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PRESIDENCY of CIVIL AVIATION

JEDDAH

SAUDI ARABIA

AIRCRAFT ACCIDENT REPORT

Saudi Arabian Airlines

Lockheed L-1011, HZ-AHK

Riyadh, Saudi Arabia

August 19th 1980

H.E. Sheikh Nasser Al-Assaf
President of Civil Aviation
Presidency of Civil Aviation
Jeddah, Saudi Arabia

Dear Sir:

16 January 1982

I hereby submit the report on the circumstances of the accident involving Lockheed L-1011, HZ-AHK which occurred at Riyadh, Saudi Arabia, on August 19, 1980.

Respectfully,

E. D. Dreifus
Director of Civil Aviation Safety
Presidency of Civil Aviation

ACKNOWLEDGEMENTS

The Presidency of Civil Aviation appreciates the valuable assistance received from the United States National Transportation Safety Board personnel and its advisors; from the British, Department of Trade, Accidents Investigation Branch and from Saudi Arabian Airlines personnel.

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Kingdom of Saudi Arabia
Ministry of Defense and Aviation
Presidency of Civil Aviation
Jeddah, Saudi Arabia

Saudi Arabian Airlines
L-1011, HZ-AHK, Flight 163
Riyadh, Saudi Arabia
August 19, 1980

SYNOPSIS

About 1808 GMT on August 19, 1980, Saudi Arabian Airlines, Flight 163, a Lockheed L-1011 TriStar, departed Riyadh, Saudi Arabia enroute to Jeddah, Saudi Arabia. Flight 163 returned to Riyadh after an uncontrolled fire developed in the C-3 cargo compartment of the aircraft. The flight landed at about 1836 and then taxied clear of the runway and came to a stop on an adjacent taxiway.

While parked on the taxiway, the aircraft was destroyed by the fire and the three hundred and one persons on board the flight were killed.

The Presidency of Civil Aviation determines that the probable cause of this accident was the initiation of fire in the C-3 Cargo compartment. The source of ignition of the fire is undetermined.

Factors contributing to the final fatal results of this accident were (1) the failure of the Captain to prepare the cabin crew for immediate evacuation upon landing, and his failure in not making a maximum stop landing on the runway with immediate evacuation, (2) the failure of the Captain to properly utilize his flight crew throughout the emergency (3) the failure of C/F/R headquarters management personnel to insure that its personnel had adequate equipment and training to function as required during an emergency.

1. FACTUAL INFORMATION

1.1 History of the Flight

At 1332 GMT 1/ on 19 August 1980, Lockheed L-1011, HZ-AHK, owned and operated by Saudi Arabian Airlines (Saudia), departed Karachi, Pakistan. It was operating as Saudia Flight No. 163 (SV163) enroute to Jeddah, Saudi Arabia, with a scheduled intermediate stop at Riyadh, Saudi Arabia.

The two hours and thirty four minutes flight from Karachi to Riyadh was uneventful. The aircraft landed at Riyadh at 1606. All passengers then disembarked with their carry-on-baggage for immigration and customs clearance. Baggage for all passengers, both continuing and deplaning was also unloaded from the airplane for customs clearance. Fuel was added and continuing passengers, who had deplaned, were boarded along with those passengers joining the flight in Riyadh. After the baggage was loaded, the aircraft departed the gate at 1750.

The aircraft was airborne from Riyadh about 1808 with a total of 301 personnel on board. There were 287 passengers, which included 15 infants, and 14 crew members.

After departure, SV163 was cleared to Jeddah via green airways number 53, to cruise at an assigned altitude of 35,000 feet (FL 350). The estimated arrival time in Jeddah was 1920. The initial climb toward Jeddah was uneventful until 1814:54, 6:54 minutes after takeoff, when the flight crew was alerted by both visual and aural warnings indicating smoke in the aft cargo compartment (C-3).

A total of 4 minutes and 21 seconds was spent by the flight crew in confirming the warning and when it became clear that a valid warning existed, the Captain elected to return to Riyadh. The Flight Engineer (F/E) had gone into the passenger cabin to investigate the situation and on returning to the cockpit, about thirty six seconds later, at about 1820:16, he informed the Captain that there was a fire in the cabin (see Apendix D - Cockpit Voice Recorder and Figures 1 and 2).

At 1820:17 while climbing through about 22,000 feet, the First Officer contacted Riyadh and said, "163, we are coming back to Riyadh". At this time, the return to Riyadh was initiated. When queried by Riyadh as to the reason for the return, SV163 stated, "We got fire in the cabin, please alert the fire trucks". Riyadh cleared the aircraft to begin an immediate descent and gave priority for landing, at which time Riyadh advised the crew that the aircraft was then 78 miles out. Riyadh then queried if the fire was in an engine and SV163 responded at 1821:09, "negative, in the cabin". At 1821:15, Riyadh requested

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1/ All times contained herein are Greenwich Mean Time (GMT) based on the 24-hour clock, unless otherwise noted.

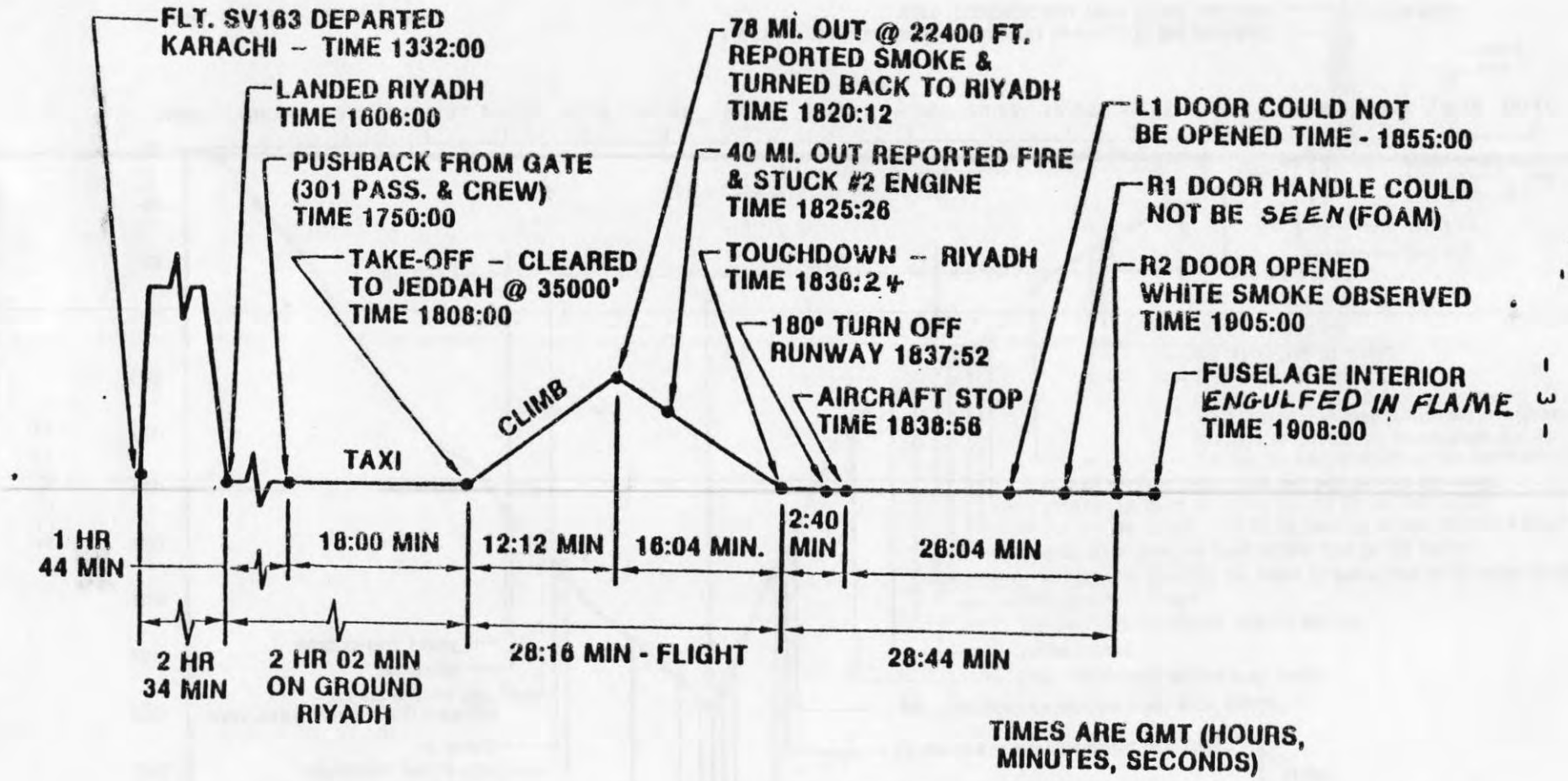


FIGURE 1

SV163 (S/N 1169) flight profile.

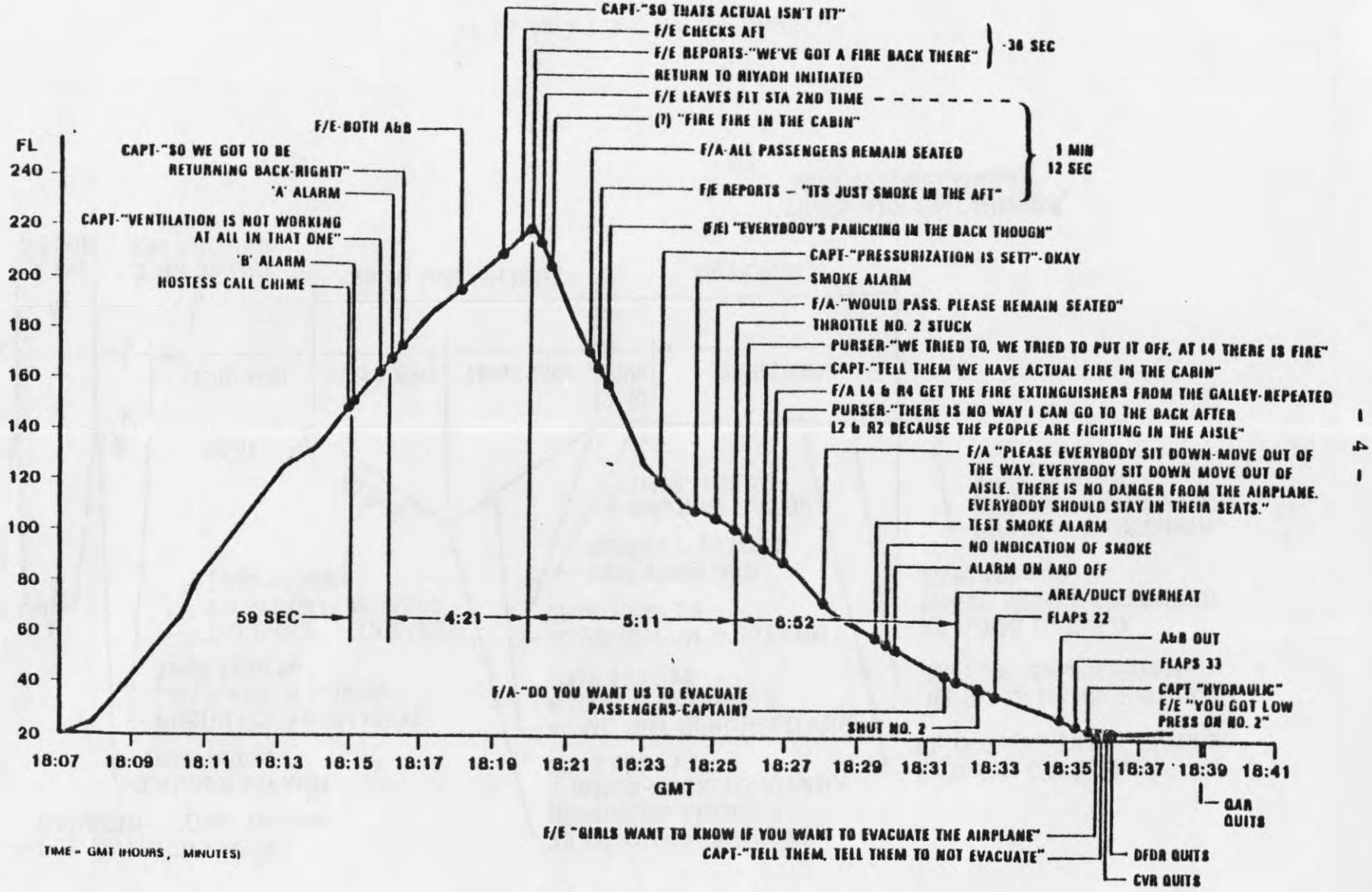


FIGURE 2

Figure 2

Flight profile and sequence of events.

the number of passengers onboard. At 1821:27, SV163 replied, "don't know exactly, think we have full load".

At 1821:53, the F/E, who had just returned from the second trip to observe conditions in the cabin, informed the Captain that it was just smoke in the aft of the aircraft. The Captain acknowledged and again informed the flight deck crew that they were returning to Riyadh.

At 1822:08, the F/E stated that everyone was panicking in the back. At 1822:53, the F/E asked if the fire trucks were alerted and the Captain acknowledged that they were. At 1823:04, the Captain again asked the First Officer (F/O) to alert the fire trucks and he acknowledged that they were standing by. At that time, the Captain called for the "Landing Preliminary" checklist.

At 1824:16, there is another aural smoke detector warning. The F/E said, "what can I say"; the Captain said, "Okay" and the F/E then said, "I think it's alright now". The crew then finished the Landing Preliminary checklist.

At 1824:41, there was another aural smoke detector warning and the F/E said, "There goes A".

At 1825:26, the Captain stated that the throttle of the No. 2 engine was stuck and informed the cockpit crew that he was going to shut the engine down. Immediately thereafter, a female cabin attendant came into the cockpit and informed the crew that there was a fire in the cabin.

At 1825:55, the Captain told the F/E to inform Riyadh that there was an actual fire in the cabin now. Riyadh then advised that the fire trucks were in the standby position and were ready. One of the cabin attendants came to the flight cockpit after attempting to go the rear of the cabin and said, "there is no way I can go to the back aft of L2 and R2 because the people are fighting in the aisles".

1827:02, the Captain said that they must get down as soon as possible.

At 1827:40, the CVR recorded announcement by the cabin crew to remain calm. They were given in English, Arabic and Urdu. The announcement was as follows:

> " Please everybody sit down, move out of the way, everybody sit down, move out of the aisle, there is no danger from the airplane, everybody should stay in their seats. "

At 1828:40, the F/E asked the F/O if he informed Riyadh to have the fire trucks go to the back of the aircraft as soon as possible. The F/O replied that he had. The Captain then told the F/O to advise Riyadh about the fire trucks and the F/O complied by calling Riyadh tower and said,"please advise fire trucks to be at the tail of the aircraft after touch, please". At this time Riyadh tower contacted Fire 3 at the airport and said, "Okay, Sir, the fire on the cockpit when the aircraft land, I want you to follow them the tail, from his tail. Drive behind it from the tail. Okay, Okay, Hamad". There was then an extensive discussion between the tower and the fire trucks as to the location of the fire.

At 1829:01, a cabin attendant came forward and advised the crew that there "is too much smoke in the back". The Captain at this time, was occupied with locating the Riyadh runway. At 1829:34, the F/E said, "Okay, I am going to test the system again" and at that time there was the sound of the smoke detector. The F/E said, "Okay, there's both 'A' and 'B' loops working again and said, "and no indication of smoke". When the Captain questioned him about this statement, the F/E said there was no indication of smoke (referring to the warning devices "A" and "B") but the cabin was filled with smoke in the back.

At 1829:56, the F/E suggested that they shut No. 2 engine when they are on short final and the Captain agreed.

At 1829:59, there was another smoke warning signal and the F/E said, "there is 'A' again".

At 1830:41, the Captain called for the final checklist. At that time, the CVR picked up the cabin attendant voices trying to calm the passengers.

At 1831:30, a cabin attendant asked the Captain if they should evacuate. He responded by saying, "What". The cabin attendant repeated the question and the Captain said, "Okay". 2/

At 1831:34, the Captain called for flaps 10 and then called for final checklist to the box. 3/

At 1832:10, a cabin attendant again asked the Captain if he wanted them to evacuate the passengers. The Captain responded by telling the cabin attendant to take her position. At 1832:19, the F/E reported an area duct overheat condition. At that time, the Captain called for 18 degrees of flap.

At 1832:33, SV163 transmitted, "we got the runway in sight, are we cleared to land?" and Riyadh replied "affirmative, you are number one for approach and you can contact the tower, 118.1". The response from SV163 was "118.1, 163".

2/ The "Okay" was determined to be in reference to a prior non-related question.

3/ Items in a section of the checklist that have been boxed off are completed after the landing gear has been extended.

At 1832:48, the tower cleared SV163 to land and gave the wind as 320° at five knots. At 1832:52, the Captain stated that he is shutting down number 2 engine. At about the same time, the F/O acknowledged the clearance to land and questioned the tower again about alerting the fire trucks. The tower responded that they have been alerted.

At 1833:31, the Captain called for gear-down after which he informed his F/O that the two-engine landing procedure is the same as the three-engine landing procedure.

At 1834:02, subsequent to the shutting down of number two engine, SV163 called "Tower, SV163", and the tower responded, "go ahead 163, wind 320 at 5". At 1834:10, SV163 replied, "one six three is cleared to land, we have only one and three".

At 1834:25, the Captain requested that the F/E complete the final landing checklist which he did. At 1834:44, the F/E says, "Both loops A and B are out". At this time, the CVR again picked up the attempts by the cabin attendants to calm the passengers. At 1835:17, the F/E informed the Captain that the cabin attendants wanted to know if he wanted to evacuate the aircraft. The Captain did not respond to the F/E and called for thirty-three flaps.

At 1835:25, there was another aural smoke warning heard and the F/E stated, "that is 'A' again". Immediately thereafter, the "C" cord aural tone was heard indicating that the aircraft was 500 feet above ground level. The aircraft at this time was on the final portion of its landing approach. At 1835:36, the Captain called, "Hydraulic" and the F/E responded that they have low pressure on number two.

At 1835:57, the Captain stated, "tell them, tell them to not evacuate". From 1836:18 until 1836:21, the CVR picked up the voice of the F/E giving his required altitude callouts of "fifty", "forty", "thirty". Immediately after the "thirty" call out, the CVR ceased to operate. The aircraft landed on Runway 01 at 1836:24.

Witnesses observed smoke coming from the rear of the aircraft while the aircraft was on a short final approach.

The aircraft continued its landing roll-out and according to DFDR and QAR 4/, it made a right 180° turn-off at the end of the runway at 1837:59 and came to a stop on the taxiway at 1839:03 which was 2 minutes and 40 seconds after touchdown. During this period of time, SV163 asked the tower if there was any fire noted in the tail of the aircraft and the tower responded after checking with the fire vehicles, that no fire was noted. This was acknowledged by the aircraft (see Appendix F).

4/ Quick Access Recorder which records identical parameters as the DFDR. The touchdown time was established by reference to the QAR, DFDR, CVR and tower times.

About 1839:06, the tower asked SV163 if they wanted to continue to the ramp or to shut down. SV163 said "standby" and immediately thereafter stated, "Okay, we are shutting down the engines now and evacuating". During this time period and immediately thereafter, there were communications between tower and fire fighters regarding an increase in the fire and their requests to the crew to shutdown the engines. It should be noted that the tower did not make provisions for a common frequency between the aircraft and C/F/R personnel.

At 1840:33, after being told by the tower that they have fire in the tail, SV163 stated, "Affirmative, we are trying to evacuate now". This was the last transmission received from the aircraft.

After further conversations by the tower and fire personnel regarding the fire and the need to have the engines shut down, the engines were shut down at 1842:18 or 3 minutes and 15 seconds after the aircraft has come to a stop on the taxiway.

Attempts by the crash, fire, rescue personnel (CFR) to enter the aircraft and open the doors were unsuccessful until the No. 2 door on the right side of the aircraft was opened at about 1905, about 23 minutes after all engines had been shut down. At 1908, the fuselage interior was observed to be engulfed in flame. (see Figures 1, 2, and 3)

Witnesses observed 'SV163 to make a normal landing; however, smoke was coming from the rear of the aircraft. One witness, who responded to a call from the tower, arrived at the airport as the aircraft was approaching the runway. He stated that after the aircraft landed, he followed it down the runway and caught up with it as it passed the B-7 turn-off. The B-7 high-speed turn-off is 1,100 meters or 3,609 feet from the end of Runway 01. He stated that by that time the aircraft was taxiing slowly and it made a slow turn-off at B-8 (end of runway 01). After it stopped on the taxiway, the witness parked his car just behind and to the right of the aircraft. He observed fire through the windows on the left side of the cabin between the L-3 and L-4 doors. He said there was no fire outside the aircraft at this time.

He could not see any movement in the cockpit or cabin. He stated that just after the engines were shut down, there was a big puff of white and black smoke emitted from the aircraft belly just forward of the wings.

Most of the fire firefighting personnel said that the aircrafts' engines were shut down about three minutes after the aircraft stopped. Within a minute, they observed smoke rising from the top of the fuselage just forward of the No. 2 engine intake. The smoke was followed almost immediately by flames.

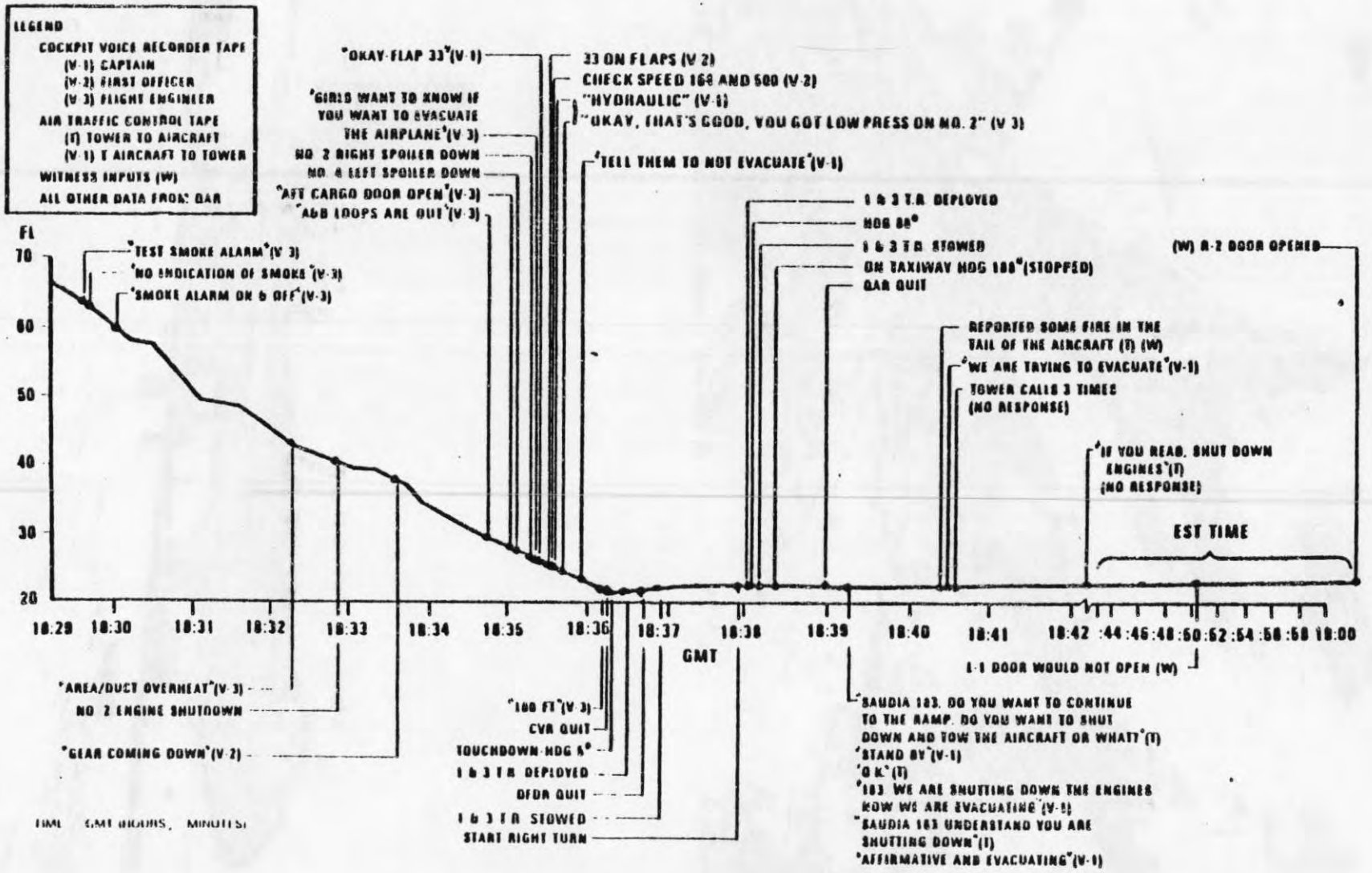


FIGURE 3.

Sequence of events during approach to Riyadh and after landing.

PHOTO NO. 1 - OVERALL VIEWS OF AIRCRAFT.

Another witness stated that there was a wind blowing and that the engines were wind-milling fast. This witness then observed flames coming from the aircraft near the left 3 and 4 doors (L3 and L4). He stated that attempts by the firemen to open the forward left No. 1 (L1) door were unsuccessful. The firemen then proceeded to the R1 door but upon noting that its handle could not be located due to it being covered by foam, they proceeded to the Right No. 2 door (R2). This was opened and a fireman called into the passenger cabin but received no response. Shortly thereafter, flames were observed to come out of the R2 door. About this time, witnesses noted that the fire trucks were depleting their foam.

The accident occurred at night during moonlight conditions at latitude 24°43'1"N and longitude 46°43'1"E.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	14	287*	0
Serious	0	0	0
Minor/none	0	0	2

*Includes 15 infants

1.3 Damage to Aircraft

The aircraft was destroyed by fire.

1.4 Other Damage

None

1.5 Personnel Information

The crewmembers were properly certificated for the flight and received the training required by current regulations (see Appendix B).

The crewmembers had been on duty about 9:45 hours prior to the accident, and had 16:50 hours rest time prior to reporting on duty the day of the accident.

1.6 Aircraft Information

The aircraft was certificated and maintained in accordance with existing regulations. Its center of gravity was within the prescribed limits for the flight.

A review of the maintenance records revealed that all required inspections had been performed (see Appendix C).

1.7 Meteorological Information

At the time of the accident, the weather at the airport was clear. The surface observations at Riyadh were as follows:

1800, surface aviation observation: clear, wind 360° at 6 knots, ceiling and visibility O.K., temperature 35° Centigrade, dew point 6° Centigrade, altimeter 1007 millibars.

1.8 Aids to Navigation

Riyadh International Airport is equipped with TACAN, VOR-DME, NDB and an ILS. One VOR/DME is located between Runway 01 and Runway 30. There is an ILS available for Runway 30. The navigation aids were checked after the accident and found to be satisfactory.

1.9 Communications

There were no known communications malfunctions. However, no provisions were made for direct communications between the aircraft crew and C/F/R personnel.

1.10 Aerodrome Information

Riyadh International Airport is 634 meters (2,082 feet) above sea level. Runway 01 is 4,100 meters (13,451 feet) in length and 45 meters (148 feet) in width.

It was equipped with Medium Intensity Runway Lights (MIRL), 3-bar visual slope indicators (VASI) and SALS.

1.11 Flight Recorders

The aircraft was equipped with a Fairchild A-100 CVR, S/N 5047. The recorder was removed from the aircraft and copies of the 30-minute tape were made for immediate use by the Investigation team. The original tape was hand carried to the N.T.S.B.'s laboratory in Washington, D.C. where an initial transcript was made. Another transcript was made by the investigation team in Riyadh. The two initial transcripts were combined and a final official copy was completed on 19 March 1981. The recording was considered to be excellent up to the time that the CVR ceased to function when the aircraft was about 30 feet in the air and on its landing approach.

The elapsed CVR time accuracy was derived using a 400 HZ alternator frequency which had been recorded on the tape prior to the time electrical power was lost. Elapsed time accuracy was determined to be + .005 seconds. Times appearing on the transcript are expressed in minutes and seconds from 1800 GMT. As an example, "04:46" would be "1804:46" (See Appendix D).

The aircraft was equipped with a Lockheed DFDR 209E-6, S/N 826. The recorder had been removed from the Aft Electronics Equipment Area (AEEA) and was found to be covered with a heavy coating of black soot. A sample of the soot was sent to the Federal Bureau of Investigation (FBI) for analysis and found to consist of products of combustion of urethane type material.

There was no evidence of mechanical or fire damage other than the sooting of the recorder's outer case. The DFDR operated normally and print-outs of the data in engineering units were made.

The aircraft was also equipped with a Lockheed Air Service, Model 280A, P/N 10119A 100-103 quick access recorder (QAR) which was located in the forward electronic service center (FESC). The QAR records the same information as the DFDR from the Flight Data Acquisition Unit (FDAU). The QAR in conjuction with the Flight Data Acquisition Unit (FDAU) samples and records data from one-hundred and nineteen discrete signal monitors and sensors in selected aircraft systems. This data provides a record of operational parameters and is the information base for post-flight monitoring of aircraft system performance and preventive maintenance trend analysis. The Cockpit Voice Recorder ceased operation just prior to touchdown at about 1836:23. The DFDR ceased operation just after touchdown at about 1836:28.

Readouts and correlation of the DFDR, QAR and CVR recordings encompassed the entire flight from the time SV163 taxied into position for takeoff at Riyadh until both the CVR and DFDR failed during the final portion of the landing phase on SV163's return to Riyadh. The QAR continued to operate and did not fail until about 2 minutes and 1 second after touchdown. The 180° turn from the runway had been made and the aircraft was coming to a stop at the time of its failure. The additional QAR data provided information to perform a required brake-energy study to help determine the aircraft's ability to make a maximum performance stop on the runway.

QAR power is cutoff when the rotating beacon is turned off. A witness near the aircraft stated that the rotating beacon ceased to operate as the aircraft came to a stop.

DFDR/QAR and CVR data were plotted and are reflected as profiles in Figures 1, 2, and 3 of this report.

1.12 Wreckage and Impact Information

1.12.1 Structures

Examination of the aircraft revealed that with the exception of the cockpit window surround structure, fuselage door surround structure, center engine fixed inlet forward structure, fuselage window surround structure, and the empennage structure aft of fuselage station (FS) 1860, all of the upper fuselage structure of the aircraft had been consumed by fire.

An intense fire had been present within the cockpit and passenger area and the resultant structural damage had been largely confined within this area with the exception of the aft C-2 and C-3 cargo compartments. The floor support structure of the flight station adjacent to and forward of, the pilot's seat had collapsed. The glare shield on the co-pilot's side was essentially intact; however, most of the Auto Pilot and Flight Director components were missing with the remainder severely affected by fire. The flight station equipment and furnishing including the flight engineer's panel was severely burned and essentially destroyed.

The furnishings and equipment within the cabin areas such as the seats, class dividers, out-board overhead stowage modules, and service center modules, were affected by fire to varying degrees ranging from heavy sooting to complete consumption.

One double seat unit on the left just aft of the L-3 door and three center rows of seats in the center section just aft of the service area were intact. These seats were burnt and charred to some extent and were covered with the remains of burnt ceiling panels.

A section of the floor on the left side of the forward passenger cabin had collapsed onto the containers in the C-1 cargo compartment. The collapsed section extended from about FS 429 aft to about FS 629. The center floor structure in the overwing area of the passenger cabin from about FS 1043 aft to FS 1103 had also collapsed. The floor above the cheek area from about FS 449 to about 529 had been destroyed by fire (see Photos 2 and 3).

The center engine fixed inlet structure and miniskirt and saddle structure from approximately FS 1625 aft to FS 1856 had been partially consumed by fire. The forward section of the fixed inlet structure had collapsed into the aft passenger compartment.

The upper portions of the aft pressure bulkhead were destroyed by fire. Portions of the fuselage structure at FS 1860 above WL 182 had been consumed by fire. The center engine "S" duct from approximately FS 1860 aft was intact.

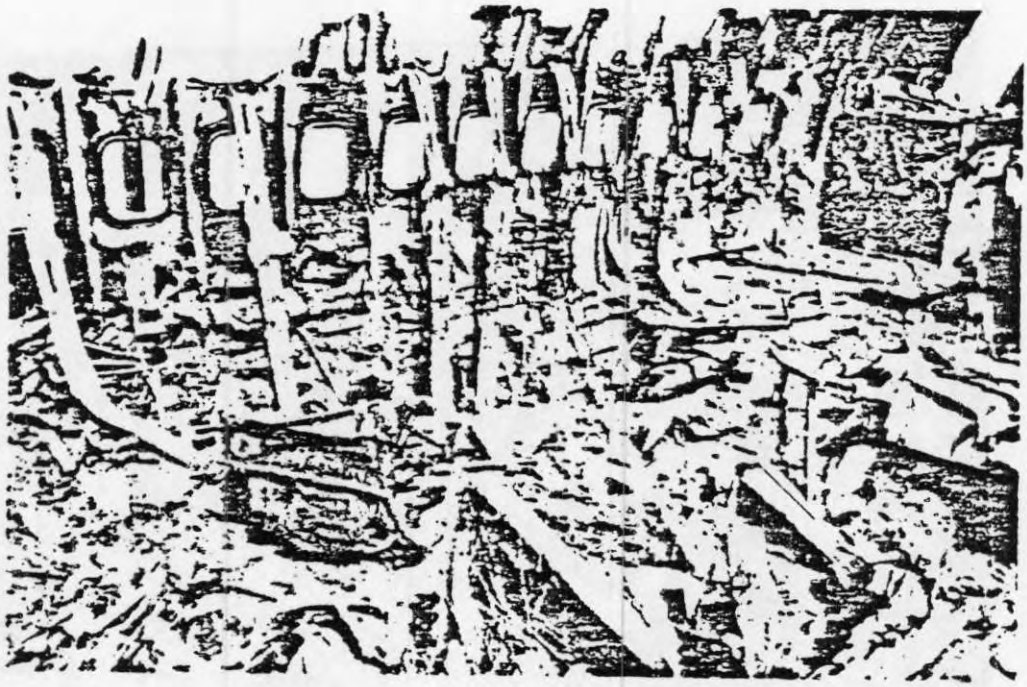


PHOTO NO. 2 - FLOOR COLLAPSE INTO C-1 AREA

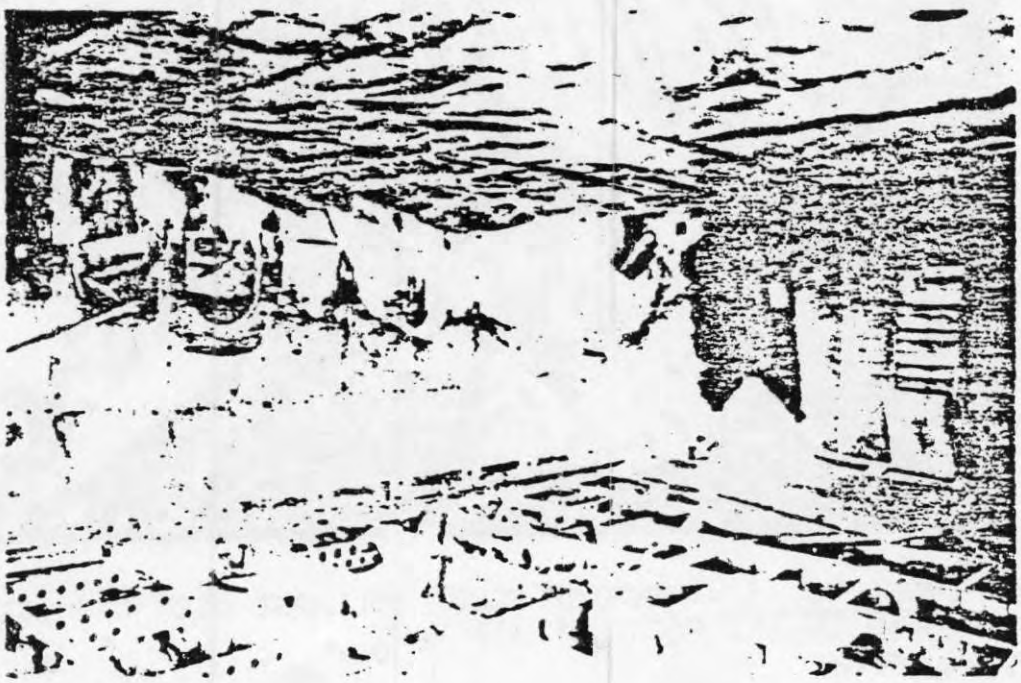


PHOTO NO. 3 - C-1 AREA FROM INSIDE C-1 COMPARTMENT

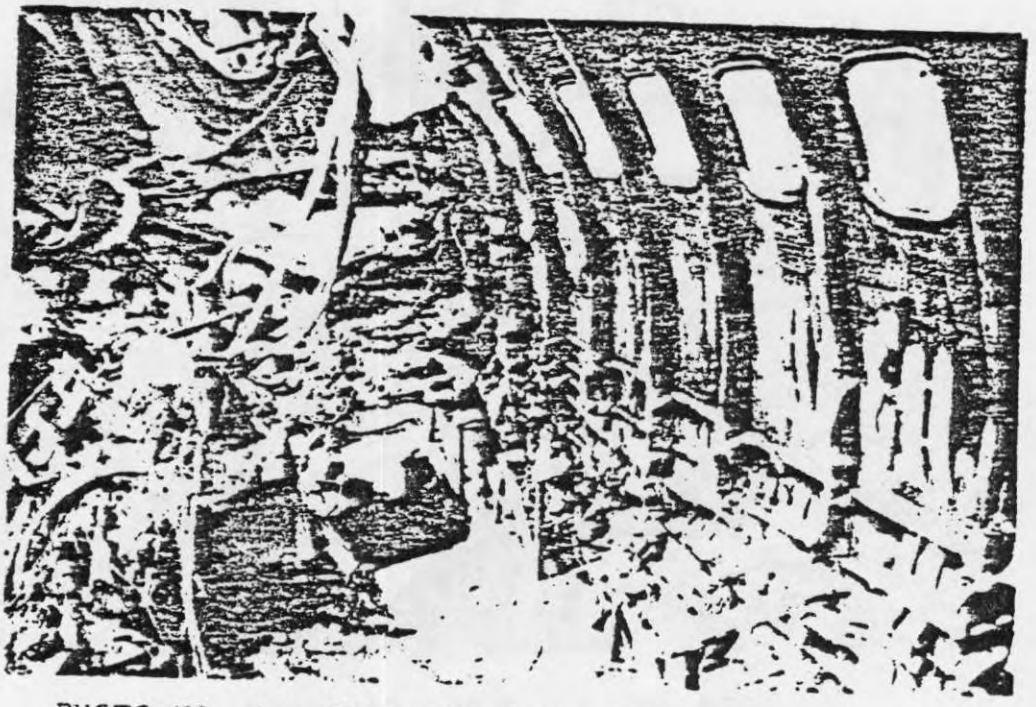


PHOTO NO. 4 - VIEW OF FLOOR COLLAPSE OVER C-3 AREA. TAKEN TOWARD AFT OF AIRCRAFT.

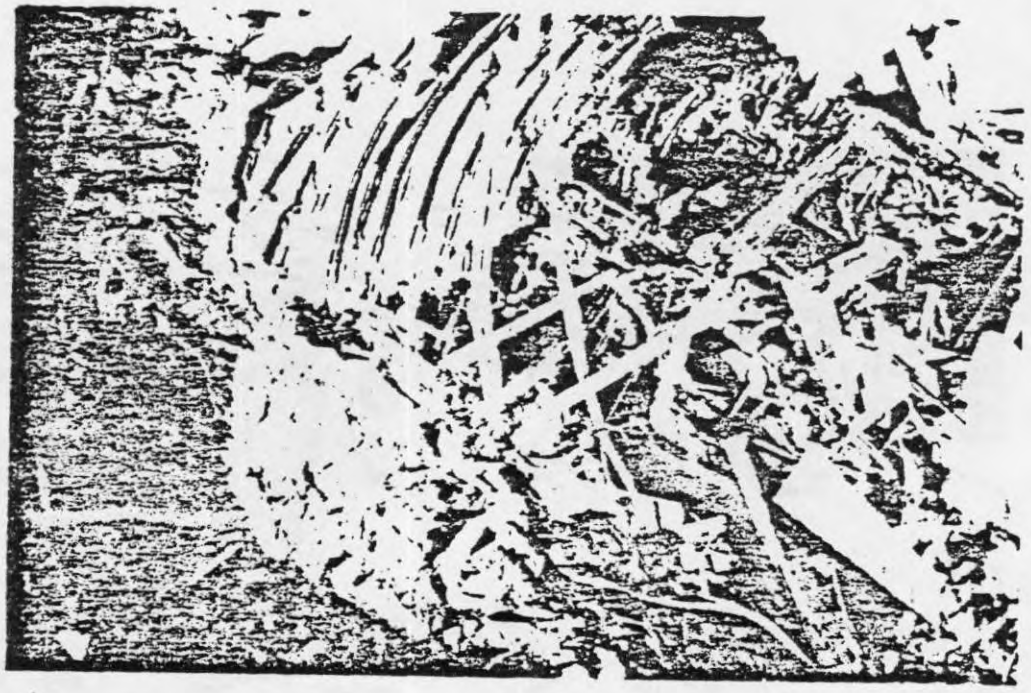


PHOTO NO. 5 - VIEW OF FLOOR COLLAPSE OVER C-3 AREA. TAKEN TOWARD FRONT OF AIRCRAFT.

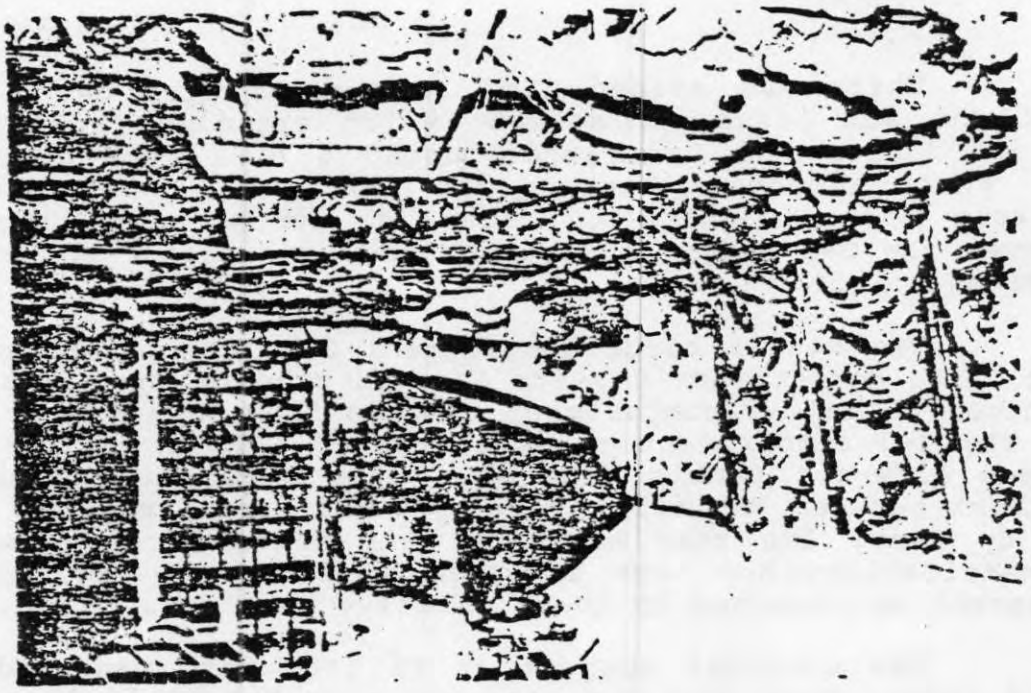


PHOTO 6 - C-3 COMPARTMENT. VIEW TOWARD AFT OF AIRCRAFT. NOTE COLLAPSED FLOOR AT REAR RIGHT.

PHOTO 7 - C-3 COMPARTMENT. VIEW THRU HOLE IN FLOOR FROM C-3 AREA UP INTO LEFT REAR CABIN AREA.

A large hole was burned through the floor on the left side near the pressure bulkhead in the area of the aft lavatory installations.

There was evidence of an intense fire on the left side of the aft passenger section which extended from FS 1545 aft to FS 1763. This area encompassed 6 dual seat configurations. Floor structure beneath the six seat section over the cheek area and a section of floor in the adjacent passenger aisle over the C-3 cargo compartment had been destroyed by fire. (See Photos 4 & 5).

The center cargo compartment C-2 (containerized) and the aft cargo compartment C-3 are located beneath the aft passenger section. The C-2 compartment extends from FS 1363 aft to FS 1625. The C-3 compartment extends from FS 1625 aft to FS 1792. The Nomex blow-out panels located on the left wall of the C-2 compartment between FS 1625 and FS 1545 had been partially destroyed by fire. The heat exchanger air outlet screen assembly duct installations had been consumed by fire, however, the screen assemblies remained in their relative positions.

The vertical support at FS 1605 was fractured at a point 12 inches down from its attachment to the BL 80 longitudinal support. The upper portion of the vertical support at FS 1685 showed evidence of buckling and exposure to fire and heat at the BL 80 attachment point.,

The C-3 cargo compartment left side wall and adjacent fuselage structure (cheek area) had been severely affectd by fire. The FS 1625 bulkhead aluminium face sheet and aluminium core at the left upper corner was split open exposing the core. The surrounding area in that corner extending from the upper horizontal cross support downward about 4 feet and inboard to the blow-out grill was intact. The balance of the bulkhead exhibited random charring and sooting but with no significant damage.

The hole in the ceiling of the forward left side of the C-3 compartment extended from about FS 1675 aft to about FS 1725 and from BL 80 inboard about 40 inches. The cabin floor material above the hole was also burned away. The initial observation of the material surrounding the hole from the C-3 into the cabin revealed a "shingle" type pattern of the debris. That is, the material was burned away more at the bottom and less at the top generally in a tapered manner. Such a burn pattern indicates fire from the inside of C-3 burning upward and outward into the cabin area. (See Photos 6 & 7).

The Nomex fabric ceiling liner was burned away from the left longitudinal support (BL 80) inboard about 60 inches and in the aft direction from FS 1625 to FS 1725. The left side wall Nomex blow-out panels were also fire and heat damaged.

The C-3 left wall upper longitudinal support in the vicinity of FS 1645 was consumed by fire. An 18-inch section of the associated horizontal cross beam lower cap was burned away. The vertical support at FS 1645 showed a partial fracture and buckling 3 inches down from longitudinal support BL 80 (FS 1676) attachment point. A burned section of the longitudinal support lower cap which measured about 14 inches in length remained attached to the vertical support. A concaved area showing a diameter of about 5 inches with a depth of 1 1/2 inches existed on the FS 1665 horizontal support beam lower cap at a point 30 inches inboard from BL 80. The web area adjacent to the above was buckled in the aft direction.

Examination of the aft bulkhead of the C-3 cargo compartment showed a skin burnoff at its inboard corner at about BL 13. The back skin panel (aft side of C-3) had a burn off of about one square foot. The honeycomb structure between the two aluminum sheets was in place. The forward skin panel (in C-3 compartment) had about 1 to 2 sq. in. of the aluminum burnt away. This area had been protected by "close out" angles of 775T6 aluminum material. Examination indicated that this had occurred late in the fire sequence.

The upper end of the vertical support at FS 1685 had fractured and was bent 180 degrees in the outboard direction. The fracture occurred about 4 inches down from the transverse floor beam attachment point. The vertical support at FS 1705 was attached to the lower cap section of the transverse support beam. The web and upper cap of the support beam were missing. The vertical support at FS 1778 had been consumed by fire with the exception of the lower 8 inches. The transverse beam was bent downward and twisted in the forward direction. The bend and twist started at a point 15 inches outboard of the aircraft centerline.

The fuselage skin above and below WL 200 in the left cheek area was severely affected by fire.

The stringers and associated vertical support members below WL 200 in an area outboard of the C-3 compartment between FS 1645 and FS 1685 were severely affected by fire. Additional damage to posts and stringers occurred from FS 1785 to FS 1792.

The protective covering over the pneumatic manifold and heat exchanger located outboard of the C-3 compartment's left wall had been consumed by fire. The fiber glass ducts leading to the 5 cargo heating air supply vents had fallen downward and were in various positions within the burned debris behind the compartment left wall.

1.12.2 Systems

1.12.2.1 Environmental Control System (ECS)

None of the equipment in either of the Environmental

Control System bays showed signs of fire or smoke damage. The turbine bypass valves were all in the pre-position setting which is about 37 degrees open. This was determined by noting the valve position indicators on packs 1 and 3 and by removing and inspecting the valve on pack 2. The indicator does not affect valve operation. The pre-position valve setting is a position established by the temperature control system when a pack is shut down. This action requires AC power. Such a valve setting indicates that all three packs were shut off and the valves pre-positioned before engines were shut down and AC power was lost.

The controllable exhaust and outflow valves and their positions were found as:

Forward electrical service center	- Closed
Mid electrical service center	- Closed
Galley venting	- Closed
C-3 cargo venting	- Closed
Forward out-flow valve	- Closed
Aft outflow valve	- Slightly Open (3/8") (0.4")

1.12.2.2 Pneumatic System

Ducting was inspected in detail in all fire damaged areas from No. 2 engine and APU forward and no evidence of pneumatic duct rupture or leakage was found. The 8-inch line running through the cheek area alongside the C-3 cargo compartment did not appear to have suffered any structural damage. All the duct insulation was burned away or mechanically destroyed along the outerside of the C-3 compartment. Forward of the severely burned area, the insulation was intact.

1.12.2.3 Overheat Detection System

An overheat detector system is installed adjacent to the pneumatic ducting to detect and annunciate Bleed Air Leaks. Resistance checks were made of the "J" area loop, which is the loop adjacent to the aft engine bleed duct in the left-hand cheek. The resistance of the "B" channel of the "J" loop was 62 ohms. This indicates that the sensor was permanently alarmed and had been exposed to temperatures of at least 1500°F. At any resistance less than 100 ohms the circuit will alarm. Normal resistance is greater than 1000 ohms. Channel "O", a wing loop, was checked for reference and had a resistance of 1600 ohms.

1.12.2.4 Pressurization

The cabin pressure control panel was recovered from the wreckage but was severely fire damaged. Some of the Indicator positions were found as follows (Figure No. 4):

o Altitude Set	26,000 flt/2000 ft. cabin alt.
o Baro Set	29.9 in Hg/1012 mb
o Mode Set	Standby (note 1 and 2)
o Manual Select	Manual (note 3)

Notes:

1. Dials were burned off. Position determined by set screw location.

2. Switch was loose - may not be actual position at time of fire.

3. Switches, if depressed, will release if the Teflon detent latching system is destroyed.

The Lockheed California Company prepared a pressurization system summary as the result of on-site findings and subsequent testing. It is quoted, in part:

"Summary, Pressurization System

- o A pressure profile consistent with the final aircraft configuration would develop from the following sequence of events:
  - Normal procedures were followed during climb and descent. Descent rate from flight altitude was relatively rapid and a suitable cabin descent rate was selected to reach zero differential at touchdown.
  - During approach, with the cabin altitude at 2000 feet, STANDBY mode was selected with a HOLD rate.
  - At some time, probably during the later stages of the flight, the avionics and galley overboard vent valves were closed.
  - Just prior to engine shutdown, the ECS packs were closed down, thereby effectively eliminating any ventilation air for the fuselage interior. This could have triggered a flash fire with a burst of smoke projecting downward out of the OFV as the valve continued closing during engine shut down.
- o There is no evidence of any valve or pressure controller malfunction.5/"

1.12.2.5 Cargo Compartments

The L-1011 has three pressurized cargo compartments. The forward compartment (C-1) extends from the rear of the ECS bay and nose wheel well to the galley. The mid compartment (C-2) extends from the main gear wells and hydro bay to FS 1625. The aft compartment (C-3) abuts the mid and extends aft to FS 1792 (Figure No. 5).

5/ There was, however, fire damage to the wires controlling the aft outflow valves (OFV) which could have influenced the final valve position.

The forward and mid compartments for HZ-AHK were designed for palletized or container cargo. The aft compartment (C-3) is used for bulk baggage/cargo and animal transport.

C-1, C-2 and C-3 cargo compartments are Class "D" compartments. Each compartment is heated by a closed loop recirculation system in which compartment air is circulated over the bleed air ducts in a low effectiveness heat exchanger.

No fresh air was supplied to the C-1 or C-2 compartments; but 165 CFM of cabin exhaust air (controllable either manually or automatically) could be circulated through C-3 of HZ-AHK to provide cooling and ventilation for animal transport (see Appendix L). An additional fixed flow of 10 CFM was supplied to the C-3 compartment.

a. Normal Operation - Heating and Ventilation

The heating system can be selected on by the F/E at the ECS monitor panel. If on, the heating system is fully automatic and will cycle a fan to maintain a selectable C-3 temperature between 50°F and 65°F. If cargo temperature reaches 95°F, a "hot" light will illuminate on the F/E panel. All sensors are located in the fan inlet.

The aft cargo vent system is controlled at the ECS monitor panel. When the system is turned on, overboard valve (A), and inlet valve (D) will open and vent fan (E) will come on. Valve (B) will remain closed. The close light on the switch light will extinguish when any valve opens. Valve (C) will maintain the 165 CFM overboard flow. Valve (C) is a preset flow control valve with no manual control (see Figure 16, Appendix L). Valve (D) is a fixed (10 CFM) flow which is operative at all times.

b. Cabin Pressurization

In event of depressurization, the F/E can unlatch the Cool Air OVBD switchlite which will open valve (B) and close overboard valve (A). Valve (D) and fan (E) will not be affected. In this mode, air is directed under the C-2 floor and to the aft out-flow valve.

c. Smoke Detector Operation

If either the A or B smoke detector alarms, there will be an aural warning; valves (A), (B), and (D) will close; and fan (E) will stop. When all valves are closed, the "Close" legend will illuminate in the cargo vent switchlite. If the smoke detector clears, valves will not reopen automatically, but must be recycled manually to be opened.

d. Aft Electronics Equipment Center (AEEC) Venting

To provide cooling for the AEEC, a portion of the cabin exhaust air passes through the compartment and is exhausted through the fuselage overflow valves. An AEEC overheat sensor alarms at 125°F.

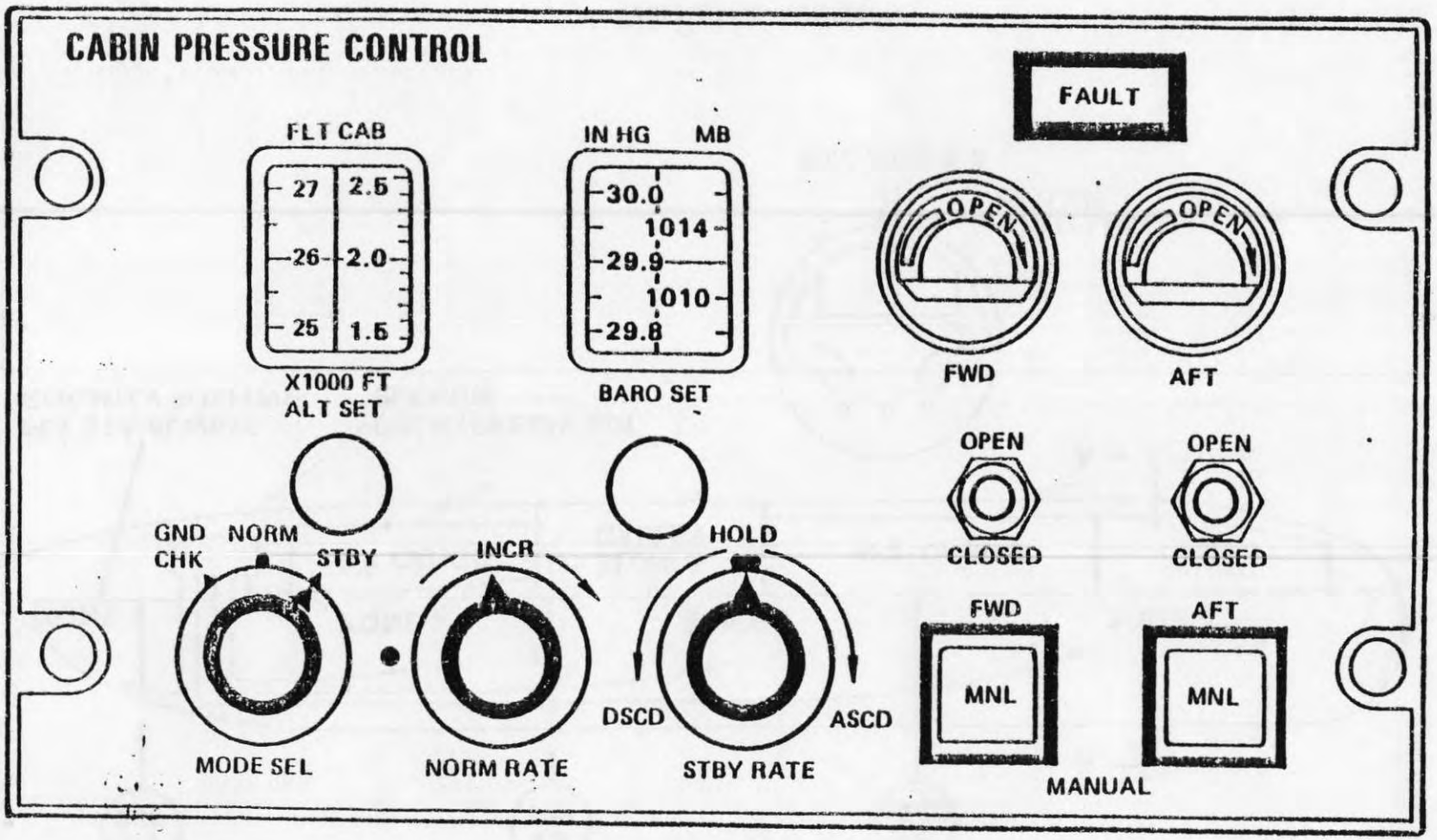


FIGURE 4

Cabin pressure control panel.

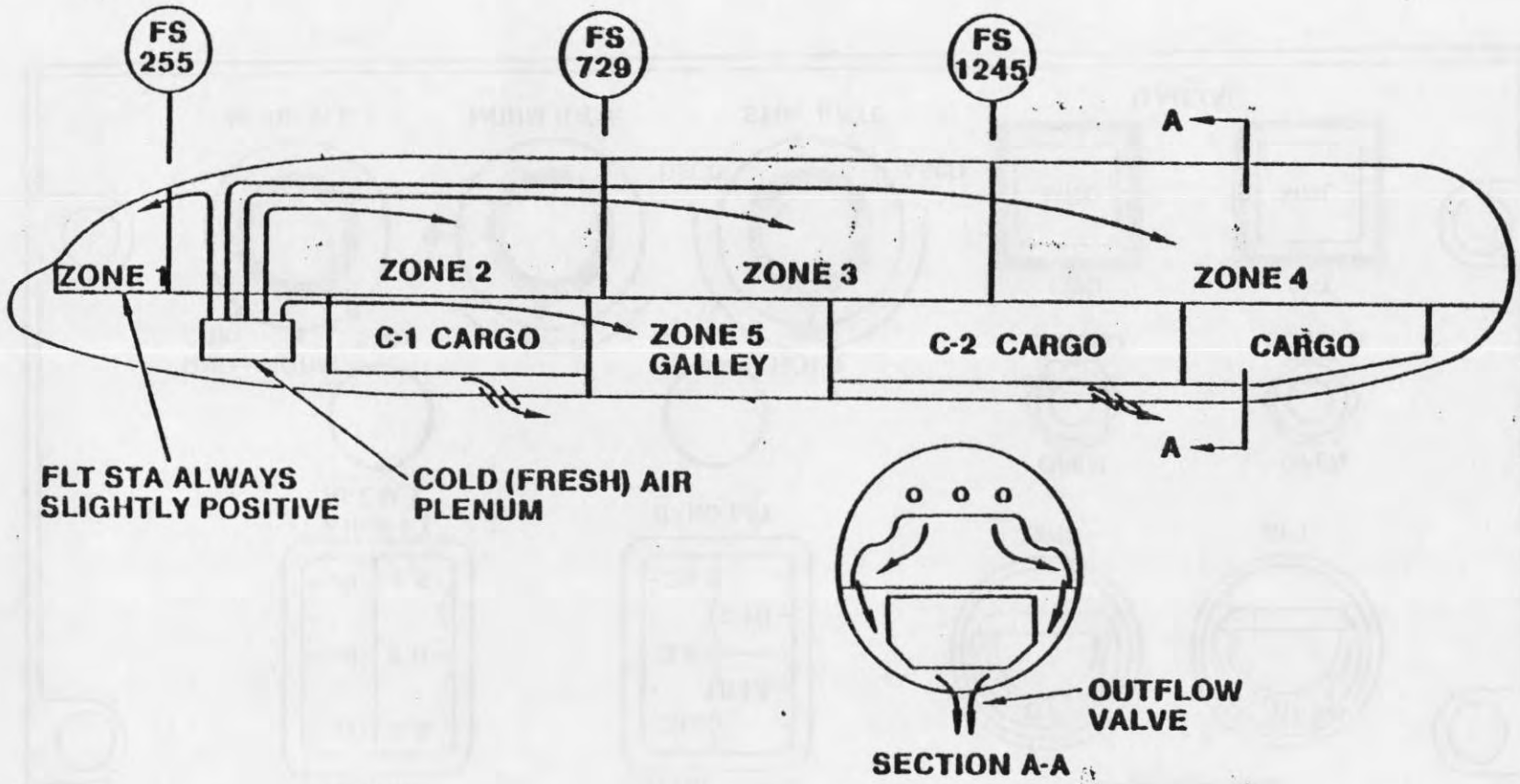


FIGURE 5

Ventilation schematic.

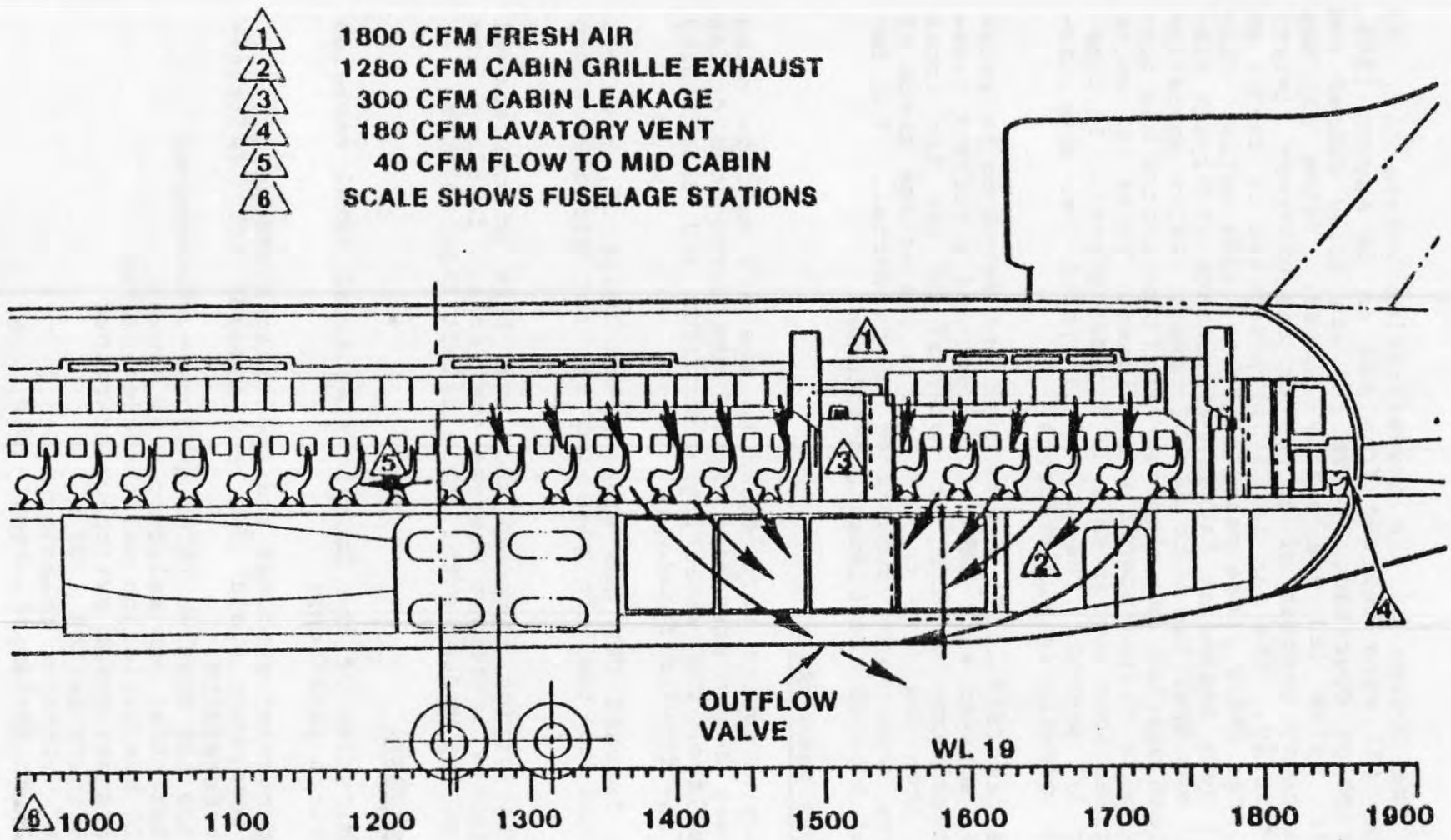


FIGURE 6

L-1011 aft cabin airflow.

In the course of the investigation Valves (A), (B) and (D) and fan (E) were removed from AHK on 24 August 1980. All valves are motor operated. Valve (A) was fully closed and tightly sealed. Valve (B) was nearly closed. Valve (D) was open and had a heavy deposit of carbon on the upstream (inlet) side of the butterfly. The fan had a heavy deposit of carbon on the blades, spinner and a dense material on the side walls. Valves (B) and (D) were tested at Saudia Maintenance at Riyadh Airport. Valve (D) was operated with 28 VDC power. Valve operation was normal in both opening and closing. Position switch was normal and gave a valve closed signal when closed. Valve (B) which was about 5 degrees open was given a 28 V close signal. It closed in less than 1/2 second. The valve was cycled open and closed and operated normally in all respects.

The fan (S/N 1119) was removed and found to be seized. The fan was sprayed with LPS-3 lubricant and a solvent cleaner which removed some of the tar material on the fan inner wall. The fan then was free to turn and a resistance check of all three phases show motor resistance to be normal. The fan had a deposit of soot on the blades and spinner.

1.12.2.6 Smoke Patterns

Heavy deposits were found on the aft outflow valve (OFV). There was heavy streaking behind the continuous drains in the aft fuselage. The streaking diminished and essentially disappeared on the forward fuselage.

The forward OFV had some carbon build up, however, it was restricted to the aft gate and was not streaked along fuselage skin.

Investigation revealed that the fire in the aft of the aircraft started in-flight whereas the forward fuselage fire occurred while on the ground after the aircraft came to rest.

1.12.2.7 Electrical

Examination of the Cockpit electrical panel revealed the following switch positions:

- Generator switches and indications-undetermined
- Generator field (GF) and breaker (GB) switches-undetermined
- Bus tie breaker (BTB) switches-undetermined
- Essential bus selector - B3 Manual
- DC bus isolation switch-undetermined
- Standby power switch-undetermined
- Battery switch - ON
- AC voltmeter selector - Gen 1
- DC voltmeter selector - BAT

In the mid electrical service center (MESC) the physical position of switch gear was observed:

GB1, GB2, GB3 - Contacts open
BTB, BTB2 - - - Contacts open
BTB3 - - - - - Contacts open
Battery cockpit feeder current limiter - Open
AC Hyd. Pump System A and B - Open

Wire bundles in the cabin overhead were destroyed by fire and no data could be obtained.

In the left cheek adjacent to the C-3 cargo compartment varying degrees of wire damage existed. Following removal of debris, the ECS bleed air duct, and hydraulic lines, detailed examination of wire bundles was accomplished.

Generator feeders from the No. 2 engine and the APU contain aluminium conductors. These were melted by the heat.

Other bundles through the area evidenced almost total loss of insulation material in the more severe fire damaged areas. Wire insulation material is Kapton which resists heat decomposition except in the event of direct flame contact.

One of the No. 8 gauge wires (P.N. 2436-6B8) was apparently severed by electric arcing and approximately 1 inch of the bare copper conductor was missing. The forward end of the severed wire had all strands of the conductor fused in a relatively smooth flat face. The aft end was fused. This wire is oriented at 6:00 o'clock on the outside of the bundle. Several other wires were severed at this same general location.

At FS 1700 this same No. 8 gauge wire showed evidence of arcing for a length of approximately 1 inch but was not severed. The other wires in the bundle did not appear to have arced. At FS 1625 several small wires were severed at the forward edge of a metal loop clamp. A segment of this wire bundle was removed intact for laboratory analysis. The segment was removed from FS 1500 to FS 1725 disconnect panel.

Examination of the wire bundle revealed no eivdence of "wet wire arcing". The broken wire end globules were not flat or concave as found when wire-to-wire arcs occur in the presence of moisture. Duplication of the actual broken wire ends found on HZ-AHK was accomplished in a laboratory test by burning a duplicate harness which was electrically energized. A gas torch was used as the fire source.

1.12.2.8 Hydraulic System

The hydraulic reservoirs were drained to measure the fluid.

Results in U.S. gallons:

X X X X X X X X X X	A System	B System	C System	D System
AS FOUND	2.6	Empty	5.88	4.7
NORMAL OPERATION	3.1	2.8	5.7	2.2
RESERVOIR CAPACITY	5.7	5.7	12.5	5.7

NOTE: (1) "D" reservoir was overfull.

Hydraulic service center accumulator readings were taken prior to draining the reservoirs.

Results: (Direct reading gauges)

B System Brake	1,000 psi
B Reservoir	800 psi
A Reservoir	1,000 psi
C Brake	2,400 psi
C Reservoir	1,000 psi
D Reservoir	1,400 psi

The investigation showed fire effects on systems, "A" and "B". Only system "B" reservoir was depleted. "A" shows a loss of part of its fluid quantity. "A" and "B" systems run through the left lower cheek area of the fuselage. System "A" pressure and return lines also run aft to power the rudder (one of three systems to the rudder). System "A" is one of four systems powering the stabilizer. System "B" pressure, return and suction lines also run aft to the engine driven pump, stabilizer and the rudder. The stainless steel pressure lines were still intact in the areas of high fire damage but the aluminum return line (System A) and the aluminum suction and return lines (System B) were burned through at about FS 1753 (Figure 7). System "B" suction line shows a petal type burst forward of the C-3 sidewall burn through areas at about FS 1629. This area is along the left hand side outboard of the C-3 baggage compartment liner. The petal rupture showed no signs of fire damage.

The "C" System lines going forward along the L.H. cheek area to the nose landing gear, passed through a fire and high heat area outboard of the C-1 baggage liner. These lines were blackened by the fire but show no visual breaks (Stainless steel and aluminum). The "C" System reservoir contained a normal quantity of fluid. Nose steering thus was not affected, nor was landing gear extension. The parking brake was mechanically set. The ram air turbine (RAT) was not deployed. There was dripping hydraulic fluid from the aft lower fuselage drains and from around the aft pressurization outflow valve.

The "B" System pressure line from FS 1575 aft to the pressure bulkhead was removed and pressure tested with water and air at 3,000 psi. It did not leak. The remaining hydraulic lines that passed through the rear fire area were visually inspected for signs of cracks or pinholes. None were found to indicate leakage.

The emergency fuel shut-off valves to No. 2 engine were determined to be open. These two shut-off valves (primary and secondary) would normally be open unless the flight crew shut down the No. 2 engine with the fire-pull handle. Other evidence also indicated the No. 2 engine was shut down by the normal fuel/ignition switch. This was that the "B" and"C" Hydraulic firewall shut-off valves were in the open position.

The No. 2 engine driven pump was removed and no evidence of fluid overheat was found. The air turbine motor, hydraulic case drain filter was checked. The filter showed no signs of contamination nor overheated fluid. Also the "B" System return filter was checked and found to be free of any abnormalities.

Examination of the APU did not reveal any evidence of fire or overheat. Based on the aircraft records, the APU was placarded inoperative.

The main landing gear brakes were observed to be "off" approximately 10 hours after the accident. In order to determine why the brake pressure had bled off, the System "B" brake return line shut-off module, for parking brakes, was removed for testing. The module tested satisfactorily. The brake shuttle valves were removed and found to be in the "B" System position. When the shuttle valves were removed, some hydraulic fluid was in evidence. The reason the brakes were not in the "ON" position, although the parking brake lever was set, was not determined. For further details, see Figures 7, 8, and 9.

1.12.2.9 Control Systems

Review of the CVR and DFDR indicates that there were two control system anomalies during the descent and approach to Riyadh. These were a "stuck" engine No. 2 throttle and a slow retraction of No. 4 left spoiler.

Testing revealed that the slow retraction of No. 4 spoiler was associated with the decay of "B" hydraulic system pressure after the shut down of No. 2 engine.

Testing also revealed that heating and subsequent slight cooling of the throttle control cable rollers and/or seals could cause a stuck throttle condition.

There were no other control problems or anomalies during the flight.

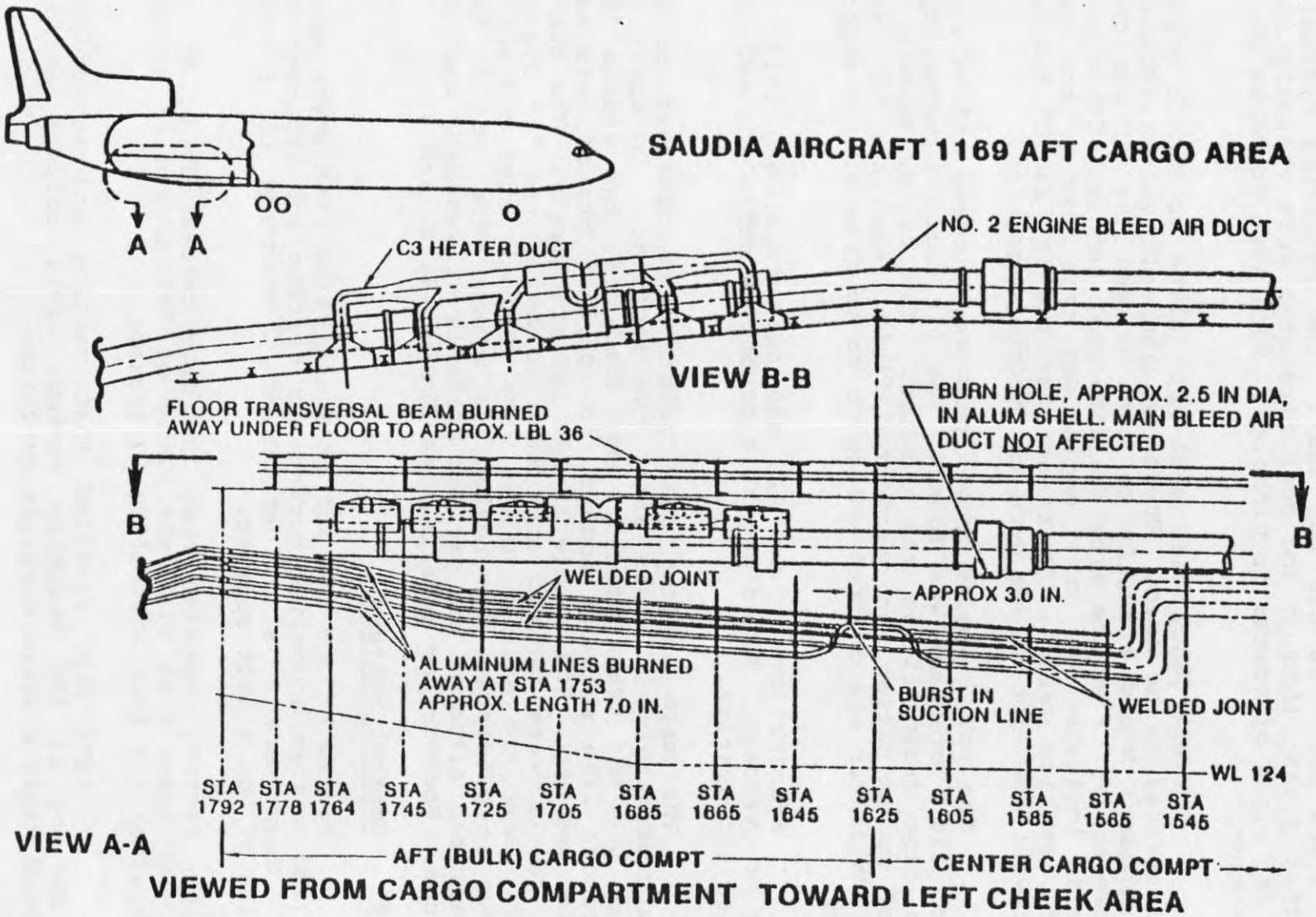
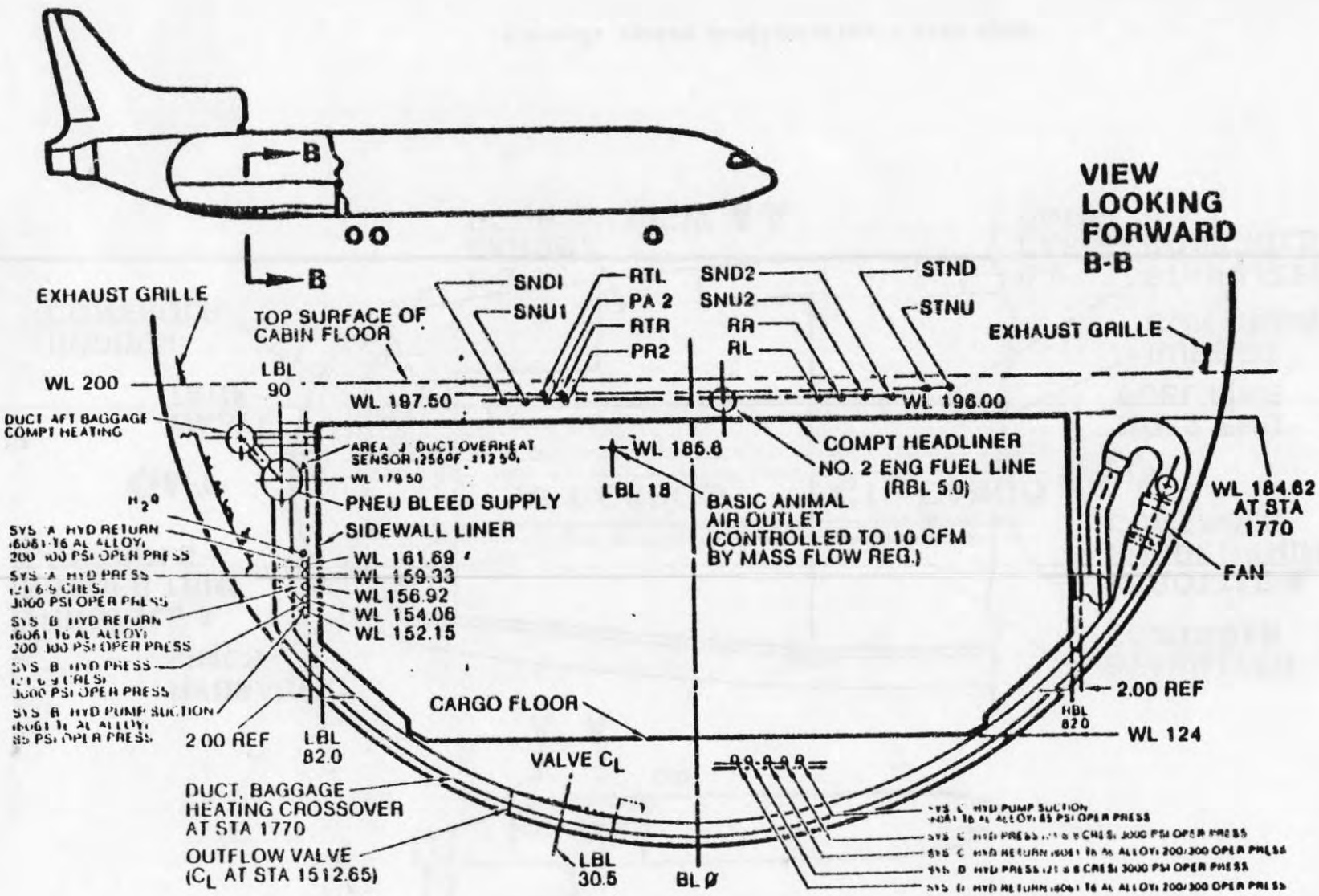


FIGURE 7

Aircraft system configuration aft cargo area



Aircraft system configuration

FIGURE 8

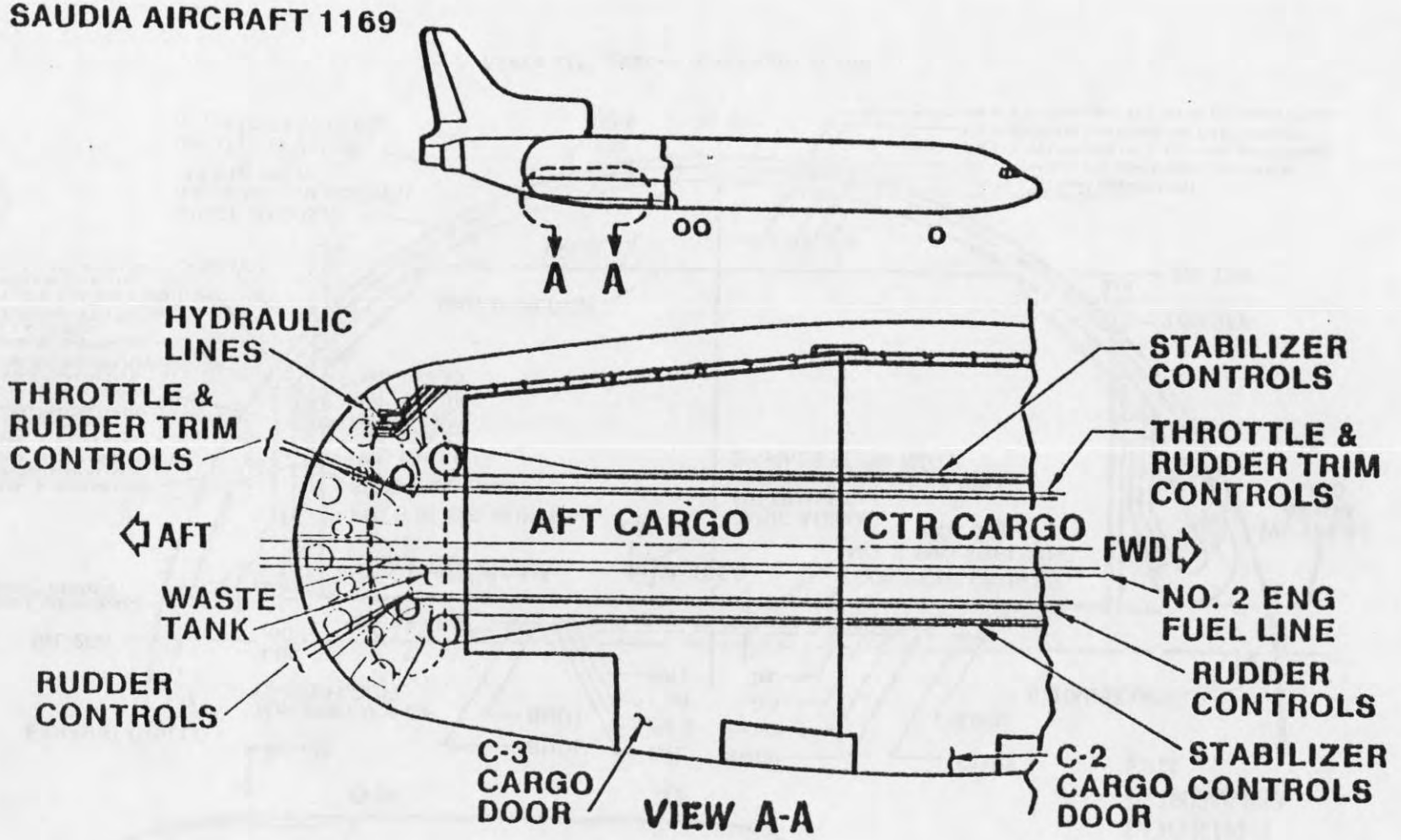


FIGURE 9

Aircraft system configuration - plan view.

1.13 Medical and Pathological Information

A review of the flightcrews' medical records revealed that there was no pre-existing medical problem which would have affected their ability to conduct the flight safely.

All deaths occurred as the result of smoke inhalation and fire. The Captain and F/O were in their seats and had sustained charring burns. Their bodies were buried before autopsy authorization was received. The body of the F/E who was found in his seat, was autopsied as were the bodies of 10 identified cabin crewmembers.

Not all of the passengers' bodies were viewed by the investigation team but many were, and none showed evidence of impact or crushing type injuries. The only bone fractures noted were those associated with heat induced muscle contractions. Some bodies were fully clothed and showed burns of 1st degree only on the exposed surfaces. Some bodies had no burns while others were severely charred.

The post-mortem examinations of the bodies of the F/E and the cabin attendants were conducted at the Riyadh Central Hospital. These showed some degree of charring burn on various parts of the body. All autopsied bodies had sustained 2nd and 3rd degree burns, with exception of one body which was 100% charred. A few of the bodies were partially clothed, thus the unburned clothing provided some protection and only 1st degree burns were noted under the covered areas. No internal injuries or abnormalities were noted. Soot was present in every trachea. Blood samples from each of the examined bodies were taken for analysis as well as one additional blood sample which was obtained from the body of a passenger.

Tests conducted to determine carbon monoxide levels revealed that the F/E's CO level was 48%. The CO level in the other eleven blood samples ranged from 42% to a high of 58%. The sample which produced the highest percentage level (58%) was taken from the body of the purser.

The effects of carbon monoxide (CO) would have varied from person to person according to:

(a) Their CO base-line state, i.e. smoker/non-smoker and the degree of possible CO poisoning prior to landing - according to their location in the aircraft.

(b) Their level of activity affecting heart respiratory rate. When the carbon monoxide saturation level reaches 45-50% the subject is incapable of exertion; he is confused and on the verge of unconsciousness. Vision becomes dim; clear thinking becomes difficult and the individual is likely to have difficulty in

rising from his chair or walking without assistance. Even at lower levels, around 30%, there is impaired judgement and some loss of vision. These effects are all aggravated in an 'exercise' situation.

Some of the toxic gases that most likely were present in the cabin and cockpit are, Nitrous oxide; hydrogen cyanide; formic acid; acrolein; sulphur dioxide; halogen acids; ammonia; aldehydes and azo-bis-succinonitride. The detrimental effects of these gases would add to the complications of the effects of CO.

Most of the bodies in the cabin were located forward of L2 and R2 doors (see Figure 10).

1.14 Fire

The first indication of a problem on Flight 163 was at 1814:54 when the C-3 cargo bin smoke detector alarmed and the F/E reported, "B aft cargo". The second "A" smoke detector alarmed at 1815:54. When the F/E returned from inspecting the cabin about 1820:16, he reported, "we've got a fire back there". It was not determined whether he actually saw fire or saw smoke and smelled odors which led him to conclude that there was a fire. About one minute later, at 1820:37, a cabin attendant, came into the cockpit and said, "Fire ..... fire in the cabin". The F/E made a second trip into the cabin and at 1821:53 reported "... just smoke in the aft".

The precise location of the initial fire was not determined. The only remarks made by the F/E and cabin attendant were in generalities about the smoke and fire being "in the back of the cabin". There was no indication of smoke being observed by anyone prior to the warning of the smoke detector. There was evidence of intense fire on the left side of the aft passenger section aft of the L-3 door. The burn-through of the cabin floor structure in this area was localized beneath the second through sixth row of dual seat units forward of L-4. The aisle floor adjacent to the sixth seat unit was burned through, causing a hole which extended nearly to the left floor track of the left row of the center seat units. The cabin floor that was most severely burned and was destroyed by fire extended from fuselage station (FS) 1545 aft to FS 1763. The "cheek" area outboard of this area and that area aft to the rear bulkhead was open and severely damaged by fire. All cabin wall liner material and overhead storage units were destroyed by fire in the same area.

The aircraft was equipped with fire extinguishers, one each positioned in the following locations:

Six C02 fire extinguishers located at the flight deck (left side), L-1, L-2, galley, L-3 and L-4.

One dry chemical extinguisher positioned in the galley.

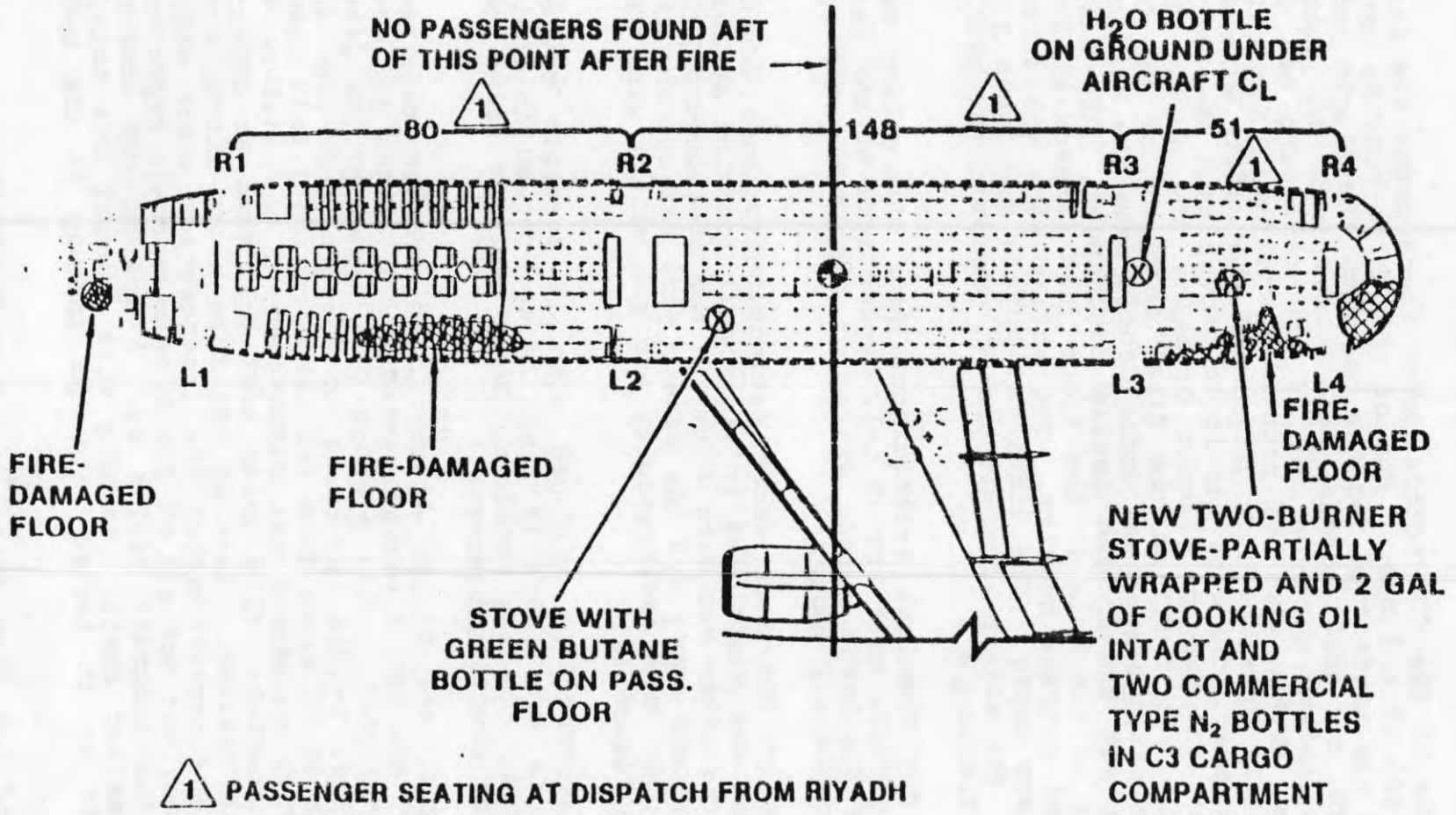


FIGURE 10

Passenger placement, fuselage fire damage (floor) and significant articles.

Four H2O (water) extinguishers, one each positioned near R-1, R-2, R-3 and R-4.

Three of the CO2 bottles were found under the first left-hand seat aft of L-3 door. One of the three bottles was a larger size and was identified as the one from the flight deck. The safety wire on that bottle was broken and the bottle discharged. The safety wire on one of the remaining two CO2 bottles was also broken and the bottle discharged. The third bottle had a little pressure left in it and the safety wire was still intact, however, the wire was loose enough that the bottle could have been discharged without breaking the wire. The fourth CO2 bottle was found on the first seat aft of the L-3 aisle seat. The extinguisher was under debris from the ceiling. The safety wire was broken and bottle discharged. The fifth bottle was found in the hole in the floor just forward of L-4. The bottle showed extreme heating. The safety wire was intact and the bottle was empty. The sixth CO2 bottle was found just forward of R-3. The safety wire was broken, however, the bottle was only partly discharged.

The dry chemical extinguisher from the galley was located under the first seat aft of L-3, center side of the left side aisle. The discharge nozzle was burnt completely off and the bottle was completely empty.

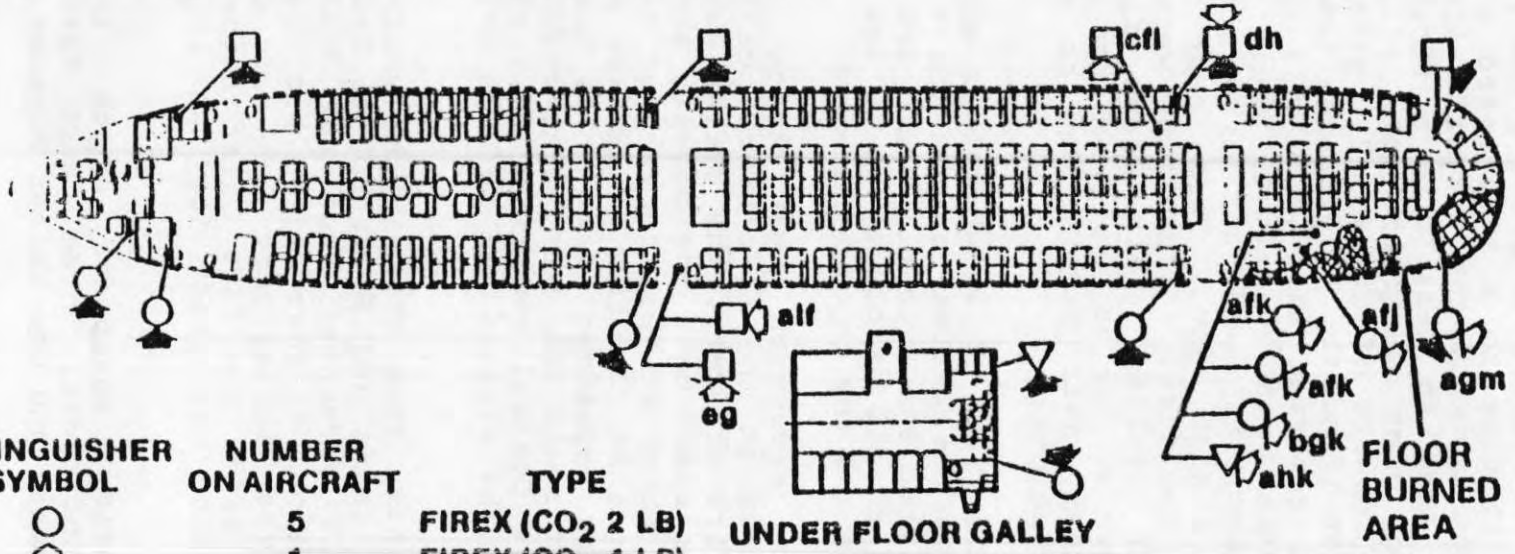
Three of the four water extinguishers were found. One of the bottles was positioned in its normal location at R-3, fully charged. The other two were found in the area around R-2. One of the bottles was empty and the safety wire was broken, the other was blown open from overpressure, and the safety wire was still intact (see Figure 11).

The aircraft is equipped with 12 portable oxygen packs. Six O2 packs were found in their cases, stowed in their brackets and unused. The six remaining packs were not found nor were their cases or mounting brackets.

At 1824, the Riyadh Airport fire station received the alarm through the ATC direct telephone that Flight 163 was returning to the airport. This message was logged in the fire station as a TriStar L-1011 returning to airport with fire in the cockpit and about 50 miles from the airport with a full load of passengers. Fire equipment was dispatched to the taxiway B intersections to standby. Nine units took positions at intersections along the taxiway. Each of the fire units turned out in pursuit as the aircraft passed the intersection where they were waiting. Some, but not all of the fire personnel, reported seeing smoke as the aircraft rolled by. A few of the others said that they smelled smoke. Nothing else unusual was noted about the aircraft as it taxied onto the taxiway at the B-8 intersection.

Most of the fire fighting personnel state that the aircraft engines were shutdown about 3 minutes after the aircraft parked. When the aircraft parked, the Fire trucks assumed positions which correspond with clock positions of 2, 4, 7, 10 and 11.

FIRE EXTINGUISHERS — NORMAL LOCATIONS AND AS FOUND AFTER FIRE



EXTINGUISHER SYMBOL	NUMBER ON AIRCRAFT	TYPE
○	5	FIREX (CO_2 2 LB)
⬡	1	FIREX (CO_2 4 LB)
▽	1	FIREX (DRY CHEM)
□	4	FIREX (H_2O)

NOTES:
- ◆ FIREX NORMAL LOCATION
- ◇ FIREX LOCATION FOUND AFTER FIRE

NOTES:
- a DISCHARGED
- b 1/2 DISCHARGED
- c PARTIALLY DISCHARGED
- d FULLY CHARGED
- e BLOWN OPEN
- f SAFETY WIRE BROKEN
- g SAFETY WIRE NOT BROKEN
- h SAFETY WIRE CONDITION NOT NOTED
- j FOUND IN SEAT
- k FOUND UNDER SEAT
- l FOUND ON FLOOR
- m FOUND IN HOLE IN FLOOR

FIGURE 11

L-1011 interior arrangement for Saudi Arabian Airlines.

Those personnel who were in a position to observe the rear portion of the aircraft after it came to a stop noted a puff of heavy white smoke coming from beneath the aircraft aft of the wings. Most of them said that in less than a minute after their trucks were positioned, they observed smoke rising from the top of the fuselage just forward of the No. 2 ergine intake. This smoke was followed almost immediately by flames (see Figure No. 12). All fire personnel reported that when this smoke and flame was sighted at the top of the fuselage, their monitors (turret discharge nozzle assemblies) were put into action and their agent was applied at a high rate. Those near the fire applied their agent against the fire. Those that were at the front half of the aircraft applied their agent along the fuselage from the cockpit back as far as their monitor pressure would reach. They stated that their purpose was to cool the fuselage. There were two exceptions:

(1) The driver of truck No.5, which was positioned on the dirt some distance from the taxiway and at the 4 o'clock position of the aircraft had problems with his truck and was unable to re-position. He applied all of his agent at low rate on the right side of the fuselage and the top of the wing.

(2) The other exception was truck No. 8. Initially, No. 8 was positioned, at the 12 o'clock position and in the words of one of the fire officers, the driver was starting to panic and to apply his agent onto the cockpit area. The officer manned the truck and moved it just forward of the right wing and applied its agent against the fire which was near the No. 2 engine inlet. The Fire Department Log shows that truck No. 8 was the first one to return to the station to refill. The time was 1932. At 1907, Fire Control requested that the Civil Defense come to the airport. The first Civil Defense units were logged in at 1918.

There were nine units from the airport which participated and 17 personnel; 16 units and 50 personnel from Civil Defense, and 2 units and 10 personnel from the RSAF. One thousand two hundred sixty gallons of foam (AFFF) was used. Use of other agents is unknown. The last airport fire unit returned to the station at 0512. At 0645, the Fire Chief informed the ATC Tower that the fire station was ready for the airport to open.

Airport firefighting equipment which initially responded were two Chubb Pathfinders, three Chubb Patrollers, one Gloster unit, two Ramchargers, and one Walter Pursuer.

Thirteen firefighters who initially responded to the incident were interviewed to determine their actions and their knowledge of firefighting and rescue procedures. Most of them had never fought an actual aircraft fire nor a training fire.

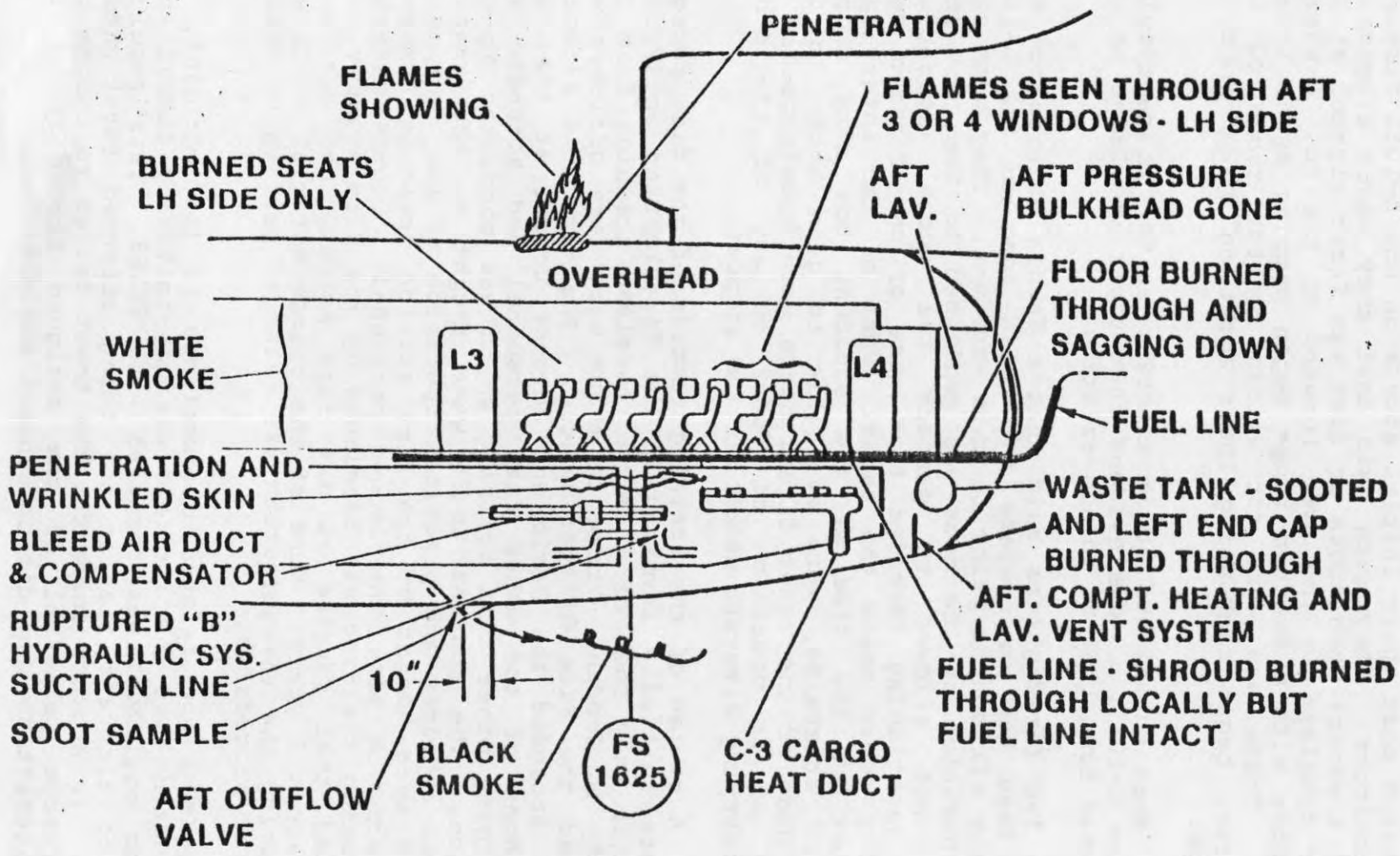
They all stated that their initial attack on the L-1011 fire was with the monitors. They each said that they began dispensing agent (AFFF & water) when smoke or fire was first sighted at the top of the fuselage in the area forward of the No. 2 engine intake. Those within monitor range began pumping agent toward that area. Those who were not within monitor range of the affected area, began dispensing their agent on other areas of the fuselage.

When questioned about aircraft exits, in particular those on the L-1011, it was evident that their knowledge on the subject ranged from limited to non-existent.

Two firefighters said that a Saudia maintenance man had shown them how to operate the cabin door on the L-1011 approximately six months prior to this accident. They both said that the operation of the door was explained to them but that they were not allowed to perform the actual operation. Additional questioning revealed that none of the firemen were aware of any doors below the cabin. None of the interviewed firemen knew at the time of the accident how many doors, emergency or otherwise, were available to gain entry to the aircraft. None of the other firefighters were knowledgeable of the number of or operation of doors on any of the other passenger-carrying aircraft which use the airport.

A review of the training records of the fire personnel who were initially involved in the firefighting activities revealed that only four of them had received training from the Fire Academy in Jeddah. Three of these were fire officers who had attended the Fire Officer Course. The other, a Fireman/Driver had attended the Basic and Advance Course at the Fire Academy. None of the other fire personnel had attended any formal training other than training which was conducted at the fire station. The courses which were taught at the station consisted of lectures and practical operation of the equipment. The courses were taught by the fire station training officer, fire officers, or more experienced personnel. Course material for the station training was furnished by the Fire Academy. It was reported that courses at the Fire Academy had not been taught in about 3 years. None of the course material which was reviewed during the investigation was found to pertain to rescue operations or procedures.

In a non related circumstance to the accident, it should be noted that the airfield was not initially closed when firefighting equipment was occupied with SV163. This resulted in operating aircraft traffic not being afforded firefighting protection. In another instance, the tower failed to inform the on-scene rescue personnel of the assigned frequency of the accident aircraft so that direct contact could be made.



Aft fuselage conditions witnessed on ground.

FIGURE 12

1.15 Survival Aspects

The accident was survivable. The first door was opened about 23 minutes after all engines had been shutdown. The first rescue attempt was conducted at L-1 door.

Most witness statements agree in content but differ slightly in the time factor element. A witness who participated in the first two efforts to open the doors stated that he was aboard fire truck No. 4 as it was positioned near the left rear portion of the aircraft. He observed thick white smoke flowing from the bottom rear fuselage. At that time the aircraft engines were still running. A few seconds later, he observed smoke near the top of the fuselage, forward of the No. 2 engine inlet. According to him, this smoke was followed almost immediately by flames in the same area. As the driver of No. 4 started applying agent via the monitor, the witness dismounted and moved toward exit L-1. His route was outboard of No. 1 engine which he thought was still running. On approaching L-1, he observed the fire chief and other people attempting to reach the L-1 emergency handle via a ladder which was placed on top of fire truck No. 6. While fire personnel steadied the ladder, he climbed up and pulled the emergency handle. He was not certain if the door moved or not. An additional effort was attempted while he held onto and rode the monitor. While on the monitor, he pushed on the door to no avail. Most of the group then moved to R-2 where another ladder had been positioned by other firemen. A fireman then climbed the ladder, operated the handle and the door opened in the emergency mode. The cabin was observed to be full of smoke and no life was observed nor were any human sounds heard. R-2 door was opened at 1905 - 26 minutes after the aircraft came to a stop and 23 minutes after the shutdown of all engines.

Shortly after (about 3 minutes) R-2 was opened, flames were seen progressing forward from the rear section of the cabin.

1.16 Tests and Research

1.16.1 C-3 Cargo Smoke Detection System Test

A test was conducted to determine if the C-3 aft cargo smoke detection system had operated properly and was not defective. The detectors were tested and it was found that they operated as prescribed.

1.16.2 Tests of Materials at London Police Forensic Science Laboratory

Some debris and soot samples from the C-3 cargo compartment; the areas in the vicinity of the compartment and from the area of the aft outflow valve were sent to the Metropolitan Police Forensic Science Laboratory in London. Examination of these materials did not reveal any evidence of products of an incendiary mixture or device.

1.16.3 Examination and Tests to Determine if Incendiary Materials were Present

A Specialist qualified in the detection of aircraft sabotage participated in the investigation to determine if there was any evidence of sabotage in the wreckage.

The examination of the baggage and other items that had been removed from the C-3 cargo compartment disclosed that the baggage was scorched and burnt in various degrees. There was no evidence found to suggest damage from the detonation of an explosive device, and there was nothing to suggest burning originating from an incendiary device in any of the baggage. A 4-litre can, labelled Caltex Diesel engine lubricating oil was found to be sooted but had not leaked and was full of fluid (see Appendix I).

The Specialist submitted an addendum to his report after he had received the analysis of the burst hydraulic pipe. He states that he was unable to conclude the cause of the fire; however, he found no evidence of "a positive nature of criminal activity".

1.16.4 Examination by the British Royal Aircraft Establishment

In April 1981, an examination of the burst B system hydraulic pipe was completed by the Materials Department of the Royal Aircraft Establishment located in England.

The general conclusion was that the pipe had been subjected to a period of heating which caused a reduction in its strength lending to a burst. They stated that there was no evidence of fatigue and the intergranular nature of the fracture strongly suggested hot tearing conditions. They also stated that the fracture surfaces suggested that no flame had been playing on them for any appreciable time after the burst had occurred. (see Appendix K).

1.16.5 Selected Tests and Research by the Lockheed-California Co. and F.A.A. Technical Center

1.16.5.1 Tests of Phosphate Ester Hydraulic Fluid

The Lockheed California Company conducted tests to determine the ignition behavior of the type of hydraulic fluid used on the aircraft. The fluid was tested in the form of a stream, a pool and a mist. Ignition sources were a flame, an electric arc and a hot surface.

Findings from the tests were:
(1) Ignition of phosphate ester hydraulic fluid:

- Mist will ignite and burn at room temperature. Liquid must be heated to 350°F to burn.

- The temperature of hot metal must be in excess of 1000°F to ignite fluid. An electrical arc or open flame will ignite a mist at room temperature.

(2) Conditions influencing combustion:

- An air flow is needed to sustain combustion. In still air, the fluid tends to self-extinguish in the products of combustion.

- Heat transfer affects burn time.

"These findings imply that sudden release of hydraulic fluid (no mist) through a tube rupture would not provide a prolonged contribution to the cheek fire. Hydraulic fluid was found to be draining from the area of the burst pipe during the onsite inspection".

1.16.5.2 Landing Performance Tests

An analysis of aircraft stopping performance was made using data from the QAR to provide an estimate of the difference between the time actually experienced in bringing the aircraft to a stop and the time that would have been required had maximum wheel braking been employed. Also considered was the question of whether any wheel braking had been applied because the rollout after touchdown was of such long duration.

It was concluded from the deceleration profile that some wheel braking had been applied, but braking levels were not at a moderate or a maximum level. It was estimated from the analysis that the aircraft could have been stopped 2.4 minutes sooner had maximum braking been employed. However, the deceleration rate would have approached 0.5g and the pilot might have been reluctant to execute such severe braking. With braking limited to moderate (0.25g deceleration) the stop would have been much faster than normal, but would have required only a few seconds more than for a stop with maximum braking.

Regarding the availability of braking, Lockheed states:

"It is pertinent in considering braking during the actual landing that the B hydraulic system pressure (not fluid) had been lost because of events associated with shutdown of engine No. 2. When B system pressure is lost, the B-brake accumulator provides adequate pressure to permit maximum braking to be applied and released four times. However, procedures to be observed when B system pressure is lost call for selection of ALTERNATE brakes (associated with C-system) in lieu of NORMAL brakes (B-system). Selection of ALTERNATE brakes was not evident from conversations recorded by the CVR nor by the available evidence. The onsite inspection found the brake selector switch in the NORMAL (B-system) position and the brake selector valves in the NORMAL position.

Witnesses indicated that when the aircraft reached the taxiway and was brought to a stop, it then rolled about 5 feet further before being brought to a final stop. This additional movement possibly prompted the flight crew to select the parking brakes (hydraulic pressure for parking brakes supplied by B-system brake accumulator). The aircraft parking brake controls were found set by the onsite inspection members.

Regardless of whether NORMAL or ALTERNATE brakes were selected during landing at Riyadh, procedures to be observed would provide adequate hydraulic power (pressure and flow) for a maximum braking stop."

1.16.5.3 Electrical Testing of Wire Harness

A segment of a wiring harness from the left-hand cheek area was removed and transported, in accordance with procedures established with the NTSB, to the Rye Canyon Research Laboratory, Plant 2, for analysis. The segment was subjected to visual examination to determine if wire faults were the source of ignition. Conclusions were:

(1) No pre-existing wire damage had existed.

(2) No ground faults to metal harness clamps were present.

(3) No evidence of wet-wire faults was disclosed.

A facsimile of the harness segment was fabricated and subjected to fire testing conducted as follows:

(1) Molten aluminum at 1200°F to 1500°F was poured from a ladle over the electrically energized harness. No electrical arcing resulted.

(2) A flame 6 inches in diameter at 1800°F was applied to the harness and caused wire insulation to burn and char. Arcing occurred between conductors. After approximately 5 minutes, the arcing caused wire conductor fusing, severing, and blocking. Arcing and small flames from insulation continued after removal of the flame until circuit breakers tripped.

The fire test duplicated wiring harness damage observed in the cheek area. It was concluded, from the testing, that the fire caused wire insulation damage and resulting arcing between wires.

Three wires removed from the electrical harness were submitted to the Rye Canyon Research Laboratory for analysis of the wire insulation for evidence of phosphate ester hydraulic fluid. Analysis revealed a high phosphorus content on two of three wires. This condition was judged to be consistent with spillage of phosphate ester hydraulic fluid but could also be attributed to the AFFF fire 'fighting agent used during the fire fighting effort.

1.16.5.4 Tests and Conclusions by Lockheed regarding Fuselage Doors and Hatches

Post-accident inspection of the aircraft revealed the forward outflow valve closed, the aft outflow valve substantially closed, and all cool air overboard valves closed. Such valve positions are unusual after touchdown. With the valves thus positioned, the effect of cabin residual pressure on door opening characteristics was considered. Two tests were conducted after the accident to validate the previous certifiction testing to define door-opening pressure.

In the first test series, the cabin pressure was lowered slowly (approximately 200 feet per minute) by use of a small cabin inflow (one ECS pack) and a fixed outflow opening.

During this test, the door unseated, moved inboard in several separate, finite movements, then travelled upward. The upward movement was in a smooth and continuing motion once it had begun. The combination of a low air inflow and a fixed

outflow valve position led to a marked pressure decay once the door had unseated. Determining the door-opening pressure, therefore, was subject to interpretation.

To more closely define door opening pressure, the second test series were run with high ECS air inflow (three ECS packs), minimum uncontrolled outflow (cool air overboard valves closed), and the pressurization system used to maintain a constant test pressure within the limits of its capability. Doors L-1 and R-2 on the test aircraft were used. Door L-1 opened at a pressure differential of 0.20 pounds per square inch differential (psid). Door R-2 opened with some delay at a cabin differential pressure of 0.35 psid and opened rather rapidly at a 0.30 psid.

Consideration of all available evidence indicates that there was little or no pressurization differential between the cabin and ambient pressure at the time of touchdown and that the doors could have been opened immediately after touchdown.

1.16.5.5 Oxygen System Research and Tests

Research indicates that the flight station oxygen system and the passenger oxygen system were not utilized during the flight.

1.16.5.6 Research Conducted to Determine Center of Gravity Shift as Related to Passenger Movement

Significant in-flight passenger movement could provide an indication of the progress of the cabin fire to determine whether the passenger movement had occurred in flight using the effect on pitch trim, information from the DFDR was analyzed. Two salient conclusions are:

(1) There is no indication of a major movement of passengers either prior to or immediately after initial operation of the smoke detector system and aural warning.

(2) Although some passenger movement occurred while the aircraft was airborne, the final massive forward movement apparently occurred after the aircraft had landed.

These findings indicate that, despite the early reported presence of smoke6/ and, later, flames in the aft cabin, the cabin environment was such that the cabin crew was successful in keeping passenger movement to a minimum. After landing, however, the cabin conditions altered and a passenger movement forward took place.

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6/ Acrid smoke such as generated by a hydraulic fire could not have been tolerated and passengers would have been forced to move forward early in the flight sequence.

1.16.5.7 Cabin and Cargo Compartment Flame Testing

In an attempt to determine the origin of the fire and to examine the probable nature of its progression, flame tests were conducted with partial simulation of the cabin and C-3 cargo compartment. These tests were directed toward the cabin flooring support beams, cargo compartment liners, and passenger seats. In addition, a test was conducted simulating the C-3 cargo compartment by utilizing a converted bus. Testing was as follows:

1. Cabin Carpet/Floor Panel Test (Lockheed) 7/ - To examine how various fuel sources possibly present in carry-on baggage could be ignited and the effect of the associated fire on carpet and flooring panel. Carpet and floor panel were the same as those on the accident aircraft. The results of the tests showed that spilled fuel fluids burning on carpeted floors self-extinguish with only superficial damage.

2. Cabin Floor/Cargo Ceiling Burn (Lockheed) - To consider liquid fuel spilled on carpet and leaking through on to the cargo compartment ceiling liner. The test set-up implied a discontinuity in the floor paneling (discontinuities are not common). The test used 100 ML of white gasoline on the carpet and 50 ML on the cargo ceiling. Test 2 of this series used 150 ML of Kerosene on the carpet and 100 ML on the cargo floor. The results showed that spilled fluids in the quantities mentioned burning on the cabin floor and the cargo compartment ceiling simultaneously self-extinguish with only superficial damage to the cabin floor but with penetrations of the ceiling liner possible.

3. Cargo Compartment Ceiling Liner/Cabin Floor Tests (Lockheed) - To consider the penetration of the compartment ceiling liner and (in some tests) the cabin floor panel/carpet from an open flame from below. The results were that a 1300°F 6" diameter butane flame will penetrate the ceiling liner of .030 Nomex in 43 seconds and a 1500°F similar flame will penetrate it in 36 seconds. No penetration occurred during the period of the tests when these tests were conducted using .020 two-ply fiberglass instead of Nomex. The overall conclusions were that upward burning penetrates the cargo ceiling liner and cabin floor in a short period of time.

4. Cargo Compartment Sidewall Liner/Blowout Panel Tests (Lockheed) - Open flame was applied to the cargo compartment liner, with and without blowout panels. The results indicated that the blowout panel remains secure under severe flame or heat exposure; however, the corner and ceiling confines heat and creates hot spots.

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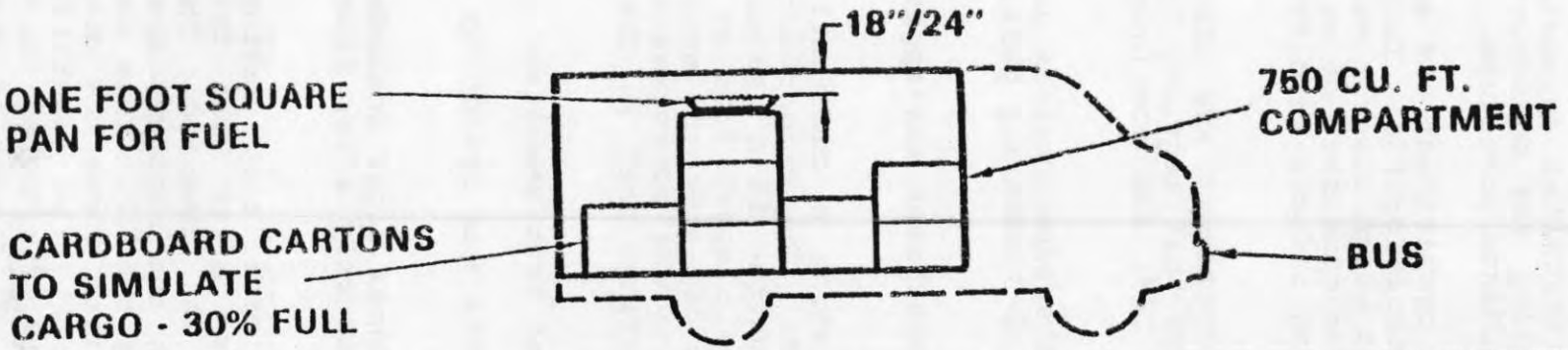
7/ All tests and research conducted by the Lockheed California Company were in coordination with the U.S. NTSB and FAA and were reviewed by either both or one of these governmental agencies.

5. Cabin Floor and Floor Beam (Lockheed) The FS 1685 floor support beam which is located above the C-3 cargo compartment was consumed by a high intensity fire outboard from left butt line (LBL) 40 to the fuselage skin. The test was conducted to determine the heat/flames involved in this event. The test flame caused damage to the beam and floor panel above, but not to the same degree as the fire damage observed on the aircraft. The beam/floor panel damage on the aircraft was the result of fire from below as determined by the reverse-single burn-away of the beam and the flooring materials. It was not positively determined whether this was the result of the original fire or the general fire condition after the aircraft was brought to a stop.

6. Seat Row Ramp Test (Lockheed) - A test to examine the ignition of a fuel spill under a passenger seat. The test was conducted with the floor panel inclined at an 18 degree slope to take into account the nose-high attitude of the aircraft at rotation on takeoff and during the subsequent climb. Eighteen degrees was experienced at rotation, however, this exceeds the normal climb attitude. The objective of the test was to determine if liquid products from burning of the polyurethane seat materials would flow rearward to collect in a pool at the lower end of the ramp. At the completion of the test, 1 quart of liquid had collected. Flames from the burning seat material were abundantly evident, being 5 to 6 feet high. Similar flames, had they been present in the aircraft, should have been obvious to the cabin crew.

7. Simulated C3 Cargo Compartment Fire Test. (FAA Technical Center) A test series approximating possible conditions in the C3 compartment was conducted at the FAA Technical Center. A 750-cubic foot simulated cargo compartment was used. This test series was conducted to determine the effects of airflow shut off on a small cargo fire in a compartment similar in volume to the C3. The tests are outlined in Figure 14. The tests indicated that a small cargo fire, such as one started by a match or cigarette on or in a bag could easily reach a temperature that would penetrate the L1011 Nomex liner. They also indicated that a slow growing fire, in a compartment the size of C-3, could burn for a long duration before the O2 would be reduced enough to cause a major reduction in flaming.

8. Class "D" Cargo Compartment Fire Simulation. (FAA Technical Center) The FAA at their Technical Center is conducting (December 1981) a test program to determine what design features and materials are necessary to safely contain likely fires in class D cargo compartments. (Refer to Appendix H). The results of the entire test program when completed will be documented in a technical report by the FAA. However, because of the similarities of the first test set up and the C-3 cargo compartment the results were released to the accident investigation team for their use. The following is a description of the test and summary of results:



TEST NO. 1

- A - 1 PINT METHYL ALCOHOL
- B - AIR SUPPLY SHUT-OFF
- C - ALCOHOL IGNITED
- D - ALCOHOL CONSUMED IN 5-MINUTES
- E - NO EFFECT FROM LACK OF AIR
- F - CEILING TEMP 1700°F

TEST NO. 2

- A - 1.5 PINT DENATURED ALCOHOL WITH POLYESTER JACKET FOLDED ON TOP
- B - AIR FLOW 175 CFM
- C - JACKET EDGE IGNITED
- D - SMOKE DENSITY AT DETECTOR TRIGGER LEVEL IN 3 MIN.-AIR FLOW SHUT-OFF
- E - NO EFFECT FROM LACK OF AIR
- F - JACKET MOSTLY CONSUMED TEST STOPPED IN 23 MINUTES

TEST NO. 3

- A - 3 SYNTHETIC ARTICLES OF CLOTHING (WGT 3.8#) WRAPPED AROUND BOX OF MATCHES (2.5 X 1.5 X 5") THEN WRAPPED IN NYLON JACKET
- B - AIR FLOW 175CFM
- C - ONE CORNER IGNITED
- D - SMOKE DENSITY AT DETECTOR TRIGGER LEVEL IN 3 1/4 MIN. - AIR FLOW SHUTOFF
- E - 9.5 MIN. LATER MATCHES IGNITED
- F - NO EFFECT FROM LACK OF AIR
- G - BUNDLE CONSUMED IN 32 MINUTES

FIGURE 13

Simulated C3 cargo compartment fire test.

The test compartment used was the same as shown in Figure 13, with the following modifications::

(1) A drop ceiling was installed approximately 12 inches below the bus roof. The ceiling was constructed of Lockheed Nomex cargo liner fastened to aluminum structure.

(2) Airflow in the cargo compartment was supplied by a fan forcing air through an adjustable orifice. This airflow was 130 CFM until smoke detection, at which time it was terminated. The outlet for the airflow system consisted of an opening with a check valve to prevent air being induced into the compartment after airflow shut off.

(3) Airflow above the compartment was simulated using a fan at one end to draw air through that section, from an opening at the other. Airflow was 260 CFM, and continued for the entire test.

(4) A smoke detector of the same type as used in the C-3 compartment was installed using a C-3 mounting panel supplied by Lockheed.

(5) The volume of the compartment was approximately 620 cu. ft.

The test was conducted using a combination of boxes and actual baggage as a fire load. The compartment was approximately 1/3 full. The fire was ignited in a canvas type bag using two packs of matches set off by a spark from an igniter. Airflow in the compartment was shut off when the smoke detector activated. The total test duration was approximately 10 minutes. The fire was not completely extinguished in the baggage for approximately 2 hours.

The following are pertinent test results:

(1) A large amount of smoke was needed to alarm the detector.

(2) Burn-through of the Nomex liner occurred around the same time as smoke detection, shortly after flame impingement.

(3) The fire intensity oscillated during the test. High intensity for a minute or so after burn through, then subsiding as O2 in the compartment was consumed. Then as fresh air entered the compartment through the rupture, the fire would gain intensity thus again consuming the O2. This was vividly demonstrated by the smoke exiting from above the compartment. At, and shortly after burn through, large quantities of smoke poured against the airflow, out the air inlet above the ceiling (this would be into the cabin). This smoking stopped, with all smoke then exiting out the fan outlet (outlet valve

on aircraft). After a short period smoke again exited the inlet. This oscillation occurred 3 or 4 times during the test.

(4) The smoke detector came on at 2 minutes 59 seconds and went out at 5 minutes 44 seconds. It was determined that soot deposits on the lens of the detector caused the warning to go out. Subsequent tests also showed that heating of a detector can cause intermittent alarms.

(5) Temperatures of significant magnitude and duration to penetrate a floor panel, were measured in the area above the ceiling liner.

(6) The temperatures above the liner oscillated during the test with the highest peak being the first one just after burn-through.

(7) The hole burnt through the Nomex liner was very similar in size and nature to that of the one in C-3.

(8) Damage in the compartment was confined to the hole in the liner and baggage directly under the hole.

(9) Cabin Fire Simulation. (FAA Technical Center) The FAA, at their Technical Center, conducted a test in conjunction with a cabin materials program, simulating an inflight cabin fire. This test points out the development spread and hazards associated with an inflight fire, a full report on this test will be included in a technical report on full-scale fire tests issued shortly by the FAA.

The test was conducted in a C-3 aircraft modified to resemble a wide body aircraft. (Refer to Report No. FAA-NA-79-42) Measurements of heat, smoke, oxygen, and toxic gasses were taken at various locations in the fuselage. Six sets of triple aircraft seats and a small portion of carpet were the only combustible aircraft materials used in the cabin.

A fire was started in a "carry on" bag under one of the seats. (This could also represent flame coming through a hole in the floor). A simulated inflight airflow system was used in the cabin, changing the air approximately once every 4 minutes. When one seat of the triple became fully involved in the fire (only a few minutes after the bag was ignited), the airflow to the cabin was shut off.

The following are the results of the test:

(1) Seats rapidly became involved in the fire.

(2) Smoke from the burning bag went up to the ceiling before being drawn down through the ventilation system.

(3) The burning of one triple seat produced vast amounts of smoke and gas.

(4) Shutting of the ventilation system produced clearing of smoke and gas at lower levels because stratification resulted.

(5) A flash fire occurred a few minutes after airflow shut off. Conditions in the adjacent section of the cabin went from very good (little heat, some smoke and gasses at high levels), just prior to the flash fire, to a completely non-survivable condition within less than 30 seconds.

1.16.5.8 Throttle Control Cable Heat/Flame Tests

Throttle control cable tests were conducted to determine the extent of increased drag experienced in throttle cable operation if fairlead nylon rollers and/or bulkhead seals are heated to the plastic state and subsequently are cooled.

The throttle cables for the No. 2 engine are routed aft through fairleads in the floor support beams and through seals in the aft pressure bulkhead. Fairlead rollers and the aft pressure bulkhead seals are fabricated from nylon thermoplastic impregnated with molybdenum disulphide.

The tests were conducted on a mock-up of the throttle control cables from approximately FS 1383, above the C-2 cargo compartment, to FS 1862 aft of the pressure bulkhead. Prodution control cables, fairleads, pulleys, and pressure seals were used. Because transient heat applied to the rollers and seals tended to dissipate into surrounding support bracketry, the mockup tests were supplemented with tests involving use of rollers attached to individual brackets. With individual brackets, heatsoak and cooling conditions were more easily controlled.

Heat was applied to the fairlead rollers by a propane torch directed downward from above. The test was repeatd with a heat source below the rollers. Maximum break-away force developed during the repeated tests was 48 pounds.

The throttle cables are 3/32 inch diameter and are Locklad when routed through the floor beam fairleads, but are bare at the aft pressure bulkhead seals.

Melt temperatures for the nylon thermoplastic material is 460 to 470°F. Under melt temperatures, no increase in drag was experienced in the simulated throttle cable. After heating to 500°F and full cool down, break-away force for a single bulkhead seal ranged from 8 to 95 pounds. Break-away force for fairlead roller was 12 to 80 pounds. Rollers are installed above and below the cable at each fairlead. Break-away force for the cable at the fairlead rollers varied according to the extent that the cable routing brought the cable in contact with

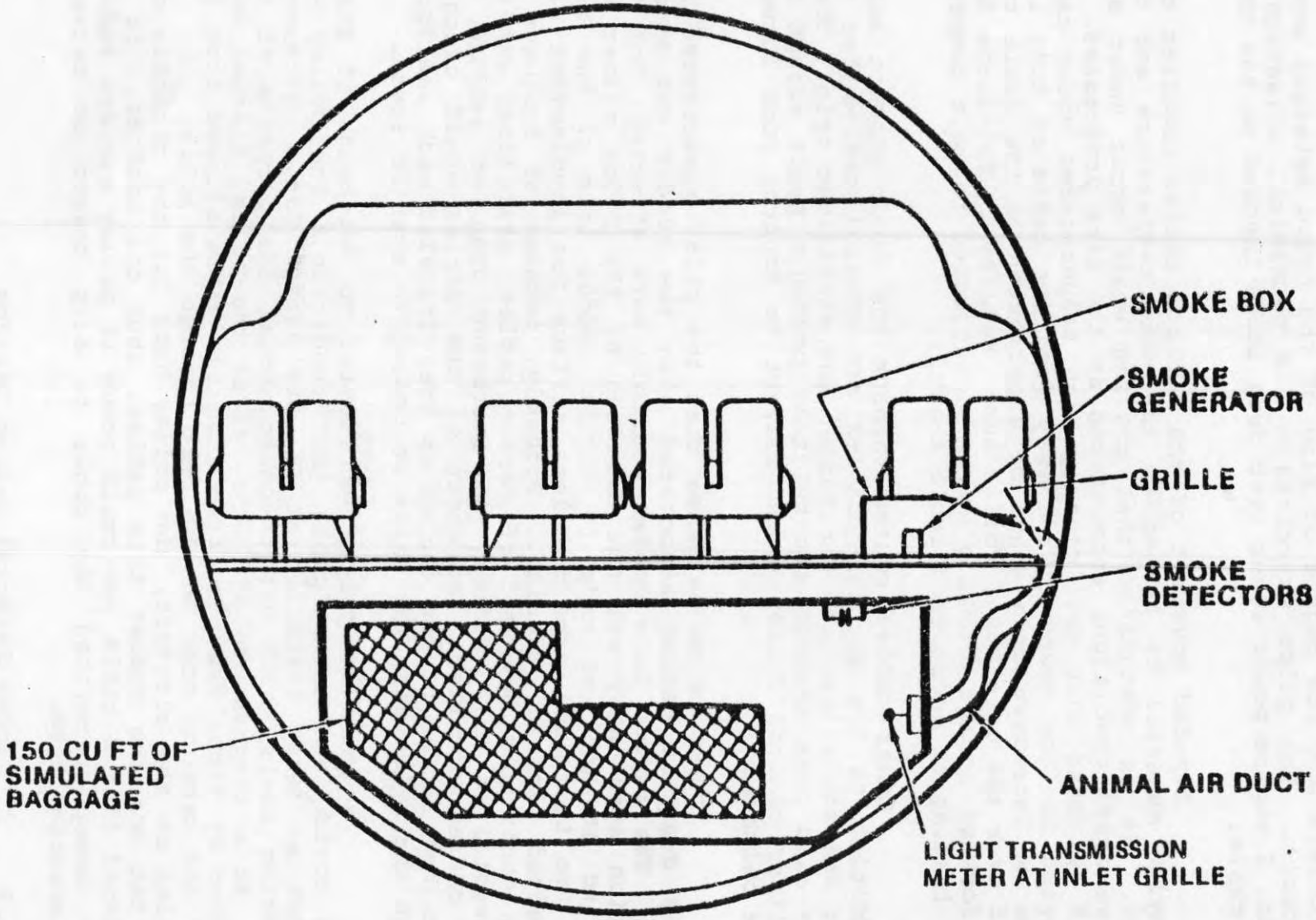


FIGURE 14

Smoke detector test arrangement.

the rollers and the degree of flow of the nylon material around the cable. The pilot exercises a 2.6 mechanical advantage at the No. 2 engine power lever over drag loads imposed on the throttle cable.

Impeded movement of the control cables requires that the nylon material be heated to the melt temperature and then cooled. It is postulated that cooling would occur under some altered draft conditions encountered as the fire progressed. It should be noted that sufficiently high temperatures would cause the nylon to flow downward and away from the cable so that little or no increased drag would be experienced as the cable travelled over the bare steel roller hub. Rollers in fairleads further forward or aft probably would be subjected to melt temperatures leading to encumbered cable travel.

Other cables routed through the floor support beams in addition to the throttle cables are control cables for the rudder and stabilizer and for rudder and stabilizer trim. These cables also pass through aft bulkhead pressure seals except for stabilizer control cables which convert to control rods forward of the bulkhead.

There is no evidence that the pilot experienced increased drag in cables associated with the rudder and stabilizer. The rudder trim cables possibly were affected, but the condition apparently was not detected by the pilot either because no attempt was made to adjust rudder trim or the bare cable (no Lockclad) provided less surface for involvement with the melted plastic material. Probably, because of frequent or nearly continuous movement of rudder cables, stabilizer cables, and stabilizer trim cables, no increased drag or seizing of these cables occurred. Movement of the cables would cause a 'broaching' action of the cables as they traveled back and forth through the nylon material while it cooled to a solid state.

A phenolic pulley was tested to determine if fire-damage could lead to a "cable jam" condition. The pulley was the same as those installed at FS 1808 except for a difference in bearing seals which was inconsequential for purposes of the test. At a temperature of 720°F, after the pulley flanges were destroyed by fire, the simulated throttle cable slipped from the pulley and came to rest on the bolt through the pulley hub. As installed on the aircraft, the pulley hubs for the throttle cables, but not the rudder trim cables, abut one another. It is considered that a cable jam could occur if pulley warpage and/or flange damage permitted the cable to slip toward or between these abutting hubs.

1.16.5.9 J. Smoke Detector System Testing

To evaluate the response of the smoke detector system to smoke in the aft passenger cabin, testing was performed by use of the arrangement depicted in figure 14. Test results

confirmed that smoke in the aft cabin can cause actuation of the smoke detector system. However, other tests previously mentioned show that the majority of the smoke from a fire under a seat would rise to the cabin ceiling before being drawn down through the ventilation system. The test provided a dense smoke condition directly connected to the cabin inlet to the ventilation system ducting. Under actual aft cabin fire conditions, smoke would be less dense in early stages of the fire, particularly if the fire origin were remotely located from the duct inlet.

The test was accomplished with the C3 cargo compartment loaded with 150 cubic feet of simulated luggage (total compartment volume is 750 cubic feet) and the fuselage pressurized to 4 psid. A color video camera was mounted in the compartment to record smoke patterns against a target panel. In addition, an acrylic plate was installed to permit direct viewing of the compartment from the cabin. A smoke box was installed in the cabin to inject smoke directly into the grille (ventilation system inlet) at FS 1735. The smoke density was measured at a light transmission meter as it entered the cargo compartment. Smoke was generated by use of a smoke candle.

Both A and B smoke detector loops annunciated within 31 seconds. A puff of smoke flowed through the inlet duct causing the light transmission meter to peak at approximately 30 percent. This condition actuated the smoke detectors and caused the ventilation systems valves to close and the fan to stop. At the completion of the test, smoke was visible in the compartment as a light haze.

1.17 Additional Information

1.17.1 Training

Saudia L-1011 Initial/Transition Training is conducted as follows:

Captains:	Attend ground school in Jeddah, then go to either TWA or Lockheed for simulator training. Following simulator training, TWA gives the flight training required for their type rating and initial proficiency check. They then return to Jeddah for a Differences Check Ride; then on to their line training.
First Officers:	Attend ground school in Jeddah, then go to either TWA or Lockheed for simulator training. They receive a simulator check only, then

return to Jeddah where they fly 8 hours as an observer, followed by 8 hours at the controls (2 hours of which is their Proficiency Check).

Flight Engineers: Attend ground school in Jeddah, then go to TWA or Lockheed for simulator training, and then return to Jeddah for flight training.

Recurrent Training is given in Jeddah.

1.17.2 Examples of Incidents Causing Fires in Baggage (In Part).

The following are few instances of fires being caused by matches in luggage. These examples were extracted from a British Flight Safety Focus of October 1980:

Case 1 - 1st September 1979 - BAC 1-11-500

"During baggage loading in the rear hold, a suitcase burst into flames. The case was removed quickly from the aircraft and the fire extinguished..." The case contained, apart from scorched underwear, six large boxes of "Ship" brand matches, one box of which had ignited."

Case 2: 23rd December 1979 - BAC 1-11-500

"While unloading baggage at Buton, handlers noticed a strong smell of burning. After being unintentionally hit by another case, the suitcase in question gave off billows of smoke and an acrid smell. The suitcase was removed to the Fire Training Ground and the passenger was brought to identify the case which was then opened. Several boxes of Italian/Spanish type matches were found, one box of which had ignited."

Case 3: 25th August 1980 - BAC 1-11-500

"During baggage loading a loader noticed smoke billowing out of a suit case he had just loaded. He quickly removed the case from the aircraft and informed the crew. A Fireman opened the case and found that one of six large boxes of "Safety Matches", loosely wrapped in a lady's personal belongings had ignited."

The above three instances happened to the same operator. That operator already had a "Restricted Articles" notice

in small print on Tickets issued. Subsequently they have increased the publicity on restricted articles.

There have been other instances of cargo compartment fires inflight from matches and other combustibles.

1.17.3 Post Accident Remedial Actions Taken by Manufacturer

The following modifications for L-1011 aircraft have been released by Lockheed-California Company subsequent to the accident. The first three, (a) thru (c) were in progress prior to the accident. The last (d) is a direct result of testing carried out during the accident investigation:

(a) The lavatory vent bleed air line was rerouted to move it 1 inch away from the skin insulation and a protective clip was added. Service Bulletin 093-21-197 released 10/15/81.

(b) The C-2 and C-3 Cargo Heat Exchange insulation was changed from a Tedlar (Polyvinyl Fluoride) cover to Kapton (Polyamide) cover. Service Bulletin 093-21-201.

(c) Insulation was removed from the fuselage skin under the aft lavatories to reduce the possibility of corrosion. No service Bulletin. This is a production change only.

(d) To improve the fire resistance of L-1011 C-3 cargo compartment ceiling panels, Nomex laminate panels have been replaced by high strength glass laminate panels. Service Bulletin 093-25-377 released June 17, 1981.

1.17.4 Aircraft Fire Fighting and Rescue Procedures

Chapter 12 of I.C.A.O. Doc. 137-AN/898 Part I refers to Crash/Fire/Rescue procedures that are the established criteria for such procedures in Saudi Arabia. Some of Chapter 12's most appropriate paragraphs pertaining to this accident are as follows:

12.1.10 "All personnel operating directly in involved area of the crash should be provided with adequate protective clothing, etc. . ."

12.1.13 "Rescue operations should be accomplished through regular doors and hatches where-

ever possible but rescue and fire fighting personnel must be trained in forcible entry procedures and be provided with the necessary tools."

12.1.14 "Rescue of aircraft occupants should proceed with the greatest possible speed. While care is necessary in the evacuation of injured occupants so as not to aggravate their injuries, removal from the fire threatened area is the primary requirement."

12.1.17 "Aircraft windows may often be used for ventilation. Some are designed to be used as an emergency exits. On all aircraft these exits are identified and have latch release facilities on both the outside and inside of the cabin. Most of these exits open towards the inside. Most cabin doors are used as emergency exits except those incorporating air-stair facilities. With a few exceptions these doors open outwards. When exits are used for ventilation they should be opened on the down-wind side."

12.3.20 "b) Rescue and fire fighting personnel: It will be their duty and responsibility to assist crew members in any way possible. Since crew members' visibility is restricted, rescue and fire fighting personnel should make immediate appraisal of the external portion of the aircraft and report unusual conditions to the crew members. Protection to the overall operation is the primary responsibility of the rescue and fire fighting personnel. In the event crew members are unable to function, the rescue and fire fighting personnel will be responsible for initiating necessary action."

1.17.5 Saudia Flight Manual Procedure in the Event of Aft Cargo Smoke Warning

The following is a quote, in part, for flight crew procedures to be followed in the event of smoke indications by the A and/or the B aft cargo smoke detectors. This was extracted from the L-1011 Flight Handbook dated 15 May 1975. It states, as follows:

"Consideration should be given to proceeding to the nearest suitable airport and landing, particularly with any animals in the compartment".

1.17.6 Comparison of a Fire Incident Occurring on a TWA L-1011 in 1976 with the Saudia HZ-AHK Accident.

The circumstances of an inflight fire incident which occurred on a TWA L-1011 in 1976 were reviewed during the course of this investigation. The review was conducted in an effort to determine if there were any pertinent similarities; however, no significant similarities were noted. Some of the factors reviewed are as follows:

(a) On the TWA incident the AREA OVERHEAT warning was the very first indication of the fire and pin-pointed the source location. On HZ-AHK the AFT CARGO smoke detector warning was the first indication of the fire, and 16 minutes and 15 seconds elapsed before the AREA OVERHEAT alarmed.

(b) Fire damage on the TWA incident was located in the unpressurized area of the fuselage aft body where significant moisture and condensation may be present which could affect wires with damaged insulation. On HZ-AHK, the principle fire damage occurred in the left cheek within the pressurized fuselage which has no source of moisture, as does the aft body area.

(c) Hydraulic fluid was ignited in both instances. However, in the TWA incident, the source of the fluid leak which produced a misty vapor was positively determined. In the case of HZ-AHK, no such misty vapor leak was ever discovered.

(d) Oil soaked wires were not cited as the cause of the TWA incident. Hydraulic fluid misty vapor directed onto damaged wires was ignited by electric arcs generated by the wet wire fault phenomenon. In HZ-AHK, there was no evidence discovered to suggest a misty vapor hydraulic leak. To the contrary, the "B" system hydraulic line experienced a petal rupture due to overpressure or weakening of the tubing due to excessive heat of the fire.

(e) Hydraulic system "B" was involved in both incidents, however, in the TWA case, system "B" was involved because of a leaking servo transfer line. Saudia system "B" was involved when fire caused a rupture "petal" burst of the "B" suction line which caused a loss of fluid.

1.17.7 Cargo Compartment Classifications (In Part)

The following is a quote in part of cargo compartment classifications as reflected by Part 14 of the U.S. Aeronautics and Space Code of Federal Regulations:

"Cargo Compartment Classification.

(a) "Class A. A Class A cargo or baggage compartment is one in which (1) The presence of a fire would be easily discovered by a crewmember while at his station; and (2) Each part of the compartment is easily accessible in flight."

(b) "Class B. A Class B cargo or baggage compartment is one in which (1) There is sufficient access in flight to enable a crewmember to effectively reach any part of the compartment with the contents of a hand fire extinguisher; (2) When the access provisions are being used, no hazardous quantity of smoke, flames, or extinguishing agent, will enter any compartment occupied by the crew or passengers; (3) There is a separate approved smoke detector or fire detector system to give warning at the pilot or flight engineer station."

(c) "Class C.' A Class C cargo or baggage compartment is one not meeting the requirements for either a Class A or B compartment but in which; (1) there is a separate approved smoke detector or fire detector system to give warning at the pilot or flight engineer station; (2) There is an approved built-in fire extinguishing system controllable from the pilot or flight engineer stations; (3) There are means to exclude hazardous quantities of smoke, flames, extinguishing agent, from any compartment occupied by the crew or passengers; (4) There are means to control ventilation and drafts within the compartments so that the extinguishing agent used can control any fire that may start within the compartment.

(d) "Class D. A Class D cargo or baggage compartment is one in which (1) A fire occurring in it will be completely confined without endangering the safety of the airplane or the occupants; (2) There are means to exclude hazardous quantities of smoke, flames, or other noxious gases, from any compartment occupied by the crew or passengers; (3) Ventilation and drafts are controlled within each compartment so that any fire likely to occur in the compartment will not progress beyond

safe limits; and (4) [Reserved]. Consideration is given to the effect of heat within the compartment on adjacent critical parts of the airplane. For compartments of 500 cu.ft. or less, an airflow of 1500 cu.ft. per hour is acceptable."

In its recommendations resulting from the investigation of this accident, the US. National Transportation Safety Board states, in part:

"The Safety Board notes that its predecessor Civil Air Regulation 4B.383, "Cargo Compartment Classification," contained the following regarding Class D compartments: "Note: For compartments having a volume not in excess of 500 cu.ft. an airflow of not more than 1,500 cu.ft. per hour is acceptable. For larger compartments lesser airflow may be applicable." This guideline at least suggested more conservative criteria should be followed for larger compartments while the existing rule does not address the airflow allowance in compartments larger than 500 cu.ft."

"The volume of the C-3 compartment of the L-1011 is 700 cu.ft. Safety Board investigators have been advised by FAA that the L-1011 C-3 compartment was approved as "Class D" by "extrapolations" from the 500 cu.ft. volume and 1,500 cu.ft. per hour airflow guidelines in 14 CFR 25.857 (d) (5). However, the theoretical concept of a Class D compartment is that a fire within the compartment would be extinguished by oxygen depletion, preventing its propagation. This concept apparently has been successfully applied in a narrow-bodied aircraft with limited volume compartments. However, the Safety Board is concerned that it may not be a valid concept for larger volume compartments, such as the L-1011 C-3 compartment, because much greater volumes of oxygen are available to support combustion prior to depletion and "snuffing." The additonal air supply can readily support a fire for sufficient time to allow penetration of the compartment lining, thereby providing access to an unlimited oxygen supply to support propagation of the fire."

"In fact, preliminary tests conducted at the FAA Technical Center, using a 620 7/ cu.ft. simulated Class D compartment, illustrated that a fire of sufficient intensity to penetrate the L-1011 C-3's ceiling liner in less than 1 minute burned for more than 10 minutes after the compartment airflow was shut off."

7/ Correction to quote as it was a 620 cu.ft. compartment.

"The Safety Board is aware that the type of flames used in the tests at Lockheed and at the FAA Technical Center do not duplicate the type of flame (bunsen burner) used to certify flammability characteristics of cargo and baggage compartment interior materials (14 CFR 25.855). However, the Safety Board believes that a small fire in a piece of baggage could generate localized intense heat similar to that from the propane burner used in the recent tests and that the fire could penetrate the ceiling before the oxygen supply is depleted."

"The penetration of the L-1011 C-3 compartment ceiling carries extremely hazardous consequences because numerous major aircraft components are routed between the ceiling of the compartment and the floor of the cabin. Among these items are the No. 2 engine throttle cables, the No. 2 fuel line, and flight control cables. Fire reaching these components could easily endanger the entire aircraft, and therefore, the design does not comply with the intent of 14 CFR 25.857 (d)(5). Moreover, once such a fire reaches the cabin, the cabin furnishings will become involved, and the fire will be difficult to extinguish."

"The Safety Board is aware of several instances of fire in checked baggage from ignition of matches and other items. In most of these instances, fires ignited while the aircraft were on the ground and the aircraft were not damaged. However, the possibility of such a fire while in-flight and the questionable capability of the L-1011 C-3 compartment to contain a fire by "snuffing" to keep it from spreading suggest that the "Class D" certification of the C-3 compartment should be re-evaluated."

In answer to the recommendation by the NTSB that the Class D certification of a compartment be reevaluated, the FAA stated:

"The L-1011 is not unique in having a large Class D type cargo compartment that has been demonstrated to be in compliance with the requirements of FAR 25.857(d). For this reason, the Federal Aviation Administration (FAA) does not believe specific action pertaining to the L-1011 as a special case is appropriate. Neither do we find that the limited tests cited by the Board are sufficient in themselves to justify the recommended action. In the research program discussed under Recommendation A-81-13, detection, extinguishment, and flammability of cargo compartment liners will be evaluated. Since the intent of this recommendation is embodied in the FAA research program discussed under Recommendation A-81-13, we intend no further action on Safety Recommendation A-81-12." (See Appendix H for details).

2. ANALYSIS

The flightcrew was certificated properly for the flight. They had received the off-duty time required by regulations and there was no evidence of medical factors that might have affected their performance except that the F/E was affected by Dyslexia.

The aircraft was equipped and maintained in accordance with regulations and approved procedures.

The investigation and analysis of this accident explored and concentrated primarily in four major areas. Those areas are the (1) fire origin or the causal area; (2) the flight and actions by the crew; (3) actions by Crash/Fire/Rescue services and, (4) survival aspects. In addition, the investigation went beyond these areas and probed such areas as crew background and Air Traffic Control actions.

2.1 Fire Origin

Four assumed probable areas for the origin of the fire were developed. They were based on the fire originating in the, (1) passenger cabin, (2) cheek area adjacent to the C-3 cargo compartment, (3) area immediately aft of the C-3 cargo compartment and, (4) C-3 cargo compartment.

In exploring these possible areas of fire origin, a review of the investigation findings regarding the aircraft systems are appropriate. Investigation revealed that all aircraft systems functioned normally except for anomalies associated with the fire effects of the accident. There was no detectable evidence that the fuel system leaked or that there were any pre-fire faults in the electrical, hydraulic, or pneumatic systems. Evidence indicated that the fire caused the sticking throttle which resulted in the Captain's decision to shutdown the No. 2 engine. When the engine was shut down, the engine-driven B-system hydraulic pumps began to run down which caused the low B-system pressure during the last portion of the approach to the landing. The fire also resulted in the burst of the B-system suction line and the duct over-heat signal that came on late in the flight.

In an effort to determine the exact location of the origin, fuel source or ignition of the fire, the logical analytic approach for evaluating the suspect areas was to assume that a fire started in each of the four areas and then evaluate them against the known sequence of events. These events were taken from information gained from the DFDR, QAR, CVR, ATC Tape, eyewitness reports and test findings.

2.1.1 Possible Origin in Passenger Cabin

The passenger cabin is not considered as the originating area of the fire for the following reasons:

a. No reports of fire or smoke in the cabin were made by the cabin crew until about 5 minutes after the C-3 compartment smoke warning.

b. It is improbable that a large enough amount of smoke to alarm the smoke detectors could enter the C-3 compartment from the cabin without a fairly large fire being visible in the cabin.

c. The flight and cabin crew initial reports of only smoke in cabin are not consistent with the intensity of a fire needed to penetrate the cabin floor from above. In fact tests to cause such a penetration were unsuccessful.

d. A stuck throttle cable from a cabin fire effect is improbable without the fire penetrating the cabin floor which is inconsistent with testing results.

e. The duct overheat signal would require cabin floor penetration as detectors are located approximately 12 inches below the floor and thus initially protected from a cabin fire effect.

f. Tests show that a cabin fire involving the seats would progress too fast for it to occur early in the fire sequence.

2.1.2 Possible Origin in Cheek Area

a. It is improbable that smoke from the cheek area enters the C-3 cargo compartment to activate the smoke detectors.

b. There is insufficient fuel in the cheek area for a fire of early intensity.

c. The cheek area is too remote from the throttle cable to cause a stuck cable early in the fire.

d. The duct overheat signal timing is too late in the flight, therefore, is inconsistent for a fire originating in cheek area.

e. No evidence was found to indicate that hydraulic lines in the cheek area initially were involved with fire during the flight as all hydraulic systems were normal until the last portion of the flight.

f. The electrical wire harness fire damage in the cheek area was duplicated in a laboratory flame test in approximately 5 minutes, whereas the elapsed time of the airplane fire was about 21 minutes before similar wire damage caused various events, such as the C-1 cargo door open warning.

g. The laboratory analysis of the accident airplane's wire harness from the cheek area did not find any prefire insulation damage, wet wire faults or ground faults that could have been ignition sources. Thus, there does not seem to be any probable ignition sources for a fire to originate in the cheek area.

h. Laboratory analysis also showed that the "B" system rupture in the cheek area was caused by heating and that "No flame had been playing on this part for any appreciable time after the burst had occurred".

Arguments supporting the origination of fire in the cheek area are that it has ingredients for a fire source such as electrical wires, hydraulic lines and pneumatic lines. However, there is no supporting evidence that a fire did start in this area. In fact, all evidence indicates that the fire source was elsewhere.

2.1.3. Possible Origin In Area Immediately aft of the C-3 Cargo Compartment

a. It is improbable that smoke from a fire aft of C-3 could enter C-3 in a large enough quantity to activate the detector without producing smoke in the cabin.

b. It is improbable that any smoke generated in this area would enter the cabin area and then seek its way down into the C-3 compartment without initially alerting the cabin crew prior to any detector alert. If the fire was intense enough to generate the smoke required to enter the cabin and then progress into the C-3 area, it would have been hot enough to cause an early alarm of the "J" area overheat detection loop. In addition, if smoke had been forced to the ceiling above the panels it would have been drawn off through the OFV's.

c. There was no evidence found to indicate any hydraulic leaks in the area or possible ignition sources.

d. The duct over heat signal timing is too late inflight, therefore, is inconsistent for a fire originating aft of C-3.

e. There is no mention or indication of an acrid substance in the smoke which would indicate hydraulic fluid as the fuel for the fire. If such a fire happened in flight, the passengers would not have been able to tolerate the acrid smoke and would have moved forward. Such an occurrence was not detected by the C.G. study. It was concluded that the major movement took place after the aircraft landed.

f. The fire damage in the C-3 compartment cannot be accounted for with a fire origination aft of C-3.

g. The lavatories are directly over the area aft of C-3 however, there was no mention of a lavatory fire.

h. Fire was seen in windows between L3 and L4. Had a fire began in the area of the lavatories and progressed forward to that point, the smoke should have precluded the fire from being visible. ,This would, most likely, have made the entire fuselage non-survivable before the aircraft landed.

i. There was no evidence of flame propagation between the cargo ceiling and cabin floor from aft of C-3 to the cabin floor from aft of C-3 to the area of burn-through in the ceiling of the C-3 cargo compartment.

2.1.4 Possible Origin in C-3 Cargo Compartment

To evaluate the possibility of a fire starting in the C-3 compartment, an assumption will be made that evidence of the source of ignition was consumed by the fire.

For clarity, the analysis will follow the chronological order of events that are considered to be pertinent.

At 1815, following fire ignition, smoke was generated in sufficient quantity to set off the "B" system smoke detector. The actuation of the "B" smoke detector secured the pet ventilation air inflow and outflow valves as well as disrupting power to the inflow fan (This fan was inoperative at aircraft dispatch and was listed in the ships' log). As the smoke continued the "A" system detector was triggered about one minute later, confirming the presence of smoke in C-3 cargo compartment.

Approximately four minutes elapsed before the aircraft was turned back to Riyadh. During some of this period, the flight engineer left and returned to the cockpit with a report "fire back there". A short time later at 18:21:33, he left the cockpit again and upon return to the cockpit reported "it's just smoke in the aft". These inputs could indicate that the C-3 ceiling penetration happened early and that the burning material was near the top of the C-3 compartment.

Penetration of the C-3 compartment liner permits access to an eight-inch space between the cargo compartment ceiling and the bottom of the passenger floor. This space is open across the aircraft (left to right hand sides) between each twenty inch spaced transversal. Smoke can be driven through these channels to the cabin sidewall exhaust grill and can enter the cabin.

The Captain reported a stuck No. 2 engine throttle lever at about 18:25. It can only be assumed, at this point, that the fire penetrated the cargo ceiling liner left of the aircraft centerline, in line with or near to the throttle cable run located at BL35L. The throttle control cables are routed in this area between the cargo compartment ceiling and the passenger floor and are threaded through holes in each transversal. The controls consist of lockclad cables (carbon steel core with a swaged aluminum jacket) suspended between fairlead nylon rollers approximately every eight feet apart along the cable run. As determined by laboratory tests the fairlead rollers soften and melt at approximately 500°F and adhere to the lockclad cable causing substantial increase in system friction. This can occur with a small amount of cooling.

About 18:26, eleven minutes after the first smoke alarm, a cabin attendant reported seeing fire in the left rear cabin. It can be assumed that the heat and flame, initially unable to penetrate the passenger floor, has followed the same path as the smoke between the transversals to the sidewall of the aircraft. Even with the pet air ventilation system closed, the fire will propagate much the same as was demonstrated in the FAA testing with a simulated compartment.

At 18:32:19, the area duct overheat signal came on. The overheat sensor is installed in the aircraft to detect hot air leaks in the high pressure pneumatic system. The system has dual loop eutectic sensors for redundancy that trigger at 255°F plus or minus 15°F. The dual loop is located outside the left hand sidewall of the C-3 compartment between the sidewall liner and the pneumatic duct and below the five compartment heating inlet ducts which penetrate the top of the sidewall liner.

This sensor location shields the sensors from direct impingement from above. Radiated heat from the eight-inch space above or sufficient fire progression would be required to trigger the sensor. This is contrary to a fire that had its origin low in the cheek area which would burn up to the exposed sensor.

At 18:32:52 the Captain elected to shut down No.2 engine which secured the "B" and "C" engine driven hydraulic pumps. Each of these systems are backed up by Air Turbine Motor (ATM) driven pumps, however, the pneumatic air source to each can be isolated by a shut off valve. When this valve is closed, as would be the corrective action for a duct area overheat, the "B" system ATM is isolated from the high pressure pneumatic drive source, causing the "B" system to stagnate or have a zero flow condition. In this state, there is no heat transfer from external heat sources and the systems' aluminum lines would be subject to damage. At 18:35:06 the Flight Engineer reported "Aft cargo door is open Sir." The electric harness powering this circuit was damaged at this point providing a false signal in the cockpit because the C-3 cargo door was found closed and latched.

At 18:35:42, thirty-six seconds after the cargo open light in response to a call of "Hydraulics" by the captain, the F/E reports "Okay, that's good you got low pressure on number two". This statement is not specific enough to determine whether it is engine oil pressure, as No. 2 engine is shut down, or hydraulic oil pressure because the pneumatic isolation valve is closed.

At 18:42, an eye witness reportedly saw flames in the aft three windows between L4 and L3 doors and finally at 18:46 a witness reported seeing flames through the fuselage skin top and aft, also through the fuselage skin on the left side, aft and below the window line.

In Summary, a fire starting in the C-3 Cargo Compartment is entirely probable as it lends itself to total agreement with the time sequence of events and facts in that:

a. The smoke detectors located in the C3 cargo compartment actuated and gave the first warning of smoke/fire.

b. Initial reports as corrected by the F/E, described smoke in the cabin, not fire, suggesting that the actual fire was not yet in sight.

c. The stuck throttle cable-run is above the C-3 cargo compartment and is accessible to a fire originating in the C-3 compartment after the compartment liner is penetrated by the fire.

d. The bleed air duct overheat detector location (in the cheek area) could be actuated by heat (225°F) radiating from a fire that has breached the C-3 cargo compartment liner and is passing outboard, under the floor, and over the adjacent cheek area.

e. There is an extensive history of fires originating in aircraft in cargo compartments where loose baggage and cargo is carried.

f. A full Scale Test shows that known facts can easily support a fire originating in C-3.

These facts include but are not limited to:

1. Ease of penetration of Nomex liner from below and evidence of fire from C-3 to cabin.

2. Fluctuation of the smoke detection signals.

3. Long duration of a fire before cabin hazard levels significantly increased.

4. Temperatures in area between the cargo ceiling and cabin floor reached a peak just after the liner burn through and then decreased, thus causing the throttle to stick.

5. Lack of damage in the C-3 compartment similar to that of the C-3 compartment of the accident aircraft. This was due to the fluctuation of oxygen levels.

2.1.5 Summary

In summary, the Presidency has been unable to determine the ignition source of the fire; however, evidence strongly supports fire origination in the C-3 cargo compartment. Evidence that the fire did not start in the cabin area or the cheek area is conclusive and there is considerable evidence that it did not start in the area just aft of the C-3 cargo compartment.

2.2 The Flight and Actions by the Crew

According to CVR information, initial system warning of smoke in the C-3 cargo compartment occurred 6:54 minutes after take off from Riyadh and while climbing through 15,000 feet enroute to Jeddah. Four minutes and 21 seconds was spent by the crew in confirming the warning.

Saudia procedures state that in the event of a single or double smoke warning, diversion to the nearest suitable airfield should be considered. Due to the complexity of electronic systems in later generation wide-bodies aircraft it is possible to have a spurious warning occur. Therefore, unless there is immediate evidence that an actual emergency exists, system checks should be accomplished prior to flight diversion decisions.

It should be noted, however, that about 3 minutes were spent by the crew in looking for the aft cargo smoke warning procedure. Evidence indicated that this difficulty was the result of a split of the Emergency and Abnormal procedures into Emergency, Abnormal and Additional. The crew apparently believed that the correct procedures were in the Abnormal section while it was actually in the Emergency section. Another factor which possibly contributed to the time required to find the location of the proper procedures was that the flight Engineer was affected by "Dyslexia". The manifestation of such a condition can cause confusion of switches, actions, etc.

The Presidency believes that Saudia should revise their checklists by reducing the divisions and providing an index identifier as in a Quick Reference Handbook.

Confirmation that a fire actually existed occurred after the aircraft had begun its return to Riyadh. An expedited descent was initiated shortly thereafter and an emergency was declared by alerting Riyadh's tower and crash/fire/rescue equipment.

The flightcrew's action up to the point of turnaround can be considered nominal, however, thereafter their actions began to deteriorate. During the descent,the Captain appeared to devote his entire attention to flying the aircraft. He could have reduced his workload by using the F/O to fly the aircraft in order to allow himself time to properly evaluate the situation.

During this same period, the actions of the F/E may have confused the Captain by underestimating the seriousness of the situation. The F/E kept saying "No Problem" when a severe problem existed. The F/E may have been saying this to bolster his own confidence that all would end well but, in doing so, he presented to the Captain an incorrect view of what was actually occurring. The F/E's actions may have contributed to the Captain's apparent lack of effective and appropriate assertive action when such action was imperative.

Nothwithstanding the preceding, the Captain had numerous other warnings that there was a fire, which is one of the most critical of aviation in-flight emergencies. The Captain should have instructed his cabin crew to prepare for an evacuation immediately upon landing. He should have called for the use of oxygen by his cockpit crew and instructed his cabin crew to use oxygen when needed. The inhalation of toxic gasses, at times, is insidious and causes physical and mental impairment which would be alleviated by the proper use of oxygen.

The F/O failed in that he was there to assist the Captain and monitor the safety of the aircraft. His limited time in the aircraft is no excuse for throughout his training he, as well as every other pilot, has been trained to act as a team member. However, in this case, it is obvious that he failed to assert himself in a manner that is so necessary of a team member when an emergency occurs.

Based on the evidence derived from the CVR and physical evidence showing non-use of O2 or smoke masks, it is concluded that the cockpit crew was not affected by the toxic gasses during the return flight and the descent into Riyadh. In addition the positive pressure of the cockpit ventilation system would tend to prevent entry of cabin air (smoke) into the cockpit.

During this same period, all evidence indicates that the cabin crew functioned normally in fact they acted commendably. They attacked the fire as well as they could and, at the same time did everything that they could to calm the passengers. They also made every attempt to keep the Captain advised of the very serious nature of events occurring in the passenger cabin, and to extract from him the essential order to evacuate immediately upon landing.

After landing, the Captain should have stopped his aircraft as soon as possible and initiated an emergency evacuation. However, he wasted critical time in taxiing the aircraft clear of the runway.

The Captain had numerous and strong indications that a critical fire situation existed prior to his landing, yet none of his actions, at this time, gave evidence of such knowledge. He appeared to reject the seriousness of the situation. The reason or reasons for such a rejection remain undetermined.

The question arises whether the aircraft could have been brought to a stop within minimum certification distance after touchdown. In this respect, the evidence showed that maximum braking capability was available and that the aircraft could have been brought to a stop on the runway with a saving of about 2 minutes time as compared to the time it took to taxi to a stop. The Presidency believes that these two minutes were significant with respect to survivability. This is especially so, if coupled with an immediate evacuation.

During this time period, the flow of fresh air was reduced thus causing greater depletion of oxygen with an accompanying increase of toxic and combustible gasses. The combination of these factors resulted in a flash fire which impaired both the flight and cabin crew to the degree that they became both physically and mentally incapable of performing their evacuation duties. Their impairment evidently occurred at a point in time just after engine shutdown but prior to initiating and evacuation.

A question arose as to the possibility that a pressurization differential prevented evacuation after the aircraft came to a stop. The evidence shows that the inside emergency door handle of R-2 was never operated. It is reasonable to assume that the flight attendants who were originally stationed at exits L-3 , L-4 and R-3, R-4 had moved forward because of fire near those exits. Therefore, there is a strong possibility that

exit R-2 was manned by not only its regularly assigned flight attendant but possibly one or more of flight attendants who had moved forward from the rear exits. If any of these flight attendants had operated the inside emergency handle while the fuselage was pressurized, the door would have opened later when fire breached through the fuselage.

A pressure profile was made which depicted the crew following normal pressurization procedures during the climb out of Riyadh and during the initial part of the return and descent. However, during descent a cabin altitude of 2,000 feet had been selected to correspond to the field elevation of 2082 feet at Riyadh. For Saudia, the usual descent rate is 240 f.p.m. In this instance a higher than usual rate was selected to ensure zero differential pressure at touchdown. This was necessary since the descent time was reduced due to the altitude versus the distance to go to touchdown.

The condition of the aircraft found by the investigating team leads to the most probable conclusion that the aircraft was not pressurized after it landed at Riyadh.

Just prior to landing, the Captain told the cockpit crew not to evacuate; however, it is not clear if such information was relayed to the cabin crew. Saudia cabin crews have the authority to initiate an evacuation should the situation dictate it. Even if the cabin crew had decided that the situation warranted breaking their procedures, they were prevented from doing so by the Captain. The Captain by allowing the engines to continue to operate after he stopped the aircraft effectively prevented the cabin crew from initiating the evacuation on their own. There was no evidence that shows that an evacuation procedure was initiated.

Based on information obtained during the investigation, there is no evidence obtained to indicate that the doors were not fully operational at the time the aircraft was brought to a stop. There was no evidence to indicate any of the door interior emergency handles had been pulled. This lack of action by the cabin crew may have been that the order by the Captain not to evacuate had been received by the cabin crew. A second and possible factor in the failure of anyone of the crew to open the doors was the fact that by the time the aircraft came to a stop the passengers were in total panic and had rushed to and against the doors which would have prevented the doors from moving inboard the necessary few inches prior to opening. However, it is more likely that the cabin crew were physically impaired by the flash fire which occurred. Since the flight crew were found still at their duty stations, it is doubtful that the evacuation command was ever issued.

Evidence was conclusive that the environmental control system (ECS) packs were shutdown before the engines were shut down. This is a normal post-landing procedure. This action resulted in the loss of any ventilation air being introduced within the fuselage. The closed and almost closed positions of the forward and aft outflow valves initially were unexplainable for they should have automatically gone to open on touch-down.

Based on standard operating procedures at turnaround, the two outflow valves were regulating; the overboard vent valves were in their normal in-flight position, that is, the forward electronic equipment compartment and the mid-electronic equipment compartment valves were closed and exhaust air was discharged through the forward outflow valve. The galley vent valve was open exhausting oven air overboard. The cabin pressurization system had been reset for Riyadh altitude and all three (3) cycle machines were operating.

The mode of operation used to control the outflow valve during short final portion of the flight cannot be determined. However, the system was found in the standby operation mode, with the standby rate set at the hold or zero rate of change position. The outflow valves by design will go to the full open position only when the system is set in the normal operating mode in actuation of the airplane squat switch. Since this did not happen, it can be concluded that at some point in the short final phase of the flight, the system operating mode was switched from normal to standby. At any time during this period, a loss of A.C. power to the actuator or loss of D.C. power which is needed to keep the actuator brake released, would lock the valve in the position in which it was found. The harnesses supplying power to the aft outflow valve are routed through the reported fire area, along the side of the C2-C3 cargo compartment. Damage to these harnesses during this period is probable.

Following the power interrupt, the forward outflow valve would be modulating to maintain pressure control. With the control in standby and at a hold rate setting, the forward valve would continue to open to maintain a 2000 ft. altitude within the cabin. At some point after the cabin reached 2000 ft. altitude and prior to shutting down engines, the packs were turned off. This probably occurred during rollout which accounts for the reduction in the smoke trail from the airplane aft outflow valve seen by the eye witnesses. It is further confirmed by finding all three (3) pack turbine bypass valves in their preposition position. The preposition setting or system start-up position is automatically attained after system shutdown and requires 30 seconds of A.C. power to drive the motor operated valves.

To summarize the outflow valve investigation, it is known that the pressurization system operating mode was changed from normal to standby during the final phase of descent

before touchdown. It is also known the aft outflow valve was open during the flight phase because of the reported smoke trail from the aft end of the aircraft, reported by eye witnesses, and the soot stained underside aft of the valve.

2.3 Actions by Crash/Fire/Rescue Services

Evidence indicated that the actions by the Riyadh crash/fire/rescue personnel was both inadequate and disorganized. Evidence also showed a lack of adequate training for the firemen and lack of useful fire protective clothing and fire-fighting equipment.

Chapter 12 of ICAO DOC 9137-AN/898, Part I establishes the criterion for C/F/R procedures which Saudi Arabia has adapted, yet, in this case all of the pertinent criteria were not followed by Airport C/F/R Services. The firemen were not properly clothed in protective clothing although they had ample warning that an aircraft on fire was approaching. They were not equipped with the tools for forcible entry nor were they trained in forcible entry procedures. They were not trained in opening the L-1011 doors and were not knowledgeable of any entry areas below the cabin doors. They had not received actual firefighting training nor actual training on L-1011 aircraft.

It should be noted that fire was sighted in the aft of the aircraft as it came to a stop on the taxi-way yet the firemen failed to take immediate entry action. This can be excused by the fact that the two wing engines were still running and the firemen had no direct communication with the crew; therefore, they were awaiting crew action. However, no excuse can be given for the failure of C/F/R action after the engines stopped 3 minutes later and until the first door was opened about 26 minutes after the aircraft came to a stop.

There is no doubt that the individual firemen on-scene did as well as they were able to, but they lacked the training and equipment to accomplish their task, a fact which is attributable to C/F/R management at the time of the accident. With this in mind, the Presidency was extremely concerned and since the date of the accident has updated the training and equipment throughout Saudi Arabia.

2.4 Survival Aspects

Postmortem examinations and toxicological findings revealed that the deaths in this accident were attributable to the inhalation of toxic gasses and/or exposure to the effects of the fire, heat and lack of oxygen. There were no unusual forces transmitted to the aircraft occupants as the landing and subsequent roll-out were normal.

In all cases examined, the trachea was covered with carbon particles which extended into the bronchiotes of the lung. In the majority of the cases the soot deposit was heavy and the carbon monoxide (CO) levels varied from 42 percent to 58 percent.

It is clear, both from the state of the bronchial tree of the deceased and the levels of carbon monoxide in all of the blood samples, that the deceased breathed heavily smoke-fillled contaminated air before they died.

There was no evidence that oxygen was used by either the flight or cabin crew. Therefore, it is a safe assumption that the occupants were incapacitated prior to exposure to heavy smoke. Such incapacitation could have occurred from at least two causes. One cause could have been by the inhalation of one or a combination of fast acting toxic gasses. Another cause could have occurred as a result of a flash fire which would consume almost all of the available oxygen thus causing immediate incapacitation.

Initially, during the period from first smoke detection until after landing when the outflow valves closed and the airconditioning packs were shut down, the crew and passengers were exposed to mild and virtually insignificant hypoxia due to exposure to a cabin altitude of about 5,000 feet. This was combined in the passenger cabin with increasing amounts of carbon monoxide and other toxic agents from the combustion of aircraft and other materials.

During this period, the occupants of the passengers cabin of the aircraft were undoubtedly exposed to these hazards, but at levels which were insufficient to severely affect them. Evidence indicates that during this period the cockpit crew was exposed to little or none of the hazards until after the aircraft landed.

After landing, the seriousness of the situation and potential hazard accelerated rapidly as the fire began burning more aircraft materials. The situation was further aggravated when the F/E shutdown the conditioning units, and the outflow valves closed, thus collecting heat and combustible gasses at the ceiling of the cabin. Hazardous conditions in the aircraft increased as the fire increased, however, they were still survivable until a flash fire occurred in the cabin just after engine shut down occurred. This caused a very rapid buildup of hazards in the cabin and cockpit (lack of O2, toxic gasses, smoke, heat), inducing almost immediate incapacitation of the passengers and crew and thereafter - death.

Based on the foregoing, this accident was survivable. The actions by the Captain in not preparing his cabin crew for evacuation and then not stopping as soon as possible on the runway to evacuate the aircraft, and the actions by C/F/R personnel contributed to the ultimate fatal results.

2.5 Other Areas

Review of the background of the cockpit crew raises some areas of concern. Both the F/O and F/E had, at one point in their careers, been dropped from the training program, or had been terminated and then reinstated. Their actions or lack of action during this accident sequence were not helpful to the Captain. Reinstatement in a flight position of terminated crewmen is not desirable.

The performance of ATC in this accident can be considered, in most cases, standard, but an error in judgement was made by not closing the airfield immediately when all C/F/R vehicles were occupied at the accident scene. In this case, however, it had no effect on the outcome of the accident. In another instance, the tower and the officer-in-charge of the firefighting personnel did not make preliminary coordination to provide the firefighters with the frequency of the aircraft. Direct communication between rescue personnel and an aircraft in distress is essential.

As the result of this accident, the U.S. N.T.S.B. made two recommendations to the U.S. F.A.A. The N.T.S.B.'s basis in making both recommendations is logical and the Presidency believes the recommendations merit positive and expedited action. The NTSB noted that the L-1011 C-3 compartment was approved as a "Class D" compartment by "extrapolations" from the 500 cu.ft. volume and the 1,500 cu. ft. per hour airflow guidlines in 14 CFR 25.857 (d) (5). The concept of a Class D compartment is that a fire within it would be controlled by oxygen depletion. This concept as it relates to the L-1011 compartment of 700 cu. ft. using a Nomex ceiling liner volume has been subsequently disproved by FAA tests.

The N.T.S.B. recommended that the "Class D" certification of the L-1011 C-3 cargo compartment be reevaluated yet the FAA responded that it has been demonstrated that a large class D type cargo compartment is in compliance with the requirements of FAR 25.857 (d). In view of the results of the FAA testing, the Presidency is concerned with the FAA's answer. There is certainly evidence that the C-3 compartment did not meet the intent of the FAR and that the FAR was inadequate for the purpose intended.

Two of the other three requirements for classification of a Class D Cargo Compartment were also not met by the C-3 cargo compartment. Therefore, it is believed, that the F.A.A. should reconsider its stand on this recommendation and take immediate positive action. (See Section 4 and Appendix H).

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated to conduct the flight, and the aircraft was properly maintained in accordance with prescribed procedures.

2. A fire probably started in the C-3 Cargo compartment.

3. The fire did not start in the Cabin area:

4. The fire did not start in the left cheek area.

5. The majority of the evidence indicates that the fire did not start in the area aft of the C-3 cargo compartment.

6. The ignition source for the fire was not determined.

7. The initial fuel for the fire was probably baggage and cargo in the C-3 cargo compartment.

8. There was no detectable evidence of a pre-fire fault in the aircraft systems.

9. The Operator's Emergency and Abnormal checklist procedures were not adequately indexed for rapid identification.

10. During the descent to Riyadh, the Captain did not brief the cabin crew regarding plans to evacuate.

11. The Captain did not fully utilize his flight deck crew during the emergency.

12. Upon landing, the cabin and ambient differential pressure was negligible.

13. The aircraft had adequate braking capability available to make a maximum stop on the runway.

14. The Captain elected to taxi off the runway prior to bringing the aircraft to a stop.

15. Toxic fumes including carbon monoxide, were being produced by burning materials and were inhaled by the aircraft occupants.

16. Autopsy findings indicated that the occupants had inhaled a high percentage of carbon monoxide.

17. There was no evidence of an attempt to open the doors from the inside the aircraft by the emergency method.

18. Crash/Fire/Rescue personnel were not properly equipped or trained. This resulted in their ations being inadequate and disorganized for the situation at hand.

19. The degree of seriousness of the accident is directly related to the actions of the Captain, and C/F/R services.

20. Investigative evidence and testing indicates that the C-3, class D compartment of the L-1011 did not meet the intent of FAR 25.857 (d) and that the FAR is inadequate for the purpose intended.

3.2 Probable Cause

The Presidency of Civil Aviation determines that the probable cause of this accident was the initiation of fire in the C-3 cargo compartment. The source of the ignition of the fire is undetermined.

Factors contributing to the final fatal results of this accident were (1) the failure of the Captain to prepare the cabin crew for immediate evacuation upon landing, and his failure in not making a maximum stop landing on the runway, with immediate evacuation, (2) the failure of the Captain to properly utilize his flight crew throughout the emergency (3) the failure of C/F/R headquarters management personnel to insure that its personnel had adequate equipment and training to function as required during an emergency.

4. SAFETY RECOMMENDATIONS

4.1 National Transportation Safety Board

As the result of findings in this accident the U.S. National Transportation Safety Board made two recommendations to the U.S. Federal Aviation Administration. These recommendations together with the FAA response are contained in Appendix H of this report.

The Presidency of Civil Aviation requests that the FAA reconsider its action regarding N.T.S.B's recommendation A-18-12 and take expedient corrective action.

4.2 Presidency of Civil Aviation

Following the accident, the Presidency made a series of recommendations to Saudia they were, in part, as follows:

4.2.1 FLIGHTCREW TRAINING AND STANDARDIZATION

1. Revise existing training programs and initiate additional programs to insure that flight crews are given adequate instruction for their immediate and aggressive response to any problems relative to safety of flight. Such programs should include instructions for immediate action to be taken upon the activation of any aircraft's fire and smoke warning devices and/or

upon receipt of any information that fire or smoke has been observed aboard an aircraft. If smoke is confirmed, the instructions should dictate a landing as soon as possible at a suitable airfield.

2. Amend Saudia's crew training program to include additional assertive and command training for junior Saudia Captains and for First Officers.

3. Establish a system so that flight crews are matched to insure that the cockpit experience level and competency is at a desirable level. Such a procedure would eliminate the scheduling of junior Captains and junior First Officers for the same flight.

4. Amend Saudia's personnel policy and practices to stop the rehiring of flight crew members for a flight crew position after they have been removed from another flight crew because of substandard performance.

5. Review and amend emergency procedures and check lists for all aircraft to separate and clarify the emergency landing evacuation procedures to prevent possible confusion of the specific steps to take in such emergencies.

6. Review Saudia's Standard Operating Procedures to insure that they are precise and contain detailed instructions and procedures. Clear, concise and easily understandable instructions should eliminate deviations and ensure standardization.

4.2.2 SURVEILLANCE AND HANDLING OF CARRY-ON BAGGAGE, CHECKED BAGGAGE

1. Saudia provide personnel to oversee the check-in security inspection and boarding on all Saudia flights. In addition, Saudia personnel should spot check for security purposes checked baggage and cargo.

2. Saudia take the necessary action to improve their surveillance and direction of the cargo handlers in regard to the methods and materials that are placed in aircraft cargo compartments.

Some of the remedial actions that Saudia has taken to date to improve their operations are:

1. Emergency check lists and procedures for all Saudia aircraft have been, or are being revised, to insure that flight crews have the information available to them so that they can take immediate decisive action whenever an emergency occurs.

2. An extensive review of crew training procedures has been accomplished to improve any areas that may be deficient.

3. Emphasis has been placed on improving any deficient areas in evacuation training.

4. The airline has incorporated all of its pilot training records into a computer system. This system will allow immediate access to crew records so that Training and Line Supervisory personnel can make prompt, comprehensive evaluations for improving the effectiveness of the training for the individual crew member, among other benefits.

5. The C-3 cargo compartment (Class D) of all Saudia L-1011 aircraft has been sealed off in an effort to confine any fire that may occur within it. The compartment no longer has the capability to transport animals.

4.2.3 OTHER AREAS

In addition to the recommendations made to Saudia, the Presidency evaluated areas for improvement within Civil Aviation, in particular, PCA Fire Services. Immediate remedial action was taken which has resulted in the Kingdom's present Fire Services now exceeding, in most cases, the international criteria established by ICAO. Further improvement in capability is planned and presently in progress.

APPROVED

Original Signed By:

NASSER AL-ASSAF
President of Civil Aviation
Presidency of Civil Aviation

16 JAN. 1982

APPENDIX A

NOTIFICATION AND FORMATION OF THE INVESTIGATION

Upon the occurrence of this accident, the Kingdom of Saudi Arabia in the exercise of its powers and in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation designated an aviation consultant from the United States to act as the Investigator-in-Charge of the accident. The Investigator-in-Charge was instructed by the Ringdom to conduct a complete and comprehensive investigation. He was informed that all functions of the government of the Kingdom would render any necessary assistance and support. The Kingdom invited participation by personnel of the State of Manufacture and appropriate aviation experts of other governments. Accordingly, the United States immediately dispatched to the scene of the accident an Accredited Representative and Advisors from the National Transportation Safety Board. The American Accredited Representative was assisted by other advisors which were selected from the U.S. Federal Aviation Administration, the Lockheed Aircraft Corporation and Trans World Airlines Inc. The Government of Great Britain provided immediate technical assistance and subsequently an Accredited Representative was designated from the Department of Trade, Accidents Investigation Branch. In addition, the carrier involved, Saudi Arabian Airlines provided immediate technical assistance to the investigation.

Upon his arrival on-scene, the Investigator-in-Charge held an organization meeting and investigative groups were established for Operations/Air Traffic Control/Weather, Aircraft Structures, Aircraft Systems, Maintenance Records, Human Factors, Witnesses, and Cockpit Voice Recorder. During the initial stages of the investigation, an expert in aircraft sabotage detection was called upon to assist.

Subsequent to the accident numerous tests and extensive research were conducted in efforts to determine the origin of the fire. All tests and research by the United States and its advisors were either conducted by U.S. Government bureaus or under the observation of those bureaus.

In accordance with Chapter 6, Section 6.11 of Annex 13 to the Convention on International Civil Aviation, a meeting was called and the States involved in the investigation were afforded the opportunity to review and comment on the draft Final Report of this accident. United States Government personnel attended and the substance of their comments are included in this report.

APPENDIX B

PERSONNEL INFORMATION

1. Cockpit Crew

Captain Mohammed Ali Khowyter

Captain Mohammed Ali Khowyter, 38, was employed by Saudia on October 1965. He was qualified initially as a DC-3 F/O in 1968. In 1969, he was upgraded to a DC-6 F/O. On 22 February 1971, he was selected to upgrade as a F/O in DC-9 aircraft and on 16 October 1979, he passed his DC-9 line checks. On 4 January 1976, he was assigned to B-737 Captain training and upgraded to B-737 Captain on 31 May 1976. He was made a Captain on B-707 aircraft on 10 May 1978 and on L-1011 aircraft on 31 January 1980. His L-1011 ground school was completed on 26 September 1979. Captain Khowyter was current. His last line check was on 23 April 1980. The Captain did not receive recurrent training due to the fact that he had not completed one year flying on the L-1011.

Captain Khowyter held FAA Airline Transport Pilot Certificate No. 184410 dated 20 October 1979, with the following ratings: Airplane, multi-engine land, B-707, B-720, B-737, L-1011. The Saudi ATP Certificate is number TA 697. His first class medical certificate was current and was dated 12 May 1980 and had no limitations. Captain Khowyter had approximately 7,674 total hours of flight time at the time of the accident, 388:38 of which were in the L-1011. He had recorded in the previous 30 days 79:20 hours flight time. In the last 7 days he had recorded 14:55 hours flying time and in the last 48:00 he had recorded 12:38 hours flight time. Captain A. Khowyter had operated into and out of Riyadh Airport on the 18th of August on a regular scheduled flight.

Review of Captain Khowyter's records indicate that he had some difficulties in training throughout his career, such as: (1) Having difficulty when requested to vary from a set pattern, (2) Being "behind" his aircraft, (3) Being slow to learn, (4) Needing more training than normally required, (5) Failing recurrent training and (6) Having problems in upgrading. However, eventually he checked out in the equipment assigned.

First Officer Sami Abdullah M. Hasanain

F/O Sami Abdullah Hasanain, age 26, was employed by Saudia on September 1977. He was qualified initially on the B-737 as a F/O on 2 August 1978. The date of L-1011 ground school completion was 26 March 1980. F/O Hasanain qualified as a F/O on the L-1011 on 7 August 1980. His last check was on that date.

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His proficiency checks and recurrent training had not been completed due to the fact that he had not been on the L-1011 equipment for a year.

F/O Hasanain held FAA Commercial Pilot Certificate No. 2252451 and CAD No. 222 dated 21 June 1977, with the following ratings: Airplane, single and multi-engine land with instrument rating.

His first class medical certificate was dated 26 April 1980 with no limitations.

F/O Hasanain had about 1615:00 total hours of flight time at the time of the accident, 125:00 of which were on the L-1011. He had recorded, in the previous 30 days, 44:09 flight time, in the previous 7 days, 17:26 flight time, and in the previous 48:00, he had flown 12:38.

Review of F/O Hasanain's training reveals the following:

November 30, 1974 - Assigned to Flight training FSI, Vero Beach.

September 9, 1975 - Telex to Saudia advising of poor progress and requesting advice on continuing in program.

September 13, 1975 - Recommended Hasanain be dropped from program by General Manager Corporate Training and Development and approved by Vice President Corporate Administration.

October 31, 1975 - Dropped from program.

March 13, 1977 - Reinstated in pilot training program as the result of committee action. This committee also reinstalled other trainees at that time.

April 5, 1978 through July 26, 1978 - F/O training on B-737.

August 2, 1978 - Released to line as F/O on B-737.

February 20, 1980 - Assigned to L-1011 F/O upgrade training.

August 8, 1980 - Released to the line as regular F/O on L-1011.

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Flight Engineer Bradley Curtis

F/E Bradley Curtis, age 42, was employed by Saudia on August 1974. He was qualified initially as a DC-3 Captain on 16 October 1974; B-737 F/O on 21 June 1977; F/E B-707/720 on 28 January 1979, and F/E L-1011 on 2 May 1980.

F/E Curtis' last line check was on 6 July 1980. His proficiency check and recurrent training had not been completed due to the fact that he had less than one year on the L-1011.

F/E Curtis held FAA Airline Transport Pilot Certificate No. 1611470, dated 30 September 1974 with airplane, multi-land FAA F/E Certificate No. 1750316 dated 11 September 1978 with turbojet powered and reciprocating engine powered ratings. He also held CAD F/E Certificate FE 358. His second class medical certificate was dated 27 June 1980 and contained the following limitations: Holder shall wear glasses which correct for near and distant vision while exercising the priviliges of his airman certificate.

F/E Curtis had approximately 650:00 total hours as a F/E at the time of the accident, 157 hours of which were in the L-1011. He had recorded, in the previous 30 days, 47 hours flight time in the previous 7 days, 15:49 hours flight time, and in the previous 48:00 hours, 12:38 hours of flight time.

Review of F/E Curtis' training records reveal:

July 13, 1974 - Hired for Saudia pilot program.

July 15, 1974 - DC-3 ground school.

October 17, 1974 - Assigned to line as a fully qualified DC-3 Captain.

March 26, 1975 - Assigned to transition training as Captain B-737.

May 13 - June 2, 1975 - Attended United Airlines training center at Denver, Colorado for simulator training. Training terminated because of "Progress Unsatisfactory" as Captain or F/O.

June 23, 1975 - Re-check on DC-3 as Captain.

January 13, 1977 - Assigned to F/O training B-737.

March 9 through 23, 1977 - Simulator training with Air Lingus. OK for flight training.

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May 1 through June 16, 1977 - Ninety five hours of flight and line instruction completed.

June 21, 1977 - Released to the line as F/O.

March 30, 1978 - Failed F/O check ride. Recommended remove from flying status.

April 18, 1978 - Case referred to General Manager Flying.

May 3, 1978 - Manager Flying B-737 recommended that he be returned to Special Flight Service (SFS).

May 7, 1978 - General Manager Flying terminated him from B-737 program and returned him to SFS.

May 14, 1978 - Termination letter from General Manager Flying.

May 15, 1978 - Request from Curtis to be considered for F/E position. He offered to pay for his own training.

May 16, 1978 - Offer accepted contingent on Curtis obtaining F/E ticket on B-707 at his own expense.

November 14, 1978 - Completed F/E training and accepted as Saudia F/E.

January 24, 1979 - Released to line as 707 F/E on all routes.

December 16, 1979 - Assigned to L-1011 upgrade training as F/E.

March 3, 1980 through March 15, 1980 - Simulator training at Lockheed California.

May 20, 1980 - Released to line as a regular F/E on all routes.

APPENDIX B

2. Cabin Crew

Miss Fatima Suppialo Francis

Miss Fatima Suppialo Francis, Purser, age 26, was hired in 1974 and completed initial safety training at Jeddah on November 20, 1974. This training qualified her to fly on 737 and 707 equipment. She completed her L-1011 training on September 29, 1975. Her last L-1011 Line Check was October 10, 1979. Her last recurrent training was at Jeddah on June 2, 1980. She had four days off prior to the day of the accident. Her medical history indicates she was physically fit.

Mr. Abden Jafer Al Rahman

Mr. Abden Jafer Al Rahman, Steward, age 27, was hired in 1978 and completed initial safety training at Jeddah on October 18, 1978. This training qualified him to fly on F-27, 737 and 707 equipment. He completed his L-1011 training on September 4, 1979. His last L-1011 Line Check was February 23, 1980 on flight 163 Karachi-Riyadh. His last recurrent training was at Jeddah on December 19,1979. He had days off on August 16 and 17. His medical history indicates he was physically fit.

Miss Zorayda Hernandez

Miss Zorayda Hernandez, Hostess, age 24, was hired in 1979 and completed initial safety training at Jeddah on June 16, 1979. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was July 16, 1980. Her last recurrent training was at Jeddah on July 12, 1980. She had three days off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Fauzia Saifuddin

Miss Fauzia Saifuddin, Hostess, age 24, was hired in 1980 and completed initial safety training at Jeddah on March 1, 1980. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was July 25, 1980 on flight 160 Riyadh-Karachi. Se had not completed a recurrent training class since she had been employed less than one year. She had three days off prior to the day of the accident. Her medical history indicates she was physically fit.

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Miss Ellen Bautista

Miss Ellen Bautista, Hostess, age 23, was hired in 1980 and completed initial safety training at Jeddah on June 9, 1980. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was April 12, 1980. Her last recurrent training was at Jeddah on June 14, 1980. She had three days off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Rita Zulueta

Miss Rita Zulueta, Hostess, age 26, was hired in 1979 and completed initial safety training at Jeddah on June 9, 1979. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was December 20, 1980. She had one day off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Margarita Sarmiento

Miss Margarita Sarmiento, hostess, age 23, was hired in 1979 and completed initial safety training at Jeddah on June 23, 1979. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was June 27, 1980. Her last recurrent training was at Jeddah on June 28, 1980. She has three days off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Lorna Bautista

Miss Lorna Bautista, Hostess, age 22, was hired in 1979 and completed initial safety training at Jeddah on June 9, 1979. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was June 5, 1980. Her last recurrent training was at Jeddah on June 7, 1980. She had three days off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Alice Manalo

Miss Alice Manalo, Hostess, age 23, was hired in 1979 and completed initial safety training at Jeddah on June 16, 1979. This training qualified her to fly on 737, 707 and L-1011 equipment. Her last L-1011 Line Check was August 5, 1980. Her last recurrent training was at Jeddah on June 22, 1980. She had

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one day off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Anndaleeb Masood

Miss Anndaleeb Masood, Hostess, age 20, was hired in 1980 and completed initial safety training at Jeddah on March 1, 1980. This training qualified her to fly 737, 707 and L-1011 equipment. She had been with Saudia less than one year and therefore had no L-1011 Line Check or recurrent training. She had three days off prior to the day of the accident. Her medical history indicates she was physically fit.

Miss Louise Henderson

Miss Louise Henderson, Hostess, age 21, was hired in 1980 and completed initial safety training at Jeddah on June 14, 1980. This training qualified her to fly on 737, 707 and L-1011 equipment. She had been with Saudia only two months and therefore had no L-1011 Line Check or recurrent training. She had one day off on August 17. Her medical history indicates she was physically fit.

APPENDIX C

AIRCRAFT INFORMATION

Lockheed Aircraft Corporation L-1011-385-1-15, Serial No. 1169, was certificated on 23 July 1979 and delivered to Saudia on 21 August 1979. It was placed into service on 28 August 1979 as HZ-AHK. It had accumulated 3,023 hours and 1,759 cycles at the time of the accident.

Saudia maintains its aircraft under a Continuous Airworthiness Program. The following is a listing of HZ-AHK's progressive maintenance times:

	Hours Since Inspection	Time Next Check Due (hrs)
Check "A"	78	3,045
Check "B"	185	3,168
Check "C"	185	3,438
Check "D"	Base Check Due at	8,000

Engines - Rolls Royce RB-211-524

	No. 1 Engine	No. 2 Engine	No. 3 Engine
Rolls Royce Serial No.	14046	14521	14034
Saudia Serial No.	203	214	298
Date Installed	11-1-79	Not changed since delivery	7-27-80
Hours Since Installed	2417.31	3023:28	185:01
Cycles Since Installed	1395	1759	106
Total Engine Hours	4436:59	3023:28	4572:56
Total Engine Cycles	2400	1760	2530

As a part of the Systems Group activities a review of Maintenance Records was conducted. The record review indicates that the approved continuous maintenance program has been followed. Records also indicate compliance with required service bulletins and mandatory airworthiness directives.

Although there were open items in the maintenance logbooks, there was nothing that indicated that any of these items caused or contributed to the accident.

APPENDIX D

COCKPIT VOICE RECORDER

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Technology
Washington, D.C.

March 19, 1981

SPECIALIST'S FACTUAL REPORT OF INVESTIGATION
COCKPIT VOICE RECORDER
(OFFICIAL VERSION)

A. ACCIDENT

Location : Riyadh, Saudi Arabia
Date : August 19, 1980
Aircraft : L-1011
Operator : Saudi Arabian Airlines (Saudia)
Flight No.: 163
NTSB No. : DCA 80-R-A024

B. GROUP

Paul C. Turner, National Transportation Safety Board, Chairman
E. D. Dreifus, Director of Safety for Saudi Arabia
A. Abdul Daim, General Manager, Air Traffic Control, Saudi Arabia
A. F. Jambi, Saudia Representative
Nasreen Ajmal, Instructor, Saudia Training Center
Charles McKinnon, CAM, Inc.
John Sheridan, Lockheed Aircraft Company
Tom Laughlin, Lockheed California Company

C. SUMMARY

An excellent Fairchild cockpit voice recorder (CVR) tape was received from the accident aircraft. The CVR stopped operating approximately 30 feet in the air during the emergency landing.

D. DETAILS OF INVESTIGATION

A Fairchild cockpit voice recorder tape was brought to the Audio Laboratory of the National Transportation Safety Board for transcription. The tape was on a standard Fairchild CVR supply reel. It was cut, leaders were added, and it was put on a standard tape reel and copied. The configuration of the splices toward the end caused some confusion because the tape loop splice and cuts occurred within a relatively few inches. Further listening confirmed that the

APPENDIX D

information on the tape was valid, and it was a normal CVR shutdown from aircraft wiring damage. The tape apparently had some leader spliced onto it.

The time was derived from the 400 Hz alternator frequency. This provided to be accurate to .005 seconds, and, therefore, should time accuracy of better than one-half of a percent be desired, the elapsed time on the CVR should be referenced with zulu time derived from the Tower and Center tapes.

Paul C. Turner
Air Safety Investigator

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
04:46 CAM-1(T)	Lima sierra lima (tayara) (aircraft)		
04:58 CAM-?(T)	Disgusting, he's calling a car an aircraft		
CAM-?	Next weekend		
		05:57 TWR	One six three, line up and hold
		05:59 RDO-2	One six three, line up and hold
06:06 CAM	((Sound of seat adjust noise))		
06:15 CAM-2	Before takeoff		
CAM-2	Before takeoff checklist		
06:19 CAM-3	Cabin alert	06:19 RDO-2	One six three requesting takeoff clearance
CAM-2	Check		
06:21 CAM-3	Transponder		
CAM-2	Stand by		
		06:25 TWR	Affirmative, clear to leave Riyadh via Durma climb and maintain three five zero, left turn from takeoff
06:32 CAM-2(T)	Three five zero (Durma)		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		06:36 RDO-2	Confirmed Saudia one six three, cleared via Durma three five zero left turn
		06:40 TWR	Affirmative
06:42 CAM-1	Tell him we're ready for takeoff		
		06:45 RDO-2	One six three ready for takeoff
		06:47 TWR	Roger
06:49 CAM-3	Cabin alert		
CAM-2	Check		
06:52 CAM-3	Transponder		
CAM-2	Check		
		TWR	* * *
CAM-3	Strobe light		
		06:55 TWR	Break, break, one six three, clear for take-off
CAM-2	On		
CAM-3	Ignition		
CAM-2	On		
06:57 CAM-3	Temp probe heat		
		06:58 RDO-2	One six three cleared for takeoff

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
06:59 -			
CAM-2	Probe heat is on		
07:03			
CAM-3	Ah, before takeoff check-list is complete		
CAM-2(T)	Our brother is listening to the radio		
CAM-1	Standard briefing		
07:33			
CAM	((Sound similar to seat motor))		
CAM-1	Trim it please		
CAM-3	Okay		
CAM-2	Eighty		
CAM-1	Check		
07:45			
CAM-1	Vee one		
07:49			
CAM-1	Rotate		
07:59			
CAM-2	Gear up		
CAM-1	Time off zero eight		
CAM-2	Clear left?		
CAM-1	Clear		
CAM-2	Flaps up ten		
CAM-1	Flaps ten		
CAM-2	Flaps four		
08:55			
CAM-2	Flaps up and climb thrust		
09:01			
CAM-3	Up and climb thrust		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
09:04 CAM	((Chime sound similar to "No Smoking" sign coming off))		
		09:12 TWR	Saudia one six three, call one two six zero, have a nice trip, good day
		09:16 RDO-1	Good night
		09:40 RDO-1	Radar control, good evening Saudia one six three initiating left turn out of five thousand
		09:54 RDO-1	Radar control do you read Saudia one six zero?
		09:55 CON	Roger, got you loud and clear squawk two five zero one
		10:02 RDO-1	Two five zero one on squawk
10:06 CAM-2	Two five zero one and two nine nine two		
CAM-1	Two nine nine two		
CAM-1	((Singing in Arabic))		
CAM-1	Arabic ((nonpertinent comment))		
CAM-1	((Whistling))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
10:52 CAM	((Sound of seat noise))		
12:11 CAM-1	Neutral off off check		
CAM-3	Say again		
12:18 CAM-1	Neutral off off check		
CAM-3	Just a second, okay gear lever		
CAM-1	Neutral		
12:23 CAM-3	Landing and logo light		
CAM-1	Off		
CAM-3	Ignition		
CAM-1	Off		
CAM-3	Seatbelt, no smoking		
CAM-1	Check		
12:29 CAM-3	After takeoff checklist is completed		
12:41 CAM-1	One nine two zero Jeddah		
12:43 CAM-3	Okay		
		13:09 RDO-1	Saudia one six three with estimates
		13:16 CON	Call Riyadh, say again, go ahead now one six three

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		13:20 RDO-1	Saudia one six three Durma position at two four Ragaba at two seven zulu lima mike at four five, Jeddah destination at one nine one five
		13:32 CON	Okay, copied Saudia one six three, call maintaining three five zero
		13:36 RDO-1	Roger
		13:36 RDO-3	Jeddah Jeddah Saudia one six three
		13:40 OPS	One six three Jeddah, go ahead
		13:41 RDO-3	Roger departed Riyadh one seven five zero, one eight zero seven, estimating Jeddah one nine two zero and the fuel is twenty eight point four
		13:52 OPS	Roger, roger one six three
14:53 CAM	((Hostess call signal followed immediately by an alternating tone at 14:54))		
14:58 CAM-3	"B" aft cargo		
CAM-1	What?		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
15:01 CAM-3	"B" aft cargo		
15:04 CAM-2	What's going on?		
15:10 CAM-3	Smoke detection "B" aft cargo		
15:14 CAM-1	Stop ventilation		
15:16 CAM-3	Smoke detection		
CAM-3	Smoke detection "B" aft cargo		
15:20 CAM-1	In "B" aft cargo		
CAM-3	Yes		
15:32 CAM-1	Did you turn it to the other one?		
15:37 CAM-3	Just in "B"		
CAM-1	What?		
15:39 CAM-3	Not in "A"		
CAM-3	Just in "B"		
CAM-1	Just "B"		
15:42 CAM-3	Yeah, "A" is okay		
CAM-1	Okay, so we can go on		
CAM-3	Yes		
15:51 CAM-1	The ventilation is not		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
	working at all in that one		
CAM-3	Yeah		
CAM	((Alternating tone))		
15:55 CAM-3	There is "A"		
CAM-1	What?		
CAM-3	Now it is "A", both of them		
15:59 CAM-1	So we got to be returning back right?		
CAM-3	Both "A" and "B" aft cargo smoke detection		
16:06 CAM-1	So we have smoke there		
16:07 CAM-3	I would say so, yeah		
16:18 CAM-1	What's the procedure for it in the checklist?		
16:20 CAM-1	Yeah, I am looking for it now		
17:10 CAM-1	((Singing in Arabic))		
17:16 CAM-1(T)	See that, what's it's name		
17:17 CAM-2	Abnormal		
17:19 CAM-1(T)	No, no checklist abnormal		
18:26 CAM-3	Both "A" and "B"		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-3	Yeah Both "A" and "B"		
CAM-3	Shall I test it again and see if it will test?		
CAM-1	Yeah		
18:34 CAM-3	It doesn't test		
CAM-1	Doesn't test?		
CAM-3	Both off		
CAM-1	So that's actual isn't it?		
18:54 CAM-3	That would ah --- I would say actual, yeah		
CAM-1	Uh		
CAM-3	I would say so, yeah both of them went		
19:00 CAM-1	We have cleared the situation		
19:17 CAM-1	There isn't anything about it in the abnormal procedures, huh		
19:20 CAM-3	Nothing about it, should I just go back there and see if I can find anything or smell anything?		
19:25 CAM-1	What?		
19:26 CAM-3	Shall I go back there and see if I can smell anything		
CAM-1	Okay, sure		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-3	Yeah		
CAM	((Sound of cockpit door opening))		
19:30 CAM-1	Have they seen it		
CAM-3	If I can see, smell something I'm think we better go back		
19:35 CAM-1	Surely check it		
CAM-3	We'll see		
19:40 CAM	((Sound similar to cockpit door slamming))		
19:41 CAM-2(T)	Strange no procedure for it		
CAM-1	No procedure for it?		
19:44 CAM-1	Tell them we're returning back		
CAM-2	To Riyadh		
19:48 CAM-1	We are sixty miles out ah ---		
19:58 CAM-1	We better go, go back to Riyadh		
CAM-1(T)	Look in the abnormal		
CAM-1(T)	By the way he's a jackass, in the abnormal it is in the checklist		
20:16 CAM-3	We've got a fire back there		
CAM	((Sound similar to door slamming))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	We do?		
20:18 CAM-3	Yes we do		
CAM-1	It's okay call please		
20:25 CAM-1	Tell him we're coming back	20:25 CON	Go ahead
		20:27 RDO-2	One six three, we're coming back to Riyadh
20:30 CAM-3	I would declare an emergency		
CAM-1	Yeah		
		20:33 RDO-?	Cleared to reverse course to Riyadh and request reason
CAM-2	Declare emergency?		
20:36 CAM	((Door slams))		
20:37 CAM-?	Fire, fire in the cabin	20:37 RDO-2	Saudia one six three, we've got fire in the cabin and please alert the fire trucks
CAM	((Noise similar to door slamming))		
		20:45 CON	Okay and cleared back and if you'd like to descend, you can descend to any altitude you like
20:50 CAM-1	Okay		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		20:51 RDO-2	One six three, we can descend to any altitude
		20:54 CON	Affirmative, you will be number one for landing and your position is one one oh seventy eight miles, confirm
		21:04 RDO-2	One six three
21:04 PA CAM-4	Ladies and gentlemen. you are requested to return to your seats		
		21:07 CON	Is fire on engine confirm?
21:08 CAM-1	Take a look in the cabin		
		21:09 RDO-2	Negative in the cabin
		21:15 CON	Check how many passengers you have on board
PA CAM-?	* *		
21:24 CAM-2(T)	How many passengers		
21:25 CAM-1	Tell him we do have full load up actually, we don't know		
		21:27 RDO-2	We don't know exactly, think we have full load

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
21:38			
CAM-2	Go back on the tower again		
CAM-4(T)	Will all passengers remain in their seats and fasten seatbelts, I repeat all passengers to remain in your seats --- all passengers remain in your seats		
21:51			
CAM	((Sound similar to door shutting))		
CAM-3	Okay, it's a ---		
CAM-1	Yeah		
21:53			
CAM-3	It's just a fire in the ah, smoke		
CAM-1	What?		
CAM-3	It's just smoke in the aft		
21:59			
CAM-1	Okay		
CAM	((Sound of chime))		
CAM-1	We're going to the Riyadh back		
22:03			
CAM-3	Okay no problem		
CAM-1	Huh?		
CAM-3	No problem		
CAM-1	Okay		
CAM-3	No problem, so we are going to be returning		
22:08			
CAM-3	Everybody's panicking in the back though		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	Six point eight the QNH		
CAM-2	One zero zero six decimal eight		
CAM-?	((Continuous talk by female voice in background))		
25:12 CAM-1	Okay zero six decimal eight		
25:26 CAM-1	Okay the throttle in engine number two, it's not returning back --- stuck		
CAM-3	Stuck?		
25:32 CAM-1	Stuck		
25:36 CAM-3	I would leave it the way it is, Sir		
CAM	((Sound of knocking))		
CAM-1	Huh?		
CAM-3	Just leave it the way it is		
25:40 CAM-1	I'm going to shut it down		
25:41 CAM-4	We tried to, we tried to put it off, at L4 there is fire		
CAM-3	There's fire?		
CAM-4	Yeah		
CAM-3	Well go put it out		
		25:45 CON	One six three, did you get the message to get us the passengers on

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
			board and fuel endurance
CAM-4	How		
25:47 CAM-3	In the ah, --- the fire extinguisher		
CAM-4	I know I said we will do it		
25:50 CAM-3	There is a fire back there		
CAM-1	Okay		
25:54 CAM	((Sound similar to door slamming))		
CAM-1 25:55	Tell them we have actual fire in the cabin		
		25:59 RDO-2	Riyadh Saudi Arabia one six three, we have an actual fire in the cabin now
26:07 CAM-3	Shall I let Jeddah know on HF?		
CAM-1	No		
		26:10 CON	Saudia one six three roger, the fire are in the standby positions and they are ready
CAM-3	No?		
CAM-1	Not with our situation		
		26:17 RDO-2	One six three

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	Zero six zero radial and back on the R NAV		
22:20 CAM-3	No problem, no problem, no problem at all		
22:31 CAM-4	Do we have time to take the carts back?		
CAM-3	What?		
22:36 CAM-4	To take the carts down to be out of our way		
CAM-3	All right, take them down		
22:38 CAM-1	Okay get the landing weight boy! get the landing weight		
22:45 CAM-3	Okay, it's will be one six zero		
CAM-2	Okay		
22:50 CAM-3	Did we declare emergency?		
CAM-1	Negative		
22:53 CAM-3	Okay, where the fire trucks waiting?		
CAM-1	Yeah		
22:55 CAM-1	There got to be a fire, fire --- the ** the fire truck got to be standing for us		
CAM-3	Okay		
23:04 CAM-1	Ask for the fire trucks		

	INTRA-COCKPIT	AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	I already asked, I already asked		
23:07 CAM-3	We definitely want		
23:10 CAM-3	We definitely, we definitely want preference to land		
CAM-1	Huh?		
23:13 CAM-3	We definitely want preference to land, that's for sure		
CAM-1	Yeah		
23:22 CAM-1	Pressurization is set? ---		
CAM-?	((Cabin announcement - unintelligible))		
23:27 CAM-1	Okay		
23:31 CAM-2	No smoking sign on		
CAM-1	Okay, no smoking sign		
23:36 CAM-1	Landing preliminary		
23:40 CAM-3	Okay landing preliminary		
23:41 CAM-3	One forty two on the bug		
CAM-1	One forty two		
23:42 CAM-2	One forty two		
CAM-3	Anti-ice		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	Off		
23:50 CAM-3	HSI heading		
CAM-1	Set		
23:51 CAM-3	Seatbelt sign		
CAM-1	On		
CAM-3	Ah		
CAM-3	Logo light		
CAM-1	It's okay		
23:55 CAM-3	Logo light		
CAM-1	Checked		
23:58 CAM-3	Altimeters		
CAM-1	Altimeters is gonna be what it is		
24:03 CAM-1	It was one zero zero two setting		
24:09 CAM-3	Okay, and airspeed, groundspeed, airspeed and EPR bugs		
24:16 CAM-3	Gross weight estimate		
24:16 CAM	((Sound of alternating tone)) ((Smoke detector aural warning))		
CAM-3	What can I say		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
24:21			
CAM-1	Okay		
24:22			
CAM-3	I think it's all right now		
CAM-1	Okay		
24:25			
CAM-2	One one zero		
CAM-3	Gross weight airspeed and EPR bugs		
CAM-1	Set and cross checked, one forty two set here two and one five five check		
CAM-2	One five five		
CAM-3	Check		
24:40			
CAM-1	Keep the oxygen to be prepared		
24:41			
CAM-3	((Sound of alternating tone three times simultaneously with above))		
CAM-3	There goes "A"		
PA			
CAM-5(T)	# # # #		
24:49			
CAM-1	((Singing in Arabic))		
24:59			
PA			
CAM-4	Would passengers please remain seated		
25:04			
CAM-2	Six point eight		
CAM-1	Huh?		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
26:18 PA CAM-4	L4 and R4 get the fire extinguishers from the galley --- ((repeated)) ((26:32))		
26:29 CAM-3	Jee's let's go on as fast as we can till we can get to approach		
26:31 CAM-1	That's it, this is the maximum		
CAM-3	Yeah		
26:34 CAM-1	Now engine number two is stuck there so something is wrong in it, I'm gonna be shut it down		
26:39 CAM	((Sound similar to cockpit call chime))		
26:40 CAM-3	Well not yet, not yet, not yet		
26:42 CAM-4	There is no way I can go to the back * * after L2 R2 because the people are fighting in the aisles		
CAM-3	Okay find a way if you can		
26:53 CAM-4	L4 R4 L3 R3 * * open the cabinet and use all your fire extinguishers and the CO2 ((27:00))		
27:02 CAM-3	I'll keep your speed up as long as possible		

	INTRA-COCKPIT	AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	Okay		
CAM-1	As soon as possible we're gonna be down		
27:16 PA(T)	(All passengers remain in your seats, etc.) ((Arabic))		
27:21 CAM-3	And your target speed is one forty one		
CAM-1	Huh one forty one is set		
27:30 CAM-3	Here's is the bug card		
27:32 CAM-1	Thank you		
27:39 CAM-2	Set on mine		
27:40 PA CAM-4	Please, everybody set down, move out of the way, everybody sit down, move out of the aisle, there is no danger from the airplane, everybody should stay in their seats		
PA CAM-4	In URDU --- sit on your seat, sit on your seat, ladies and gentlemen take your seat --- nothing will happen to aircraft, ladies and gentlemen fasten your seatbelt, don't stand like this set on your seats --- sit down, sit down ((repeated until 28:28))		
28:03 CAM-3	Piece of cake, piece of cake		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
28:10 CAM-3	As soon as we land, sir, I suggest that we turn off all fuel valves		
28:14 CAM-1	Okey		
CAM-3	As soon as we land		
CAM-1	Okay		
28:17 CAM-3	As soon as we touch down		
CAM-1	Okay		
28:22 CAM-1	Where is the runway?		
CAM-1	Can you see the runway?		
28:27 CAM-2	No not yet, not yet.		
28:29 CAM-2	Twenty eight miles		
CAM-?	# # #		
28:40 CAM-3	Did you tell the fire trucks to go to the back of the airplane as soon as possible		
CAM-2	Yeah		
CAM-1	Huh		
PA CAM-4(T)	Will all passengers remain seated, will all passengers remain seated, ((URDO)) --- ladies and gentlemen sit down, sit down (repeated)		
CAM-1	Advise them		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	Huh		
CAM-2	Advise them?		
28:50 CAM-1(T)	How?	28:50 RDO-2	Riyadh one six three
28:52 CAM-2	Advise them	20:52 TWR	Go ahead
CAM	((Sound of two knocks))		
CAM-1	Yeah yeah		
		28:54 RDO-2	Please advise fire trucks to be at tail of the airplane after touch, please
		28:59 TWR	Yes, will do
29:01 CAM-1(T)	Where is the airport, I don't see it?		
CAM-4	Captain there is too much smoke in the back		
CAM-2(T)	There is the airport road, the yellow lamps are the airport road		
CAM-1	Huh		
CAM-2(T)	The yellow lamps are the airport road		
CAM-1	That		
CAM-2	Yeah		
CAM-4	# # #		
CAM-1	Are there too much smoke there?		
29:34 CAM-3	Okay, I am going to test the system again		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
29:36 CAM	((Sound of alternating tone)) ((Smoke detector))		
29:38 CAM-3	Okay there's both "A" and "B" loops working again		
29:44 CAM-3	And no indication of smoke		
29:46 CAM-1	Huh		
29:47 CAM-3	No ah indication of smoke, however, the cabin is filled with smoke in the back		
CAM-1	Okay		
29:53 CAM-1	Now number two is stuck there the engine		
CAM-1	Okay		
29:56 CAM-3	I suggest we shut it down on short final		
29:59 CAM	((Sound of alternating tone))		
29:59 CAM-1	Yeah, short final		
30:01 CAM-3	Okay, there is "A" again		
30:03 CAM-3	And "A" is going out		
30:20 CAM	((Sound similar to door movement))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
30:27 PA(T)	((Passengers exhorting passengers to sit down))		
30:35 CAM-3	What is he saying?		
CAM-2	Trying to keep them calm, keep them down		
30:41 CAM-1	Okay flaps four please		
30:45 CAM-1	Okay, final to the box		
30:47 CAM-2	Final to the box please		
30:52 CAM	((Sound similar to seat movement))		
30:56 PA	Everybody sit down please, all passengers		
31:00 CAM-1	Okay flaps ten please, correction okay, it's okay		
CAM	((Sound of cough))		
CAM?	*		
CAM-2(T)	They are the first people		
CAM-1(T)	What?		
CAM-2(T)	They are the first people		
CAM-1(T)	Who are they?		
31:13 CAM-2(T)	They are the people we were talking about		
CAM-1	Huh		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	They are the people we were talking about		
31:18			
CAM-1(T)	Where is the airport I don't see it		
CAM-2(T)	You see those lights over there, that's the stadium		
31:22			
CAM-2	I got the field in sight		
31:25			
CAM-1	I am just trying to intercept this (radial)		
CAM-2	Okay		
31:30			
CAM-4	Shall we evacuate?		
CAM-1	What?		
31:31			
CAM-4	Did you say we should evacuate ---		
CAM-1	Okay		
CAM-4	The passengers		
CAM-3	Say again		
CAM-4	Can we evacuate all the passengers?		
31:34			
CAM-1	Flaps ten please		
CAM-3	When we're on the ground yes		
CAM-4	Okay after we are on the ground yes		
CAM-2	Flaps ten		
CAM-1	Yeah		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
31:38 CAM-1	Final to the box!		
31:40 CAM-2	Final to the box please		
31:41 CAM-3	Final to the box		
31:42 CAM-3	Okay ignition		
CAM-2	On		
CAM-3	No smoking sign		
CAM-2	Say again		
31:48 CAM-3	No smoking sign		
CAM-2	On		
31:49 CAM-3	Altimeters		
CAM-2	Set, cross checked		
CAM-3	Brake pressure		
CAM-2	Checked		
31:51 CAM-3	Radio and R NAV selector		
CAM-2	Check		
31:54 CAM-3	Okay complete to the box		
31:58 CAM-3	Okay, right after landing sir do you want me to turn off all fuel valves?		
32:02 CAM-1	No after we have stopped the aircraft		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-3	Okay		
32:05 CAM-1	Okay, I'll tell you		
32:10 CAM-4	Do you want us to evacuate passengers Captain?		
CAM-1	What?		
CAM-4	Do you want us to evacuate the passengers as soon as we stop		
32:16 CAM-1	Take your position		
CAM-4	Okay		
32:19 CAM-3	The area duct overheat		
CAM	((Sound similar to door shutting))		
CAM-1	Okay		
CAM-1	Flaps eighteen please		
32:23 CAM-2	One eight		
32:25 PA CAM-4	Flight attendants please take your position		
CAM-4	Flight attendants, please take your positions		
32:31 CAM-2	Got runway in sight?		
		32:33 RDO-2	Riyadh, one six three, we got the runway in sight, are we cleared to land?

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-1	Oh yeah, I see it		
PA CAM-4	Please take your positions		
		32:36 CON	Affirmative, you are number one cleared for approach and you can continue tower one eighteen one
		32:42 RDO-2	Eighteen one, one six three
		32:44 RDO-2	Riyadh Saudia one six three ten miles final runway in sight, cleared to land?
CAM-4	All of you sit down		
		32:48 CON	One six three cleared to land, wind three two zero at five
32:48 CAM-1	Okay, I'm shutting		
PA(T) CAM-4	((Urdu)) fasten seatbelts all of you sit down		
32:52 CAM-1	Okay, I'm shutting down engine number two		
CAM-1	It's stuck, present EPR		
		32:53 RDO-2	One six three, cleared to land, confirm you have alerted the fire trucks

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-3	Okay		
CAM-1	Okay		
CAM-3	Okay		
		32:58 TWR	Affirmative, they are ready
32:59 CAM-1	Okay, it is coming down		
		33:01 RDO-2(T)	Thank you
CAM-3	All right		
CAM-1	Okay		
33:06 CAM-2	Flaps in eighteen		
33:08 CAM-3	I'll keep our speed up as much as possible		
CAM-1	Okay, flaps twenty two		
CAM-2	Flaps twenty two		
CAM-4	Give me your attention please, be seated ladies and gentlemen, we are about to land there's no reason to panic		
33:22 CAM-3	I'll give you a hundred and fifty on down, okay		
CAM-1	What?		
33:23 CAM-3	A hundred and fifty on down		
CAM-1	Yeah sure		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
33:29 PA CAM-4	We're about to land ladies and gentlemen place your hands behind your head for impact, girls demonstrate impact position, girls demonstrate impact position		
33:31 CAM-1	Gear down please		
CAM-2	Gear is coming down		
33:35 CAM-3	Okay, you can go one ninety		
CAM-1	Good		
33:40 CAM-1	There is no, any procedure for the two engine, it's the same as three		
CAM-2	Okay		
CAM-3	Yeah		
33:45 CAM-1	I just want to confirm it, I know it God damn it		
33:52 CAM-1	Tell him that engine number two is should be shut down --- it's stuck		
33:57 CAM-2	Okay		
33:58 CAM-1	Tell the tower		
CAM-2	Yeah		
34:00 CAM-1	Yeah, we just have engine number one		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		34:02 RDO-2	Tower Saudia one six three
34:04 PA CAM-4	The girls have demonstrated impact position, please go down half a minute before touchdown, it's half a minute before touchdown, hands behind your head ((34:14))		
		34:06 TWR	Go ahead one six three, wind three two zero at five
CAM-1	Number one and number three		
		34:10 RDO-2	One six three is cleared to land, we have engine number two shut down, we have only one and three
		34:17 TWR	Copied today
PA UNK	Everybody, please sit down, everything's under control, we are landing back at Riyadh, please sit down and fasten your seatbelts, sit down and fasten your seatbelts, please ((34:25))		
CAM-1	Okay		
		34:20 RDO-2	Okay

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
34:25 CAM-1	Complete the final checklist		
CAM-2	Complete, flaps		
34:26 CAM-3	Okay, your altimeters are one zero zero seven, set and cross checked three ways, gear and anti-skid is down and checked and your flaps are at thir - twenty two		
34:39 CAM-1	Yeah, I know it		
34:44 CAM-3	Both loops "A" and "B" are out		
CAM-1	Thank you		
34:53 PA CAM-4	((URDO)) ladies and gentlemen, no need to panic, place your hands behind head for impact position		
35:06 CAM-3	Aft cargo door is opened sir		
35:11 CAM-1	Check		
CAM-3	No problem		
PA CAM-4	Now ladies and gentlemen, may I ask you to please put your hands behind your heads for the impact position ((35:17))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
35:17			
CAM-3	The girls wanted to know if you want to evacuate the airplane		
CAM-1	Okay, huh		
35:22			
CAM-3	Girls wanted to know if you want to evacuate the airplane		
35:24			
CAM-1	Okay flaps thirty three		
35:25			
CAM	((Alternating tone))		
PA			
CAM-4	Your hands behind your head until touchdown, your head between your knees, your head between your knees		
CAM-2	Thirty three on the flaps		
CAM-3	That is "A" again		
CAM	(("C" chord at 500 feet ALG))		
35:34			
CAM-1	Five hundred almostly		
CAM-2	Check speed one six four ---		
35:36			
CAM-1	Hydraulic		
CAM-2	And five hundred		
35:42			
CAM-3	Okay, that's good, you got low pressure on number two		
35:53			
CAM-1	((Singing in Arabic))		

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
35:56 CAM-3	Looking good		
35:57 CAM-1	Tell them, tell them to not evacuate		
36:01 PA CAM-4	Put your hand behind your head and head between your knees, hands behind your head ((36:09))		
CAM	((Sound similar to door opening))		
36:07 CAM-3	No need for that, we are okay, no problem, no problem		
36:12 GPWS	Minimim --- minimum		
36:12 CAM-1	One hundred		
CAM-3	One hundred		
36:15 CAM	((Loud squeal begins and continues until end of tape))		
36:18 CAM-3	Fifty		
36:19 CAM-3	Forty		
36:21 CAM-3	Thirty		
36:22 CAM	((Loud squeal)) ((End of Tape))		

APPENDIX E

DIGITAL FLIGHT DATA RECORDER

National Transportation Safety Board
Bureau of Technology
Digital Flight Data Recorder (DFDR) Group Chairman's
Preliminary Report

A. ACCIDENT

Location: Riyadh, Saudi Arabia
Date: August 19, 1980
Aircraft: L-1011 AHK-1169
Operator: Saudi Arabian Airlines
Flight No.: Saudia 163
Flight Recorder: Lockheed DFDR 209E-6 S/N 826
Flight Data Acquisition Unit: Teledyne Control
Ident. No.: DCA-80-RA-024
Report No.: 80-28

B. GROUP MEMBERS

Dennis R. Grossi: NTSB
Carol A. Roberts: NTSB
Don Smith: Lockheed Aircraft Company
Mohammed Dabbagh: Saudi Presidency of Civil Aviation
William L. Olsen: FAA,

C. SUMMARY

On August 24, 1980, a readout of the DFDR data from the August 19, 1980 Saudi Arabian Airlines L-1011 accident at Riyadh, Saudi Arabia, was conducted by the National Transportation Safety Board (NTSB) at its Washington, D.C. Laboratory. The readout station and DFDR both functioned normally, producing a high quality transcription of all parameters for the entire accident flight up to the time the DFDR stopped operating. The DFDR data was first transcribed to a 1/2" magnetic tape. This tape was then used to produce printout of the data in engineering units.

D. EXAMINATION AND READOUT

1. Accident

On August 19, 1980, Saudi Airlines flight 163 departed Riyadh, Saudi Arabia for Jeddah, Saudi Arabia. A fuselage fire was detected shortly after takeoff and the aircraft returned to Riyadh. After completing a successful landing the aircraft was taxied to an adjacent taxiway where it was subsequently consumed by fire, resulting in the loss of life to all passengers and crew.

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2. Receipt of Recorder

The recorder was delivered to the NTSB by Mr. Robert Chambers of Lockheed Aircraft Service Company at 10:30 a.m. on August 24, 1980. The shipping carton was opened and the recorder removed in the presence of the following:

1. Robert Chambers
2. Mohammed Dabbagh
3. Dennis R. Grossi
4. Faisal Rasheed
5. Carol Roberts
6. Don Smith
7. Paul C. Turner

3. Examination of Recorder

The exterior of the DFDR was found to be covered with a heavy coating of black soot. The soot seems to have impregnated the painted surfaces but could be easily scraped from all unpainted metal surfaces. A sample of the soot was taken from the underwater locator transmitter attachment fitting, which is unpainted, and sent the Federal Bureau of Investigation (FBI) for analysis.

The side covers for the electronics section were removed to facilitate the visual examination of the recorder's electronic components (see Attachment 1). This examination revealed no visual evidence of either water or heat damage. It was, however, noted that the side covers had been removed and reinstalled subsequent to the sooting of the recorder. This was evidenced by the misalignment of the unsooted portions of the side covers with the unsooted portions of the recorder body. Noting no evidence of damage, the side cover plates were reinstalled correctly.

The protective housing was then removed to permit the examination of the recorder assembly (see Attachment 1). The exterior of the recorder assembly was free of any damage and the seam between the protective cover and tape deck base was sealed with filament tape, which had no sign of heat damage. The tape and protective cover were then removed. The visual examination of the tape deck revealed no sign of damage to either the tape deck or magnetic tape. The tape was properly positioned on all roller, capstains, reels, and heads. Some normal deposits of dirt were visable on the heads and were removed using watch paper without disturbing the tape alignment. The tape deck V-belt drive assembly was also examined and found to be in proper working order.

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4. Readout of Data

Noting no evidence of damage other than the sooting of the recorder's outer case, the recorder was reassembled and installed in the NTSB's DFDR readout station for the data using the DFDR's drive motor and playback head when the DFDR is not damaged.

Before the transcription of the data could be accomplished, a directory containing all parameters recorded on the Saudi DFDR had to be established in the readout station's computerized files. Work began on this portion of the readout process on August 23, 1980, with the receipt of the directory information from the Lockheed Aircraft Co. The directory was completed on the morning of August 24, 1980.

The first attempt to readout the data began at 11:30 a.m., August 24, 1980. The readout station and DFDR both operated normally. The data for the accident flight was located using a strip chart recorder, which graphically displays up to 8 parameters. Once located, the data for all parameters were transcribed to 1/2" magnetic tape. There were no drop out during the entire transcripts. This transcription covered a time period starting at 1802 GMT through the termination of data for the accident flight at 18:36:39 and was stopped at GMT time 21:44, which had been recorded during a previous flight.

A printout of the data in engineering units from 18:36:39 GMT, when the DFDR stopped, was made on August 24, 1980. A examination of the data revealed that the N1 values for engine number one recorded in the first subframe and N2 for all engines were not valid. This resulted from a problem in the directory information used during the data transcription. This necessitated a second transcription after the corrections to the transcription program's directory were completed.

The necessary correction were made on August 25, 1980 and the section of the printout containing the invalid information was reproduced. The corrected data was then combined with the other sections of the printout and sent to Riyadh, Saudi Arabia via Pan American Airlines Flight 024 on the same day. The invalid data printout was destroyed.

In addition, the Bleed Air Temperature (BAT) parameters for engines one and three did not record valid data. The DFDR values for BAT1 and BAT3 were compared to the same parameters recorded by this aircraft in January 1980 on its

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Quick Access Record (QAR). This comparison indicated that during the accident flight and the comparison flight, a temperature of 381 degrees was recorded. This temperature is well above the maximum operating temperature of 315° and, therefore, is considered invalid.

To date, nine printouts of all DFDR parameters and one 1/2" magnetic tape of the entire accident flight have been produced by the NTSB's DFDR lab. Eight of the printouts start at GMT 17:59:20 and end at 18:36:39 when the DFDR stopped. As previously stated the first printouts produced started at 18:00:40 and ended at 18:36:39. Five copies of the printout have been supplied to members of the investigation (see Attachment 2). The NTSB is retaining in its possession the 1/2" magnetic tape and remaining printout at this time.

The DFDR with the original tape has been returned to Mr. Mohammed Dabbagh.

/s/ Dennis R. Grossi

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PERTINENT GROUND COMMUNICATIONS TRANSCRIPTIONS (In Part)

Records were reviewed and tape recordings transcribed of all known communications to and from the aircraft during the duration of the last flight. The Riyadh Air Traffic Control Center timed recordings were used as the master time base. All times are Greenwich Mean Time (G.M.T.).

Cassette tapes of the pertinent tracks containing radio contact with SV 163 were; Tower (TWR) 118.1 MHz, Terminal Area Control Center (TMACC) 126.0 MHz, and Ground Control 121.9 MHz.

The following transcript was prepared after listening to the tapes:

> All Tower identifications after time 1821:28 are recorded on 121:19 MHz unless otherwise noted. All conversations were in Arabic, English or a combination of both:
>
> Fire 3 is the Fire Supervisor
> Fire 4 is the Fire Assistant Supervisor
> Fire 5 is the fire Standby Supervisor
> Fire 6 is the Fire Control

a. ATC TAPE TRANSCRIPTS

1820:21	163	Riyadh, Saudi one six three
1820:25	TMACC	Go ahead
1820:26	163	One six three is returning back to Riyadh
1820:20	TMACC	Cleared to return course to Riyadh request reason
1820:37	163	Saudia one six three, ah, we got fire in the cabin - ah please alert the fire trucks
1820:43	TMACC	Okay and cleared back and if you like to descend you can descend to any altitude you want
1820:50	163	One six three we can descend to any altitude

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1820:53	TMACC	Affirmative, you will be number one for landing and your position is one one - ah - is seventy eight miles go ahead
1821:03	163	One six three
1821:20	TMACC	Is fire on engine? Over
1821:22	163	Negative, in the cabin
1821:23	TMACC	How many passengers you got?
	163	We don't know exactly, think we have full load
	TMACC	One six three are you able to give us passengers on board (and your endurance?)
	163	Riyadh, Saudia one six three we have an actual fire in the cabin now
1821:30	TWR TEL	Telephone Hamad
1821:32	FIRE 3 TEL	Brother speak Arabic with you slow down I don't understand what you say
1821:55	TWR TEL	Go ahead, go ahead
1822:06	FIRE 3 TEL	Good, Okay
1823:16	TWR	Fire trucks clear to cross all of you
	FIRE 4	Ibrahim
	FIRE 3	Yes, keep them, are you Almutairy
1823:55	FIRE 3	Stay at the first exit on the left after R/W one one number four is in this entrance, okay
	FIRE 3	Military, do you read me?
	FIRE 4	Yes, I can read you
	TWR	Fire all of you can read the Tower now

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	TWR	We have aircraft, will arrive after ten minutes, after ten minutes exactly
	TWR	But, keep away from the runway because we have B-737 and DC-8. Will let them depart before the arrival of that aircraft
	FIRE 3	Okay
	FIRE 3	Military, do you read me?
	FIRE 4	Yes, reading you
	FIRE 3	Stay on the on these intersection on the left
	FIRE 4	Here exactly
	FIRE 3	Keep clear of runway there is an aircraft will zero one take-off
	FIRE 4	Number eight where do you want us to part?
	FIRE 3	Tell him to come with me to the end of the runway zero one
1826:02	FIRE 3	Okay, Riyadh Tower Fire 3, Yeah, Riyadh Tower Fire 3
	TWR	Go ahead
	FIRE 3	What is the type of the aircraft?
	TWR	My dear, fire, the type of the aircraft is Tristar and it has full load, full load
	FIRE 3	Finish we are on the intersection and everything is understandable
1826:08	TMACC	Saudia one six three, Roger, fire a in standby position and ready
1826:15	163	One six three
1828:48	163	Riyadh one six three

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1828:50	TMACC	Go ahead
1828:52	163	Please advise the fire trucks to be at the tail of the airplane after touch please
1829:26	TWR	Fire one, fire one
	FIRE 3	Go ahead, Tower Okay Sir, the fire on the cockpit When the aircraft land, I want you
	TWR	To follow them the tail from his tail. Drive behind it from the tail. Okay, Okay, Hamad
	FIRE 4	Gotta please speak this information in Arabic, the cars here hearing
	TWR	Okay, dear, this information connect
	FIRE 4	Yes
	FIRE 3	Please say again, say again the last thing
	TWR	The last thing, my dear, when the aircraft land drive behind it from its tail do not go in front of the aircraft. Keep behind the aircraft.
	FIRE 3	Okay, this is something understandable
1830:01	TWR	Okay, the fire is in the cabinet of the aircraft, the fire in fact is in the cabinet of the aircraft, but the pilot wants you to drive behind the aircraft from its tail
1830:15	FIRE 3	Okay
1831:02	ATC 1	Tower ATC one radio check, how do you read
1832:29	TWR	Fire Ground

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	FIRE 3	Go ahead Tower
	TWR	Okay, regarding the landing aircraft Tristar now saying that he has a fire in cockpit and wanted trucks to follow it from behind him also cars waiting in front of him
	FIRE 3	The trucks are stopped on the runway 4A Hamad, along all the intersections (....) As you see along the runway there are no aircraft, there are no trucks driving ahead of him, all trucks will drive behind him unless when the aircraft is stopped.
	FIRE 4	Ya, Hamad, this is fire four, do you read me? Good
	TWR	I tell you lengthy life see the last exit, last exit at the runway zero one nobody there
	FIRE 3	(....) exactly at the intersection before the last one
1832:29	163	Riyadh one six three got the runway in sight are cleared to land?
1832:33	TMACC	Saudia you are number one cleared for approach
1832:40	163	One eighteen one, one six three
1832:42	163	Riyadh Saudi one six three ten miles final runway in sight are we cleared to land?
1832:46	TWR	One six three cleared to land wind three two zero at five.
1832:51	163	Cleared to land, confirm you alert the fire trucks
1832:56	TWR	Affirmative, they are ready
1833:54	TWR	Yes, but the Tristar aircraft usually taxing out from the last intersection from the end of last

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		intersection not see standby there and also the one here at B two. This at this B two suppose to be there, the aircraft landing within three minutes, three minutes to land.
	FIRE 3	I have distributed the cars along the runway
	TWR	Okay, thanks
1834:00	FIRE 4	Ya, Hamad, is this the aircraft?
	TWR	This is the first aircraft landing now it is five or six miles
	FIRE 3	This is a first aircraft (Yes) Okay
	TWR	This is a first aircraft, a first aircraft
1834:01	163	Tower Saudi one six three
1834:05	TWR	Go ahead one six three wind three two zero at five
1834:08	163	One six three we are cleared to land we have engine number two shut down, we have only one and three
	TWR	?
	163	Okay
1834:25	TWR	Tell you guys the Captain has engine number two shutdown
	ATC 1	Number two shutdown, he had engine one and three only
	TWR	Who is that, Hamad?
	ATC 1	. . . . Hamad?
	ATC 1	The aircraft is on final
	TWR	Yes it is

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	FIRE 3	(Military) do you hear me? (Military) do you hear me? Number four do you hear me?
	FIRE 3	Number four truck do you read me? Number four truck do you read me? Number four truck do you read me?
	CHIEF ATC 1	Number four truck do you read me?
	FIRE	We are reading him, love
	ATC 1	Answer him
	ATC 1	Number four, reading you, however, speak
	TWR	The aircraft on final is the emergency one, guys
	FIRE 3	Roger, Roger, Hamad
1836:24	ATC 1	It looks like if there is a smoke behind, Hamad.
	FIRE 3	Okay, Ahmed, say again
	ATC 1	Something like a smoke behind the aircraft
	TWR	Okay, did you hear that firemen?
	FIRE 3	I am not hearing anything, what is it?
	TWR	He saying that it looks like a smoke coming out of the rear of the aircraft.
1837:31	163	Ah - tower, could you advise if, do, you have any fire in the tail of the aircraft?
	TWR	Say again
1837:40	163	Do you have any fire, do you have any communication with the - ah - fire station equipment?
	TWR	Affirmative

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1837:44	163	Do they have a fire in the tail of the aircraft?
	TWR	Affirmative, they are on the runway now behind you - right behind you
1837:50	163	But - they do have actual fire? - on the tail?
	TWR	Stand by
	TWR	Guys, do you see fire in tail?
	FIRE 3	No, there is nothing
	TWR	No, no fire, hah
	FIRE 3	No fire, nothing Hamad
1838:08	TWR	They say no, nothing they can see
1838:11	163	One six three
	TWR	Okay
	TWR	Please tell me when the runway is clear guys
	FIRE 4	There is a car, there is a car still, Hamad
1839:00	ATC 1	Fire one, do you have beam lights to direct it toward the aircraft at the rear
	FIRE 3	I am directing the lights toward the aircraft, and I see nothing
	FIRE 3	I don't see anything, no fire in the engines
	ATC 1	Hamad, can you change him to the ground frequency to check with him
1839:20	TWR	One six three, you think maybe you like to continue to the ramp - or you want to shut down - tow the aircraft - or what?

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	TWR	Check with him, what I told him to either continue or shut down (one minute)
1839:28	ATC 1	There is here something like smoke, my brother, let us see the pilot to speak with him. Where is that he wants? There is something like smoke hey, you folks
	TWR	Tell you how Saudia one six three. This say shutdown engine and evacuating means that the passengers will get out well.
1839:29	163	Stand by
	TWR	Okay
1839:33	163	Okay, we are shutting down the engines now and evacuating
	TWR	Okay, and Saudia one six three understand holding position and shutting down (copied?)
	163	Affirmative, and evacuating
	TWR	Evacuating, okay
1839:43	ATC 1	There is a fire put off. Fire come from this side. There is a fire here
	ATC 1	The tail (.....) from behind there is fire, let him put the engine off.
	FIRE 3	There is a fire in the tail tell him to switch the engines off
	TWR	Engines switched off, and evacuating now. Put the fire off please
1840:00	ATC 1	Okay, we can't because the engine is running
1840:05	TWR	The pilot is with me saying that he is trying to evacuate

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	ATC 1	Haman, the smoke is increasing, what happened to the pilot?
	TWR	Did the smoke increase?
1840:10	ATC 1	Yes, the smoke is increased and engines still running
1840:17	TWR	Saudia one six three, do you read?
	163	I read, go ahead
	TWR	Okay, they reported they - ah - you have some fire on the tail of the aircraft
1840:33	163	Affirmative, we are trying to evacuate now
	TWR	Okay
1841:19	TWR	He told me that he shut the engine down already
	ATC 1	No, the engine's still running, I can hear it
	TWR	Standby
1841:38	TWR	Saudia one six three, Riyadh
1841:44	TWR	Saudia one six three, do you read?
	TWR	Saudia one six three, Riyadh, do you read?
	SV 3117 (?)	Ah - tower, probably everybody is out of the cockpit now.
1842:00	ATC 1	Yes, tell him to switch the engines off and evacuate. There is smoke in the aircraft.
	TWR	Okay to switch, just a minute
1842:06	TWR	Saudia one six three if you read shut down the engines

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	ATC 1	I say his doors are automatic
	TWR	Say again Ahmed?
1842:16	TWR	Saudia one six three, if you read, shut down the engines

No further transmissions were heard from the airplane and no doors were observed to open. The aircraft was subsequently destroyed by fire - there were no survivors.

1842:18	ATC 1	Now he shut engines, now okay
	TWR	Say again Ahmed
	ATC 1	Okay do you ask anybody to come here
	TWR	Yes there are three buses coming to you
	ATC 1	Did you call Saudia Hamed?
	TWR	Saudi on the way
	ATC 1	All traffic, all traffic hold until further notice.
	FIRE Cont	Riyadh Tower, From Fire Control Riyadh Tower, From Fire Control
	TWR	Go ahead, sir
	FIRE Cont	Can you ask Al-Leheedan if he wants car no. two (PCF) to be sent to him?
1843:00	ATC 1	There is a fire on the aircraft, and up to now nobody has put it off
	TWR	Fire, Tower
	TWR	Ahmed, Do you read me?
	TWR	Did they put the fire off or not, this is the important thing
	FIRE Cont	Riyadh Tower, Fire Control

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	TWR	Go ahead
	TWR	Did you ask Al-Heheedan, if he needs the (PCF) car or not
	TWR	Standby
	TWR	Leheedan, do you read me?
	ATC 1	He is busy now, do not call him now
	TWR	Ahmed, HM one already started, what do you think about him
1844:	ATC 1	I don't know, this needs attention, because the fire is in the rear door of the aircraft
	TWR	Is there a fire in the rear door and nobody could put if off, okay
	ATC 1	They are trying, they are trying
	ATC 1	Where is HM one?
	TWR	Still on ground, in VIP parking, did not taxi yet
	ATC 1	Okay tell him to pull up two thousand to three thousand feet before the end of the runway
	TWR	I will try to tell him that, but how is the condition of the runway is it clear?
	ATC 1	The runway is clear, runway is clear, call the air force fire trucks
1846:30	TWR	Okay Ahmed, can you see if anyone of the passengers got out of the aircraft either from the emergency doors or main doors
1846:44	ATC 1	I am trying to approach more, I cannot see because of the smoke, I am afraid of hitting someone or a truck

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1847:00	TWR	Fire Control, Al-Leheedan advises you to send all you have
	TWR	Yes, the fire is spreading in the aircraft and nobody could get out of it up to now
	TWR	Still nobody could get out and nobody can climb to the aircraft, they tried to put it off, just a minute
1850:00	ATC 1	Air Force fire do you read me?
	TWR	It needs you to go yourself
1850:30	ATC 1	It is very long distance
	TWR	Ahmed did you call the Air Force Fire
	FIRE Cont	Riyadh Tower, the fire trucks will proceed on the runway
	TWR	Proceed on the Taxiway
	TWR	Ahmed Magrabi, did the Air Force Fire arrive?
	ATC 1	ATC from Ground
	TWR	Go ahead
	ATC 1	Try to call the city fire trucks, please tell to standby
	TWR	To come to the airport?
	ATC 1	The nearest fire trucks in the city
	TWR	To come to the airport?
	ATC 1	Yes, to come to the airport, I don't think we'll be able to put the fire off here
1853:40	ATC 1	The Air Force fire behind me and we are approaching the airport

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	ATC 1	Tell Saudia maintenance to send somebody to help these people inside and to open the doors, please
	TWR	OK I will do
1854:27	TWR	Where is the fire, Ahmed
1854:30	?	The aircraft is in the end of the runway and there is a fire in its tail
	FIRE 5	Can we cross the runway
1856:00	TWR	Yes, you can cross it, Somali
	FIRE 5	We are taxiing now, Adam
	TWR	Okay Somali you can cross no problem
	FIRE Cont	Somali, do you read me?
	FIRE 5	Yes, I read you
	FIRE Cont	Al-Leheedan needs big fire trucks, tell him to send a big one
	FIRE 5	Okay I will bring it with me
	FIRE 5	No car available in the station Fahad

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WITNESS INTERVIEW

AHMED MAGRABI
August 25, 1980

Mr. Magrabi was working in his office on August 19 between 4:30 PM and 6:30 PM. He left the office at 6:30 PM and went to his home, about 2 miles from the airport. Between 9:15 and 9:20 PM he received a phone call from the Control Tower (Ali Madradi) advising Flight 163 was returning with smoke in the cockpit and the fire department had been called regarding flight 163. Magrabi left his house within 2 minutes of the call and drove directly to the approach end of the runway and parked along L.H. side of main runway to observe landing and follow aircraft. He estimated 2 to 4 minutes time taken to drive from home to runway. His car radio was selected to ground frequency to monitor fire equipment movement. He observed aircraft approaching on final - about 2 to 3 miles out. He saw nothing abnormal and is not sure about seeing any aircraft lights. Control Tower called Magrabi to advise Flight 163 was landing with No. 2 engine shutdown. He saw several fire trucks that were ready and waiting. When Flight 163 passed in front of him (side view) he saw nothing abnormal in the cockpit area and the lower rotating beacon was on. (He was not sure of any other aircraft lights being on or off). When he saw the aircraft pass in front of him, it was about 7 to 10 feet off the runway. Aircraft normally touchdown to B4, but Flight 163 touched down just beyond main runway intersections. As aircraft passed him, he saw smoke coming out of the bottom of the aircraft near the back. The smoke was dark in color - black - and about two feet wide. The smoke was thick - dense and could be seen in the car lights. He transmitted that he saw smoke as he turned to enter the runway. Upon entering the runway, he smelled smoke - smelled like trash burning - did not smell like fuel burning. The wind blew smoke away and was estimated at 10 to 15 knots. As he drove fast down the runway, the smoke smell diminished. He caught up to the aircraft just past B7 turn off and the aircraft was taxiing slowly. (He estimates his speed down the runway at 120 to 140 kilometers/hour). There were two fire trucks between him and the aircraft but he could see the aircraft clearly and was surprised to see no smoke coming out the bottom of the aircraft. While going down the runway he heard reverse thrust applied but aircraft was too far away to tell when smoke stopped or extent of smoke during the landing roll. As he followed aircraft between B7 and B8, the

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control tower asked the fire vehicles in front of him if they saw smoke and they advised that they saw no smoke. The aircraft made a slow turn off B8 at that time his car is under No. 2 engine and he can see the underside clearly and aircraft is slowly taxiing. The aircraft first stopped about 5 to 6 feet from where it finally stopped. He stopped his car behind, and slightly to the right of the tail and the fire truck lights were turned on the underside of the fuselage. (There was a ground transmission for fire trucks to turn on lights). About one minute later he drove to a position adjacent to and just off the L.H. wingtip and observed flames inside the cabin through the 3 cabin windows (maybe 4) just ahead of the aftmost door. He also saw cabin lights on inside the cabin. He saw no flame or smoke outside of the aircraft at this time. Flames inside the cabin were orange colored. He made a ground transmission to the tower to advise pilot to shut down engines and let people out (both engines on wing running). His car is moving slowly to a position in front of, and to the left of, the nose of the aircraft, and he did'nt notice any movement inside the cabin. Engines are still running as he stops car. He is sure engines are running and not just windmilling. From his position he can see that the cockpit is dark and he sees no movement in the cockpit. He calls tower a second time to ask pilot why he was not shutting down engines and tower advises that pilot said he was shutting down now and we will evacuate. He asks tower for more fire equipment from the RSAF and tower advises that there is no phone to them. His car remains at the position described, as the engines wind down and beacon light goes off, there is then a big puff of white and black (mixed) smoke that projects down out of bottom of aircraft just ahead of the wings. Smoke hits ramp and bellows up around fuselage. Smoke very different than anything he had experienced. Stings eyes - burns the nose and throat - he was sick and affected for two days. The wind is out of the north so smoke from aircraft is blown toward his car position. Three firemen, (one with an extinguisher) go under aircraft - two men near the nose gear and the third man beside LH main gear. Then #2 engine and leading edge of wing, he called tower and asked for fire fighting equiupment from all civil defense units. He proceeds in car to helicopter base (beyond B8 turn-off) and is refused assistance from them. He returned to main runway, west of aircraft and fire had moved forward in the fuselage.

WITNESS INTERVIEW

NASSER AL-MANSOUR
August 26, 1980

Mr. Al-Mansour was in his office on August 19, when flight 160 departed. Flight 160 was through flight and he was not involved in any problem with this flight. The aircraft left Karachi on time on origination of flight 163. Mr. Al-Mansour was with Ramp Supervisor Al-Agelan in the Commissary Manager's office asking about the departure of 747 aircraft HM-1. Mr. Agelan advised him that flight 163 was returning to Riyadh because of smoke in the cabin. Mr. Al-Mansour advises there was no contact by the crew of flight 163 directly to maintenance of their return to Riyadh. (Mr. Al-Mansour's truck has maintenance frequency only and is not tied in to the airport ground or tower frequencies). There is no tape record of the maintenance frequency. He went to his truck and called to the maintenance office and proceeded to runway 01. He estimates not more than 3 minutes time elapsed between the office and the runway. When leaving the office whe walked about 100 steps to his truck (short period of time) and called maint. office to request tractor tow-bar and GPU to be sent to return of flight 163. At the runway, he saw buses crossing RW 01 but he slowed down and observed green light in the tower before crossing. He drove on runway to B2 (or drove on extended runway, not sure, to the taxiway parallel to Runway 1, drove past the RSAF building towards the aircraft. He did'nt see or smell anything unusual and did'nt see the aircraft until his truck was between intersections B6 and B7. No communications were made during this drive from Runway 1 to the aircraft. He thinks he passed one bus on way to aircraft about B6 and saw a jeep about 100 yards ahead of him. At first sight of aircraft he observed no fire. He saw fire trucks with their light directed on the aircraft. He stopped his truck about 100 meters short of the aircraft. He saw aircraft emergency lights on and smoke coming out the side of the fuselage in the LH aft area between L3 and R3 doors. He did'nt recall seeing the rotating beacon on at this time. He saw several fire trucks around the aircraft and a jeep betwen him and the aircraft. Fire Chiefs truck is near the nose of the aircraft. He thinks all trucks are foaming. There are no cockpit lights, at the jeep, the ramp lead man advises people are in the aircraft and no one is getting them out. When Al-Mansour first arrived, he observed heavy flow of smoke coming out of the side of the aircraft just below the window line between L3 and L4 doors. He is sure it is coming out of the side of the aircraft rather than the top of the fuselage. He is also sure engines are not running at this time. He observed that the cabin windows are dark and the rotating beacon

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is definitely off. Also, when he first stopped he was aware that engines were not running as there was no evidence of the normal idle whine. However, he says engines were windmilling fast due to the wind velocity. Within a minute after arrival, a jeep made a V-turn in front of him and someone from the jeep advises people are inside - help them - then jeep continues to move away from the aircraft and parks near the buses. Less than a minute later, Magrabi arrives and beckons to Nasser to help the people in the aircraft. Within 3 minutes after arrival, Nasser asks fire chief if he can help open door and chief says yes. (Also, chief says he is trying to contact the pilot thru the control tower to tell him to stop engines). Nasser and fireman stand on top of the cab of the fire truck and Nasser notices fire as well as smoke coming out of the side of the fuselage between L3 and L4 doors. Ladder is positioned against aircraft and Nasser steadies ladder as fireman goes up ladder. Nasser points out door handle and fireman pulls handle. He pulls handle about 3 or 4 inches from fuselage and he says it will not open. Nasser thinks door moved 1 or 2 inches because door is not not flush. Fireman comes down ladder and Nasser goes up ladder and tries to pull handle but foam is blowing on him and deflecting off of fuselage into his eyes so he returns down ladder to top of cab. At this point he is aware that there is greater flame coming out of side of aircraft between L3 and L4. The foam and smoke make them decide to try to open a door on the other side of the aircraft. (No smoke came out of the L1 door). They took the ladder off the truck and went to right side of aircraft. Could not see R1 door or handle because of foam covering fuselage. He sees R2 door handle so the ladder is extended and positioned against the fuselage at R2 door. Fireman proceeds up ladder with Nasser supporting the legs. Fireman pulls handle down (90 degrees or more) and door opens normally. As soon as door opens, much white, thick smoke bellows out the opening. Fireman and Nasser go down ladder, fireman gets extinguisher, goes up smoke that occurred blocked his view of these firemen. While parked at the nose of the aircraft, before engines winding down, and just before big puff of smoke occurred, he saw one fire truck start to spray foam on the aft body area. Just as engine wind down noise stopped, smoke came very quickly as one big puff with no noise and forward of the wing. Could not see anymore when smoke occurred. He then left his position in front of aircraft and sped to the RSAF fire equipment location at B4 taxiway. He passed 3 vehicles. Stopped at B4 and while in car hollered - lets get going - need help - to RSAF people standing there. He then drove out B3 and back to the aircraft.

As he approached B7, he saw 2 cars (1 jeep and 1 blazer) both with Saudi markings. Almansour and one American man are at blazer and 4 men are with the jeep. As he approached the aircraft to position AM4, he can see aircraft and there is no smoke. He

left the car and asked Almansour for help from Maintenance and then directed the oncoming RSAF fire trucks spraying foam on wings and aft fuselage body. He walks down RH side (at wingtips) and can't see any fire because foam covers aircraft from the wing leading edge aftward. He didn't notice any flame or smoke in the cabin window forward of the wing (not covered with foam). He goes back to car and drives to end of runway (approach end) to clear runway for 747 aircraft HM 1 take-off. Car positioned around B1 area. After HM 1 takeoff (and an emergency aircraft landing due to low fuel), he returns to aircraft and sees much smoke between inlet to ladder, shines light into doorway and hollers inside for passengers. After no response, the fireman goes down ladder and Nasser says "lets go to R1 and try it". While going to R1 door, he notices fire truck at aft left hand side of aircraft has stopped pumping foam. Since he knows fireman can open R1 door without his assistance, Nasser goes to their truck and they confirm they are out foam. (Nasser notices flame is coming out of R2 door on his way from R1 door to the truck). Returning from fire truck and on his way to his truck, Nasser notices flames and black smoke coming out of R2 door. He can't find his truck but does locate the jeep and asks them to call for city fire trucks to assist. He also asks for cherry picker (lift cage equipment). At this point, Nasser is determined he should go to his office to assure that the city fire trucks are contacted and are coming. He made several trips back to the aircraft during the night as he stayed in the area all night.

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WITNESS STATEMENT

CAPTAIN OMAR HONKAR

At 150 N.M. from RUH I heard flight SV-163 reporting cabin fire in aft section. He requested to return to Riyadh. The second call was:

> "I want the fire trucks to be standby on arrival and follow the airplane from the tail."

The third call was made on frequency 118.1:

> "Confirm that fire trucks have been alerted."

A fourth call was:

> "I am on final with #2 engine shut down."

After the flight landed the Captain of SV163 asked Tower to confirm if he has seen any visible fire in the tail. Tower reported back there is no fire, then added yes there is fire and asked if he wanted to evacuate or every thing is normal."

Captain replied "standby", after which he added: "I am evacuating." End of last transmission to be heard from SV-163.

Tower has attempted several calls but with no reply.

I am estimating a time factor of 30 to 35 minutes between the time the airplane came to a full stop until the fire could be seen to develop out of control. Also I have heard a transmission in Arabic describing initial stages of the fire to be a "small and insignificant."

REPORT BY RIYADH TOWER

On Tuesday 19th August 1980, at time 1821Z, the APP office told us that Saudia flight no. 163 operating to Jeddah is having smoke in the cockpit and he is now about 78 DME and he wishes to return back to Riyadh A/P. At that time we alerted the fire station and they had to ready beside the runway. At time 1825Z APP O. advised us that their an actual fire in the cockpit and at once we alerted the fire people about that and we gave him priority to land until he was approaching Haijaz Point he called the TWR, when he was passing between 6 to 3 DME on final he reported that engine No. 2 is off and he is landing with No. 1 and 3 engines only and he asked us to check if there was a sign of fire in the rear engine. We asked the fire people about that. At time 1836Z the aircraft landed, when he was about to roll end, fire people reported smoke at engine No. 2. We advised the pilot about that, at the time he getting out of the runway by the last intersection, fire people reported fire at engine No. 2. They asked to switch the engines 1 and 3 off. We passed that to the pilot, at the time he switching off his engines he said "I am evacuating" twice. And that was the last contact with the pilot.

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WITNESS INTERVIEW

SAMI MOHAMMED AL-RASHIO
SUPERVISOR - FLEET SERVICES
27 AUGUST 1980

The witness stated that he was a supervisor of the crew which was responsible for cleaning the aircraft, prior to its departure from Riyadh to Jeddah on 19 August 1980. After the aircraft had been emptied of all passengers and their belongings, the cleaning crew entered to perform their functions. The witness stated that the entire aircraft was cleaned including the lavatories and all trash and other material was removed. At no time did the witness or any of his crew observe or detect any abnormalities. He specifically stated that there was no evidence of any smoke or other indication of fire having been present within the aircraft. This witness also stated that at no time in the past or on the flight in question had he observed any evidence that individuals had engaged in preparing a beverage on the aircraft.

WITNESS INTERVIEW

M.T.N.S. MUNAWEERE
25 AUGUST 1980

This witness accompanied by Mr. Herath were the aircraft refuelers which refueled Flight 163, prior to its departure from Riyadh to Jeddah. The witness stated that they go through the aircraft upon direction and position themselves near the leading edge of the right wing, just slightly outboard of the number 1 engine. A representative of Saudia positions himself on the wing of the aircraft at the refueling port, and the reloaders remain on the ground attending their truck. The refuelers operate the valves on the truck upon the direction of the Saudia man positioned on the wing.

On 19 August 1980 these witnesses refueled the flight in question and stated that they observed no observation nor detected any evidence of smoke or fire. They specifically denied having been aware of any odor associated with a fire or electric arching. They also stated that they had heard no reports within the refueling personnel of having come on any occasion, observed or witnessing such an occurrence.

They testified that in the event they did observe or detect any abnormality of any type, such a matter would be brought to the attention of the Saudia Representative who would be present at the aircraft.

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WITNESS INTERVIEW

FAROUK AMMAN

AUGUST 27, 1980

Mr. Farouk Amman is a supervisor of the cargo and baggage loading crew which supervised Flight 163 19 August 1980. The items loaded are controlled by the load control office of Saudia which issues a load sheet indicating not only what is to be off-loaded and loaded but its position within the aircraft as well.

The procedure described is normal load-unloading procedure which was followed in the case of 163.

Upon receiving permission to proceed with their duties each cargo door of the aircraft is opened and all baggage and cargo containers are removed and placed beneath the aircraft. Baggage or cargo whose final destination is Riyadh is then taken to its appropriate location. In the case of international flights such as 163 this location was the Customs area. Baggage and cargo originating from Riyadh is then ,placed into predesignated locations and the aircraft is reloaded.

After all baggage and cargo was removed from the incoming flight the supervisor, Mr. Amman, made a physical inspection within the cargo area of the aircraft. He stated that he observed no abnormalities and specifically did not detect any unusual odors or presence of smoke.

Mr. Amman volunteered that if it was known to him that any item which might be considered dangerous to the safety of the flight such matter would immediately be brought to the attention of the Saudia representative to whom he reports.

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WITNESS INTERVIEW

ABDUL AZIZ ABOUL-WALHD
SUPERVISOR - DINING AND COMMISSARY
27 AUGUST 1980

This witness stated that he was a supervisor in-charge of the crew which provided commissary service to SV 163 on 19 August 1980 prior to its departure from Riyadh to Jeddah. He personnally was on board the aircraft and observed the aircraft interior, including the galley. He testified that he observed no abnormalities, did not detect or otherwise become aware of any smoke or evidences of fire. This witness had checked with each of the members of his crew and reports that no information was received by him to indicate that the Commissary service furnishing Flight 163 deviated in any respect from their normal service.

WITNESS INTERVIEW

FRANK SHUMOCK
27 AUGUST 1980

This witness is one of approximately nine (9) American's performing work through a Japanese Company, Kawaski, for the Riyadh Area Civil Defense.. These individuals are the crew of two KV107's which provide fire rescue services. This organization has no arrangements nor responsibility with respect to Riyadh International Airport.

On the evening of 19 August 1980, this witness was jogging in the vicinity of runway 01 where he observed a L-1011 taxiing down the runway followed by fire vehicles. He stopped to observe and placed his distance approximately 80 yards off the end of the runway 01. When the aircraft reached the end of the runway he observed it turn to its right making a turn onto taxiway B. When he first observed the aircraft he did not see any smoke or fire, he does not know if the lights were on or off. During the aircraft turn on to Taxiway B he heard engines 1 and 3 "gunned". He stated he had never heard a L-1011 produce that type of engine noise during a turn.

After approximately 4 to 5 minutes he observed a thin column of smoke begin to rise just forward of the #2 engine, at this time he observed the cockpit light, to be on and states he expected the crew to exit the aircraft. By this time he observed the first evidence of smoke, the fire vehicle had positioned themselves in the approximate positions as shown on Exhibit A. He observed the smoke to increase in volume over the next 3 to 5 minutes. He observed two buses arrive at the scene, he did not observe any fire vehicle pumping during this period of time. He ran back to his base (approximately 400-500 yards) picked up a radio and informed others at the base of the incident and drove back to the aircraft, he was accompanied by approximately 8 to 10 others from the base. He estimated the time between his first observation of the L-1011 and his return to the aircraft as being approximately 12 minutes.

Upon his return he observed a small flame (about the size of a football) where he had previously seen the smoke, at this time he was approximately 100 yards away from the aircraft at approximately the 8 o'clock position with respect to the aircraft. He stated he observed a fire truck behind the right wing being pumping, this truck knocked the fire down and in approximately 2 minutes the fire reappeared more strongly on the left side of the aircraft in the area of L3 and L4, the fire was growing in intensity but did not spread forward ata rapid pace. He observed the fire for approximately 10 minutes during which time it grew much larger, he stated all the fire vehicles then backed up approximately 40 yards and then returned back to the aircraft.

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At this point in time he returned to this base and ordered the helicopter ready for action. He then observed a Blazer with red lights drive through the helicopter compound and heard the driver ask for assistance, his supervisor Bob Shirt, informed the driver that there was little they could do this late in the game. At this time the aircraft could be observed from the helicopter base with the top portion of the fuselage engulfed in fire. The helicopter took off at 2220 and dropped foam in the cockpit area knocking down, for a brief period, the fire in this area. By ground communications, from the fire team, they were ordered to back off as the firemen did not like the rotor wash. He returned to the base and exchanged their foam bucket (approximately 1700 litres) and returned to the aircraft, they dropped their bucket of approximately 500 gallons of water down the mid-line of the aircraft. They returned to the base and once again back to the aircraft where they hovered for 4.3 hours providing lighting for the scene.

He stated that by approximately 0330 body removal had started. He stated that no doors were open prior to the fire being put out. He further stated that R2 door was knocked open by using a forklift with some type of platform and that this was the first door opened, he placed the time at approximately midnight. After R2 was forced open the first 2 or 3 bodies were removed from this door, he observed this from the helicopter. He stated L2 was then opened and approximately 4 bodies were removed from this door.

He then returned to the base and drove to the aircraft bringing portable generators. From approximately 0430 to 1030 or 1100 hours bodies were removed. He assisted by holding an empty box in the area of R2 into which identification, money and other valuable were placed. He testified the workers removed bodies first from between the area of R2 and L2. He stated that some bodies were still sitting in their seats forward of L3-R3, he stated a great many people were in the area of L1, he observed most of the bodies to be removed from the left side of the aircraft. He stated he did not observe bodies in the cabin aft of the trailing edge of the wing.

APPENDIX G

WITNESS STATEMENT

CAPT. T. ABID E.W.R.

At 1850:2, I was in HZ-AHB, Saudia Flight 179 with Capt. Saeed Aftar, monitoring the development of SV 163 emergency landing. Capt. Honkar, in command of the flight, had suggested that we advise SV 163 to evacuate and assist in any manner of help.

I stepped outside of the stairs of HZ-AHB and had seen flames and the burning of the L-1011 HZ-AHK in a distant spot around the end of runway 01.

Capt. Aftar and myself took a sherry lifter driven by one maintenance man and hurried towards the site.

On Arrival:

The aircraft cockpit area had flames extending outside the frame, as far as the cabin, it was being consumed by strong fire.

Fire trucks and fighting equipment were around the west and south ends of the aircraft.

The water/chemical of streams from fire hoses each held by three firemen, positioned too far from the aircraft, were pointed at the aircraft but only reached the window level or below. Rescue team was apparent but no organization. Total confusion and absence of command described the rescue operation.

No positive attempts or trials whatever were made to open any doors of break the fuselage from the outside. It was an aircraft on fire without effective efforts to save it.

More efficient equipment (blue in color) and a helicopter arrived to the fire scene but too late, the aircraft ceiling was completely burned out.

APPENDIX G

Captain: D. Willmott
First Officer: V. Gomez
Flight Engineer: T. Palmer
Flight No. SV 3117
Act. Type: DC8 - 61
Registration: N911CL
Date: 19 August 1980

CAPTAIN'S REPORT
(IN PART)

Started engines SV 3117 and blocked out at 1817Z for ferry flight to Jeddah. ATC asked us to hurry behind a Saudi 737 as an emergency landing was expected. The 737 departed at 1830Z and we were cleared to line up but this clearance was cancelled and we heard a Saudia TriStar on the approach reporting a two engine landing. We watched the TriStar land normally and leave the runway on the taxiway at B8 and stop. The tower asked him whether he was going to continue to taxi but he requested the tower to ask the fire section if there was any visible fire. This was done on another frequency V or F and the reply was negative. Moment after this the crew reported that they were shutting down and evacuating the TriStar at about 1850.

APPENDIX G

CAPTAIN MOHAMMED SAID ATTAR

I was monitoring Riyadh frequency 118.1 for my scheduled departure. I heard HM 1 Riyadh Tower talking that SV 163 is having an emergency, if they might close the runway, stepped outside and saw flames at end of runway 01. Rode a Maintenance Sherry Lifter which was proceeding to aircraft site.

On arrival at the scene I saw the upper half of the aircraft burning from the cockpit, aft to the empennage. Also spotted firemen hosing the aircraft wings to aircraft fuselage. I stayed there for about a time, after which I returned back to call Jeddah Dispatch to inform them of the situation. Was unable to get through and decided to return back to the fire site. About that time fire fighting units from the City Fire Department plus units from RSAF were already at the site. It was a few minutes and the fire was put out. Galley door was opened and entry was made by firemen who advised some evidence of lights and electricity (hot lines).

A maintenance avionics man arrived and with whom I made an entry to the galley and the mid electronics area where we checked and made sure the batteries were dead. Galleys was intact, the worse area was the lift and the lift chutes where the fire descended from. Upon leaving aircraft, was called by Major Bajwad to accompany his up sherry lifter because they noticed some smoke coming from the cockpit area.

The small fire was restarting which was quickly put out. Of my observations, everything was burnt but most of the pax we concentrated in the front areas, slightly aft of service center two forward to the cockpit.

This is an eye witness report of what I have seen.

Captain Mohammed Said Attar
L-1011

APPENDIX H

N.T.S.B. RECOMMENDATIONS WITH F.A.A. RESPONSE

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: February 10, 1981

Forwarded to:

Mr. Charles E. Weithoner
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-81-12 through 13

The National Transportation Safety Board sent a U. S. Accredited Representative and accompanying advisors to participate in the investigation of the Saudi Arabian Airlines Lockheed L-1011 accident at Riyadh, Saudi Arabia, on August 19, 1980. The accident involved an in-flight fire in the aft area of the aircraft. Even though the aircraft was landed successfully, the fire spread and all 301 occupants died as a result. The investigation, conducted in accordance with the provisions of International Civil Aviation Organization Annex 13, is continuing and a report of the investigation will be issued by the Kingdom of Saudi Arabia upon completion. As part of U.S. assistance in the investigation, tests and research were conducted at the Lockheed California Company and at the Federal Aviation Administration (FAA) Technical Center, Atlantic City, New Jersey.

The fire ignition source and exact area in which the in-flight fire originated have not yet been determined. The aft baggage compartment (C-3), among others, where bulk baggage is carried beneath the aft cabin floor, is being investigated as a possible origination area. Among the tests conducted to evaluate certain hypotheses regarding fire propagation were fire penetration tests of the C-3 compartment lining materials. One test showed that a 5-inch diameter, 12-inch-high propane burner flame (1,800° F) placed beneath the C-3 compartment ceiling penetrated the ceiling liner in less than 1 minute and then penetrated the cabin floor and carpet material in less than 2 minutes. A second test using the same burner showed that a 3- to 4-foot-high flame (1,160° F, fuel rich) penetrated the ceiling liner in 25 seconds, and then the cabin floor and carpet material in 4.5 minutes.

The C-3 compartment of the L-1011 is certificated as "Class D" under the provisions of 14 CFR 25.857(d). That rule states, A Class D cargo or baggage compartment is one in which--

(1) A fire occurring in it will be completely confined without endangering the safety of the airplane or the occupants;

(2) There are means to exclude hazardous quantities of smoke, flames, or other noxious gases from any compartment occupied by the crew or passengers;

(3) Ventilation and drafts are controlled within each compartment so that any fire likely to occur in the compartment will not progress beyond safe limits;

*****

(5) Consideration is given to the effect of heat within the compartment on adjacent critical parts of the airplane. For compartments of 500 cu. ft. or less, an airflow of 1,500 cu. ft. per hour is acceptable.

The Safety Board notes that its predecessor, Civil Air Regulation 4B.383, "Cargo Compartment Classification," contained the following regarding Class D compartments: "Note: For compartments having a volume not in excess of 500 cu.ft. an airflow of not more than 1,500 cu.ft. per hour is acceptable. For larger compartments lesser airflow may be applicable." This guideline at least suggested more conservative criteria should be followed for larger compartments while the existing rule does not address the airflow allowance in compartments larger than 500 cu.ft.

The volume of the C-3 compartment of the L-1011 is 700 cu. ft. Safety Board investigators have been advised by FAA that the L-1011 C-3 compartment was approved as "Class D" by "extrapolations" from the 500 cu. ft. volume and 1,500 cu. ft. per hour airflow guidelines in 14 CFR 25.857(d)(5). However, the theoretical concept of a Class D compartment is that a fire within the compartment would be extinguished by oxygen depletion, preventing its propagation. This concept apparently has been successfully applied in narrow-bodied aircraft with limited volume compartments. However, the Safety Board is concerned that it may not be a valid concept for larger volume compartments, such as the L-1011 C-3 compartment, because much greater volumes of oxygen are available to support combustion prior to depletion and "snuffing." The additional air supply can readily support a fire for sufficient time to allow penetration of the compartment lining, thereby providing access to an unlimited oxygen supply to support propagation of the fire. In fact, preliminary tests conducted at the FAA Technical Center, using a 770 cu.ft. simulated Class D compartment, illustrated that a fire of sufficient intensity to penetrate the L-1011 C-3's ceiling liner in less than 1 minute burned for more than 10 minutes after the compartment airflow was shut off.

The Safety Board is aware that the type of flames used in the tests at Lockheed and at the FAA Technical Center do not duplicate the type of flame (bunsen burner) used to certify flammability characteristics of cargo and baggage compartment interior materials (14 CFR 25.855). However, the Safety Board believes that a small fire in a piece of baggage could generate localized intense heat similar to that from the propane burner used in the recent tests and that the fire could penetrate the ceiling before the oxygen supply is depleted.

The penetration of the L-1011 C-3 compartment ceiling carries extremely hazardous consequences because numerous major aircraft components are routed between the ceiling of the compartment and the floor of the cabin. Among these items are the No. 2 engine throttle cables, the No. 2 fuel line, and flight control cables. Fire reaching these components could easily endanger the entire aircraft, and therefore, the design does not comply with the intent of 14 CFR 25.857(d)(5). Moreover, once such a fire reaches the cabin, the cabin furnishings will become involved, and the fire will be difficult to extinguish.

The Safety Board is aware of several instances of fire in checked baggage from ignition of matches and other items. In most of these instances, fires ignited while the aircraft were on the ground and the aircraft were not damaged. However, the possibility of such a fire while in-flight and the questionable capability of the L-1011 C-3 compartment to contain a fire by "snuffing" it to keep it from spreading suggest that the "Class D" certification of the C-3 compartment should be reevaluated.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Reevaluate the "Class-D" certification of the L-1011 C-3 cargo compartment with a view toward either changing the classification to "C," requiring detection and extinguishing equipment, or changing the compartment liner material to insure containment of a fire of the types likely in the compartment while in-flight. (Class I, Urgent Action) (A-81-12)
>
> Review the certification of all baggage/cargo compartments (over 500 cu. ft.) in the "D" classification to insure that the intent of 14 CFR 25.857(d) is met. (Class II, Priority Action) (A-81-13)

KING, Chairman, DRIVER, Vice Chairman, McADAMS, GOLDMAN and BURSLEY, Members, concurred in these recommendations.

By: James B. King
Chairman

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20591

OFFICE OF
THE ADMINISTRATOR

May 11, 1981

The Honorable James B. King
Chairman, National Transportation
Safety Board
800 Independence Avenue, SW.
Washington, D.C. 20594

Dear Mr. Chairman:

This is in response to NTSB Safety Recommendations A-81-12 and A-81-13 issued by the Board on February 10, 1981. These recommendations resulted from the Board's participation in the investigation of the Saudi Arabian Airlines Lockheed L-1011 accident at Riyadh, Saudi Arabia, on August 19, 1980.

A-81-12. Reevaluate the "Class-D" certification of the L-1011 C-3 cargo compartment with a view toward either changing the classification to "C," requiring detection and extinguishing equipment, or changing the compartment liner material to insure containment of a fire of the types likely in the compartment while in-flight.

FAA Comment. The L-1011 is not unique in having a large Class D type cargo compartment that has been demonstrated to be in compliance with the requirements of FAR 25.857(d). For this reason, the Federal Aviation Administration (FAA) does not believe specific action pertaining to the L-1011 as a special case is appropriate. Neither do we find that the limited tests cited by the Board are sufficient in themselves to justify the recommended action. In the research program discussed under Recommendation A-81-13, detection, extinguishment, and flammability of cargo compartment liners will be evaluated. Since the intent of this recommendation is embodied in the FAA research discussed under Recommendation A-81-13, we intend to take no further action on Safety Recommendation A-81-12.

A-81-13. Review the certification of all baggage/cargo compartments (over 500 cu. ft.) in the "D" classification to insure that the intent of 14 CFR 25.857(d) is met.

FAA Comment. The FAA concurs in principle with this recommendation. The severity and progression of the Saudi Arabian fire caused the FAA to immediately question the efficacy of the Class D fire containment

concept. Immediately after the accident, the FAA began formulating a research program, to be accomplished at the Technical Center, to conduct a comprehensive reevaluation of the concept and regulatory standards for Class D cargo compartments. Prior to issuance of the Board's recommendation, the FAA met informally with the NTSB staff to discuss the preliminary results of the accident investigation. At that meeting, the Board staff members were advised of our program. On January 15, 1981, the Office of Aviation Standards formally requested the establishment of a research program. A copy of that request is enclosed. We believe the program we have initiated exceeds the intent of the NTSB's recommendation, and we will keep the Board informed of significant progress in this area.

Sincerely,

J. Lynn Helms
Administrator

Enclosure

AWS-120

R, D & E Effort Request; Cargo Compartment Fire Containment

Associate Administrator for Aviation Standards, AVS-1

A. P. Albrecht
Associate Administrator for Engineering and Development, APO-1

Request for R, D & E

Please conduct the R, D and E outlined in the work statement below pertaining to fire containment capabilities of cargo compartments. This request stems from the recent Lockheed L-1011 inflight fire in Saudi Arabia. The R, D and E results will be used in an assessment of the adequacy of current regulations and, if necessary, in the development of revised regulations and policy.

Background and Reasons for Request

On August 19, 1980, a Saudi Arabian L-1011 experienced an inflight fire shortly after takeoff. Although the airplane landed successfully at Riyadh, all 301 persons aboard the airplane died in the fire.

Although conclusive findings regarding the origin and scenario of the fire have not been released by the Saudis, evidence obtained to date by U.S. investigators points to the possibility that the fire originated within the aft C-3 cargo compartment and burned through the compartment fire barrier liner and adjacent structure, and into the passenger cabin. A large burned hole was found in the cabin floor above the C-3 compartment.

The C-3 compartment was designed to FAR 25 class D cargo compartment standards. The severity and progression of the fire give reason to question these standards.

FAR 25.857 contains the requirements for various classes of cargo compartments. Classes A through C require fire extinguishing agents. Class D, however, depends on fire isolation and containment for fire protection. For the Class D, FAR 25.857 spells out requirements regarding fire isolation and containment, protection against smoke and toxic gases, ventilation control, and effect of heat on adjacent structure. FAR 25.855 requires a compartment fire barrier liner which passes a bunsen burner test. The Class D standards are based on fire containment tests which were conducted in 1950 in a 270 cubic

foot compartment typical of transports at that time. Since then, airplanes and class D compartments have grown many times in size. Looking at the standards vis-a-vis the L-1011 fire, we are concerned mainly with whether or not these standards have kept up with the state-of-the-art and remain adequate.

Work Statement

Please conduct literature searches, design assessments, fire testing, and associated investigations, as necessary, to determine what design features and materials are necessary to safety contain likely fires in class D cargo compartments, over a range of compartment sizes. Determine whether or not compartments, particularly large ones, designed per current standards can safely contain the fires.

One aspect of this is the fire scenario. We need to know what types and intensities of deep seated fires, if left unchecked, are likely to develop within various size compartments. If your research indicates that compartment shape or some other parameter significantly affects fire intenstity, additional studies can be initiated. We need information which can be useful in design. The information, for instance, might include time histories of temperatures, heat outputs and internal pressures at various points in the compartment. Is there a limiting compartments size above which the class D concept is impractical? What is the effect of airflow, or leakage, into the compartment?, What are the potential for, and the effects of, flash fire?

Another aspect concerns materials and detail design. This essentially weighs the compartment agains the fire scenario. It entails an assessment of existing standards and, if these standards are found deficient, the establishment of a data base for new standards. For this, fire containment tests should be conducted on various size compartments constructed with fire barrier liners found to barely meet the FAR 25 standards. This should represent a worst case situation. The main concern here is the performance of the compartment fire barrier liner in a prolonged fire, since the liner, in effect, determines containment. This should take into consideration the effect of heat soak on liner integrity and the ability of the liner to protect adjacent primary structure, the properties of which can deteriorate rapidly at elevated temperatures.

If the current standards in FAR 25 are found to be deficient, work should begin on development of a comprehensive new set of standards for the design, substantiation, and certification testing of class D compartments, and especially for the testing and screening fo fire barrier liners. If the de elopment of new standards is found to be necessary, we wish to cooperate with you closely in this.

[illegible]
[illegible]
sion of the [illegible]

Please coordinate with the Northwest (Lead Region) and Western Region aircraft certification offices, and their transport manufactures, and obtain information on materials and design practices for an assessment of state-of-the-art compartments. We are informing both regions of this program and requesting their cooperation.

After you have had a chance to review our requirements, we would appreciate the opportunity to have detailed planning discussion covering project requirements, timing, direct coordination, and the impact this may have on any other high priority agency programs, in order that we can jointly reach appropriate decisions. Once the program is underway, we would expect to establish frequent informal information exchange meetings and, less often, formal progress reviews so that we can make optimum use of interim findings.

The principal contact in this office is Henri Branting, AWS-120, FTS 426-8352.

Priority

Because this request for R, D and E concerns the adequacy of existing regulations, timing of the program is important. Work should be started as soon as possible and assessment of current regulations should be completed by December 31, 1981. If new standards are found to be necessary, we request that development work be completed by December 31, 1982.

/s/
Walter S. Luffset

AWS-124:HBranting:meb''x68382:12/5/80
cc: AVS-1
AWS-1
AWS-1 (2)
AWS-100
AWS-120 (2)
ID: H/FIRE

APPENDIX I

REPORT OF EXAMINATION OF WRECKAGE BY MR. ERIC NEWTON I.S.O., M.B.E., C. ENG., F.R.Ae.S.

ACCIDENT TO SAUDIA LOCKHEED 1011 HZ-AHZ RIYADH ON 19-Aug-1980

REPORT ON EXAMINATION OF AIRCRAFT WRECKAGE AT RIYADH

BY

ERIC NEWTON I.S.O., M.B.E., C. Eng., F.R.Ae.S.

Specialist Investigator and Adviser

1. BRIEF CIRCUMSTANCES

The above aircraft took off from RIYADH at about 18.07 hrs bound for Jeddah. According to the cockpit voice recorder, about 7 min 20 sec after take off there was a flight deck warning of smoke in the rear cargo compartment C.3. and about 1 min 10 sec later a second smoke warning from the same compartment. About 4 min later a decision was made to return to RIYADH during which time the Flight Engineer had confirmed that a fire existed in the rear of the aircraft. An attempt was made by the cabin staff to extinguish the fire but apparently this was not successful and the cabin began to fill with smoke. A successful landing was carried out at RIYADH at about 18.36 hrs and the aircraft was taxied off the main runway. After coming to a stop the fire and smoke intensified. No doors were opened and no evacuation took place. The first trucks were quickly on the scene but in spite of their efforts all the occupants of the aircraft lost their lives.

2. STATUS IN THIS INQUIRY

Following a telephonic request to England on 24 August by the Investigator-in-Charge of this Inquiry for specialist assistance I agreed to assist the team into the possibility of incendiary or explosive device having contributed to this accident and to assist and advise generally in the detection of the origin of the fire. I arrived in RIYADH on 25 August.

3. EXPERIENCE AND QUALIFICATIONS

I am an independent aircraft accident investigator, specialist and advisor. I retired from the British Government's Aircraft Accident Investigation Branch (A.I.B.) in 1975 after 33 years service. I was Principal Inspector in the engineering division and, in addition to normal aircraft accident investigations, I have made a special study, over the last 30 years, in the detection of explosive device damage in aircraft wreckage. I have investigated a number of such cases in various parts of the world.

I am a Chartered Engineer (C. Eng.) 1968, London, and a Fellow of the Royal Aeronautical Society, London, (F.R.Ae.S.) 1962.

4. INSPECTION

With the excellent cooperation and assistance from the Saudi Aviation authorities and the Board of Inquiry team members I carried out an examination of the aircraft wreckage at RIYADH between 26 August and 28 August 1980.

APPENDIX I

My examination confirmed that a major fire had developed on the ground, and there was evidence of fire in the air. This involved the passenger compartment and beneath the passenger cabin floor with notable intensity in the rear cargo compartment C3. The entire passenger compartment and upper fuselage from the vertical fin to the flight deck was gutted by fire. The lower galley although scorched and sooted showed no severe burning and there was nothing to suggest that the fire originated inside this galley.

Smoke and oily soot deposits were noted trailing off from the many drains and vents along the outside lower belly of the aircraft, particularly below the aft cargo compartment and this was consistent with having occurred whilst the aircraft was in flight. Fire damage to the left-hand side skin of the fuselage was notable at the outside of the aft cargo bay C3. This damage was below cabin floor level and the outer skin had been burnt through in several places. It is considered probable that this particular damage occurred after the aircraft had landed. There was no evidence to indicate that the pressurized fuselage skin had been penetrated by fire in flight. The forward cargo hold was scorched and the L.H. cheek area was burnt, with passenger floor collapse.

All the baggage and items from the rear compartment C3 had already been removed and these were inspected. All baggage was scorched and burnt in various degrees but all burning was of low intensity from outside towards the inside, and was secondary in nature. There was nothing to suggest damage from detonation of an explosive device. There was nothing to suggest burning originating from an incendiary device in any of the baggage. Two large steel nitrogen cylinders were undamaged and intact. A 4-litre can, labelled Caltex (Pakistan Ltd) Diesel engine lubricating oil with a Saudia Jeddah baggage tag on the handle was sooted but, although full was not leaking and this item is not considered to have played any part in the fire. A large roll of bamboo cane screen was noted to be burnt locally, but inspection revealed nothing suspicious and again the burning was of a secondary nature and was from outside towards inside. All the baggage containers had been removed from other cargo compartments and apart from soot and local burning nothing of an unusual nature was observed and all damage was consistent with secondary burning from the outside.

Rear cargo compartment C3

An intense fire, of some duration, had been burning on the left-hand side (cheek area) of this compartment. The whole compartment was burnt generally and soot covered, including the smoke detector units. On the left-hand side, close to the forward bulkhead, cheek area, a hydraulic low pressure pipe (alum-alloy) for the B system was noted to have burst. The fracture was typical with a burst whilst the pipe was pressurized. This pipe had been hot, and aft of this position the pipe was melted completely in several places. This latter damage is considered to be secondary to the pressure burst. The area close to the pipe burst position, and above it, showed a high degree of burning and a

torching flame pattern upwards through floor level was evident. A large loom of electric wires is routed close to this burst position. In this area the wires were burnt and the insulation destroyed. Some of the copper wires were fractured and the ends gave the impression of melting and possible electrical arcing. The underside of the hot air duct, with its thermal insulation burnt off in this area above (about one foot) the pipe burst, also showed intense heat and deposits. An intense fire had developed aft of this position, and foreward with notable diminishing burning pattern forwards into the adjacent cargo bay cheek area. A large hole had been burnt through the cabin floor including the walkway aisle above and to the rear of the burst pipe area. Substantial fire damage had occurred in this cheek area and several substantial aluminium structural members had melted. The impression gained was of a fire developing over some minutes. Particular attention was paid to the rear lavatories (toilets) area aft of the burst pipe, and the pipe area for any evidence of an explosive or incendiary device. Nothing of this nature was found. No evidence of a timing device was found. There was no structural damage suggestive of explosive pressure. No high velocity penetrations or small fragments were found in any of the remaining structure.

There was no evidence of fire or major mechanical damage at the engines. The wing tanks were intact, and aircraft fuel does not appear to be involved in this fire.

I did not find any cooking stoves in the passenger compartment but I have examined one Butane type gas stove which I understand had been found and removed from the passenger compartment. Although this item was damaged and scorched my examination did not reveal any useful evidence as to the cause of the fire from this item.

I found no evidence in the burnt out passenger compartment which indicated or suggested a primary cause of the fire.

I have advised that the burst hydraulic pipe be subjected to independent metallurgical examination in a laboratory in the U.K. under supervision of the British Accidents Investigation Branch (A.I.B.) and this is in progress. Pending the results of this examination it is not possible to say whether this failure is of primary or secondary importance. It is considered however, highly probable that a serious fire fed by hydraulic oil existed at some stage in the area of the cargo compartment C3. I have not been able, with certainty, to establish a positive ignition source, but damaged electric cables with possible arcing are in the vicinity of the burst pipe. Ignition from a hot surface, say the duct pipe is less likely because of the thermal insulation and the fact that Skydrol hydraulic fluid requires a temperature of approximately 700°C for spontaneous ignition from a hot surface (ventilated area).

APPENDIX I

5. ANALYSIS AND DISCUSSION

The evidence from the cockpit voice recorder (C.V.R.) readout, together with inspection of the wreckage indicates that a fire occurred in the rear of the aircraft which the crew were unable to extinguish. It would appear that the first indication of trouble, at least to the flight deck crew, was the operation of the smoke warning signal indicating from the aft cargo compartment C3. Inspection of the wreckage showed that an intense fire in the cheek area, left-hand side had occurred in this compartment. Heavy smoke and soot deposits were general in this compartment. A burst hydraulic pipe was found in the L.H. cheek area. An intense fire pattern torching upwards to floor level was above this pipe. A hole was burnt in the cabin floor above this location. Electric cables with a number of melted or arced ends were in the vicinity. The roof of the cargo compartment was burnt and distorted and the control cables routed through this area damaged.

It would appear that the rear cargo compartment C3 is a focal point in the discussion of fire origin. Of primary importance will be the metallurgical findings of the burst pipe examination. If of a primary nature then this failure must be of prime consideration. If secondary, that is to say, the pipe failed because of excess heat after the aircraft landed, then the consequent sudden release of pressurized hydraulic oil into an already burning aircraft, could explain why, after a successful landing, a sudden and fatal disaster from fire occurred.

NOTE for interest - SKYDROL, hydraulic oil burns with a yellow flame accompanied by volumes of white smoke.

6. FINDINGS

1. The evidence indicates that a serious fire occurred in flight in the rear of the aircraft which the crew could not control or extinguish.

2. Upon the available evidence I have not been able to establish the primary cause of this fire.

3. I found no evidence which indicated or suggested that the fire was caused by deliberate operation of an incendiary or explosive device aboard the aircraft.

4. A burst hydraulic oil pipe was found in the L.H. cheek area of the rear cargo compartment C3 and the early smoke warning to the crew was from this compartment.

   This compartment had sustained an intense fire of some duration in the area of the burst pipe.

5. The release of hydraulic oil is considered to have played some part in the ultimate catastrophic fire.

6. The very rapid development of the fire to catastrophic proportions occurred after the aircraft landed.

28 August 1980
RIYADH

ERIC NEWTON. I.S.O., M.B.E., C.Eng. F.R.Ae.S.
Specialist Investigator and Adviser.

APPENDIX J

REPORT OF EXAMINATION BY THE LONDON POLICE FORENSIC SCIENCE LABORATORY

DEPARTMENT OF TRADE
Accidents Investigation Branch
Kingsgate House 66-74 Victoria Street London SW1E 6SJ
Telephone Direct Line 01-212 7752
Switchboard 01-212 7676

Mr R Schleede
National Transportation
Safety Board
800 Independence Avenue SW
Washington DC 20594
USA

Your reference

Our reference
EH/B188

Date
4 November 1980

Dear Mr Schleede

ACCIDENT TO SAUDI ARABIAN AIRLINES TRISTAR HZ-AHK AT RIYADH ON 19 AUGUST 1980

I enclose two copies of the report by Mr F Lewis of the fire section of the Metropolitan (London) Police Forensic Science Laboratory on the debris samples from HZ-AHK.

One copy is for you and the other for Mr McKinnon. I do not have a contact address for Mr McKinnon and, if he has returned to the United States, I shall be grateful if you will pass the copy to him. I shall also send a copy addressed to him via our Embassy in Saudi Arabia and the Saudi authorities. This is the method which we have used to send telex messages.

I hope that the report will be of use to you though, of course, its main finding is the negative one of there being no indications of incendiary devices present in these samples.

Considering the contamination of the "PET" air fan by Hyjet IV traces, I understand from Mr Lewis that the single component found is the major component of Hyjet IV and is not markedly different in volatility from the other components. Its presence is, therefore, indicative of a lesser degree of Hyjet IV contamination (with increasing levels of Hyjet IV in the atmosphere this would be the first component to show up, in any deposits) and suggests that the fan was not operating when C3 air became contaminated with Hyjet IV to the degree that is evident in the outflow valve samples. Perhaps, following this line of thought, the presence of bispherol A may, in this sample, have some significance for you in determining a sequence of fire in C3 but unfortunately none of this is very positive evidence.

If you have any questions arising out of the report or if there is any more help that I can give please do not hesitate to contact me.

Yours sincerely

Charles I coghill
S Inspector of Accidents (E)
for the

Lab Ref: U/10107/80

Tel: 01-230 1212 Switchboard
01-230 Direct

APPENDIX J

21st October, 1980.

REPORT

This report concerns ten items of debris submitted to this laboratory by Mr C Goghill of the Department of Trade Accident Investigation Branch. These items had been removed from a Saudi Arabian Airlines Lockheed 1011 airliner, HZ AHK, at Riyadh airport. Before commencing a detailed examination of the items I spoke with Mr Coghill and his colleagues, including Mr E Newton, and was shown photographs and plans of the damaged aircraft. I also visited Heathrow Airport, where I inspected a similar Saudi Airlines L1011, HZ AHD.

The debris was packed in polythene bags, many of which were insufficiently sealed. The use of polythene bags, rather than nylon bags or other vapour-tight packaging precluded a meaningful examination for volatile liquids being made. Analysis was therefore confined to the organic materials of low volatility together with the inorganic components. During the examination reference was made to a number of undamaged 'control' samples from the airlines' stores at Heathrow.

As the debris did not bear any consistent method of labelling, the samples were numbered AIB/1 -10 prior to my examination. Undamaged control samples were labelled AIB/11 - 19 and a sample of Chevron Hyjet IV was AIB/20. The control samples that I received were as follows:-

AIB/11	INSULATION MATERIAL
AIB/12	SEAT CUSHION
AIB/13	PILLOW
AIB/14	LIFEJACKET
AIB/15	SEAT BELT
AIB/16	ASHTRAY
AIB/17	SEAT POSITION REGULATOR TUBE
AIB/18	FLOOR PADDING
AIB/19	PIECE OF CARPET.

My examination of the control samples was not exhaustive, but limited purely to features that were particularly relevant to my examinations with regard to the debris samples. I shall therefore not describe them in detail. I did, however, conduct a thorough analysis of the hydraulic fluid, AIB/20, the details of which are below.

The items of debris fell into two categories: general debris and soot samples. My findings are as follows:-

GENERAL DEBRIS

AIB/1. DEBRIS FROM O/B OF SUCTION LINE AT F/S 1630

This was principally aluminium. There was a very small amount of red material in the item, the crystalline structure of which could not be identified; traces of magnesium, phosphorus and zinc, however, appear to be associated with the red partic

AIB/2 DEBRIS FROM F/S 16/0, ABOUT 12 INCHES ABOVE SUCTION LINE

Red material in this item appeared to be made up of a mixture of pink, yellow and brown phases, which I designated A, B, and C respectively.

A (Pink) was composed of aluminium hydroxide together with a mixed crystalline material.

B (Yellow) was an amorphous solid.

C (Brown) consisted of magnesium oxide and aluminium, probably with a little calcite.

AIB/8 TWO ASHTRAY ASSEMBLIES

These were two badly heat damaged aluminium ashtrays. There was a very small amount of orange coloured residue around the lid of one of these, but again no specific red compound was identified. Traces of iron, chlorine, sulphur, calcium magnesium and zinc were associated with the coloured material. A very small amount of amorphous grey material was also adhering to the same ashtray.

AIB/9 METAL FROM UNDER SECOND ROW OF SEATS AFT OF L3 DOOR

This metal was mostly aluminium, alloyed with magnesium. Pieces of other metal in this item had not melted, and might have originated from the seat release mechanism.

AIB/7 SEAT MATERIAL FROM SECOND ROW OF SEATS AFT OF LEFT DOOR

AIB/10 SEAT MATERIAL AND PART OF SEAT BELT FROM SECOND ROW

These samples of debris were examined microscopically, but no red material or any other material of significance was found for further analysis.

HYDRAULIC FLUID AND SOOT SAMPLES

AIB/20 CONTROL SAMPLE OF CHEVRON HYJET IV

This liquid was analysed in detail, and found to consist principally of a mixture of phosphate esters. Of the eight major components, I positively identified two as tributyl phosphate and triphenyl phosphate. Four of the others were tentatively assigned as 2,6, tertbutyl - 4 methyl phenol, bisphenylisopropyl-phenylphosphate, bisisopropylphenylphenylphosphate, and trisisopropylphenylphosphate. Upon ashing, there was no identifiable inorganic crystalline structure, but traces of silicon, phosphorus, calcium, iron and sodium were present.

AIB/3 SPECIMEN 6 FEET BEHIND AFT OUTFLOW VALVE.

Four of the components of Hyjet IV were identified in this sample of soot-like material; in addition bisphenol A was present. This compound is a major pyrolysis product of epoxy resins and polycarbonates. It is also a minor pyrolysis product of polysulphones. Very little crystalline material was present in the sample, some of this was possibly calcite.

AIB/4 SOOT REMOVED FROM AFT OUTFLOW VALVE

All five of the phosphate ester components of Hyjet IV were identified in this soot. Bisphenol A was also present. Examination for inorganic components revealed the presence of ammonium chloride and ammonium fluorosilicate.

AIB/5 SCRAPINGS FROM BACKSIDE OF TURBINE BYPASS VALVE NO. 2 APP. J

No phosphate esters or bisphenol A were identified in this item. The sample consisted of a very small amount of amorphous material, together with a little quartz.

AIB/6 SOOT SAMPLE FROM PET AIR FAN INLET SPINNER

This sample of soot conatined fibres of several colours. Indications of only one Hyjet IV componant were present, together with bisphenol A. Calcite, gypsum and sodium chloride were also identified in the soot.

DISCUSSION

As I did not visit the scene, and am unaware of the results of all of the agencies investigating the incident, I am not, of course, in a position to interpret fully the significance of my findings. I did not, however, in any item find characteristic traces of any incendiary mixture or device.

I did not identify any specific red material in either item AIB/1 or 2. This could be because either the red material was an organic compound present in only trace quantities, or that the 'red' compound was in fact composed of a number of separate phases (e.g. pink, yellow and brown). I have also received no instructions as to possible sources of any red compound or its significance. One of a number of colour slides that I have seen does, however, show red run marks around a duct, together with a red discolouration beneath. No insulation is visible on the duct. This suggests that this red material is associated with a liquid, or molten material, which had run after the fire has been burning for some time.

The results of my soot examinations show that a mist of the hydraulic fluid, Hyjet IV had spread through the air conditioning system aft of the C3 compartment. I am unable to attache any particular significance to the inorganic materials present in these samples.

CONCLUSION

I found no evidence of any incendiary mixture or device in samples AIB/1-10. These items are at present still in my possession, and if any further examination is required please do not hesitate to contact me.

F.A.S. Lewis, B.Sc., L.R.S.C., M.Inst.P.
Senior Scientific Officer.
Head of Fire Investigation Unit.

APPENDIX K

REPORT OF CHEMICAL ANALYSIS BY THE BRITISH ROYAL AIRCRAFT ESTABLISHMENT

Procurement Executive, Ministry of Defence
Royal Aircraft Establishment
Materials Department
Farnborough Hants GU14 6TD
Telex 858134 Telephone Aldershot (02521) 24461 ext 2824

FOR THE ATTENTION OF: MR C I COGHILL
Inspector of Accidents (Engineering)
Chief Inspector of Accidents
Department of Trade
Accidents Investigation Branch
Kingsgate House, Victoria Street, SW1E 6SJ

Your reference

Our reference RAE(F)MT/4/7/E1160

Date April 1981

ACCIDENT TO LOCKHEED 1011: REGISTRATION HZ-AHK AT RIYADH AIRPORT, SAUDI ARABIA 19 AUGUST 1980

Reference: Section of light alloy hydraulic pipe and various small pieces for chemical analysis.

A piece of light alloy hydraulic pipe removed from the wreckage of the above aircraft was received by Materials Dept, RAE for metallurgical examination to determine the conditions under which the pipe had burst.

The piece of pipe in question is illustrated in Fig 1. It can be seen that the pipe had split longitudinally, adjacent to a fabricated bend, and the split was followed by outward peeling of the wall. The initial split was approximately 1.5 in long.

An adherent, sooty deposit occurred generally on the outside of the pipe in the region of the burst but there was no evidence of any such deposit on the inside surface of the pipe but that on the fracture surfaces was not adherent being easily removed by a cleaning agent.

The longitudinal fracture was intergranular with a number of secondary branch cracks emanating from the primary crack. No evidence of fatigue was found and the intergranular nature of the fracture strongly suggested hot tearing conditions.

The general conclusion was that the pipe had been subjected to a period of heating during which an adherent sooty deposit had formed. This had caused a reduction in the strength of the pipe which had then burst. The state of the inner surface of the pipe and the fracture surfaces themselves suggested that no flame had been playing on this part for any appreciable time after the burst had occurred.

Micro probe analysis of various small pieces of flange section from heat exchanger Manifold to C3 cargo pit heating duct.

Four sections indicated in Fig 2 were taken from the damaged region of the above part and quantitatively analysed by electron probe. The results are as follows:

A section through glassy deposit at rim of flange, arrow 1, contained high concentrations of Ca, Si & O_2 with smaller amounts of Al & Fe. The deposit appears to be mainly calcium silicate.

Three other sections, arrowed 2, 3 and 4, through damaged zones and accretions, contained moderate concentrations of Al with Fe, O_2 and smaller quantities of Ca, Si & Mn. The base manifold material was commercially pure titanium.

P M L Smith

Fig 1 Hydraulic Pipe

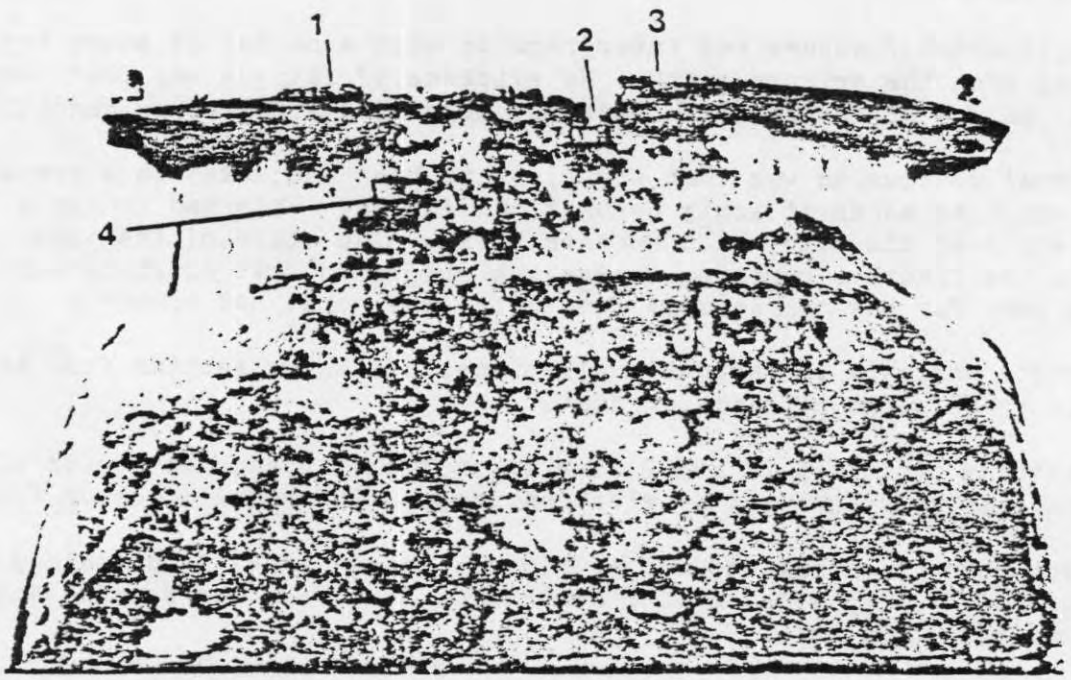


Fig 2 Flange Section from Heat Exchanger

APPENDIX L

DISCUSSION OF SELECTED AIRCRAFT SYSTEM

Due to the circumstances of this accident certain L-1011 aircraft systems and equipment were selected to be discussed in detail.

Smoke, Fire and Overheat Warning Systems

The Lockheed L-1011 operated by Saudia incorporates Fire protection systems which provide detection and in some cases, extinguishing capability. The three engine compartments, the APU and the extinguishers are provided for the engines and APU. Wheel wells have dual fire detection loops. There are detection and warning systems for Nacelle/Pylon overheat, Galley Duct Overheat, and engine bleed air duct and area overheat. Smoke detectors are located in the under-floor galley and in the AFT Cargo compartment.

1. Smoke Detection System

There are three smoke detectors in the aircraft. Two of the detectors are located in the forward end of the AFT cargo compartment (C-3). The third smoke detector is located in the Galley ceiling and does not have an A or B system designation as its sensors are independent of the loop selection switch which is located on the smoke detection panel on the Flight Engineer's upper instrument panel. Each of the above detectors controls an independent light on the smoke detection panel as well as an aural warning.

When the three position rotary selector switch is positioned to BOTH, all three smoke detectors (and the galley duct overheat sensors) are powered. Any detector unit which senses smoke will illuminate the appropriate light on the smoke detection panel and sound an intermittent aural warning in the flight station. When the selector switch is positioned to A, the system B detector in the cargo compartment is deactivated. When the selector switch is positioned to B, the A detector in the cargo compartment is deactivated. The Galley smoke (and Galley Duct Overheat) sensors and their associated circuits are powered when the selector switch is in any position.

A flashing GALLEY light accompanied by an intermittent aural warning indicates a Galley smoke condition (a steady GALLEY light with the intermittent aural warning indicates a galley oven duct overheat). A steady A or B AFT cargo light accompanied by the intermittent aural warning indicates smoke has been detected in the AFT cargo compartment by either A and/or B

smoke detectors. The AFT cargo vent valves will close automatically and the vent fan will shut off. Whenever smoke has beeh detected and the warning system activated, the aural warning can be silenced by pressing the TONE CUTOUT switch located on the SMOKE DETECTION Panel; however, the indicator light(s) will remain on as long as smoke is detected.

2. Bleed Air System

The L-1011 pneumatic system utilizes both low and high pressure air bleed from each of the three engines and air from the APU. The air is distributed to the aircraft systems requiring bleed air (Air-conditioning, wing anti-icing, engine starters and the B and C hydraulic system air turbine driven pumps), through manifolds and ducts. Three pressure indicating gauges on the engineer's ENGINE BLEED CONTROL Panel (Fig. 2) indicate pressure in the engine ducts downstream of the engine isolation valve. The engine isolation valve is electrically de-energized to open with air pressure. The Flowbar in the Engine Isolation Valve Switchlight is illuminated when the valve is open. The valve modulates to regulate the downstream pressure and also acts as a check valve to present reverse flow except during certain operations such as engine starting. A duct overheat warning system comprises continuous dual area overheat temperature sensors installed along the outside of each duct and component carrying high pressure air to detect significant hot air leakage, thermal switches with automatic shutdown of a faulty unit, and warning lights on the pilot's and engineers' panels. There are no aural warnings associated with this system.

3. Bleed Air Overheat Warnings

a. Duct Overheats: Engine bleed air duct overheats are detected by temperature sensors which are located in the duct just downstream of the ejector (which regulates the amount of high pressure air to be used, and modulates to maintain the required system temperature). A duct overheat is the result of failure of the ejector to control air input from the high pressure bleed. When this overheat is sensed, the high pressure and the engine isolation valves close (flowbars extinguish) and lock closed. They will remain locked closed until both the switches are pressed to off. The DUCT OVHT light on the engine bleed control panel and the AREA/DUCT OVERHEAT light on the caution and warning panel then illuminate.

b. Area Overheats: Two continuous loop sensors run along each duct of the bleed air system. These sensors will alarm at 255 $\pm$ 10 degrees F. When the sensor(s) detect hot air leakage from a duct, warning lights are illuminated on the engine bleed control panels and the pilot's caution and warning panel.

APPENDIX L

The bleed air system is divided into seven areas for overheat detection. Each of the seven bleed air duct areas and the left and right wing anti-icing ducts are monitored by an A & B loop sensor. If either loop detects an area overheat the related area overheat light on the engineer's panel and the AREA/ DUCT OVERHEAT Light on the pilot's caution and warning panel will illuminate. The duct area overheat lights are warning lights only. There is no automatic shutdown of the system.

An over-temperature sensed around the duct from the engine isolation valve to the cross bleed and flow control valve for systems 1 and 3 will illuminate an area overheat light D for engine No. 1 and E for engine No. 3. An overtemperature sensed around the duct from the No. 2 engine isolation valve to the ATM isolation valve will illuminate the AREA OVERHEAT Light J. If overtemperature is sensed around the duct from the ATM isolation valved to the cross bleed valves and No. 2 Pace flow control valve, AREA OVERHEAT Light H will illuminate.

The ducts from each pack flow control valve run forward through the forward cargo compartment and the forward cargo heat exchanger. An overtemperature sensed around one of these ducts will illuminate related area overheat light (A, B or C).

Since the ducts are located close together in the A, B & C runs, the duct sensors are rigged so that if one senses an overheat it will inhibit the others from providing a signal. If a duct leak occurs in the forward cargo heat exchanger compartment, a separate (compartment) sensor will turn on all three (A, B & C) pack area overheat lights. A leak in the MID or AFT Cargo Heat exchanger will illuminate the area J overheat light.

4. Aft Cargo Vent Air System

The AFT cargo ventilating system consists of an inlet fan and inlet valve, and overboard flow control valve and an overboard bypass valve. The system is controlled and monitored by the AFT cargo vent control switch located on the ECS monitor panel.

When the system is turned on by pressing the control switch, forced ventilation (Pet air) is provided in the compartment by the inlet fan drawing air from behind the main passenger cabin sidewall liner, through an inlet valve into the cargo compartment. The air is then discharged through the over-board flow control valves. During normal operation the overboard bypass valve will be open. When the AFT cargo vent switch is released, or when a signal is received from one or both of the AFT cargo compartment smoke detectors, all three valves will close

and the fan will stop, effectively sealing the compartment. When all valves have closed, the close legend in the AFT cargo vent switch illuminates. When the cool air overboard switch is released, the overboard valve closes and the overboard bypass valve opens. The compartment air will exhaust into the area behind the compartment sidewall and out the AFT outflow valve. This will reduce the volume of cabin air going overboard but still provides minimum ventilation (see Figure 12).

5. Passenger Doors and Emergency Egress

Doors

The aircraft is equipped with eight (8) doors, six (6) 42" x 76" type "A" passenger doors and two (2) 24" x 60" type "I" emergency exits. The passenger doors are normally operated electrically from either inside or outside. When opened electrically, the evacuation slide leer must be in the "Detach" position to prevent the slide from being deployed when the door is opened. To close the door, the lever must be in the "Engage" position to arm the "Close" switch.

When the door is to be opened electrically from the outside, it is necessary to pull the external (red) T-Handle down to the first detent position to move the evacuation slide selector lever to the detached position. The toggle switch, located in a small recess just below the THandle, can then be used to power the door open. Restowing the T-Handle will arm the latches to receive the girt bar and arm the close switch so the door can be closed electrically.

The L-1 door can be opened and closed mechanically from either inside or outside by use of a hand cran. The remaining doors can only be cranked open and closed from inside the aircraft.

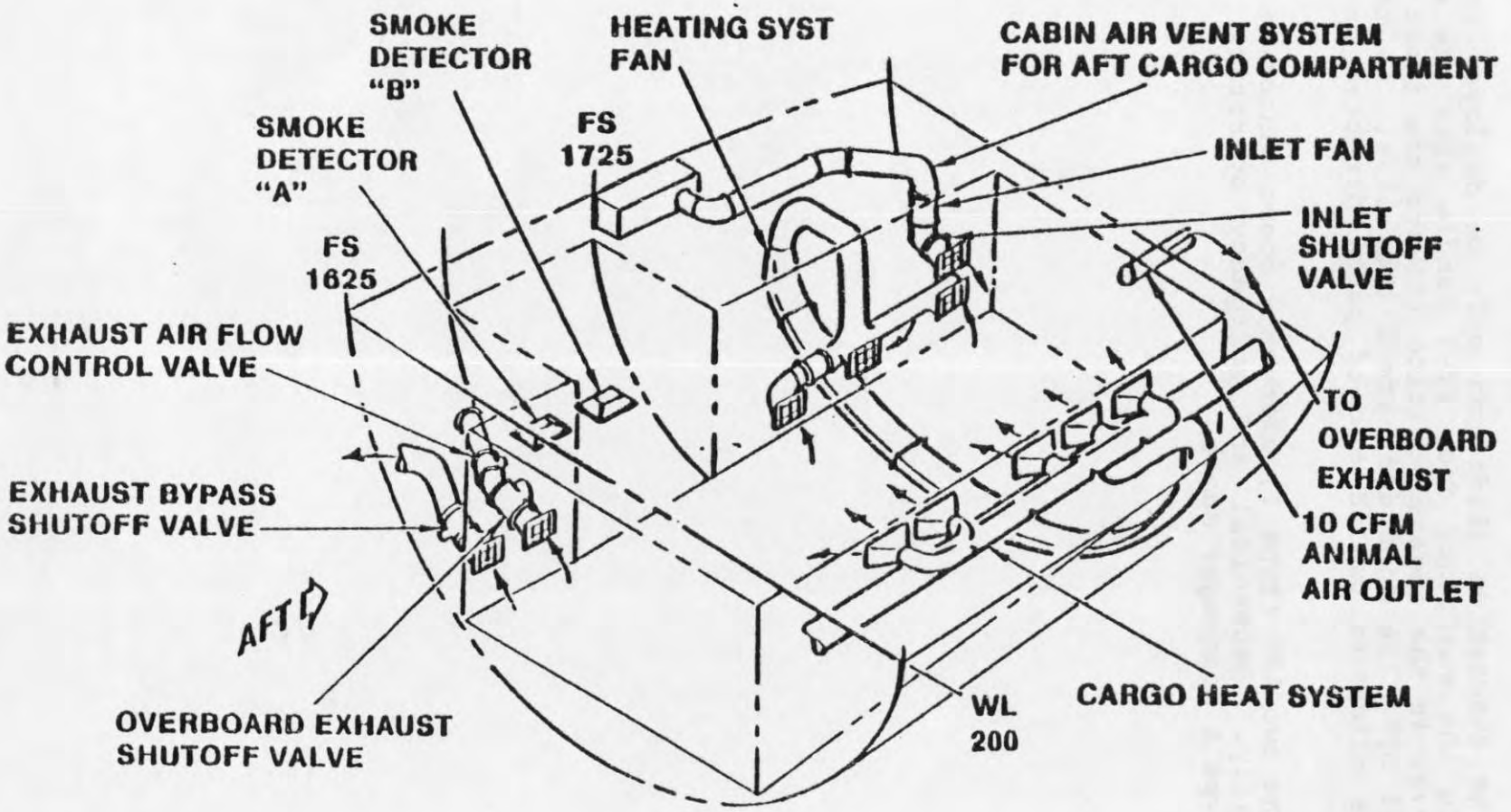
As the door is closed, either electrically or mechanically, energy is stored in a spring counterbalance to provide the energy required to open the door quickly in an emergency.

With no electrical power available on the aircraft, any door can be opened from the outside by pulling the external T-Handle all the way down. This will move the emergency slide lever to the "Detach" position (First detent), remove the lockpin (second detent) and (all the way down) release the motor clutch. The door will be driven open by the counterbalance without extending the slide. If the door is to be opened using the T-Handle from the inside without deploying the slide, the evacuation slide selector lever must be moved to the "Detach" position before the T-Handle is pulled.

APPENDIX L

The evacuation slide can only be deployed from inside. Pulling the emergency door (T-) Handle with the evacuation slide lever in the engage position (toward the front of the aircraft) will open the door and extend the slide. As the door moves up, the slide is pulled out of pack, directed overboard and inflated.

The two AFT (type I) emergency doors cannot be operated electrically. Mechanical and emergency operation is the same as the type A passenger doors.



C-3 cargo compartment heating and ventilation air systems (S/N 1169).

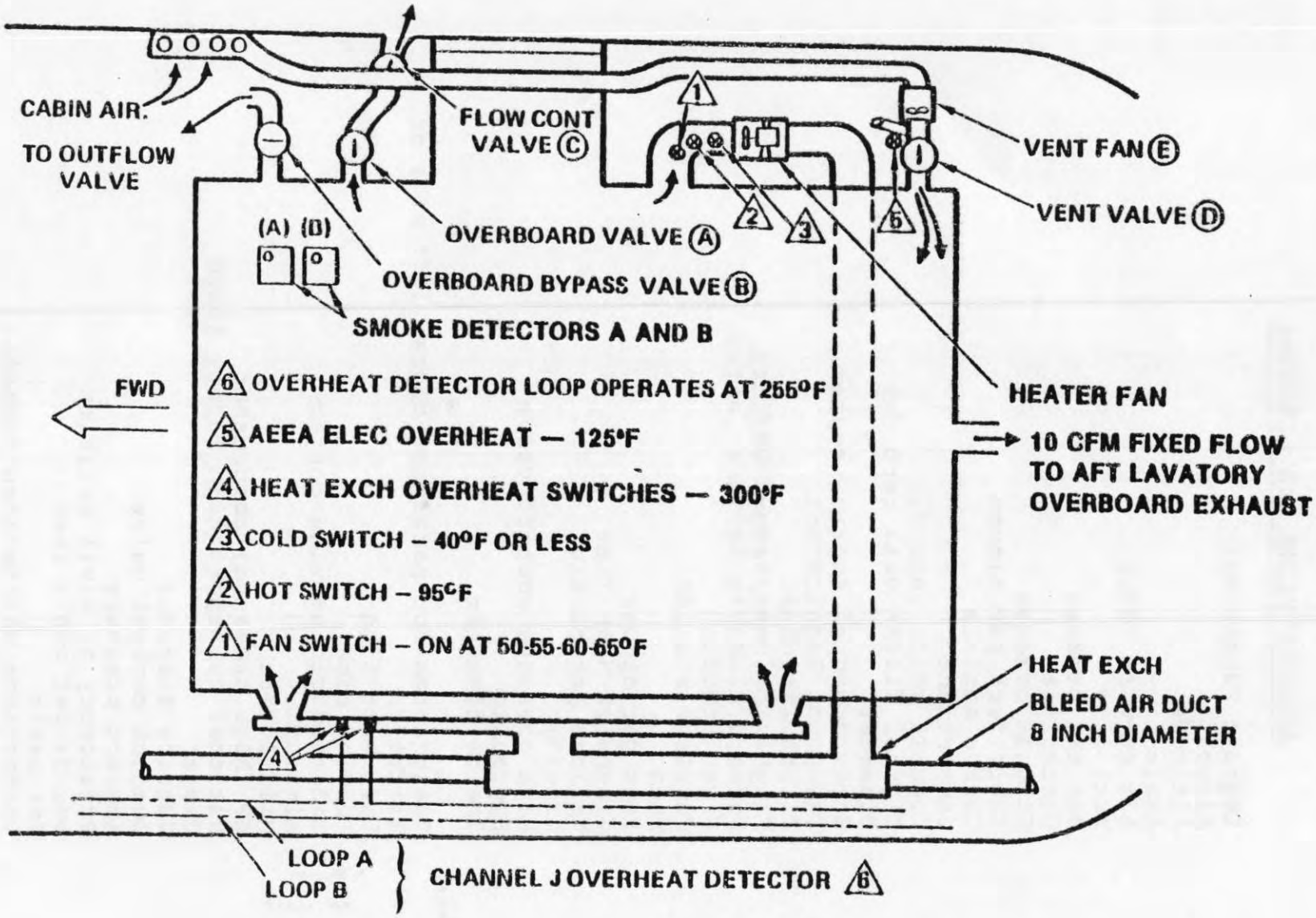


FIGURE 16

Schematic, C-3 compartment ventilation and heating system.

APPENDIX M

ABBREVIATIONS AND ACRONYMS

°F	Degrees Fahrenheit
A/C	Aircraft
alt	Altitude
amb	Ambient
ATM	Air turbine motor
BL	Butt line
BTB	Bus tie breaker
C/L	Centerline
CB	Circuit breaker
cfm	Cubic feet per minute
CO	Carbon monixde
COMPT	Compartment
CVR	Cockpit voice recorder
DFDR	Digital flight data recorder
dia	Diameter
ECS	Enrivronmental control system
ER	Equipment Requirement
F/A	Flight Attendant
F/E	Flight Engineer/Second Officer
FESC	Forward Electric Service Center
FR	Fire Retardant
FS	Fuselage station
ft	Feet
fpm	Feet per minute
GMT	Greenwich Mean Time
gpm	Gallons per minute
g	Gravity
HPSOV	High pressure shutoff valve
hyd	Hydraulic
I.D.	Inside diameter
L1, L2, L3, L4	Designation for passemger doors, left side of aircraft
LBL	Left butt line
LE	Leading edge
MESC	Mid-electric service center
min	Minimum
ML	Milliliters
N3	HP (high pressure) compressor
NTSB	National Transportation Safety Board
02	Oxygen
O.D.	Outside diameter
OFV	Outflow control valve
pamb	Ambient pressure
PCA	Presidency of Civil Aviation
pcf	Pounds per cubic feet
pneu	Pneumatic
PMR	Performance maintenance recorder
psia	Pounds per square inch, absolute
psid	Pounds per square inch differential
psig	Pounds per square inch gage

APPENDIX M

PVC	Polyvinyl chloride
QAR	Quick access recorder
R1, R2, R3, R4	Designations for passenger doors, right side of aircraft
reg	Regulator
S/N	Serial number
Saudia	Saudi Arabian Airlines
scfh	Standard cubic foot per hour
SOV	Shutoff valve
T	Temperature
TR	Transformer-rectifier
TSO	Technical Standard Order
WL	Water line

APPENDIX N

LISTING OF FIGURES AND PHOTOGRAPHS

Figures

Photographs