of the same volume, allows us to check whether a battery of the same type could causes a short circuit to ignite the leaking gasoline and the detonation pressure is recorded from this experiment is the basis of the structural destruction analysis.

After numerous tests of differing volumes, we found that the amount of oxygen contained in the recipient increases the growing capacity, inviting more heated flames and eventually detonating, as the pressure may reach 290PSI.

As the 1000-liter bin was not available, a test was conducted on a wooden case. For the honeycomb material used in the bin, a 375-liter bin (for B-727 aircraft) was used for burning and destruction tests. The tests show that the explosion created in the smaller bin was capable of ripping open the lid while emitting a large volume of thick smoke with the burn. This does resemble the physical situation. The test report is given in Attachment 3.

2.1.4 Structural destruction analysis

Structural damage at the scene shows where the skin ripped off along the rivet line, and where some rivet holes were forced open and the longeron and the reinforced ribs either bent or broke off. Three longerons were found on the runway. They were destroyed by an expansion force that developed from inside out, by shear and even by tension. Tension may have caused most of the peeled paint. The instant explosion must have caused the evenness of the longeron opening.

All the rivets and the longeron at the scene were destroyed. The long duration of stress destroyed the fragile rivet joint first and then the remaining pressure broke the longeron. The peeled paint on the skin as a result of impacts by heavy objects suggests how the explosion developed and how the objects hit one another. Rivets in the neighborhood of the impacts show peeled paint too. As a complicated chemical reaction, the vapor explosion itself may create the tensile/shear-resistant performance on single elements at a much higher level than 290PSI as suggested in the test; the 290PSI pressure was capable of destroying the latch of the bin. The most fragile component is the rivet joint. The rivet can endure as much as 500~600 lbs. of stress in the direction of the shear, though when joined with the skin, the tensile performance drops because of the installation work. Instantaneous tension could easily tear it off the opening, though the rivet itself would not break with the shearing of tearing force and this does match what we found at the scene. The thickest part of the longeron and the reinforced rib is .050 inches and they can be destroyed by the impact of a rapidly inflated gas. As the skin in this area was not ripped open, it does suggest that most of the energy was directed on the joint of the rivet/longeron. At the scene, we found the damaged bin and the door panel of the front section (row 5) near by the seat, though it was apparently intact and only suffered damage on the latch. This suggests that the vapor explosion inside the bin may have first exploded off the door to let in fresh air for a powerful secondary explosion. The conclusions given by the Chungshan Institute of Science and Technology (CIST) on the rebuilt bin explosion test report (Attachment 3) show that when the bin became exposed to the outside fresh air, the remaining fuel kept on burning for the secondary vapor explosion. The secondary explosion caused by the mixture of fuel and gas under proper circumstances is much more powerful than what the airframe and the interior furbishing can withstand. See Attachment 4 for the rigidity test and assumptions of the airframe aluminum components.

2.2 Management of hazardous materials

2.2.1 Hazardous materials carried onboard

The inspection regulations concerning bottles and cans given in Upgraded Security Inspection Program contained in 1.18.1 are also available in the Improvement Program on Security Inspections, though the Program is found in different meeting and training documents of the office rather than in any official operation procedure. The documents were given to the trainee section chiefs and policemen after training as publicity campaign materials. Verbal instruction was not enough to make the on-duty police force fully understand whether there was an inspection procedure for bottles and cans, or there would be any standards of training and review.

The bottles carried onboard by passengers containing the so-called bleaching liquid and softener was confirmed by tests to have gasoline. More than one piece of evidence gathered at the scene show reaction of the gasoline [the remaining inner wall of the upper part of the blue bleaching liquid bottle of exhibits No. 210 and No. 585 showed gasoline (Fig. 1.14-3 and 1.14-4)]. The inflammable and hazardous materials did pass the security check before being carried onboard.

2.2.2 Security check at the airport

Interviews with the assigned carryon luggage security personnel and videotapes indicate that the security personnel took out one of the

so-called bleaching liquid bottles a passenger was carrying, inspected it and then checked the other bottle too. The inspector said he had noticed a smell of bleaching liquid and saw some dried bleaching liquid around the mouth of the bottle and determined that it was bleaching liquid. The passenger was allowed to pass without having the bottles opened.
It is not difficult to notice gasoline (due to its particular odor), however a bottle containing such a fuel with its bottleneck sealed with silicon glue (Fig. 1.14-1 and Fig. 1.14-4) could keep prevent the smell from being detected. This suggests that the X-ray machine used at the security inspection did not detect gasoline.

The motorcycle battery found on the floor under seat 5C (exhibit No. 584, Fig. 1.14-1) is not of an aircraft material. The flight attendants serving the flight indicated that they had not found the item in the bin when conducting the pre-boarding cabin check. Obviously, the battery may have been in the travel bag of the passenger, who passed the security check and went onboard with the battery. The X-ray machine did not detect the battery either.

2.2.3 Authority of management of hazardous materials

There used to be no government authority at all when it came to the management of hazardous materials. The Civil Aeronautical Administration then cited [Organic Regulations for Aviation Police Department under the National Police Administration]: "To execute civil aviation operations, Aviation Police shall be subordinated to the Civil Aeronautical Administration under the Ministry of Transportation & Communications". Then Aviation Police was designated to stipulate types and descriptions of hazardous materials carried onto an aircraft. Being the highest authority governing cargoes carried onboard aircrafts; the Civil Aeronautical Administration shall work with Aviation Police to stipulate types and description of hazardous materials before submitting it for approval and announcement by its superior. The wording adoption of the hazardous material management regulations prepared by IATA quoted from Civil Aviation Industry Management Regulations and Civil Aviation Fixed-wing aircraft Operation Procedure of 1.18.1 did not make the issue understandable.

2.3 Security check resources and capability

2.3.1 Security check equipment

All carryon luggages that go onboard UNI873 before its departure from Taipei have to go through the inspection room located on the East Side of the Taipei Airport. In the inspection room there are 3 mono-scale X-ray scanners. The one on the left side is for male passengers; the one on the right side is for female passengers, and the middle one is a standby unit. Each of the American-made EG&G System 8B X-ray scanners (Serial No. 920098-9200100) has a metal detector attached. Bought in January 1992, these machines were well maintained, though the X-ray scanner is unable to detect forged bottles or any liquids it may contain.

The mono-scale X-ray scanners used to check carryon and check-in luggage in the inspection room located on the East Side of the Taipei Airport has a fixed-type single X-ray emitter that emits X-rays right on the objects being checked. Manual reading is necessary to determine presence of hazardous materials. The screen turns orange when it detects organic or low-density substances and blue when it detects inorganic or high-density metal. The higher the density, the darker the blue becomes. When an object being checked is blocked by another object in the handbag or covered by high-density material, it cannot be identified on the screen nor can hazardous material marking be identified. When the container is made of high-density material, its contents cannot be detected either.

It is understood that the FAA does not certify the machine and there are no regulations in association with certification of security machines in the Republic of China. The security check equipment bought does not meet our needs, making the work of security inspectors even harder.

2.3.2 Training of security inspectors

Data in the Aviation Police Taipei Office indicate that there are two sources of security inspectors: contracted personnel and the police system. The internal training is rated on new recruits training, general training, quarterly training and monthly service training.

Suggested by the records of 1998 and 1999 training delivered to the Aviation Police Taipei Office security inspectors serving UNI873 and interviews with them, a portion of the new recruits never underwent any formal security check training, instead, they took instruction from other on-duty senior inspectors. With general training, quarterly training and monthly training, there is always a lack of trainees (attending) because of their work shifts. The beginner level training has no specific materials; annual training has no specific courses on hazardous materials or has courses but no physical tests of hazardous materials. Training records show only attendance rather than training performance. These types of informal training never reveal to us how much a trainee has taken. Additionally, the on-duty senior inspectors do not follow any standards when delivering instructions. Expertise and experience is lost causing the policemen in service to be rated unequally.

2.3.3 Security checks

The motorcycle battery (exhibit No. 584) that is rated as banned items (1.18.1) successfully passed through the Aviation Police detector; bleaching liquid (exhibit No. 210 and 585) that is rated as corrosive material and a banned item (1.18.1) were also carried onboard after passing through security inspection personnel.

2.3.4 Aviation Police Security Check Regulations

The Aviation Police Security Check Regulations were carried in the Airports Security Check Handbook published by the National Police Administration under the Ministry of the Interior on Nov. 5 1993. The handbook contains 11 pages, 25 articles and resembles the provisions contained in Taiwanese Civil Airports Security Check Regulations announced by the Ministry of the Interior. It carries only policy regulations and check directions; no detailed operations were given. On the other hand, Aviation Police has the [Upgraded Security Check Programs], [Improvement on Security Check Programs], [Enhanced Air Safety Check Programs], [Security Check Programs] and [Upgraded Airports Security Check Detection Programs] among other programs and plans. All these programs or plans carry repeated details and they fail to be filed on a uniform basis for easy access. When it comes to operation regulations and performance codes, there is just no standard data for reference at all.

2.3.5 Airlines security check

The contractor responsible for cabin cleaning has many divisions such as aviation, engineering, operations and flight attendants, each having a different responsibility. Each division carries out its own pre-boarding cabin cleaning and signs the checklist after detecting no irregularities to indicate that the task has been successfully executed. Only when each and every sector responsible has signed the checklist, can the cabin cleaning shall be declared successfully completed. Most of the checklists traced by personnel from Aviation Police Taipei Office lack signatures. Interviews with some operator personnel reveal that few know what their assignments are; some even believe it is not their job. All the cabin-cleaning checklists are filed with the Aviation Police for reference after the aircraft departs from the airport. Flaws in the checklists receive no comments or suggestions for improvement.

2.4 Execution of emergency command in military-civil airports

2.4.1 Execution of procedure of accident reports

Article 12 of the fire fighting rescue and support agreement entered by the Air Force 401st Air Wing stationed at Hualien Air Base, Hualien Airport states: *To ensure the safety of aircraft, airliner and facilities of both the military and the civil aviation, upon notification given by the control tower of an emergency, both the military and the civil fire fighting units shall start the alarm system to page the situation while rushing to the scene to provide rescue effort.*

Interviews with the Aviation Data personnel at the airport indicate that when notified of the accident via the extension line, an immediate notice was given to the fire squad, where a total of 5 fire fighters including the captain were on duty. Upon receipt of notification, the on-duty personnel answering the phone did not start the alarm system nor broadcast the situation as instructed above; instead, 2 on-duty personnel and 1 fire engine were dispatched. The other two people moved only when they heard the siren of the fire engine that had been dispatched earlier.

2.4.2 Commanding system

According to the Commercial Aircraft Accidents Procedure Regulations at Hualien Airport, Chief of airport flight operations of the airport shall have the commanding right. The scene commander must coordinate all the support provided by the airport and other divisions for maximum performance. As the Chief of airport flight operations was on a business trip, the airport flight operations first officer served as the replacement (in name only). It is stipulated that the airport flight operations first officer serve as the replacement for the Chief of airport flight operations, however the airport flight operations first officer had not been duly trained for this task and was unable to execute the commands at the scene.

Interviews with the Chief of Staff of the Air Force 401st Wing and both the military and civil fire fighters and guards working at the scene indicate that the Chief of Staff of the Air Force 401st Wing was in command at the scene, directing the fire fighters, paramedics, and guards, as well as the support force executing the rescue effort. The regulations and the agreement that designate command to the airport do not match the situation.

According to regulation, in the simulated rescue drill for commercial airliner accidents, the airport is in charge and the Air Service shall establish the rescue command center (the primary control station) and the scene commander shall be responsible for the fire fighting, first-aid and rescue efforts while allocating duties to the fire fighting and rescue forces coming from other agencies. At the same time, the scene commander is to time and progress to the primary control station. In the accident in reference, the military provided full support; only the airport commander, who lacked appropriate training for handling emergencies, failed to fully execute the authorized command. The stipulated commanding system failed to be fully executed.

2.4.3 Full play of all agencies working at the scene

Governed by the Commercial Aircraft Accidents Processing Regulations and the Commercial Aircraft Accidents Emergency Processing Regulations for UNI AIR at the Hualien Airport, agencies assigned to the scene shall include Chief of airport flight operations, On-Duty Officer, Airport Fire Squad, Air Base Fire Squad, Airport Medical Room, the airline and Aviation Police station. All these agencies shall be available when an accident occurs and they shall take orders from the scene commander.

When the accident occurred, the Airport did have its coordination team available and the Data Operator was responsible for the transmission of all data. A fire team was formed by both the airport fire squad and the Air Force fire squad, though the Air Service fire squad was not in charge of the operation. Four aviation policemen and the air base security squad formed the security team, though there was no commanding system available. One airport nurse, the airport operation personnel and the Air Force Medical Squad formed the rescue team and the airport nurse was not in charge of the operation as he was supposed to. However, the airline failed to have all duties designated to handle aircraft accidents as stipulated in the Commercial Aircraft Accidents Processing Regulations and there were no backup teams for systematic supports as suggested in the Commercial Aircraft Accidents Emergency Processing Regulations. Without any appropriate formation of human resources provided by the airport or the airlines, the operations executed at the scene were never realized as they were supposed to be.

2.5 Fire fighting, rescue at the airport and personnel training

The aircraft was on fire at 1236 after the explosion and the fire was only completely extinguished at 1345. The effort took more than 1 hour. In this section, we will discuss fire fighting, rescue at the airport and personnel training.

2.5.1 Joint effort of the military and civil fire fighters

After it met with the effort waged by the fire engines posted in the Hualien Airport, the Air Force 401 Wing and sent by the police of both Hualien

As a Class 7 airport rated by IATA, the fire fighting squad at the Hualien Airport is subordinate to the airport and it owns two large high-performance fire engines [(Protector 3000, of 3000 gallons), (Emergency One, of 3000 gallons)], one backup fire engine (SHKOSHM-1500, of 1500 gallons), and a lighting vehicle. Each of the two fire engines dispatched that day had two people on board to conduct the first round mission.

2.5.2 Firefighting skills

The Civil Aeronautical Administration does not provide any guidelines to airports concerning firefighting skills and procedures during air accidents. Consequently, the criteria given in the sections of the manual concerning rescue and first aid will be used to evaluate the firefighting skills involved in the rescue effort.

Human life comes first

According to the ICAO Airport Service Manual Part I Rescue and Firefighting, 12.2 Fighting aircraft Fire 12.2.1: "*The prime mission of the airport rescue and firefighting service is to concentrate firefighting efforts on those areas of the aircraft to permit the evacuation of the aircraft occupants."*

Clause 4, 5 of the Firefighting Support Agreement of Air Force 401st Air Wing stationed at Hualien Base, Hualien Airport states: *"The goal of all rescue efforts for either a commercial of a military aircraft shall be first to protect human life and then property."*

The Firefighting procedure of the air service fire squad stationed at Hualien Airport reads: "*The prime aim of firefighting efforts engaged on either an aircraft or building shall be to protect human life.*"

The above articles state that protecting human life come first in all firefighting laws covering military-civil joint efforts. The Chief of Staff of the Air Force 401st Air Wing - the scene commander on the day of the accident, stated that the aircrew counted only 59 passengers evacuating from the cabin at 1236. However, at 1307 the airport flight operations information officer produced the cabin manifest that confirmed a total of 90 passengers on board. The two figures suggest difference in number of passengers evacuated during the 31 minutes between 1236 and 1307. Although the final count did confirm that all passengers had evacuated safely, the military and civil firefighters and other personnel working at the scene were neither aware if all passengers had evacuated from the aircraft nor did they make any attempt to rescue human life from inside the aircraft. This is against the principles indicated above.

Assignment of fire engines

At the time of the accident, the wind was coming from 140 degrees and when the aircraft stopped, the wind turned from the left side of the aircraft toward the right side of the tail. According to ICAO airport Service Manual (Fig. 2.5-1), the fire engine was by the aircraft in an upwind position and the firefighting effort was concentrated on the initial location of the fire.

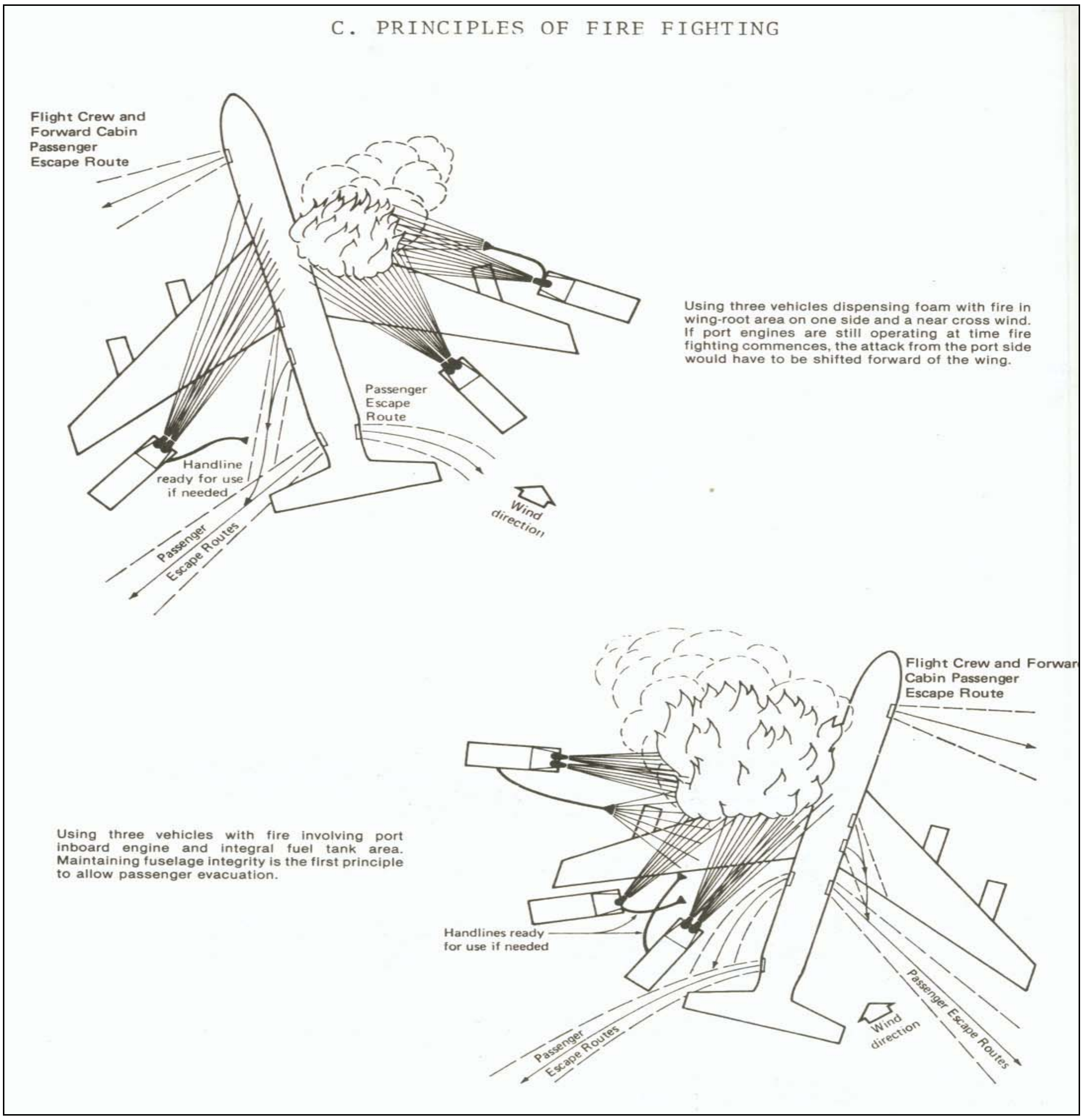


Fig. 2.5-1 ICAO airport Service Manual

Hose

The accident took place at the airfield when the aircraft engines were off. The aircraft had all seven rescue exits open and only a part of its fuselage on fire. With the wind coming from 140 degrees, the Hualien City Fire Squad was notified at 1259 and the first fire engine arrived the scene on the left side of the aircraft at 1312. Hoses were introduced into the aircraft from L1 door. The airport’s No. 2 engine had hoses in the aircraft at 1307 and 1317 and the hoses were pushed from the tail section forward. The fire was under control in approximately 10 minutes, at 1325. It took the firefighters some 30 minutes to decide to use hoses inside the aircraft. Up until that point, firefighters only used turrets to spray chemical foam into the skin hole measuring 1.45 0.42 meters. Some fire engines on a lower position could only aim the turret up at the skin, resulting in smaller coverage of the fire agent than the space of the hole. At the same time, the Air Force's No. 4 fire engine and the sir station's No. 2 engine were still shooting water from hoses. This is why it took more than one hour to extinguish the fire.

2.5.3 Other supporting agencies

It is important for firefighters to know the location of all facilities before an operation at the airfield. This includes the location of chemical refills and hydrants, the gridiron pattern of the aircraft, and dangerous and destruction sections of different types of aircraft. The investigation conducted by this office suggests that neither the Air Force 401st Air Wing fire squad, the Air Force Chiashan Air Base Fire Squad nor the Hualien City/County firefighters had access to such information. As a result, the firefighting effort took a long time.

2.5.4 Airport firefighters

The Hualien Airport is a Type 7 airport as rated by ICAO and a Class B airport as rated by the Civil Aeronautics Law. At the time of the accident, there were 2 large high-performance fire engines [(Protector 3000, 3000 gallons), (Emergency One, 3000 gallons)], a standby engine (SHKOSHM-1500, 1500 gallons) and a lighting vehicle at the airport. Each of the two engines assigned on that day had two firefighters on the first shift. There is no specific regulation in the operation manual or is there any international regulation concerning the number of firefighters on each of the two high-performance vehicles. Each fire engine would need four people to operate the turrets and the hoses on board (one commander, a driver and turret operator and three hose operators). As the airport is open 15 hours a day (2300-1400 UTC), it would mean 1,680 man hours in a two-week public servant working time of 84 hours, and would resultantly require 20 people. This figure does not consider worker absences or vehicle and equipment downtime. The Airport Organization Law states that the Hualien Airport should have a total of 15~19 firefighters. The station firefighting force stands at nine and is without sergeants or captains.

2.6 Medical service provided to air crash victims by the airport paramedics

2.6.1 Quantity and capacity of airport paramedics

The airport paramedics entered into a medical support agreement with Taiwan Christian Menor Church, the Armed Forces' Hualien General Hospital, the Buddhist Tzuchi General Hospital and the Provincial Hualien General Hospital. The agreement states that air crash victims shall receive priority treatment. Unfortunately, the civil agencies and Air

Force 401st Air Wing provided ambulances and office vehicles unaware of the agreement with the hospitals. The paramedics did not know the capacity of the contracting hospitals and resultantly some victims had to be transferred to other institutions. This was a waste of medical resources and time.

According to the Hualien Airport Paramedics organization, the paramedic service and the personnel posted at the station is led by the nurse of the paramedic team. Art. 5 of the Hualien Airport Civil aircraft Accident Procedure indicates: *The paramedic service is composed of the airport emergency service and the airlines (or agency) of the accident aircraft.* The firefighting support agreement signed by the Air Force 401st Air Wing at the Hualien Air Base shows that no medical support should ever be provided. Paramedics responding to the accident were not trained as outlined in the agreement. Of the seven-member rescue team involved in the accident, not one did anything beyond pacifying the uninjured passengers gathered in the airport VIP room and helping those suffering minor injuries apply first aid. No members of the airlines were either present during the rescue effort or reported to the nurse of the paramedic service.

As all 31 members and 7 vehicles of the 5th Medical Squad of the Air Force 401st Air Wing, in addition to outside medical resources, were fully engaged in the rescue effort, it is apparent that the airlines lack the medical resources necessary to deal with an accident.

2.6.2 Airport medical resources

According to the organization regulations stipulated by Civil Aeronautical Administration under the Ministry of Transportation and Communication for the airports, the Hualien Airport is supposed to have a physician and a nurse. While there is a nurse on the staff of the airport, the nurse was not on duty at the time of the accident. This does indicate the shortage of medical resources in the airport.

2.7 Air crew emergency reactions

2.7.1 Main cabin evacuation procedure

The captain applied the aircraft's emergency brakes after the explosion and, following standard procedure, attempted to emit the EVAC, EVAC, EVAC signal using the PA system before turning off the engines. After turning off the engines and leaving the cockpit, the captain used his flashlight to check the cabin. Because of the thick smoke, he called out asking if anyone remained but turned off the battery and left the aircraft from L1 when there was no reply. Remaining alongside the aircraft, he assisted injured passengers. The chief flight attendant, who had left the aircraft earlier, did not report to the captain whether there were still passengers left onboard. The captain was the last of the aircrew to leave the aircraft and was unsure if there were passengers left behind. The two severely injured passengers left the aircraft on their own.

After calling EVAC, EVAC, EVAC, the co-pilot grabbed the flashlight and the fire extinguisher and proceeded to extinguish the fire together with L1' flight attendant. They then attempted to rescue more passengers. While they heard passengers crying for help, they were unable to see them due to the thick smoke. The co-pilot left the aircraft first and then tried to enter into the cabin again from the tail ladder. Again the thick smoke halted him. When the co-pilot turned to the right wing, the passengers in 7H and 8H appeared at R2 emergency exit. He then helped the two severely injured passengers leave the aircraft from behind the wing. (The previous paragraph says that they left on their own? LJB)

The chief flight attendant left the aircraft after 2 or 3 more passengers had left the aircraft from L1 emergency exit. She then assisted other passengers by the slide raft. According to articles 8-6-5 and 8-7-5 of the flight attendant handbook's emergency evacuation procedure, the flight attendant by the evacuation door shall encourage two passengers to go down the side raft and then assist the other passengers by the sideway. The flight attendant failed to do this. As consequence, there was one flight attendant left by L1 door assisting the passengers while the chief flight attendant was assisting by the sideway. No one was at the R1 door to help passengers evacuate. There were two flight attendants by L4 door evacuating passengers (the A5 door is not open) but no one by that door's sideway. There was a lack of resources by the aircraft.

The aircrew in this case failed to adequately assist passengers and guide them from the aircraft safely, to count them and verify that everyone had left, or to gather them near the aircraft, as suggested by the UNI AIR flight attendant handbook and the aircrew emergency evacuation manual.

2.7.2 Relaying the evacuation order

Article 8-7-2 of the UNIR AIR flight attendant handbook states that the captain shall send all messages to the supervisor, who will relay them to the aircrew. At the time of the explosion, the evacuation signal was not relayed from the cockpit to the flight attendants in the front section. They concluded that the PA was off because there was no power available and the evacuation path was packed with passengers. They did not have time to reach the portable loudspeaker located in the bin above the seats of the first row. Since the aircraft was not equipped with an Evacuation Signal Panel, the flight attendants in the rear section did not receive the evacuation order. Following the pleas of passengers, the flight attendants opened the L4 evacuation exit after the aircraft had come to a full stop.

Art. 19 of the Republic of China Airlines Fixed-Wing Aircraft Operations Procedure states that all portable loudspeakers must accessible to the flight attendants. FAR121.207, 125.309 of the U.S. Civil Aviation Law requires that the aircraft carry at least two portable loudspeakers and be located with easy access near designated seats in both the front and the rear sections of the aircraft. JAR-OPS-1.810, AMC-OPS-1.810 of EU Civil Aviation Law also states that portable loudspeakers must be accessible to the flight attendants.

The flight attendant handbook states that during an emergency evacuation, the front section flight attendant shall be by the aisle of L1 and R1 emergency exits and that her normal seat must be near the L1 exit aisle. However, the portable loudspeaker is located in the main cabin bin, without easy access to the flight attendant in case of emergency. This hindered communication between the front and the rear sections of the main cabin.

Chapter 3 Conclusions

3.1 Findings

1. This accident is not associated with the aircraft system, pilot's maneuvers, aircraft maintenance, aviation control or weather.

Evidence tests and laboratory work

2. The laboratory tests on evidence collected by the Criminal Police Bureau revealed bleaching liquid and softener bottles containing a flammable material (gasoline) were onboard the aircraft. (1.14.1)
3. The motorcycle battery found at the explosion scene shows metal conductor fragments on the polarity rod that is of the same material as the metal conductor found among the fragments on the runway. (2.1.2)
4. The analysis conducted by Chungshan Institute of Science & Technology indicates that a short in the battery could have ignited the vapor (2.1.2; Attachment 3; CIST "Aircraft Bin Explosion Reconstruction Test").
5. Gasoline leaking from the bottle filled the bin and vaporized. The gas vapor ignited when the battery short-circuited. (2.1.3; Attachment 3; CIST "Aircraft Bin Explosion Reconstruction Test").

Management of hazardous materials and security check

6. The Civil Aeronautical Administration fails to assign responsibility for hazardous materials management to any agency. (1.8.1; 2.23) in its Organization Regulations and Procedures.

7. There is no agency responsible for systematic compilation of Hazardous Materials Processing Regulations prepared by ICAO. (2.2.3)
8. The security inspection systems available in the airport failed to detect illegal containers or identify the liquid they contain. The mono-scale X-ray instrument depends on manual reading for materials of potential hazard. The security inspection system does not meet the physical requirements and additionally demands additional security inspectors and a heavy workload. (2.3.1)
9. Some new recruits lack proper security inspection training and initial training on specific materials. There is also no annual training on physical testing of hazardous materials. Training records show only attendance and no review records, therefore preventing accurate assessment of trainees. Poor training by senior personnel results in incompetent inspectors. (2.3.2)
10. The prohibited motorcycle battery went undetected by the Aviation Police instruments and the bottled gasoline passed by the inspector. (2.3.3)

Survival factors and aircrew emergency measures

11. Injured passengers were seated between row 5~11; therefore, that this was the sector where the explosion took place. (1.13)
12. The fragments from the seat of the severely injured passenger extend from the left row toward the right; therefore, the explosion forced the bin open rightward and downward. (1.13)
13. The 3-year-old boy who suffered a minor injury was not seated alone. (1.13)
14. The R3 emergency exit was not open. (1.15.2)

15. Following the explosion, the captain gave the order to evacuate right after applying the brakes and before turning off the engines. (1.15.2)
16. The chief flight attendant manually opened the L1 sideway and then left the aircraft to assist the passengers along side the aircraft. This was contrary to the standard procedure given in the flight attendant handbook. (1.15.2)
17. Thick smoke in the main cabin prevented the aircrew from completing their checks before leaving the aircraft. (1.15.2)
18. The main cabin paging system failed after the explosion and flight attendants were unable to reach the portable loudspeaker. This prevented the evacuation message from reaching the rear section of the main cabin. (1.15.2)
19. The flight attendant responsible for the L1, R1, L4 emergency exits failed to enlist passengers who had left the aircraft earlier to provide assistance to those following on the sideway. As a result, several passengers were injured sliding down the sideway. (1.15.2)
20. Two disabled passengers were the last to leave the aircraft, as there was no one to assist them. The emergency evacuation took four minutes. (1.15)
21. The aircrew failed to determine whether there were more passengers left onboard, failed to guide all passengers to a point 200 feet upwind and then failed to count them. (1.15.2)
22. The airline failed to join with the airport to provide aid as stipulated by the UNI AIR Commercial Aircraft Emergency Program at Hualien Airport.
23. Some of the flight attendant training courses were missing from on-duty training. (1.15.2)

Firefighting

24. Firefighters' were unfamiliar with the airframe and were unaware of areas critical in fires. Their focus on the exterior of the aircraft during the critical initial moments allowed the fire inside the cabin to expand. (2.5.2)
25. The firefighting equipment and vehicles at Hualien Airport do meet the standards suggested by ICAO for a Type 7 airport. (1.15.3)
26. The firefighting gridiron pattern used by the airport fire squad is different from the one used by the Air Force 401st Wing stationed at the airport. (1.15.3)
27. Stemming from their unfamiliarity, the airport's fire squad and other agencies initially only sprayed chemical agent and water using turrets at the broken skin. Only after 30 minutes did they begin to use pressurized hoses inside the aircraft. (1.15.3)
28. It took 1 hour and 9 minutes to extinguish the fire, leaving the upper part of the airframe fully consumed by the fire. (1.15.3)
29. Upon receipt of the alert, the first airport fire vehicle rushed to the scene without first notifying the other vehicles. (1.15.3)
30. The airport fire squad was short in resource (under-staffed or under-equipped?) and the first fire engine was manned by only two firefighters. (1.15.3, 2.5.4)
31. The auxiliary firefighting agencies were uninformed of water refill sites, dangerous sectors, destruction sectors inside the aircraft and the layout of the inside of the airport. (2.5.1, 2.5.3)

Emergency commanding

32. Discrepancies in physical responsible, scene commander and the operation agreement. (1.15.4)

33. It is stipulated in governing laws that the first operator should be in replacement of the aviation chief, he (she) would then be the scene commander, though the airport flight operations first officer has not been duly trained for this duty. (1.15.4, 2.4.2)
34. Poor structure of an inter-division command system that covers firefighting, medical care and security agencies backed by a mutual support system. (2.4, 2.5, 2.6)
35. The commander, scene commander and the supervisors did not have relevant information or the proper equipment to communicate with the backup forces. (2.4.3)
36. The outdated bell used by the tower to notify the firefighting agencies failed to give the proper alarm. (1.15.4)
37. The Civil Aeronautical Administration failed to establish principles for airport emergency plan, rescue, and firefighting and first-aid effort as suggested by Airport Service Handbook of ICAO, for relevant operation procedures in the airport. (1.15.3~1.15.5)

Medical service

38. Air Force 401st Air Wing failed to check and sort 28 injured passengers before sending them to the hospital. (1.15.5)
39. The airport paramedics are under-staffed, having only one assigned nurse. (1.15.5, 2.6.2)

3.2 Probable cause to the accident

A flammable liquid (gasoline) inside bleach and softener bottles and sealed with silicone was carried on board the aircraft. A combustible vapor formed as the leaking gasoline filled the stowage bin, and the impact of the landing aircraft created a short in a battery. The short ignited the gasoline vapor and created the explosion.

3.3 Contributing factors to the accident

3. The Civil Aeronautical Administration Organic Regulations and its operational bylaws fail to designate any entity as responsible for hazardous materials.

4. The Aviation Police fail to properly recruit and train personnel, to include preparing training materials and evaluating training performance. Some new recruits were found to have not received any formal security check training, but instead were following instructions from senior inspectors. Consequently, new inspectors cannot be relied upon to identify hazardous materials.

4. The detectors and inspectors failed to detect the hazardous materials. The detectors used by the Aviation Police did not detect the banned motorcycle batteries, nor did security inspectors detect the liquid bleach, a banned corrosive substance.

Chapter 4 Recommendations

4.1 Interim Flight Safety Bulletin

To prevent similar occurrence from happening again during investigation, the Council issued an Interim Flight Safety Bulletin on September 1, 1999 to alert regulatory agencies that following actions be taken immediately:

1. To upgrade emergency notification, the military and civil agencies at shared airports should conduct scene commanding and coordination drills.

2. To upgrade the firefighting agencies stationed in airports shared by the military and civil agencies having identifying types and structure (such as fuel tank section) of the aircraft operating in the airfield, so that immediate solutions could be provided in case of an accident.

3. Inspections at airports to insure that firefighting facilities are fully equipped, personnel are properly trained and emergency and rescue operation regulations are followed.

4.2 Safety Recommendations

To: UNI AIR

2. Implementation of a standard evacuation procedure and training of flight attendants thereon. The procedure shall specify the positions of

flight attendants for assisting evacuating passengers, directing passengers at the end of the sideway, conducting a check before leaving the aircraft, the assembly, evacuation, and check of unhurt passengers, which will be reported to the scene commander. (ASC-ASR-00-11-001)

4. Improved training for company emergency teams, with the aim to increase coordination with the backup operations provided by the airport. (ASC-ASR-00-11-002).
5. The installation of an emergency starts system or easily accessible loudspeakers to improve the communications between the front and the rear section of the aircraft. (ASC-ASR-00-11-003).

To: Civil Aeronautical Administration, Ministry of Transportation & Communications

7. The Organic Regulations and the bylaws shall clearly designate an agency responsible for the control of hazardous materials. (ASC-ASR-00-11-004)

8. Stipulation of airport emergency plans with mandatory regulations for command, firefighting and paramedic efforts, so that airports may formulate their own operation procedures accordingly. (ASC-ASR-00-11-005)

9. Review of firefighting and paramedic resource allocation, to ensure that they can handle any emergency. (ASC-ASR-00-11-006)

10. The airports shall provide associated training and information to the backup agencies to ensure successful collaboration during emergencies. The training shall cover dangerous areas and destruction areas of different aircraft models, firefighting and rescue effort patterns in airports used by the military and the civil operations, substitute routes in case of emergency, firefighting water supply spots and medical treatment zones among others. (ASC-ASR-00-11-007)

11. Review conducted of the authorities of joint command, firefighting, paramedic and security during aircraft crash and severe accident operations, emergency operation processes and on-site communication systems as referred to in the agreement for airports shared by the military and civil operations. Intensive joint drills should be conducted with participation of all agencies. (ASC-ASR-00-11-008)

12. Review of the organization of emergency teams and crewmember emergency structure of all airlines at all airports, to ensure that the organizations are capable of handling their tasks. (ASC-ASR-00-11-009)

To: The Aviation Police Bureau of the National Police Administration, Ministry of Interior Affairs

5. Clearly define management authority of hazardous materials with the Civil Aeronautical Administration under the Ministry of

Transportation & Communications. (ASC- ASR-00-11-010)

6. Coordinate with the Civil Aeronautical Administration to compile the Hazardous Materials Handling Code of the International Air Transport Association and prepare relevant regulations for local industry. (ASC-ASR-00-11-011)

7. Upgrade security inspection equipment in airports to capably detect hazardous liquid contained in bottles and cans. (ASC-ASR-00-11-012)

8. Establish recruitment plan, and conduct training and regular on-the-job training for security inspectors. Associate training materials with systems for evaluation of performance of the training. (ASC-ASR-00-11-013)

5. Conduct a full-scale evaluation of security inspection capabilities of all airports. (ASC- ASR-00-11-014)

Appendix A UNI AIR Cabin Clearance Check Record

<table>
<tr><td colspan="4">Domestic Service Aircraft Cabin Clearance Check Record</td></tr>
<tr><td>Airline</td><td>UNI</td><td>Flight</td><td>873</td></tr>
<tr><td>Service route</td><td>HUN</td><td>Boarding time</td><td>11:55</td></tr>
<tr><td>Number of passengers</td><td>170</td><td>End of boarding at</td><td>12:05</td></tr>
<tr><td>Flight status</td><td>On time</td><td>Flight delay</td><td></td></tr>
<tr><td colspan="4">Cause to delay: Departure time:
☐ Loading ☐ Manifest ☐ Late passenger ☐ Aircrew shift
☐ Supplies ☐ Cabin clearance ☐ Mechanical problem ☐ Incorrect passengers
☐ Catering ☐ Check-in ☐ Balance sheet ☐ Unloading
☐ Weather ☐ Security check ☐ Missing boarding pass ☐ Others</td></tr>
<tr><td colspan="4">Cabin clearance shall be conducted in pursuance of Aircraft Security Checklist, Security code Attachment 91 given by ICAO. The security check shall be conducted as follows:
(1) Cockpit & the lavatories (4) Galley
(2) Top bins in the main cabin (5) Main cabin lavatories
(3) Passenger seats in the main cabin (6) Tail galley
(Cargo compartment: Check for human or hazardous materials that would be located in spaces between cargo pallets and containers).
Miscellaneous:

Signed by the cabin clearance check responsible assigned to this flight:
August 24 1999</td></tr>
</table>

Remarks:

(1) Upon receipt of information of explosives on board of an aircraft, a

cabin clearance shall be conducted in pursuance of Aircraft Security Checklist, Security code Attachment 91 given by ICAO.

(2) For delays by other reasons than the listed ones, please check " Miscellaneous".

(3) When conducting cabin clearance, the airline shall produce this record and the passenger manifest to the Aviation Police for filing.

Appendix B ATC Tape Recorder Transcript

Transcript of Traffic Recording between Air Force 8th Communication Squad Hualien Control Tower with UNI AIR 873 on August 24 1999			
Weather report: At 1200, visibility 9999, ceiling 6000 wind 140 AT 06 QNH 1014			
Time	Channel	Speaker	Contents
1230:30	N	UNI-873	HLN TWR GOOD AFTERNOON UNI-873 VISUAL APPROACH ONE FIVE DME TO AIRPORT
1230:35	N	TOWER	UNI-873 YU R/W 21 QNH 1014 CONTINUE APPROACH REPORT FIVE DME
1230:40	N	UNI-873	R/W 21 1014 CONTINUE REPORT GIVE UNI-873
1230:56	N	TOWER	TNA-001 CONTACT HLN APP 119.1 GOOD-DAY
	N	TNA-001	119.1 THANK YOU GOOD AFTERNOON
1231:46	N	TOWER	FAL-7933 MARK-2 RIGHT TURN OF RUNWAY CONTACT GROUND SEE YOU
	N	FAL7933	SEE YOU FAL-7933
1232:31	N	TOWER	UNI-873 SAY YOUR DME NOW
1232:34	N	UNI-873	EIGHT POINT FIVE
	N	TOWER	ROGER
1233:56	N	UNI-873	HLN TOWER UNI-873 FIVE DME
1233:59	N	TOWER	UNI-873 CHECK WHEELS DOWN CLEARED TO LAND WIND 140 AT 6.
1234:04	N	UNI-873	CLEARED TO LAND UNI-873
1236:36	N	TOWER	UNI-873 TOWER
1236:40	N	UNI-873	GO AHEAD
1236:41	N	TOWER	DO YOU HAVE ANY PROBLEM IN YOUR TAXING? PLEASE REMAIN WHERE YOUR ARE
1236:45	Switch	TOWER	INSTRUCTOR CALLING FIRE ENGINES
1236:47	Switch	Air Service	OK, OK
1236:48	N	TOWER	FIRE ENGINE, TOWER
1236:53	N	TNA-018	HLN TOWER TNA-018 TAXI WITH YOU
1236:55	N	TOWER	TNA-018 HOLD SHORT OF RUNWAY
1236:57	N	TNA-018	HOLD SHORT OF RUNWAY 018
1237:05	N	TOWER	MAY DAY MAY DAY MAY DAY
Hualien Air Base Accident Paging			
1237:09	Telephone	TPWER	HLN TOWER paging, accident paging, UNI-878,

			correction UNI-873 MD-90 remains at No. 2 opening, engine on fire, requesting for immediate backup, Service Room, Service Room, Service Room, Air Wing Chief, Supervisor, Supervisor, contact OK. Combat Division, what? Please hold. Combat Division, contact OK, Flight Control, contacts OK. Firefighting, contact OK. Workshop, contact OK. Repair, UNI engine problem, at No. 2 opening, immediate rescue.
1237:14	Switch	TOWER	TOWER call for fire engines, rush, for UNI.
		Aviation	OK, OK
1246:18	Switch	TOWER	We remain on runway, F.O.D. operations suspended (with Operation Control Center 4)

Appendix C UNI-873 Cockpit Voice Recorder (CVR) Transcript

Local Time	FDR GMT	CVR Time	Speaker	Contents
1209:47	0410:24	0004:18	ATC	Glory 873 push back approved.
1209:49	0410:26	0004:20	Co-pilot	873 push back approved.
1209:52	0410:29	0004:23	Pilot	Ground
1209:53	0410:30	0004:24	Ramp	Go ahead
1209:54	0410:31	0004:25	Pilot	Push back approved, right engine on
1209:55	0410:32	0004:26	Ramp	OK, roger, push back right engine on
1210:57	0411:34	0005:28	Pilot	Here it comes again
1211:19	0411:56	0005:50	Pilot	2 pack at 0
1211:39	0412:16	0006:10	Ramp	Tow cart OK, brake
1211:43	0412:20	0006:14	Pilot	OK brake OK
1211:45	0412:22	0006:16	Ramp	Roger
1211:54	0412:31	0006:25	Pilot	Here comes the MESSAGE again
1211:57	0412:34	0006:28	Co-pilot	Just like in the morning
1211:59	0412:36	0006:30	Pilot	Right
1212:00	0412:37	0006:31	Pilot	KG Wang you may go
1212:14	0412:51	0006:45	Co-pilot	Glory 873 request taxi
1212:16	0412:53	0006:47	ATC	Glory 873 taxi to runway one zero
1212:19	0412:56	0006:50	Co-pilot	Runway one zero Glory873
1212:20	0412:57	0006:51	Pilot	Clear right
1212:21	0412:58	0006:52	Pilot	OK after start
1212:22	0412:59	0006:53	Co-pilot	After start Aircond supply, auto, Anti-ice off, Annun
1212:23	0413:00	0006:54	Pilot	Panel check, spoilers/auto brakes arm/take off, after start check completed
1212:31	0413:08	0007:02	Pilot	Flight control check
1212:51	0413:28	0007:22	ATC	Uni873 contact tower good day
1212:54	0413:31	0007:25	Co-pilot	873 contact tower
1212:56	0413:33	0007:27	Pilot	Rudder, full left, full right

1213:06	0413:43	0007:37	Area Mic	Taxi check, flight control check, battery charging check, take off briefing/data complete for runway one zero, speed set, taxi check completed
1213:29	0414:06	0008:00	Co-pilot	Sungshan tower Glory873
1213:32	0414:09	0008:03	Tower	Glory873 tower hold short runway
1213:34	0414:11	0008:05	Co-pilot	Hold short runway Glory873
1214:00	0414:37	0008:31	Co-pilot	It's us, any aircraft xx
1214:03	0414:40	0008:34	Pilot	OK
1214:04	0414:41	0008:35	Co-pilot	One at 2000, 6, 7, 8 miles
1214:07	0414:44	0008:38	Pilot	8 mile hurry
1214:10	0414:47	0008:41	Co-pilot	Glory873 ready departure

1214:13	0414:50	0008:44	Tower	Glory873 Roger
1214:38	0415:15	0009:09	Tower	Glory873 taxi into position and hold inbound traffic final outer marker
1214:42	0415:19	0009:13	Co-pilot	Roger, position and hold Glory873Before take off check, enunciator panel check, air off on, flat/slats
1214:45	0415:22	0009:16	Pilots	Eleven/TO, radar on, hydraulic pump on, brake temperature 150 degree, before take off check completed.
1215:27	0416:04	0009:58	Pilot	Aircraft invisible, unclear
1215:35	0416:12	0010:06	Tower	Glory873 wind 300 at 4 clear for take off
1215:39	0416:16	0010:10	Co-pilot	16 clear for take off Glory873
1215:52	0416:29	0010:23	Pilot	You have control
1215:53	0416:30	0010:24	Co-pilot	I have control
1215:59	0416:36	0010:30	Pilot	Stable
1216:00	0416:37	0010:31	Co-pilot	Take off thrust
1216:14	0416:51	0010:45	Pilot	80
1216:15	0416:52	0010:46	Co-pilot	Check
1216:25	0417:02	0010:56	Pilot	V one
1216:28	0417:05	0010:59	Pilot	Rotate
1216:33	0417:10	0011:04	Pilot	Positive climb
1216:34	0417:11	0010:05	Co-pilot	Gear up
1216:49	0417:26	0011:20	Tower	Glory873 contact Taipei approach 119.6 good day
1216:53	0417:30	0011:24	Pilot	Good day
1216:54	0417:31	0011:25	Co-pilot	Climb thrust
1216:59	0417:36	0011:30	Co-pilot	Auto pilot
				Taipei approach good afternoon
1217:09	0417:46	0011:40	Co-pilot	Glory873 airborne passing two thousand two

1217:13	0417:50	0011:44	Approach	Good afternoon Glory873 Taipei approach Climb maintain 10 thousand
1217:17	0417:54	0011:48	Pilot	Climb maintain one zero thousand Glory873
1217:20	0417:57	0011:51	Co-pilot	Ten thousand
1217:21	0417:58	0011:52	Pilot	check
1217:22	0417:59	0011:53	Pilot	The message would disappear off
1217:27	0418:04	0011:58	Co-pilot	Pressure comes
1217:56	0418:33	0012:27	Co-pilot	Four thousand feet flaps up
1218:00	0418:37	0012:31	Co-pilot	Taipei approach Glory873 Oscar four thousand
1218:04	0418:41	0012:35	Approach	Glory873 radar contact
1218:18	0418:55	0012:49	Co-pilot	Slats in
1218:20	0418:57	0012:51	Area Mic	Click (sounds like flap handle moving)
1218:26	0419:03	0012:57	Pilot	Heading 1130 heading select
1218:30	0419:07	0013:01	Co-pilot	Heading select
1218:31	0419:08	0013:02	Pilot	Turn more, turn left, turn left, turn left, turn left, 12, 110
1218:37	0419:14	0013:08	Pilot	Taipei Glory873 request heading 110 due to weather
1218:42	0419:19	0013:13	Approach	Glory873 approved
1218:44	0419:21	0013:15	Pilot	Thank you
1219:13	0419:50	0013:44	Co-pilot	Clear
1219:15	0419:52	0013:46	Pilot	OK
1219:23	0420:00	0013:54	Pilot	Taipei Glory873 clear for weather
1219:26	0420:03	0013:57	Approach	Glory873 direct to wader
1219:28	0420:05	0013:59	Pilot	Direct to wader Glory873
1219:30	0420:07	0014:01	Co-pilot	Execute
1219:32	0420:09	0014:03	Pilot	Nav
1219:35	0420:12	0014:06	Co-pilot	Nav
1219:41	0420:18	0014:12	Co-pilot	After take off

1219:50	0420:27	0014:21	Co-pilot	Nine for ten
1220:09	0420:46	0014:40	Pilot	Why xx, it must be at 300
1220:14	0420:51	0014:45	Co-pilot	Vnav capture
1220:21	0420:58	0014:52	Co-pilot	Oh, it came down
1220:24	0421:01	0014:55	Co-pilot	Ten thousand
1220:26	0421:03	0014:57	Pilot	Check
1220:50	0421:27	0015:21	Pilot	Taipei Glory873 maintain one zero thousand
1220:53	0421:30	0015:24	Approach	Roger
1220:54	0421:31	0015:22	Co-pilot	You can't pull it up, you release it, it goes up
1221:21	0421:58	0015:52	Co-pilot	2275 16 tons, 8254 32
1221:33	0422:10	0016:04	Co-pilot	Good weather in Hualien, visual
1221:41	0422:18	0016:12	Co-pilot	approach Flap 40 manual brake MSA 13300 west, 4100 south and east, good weather
1222:52	0423:29	0017:23	Pilot	What time did we take off? 15 yes?
1222:55	0423:32	0017:26	Co-pilot	16
1222:56	0423:33	0017:27	Pilot	Write 16, don't you?
1222:57	0423:34	0017:28	Co-pilot	Yes
1224:43	0425:20	0019:14	Approach	Glory873 contact Hualien 119.1
1224:46	0425:23	0019:17	Pilot	Good day
1224:47	0425:24	0019:18	Approach	Good day
1224:53	0425:30	0019:24	Co-pilot	Hualien approach good
1224:58	0425:35	0019:29	Approach	afternoonFlory873 Three DME to Wader maintain one zero thousand xxx Glory873 Hualien approach runway two one QNH1014VMC surface wind 140 at 6 number two in sequence
1225:08	0425:45	0019:39	Pilot	Runway 21 VMC 1014 Glory873

1225:13	0425:50	0019:44		Override
1225:13	0425:35	0019:44	Approach	Glory873 fly heading 160 decent and maintain 6000 vector for visual approach
1225:20	0425:57	0019:51	Pilot	Heading 160 descent maintain 6000 Glory873 6000
1225:27	0426:04	0019:58	Co-pilot	Six thousand Approach brief complete, seat belt sign on,
1225:33	0426:10	0020:04	Pilot	Annunciator panel check cabin pressure set, speed bug
1225:38	0426:15	0020:09	Pilot	Set, set
1225:39	0426:16	0020:10	Pilots	Descent check completed
1226:46	0427:23	0021:17	Approach	Glory873 turn right heading 200 descend and maintain two thousand
1226:51	0427:28	0021:22	Pilot	Turn right heading 200 descend and maintain two thousand
1226:54	0427:31	0021:25	Co-pilot	200 two thousand
1226:55	0427:32	0021:26	Pilot	Check
1227:38	0428:15	0022:09	Approach	Glory873 turn right heading 220
1227:42	0428:19	0022:13	Pilot	Turn right heading 220 Glory873
1227:44	0428:21	0022:15	Co-pilot	220
1228:15	0428:52	0022:46	Co-pilot	Instructor, is there any speed control
1228:18	0428:55	0022:49	Pilot	There must be number two, they told us number two
1228:20	0428:57	0022:51	Co-pilot	Flap 11 slats set, slat set
1228:51	0429:28	0023:22	Co-pilot	Yes, number two
1230:12	0430:49	0024:43	Pilot	Hualien Glory873 airport insight
1230:15	0430:52	0024:46	Approach	Glory873 clear visual approach runway 21 radar service terminated contact Hualien tower 118.1
1230:22	0430:59	0024:53	Pilot	Have good day

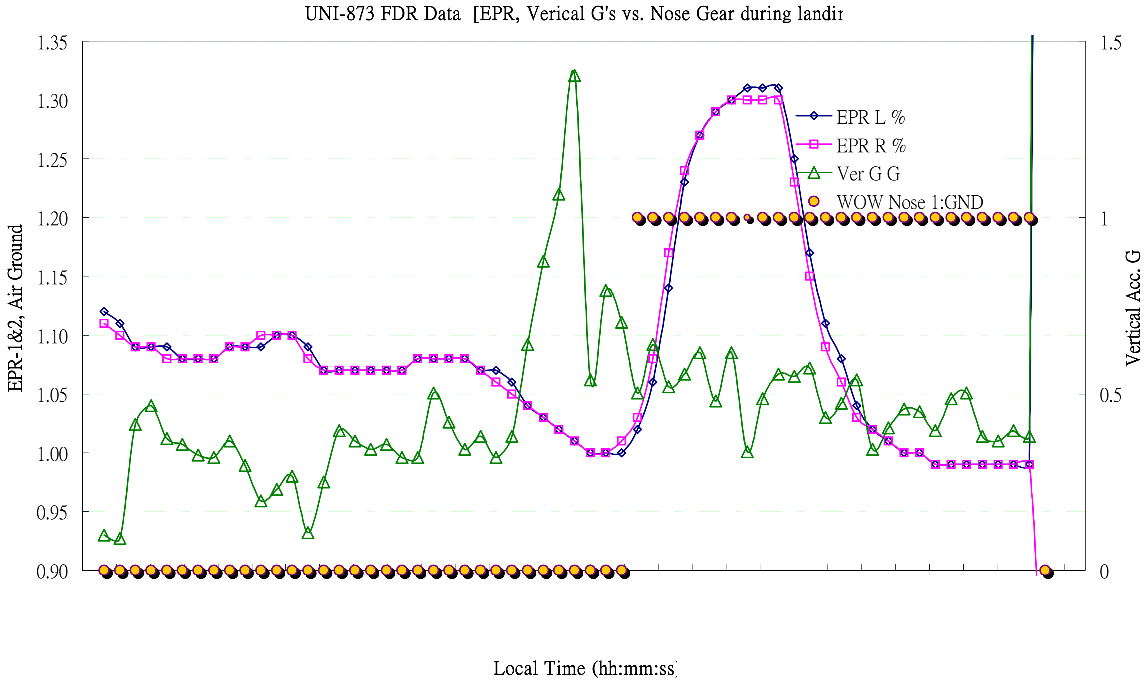
1230:23	0431:00	0024:54	Approach	Have good day
1230:27	0431:04	0024:58	Co-pilot	Check for visual
1230:30	0431:07	0025:01	Pilot	Hualien tower good afternoon Glory873 visual approach one five DME to airport
1230:35	0431:12	0025:06	Tower	Glory873 Hualien runway 21QNH 1014 continue approach report 5 DME
1230:41	0431:18	0025:12	Pilot	Runway 21 1014 continually report five Glory873
1230:46	0431:23	0025:17	Pilots	One four altimeters set and cross check
1230:47	0431:24	0025:18	Pilot	Hydraulic pump on
1230:51	0432:28	0026:22	Co-pilot	We have landed
1230:53	0432:30	0026:24	Pilot	Yes
1232:08	0432:45	0026:39	Co-pilot	Flap 11
1232:31	0433:08	0027:02	Tower	Glory873 say your DME now
1232:33	0433:10	0027:04	Pilot	Eight point five
1232:35	0433:12	0027:06	Tower	Roger
1232:36	0433:13	0027:07	Co-pilot	Flap fifteen
1232:38	04338:15	0027:09	Area Mic	Click (sounds like flap handle moving)
1232:44	0433:21	0027:15	Area Mic	Chime..chime (sounds like interphone chime from cabin)
1233:18	0433:55	0027:49	Co-pilot	Gear down
1233:21	0433:58	0027:52	Area Mic	Sound like nose gear moving and auto stabilizer trimming
1233:33	0434:10	0028:04	Co-pilot	Flap twenty-eight
1233:37	0434:14	0028:08	Co-pilot	Flap 40
1233:41	0434:18	0028:12	Co-pilot	140
1233:43	0434:20	0028:14	Pilot	Landing gear
1233:44	0434:21	0028:15	Co-pilot	Down three green
1233:45	0434:22	0028:16	Pilot	Spoiler/autobrake out, flap/slats
1233:47	0434:24	0028:18	Co-pilot	Flap 40 land
1233:48	0434:25	0028:19	Pilot	landing check completed

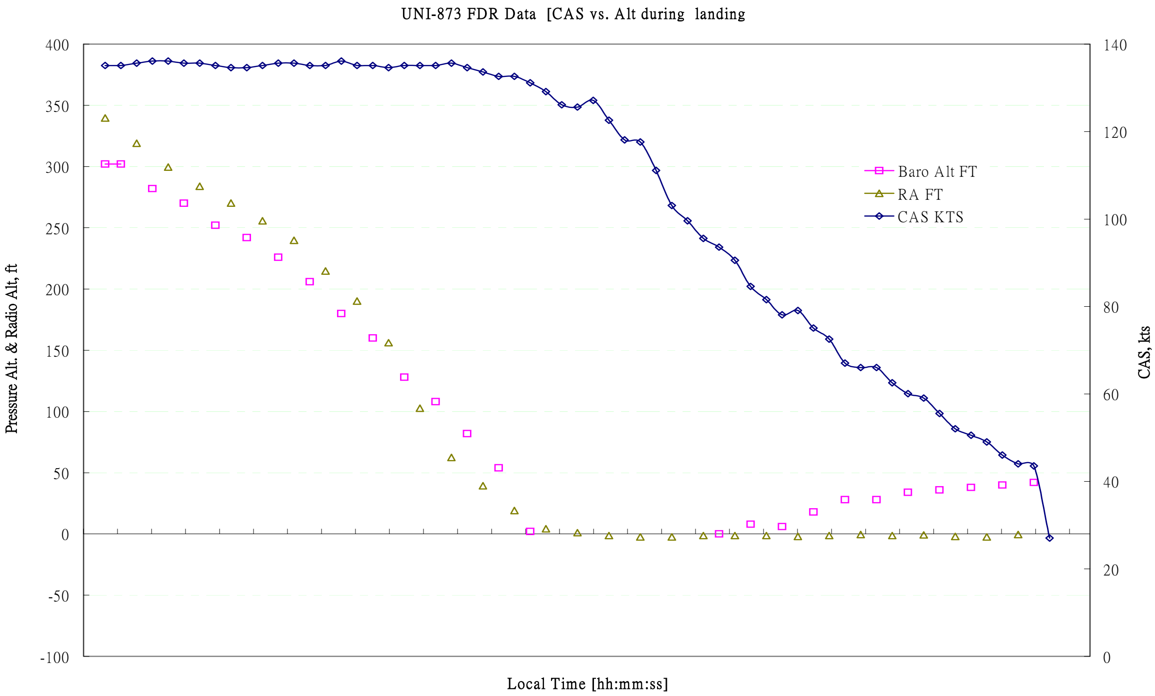
1233:50	0434:27	0028:21	Co-pilot	Runway insight
1233:52	0434:29	0028:23	Pilot	Tower has not said landing yet
1233:54	0434:31	0028:25	Co-pilot	No report 5 mile yet
1233:56	0434:33	0028:27	Pilot	Hualien tower Glory873 five DME
1233:59	0434:36	0028:30	Tower	Glory873 check (wheels) down clear to Land when 140 at 6
1234:03	0434:40	0028:34	Pilot	Clear to land Glory873
1234:04	0434:41	0028:35	Co-pilot	Clear to land
1234:24	0435:01	0028:55	Pilot	Too high
1234:25	0435:02	0028:56	Co-pilot	Too high
1234:28	0435:05	0028:59	Co-pilot	Yes, too high
1234:38	0435:15	0029:09	Co-pilot	Heading select
1235:07	0435:44	0029:38	Pilot	500 stable
1235:08	0435:45	0029:39	Co-pilot	Check
1235:09	0435:46	0029:40	Pilot	Clear to land
1235:10	0435:47	0029:41	Co-pilot	Autopilot disconnect
1235:53	0436:30	0030:24	GPWS	One hundred
1235:55	0436:32	0030:26	GPWS	Fifty, forty, thirty, twenty. ten hold,
1235:58	0436:35	0030:29	Pilot	hold, hold, hold, I hold it
1236:07	0436:44	0030:38	Pilot	I just pulled it hard.
1236:10	0436:47	0030:41	Co-pilot	Or it would have collapsed
1236:12	0436:49	0030:43	Pilot	You had too fast a drop rate
1236:14	0436:51	0030:45	Pilot	Eighty
1236:21	0436:58	0030:52	Pilot	OK sixty I have control
1236:22	0436:59	0030:53	Co-pilot	You have control
1236:32	0437:09	0031:03	Area Mic	Sound of explosion
1236:33	0437:10	0031:04	Co-pilot	Oh! Shit
1236:34	0437:11	0031:05		End of recording

Appendix D FDR parameters

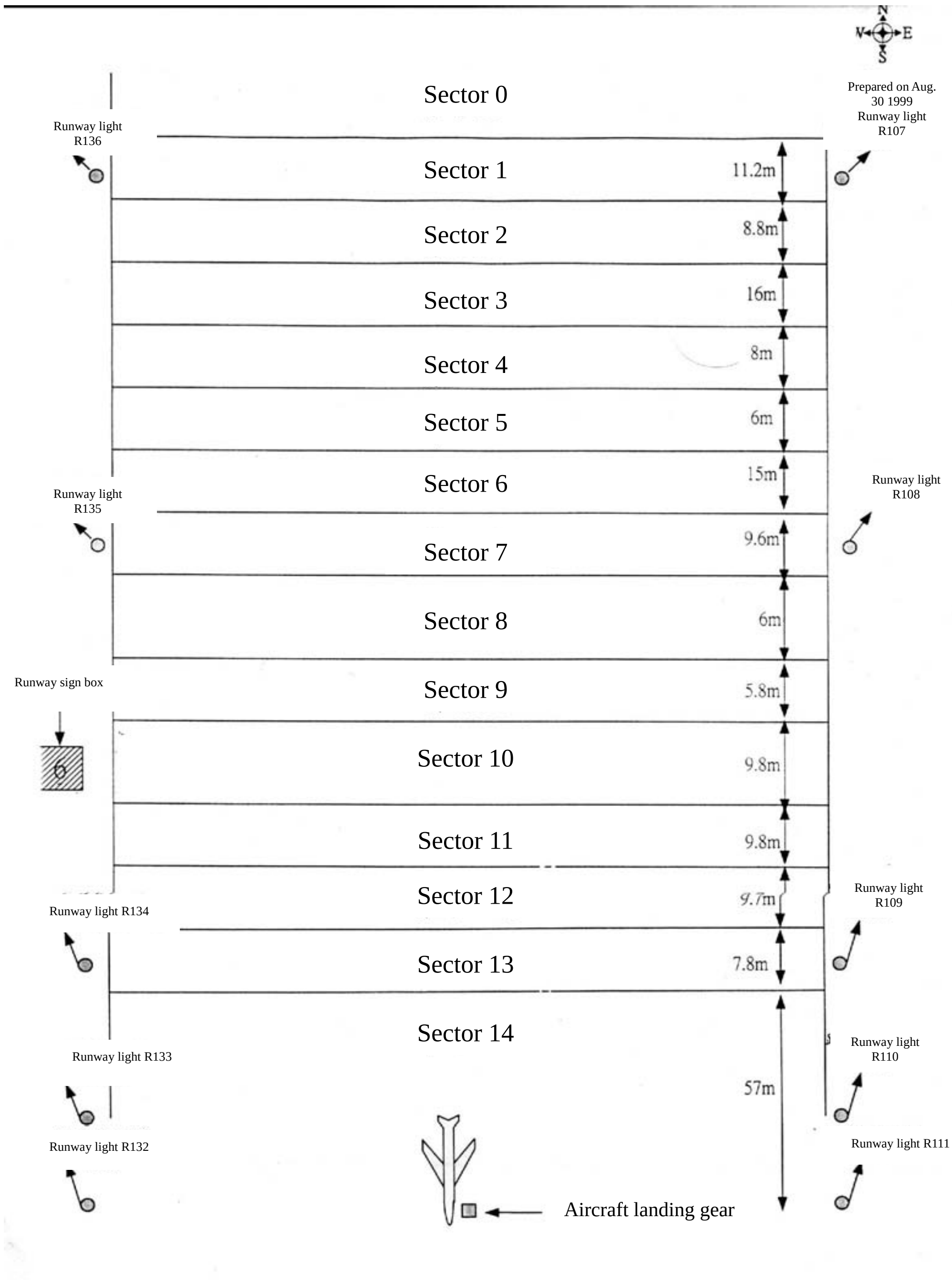
Appendix E FDR partial parameters

Appendix F FDR parameter charts





Appendix G UNI AIR 873 explosion layout of fragments on runway



Remark: Compiled by CIB/FSD

Appendix H Passenger Questionnaire On Evacuation Process

Dear UNI AIR 873 flight passengers, assigned to conduct investigations on the accident, the AVIATION SAFETY COUNCIL (ASC) is hereby to gather information on evacuation of the passengers and the rescue effort involved in this accident. For the sake of safety of traveling on flights conducted by R.O.C. aircraft, we would appreciate your cooperation of answering the following questions and return the questionnaire in the envelope provided back to this office. You information would be of much importance, as we would complete the investigation as soon as possible based on your information. Besides, we like to take this opportunity to convey our apologies and best regards to those passengers who have suffered psychological and physical harm.

Passenger's name:________________ Sex:_____________________

Age:____________________________ Telephone:_______________

1. Where were you seated when the explosion took place on board the aircraft? Through which exit and evacuation route did exit the aircraft? (See Figure 1, Table 1)
3. Did you receive assistance from others during our evacuation effort after the explosion? If yes, please check one of the following and give the number of people, location, and details on the assistance you received from that person. (See Figure 1, Table 1)

   ☐ No assistance

   ☐ flight attendants, seated at_____________

   Detail of the assistance

☐ pilots, seated at____________

Detail of the assistance

☐ servicemen, seated at____________

Detail of the assistance

☐ firefighters, seated at____________

Detail of the assistance

☐ Others, seated at____________

Detail of the assistance

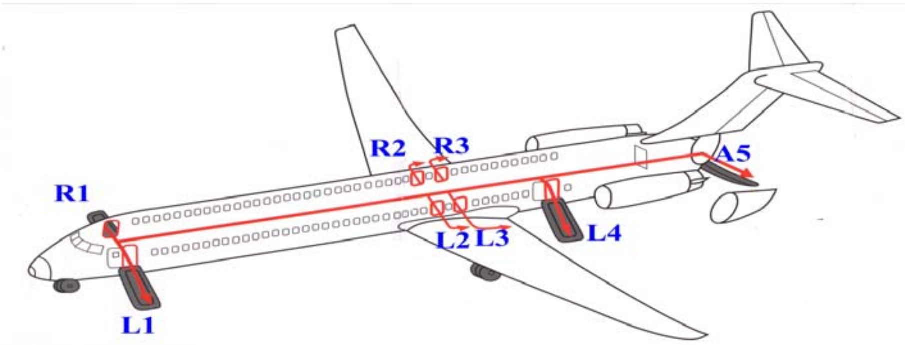


Fig. 1

Table 1 MD-90 Seating layout

L1 Emergency exit

R1 Emergency exit

Business-class cabin

1A	1C BSCT
2A	2C
3A	3C

1H	1K
2H	2K
3H	3K

Economy-class cabin

5A	5B	5C
6A	6B	6C
7A	7B	7C
8A	8B	8C
9A	9B	9C
10A	10B	10C
11A	11B	11C
12A	12B	12C
13A	13B	13C
14A	14B	14C
15A	15B	15C
16A	16B	16C
17A	17B	17C
18A	18B	18C
19A	19B	19C
20A	20B	20C
21A	21B	21C
22A	22B	22C
L2 exit	23B	23C
24A	24B	24C

L3 exit

25A	25B	25C
26A	26B	26C
27A	27B	27C
28A	28B	28C
29A	29B	29C

L4 exit

35A	35B BSCT	35C
36A	36B	36C
37A	37B	37C

A5 exit

5H	5K
6H	6K
7H	7K
8H	8K
9H	9K
10H	10K
11H	11K
12H	12K
13H	13K
14H	14K
15H	15K
16H	16K
17H	17K
18H	18K
19H	19K
20H	20K
21H	21K
22H	22K
23H	R2 exit
24H	24K

R3 exit

25H	25K
26H	26K
27H	27K
28H	28K
29H	29K
30H	30K
31H	31K
32H	32K
33H	33K
34H	34K
35H	35K
36H	36K
37H	37K

4. Were you injured as others pushed you during evacuation after the explosion on board of the aircraft? If yes, please give details.

   ☐ No

   ☐ Yes

   Please describe.

5. Were you injured in the moment of the explosion and during evacuation after it? If yes, please give details.

   * Moment of the explosion

   ☐ No

   ☐ Yes

   Please describe

   * During evacuation

   ☐ No

   ☐ Yes

   Please describe

6. Did you see the evacuation indicator light on the floor or the emergency light on top of the emergency exit of the aircraft during your evacuation after the explosion? If yes, please give the location on Fig. 2 and describe. Did you see the oxygen mask fall down from above your seat?

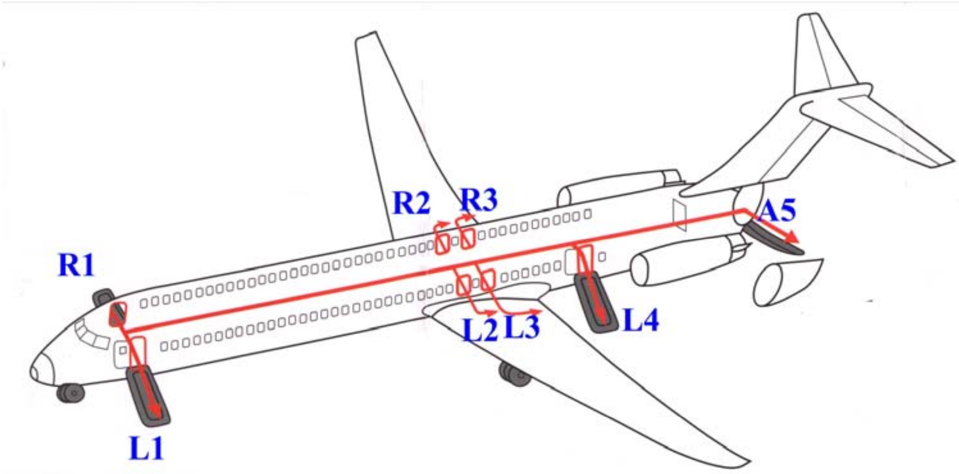


Fig. 2

7. Did you observe any rescue efforts conducted by the fire squad after the explosion? If yes, please describe in time sequence (How many fire engines? Color of the fire engines? How many firefighters? What time did the firefighters arrive? Firefighting manner?)
8. Did you witness any rescue efforts conducted by paramedics? If yes, please describe in time sequence (How many ambulances? Color of the ambulances? How many paramedics people? What time did the paramedic people arrive? Rescue manner?)
9. Would you suggest anything to the airlines and the government agencies on the evacuation process after the explosion on board of the aircraft? If yes, please describe.

Appendix I Testimony on Passengers' Evacuation

Thirteen injured passengers were interviewed and a questionnaire (Appendix H) was sent to all passengers asking them to relate their experiences during evacuation. As of today, 23 replies have been received with 22 passengers indicating that they did not receive assistance from a flight attendant. An 80-year-old passenger suffered a severe injury going down the slide raft when there was no one to receive him at the bottom. L4 flight attendant helped four passengers evacuate. The following is based on their statements.

The passengers seated in front of the area of the explosion (row 7) were all evacuated from R1 and L1 exits, including the 8B passenger (50 years old, male, who suffered 3rd-grade burns and eventually died 47 days after the accident), who was evacuated from L4 door were guided and assisted by the flight attendants. (Whom did the flight attendants help? All these people? Just the burn victim? Please make this passive sentence active "The flight attendants helped…" LJB) The 11h passenger (79 years old, female) injured her abdomen when she sled down the slide raft and hit the ground hard.

The 13 injured passengers indicated that more than five injured passengers were evacuated from R2 door while four injured passengers were evacuated from R1 door.

The 7H passenger (40 years old, male), who was injured himself, stated that after the explosion he pushed his son and daughter to the exit while his wife, seated in 8H (30 years old, female) with her face fractured and full of blood, had passed out. The 7H passenger never heard a crewmember asking if anyone needed help. He yelled twice for help by no one answered. He then pulled his wife off from the rear edge of the wing from R2 and there met the co-pilot, who then helped them off the aircraft and moved them to the lawn. An Air Force sedan then took them to the hospital. The passenger does not recall having received any assistance from a flight attendant. The 8K passenger (son of the 7H passenger, 9 years old, male) says the seat back and the dinning table of both 8H and 8k were in vertical position during takeoff and landing and he was looking out when the explosion took place. Suddenly he felt hot air and saw fire on the upper left. The oxygen mask had fallen down and only his parents were on board (the only people on the airplane? LJB) and he did not see any lights on the floor. When the passenger evacuated from the front door (R1), a flight attendant and a pilot provided assistance by the slide raft.

The 6B passenger (63 years old, female) and the 6C passenger (65 years old, male) left the aircraft from the front door R1 without guidance or assistance from a flight attendant.

The 8a passenger (14 years old, female) indicates that she left the aircraft from the R2 exit by the right wing and did not receive assistance from any flight attendant.

The 9th passenger (25 years old, female) evacuated from the R2 exit and she left the aircraft from the front edge of the wing and ran over to the left wing, where there were two flight attendants. She did not see any lights on the floor.

The 10H passenger (41 years old, male) stated that he evacuated from the R2 exit with other passengers and then jumped off the aircraft from the front edge of the wing. The flight attendants were gathered by the left wing at that time.

The 14C passenger (40 years old, male) opened the L2 door and then the L3 door, and finally proceeded with other passengers to the L4 door to exit the aircraft. Two flight attendants were by the L4 door providing assistance to the passengers.

Appendix J   Air Force 401st Wing

August 24 UNI AIR B17912

Accident Rescue Effort Review Report

1. The accident:

The UNI AIR MD-90 No. B17912, flight No. 873 took off from Taipei at 1216, scheduled to land in Hualien at 1238 on runway 21. When the aircraft was rolling up to 5,700 feet, (rolled 5,700 feet down the runway? LJB) the tower controller saw smoke coming out of the aircraft and at 1248, the UNI AIR captain made the MAYDAY-MAYDAY call. The aircraft stopped at 6,300 feet. The 401st Wing rescue vehicles and ambulances rushed to the scene. Emergency personnel found a large opening in the left side of the fuselage (row 7) with fire and smoke coming out. The aircraft carried 96 people (including the aircrew), 28 of which were injured (11 taken to Tsuchi Hospital, 17 to Hualien Armed Forces Hospital). Sixty-eight were unhurt. At 1430, the emergency team and a number of experts were invited to provide solution. This emergency team was disbanded at 0800 on August 25 when the effort at CIB and other associated agencies.

2. Detail of the support provided by 401st Wing:

Table of support provided to UNI AIR B17912 accident of August 24								
	Resources	T-6	N-1	Chemical	Sweeper	Ambulance	Oxygen cylinder	Runway light
Air wing	32							
Fire squad	56	8	1	315				
Fire squad (Chiashan)	24	4	2	180				
Paramedic	21					7	1	
Service (FOD)	112				4			2
Security	24							

Total	269	12 sorties	3 sorties	495 gallons	4 sorties	7 sorties	1 bottle	2

3. Review:

(1) When 401st Air Wing received the accident phone call from the tower at 1248, the wing immediately dispatched two T-6 fire engines and one N-1 fire engine to the scene (each with four people). Two civil aviation fire engines arrived five minutes later but each had only one crewmember on board.

(2) As per Item 4 of the Agreement on Fire Support to Military & Commercial Aircraft in Case of Accident civil agencies are in charge of the operation and the airport director the commander at the scene. However, the military was in charge of the operation, as the late-arriving airport director refrained from assuming command.

(3) The 401st air Wing posted security guards at the accident site but allowed unauthorized people (including journalists) to enter the site.

(4) The firefighters' unfamiliarity with the commercial aircraft slowed the efforts of the military agencies in charge.

(5) The 401st Air Wing dispatched seven ambulance sorties, with the air wing chief even providing his own car for use as an ambulance. Ambulances from other civil agencies arrived 30 minutes later. Running patients to the hospitals took too long.

5. Suggestions:

(1) The airport should upgrade its firefighting and rescue resources and improve its control of and the alertness of its on-duty personnel.

(2) The airport is to adhere to item 4 of the Agreement on Fire Support to Military & Commercial Aircraft in Case of Accident by ensuring that civil agencies are in command at accidents involving civil aircraft. All associated personnel in the airport shall be present immediately at the scene.

(3) The airport shall enhance access restrictions at accident scenes.

(4) The airport shall provide rescue task protocols for all types of commercial aircraft to fit the military for reference. The airport shall conduct appropriate drills.

(5) The airport is to review its ambulance requirements and enter into agreements for the support of private ambulances.

Attachment 1 UNI AIR MD-90 B-17912 Aircraft Hualien Airport Explosion Scene Survey Report

Evidence Inventory

Judgment Division under Criminal Investigation Bureau

Attachment 2 Failure analysis of broken shielded wire and battery wires

Chung Shan Institute of Science and Technology

1. Preface:

In order to support the investigation task on the accident of UNI AIR MD-90 B-17912, the Aviation Safety Council has tasked the Aero Materials Laboratory under the Chung Shan Institute of Science & Technology to conduct analysis and gathering of wire (hereinafter referred to as #1 wire) from the runway for survey of its composition, fracture surface, fracture mode and root cause. The task would also include the comparison of the remaining wires (hereinafter referred to as the positive and negative wires) on the positive and negative polarities of the GTX4L-BS battery to ensure the connection among the three wires. Secondly, the laboratory ran a simulation by connecting identical wires to an identical battery to analyze the short circuit and temperature characteristics of both the battery and the wire.

2. Test procedure:

1) Conduct a macro observation of the wires and determine their diameter.
2) Observe the fracture surface of the wires using a Scanning Electronic Microscope (SEM) and an Energy Dispersion Spectrum (EDS) for analysis of composition of both the surface and the fracture surface of the wires.
3) Simulate a short circuit using identical wires and batteries, testing the temperature of the battery and the wire.

3. Test results and discussions:

(1) Wire aspect and diameter

As shown in figure 1, we have the aspect of the #1 wire and the slightly straightened positive and negative wires. The #1 wire is a round wire of 376 mm in length with a plastic (or probably PVC) shield that is normally dark red. The shield shows decomposition with a charred portion caused by high temperature (about at 85~227°C) or carbon build-up. There is no shield either on the ends or in the middle. The #1 wire has one bare silver-colored (A) end and one bare dark brown (B) end. The positive wire (P wire) is a bare metal wire measuring 21 mm. The torn-off end (upper site) is a dark brown color and the middle part is silver. The cut-off end (lower site) is a copper color. The negative wire (N wire) is also bare metal, brown with a portion of a copper color, measuring 15 mm.

Figure 1 also shows the diameters of the three wires. The #1 wire measures between 0.38 mm to 0.47 mm, the positive and negative wires both measure between 0.45 mm to 0.47 mm. As the caliper is unable to measure the minimum diameter of the fracture surface, we then used the SEM to check the minimum diameter. Again, with the negative wire squeezed to deform, some of the wire section are now in an oval section and a part of the diameters have gone beyond the diameter range. The #1 wire is shown its both ends with necking and we shall presume that there was a certain overstress tension destruction and the two ends shall be marked as A and B. There is necking on one end of each of the positive and the negative wire. It is should be the overstress tension destruction (see #09906-2 materials test report; 10, 13, 1999) where the wires are marked as P and N. Another opposite sites of the wires ends (P and N) has no the phenomenon of necking, which was result by cutting destruction. The maximum diameter of the wires is 0.47 mm presumed their original diameter. The diameter is between AWG #24 (Conductor Diameter: 0.511 mm) and AWG #25 (Conductor Diameter: 0.455 mm). The diameter of the middle portion having no shield (figure 1 C, D) is 0.45 mm, smaller than the original one. We shall presume that the #1 wire underwent load that forced the diameter to become smaller.

(2) #1 Wire material

Segments C and D of the #1 wire used to be silver color and when slightly scraped, the C portion showed a red brass color, indicating that the #1 wire is a plated round wire. SEM image shows C with scratches and D without scratches shown as figure 2. SEM/EDS analysis C and D (figure 2), the EDS spectrums are respectively shown as figure 3 and figure 4. The EDS spectrum of C shows copper and the minority of aluminum, which may have come from the SEM-EDS pole base and the environment. We shall presume that the #1 wire substrate is pure copper. The EDS spectrum at D shows copper, some tin and carbon, and traces of oxygen and aluminum. The copper is the substrate element of the #1 wire. The tin shall be the plating element of the #1 wire, and carbon, oxygen as well as aluminum shall resulted from the environment reactants (carbon build-up and oxides). The above analysis suggests that the #1 wire is made of copper with tin-plating.

(3) Wire fracture surface and EDS analysis

The SEM images show the A, B, P and N end lateral view of the three wire segments. As shown in figure 5, reveal that the #1 wire A end has the remarkable necking and the scratches on surface. As shown in figure 6, reveal that the #1 wire B end has necking and the surface discolored with scratches. Figure 7 shows the lateral aspect of the positive wire with the P end showing necking. Broken plating appears on the surface (dark brown color by visual) 1.7 mm from the fracture. The uneven substrate at 1.7 mm-2.2 mm from the fracture shows peeled plating also. The N end of the negative wire shows necking and squeezing shown as figure 8. When we compare the lateral aspect of the A, B, P and N ends of the wires, we should realize that there is much difference between the positive wire P fracture surface and the fracture surface of the negative wire N and the #1 wire A and B.

When we keep on observing the A, B, P and N end of the 3 segments of the wires under SEM and analyzing the key components of the fracture surface and the surface of the wire using EDS, we would come to have figure 9 where the fracture surface of the A end of the #1 wire comes in half-moon shape of 300μm (0.3 mm) in length, and 200μm (0.2 mm) in width. As the left side of the fracture surface is deformed by pressure (opposite side view of figure 6), its surface comes in a spiral form. The magnified view of figure 9 shows the broken A1 and the SEM image shows neat fracture surfaces, full of dimples of 5~10 μm in diameter, shown as figure 10, resulting from tension overstress destruction. When we check the composition of the fracture surface of figure 10 using EDS, we would realize that there is copper, carbon, and oxygen in minimal amount, as shown in figure 11. We shall then presume that copper is the key element of the substrate of the #1 wire and carbon and oxygen have resulted from the environment reactant.

Figure 12 shows the SEM image of the broken B end of the #1 wire and the fracture surface is round, 200 μm (0.2 mm) in diameter, showing visible necking. Figure 13 shows the fracture surface of B1 in figure 12, which is a magnified observation and the SEM image shows the fracture surface covered by deposition, with minor dimples (1~3 μm in size). Analysis of the broken B1 surface using an EDS system reveals that the key elements are copper with minimal amount of carbon, oxygen, aluminum, chlorine, silicon, sulfur, potassium and calcium shown as figure 14. In which, copper is the substrate element of the #1 wire and carbon, oxygen, aluminum, chlorine, silicon, sulfur, potassium and calcium have come from the environment reactants. As the B end of the wire shows discolor as a result of the many deposition (but A end shows only carbon and oxygen), we shall presume that the B end of the #1 wire suffered overstress destruction during extension and the fracture surface must have burned and deposited by contaminates. In which the chlorine and potassium probably resulted from the bleaching agents.

The SEM image shows necking on the P end of the positive wire. Within 1.7 mm of the broken end surface is dark brown with broken plating melted, and matrix uneven. It is presumed that it was partially melted by overheat.

Besides, it was corroded and deposited by contaminants. At 1.7 mm~2.2 mm from the fracture, there is peeled plating shown as figure 15. Usually a metal wire occurs necking, that is revealed the wire sustained an axial tension load. However, the positive wire P end fracture surface is shown around the broken end and the side of the wire. Furthermore, the fracture surface is shown broken plating, uneven, discolor and pollutant deposition, all indicating that the fracture surface has undergone overheated melting and corrosion. The battery plastic casing (polypropylene, PP) near the P end of the positive wire is tested at 165.7°C shown as figure 16. And the battery lead plate has a melting point of 323°C. Due to both the battery plastic casing and the battery lead plate were shown no melting which are very near the local melted P end of the positive wire, therefore, it is deduced that the overheated melting of the P end of the positive wire did not occur after the explosion in the cabin. Had the positive wire melted after the explosion, both the battery plastic casing and the lead plate nearby would have been destroyed. On the contrary, the overheated melting of the P end of the positive wire had occurred before the explosion in the cabin, and the overheated melting had only occurred near the broken end of positive wire, the wire overheated melting probably caused by short-circuited.

EDS analysis of the composition of the scrapped surface in figure 15 reveals only copper, shown as figure 17, and therefore copper must be the substrate element of the positive wire. EDS analysis of P2 (shown in figure 15), the spectrum shows the primary element of copper and tin, and the minor elements of oxygen, carbon, aluminum, silicon, lead and iron in minimal amount shown as figure 18. The copper is the substrate element of the positive wire and the tin is plating. The lead and iron were resulted from the polarity components. The oxygen, carbon, aluminum and silicon probably were resulted from the environment reactants. The EDS analysis given in P1, P2 indicate that the positive wire was copper wire with tin-plating, which is the same as the #1 wire. EDS analysis of the P3 dimpled surface (shown in figure 15), the spectrum shows the elements of iron, copper, oxygen and lead, plus trace amounts of carbon, aluminum, silicon and calcium shown as figure19. The copper is the substrate element of the positive wire. The iron, aluminum, silicon, lead, calcium and oxygen probably resulted from the oxides and carbides, which were come from the environment reactant and the deposited contaminant. The dimpled surface at P3 may be resulted from the high temperature, above 1083°C (the melting points of tin and copper are 232°C and 1083°C, respectively), generated by the arc of the short circuit. The completely burned pure copper substrate formed the crater and later deposited the contaminant (oxides and carbon buildup).

The SEM image shows that the fracture N of the negative wire was squeezed to form a triangle of 200 μm (0.2 mm) in height and 100 μm (0.1 mm) in width shown as figure 20. A magnified image of the N1 fracture surface (shown in figure 20) shows a large number of dimples of 5~10 μm in size shown as figure 21. The N1 fracture surface is resulted by overstress destruction. EDS analysis of the fracture surface (shown in figure 21) that the spectrum reveals the primary elements of copper and lead, the minor element of oxygen, and the magnesium, aluminum, silicon, calcium and iron in minimal amount shown as figure 22. The negative wire substrate was copper with lead coming from the lead polarity rod. The magnesium, aluminum, silicon, calcium, iron, oxygen and carbon were resulted from the environment reactant. EDS analysis of the N2 negative wire surface (shown in figure 8) that the spectrum reveals its primary components are copper with tin, oxygen and aluminum in minimal amount shown as figure 23. Copper is the substrate element of the negative wire and with tin-plating. The aluminum and oxygen were probably resulted from the environment reactant.

By the EDS analysis results reveal that the three wires are all the round tin-plated copper wires.

A comparison of the fracture surface of the 4 ends of the three wires reveals that the A end of the wire and the N end of the negative wire were fractured alike sustained tension, though they do not show visible connection (as one has a half-moon dent and the other a triangular protrusion). A ductile fracture would produce the necking and the cup and cone would be used for comparison. In this case, we may see that the A end of the wire and N end of the negative wire are similar. However, severely contaminated by lead and burn (having oxygen, carbon), the N fracture surface would not show the visible proof of both A end and N end were identically connection by the micro fracture surface aspect. Despite the face that the B end of the #1 wire and the P end of the positive wire show carbon buildup in faded color, there is much difference between the side and the fracture surface. In case of the P end of the wire, there is a large amount of oxides and carbides, along with evidence of melting, burn and discolor due to the high temperatures. All these resulted from the local arc created by the short circuit.

(4) Wire short circuit simulation test

A new GTX4L-BS lead-acid motorcycle battery with a surface and ambient temperature of 26°C was charged. Within five minutes of charging, the surface temperature of the battery rose to 33°C with the voltage at 12.7V.

A new 0.47 mm wire (PVC-shielded copper wire) one of end was connected to the battery positive polarity terminal, then the other wire end short-circuited to the battery negative polarity terminal. When connected, the arcing and spark would be occurred and the end would be melted. The plastic shield would also melt and soften. Due to arcing and spark are occurred shortly, it was very difficult to measure the maximum temperature in the wire. However, as the wire melted, the local temperature where arcing and spark occurred would be over 1083°C, which is the melting point of copper. In another test, prepare two new wires (PVC shielded copper wire) of 0.47 mm in diameter, with one wire connected to the battery positive polarity terminal and the other wire connected the battery negative polarity terminal. Then the two wires short circuit. When connected, the wire would produce arcing and spark and the end and plastic shield would melt. The two tests results revealed that the wire of 0.47 mm in diameter would not be connected to a new lead-acid battery for motorcycles in short circuit.

As the flash point of gasoline vapor is 225°C and battery casing (PP) is 165.7°C, the battery would ignite before reaching the flare point of the gasoline. Accordingly, it would be less probable to see the connection of a wire connected to an old battery in short circuit (not being duly secured) to have the surface temperature of the battery go up to ignite the vapor.

4. Conclusions

1) The tests demonstrate that the wire gather from the runway is the same material as the two wires connected to the positive and negative battery terminals. It is a round copper wire 0.47 mm diameter between AWG#24 and AWG#25.
2) The broken wire from the runway has one end that appears to be the same as that of the negative wire. The contaminated fracture surface of the negative wire is difficult to verify the both wires have identically connection.
3) Melting, burns and discolor at the P end of the positive wire suggests that there was a short circuit and arcing before the battery was destroyed.
4) The simulation demonstrated that connecting the two terminals with one copper wire would create a short circuit or arcing and melt the contact.

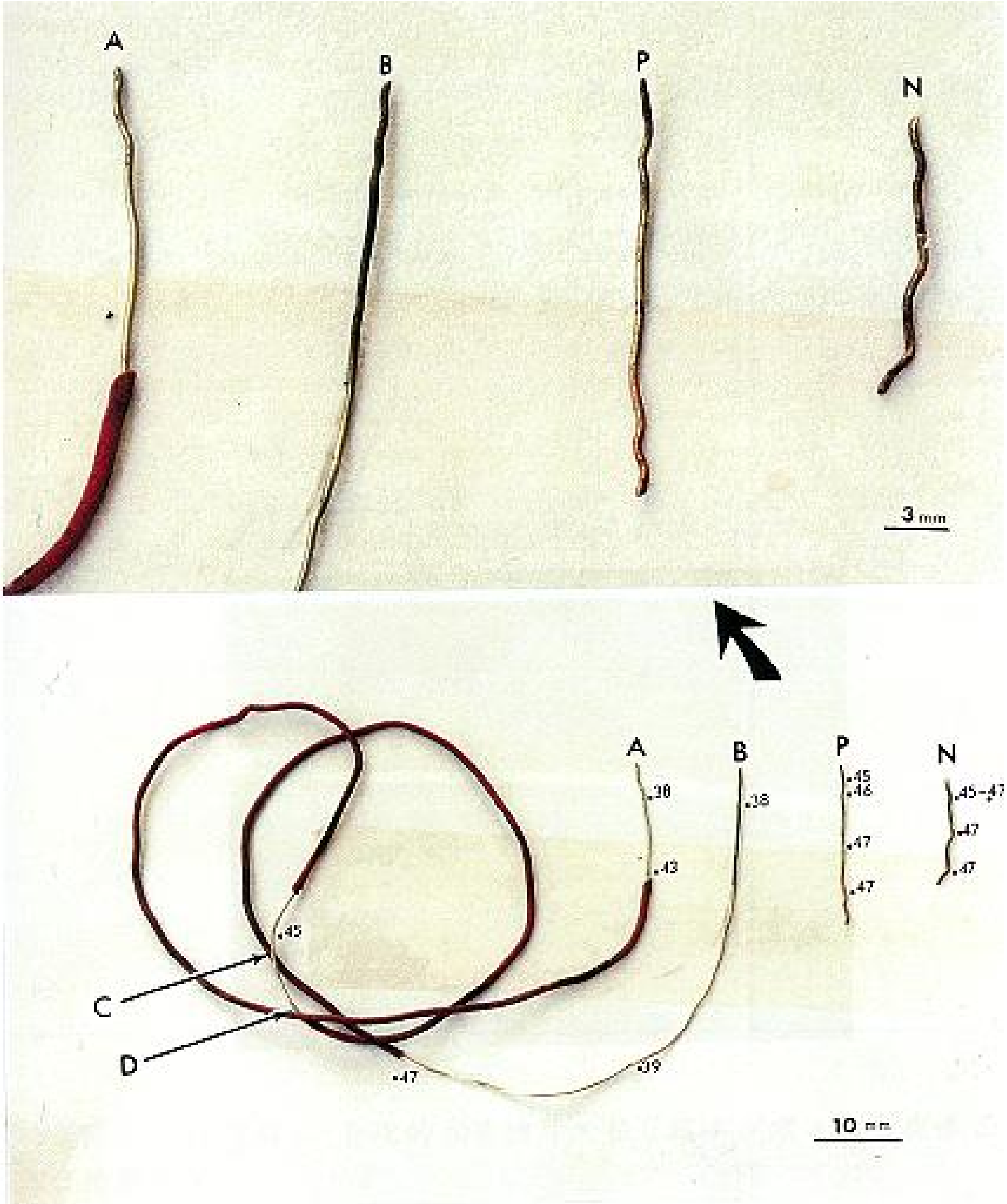


Figure 1. The mage of the three wires and their diameters. From left to right, there is the #1 wire gathered from the runway, the battery positive and negative wire. Most of the plastic shields of the #1 wire are red and the others are charred black. The broken end of A, B, P and N wires are a silver color and others are a red brass. The B and P ends turned dark brown.

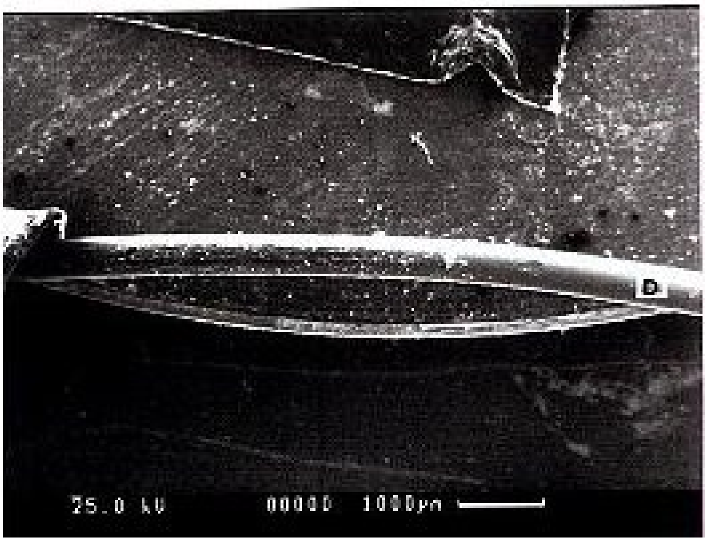


Figure 2. SEM image of segments C, D of the #1 wire. The C segment is scratch. The segment D remains unmarked.

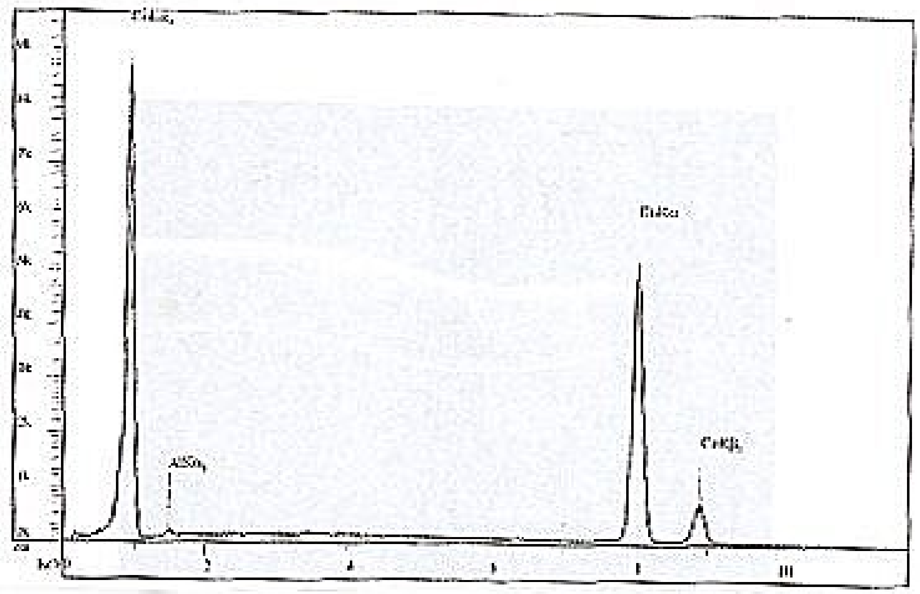


Figure 3. EDS spectrum of C in figure 2. It shows the #1 wire substrate of copper with aluminum coming from the environment reactant.

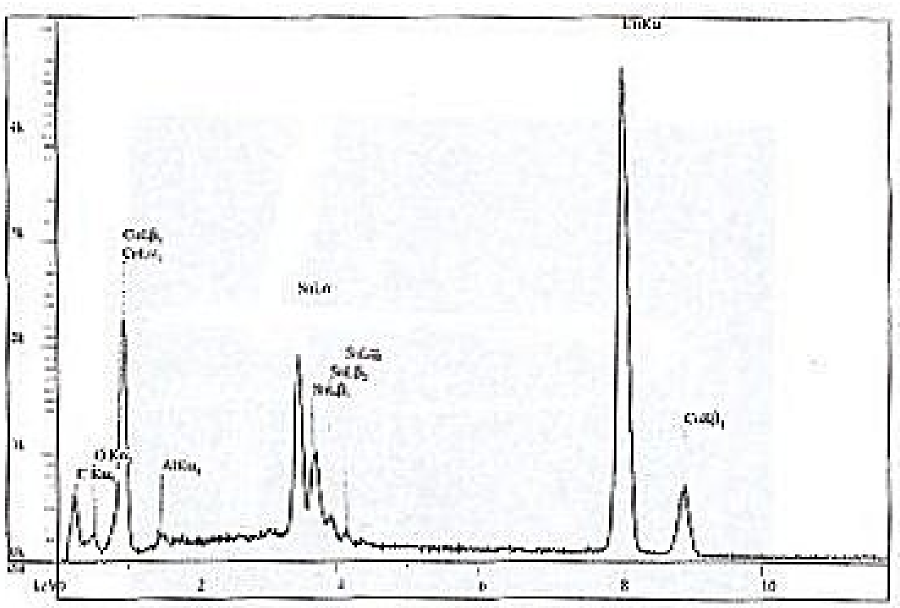


Figure 4. EDS spectrum of D in figure 2. It shows that except the #1 wire substrate of copper and tin-plated surface, the other elements come from the environment reactant.

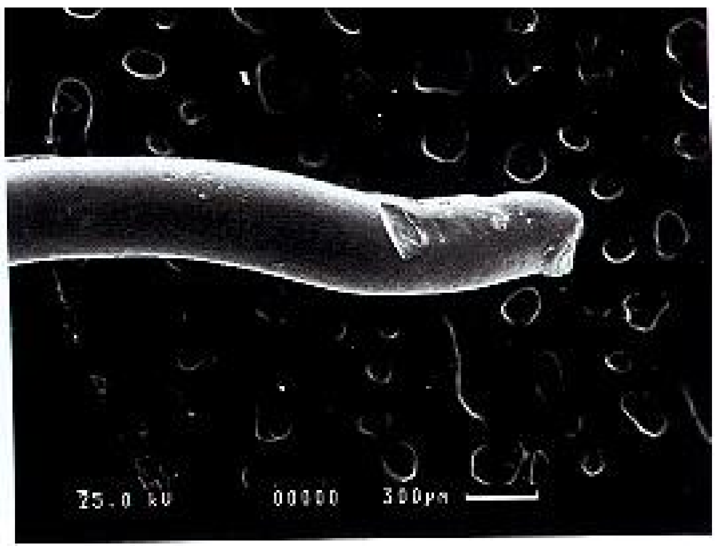


Figure 5. The SEM image of A of the #1 wire. The lead has visible necking and the surface shows scratches.

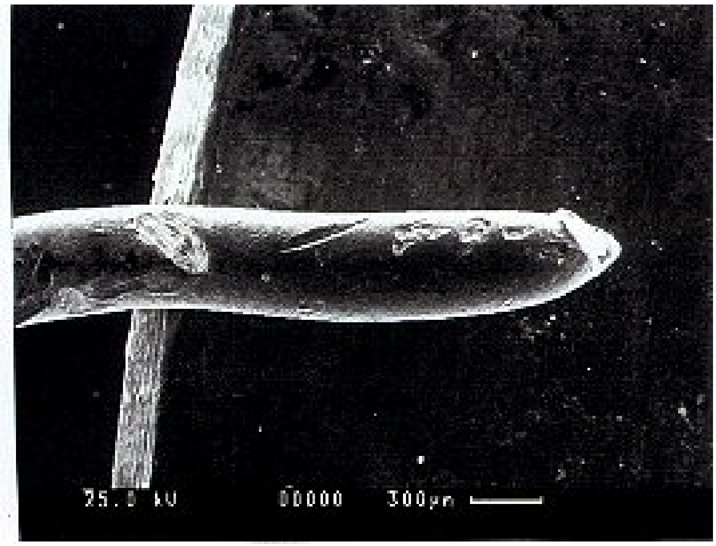


Figure 6 The SEM image shows B of the #1 wire. The lead has visible necking and the surface is faded with scratches.

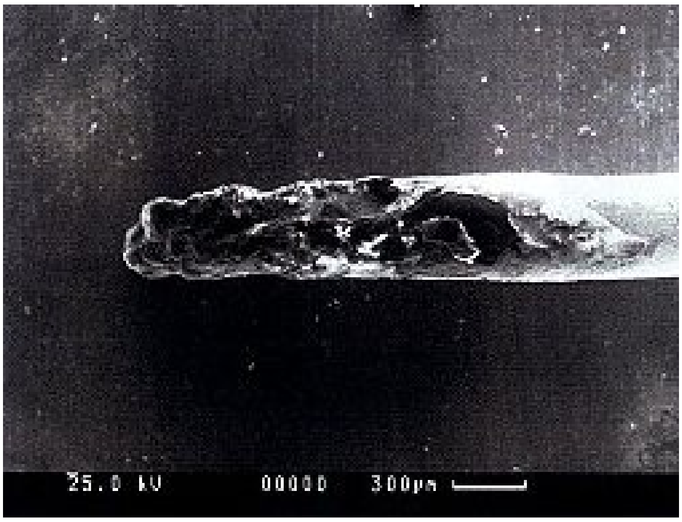


Figure 7. The SEM image shows the P of the positive wire. The lead has necking and the broken surface is a dark brown color, with broken plating and uneven on the substrate.

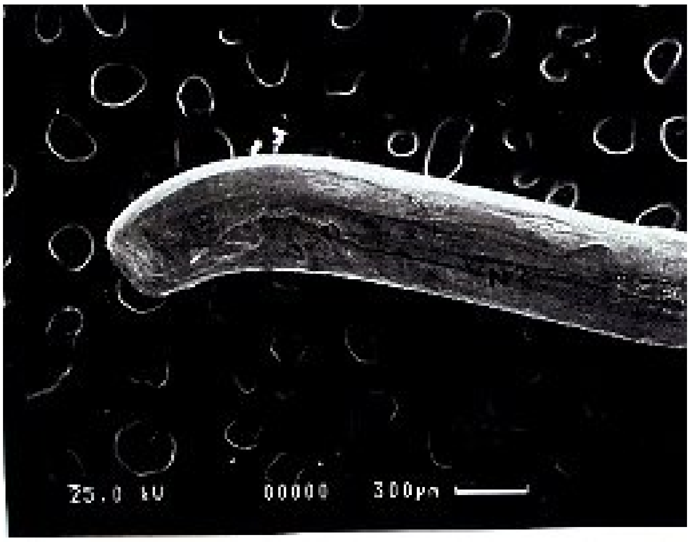


Figure 8. The SEM image shows N side of the negative wire. The broken surface shows necking and squeeze marks.

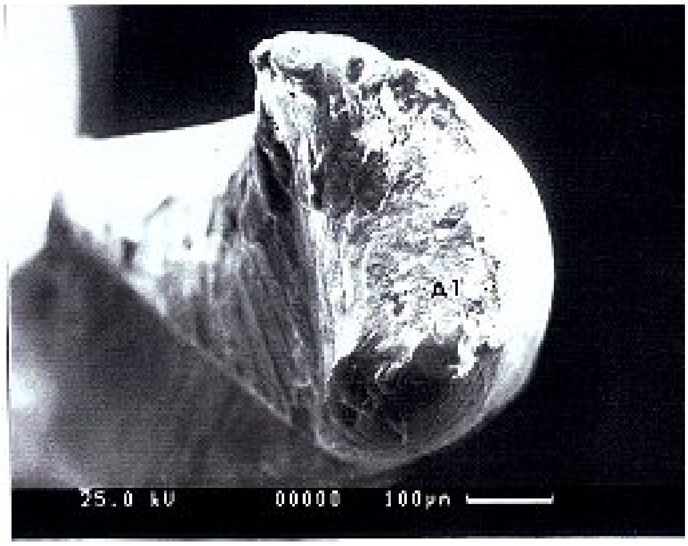


Figure 9. The SEM image shows A fracture surface of the #1 wire. The fracture surface is half-moon shaped with the left side squeezed into a spiral form.

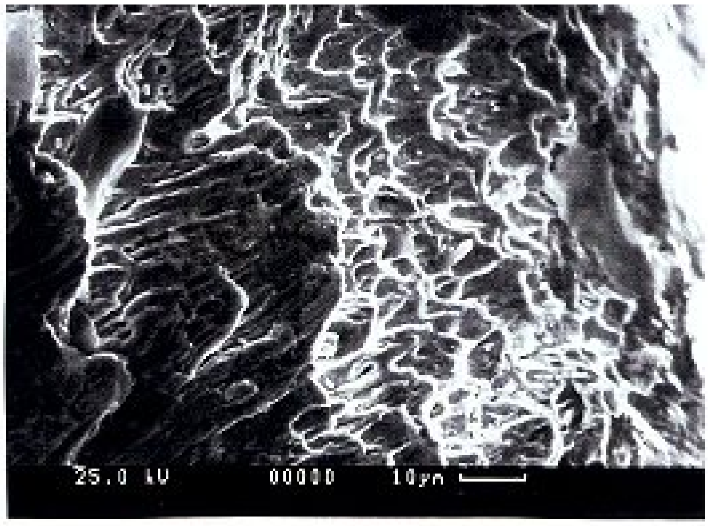


Figure 10. The SEM image shows the fracture surface of A1 in figure 9. The fracture surface is clean with sharp dimples, result by overstress.

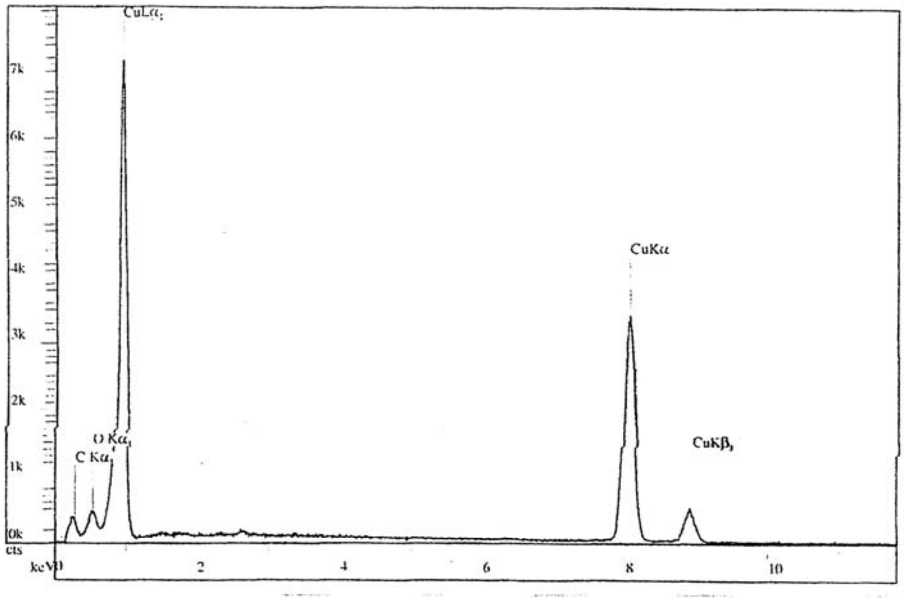


Figure 11. EDS spectrum of the fracture surface in Figure 10. The primary element of the #1 wire substrate is copper, with carbon and oxygen resulted from the environment reactants.

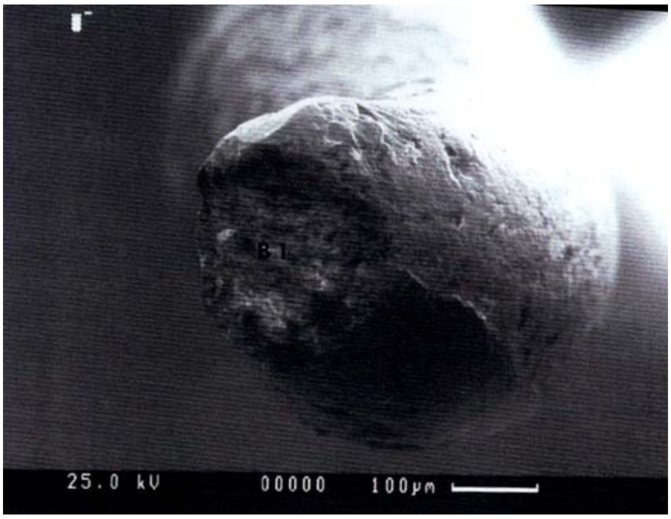


Figure 12. The SEM image shows B fracture surface of the #1 wire. The fracture surface is round and shows clear necking.

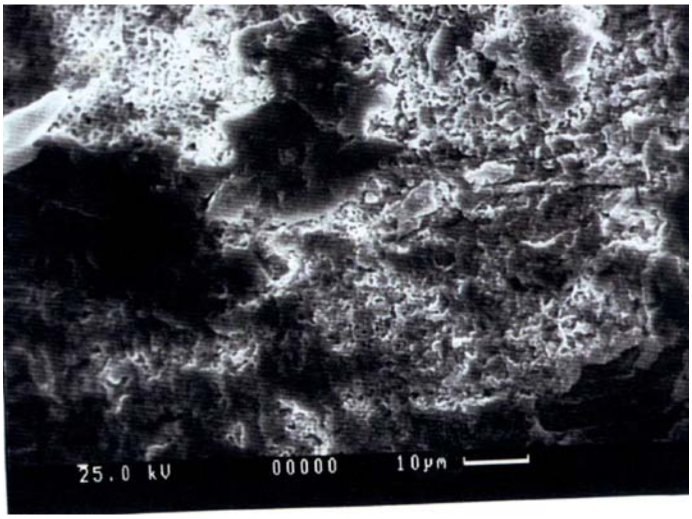


Figure 13. The SEM image shows B1 (figure 12) fracture surface of the #1 wire. The fracture surface has deposited and minor 1~3 μm diameter dimples.

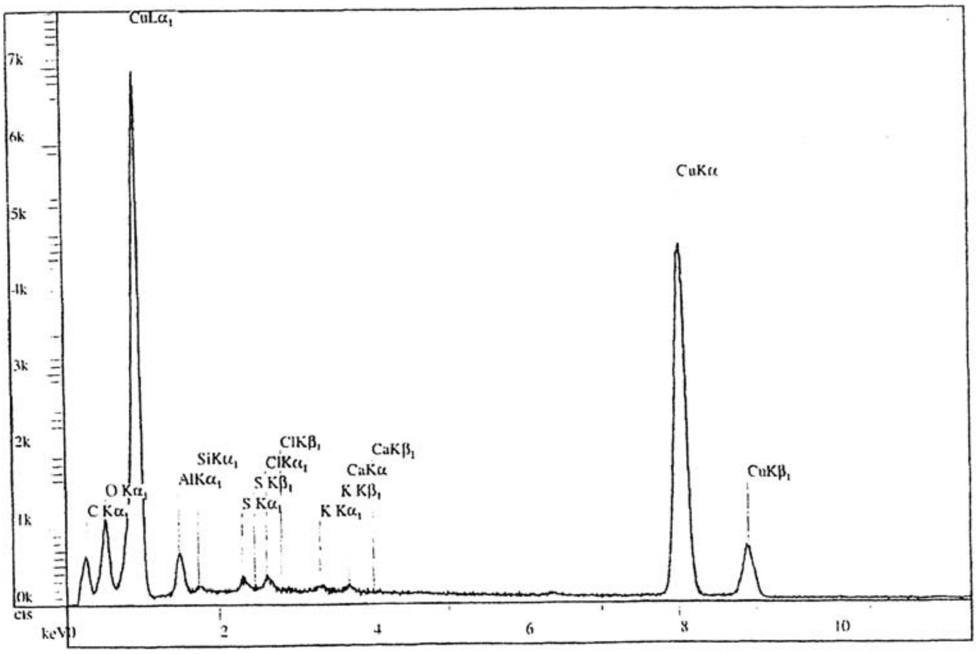


Figure 14. The EDS spectrum of the fracture surface in figure 13. The copper is the substrate of #1 wire. Aluminum, silicon, chlorine, potassium, calcium, sulfur, carbon and oxygen resulted from the environment reactants.

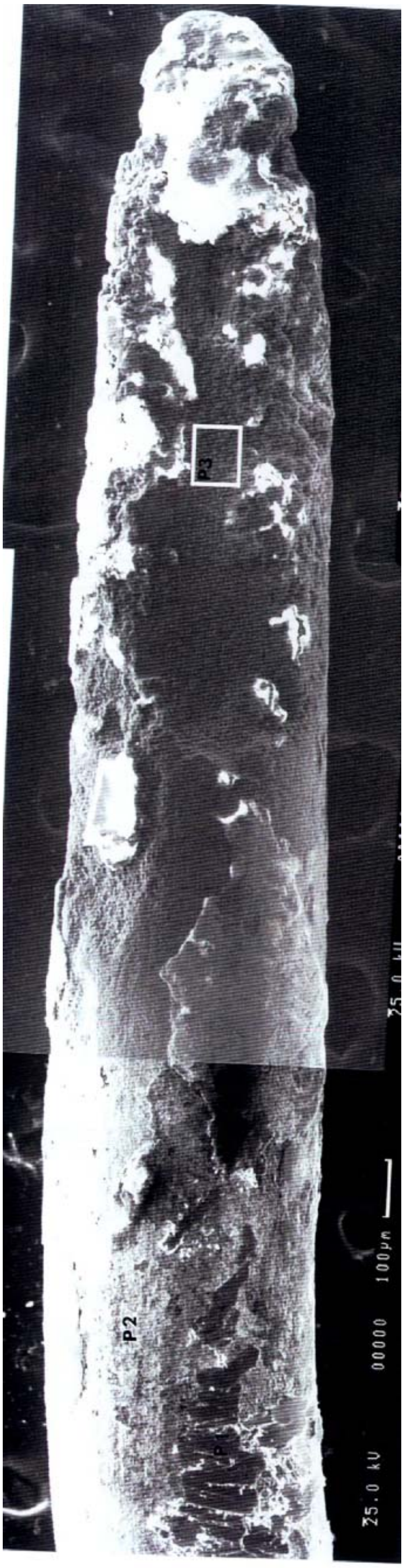


Figure 15. The SEM image shows P fracture surface of the #1 wire, showing necking. Within 1.7 mm from the fracture, it is dark brown with broken plating and dimples. In 1.7 mm~2.2 mm from the fracture, it is silver color with peeled plating. The fracture surface was overheated and melted, and the fracture surface deposit environment reactant and contaminants.

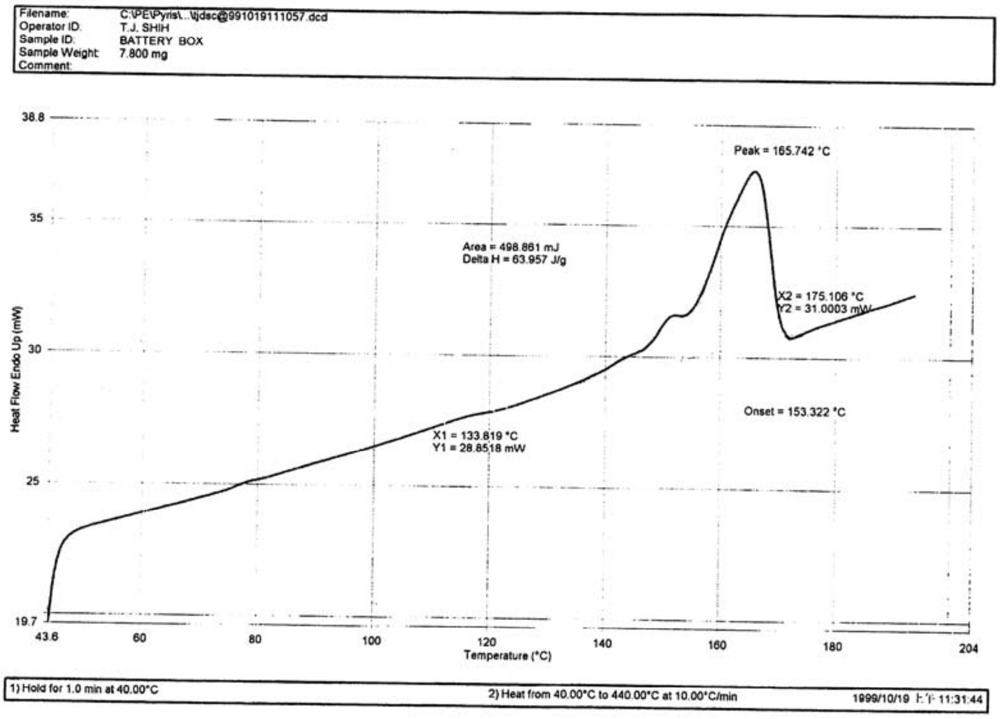


Figure 16. Thermal analysis curve of the battery casing.

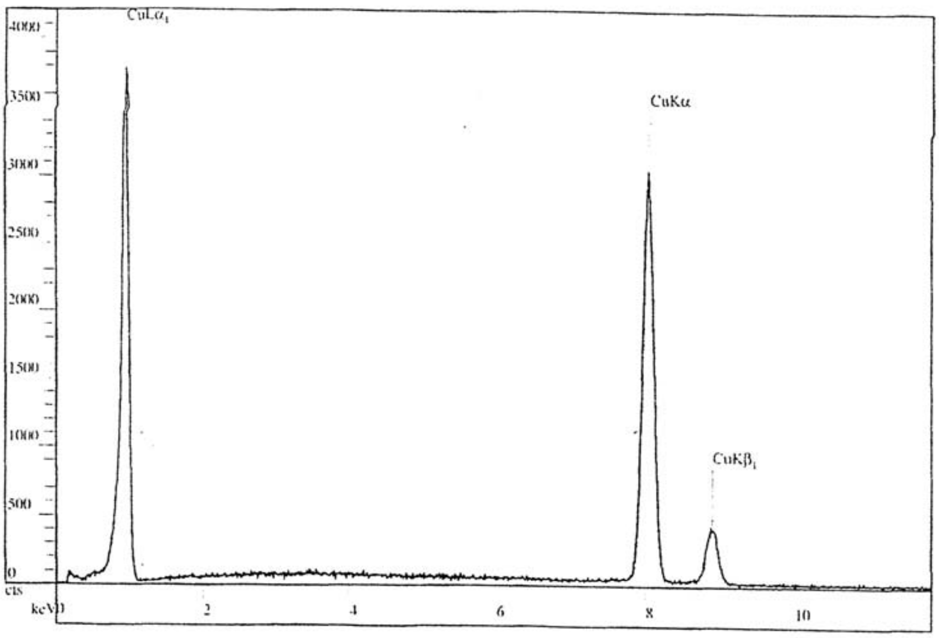


Figure 17. The EDS spectrum of fracture surface of P1 in Figure 15, demonstrating that the substrate is copper.

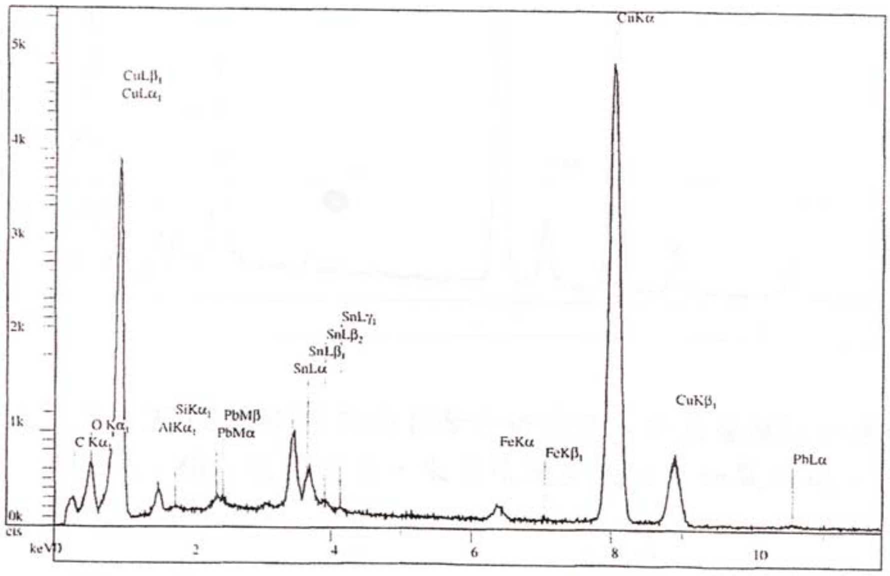


Figure 18. The EDS spectrum of fracture surface of P2 in Figure 15, revealed that the substrate is copper with tin-plating, and aluminum, silicon, chlorine, potassium, calcium, sulfur, carbon and oxygen resulted from the environment reactant.

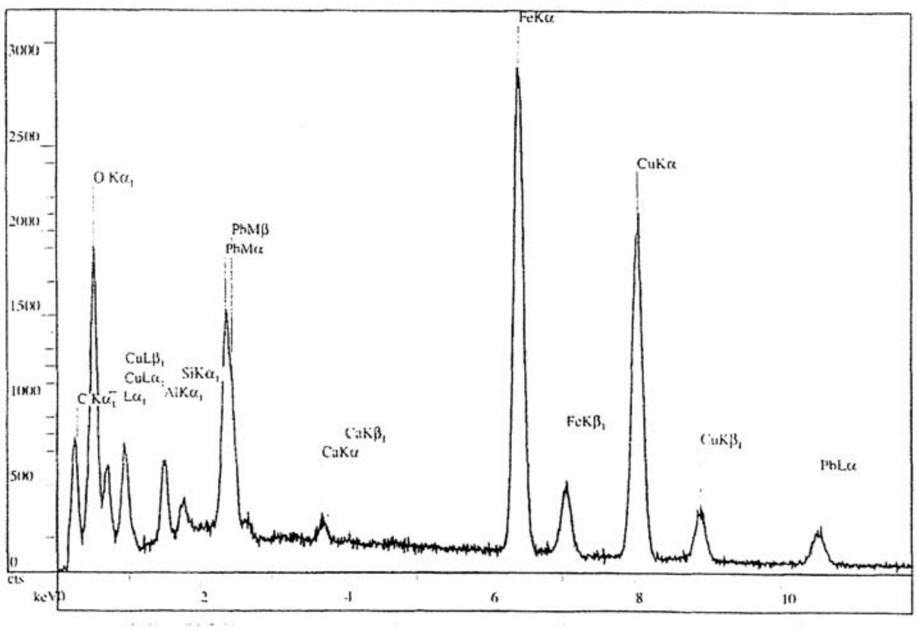


Figure 19. The EDS spectrum of fracture surface of P3 in Figure 15, showing that the substrate is copper, and aluminum, calcium, iron, oxygen and carbon come from the environment reactant.

Figure 20. The SEM image shows the N fracture surface of the negative wire. The fracture surface shows it squeezed flat into an almost triangle form.

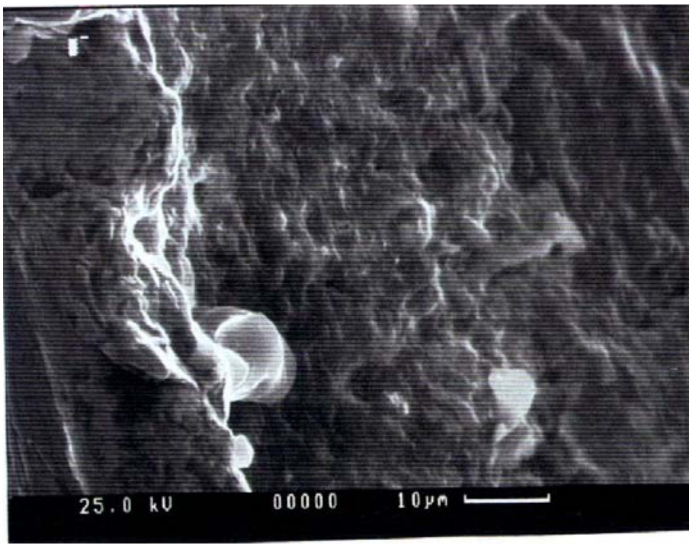


Figure 21. The SEM image shows N1 fracture surface in Figure 20. The fracture surface shows dimples, result by overstress.

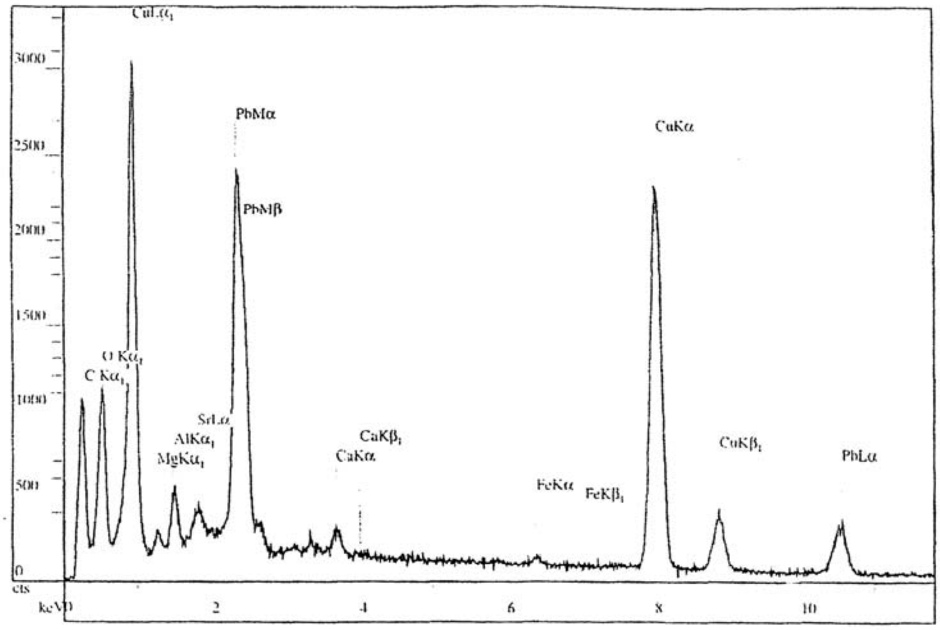


Figure 22. The EDS spectrum of surface of figure 21, showing that the substrate of the negative wire is copper, with magnesium, aluminum, silicone, calcium, iron, oxygen and carbon coming from the environment reactant.

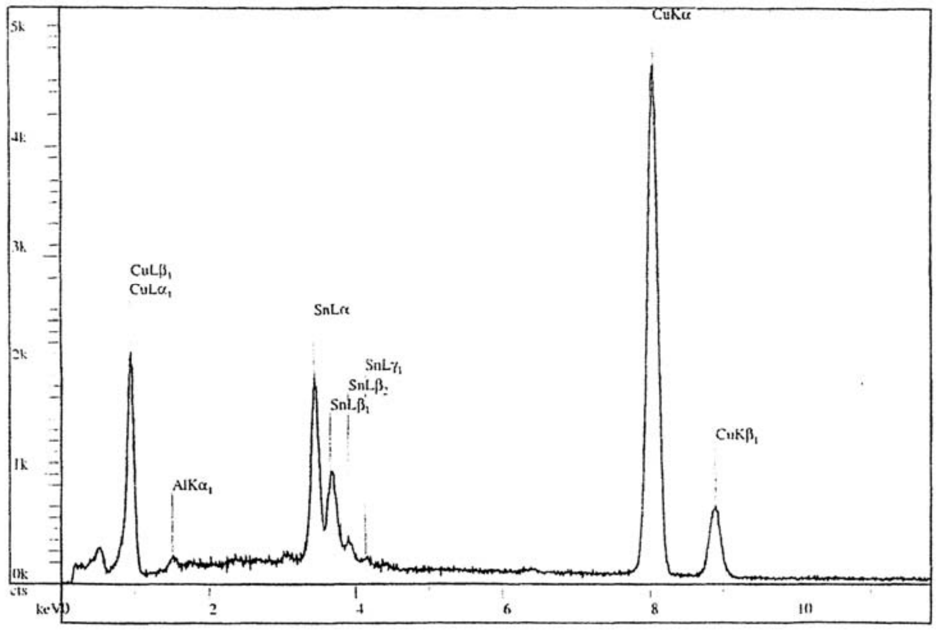


Figure 23. The EDS spectrum of N2 surface in figure 8, showing that the substrate of the negative wire is copper with tin plating, while aluminum and oxygen came from the environment reactant.

Attachment 3 Aircraft Bin Explosion Reconstruction Test

Chung Shan Institute of Science and Technology

Classification	Ordinary
Document No.	89DP001H-001
Total pages	29

Aircraft Bin Explosion Reconstruction Test

Prepared by: Division 2, Laboratory 4,
Chungshan Institute of Science & Technology

Report Data Sheet

1. Report No.: 89DP001H-001	2. Classification: Ordinary	3. Date: Sept. 10 2000	6. total pages: 29
7. Title of the report: Aircraft Bin Explosion Reconstruction Test			
6. Prepared by: Division 2, Laboratory 4			
7. Project host: HSU Long-chih			
8. Prepared by: LIU Ching-kun			
9. Key project:		10. Project code: 89DP001H	
11. Byproject:		12. Byproject code:	
13. Key words: Air safety, bin, vapor explosion			
14. Report distributed to and copies:			
15. Reviewer	16. Approved by	17. Verified by	

1. General

In August 1999, as a UNI AIR MD-90 aircraft rolled on the runway at the HUALIEN airport upon its arrival, an explosion ripped open a stowage bin and started a fire. After the accident, Hsinchi liquid bleach and fabric softener bottles containing gasoline were found on the runway. Investigators detected gasoline on the clothing of more than one passenger and found a 12V-motorcycle battery under a seat in the main cabin. The evidence suggests that gasoline leaking from the bottles contacted the battery and caused a short circuit. Sparks then ignited the gasoline vapor.

The Aviation Safety Council (ASC) asked the Aero Materials Lab and this office in April 2000 to conduct a simulation of the vapor explosion that might have taken place in the stowage bin. In June 2000, ASC entered into an empowering contract with this office to reconstruct the UNI AIR 873 Stowage Bin Explosion, with the following conditions:

1) To simulate an environment of with liquid bleach and softener bottles containing gasoline possibly leaking during ordinary transport. (Provided by Aeronautical Materials Lab in this Institute)
2) Using a physical UNI AIR MD-90 aircraft stowage bin (or a replacement), ASC attempts to verify whether a battery of the same type would trigger the volatile gasoline vapor contained in the bin as the one found at the scene. The explosion scene is also checked.
3) Measurement of the explosion power using a pressure gauge for ASC's evaluation and comparison to the physical damage suffered

by UNI AIR 873 flight.

4) To record the explosion development using high-speed cameras.

5) To provide consultancy service in association with this reconstruction.

2. Discussions held with the Aero Materials Laboratory on "Simulation of Aircraft Bin Explosion", we have come to agree on the following tasks:

1) Assignments to this office:

a. Entering into contract with ASC.

b. Design and preparation of the prototype stowage bin

c. Preparation of the stowage bin rack

d. Measurement of explosion in the stowage bin

e. High-speed cameras and film cameras (to be provided by Division 6 Laboratory 2, CIST)

f. Test sites: Chiupeng, Chingshan.

g. Firefighting support

h. Travel, lodging, visit and site expenses

2) Assignment to the Aero Materials Laboratory:

a. Test of gasoline leakage from bleach bottle sealed with silicon, and the possibility of an explosion.

b. Vapor concentration and initial concentration in stowage bin.

c. Ignition of vapor from sparks using a 12v motorcycle battery

d. Vapor explosion test in a bin of reduced size

3. Theoretical forecast

1) Physical & chemical properties of gasoline:

a. Physical property: (20°C, under 1 atmospheric pressure): liquid

b. Solubility in water: 1 to 100ppm/100ml.

c. Molecular weight: mixed

d. Steam pressure: 300 to 600mmHg at 20°C

e. Boiling point: 40 to 200°C

f. Floatability: Floatable

g. Odor: Gasoline, at 0.25ppm.

h. Flash point: -43°C (closed)(octane value 60); -38°C (closed)(octane value 100); -46°C (closed) aircraft fuel.

i. Specific gravity: 0.75 to 0.85 at 20°C

j. Color: Non-color to red or violet

k. Explosion limit: 1.4 to 7.6%

l. Fusing point: -90 to -75°C

2) Environmental conditions:

a. Ambient temperature: 25°C (298K)

b. Atmospheric pressure: 1 atm (1.013 bars)

c. Volume in closed room: $1M^3$ (1000L)

d. Gasoline volume: 3.6L (premium gasoline)

3) Explosive force:

Suggested by reference [1]: Using the initial explosion energy figures given in 10J, the lower explosion limit: LEL of gasoline (or propane) vapor is 1.4% and the upper explosion limit: UEL of gasoline vapor is 7.6%. The higher the explosion limit, the wider the upper and lower explosion limit becomes, and vice versa. The explosion temperature and pressure of vapor affect the upper and lower limit of the explosion concentration. Usually the higher the explosion temperature and pressure, the wider the upper and lower explosion limit, and vice versa. Additionally, the lower the absolute humidity of the vapor, the wider the upper and lower limit of the explosion, and vice versa.

With the gasoline vapor in enough time for volatilization and when turned into solution after even mixture with air, being the molecular weight of gasoline (C4~C8 alkane) 86 (average of C6) and the specific gravity: 0.8, the mol or gasoline would be 3600×0.8/86=33.5mol and at 25°C: 1atm (100Kpa), when fully volatilized, a total of 750L would be produced (this is unclear and needs to be divided into two or more separate sentences. LJB). That is to say, the total volume of the fully volatilized vapor of 3.6L would go at 75% and as it has gone over the explosion upper limit, a explosion would be imminent!

In fact, the maximum concentration of the mixture of air with gasoline would depend on the saturated steam pressure of the time. Suggested by CPC, 95 (octane? LJB) unleaded gasoline at 37°C would have an average steam pressure of 51Kpa; in other words, the steam would be as much as 51% of the volume. At 25°C, the steam pressure lowers to 40Kpa. Its volume is then 40%, and would still be over the explosion upper limit. If the vapor is to explode, it must take place before the vapor becomes over-saturated. Ignition may take place at between 1.4%~7.6%. Suggested by reference [1]: When the container has the volume of 7L, at 4.0%, the maximum explosion pressure created by the vapor explosion would be 7.4 bar (107.33 psi) and the boost would be 370 bar/sec. Accordingly, we have selected the 500psi explosion sensor.

4. Preliminary test

1) Material: 5.95 unleaded gasoline

6) Minor bin (60cm*40cm*40cm, PE, of 96 liters)

7) Inflammable gas detector (MSA Gasport 321ML)

8) Plastic cup

9) Pressure gauge

10) High-speed cameras

2) On June 15, a 96-liter simulated bin vapor ignition test was conducted to determine if a spark from the 12v battery would ignite the vapor inside the bin, as shown in Picture 1 (a)~(d).

3) On July 12, 96-liter and a 400-liter simulated bin vapor ignition tests were conducted using a high-speed camera to record the ignition process. The results indicated that the 96-liter bin ignition was successful, as shown in Picture 2 (a)~(c). Boost was detected too, as shown in Fig. 2. The 400-liter simulated bin ignition was also successful, as shown in Picture 3 (a)~(c). However, there is no reliable data as the instant peak value exceeded the upper limit. Both sensors were damaged in the 400-liter simulated bin test.

   Conclusion: Thanks to the air, the large bin has a higher explosion power than that of the smaller bin.

4) On July 25, a 1000-liter simulated bin vapor ignition test was conducted using a high-speed camera to record the ignition process. The 96-liter bin successfully ignited, as shown in Picture 4 (a)~(c). The ignition was successful and the explosion was a little larger than that obtained using the 96-liter and the 400-liter bins. However, boost was not tested for and the quantitative result remains to be verified.

5. Formal test

1) The following is the table of the test material:

Table 1 Characteristics of the stowage bin explosion reconstruction test

Bin No.	A	B

Material	FRP + aluminum honeycomb	Wood + acrylic
Dimension	Φ75cm half-circle × 152cm L	$200 \times 100 \times 50cm^3$
Volume	350 liters	1000 liters
Fuel capacity	1.3 liters	3.6 liters
Explosion energy	12V battery + wire sparks	12V battery + wire sparks
Vapor concentration	Inflammable gas sensor (MSA Gasport 321ML)	Inflammable gas sensor (MSA Gasport 321ML)
Boost	Piezo-electric boost detector	Piezo-electric boost detector
Camera record	High-speed camera + BetaCam	High-speed camera + BetaCam
Remarks	(1) The 727 bin is provided by ASC. (2) Explosion power supply is the same type of battery as collected from the scene.	Bin purchased by this office.

2) Time:

August 15 ~ August 19 2000, in Sector 600 at Static Power Test Site at Chiupeng Base.

3) Layout

Description of the test site and layout of the test material:

(1) The bin is placed horizontally on the stand, 80cm above the ground and centered on the test site.

(2) A high-speed camera and VCR is set up 50m from the test center.
(3) Both the bin explosion control and boost monitoring system are located in Room 675.
(4) For other locations, please refer to Fig. 1.

6. Test procedure & results

1) Simulation using a reinforced wood and acrylic stowage bin

In the 0725 test, both the wood and the acrylic board performed perfectly in terms of elasticity. After the explosion, high-speed photography revealed the wood and acrylic boards bulging but not exploding. The bin had been reinforced with wood and then sprayed with gasoline. Gray tape was used to seal the ventilation opening.

2) The 1st, 2nd, 3rd and 4th simulated 1000-liter bin test

To simulate the possibility that the battery may have been carried inside a backpack, the carton holding the 12V-battery spark generator was placed in a plastic bag. The bin was filled with rags, 0.5 liter gasoline was fed into the carton, and then approximately three liters of gasoline were sprayed evenly in the bin.

Test result: The 12V battery spark generator successfully started and the 0.5mm mono-thread wire melted into 2 segments. This shows that the spark temperature had raised to over 1000°C yet the bin showed no sign of explosion.

The vapor inside the carton ignited although the outside of the carton showed no damage. No exterior flash was evident on the high-speed camera.

3) The 5th and 6th simulated 1000-liter bin test

The backpack carrying the battery underwent four tests and proved that the spark could not ignite the vapor outside the backpack. The battery was then removed from the carton and placed in the bin with rags. One liter of gasoline was sprayed evenly in the bin and the opening of the bin sealed with gray tape.

The 5th test result: The 12V-battery spark generator successfully started and melted the 0.5mm mono-thread wire into two segments. There apparently was an explosion in the bin but the fire extinguished immediately. The explosion sequence is shown in Picture 5 and the boost test is shown in Fig. 3.

The 6^{th} test result: The upper part of the rag shows no signs of burns, but has dried. The gray tape is unbroken but shows blistering from the high temperature. The 12V-battery power cord is severely damaged. We believe that the sudden fire and oxygen deprivation caused this damage. The explosion sequence is shown in Picture 6 and the boost test is shown in Fig. 4.

4) Simulated test on the inner casing of Boeing 727 bin

A Boeing 727 storage bin has a capacity of 350 liters and has a 10cm-wide opening above the lid and a 3cm-wide opening to its left. The lid is secured by a mechanical spring located in the center. To keep vapor from leaking, both openings were sealed with gray tape. This bin was not sealed as tightly as the wooden bin because the tape used was too narrow. The battery was placed in the bin along with newspapers, and then sprayed with approximately three liters of gasoline. Finally, a liquid bleach bottle half filled with gasoline was placed in the bin, as shown in Fig. 9.

Test result: In the first test, the power cord of the 12V battery was not properly connected and the battery did not start. In the second attempt, the 12V battery spark generator successfully started and melted the 0.5mm mono-thread wire into two segments. There apparently was a momentary explosion in the bin, but it did not open the bin door. In the third attempt, the 12V battery spark generator successfully started and melted the 0.5mm mono-thread wire in two. An explosion occurs in the bin that opens the bin door. Air sufficient to keep the fire lit triggers a second explosion that engulfs the bin in fire. The explosion does not destroy the bin structure. Picture 9 shows the explosion sequence and the explosion test results are in Fig. 7.

5) The 7th and 8th simulated 1000-liter bin test

After the B727 aircraft bin inner casing simulation, newspaper was placed in the 1000-liter bin and sprayed with three liters of gasoline. A new 12V battery spark generator was placed inside and then the bin sealed with gray tape (is this “gray tape” mentioned throughout duct tape? LJB).

Test results: In the 7th test, the 12V-battery spark generator’s lead wire is too short and the battery does not start. On the 8th try, a new 12V-battery spark generator successful starts and melts the 0.5mm mono-thread wire into two segments. Then there is instantaneous explosion in the bin and the fire immediately extinguishes. The Picture 7 shows the explosion sequence and the explosion test results are shown in Fig. 5.

The upper part of the newspaper is completely burned. The gray tape shows burn signs but did not break. We believe that the bin lacked oxygen necessary to sustain the fire.

6) The 9th simulated 1000-liter bin test

A review on the first eight simulated 1000-liter bin tests shows that they are different from the lead test conducted at Chingshan Test site in the following manner:

(1) Reinforced bin structure

(2) To simulate the battery in the backpack, the 12V-battery spark generator is placed in the carton and then wrapped in a plastic bag, a factor that was ruled out in the 5th test.

(3) The bin that is filled with rags (newspaper is used at the Chingshan

Test Site), a factor that is ruled out in the 7th test.

(4) The bin opening was sealed with gray tape. In the test conducted at Chingshan, a tape was used but did not seal the opening well.

Discussions suggest that the bin may have a capacity of 1000 liters but the instant pressure created by the explosion is unable to destroy the structure of the wooden case. Also the fire lacks air and extinguishes. We therefore decided to conduct the test at the Chingshan Test Site and remove part of the reinforcement and the opening seal. With the bin filled with newspaper and sprayed with three liters of gasoline, a 12V-battery spark generator ignited the vapor.

Test result: The 12V-battery spark generator starts successfully and an explosion is generated instantly in the bin. The fire expands from the opening to engulf the entire bin. The explosion sequence is shown in Picture 8 and the explosion test result is shown in Fig. 6.

7) 12V battery spark generator energy test

Test result: The spark sequence triggered by the 0.5mm mono-thread wire is given in Picture 10 and the current development test results in Fig. 8. Should the voltage be 12V, the current development in time shall be multiplied by the estimated voltage energy for some 5 Joule.

7. Results & discussions

1) For an estimate of the possibility of gasoline leaking from the liquid bleach fabric softener bottles during ordinary transport, please refer to Aeronautical Materials Report [2] prepared by First Department.
2) A short circuit in a 0.5mm mono-thread wire of a 12V battery produces 5.0 Joules of energy. After repeated tests, the energy produced would still be capable of igniting the vapor when gasoline concentration remains within the upper and lower limits

(1.4%~7.6%).

3) When the stowage bin is smaller than 200 liters in volume and the vapor concentration goes down to below the explosion limit, the spark energy generated by the 12V battery in short circuit would be capable of triggering the vapor for a explosion. Without air, the energy released by the explosion is incapable of destroying the bin. Even with the lid left unsealed, there is not sufficient air coming in from outside to keep the remaining fuel burning.
4) When the stowage bin is larger than 400 liters and the vapor concentration is under the explosion limit, the spark energy generated by the 12V battery not only will ignite the vapor, but if air is allowed to enter, the remaining fuel will ignite in a secondary explosion.
5) A 1000-liter wooden bin does not hold enough vapor energy to destroy itself. When the bin is sealed to keep air from entering, the remaining fuel does not burn. However, an opening in the bin will allow the remaining fuel to burn and create a secondary explosion.
6) As the inner casing of the B727 aircraft bin has an opening contacting the outside, when the vapor concentration reaches the lower limit of explosion, the spark energy generated by the 12V battery in instant short circuit would not only be capable of triggering explosion, once air is fed in from the outside when the front lid is forced open as shown in Picture 9, the instant explosion (100ms~300ms) would keep the flame on. A high-speed picture shows that after the front lid opens and then closes up, pressure would be released to the atmospheric pressure. The explosion may not be capable of destroying the bin, but if the bin is contained in the fuselage, the fuselage itself would become a second closed

room the pressure would create a catastrophic secondary explosion.

7) The time sequence picture of the 1000-liter bin explosion shows secondary explosion. In this case, the flame depends on the existence of oxygen, just if the bin is big enough and fed with oxygen for an explosion. Poor air tightness or local weakness in the airframe (such as a latch on the bin) could allow in sufficient fresh air after the first explosion. Vapor may also escape outside the bin to trigger secondary explosion.
8) The following table shows the explosion pressure results:

	Initial pressure (psi)	Remote pressure (1.35m) (psi)	Flame speed* (m/s)
100 liters	292.5	97.5	NA
1000 liters (5)	112.45	16.05	4.5
1000 liters (6)	161.94	13.75	4.3
1000 liters (8)	229.42	103.19	4.2
1000 liters (9)	179.94	22.93	4.7
350 liters	31.48	197.22	NA

* Flame speed is obtained based on estimates by the high-speed camera.

Without any information on inner destruction, we have the following table of standards of damage created by ordinary explosions on both aircraft and personnel.

Target	Excess pressure (psi)	Destruction
Aircraft	>	Total destruction of all aircraft.
	14.5	Total destruction of non-metal skin of aircraft
	7.25~14.5	Medium or severe damage in cargo planes, minor

	3~7.25	destruction in military aircraft
Human	>	Death
	14.5	Severe harm to internal organs
	7.25~14.5	Fractures, harm to auditory organs
	4.3~7.25	Minor injury
	3.0~4.35	

8. Reference literature

[1] H. Burg and T. almond, "Explosions, course prevention protection", pp 7~9, Springer-Verlag, New York 1981.

[2] LIN san-wo, "Simulated Test Report on Aircraft Stowage Bin Vapor Explosion", Technical Report ARL-89I-005, First Dept., Chungshan Institute of Science & Technology, 2000, 8.

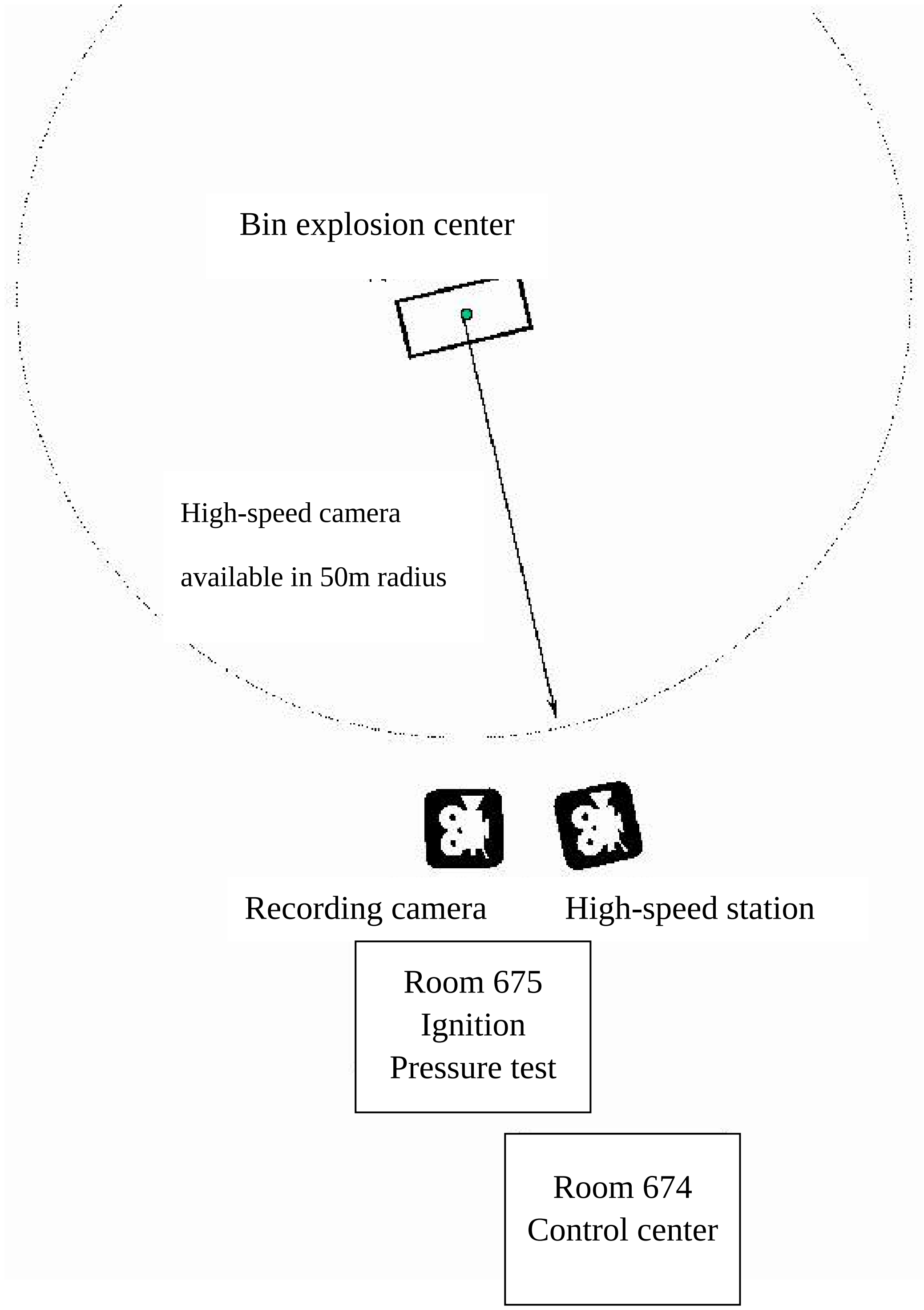
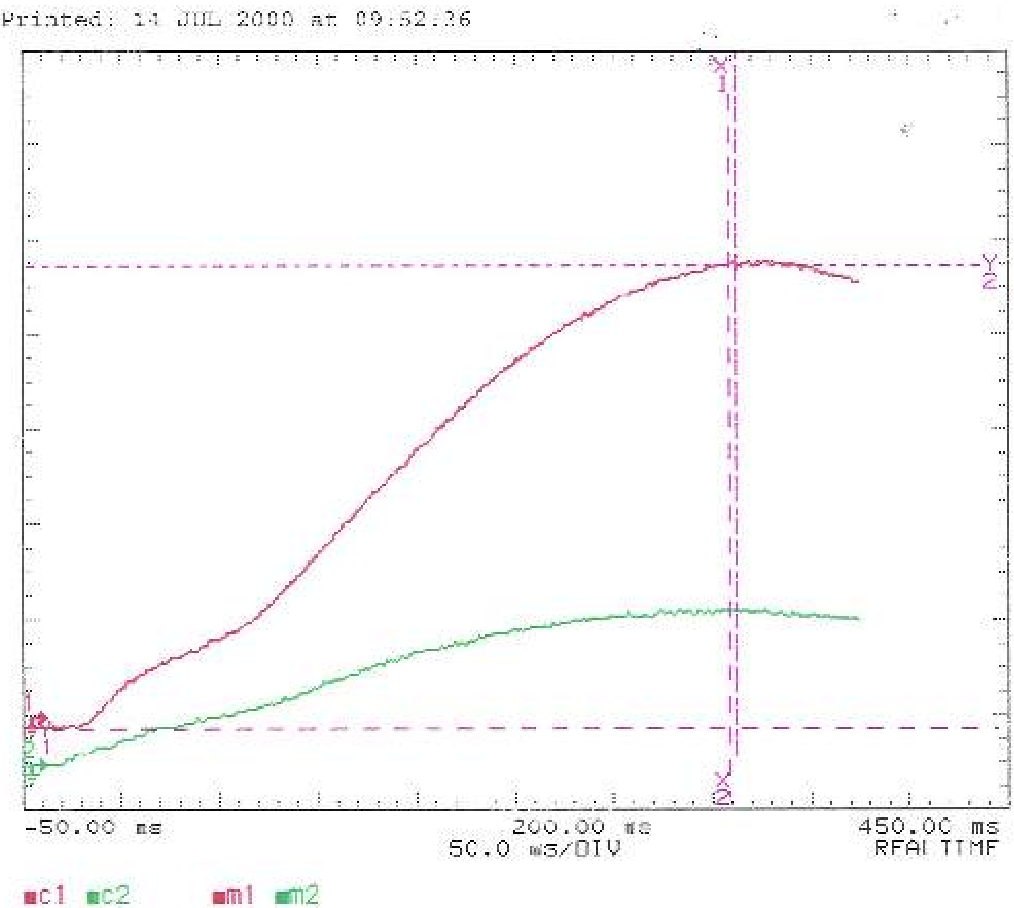


Fig. 1 Demonstration of locations of stowage bin vapor explosion test

照片一. 96 公升模擬置物箱先期試驗(一)，汽油濃度高於爆炸下限兩倍，有氣爆現象，產生大火團，但無法持續燃燒

照片二. 96 公升模擬置物箱先期試驗(二)



Markers

Y2marker(m1)	=	285.000 mV
Y1marker(m1)	=	7.50001 mV
delta Y	=	292.500 mV
X2marker(m1)	=	1.67400 s
X1marker(m1)	=	1.65600 s
delta X	=	18.0000 ms
1/delta X	=	55.5556 Hz

起始點壓力：292.5 psi

遠端壓力： 97.5 psi

	Sensitivity	Position	Probe	Coupling	Impedance
Channel 1	60.0 mV/div	180.000 mV	1:1	dc	1M ohm
Channel 2	60.0 mV/div	210.000 mV	1:1	dc	1M ohm

	Sensitivity	Position	Timebase	Delay	Sampling
WMemory 1	60.0 mV/div	180.000 mV	300 ms/div	498.691 ms	RealTime
WMemory 2	60.0 mV/div	210.000 mV	300 ms/div	498.691 ms	RealTime

Trigger Mode: Edge
On the Positive Edge of Channel1
Trigger Level(s)
Channel1 - 37.5000 mV (noise reject OFF, coupling DC)
Holdoff - 40.000 ns

圖二. 100 公升模擬置物箱先期試驗(二)之爆壓量測結果

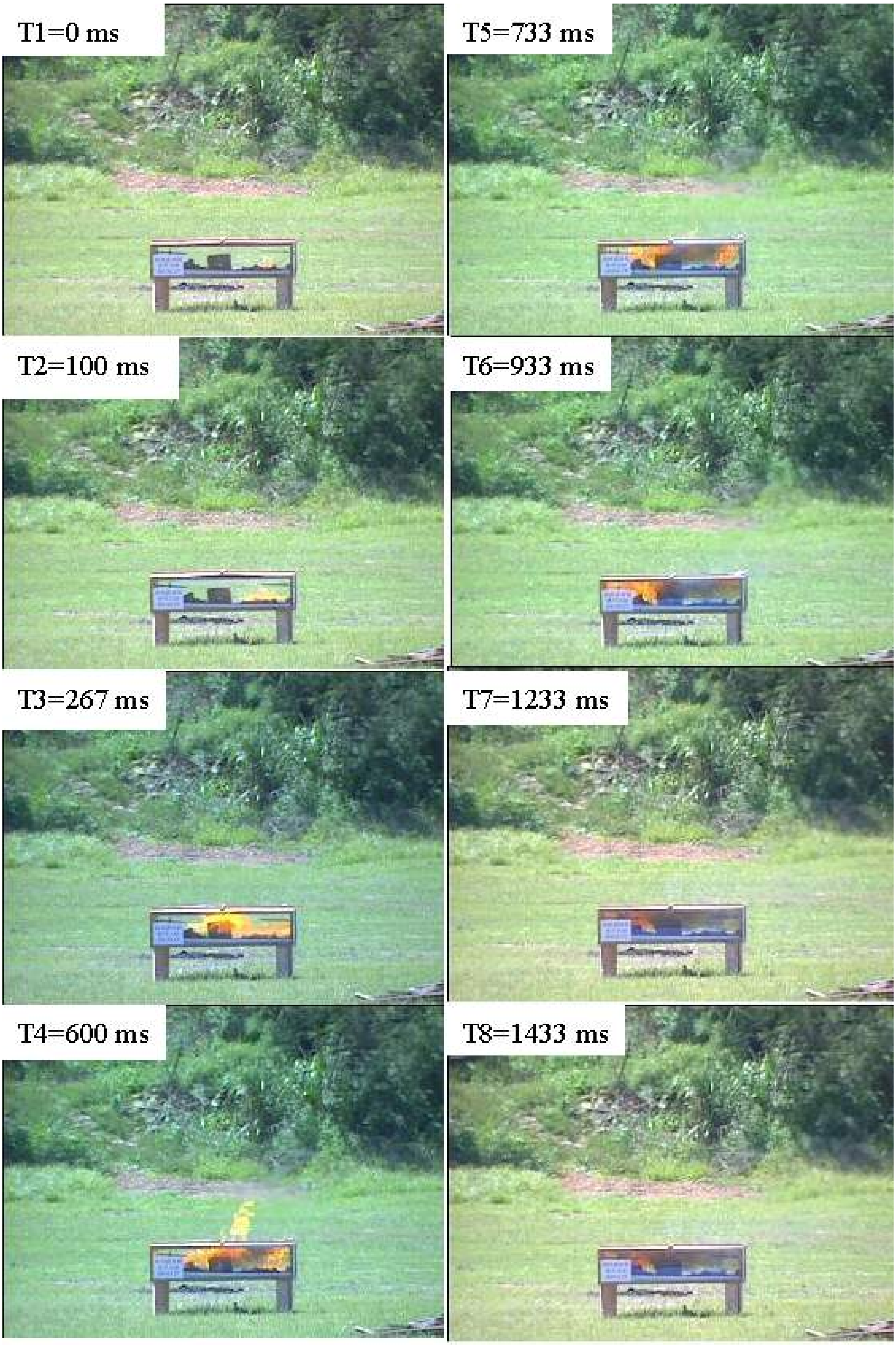
a.置物箱起爆前一瞬間

b.置物箱起爆後起火燃燒

c.置物箱起爆產生之碎片及因高溫損毀之爆壓感測器

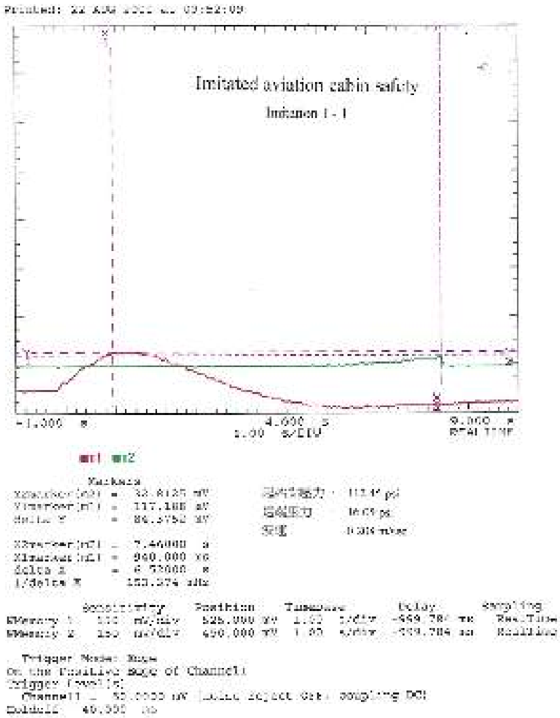
照片三. 400 公升模擬置物箱先期試驗

照片四. 1000 公升模擬置物箱先期試驗



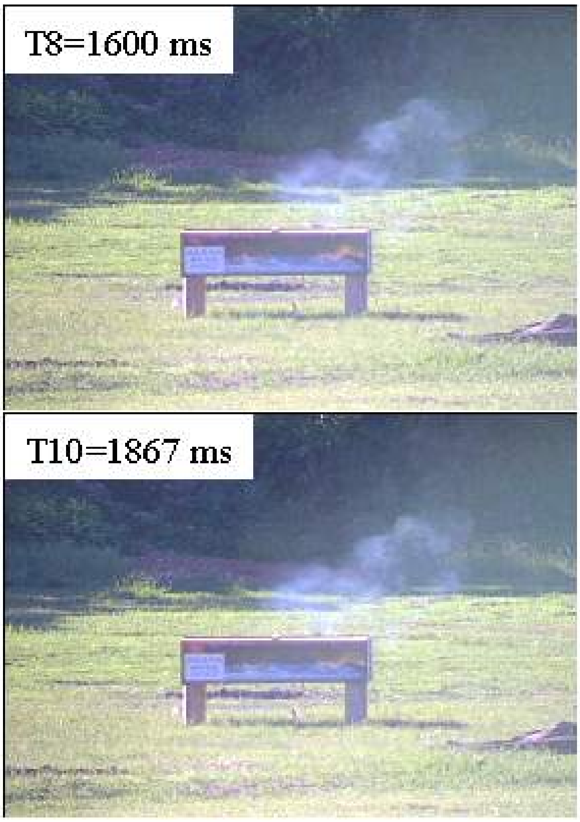
照片五. 1000 公升模擬置物箱正式試驗(五)

照片五. 1000 公升模擬置物箱正式試驗(五續)

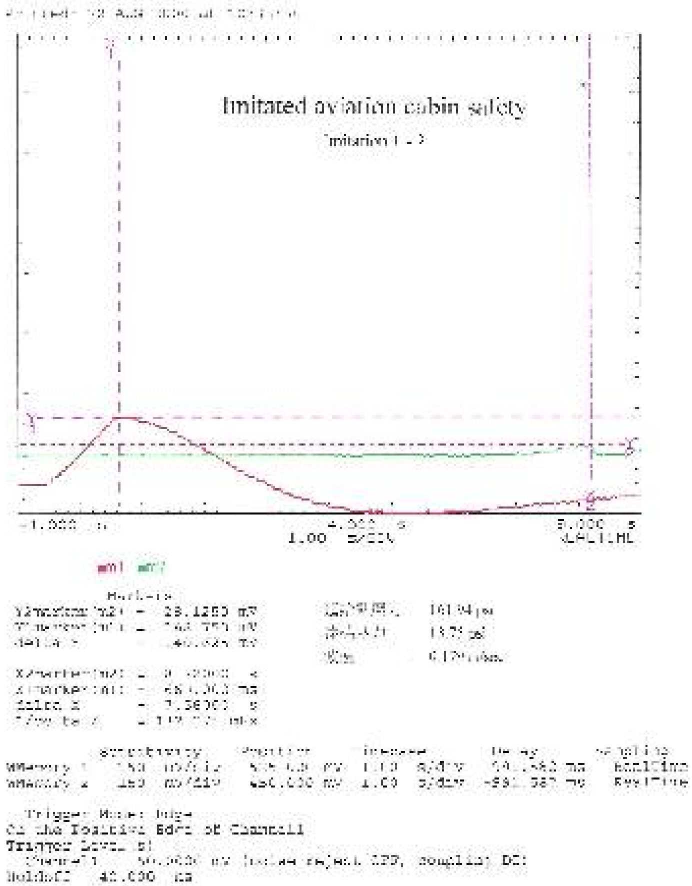


圖三. 1000 公升模擬置物箱正式試驗(五)之爆壓量測結果

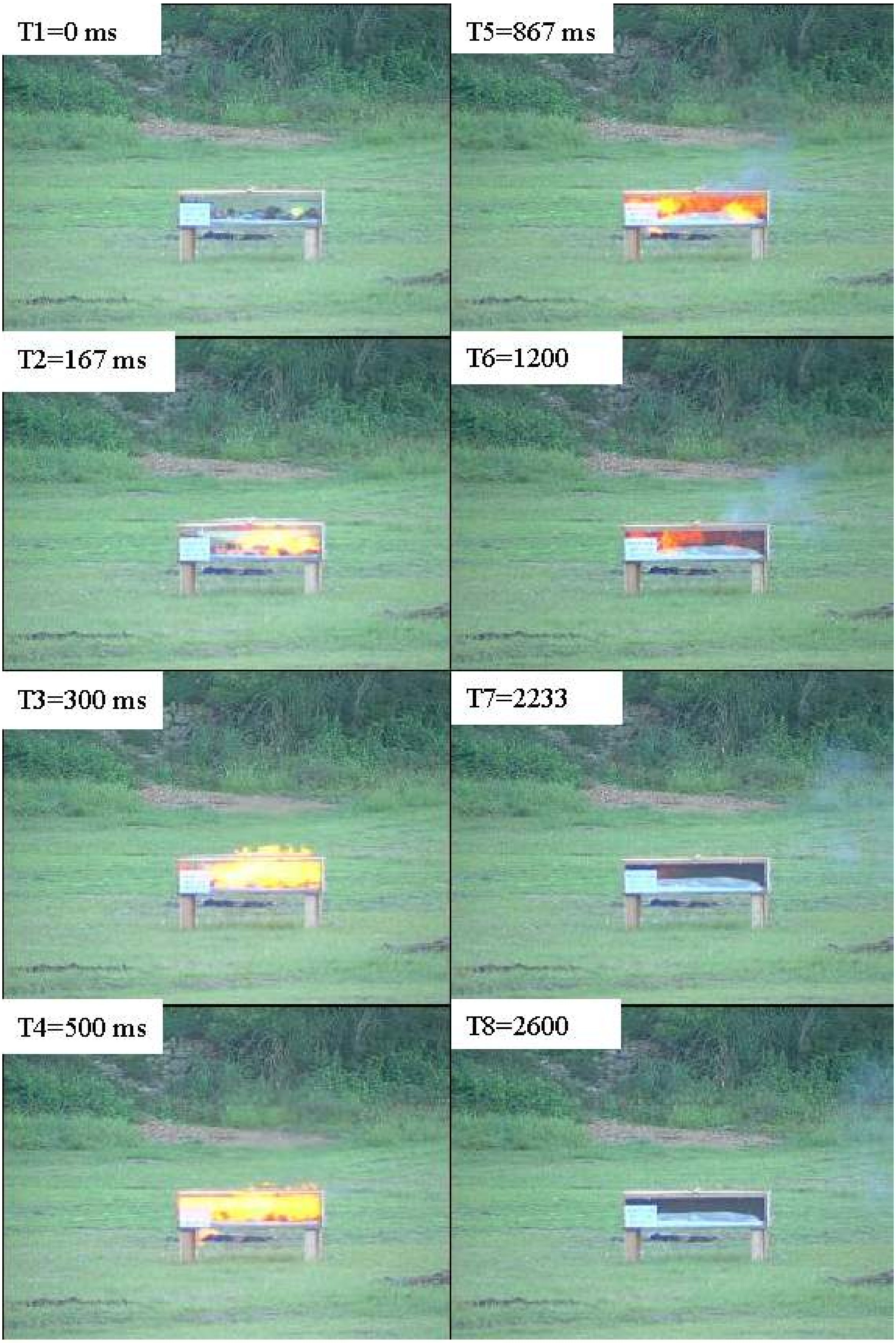
照片六. 1000 公升模擬置物箱正式試驗(六)



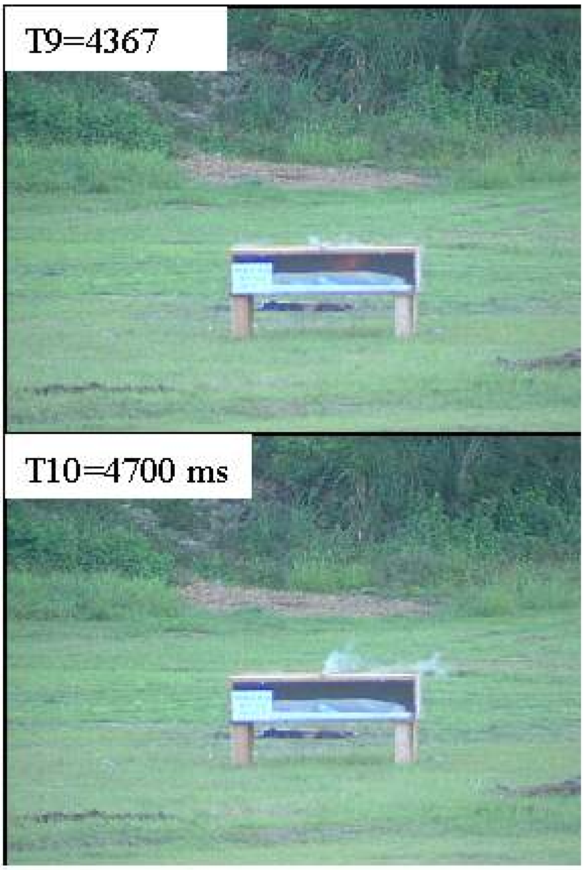
照片六. 1000 公升模擬置物箱正式試驗(六續)



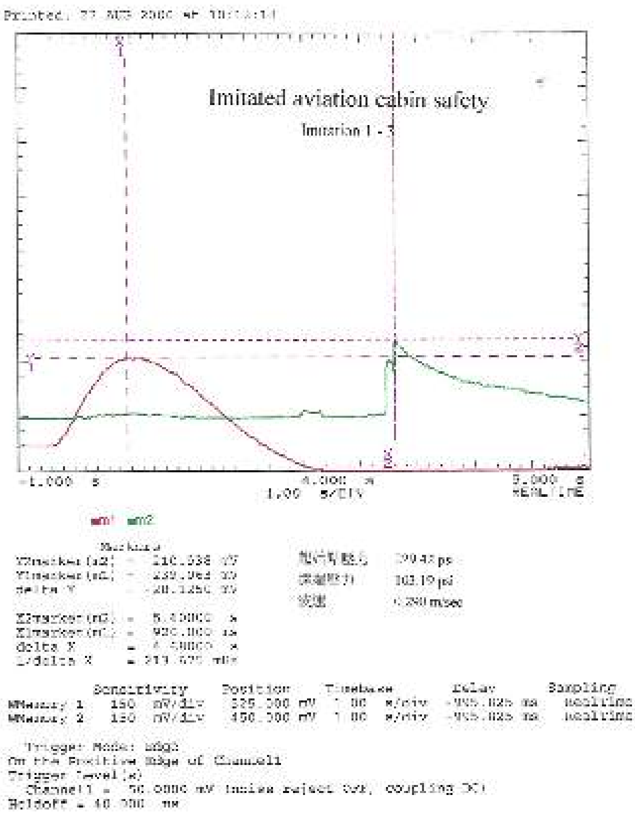
圖四. 1000 公升模擬置物箱正式試驗(六)之爆壓量測結果



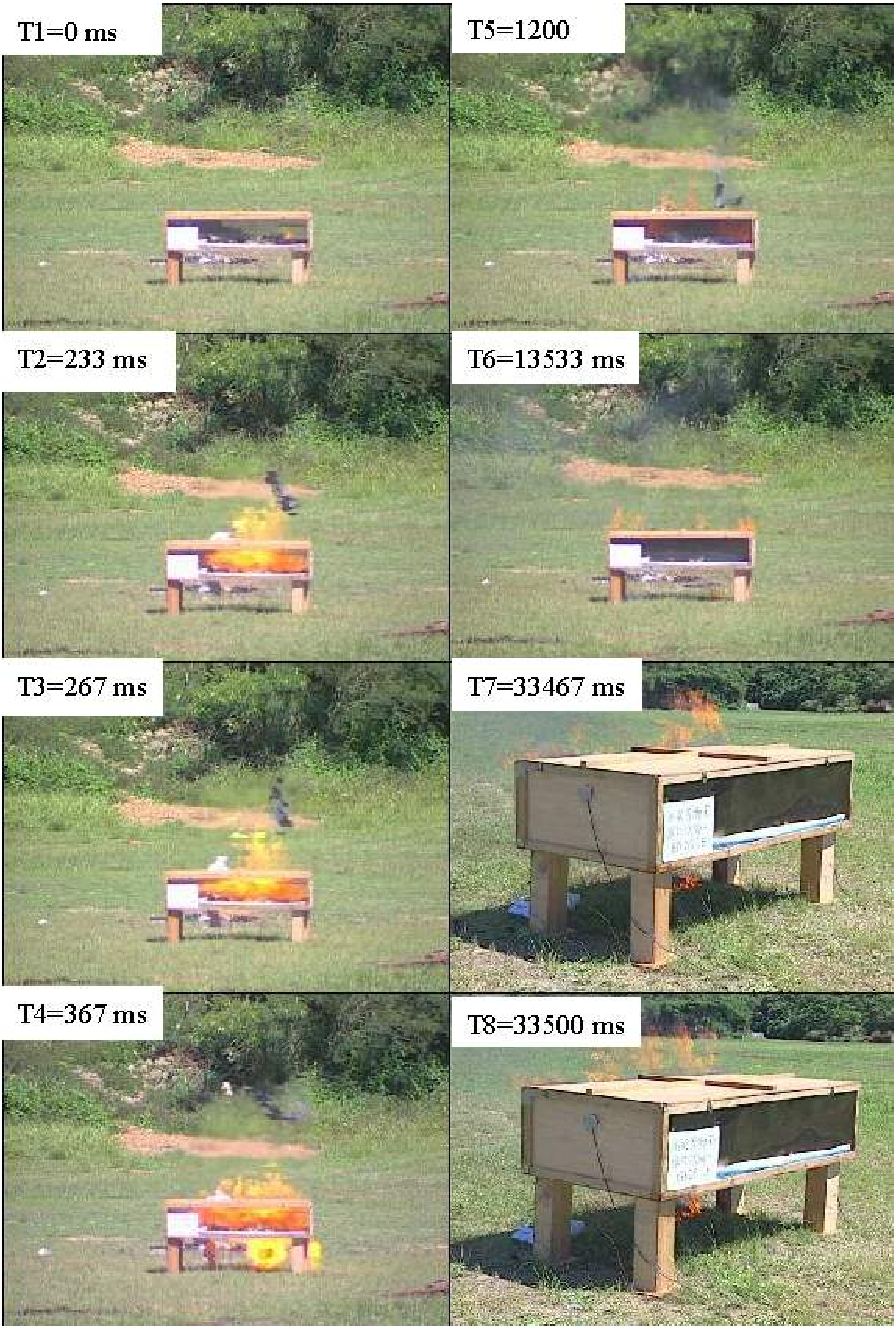
照片七. 1000 公升模擬置物箱正式試驗(八)



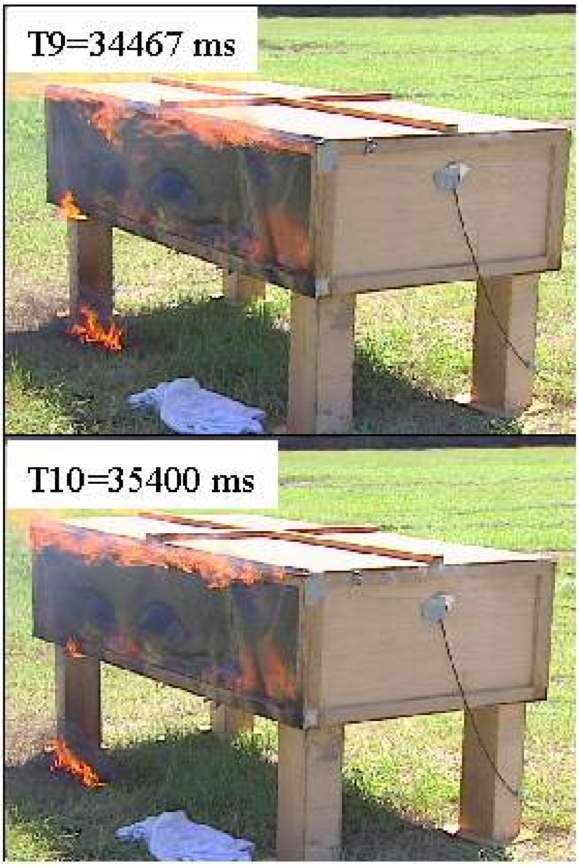
照片七. 1000 公升模擬置物箱正式試驗(八續)



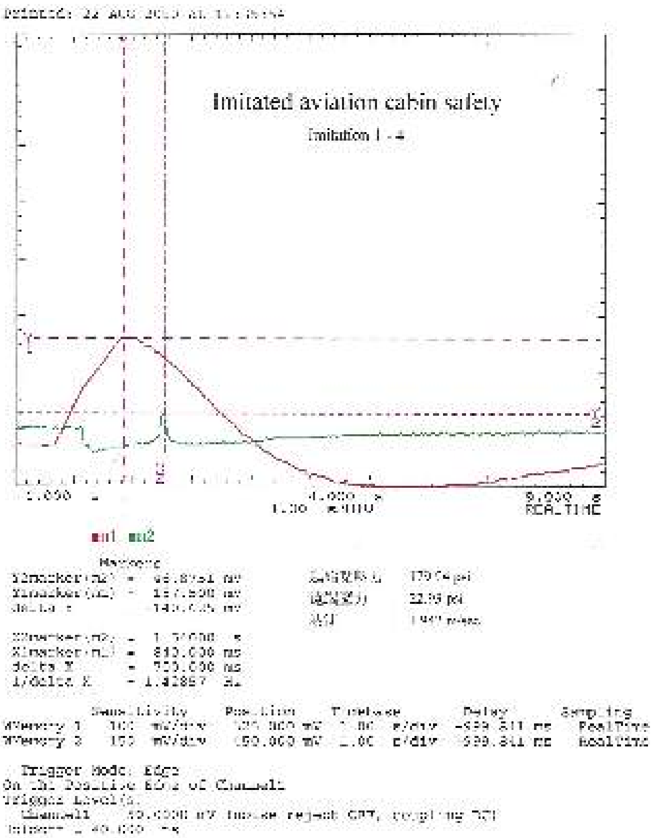
圖五. 1000 公升模擬置物箱正式試驗(八)之爆壓量測結果



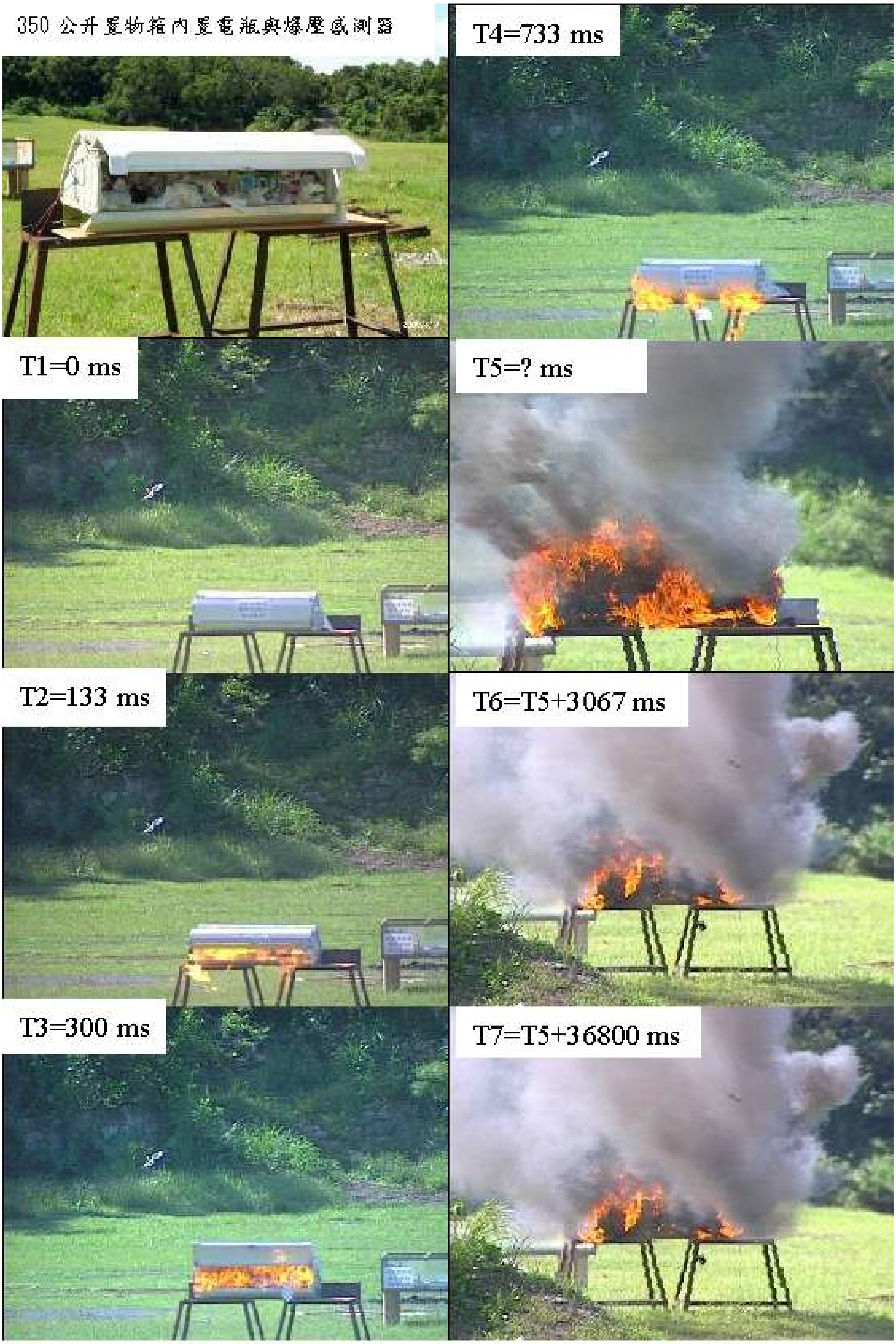
照片八. 1000 公升模擬置物箱正式試驗(九)



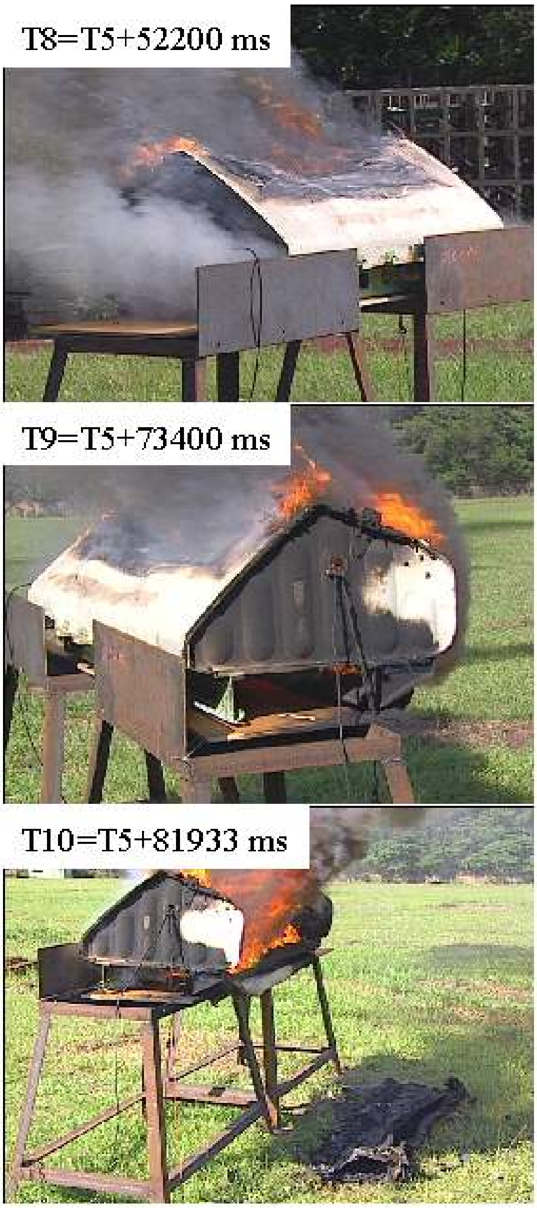
照片八. 1000 公升模擬置物箱正式試驗(九續)



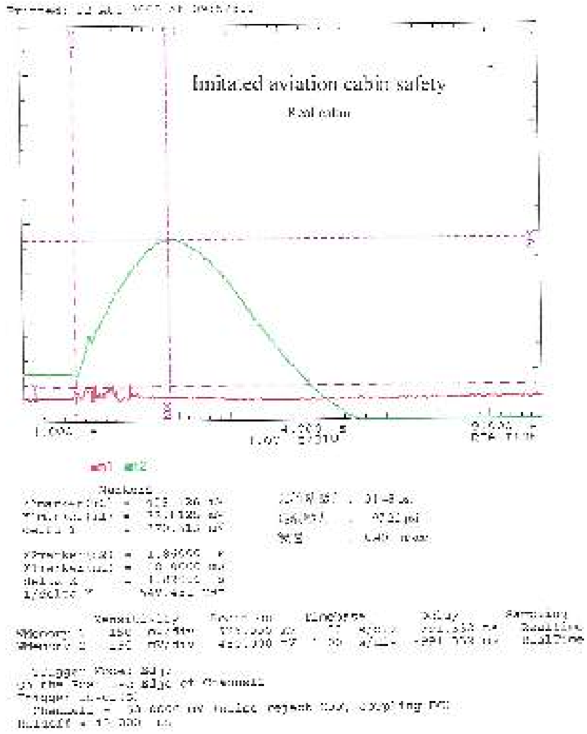
圖六. 1000 公升模擬置物箱正式試驗(九)之爆壓量測結果



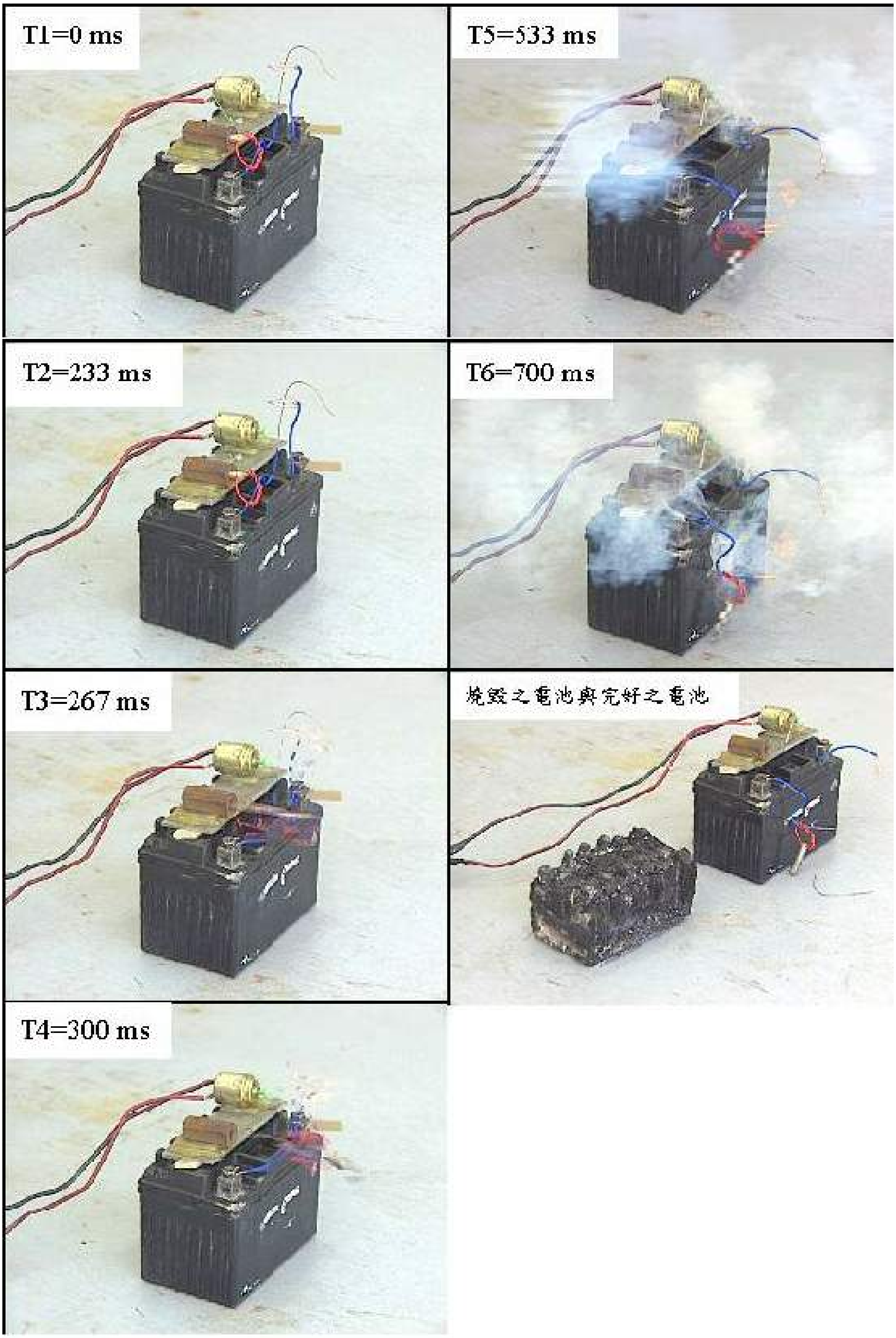
照片九. 350 公升模擬置物箱正式試驗



照片九. 350 公升模擬置物箱正式試驗(續)

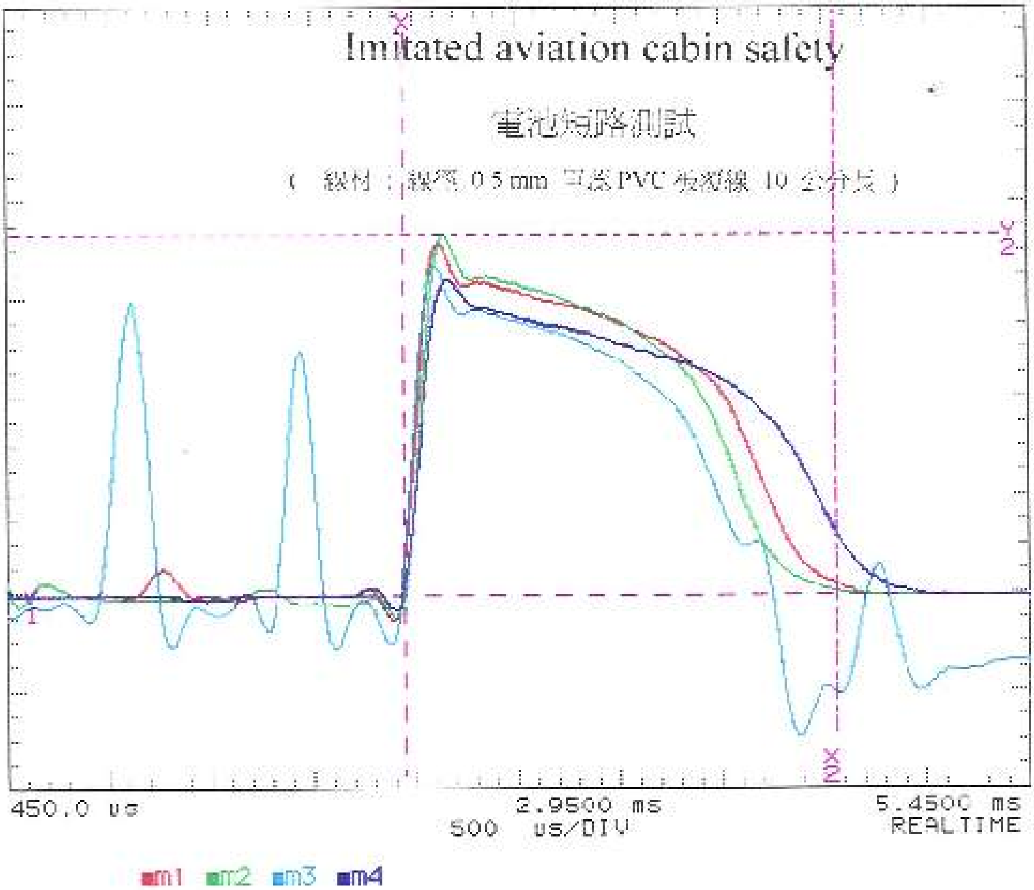


圖七. 350 公升模擬置物箱正式試驗之爆壓量測結果



照片十. 電瓶短路產生火花之現象歷程

Printed: 25 AUG 2000 at 10:33:56



Markers

Y2marker(m2)	=	3.68750	V
Y1marker(m2)	=	0.00000	V
delta Y	=	3.68750	V
X2marker(m2)	=	4.66000	ms
X1marker(m2)	=	2.55000	ms
delta X	=	2.11000	ms
1/delta X	=	473.934	Hz

I.	Imax	359.37 Amp	△T	2.20 mS
II.	Imax	368.75 Amp	△T	2.11 mS
III.	Imax	337.50 Amp	△T	2.51 mS
IV.	Imax	325.00 Amp	△T	3.37 mS

	Sensitivity	Position	Timebase	Delay	Sampling
WMemory 1	1.00 V/div	2.00000 V	500 us/div	3.20000 ms	RealTime
WMemory 2	1.00 V/div	2.00000 V	500 us/div	600.000 us	RealTime
WMemory 3	1.00 V/div	2.00000 V	500 us/div	4.90000 ms	RealTime
WMemory 4	1.00 V/div	2.00000 V	500 us/div	600.000 us	RealTime

Trigger Mode: Edge
On the Positive Edge of Channel1
Trigger Level(s)
Channel1 = 50.0000 mV (noise reject OFF, coupling DC)
Holdoff = 40.000 ns

圖八. 電瓶在短路產生火花過程中之電流歷程

Attachment 4

Materials Test Report

Chung Shan Institute of Science and Technology

Materials Test Report

Chung Shan Institute of Science and Technology Aeronautical Research Laboratory Aero Materials Department	Charge No. 10844 Report No.

Project Material Failure Analysis		Applicant/Department Aviation Safety Council	
Part Name Plates		Part No.	Stock No.
Material 2024-T3, 7075-T6	Specification	Lot No.	Heat No.
Test Method Tensile test			

Results

1. Preface

1) The UNI AIR maintenance shop provided a number of tensile test pieces for tests assigned by this office.

2. Results

1) The results delivered by Attachment 1 suggest the following:

Material	Thickness	Test piece No.	Average drop (Ksi)	Maximum pull (Ksi)	Extension average (%)	Maximum tensile force (Ksi)
Extrusion	0.032	1, 2, 3	73.6	89.5	13	78

7075-T6						
Clad 2024-T3	0.032	4, 5, 6	51.3	76	19	60
Extrusion 7075-T6	0.040	7, 8, 9	6.9	85.6	13	78
Clad 2024-T3	0.050	10, 11, 12	46.3	69.4	19	60
Extrusion 7075-T6	0.050	13, 14, 16	72.7	85.8	15	78
Extrusion 7075-T6	0.050	13, 14, 16	72.7	85.8	15	78
Extrusion 7075-T6	0.071	19, 20, 21	78.5	91.2	15	78
Extrusion 7075-T6	0.080	22, 23, 24	72.8	83.5	14	78

Remarks: The design value is taken from MD-90 structural maintenance manual Book 3 Fig. 2

MATERIALS REPORT

Chung Shan Institute of Science and Technology Aeronautical Research Laboratory Aero Materials Department	Charge No. 10844 Report No. T05069

Project Material Failure Analysis	Applicant/Department/Address Aviation Safety Council		
Nomenclature Tensile force, shearing & rivet	Manufacture N/A	Part/Stock No. N/A	Roll/Series No. N/A
Material N/A	Specification N/A	Batch No. N/A	Receiving Lot N/A
Test Item Tensile Test	Test Method SIP-138	Purchase No. N/A	Reference No. N/A

Results: Without a written consent of this office, this report may not be reproduced in part, though a full reproduction of the report is allowed.

Spec. ID	**Diameter inch**	**Area Inch^2**	**Test Temp. °F**	**Yield Strength Ksi**	**Ultimate Strength Ksi**	**Elongation %**	**Reduction Area RA%**
1	0.249*0030	0.0075	RT	72.1	89.1	13	**
2	0.249*0030	0.0075	RT	76.7	89.8	13	**
3	0.249*0030	0.0075	RT	72.1	89.6	13	**
4	0.245*0029	0.0071	RT	52.7	76.0	19	**
5	0.245*0029	0.0071	RT	50.7	76.1	18	**
6	0.245*0029	0.0071	RT	50.6	75.9	20	**
7	0.246*0037	0.0091	RT	72.5	85.5	12	**
8	0.246*0037	0.0091	RT	70.8	85.5	14	**
9	0.244*0037	0.0090	RT	66.4	85.8	14	**
10	0.240*0046	0.0110	RT	47.1	69.6	18	**
Remarks: This report is only responsible for the test samples.							

Spec. ID	Diameter inch	Area Inch^2	Test Temp. °F	Yield Strength Ksi	Ultimate Strength Ksi	Elongation %	Reduction Area RA%
11	0.240*0046	0.0110	RT	45.6	694	21	**
12	0.240*0046	0.0110	RT	46.2	69.3	17	**
13	0.242*0046	0.0111	RT	73.9	85.9	14	**
14	0.244*0046	0.0112	RT	73.3	85.4	15	**
15	0.241*0046	0.0111	RT	71.0	86.1	15	**
16	0.248*0058	0.0144	RT	71.0	84.5	12	**
17	0.247*0058	0.0143	RT	72.3	85.2	15	**
18	0.246*0058	0.0143	RT	74.5	85.0	14	**
19	0.246*0066	0.0162	RT	77.5	91.2	15	**
20	0.246*0066	0.0162	RT	78.8	91.2	15	**
21	0.245*0066	0.0162	RT	79.3	91.2	15	**
22	0.245*0074	0.0181	RT	72.1	83.3	13	**
23	0.244*0074	0.0181	RT	73.3	83.6	14	**
24	0.243*0074	0.0180	RT	73.0	83.6	14	**

Remarks:

1. This report is only responsible for the test samples.

ASC-AAR-00-11-001

統 一 編 號

1009000141

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