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EVACUATION PATTERN ANALYSIS OF A SURVIVABLE COMMERCIAL AIRCRAFT CRASH

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ABSTRACT

The evacuation pattern of 99 of 106 survivors of a jet transport crash involving a post crash fire is described, factors possibly effecting the suffocation and ultimate death of 16 passengers are listed and photographs and diagrams are presented.

FOREWORD

The data from which this preliminary report was developed was gathered through the cooperative efforts of many persons and groups in the aviation safety field – investigation personnel of the Civil Aeronautics Board, Flight Standards Division (FAA), Aviation Medical Division (FAA), Civil Aeromedical Research Institute (FAA), United Airlines, Douglas Aircraft Company and many others.

Within the Civil Aeromedical Research Institute, research personnel of the Emergency Evacuation, Survival Equipment, Physical Anthropology and Crash Safety Sections in the Protection and Survival Branch, and photographers in the Audio-Visual Service, combined their efforts as a team to investigate and analyze the results of this transport accident. Without this team effort and the assistance and cooperation of other agencies and personnel this report could not have been prepared.

NOTE: Major portions of this report were presented under the same title at the 33rd annual meeting of the Aerospace Medical Association at Atlantic City, New Jersey on April 10, 1962.

INTRODUCTION

In the past, the aviation industry – Government, manufacturers, airline operators, research groups and other experts – has paid major attention to the problem of providing rapid emergency escape facilities for occupants of transport aircraft, particularly in high density tourist compartments.

Why then, did sixteen of 122 occupants of a modern jet airliner perish while attempting to evacuate a virtually intact – but smoke filled – aircraft at Denver, Colorado on July 11, 1961?

In attempting to answer this question, this preliminary report reviews some factors which were apparently related to the evacuation pattern (developed through research investigation and analysis), the methods of determining the location of the deceased passengers, and lastly, recommends areas which appear to require further consideration and/or research in relation to preventing similar occurrences in post crash fires.

THE ACCIDENT

Prior to landing at Denver, an apparent malfunction of the plane's hydraulic system occurred and the captain declared an "alert"; three pieces of emergency fire-fighting equipment at the airport were immediately driven to and stationed near the far end of the intended runway.

Aboard the aircraft, passengers were notified of the situation by the captain, but were reassured that the landing would probably involve nothing more than perhaps a "hard" touchdown.

Insofar as can be determined, no emergency evacuation instruction was given the passengers by any of the crew members prior to the landing.

According to witnesses, the plane touched down normally within fifteen hundred feet of the near end of the runway and proceeded down the runway in a straight line for several hundred feet, before it began to veer off to the right. As it skidded off the runway, it gradually yawed to the right and slid almost sideways across open ground, striking a panel truck — killing the driver. Toward the end of this gradual deceleration, the aircraft struck the sheer edge of an incompleted taxiway, on which the aircraft finally came to rest (Fig. 1).

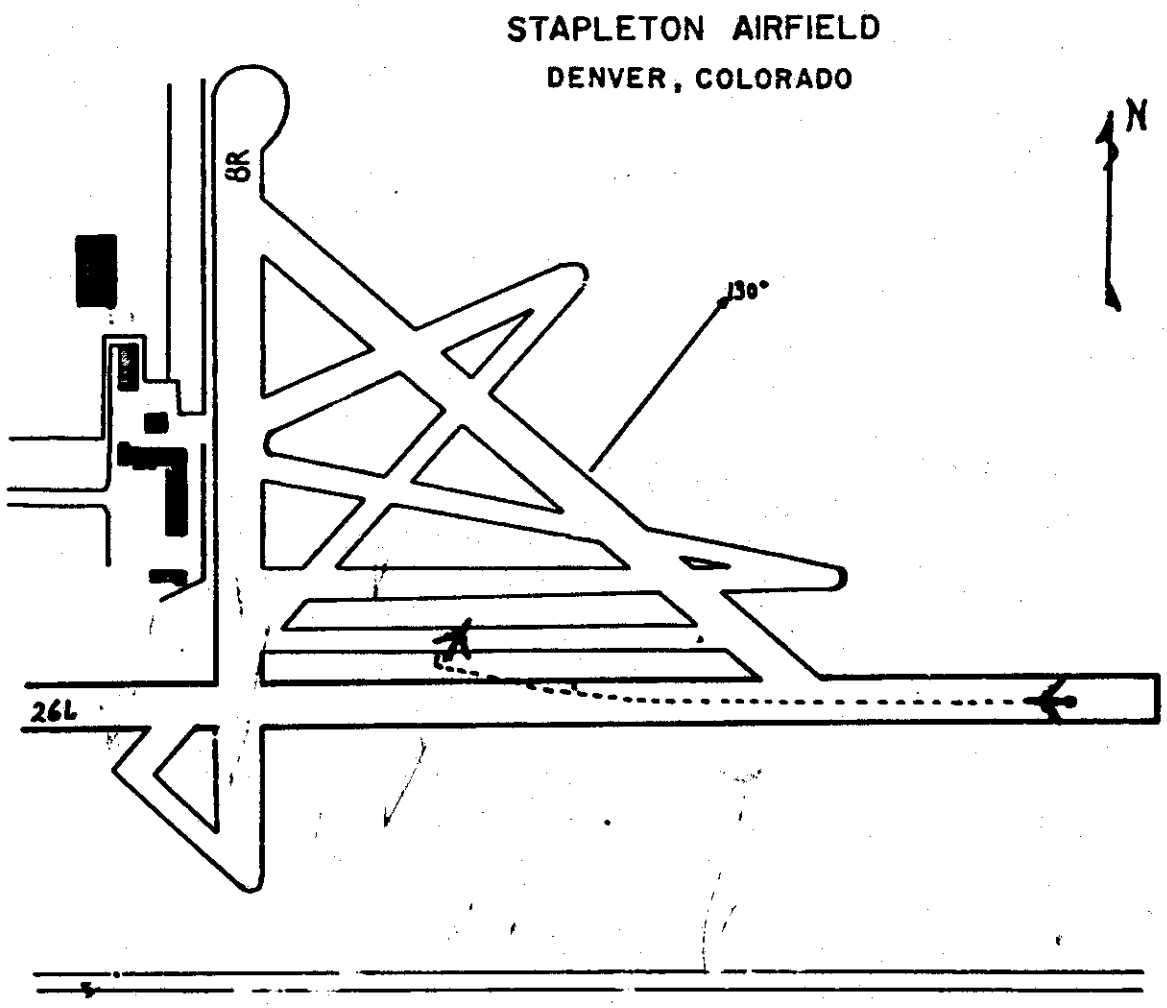

FIGURE 1

During the plane's slide across open ground, (Fig. 2) the landing gears were torn completely off and as the aircraft slid up over the two-foot high edge of the concrete taxi strip, three of the four engines tore free – small fuel fires immediately erupted near and below the forward portion of the aircraft, where several of the engines had come to rest.

Evidence indicates that decelerative forces were extremely low throughout the accident, and no impact injuries of any consequence occurred within the aircraft.

Soon after the aircraft came to rest, two major fire areas developed. One was near an engine in front of the right wing; this fire, following fuel on the ground, soon traveled to the forward righthand portion of the fuselage. The other major fire was concentrated at the left wing root, within which the number 1 engine had become lodged.

The three airport fire trucks reportedly reached the aircraft within 1 to 2 minutes after impact and were driven to an area near the right side of the aircraft, from which point the firemen vainly attempted to control the fire.

However, prior to arrival of the fire trucks and immediately after the aircraft came to rest, the cockpit crew and the stewardesses in the forward (First Class) cabin opened the forward, lefthand passenger door and deployed the evacuation chute; the chute was not inflated due to the short distance (approximately 4.5 feet) between the doorsill and the ground. The service door on the opposite (righthand) side of the cabin was not opened by the crew, because of the large fire near this exit.

FIGURE 2

Evidence indicates that 26 of the 36 first class passengers and all five of the forward crew members utilized the lefthand passenger door for escape, despite the increasing magnitude of the fire at the left wing root, which eventually consumed a major portion of the aircraft before the fire was finally brought under control (Fig. 3).

The two righthand over-wing exits were reportedly opened by several passengers, and were utilized by approximately nine of the first class passengers and eleven adults and a child from the forward part of the tourist cabin.

Since the fire was quite intense at the left wing root, it is doubtful that the lefthand over-wing exits were opened.

In the rear (Tourist) section of the aircraft, one of the two stewardesses was sitting in the lounge; the other, wearing her shoulder harness and seatbelt, sat on a crew seat directly adjacent to the rear, lefthand, passenger door. As the aircraft slid sideways to a stop, paraphernalia (pillows, magazines, and other passenger comfort items) was ejected from an upper storage locker on the righthand side of the aircraft and deposited in a pile "knee deep" against the passenger door. Due to the debris piled up against the door, the stewardess did not attempt to open it; however, due to structural deformation of the fuselage under the door resulting from impact with the panel truck (Fig. 4), the door could not have been opened by the stewardess.

FIGURE 3

FIGURE 4

The other stewardess (who had been sitting in the lounge) opened the rear, righthand service door, placed the escape chute in position, inflated it, and then started assisting the tourist passengers through this exit (Fig. 5).

FIGURE 5.

It is noteworthy that as soon as the doors and exits were opened, dense smoke began to funnel back through the entire cabin, making sight and breathing extremely difficult. It is also noteworthy (according to survivor statements) that there was little or no hysteria; in fact, there apparently was a remarkably degree of calmness displayed by most, if not all of the occupants.

Distribution of the occupants of the aircraft in relation to the number of exits utilized provides an interesting picture (Fig. 6 – it was impossible, due to legal complications, to obtain information from some of the survivors and therefore, the seating diagram is not complete). There were thirty-six passengers and five crew members in the forward cabin-cockpit area; three exits were available in this accident for evacuation of these forty-one persons – a ratio of one exit for each 14 persons.

Seventy-nine passengers and two crew members occupied the tourist compartment, for which there was only *one* exit (a service door) available for evacuation. *All of the fatalities were in this rear compartment*, whose ratio of exit to occupants was 1:81, as compared to 1:14 in the forward compartment.

As noted before, as many as 12 to 14 persons in the tourist cabin apparently went forward and used the exits available in the first class cabin. If these fourteen persons (including one infant in arms) did use the forward exits, the remaining sixty-seven persons apparently attempted to use the only other exit available in the aircraft – in the rear – but only fifty-one were successful.

In attempting to determine why all of these sixty-seven tourist passengers were unable to evacuate the aircraft through this one exit, several major factors bear scrutiny; (1) the width of the aisle between the rows of triple seats in the tourist section was 15.5 inches, or approximately two thirds of the 22 inch aisle width in the first class section. This narrow aisle width in the tourist cabin would require that the evacuating passengers stand in single file, while waiting to move toward the exit at the rear of the aircraft, (2) there were no over-wing or

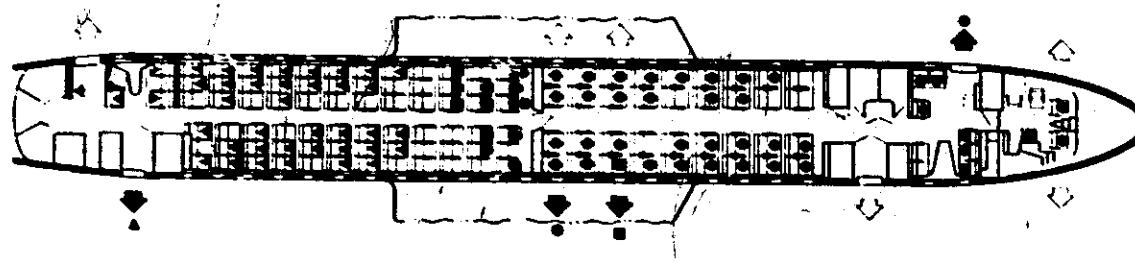

FIGURE 6.

window exits available within the tourist cabin, (3) a floor-to-ceiling partition separated the tourist cabin from the first class section, effectively blocking from the view of the tourist passengers any sight or sign of the over-wing exits available in the first class cabin, and (4) there was no placard or indication on the aft side of the partition to indicate the existence and availability of emergency exits in the first class cabin.

During the routine CARI investigation of this accident, in cooperation with the Civil Aeronautics Board, it was determined that the persons, who had succumbed from carbon monoxide poisoning while attempting to evacuate the tourist section, died in the seats shown in the lower portion of Fig. 7; these were not the seats for which they had been ticketed. It is of interest that these seats in which they died are predominantly spaced at random along the aisle. This indicates that these persons must have left their own seats and were attempting to move down the aisle toward the rear exit when they were overcome; it may be assumed that they collapsed into, or sat down in these seats to try to regain their senses and to await clearing of the aisle.

Determination of the seats in which these persons died was accomplished by detailed investigation at the scene of the accident during which evidence was obtained indicating where the occupants most likely were sitting when they were asphixiated and subsequently burned in the post crash fire.

A portion of this evidence was obtained by noting unburned areas on the covering of backrests and armrests of numerous seats (Fig. 8);

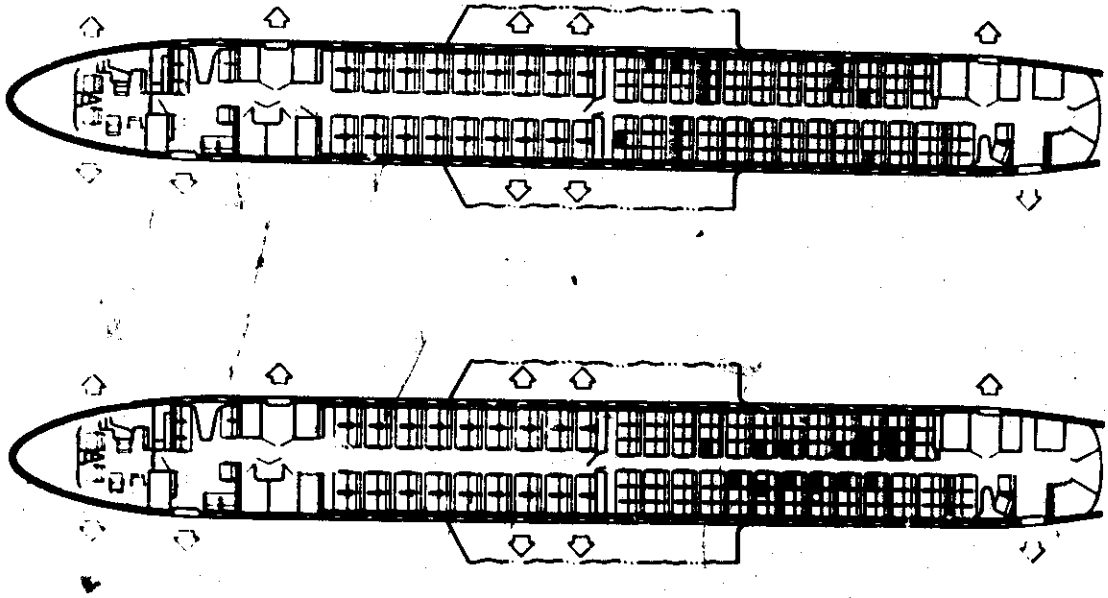

FIGURE 7.

this non-burning could have only resulted from protection of the seat covering by portions of the occupants' bodies, as indicated in Fig. 9 by the subject simulating a body in a slumped position.

FIGURE 9.

Another example of this non-burning is shown in Fig. 10, in which the center armrest is almost completely unburned, and the fabric on a portion of the backrest is not even singed. An outline of the occupants left elbow and a portion of the forearm can be seen in the aisle armrest.

Several seats were ripped out of the cabin by rescue personnel (after the fire had been extinguished) and were found outside the wreckage. Portions of the seat cushion, the seatbelt, and a part of the armrest support on one of these seats were unburned; in the seat was a ladies' jacket (Fig. 11), which the occupant apparently had been sitting on during the fire. A piece of floor track was found still attached to the seat pin (Fig. 12), effectively pin pointing the original – seated – location of one of the victims in this accident (Fig. 13).

FIGURE 10.

FIGURE 11.

FIGURE 12.

FIGURE 13

The upper portion of Fig. 7 shows the assumed location of the fatally burned persons, according to the recollections and statements of rescue personnel given during the official hearing several weeks after the accident. The variation between the location of the fatally injured persons, according to the memory of rescue personnel, as compared to the locations determined by findings of experienced investigators at the scene of the accident (as shown in the lower portion of Fig. 7), is easily apparent; this would appear to indicate that information obtained from witnesses who have been involved in a psychologically shocking experience — such as the removal of human bodies from an aircraft — should be treated with utmost caution.

SUMMARY

(1) Sixteen passengers died of carbon monoxide poisoning while attempting to evacuate an intact, modern jet transport that had been involved in a low force accident; a post crash fuel fire outside the aircraft generated a large volume of dense smoke and noxious fumes which were funneled through the passenger cabin as soon as the exits were opened.

(2) These sixteen passengers along with 65 other persons, occupied a cabin area in which aisle width was minimal and only one door exit was available — at the extreme rear of the compartment.

(3) There was no placard or other sign in this compartment indicating the existence of emergency exits in the forward (First Class) section.

(4) It was virtually impossible, due to the narrow aisle width, for cabin attendants in the tourist section to go forward and accelerate the passengers toward the rear exit.

In contrast to this:

(5) The first class cabin had *three* exits available for use by only forty-one occupants.

(6) Aisle width was approximately 40% greater than that in the tourist section.

In addition:

(7) *No* emergency evacuation instruction was given the passengers prior to the incident.

(8) The available fire-fighting equipment was unable to contain or control the post crash fire within the required time

RECOMMENDATIONS

It is recommended that:

(1) Prior to any anticipated, unusual landing situation – in which emergency evacuation might be necessary – the passengers be instructed in emergency evacuation procedures.

(2) Aisle widths in high density cabin areas be re-evaluated through a comprehensive research program in which evacuation time is related to *impaired breathing* and *sight* as may occur in a post crash fire situation.

(3) Placards or other appropriate means be utilized in transport cabins to acquaint all passengers with the location of emergency exits in other – distant – areas of the aircraft.

(4) Effective means be found through further research to contain and control post crash fires occurring on airports.

(5) Research be conducted on means of providing passengers with uncontaminated breathing air for time periods sufficient to evacuate a burning aircraft.

(6) Requirements and regulations governing the number and location of exits in transport aircraft be re-evaluated in relation to aisle width, passenger capacity and cabin compartmentation.