EMERGENCY EVACUATION TESTS OF A CRASHED L-1649

J. D. Garner
John G. Blethrow

Approved by

J. Robert Dille, M.D.
Chief, Civil Aeromedical Institute

Released by

P. V. Siegel, M.D.
Federal Air Surgeon

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I. Introduction.

The full-scale crash test of the Lockheed Constellation L–1649 aircraft was made on September 3, 1964. Upon post-crash inspection of the fuselage, it was apparent that many of the occupants might have survived the impact forces. The effect of post-crash fire on survivability was neglected for test reasons. However, it was evident that there would have been some injuries. A study of these probable injuries is included in the report No. ADS–48, "Evacuation Tests of a Crashed L–1649."

Subsequently, a working group decided to use the crashed aircraft and site for evacuation tests as a continuing phase of the over-all safety research program.

The test was planned by representatives of the Air Transport Association, Aviation Safety Engineering Research, Civil Aeronautics Board, and the Federal Aviation Agency. Four basic tests, two day and two night, were programmed.

Since the L–1649 crash was considered survivable, the fuselage presented an excellent opportunity for evacuation testing of an aircraft in a crashed condition. Due to costs of removing the heavy cargo installation forward of the wing, only the pasensger cabin aft of the cargo structure was used. This allowed the use of about forty to fifty passengers with two stewardesses acting as crew members, using a new group for each evacuation test.

A contract for preparation of the aircraft to a passenger configuration was awarded to AvSER in February 1965. Work began on the aircraft shortly thereafter with a test schedule of Test I (Day) and Test II (Night) on April 6, 1965; Test III (Day) and Test IV (Night) on April 8, 1965.

Restoration of the crashed aircraft to a practical and safe specimen was accomplished as described in Report ADS–48. A summation and analysis of passenger comments are included in Appendix 1. Stewardess questionnaire response is given in Appendix 2 of this report. The stewardesses were interviewed further on events of the evacuation and the notes taken during the interviews are reported in Appendix 3. Although the comments are short, the stewardesses' reactions are evident.

Two stewardesses each were furnished through the cooperation of ALPA, Steward and Stewardess Division; American Airlines, Trans World Airlines; and United Air Lines. These crewmembers conducted their respective evacuations according to emergency procedures recommended by their organizations.

II. Aims and Purposes.

In the four basic tests outlined, difficulties, handicaps, and obstructions and other observations were to be documented so the data and findings could be used as needed for other air transport safety programs. The general purpose of the tests was to observe the reactions of unindoctrinated passenger populations under different test conditions rather than to compare one test with another. Included in the tests for evaluation were:

1. Interior minimum emergency lighting of .05 foot-candles.
2. Exterior emergency lighting of 2 foot-candles for aid in escape.
3. A flashing strobe light in the overwing exit for passenger reaction and visibility.
4. Exit signs over doors and exit windows.
5. Passenger response to stewardess commands.
6. Debris strewn in the aisles.
7. Smoke to assess passengers' ability to locate exits with partially-obscured visibility.
8. Effects of unnautral floor angles on passenger and crew egress.
9. Rescue of injured passengers from the aircraft.
10. Rescue of infants and children (anthropometric dolls representing a 2-months-old and 2-years-old).

The data and observations were intended to:

1. Provide additional knowledge and experience useful for crew training in emergency procedures.
2. Supplement government-industry studies on emergency lighting for emergency evacuations at night.
3. Support accident investigation activities, regulatory functions and specification guidelines.
4. Provide additional information to those in aviation with related functions pertinent to emergency egress from aircraft such as manufacturers, designers, operators.
5. Point out parameters of the evacuation which need further study under more controlled laboratory conditions.

III. Facilities and Equipment.

AIRCRAFT

The crashed L-1649 came to rest on a twenty-degree hill and the fuselage broke into three separate sections—nose, center and tail. The nose section broke at the top about two and one-half feet aft of the left main cabin door. This section rested at about six degrees downward pitch. It was connected to the center section by floor and sub-structure. The second break occurred just aft of the galley. This break at the top of the fuselage left the tail section connected to the center cabin by floor beams, however, with less upward deformation of the floor than at the forward break. The center portion of the fuselage was resting at about twenty degrees upward pitch. The aft section rested at a thirty-two degree upward pitch. The cabin floors in the tail and center sections were practically free of distortion, allowing the flooring in the area to be restored except for the angle change at the aft break (See Figure 1).

All exits in the test area of the cabin were operable after the crash. These exits were the two right and two left overwing window exits, the left galley door and the aft right exit. The window exits on the left side of the fuselage were made inoperable because of the ragged, torn and shredder metal outside each exit. The left forward main door and right crew door near the flight deck were damaged in the crash and excluded from the test.

The aft right exit sill height varied from 32 inches to 33 inches from the ground. The exit was a plug type, so that when the latch pins were retracted, the stewardess lifted or dragged it out of the way for evacuations. The door weighed 46-½ pounds. The window exits were also plug type. The forward overwing exit weighed 40 pounds; the aft overwing exit window weighed 36 pounds. Window exits measured 19 x 26 inches; the door exit was 24 x 65-½ inches.

EMERGENCY LIGHTING

Installations for the emergency lighting were included in aircraft preparation. The .05 foot-candle interior lighting was accurately set by a Pritchard Spectrophotometer furnished and operated by a representative of the Photo Research Corporation. This emergency cabin light level is a current requirement for air carrier aircraft. Measurements were taken at 40-inch intervals at arm rest height in the cabin aisle, starting 40 inches aft of the forward temporary bulkhead separating passenger cabin from the cargo area and moving rearward.

Distance from Forward Bulkhead	*Meter Reading*
40 inches	.035 foot-candle
80 inches	.042 foot-candle
120 inches	.047 foot-candle
160 inches	.050 foot-inches
200 inches	.048 foot-candle
240 inches	.050 foot-candle
280 inches	.052 foot-candle
320 inches	.048 foot-candle
360 inches	.048 foot-candle
400 inches	.051 foot-candle
440 inches	.051 foot-candle
480 inches	.052 foot-candle
520 inches	.050 foot-candle
Average Level—	.048 foot-candle

The first three readings were lower due to a lack of available overlapping lights forward of the first meter reading. Illumination levels were checked toward the sides and were found to fall off progressively as the meter was moved sideward from the center of the cabin as follows:

Right Side (Triple Seats)	*Left Side (Double Seats)*
In Aisle Seat	Aisle Seat
.044 foot-candle	.032 foot-candle
In Middle Seat	Middle Arm Rest
.029 foot-candle	.023 foot-candle
In Window Seat	
.021 foot-candle	

Outside emergency lights were mounted over the aft right door and one over the two overwing

FIGURE 1.—A general view of the wreckage on the 17° to 20° slope.

exits and set at 2 foot-candles on the ground for the aft right exit and at both the leading and trailing edges of the right wing for the overwing exits. This exterior lighting had been considered by the SAE A–20 Aircraft Lighting Committee in their preliminary draft revision of ARP 503A as an aid to evacuees outside the aircraft in night emergencies. Near the windows and on the wing surface, the intensity was higher (but not measured) in order to achieve the 2 foot-candle level set at both leading and trailing edges. These were aircraft spot type bulbs adjusted by reduced voltage taps from wet cell batteries.

TAPE RECORDING EQUIPMENT

Three microphones were placed in the passenger areas on the left hat rack shelf. Number 1 was forward (over seat rows 1 and 2). Number 2 microphone was placed in front of the galley, forward cabin, and Number 3 in the aft cabin area about three feet aft of the galley. Number 1 microphone (forward) was recorded on the right channel of an Ampex dual channel recorder; Number 2 (center) and Number 3 (aft) microphones were recorded on the left and right channels respectively of a second Ampex recorder. Thus, during the tests, three microphones were recorded simultaneously on three channels of two stereo recorders as shown in Figure 2.

In-flight sound effects were played over two speakers from one recorder. One speaker was placed forward of the low wall separating the front passenger cabin and cargo section; the other was in the upper open storage (or baggage compartment) built in the left aft portion of the galley, so it was heard in the aft cabin. While the passengers were waiting for the test to start, music was played through the two speakers. At the beginning of the test, the music tape was removed and replaced by the sound effects tape containing cruising engine sounds. Near the end of the engine sounds came an announcement by the Captain of an impending "belly landing" and crash-landing noise. The end of the crash sound was the signal for the test operator to turn on a switch which triggered a series of flash bulbs, both inside and outside the cabin, and a bell. The bell and the bulbs identified the start of the test on motion pictures and tape recordings. The recorder with the forward microphone was turned on before the crash sounds occurred. The other recorder playing the sound effects tape was quickly switched to "Record" at the end of the crash sounds and documented cabin activity through the center and aft microphones.

FILM COVERAGE AND CAMERA LOCATIONS

The two day tests were photographed with 16 mm color motion picture film at 24 frames/second inside and outside of the aircraft. For night tests, infra-red sensitive film was used and run at 4 frames/second because of existing low-level illumination. Numerous still photographs were taken of events and facilities in color and black and white.

The overall motion picture coverage was interrupted by a number of electrical and mechanical malfunctions of cameras and associated equipment. Cameras were positioned inside the fuselage as follows:

1. Camera Number 1 was mounted forward of the passenger area to view the cabin looking aft. This camera functioned during all tests.
2. Cameras Number 2 and 3 were mounted in the hat rack over the forward right overwing and aft right overwing window exits respectively. Camera Number 2 ran on Test IV only and Camera Number 3 ran on Test III only, due to defective switches and circuitry.
3. Camera Number 4 was mounted in the aft right lavatory viewing the general area in the cabin and looking forward. This camera ran on Tests II and IV but failed on Tests I and III.

Two camera positions were set up outside on the right side of the aircraft as follows:

1. Camera Number 5 was placed 38 feet from the fuselage over the right wing on a six-foot-high platform for coverage of the overwing exits. This camera ran on Test I only and became inoperable due to a short circuit.
2. Camera Number 6 was positioned 25 feet directly abreast of the aft right exit on an adjustable tripod. Following the failure of Number 5 camera, this camera was moved to a position 15 feet from the fuselage and eight feet aft of the right exit as Camera Number 6A. Both aft exit and overwing were included in the view. Tests II, III and IV were photographed from the outside by this camera.

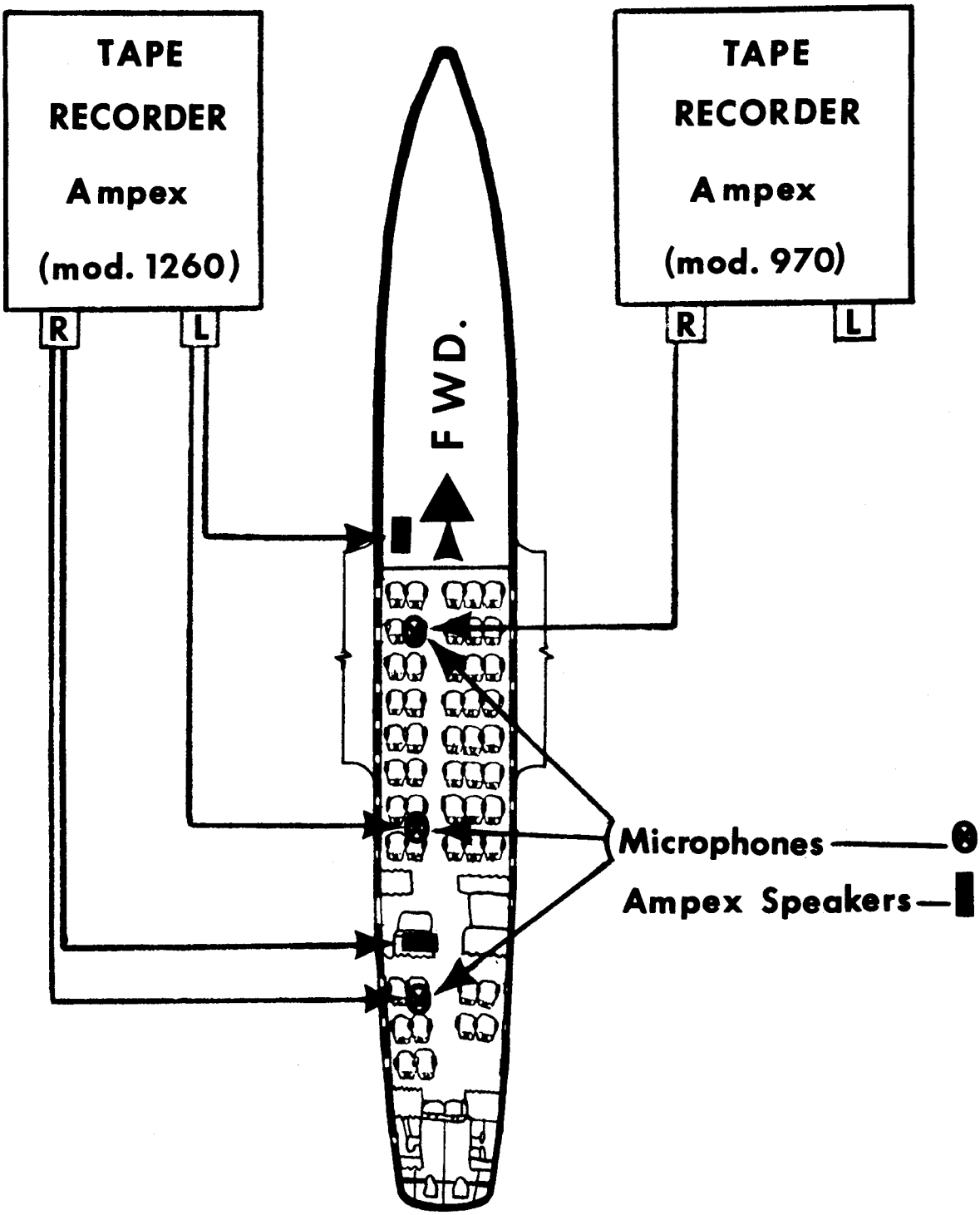

FIGURE 2.—Microphone and speaker positions for all tests.

Actual camera locations for the tests are shown in Figures 3 (Tests I and II) and 4 (Tests III and IV).

All possible prefabrication and construction was done at the FAA Oklahoma City Base and transported to the test site. This included the remote camera control system and outside platforms. Flourescent light units were assembled

for use inside the aircraft for color photography during the two day tests. A multi-outlet power station supplied electrical power for cameras and instrumentation.

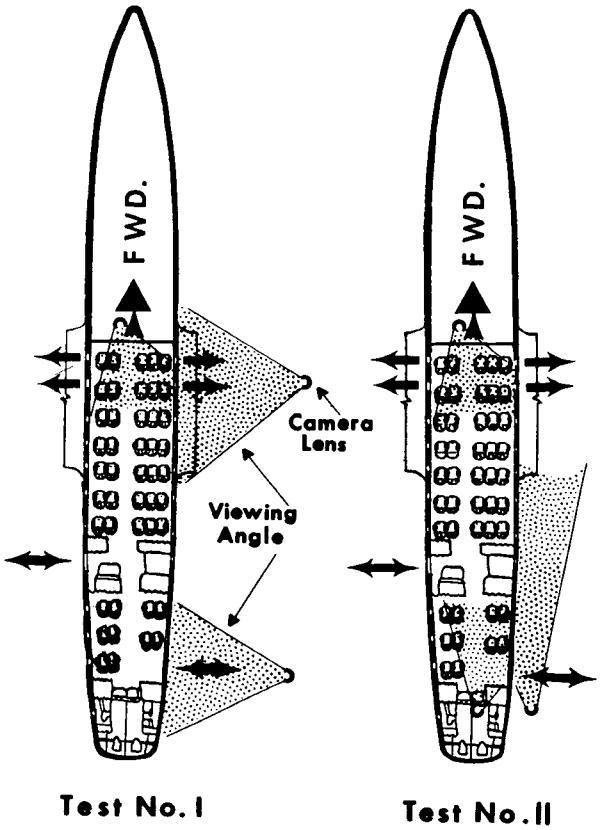

FIGURE 3.—Camera positions and viewing angles for Tests I and II.

SEAT BELTS

All seat belts were the web-through-buckle or slip-through type with varying anchor-to-buckle distances. The buckle segment was fastened to the left anchor of each seat. A few belt buckles, on small individuals, ended up on their far right side and were more difficult to release.

OTHER ITEMS

Placards—Radioactive type exit signs or placards were installed over the galley and right aft exits. One placard which had arrows pointing to the overwing exit was hung from the ceiling in line with these exits. One other placard, also with arrows, was mounted between the two adjacent right overwing exits with an arrow pointing toward each exit.

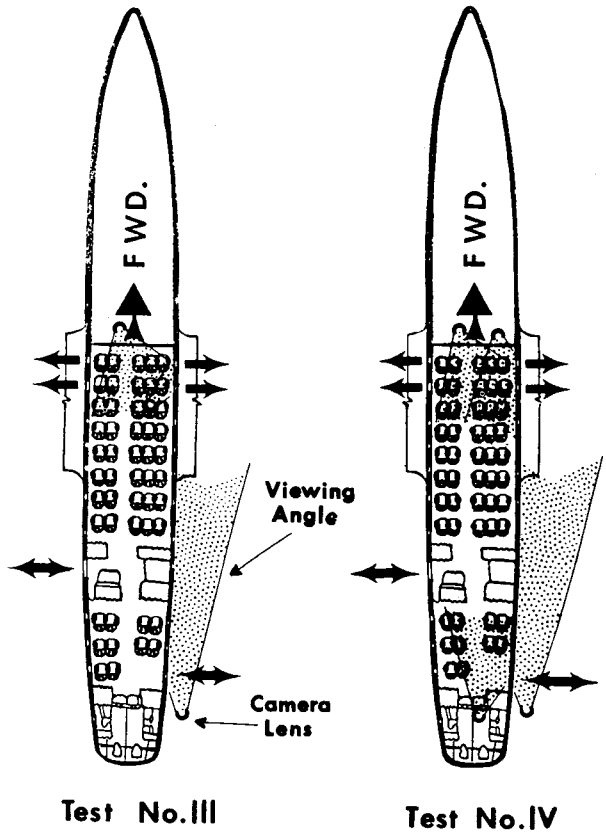

FIGURE 4.—Camera positions and viewing angles for Tests III and IV.

These placards were similar to those currently in use aboard some commercial transports. The Society of Automotive Engineers, A–20C Subcommittee, was interested in an evaluation of these placards and supplied them.

Smoke—A smoke generator was operated from the aft left lavatory area and produced a dense whitish cloud of non-toxic smoke. Because of the pitch of the fuselage, the smoke moved forward through the galley into the forward cabin at a fairly constant rate, especially after the aft door was opened which caused a chimney type draft.

Seats—Used double and triple L–1649 seats were installed for the test. Thirty-five passengers in seven rows (5 seats per row) in the forward cabin, with 39-inch fore-aft spacing, were used for Tests I and II. Two and one-half rows (double seats) spaced 39 inches provided ten seats in the aft cabin for all four tests. In Tests III and IV eight rows (5 seats per row) were installed, providing forty seats with 32-inch fore-aft spacing in the forward cabin.

Clocks—Precision clocks were used to time events. The Number 1 camera (forward inside) had one clock in view, and camera Number 5 (outside overwing) had another clock in view. The master control switch which set off flash bulbs and the bell also started the clocks.

Strobe Light—A flashing light in the aft right window exit between panes was manually turned on from outside for each test. The Fire and Rescue Committee of ALPA was interested in an evaluation of the light and provided a second flashing component for Tests III and IV which was installed in the forward right overwing exit. These lights flash fifty times per minute with a two-million lumen point source. They are capacitor discharge type through a xenon gas-filled tube. The filaments were imbedded in solid plastic for impact protection.

IV. Test Description

TEST I

The two stewardesses acting as crewmembers were made familiar with the window and door exit operations on the aircraft before the test. Essentially, the only other instruction given was for them to perform their normal functions for evacuating the aircraft, consistent with their training, as signalled by the end of the crashing sounds and light flash.

The first test occurred in the mid-afternoon of April 6, 1965. Forward of the galley, seven rows of five-abreast seats were available with 39-inch fore-aft spacing. In the aft portion of the cabin ten passenger seats were available with the same 39-inch spacing. Forty-four passengers were boarded in a population distribution as required for air carrier demonstrations, i.e., 57% male adults, 30% female adults, 8% children and 5% over sixty years of age. Two dolls were placed randomly aboard, one simulating a two-year-old child (50 pounds) and the other designed to represent a 95th percentile (by weight) two-months-old infant (13 pounds). Three anonymous "injured" passengers were placed in the last row of the forward cabin, and a fourth in the last aft left window seat in the rear cabin.

Two light-weight cardboard packages of about one cubic foot each, three briefcases and two small wrapped packages were scattered in the aisles before the test started.

A fire truck started from about 1,000 yards away at the signal and rolled up within 35 feet of the aft right exit with its siren going. The siren added materially to the realism of the tests.

Slip-over numbered jackets were used in all tests for identification of passengers.

Neither the crew nor passengers knew which exits were operable. The left galley door (route of entry) was de-activated and the left overwing exits previously bolted shut. Following the meal serving, the music tape was removed and the cruising engine sound-effects tape put on. Limited instructions were given to the passengers for their imaginary flight from Los Angeles to Phoenix, Arizona. The Captain's statement followed fifteen minutes of the cruising engine sounds:

> Ladies and Gentlemen, this is your Captain speaking. We are about to land at the Sky Harbor Airport in Phoenix in approximately one minute. You may notice some emergency vehicles on the field. This is a precautionary measure due to the fact that we cannot be sure that our nose gear is fully extended. We believe that it is extended. Please do not be alarmed. We expect a normal landing. If there is any difficulty, follow the instructions of your stewardess.

As soon as the Captain finished,the forward stewardess gave continuous instructions from her seat area in the galley for preparation for the landing. At impact, passengers were in impact position with their heads down.

The crashing sounds ended with the flash and the bell. The aft stewardess had the door, five feet from her, open within 3.6 seconds. The forward overwing exit, after some difficulty was opened in 6.5 seconds by a man sitting next to it. He passed the exit to another man who leaned it against the forward wall. Smoke filled the aft cabin very quickly and moved forward through the main cabin by the time ten people had gone out the forward exit (49 seconds from test start). The aft right overwing exit was never opened; however, a passenger was heard stating that he had attempted to open it.

The forward stewardess first attempted to open the left galley door directly to her left, but could not open it. She then "gathered up clutter" in the galley aisle between the fore and aft cabins. She began shouting, "Get those doors open" to prompt those by the window exits to open them.

The forward microphone recorded these commands throughout the test. She then moved forward through the passenger-filled aisle and arrived at the overwing exit area about twelve seconds from the start as the second person went out. She shouted instructions as she moved. Two male passengers and the stewardess tried the left forward overwing exit without success. The stewardess remained between the left first and second seat rows while shouting "leg-body-leg" and "keep moving." "Help each other when out on the wing," and when the smoke arrived, "get down low so the smoke won't get you." She went to the right aft window exit when she realized it was unused, but noticed the cabin was almost empty (1 minute, 10 seconds from test start) and abandoned the effort. The passenger flow was steady from the right forward window exit throughout the test (Figure 5). The first man (22-year-old) came out head first in a "dive" fashion while all others used leg-body-leg motions with either right or left foot first on the wing. The stewardess checked seats on her way aft and went out the aft door. Step-up distance between cabin floor and exit sill for the overwing was 23½ inches and step-down to the wing was 27 and 32 inches for the forward and aft overwing exits respectively. These step distances prolonged individual exit usage times which averaged 3.78 seconds per person for Test I from the start signal until all were clear of the exit.

Twenty-one passengers and a 13-pound doll were clear of the window in one minute and 19.4 seconds, and clear of the wing in one minute and

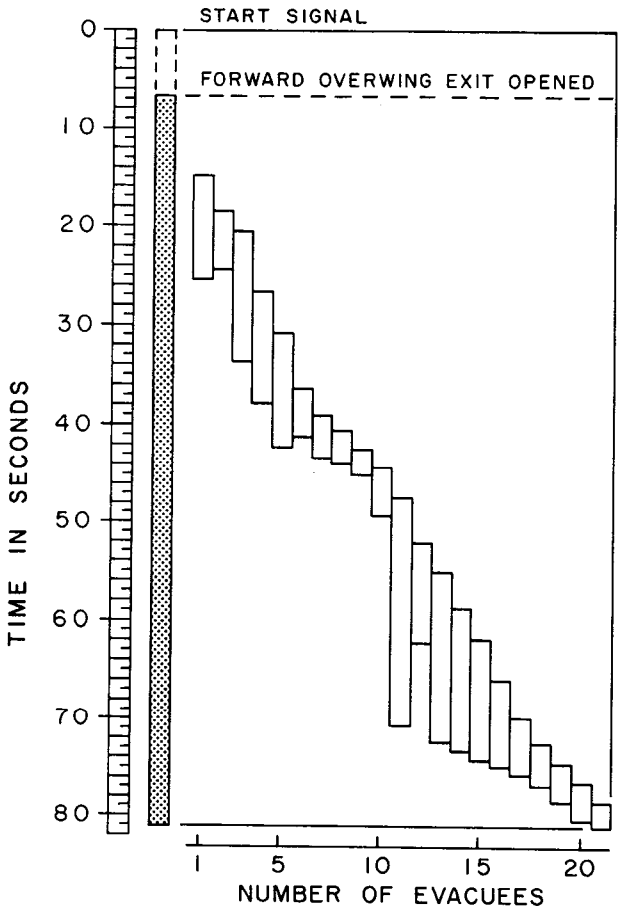

FIGURE 5.—Individual evacuation flow from the right forward overwing exit in Test I. The rectangular blocks represent each of the 21 persons and show the time the exit was in use by each individual.

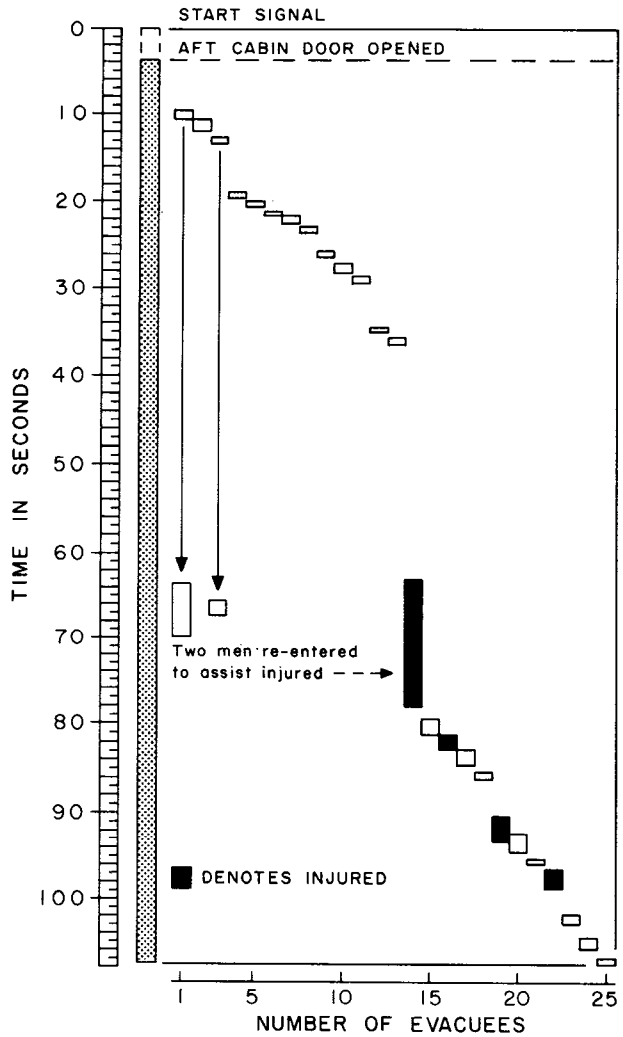

FIGURE 6.—Individual evacuation flow from the right aft door exit in Test I. The rectangular blocks represent each of the 25 persons and show the time the exit was in use by each individual.

21 seconds. Four males and two females went off the leading edge of the wing. Eight males and seven females went off the training edge. Women with tight skirts had difficulty clearing the window sill. All except three women who went aft off the wing removed their shoes after getting out on the wing. Most women sat and slid to the ground.

The flow from the right aft door was fairly steady with slight delays after the third and eleventh persons out. An "unconscious" man from the rear left window seat was the fourteenth person out. The first two men out of the door re-entered to get this "injured" passenger. The group fell against the aft bulkhead, then the "injured" man was placed in the doorway with his head hanging over the sill face down. These actions blocked the exit for almost half a minute (27 seconds). The aft stewardess directed passengers from a position back of the door generally moving only to direct help for the "injured." Nine passengers, including three "injured" from the forward cabin, and the stewardesses evacuated the aircraft within the next 26 seconds. The total time was one minute and 47.8 seconds. No major accidental injuries were incurred during the test. The evacuation flow is shown in Figure 6.

A sketch of camera coverage is shown in Figure 3. Tape recordings were obtained of the test from the three microphones inside.

TEST II

The two stewardesses scheduled for Test II were taken aboard the aircraft about an hour following Test I. They were shown the operation of the exits. Instructions were similar to those for the previous crewmembers, i.e., "At the end of the crash sounds and flash, evacuate the aircraft as fast as you can in accordance with your training." Additionally, they were asked to make a seat belt check for the landing and to make sure everyone was out after the evacuation, consistent with their training.

The seating arrangement was the same as for Test I (45 available seats). A different group of forty-four passengers boarded after dark through the left galley door. Flood lights provided lighting outside and two rows of fluorescent lights brightened the interior of the aircraft.

After the box meal, the two briefcases, three cardboard boxes, one blanket and six aircraft pillows were randomly placed in the aisle. Instructions to the passengers were completed; the music tape was changed to the sound effects tape, and cruising engine sounds played for about twelve minutes. The Captain's announcement of nose gear trouble was heard as in Test I. A small fire from gelled fuel had been set outside on the left of the fuselage and was glowing.

Although the two stewardesses had observed the afternoon evacuation from outside and were aware of the "injured" aboard and of the exits used, a premature starting signal created an unplanned situation.

Both stewardesses were distracted by the fire truck siren from outside and the premature flash. However, at the end of the crash sounds, the aft stewardess quickly was at the aft door, got it open, and one person was out on the ground before the main cabin lights were turned off eight seconds after start of the test.

The stewardess shouted, "Unfasten seat belts—Come to rear," while opening the door. A man carrying an "injured woman" aft tripped on the sloped floor. The aft stewardess tried to help and all three of them fell against the aft bulkhead. The "injured" women was "pinned" in the doorway for a short while. The forward stewardess brought an "injured" man rearward, directed help and returned to the forward cabin. Another "injured" male in the rear left window seat was helped to the door without difficulty and aided by a man standing outside on the ground. The aft cabin was emptied in two minutes and 53 seconds.

In the forward cabin at the end of the crash sounds, the forward stewardess shouted to the men beside each of the overwing exits to open them. She had moved about two rows forward of her seat when she heard cries for help and found an "injured" couple in the row of seats just forward of the galley on the right side. A man behind her from the aft cabin offered to help. This man took the women to the aft exit. The stewardess then dragged the man to the aft cabin where she directed the evacuation as noted above.

While the forward stewardess was occupied with the "injured," the right overwing exits were opened and evacuation began. Some difficulty was encountered in getting to the forward window exit because of the location of the first row

window seat back which was abreast of the forward portion of the window. The exit was removed between seat rows 1 and 2 with the row 1 seat back pulled forward by the occupant. A female passenger from the center seat, first row, was seen to step over the window seat back into row 2 and out of the forward window exit. This passenger stated she was the second person out. The other passengers from the first row, except the "injured" man in the right aisle seat, also climbed over the front row seat back and approached the forward window from row 2. (In Test I, the front row passengers walked around the seat to go out.) Although many noticed the "injured" man slumped over in his seat no-one stopped to assist him in getting out. It was difficult to determine details of this exit from the film taken under the .05 foot-candle illumination, but the seat back obstruction was confirmed by observing this window after tests.

There was less difficulty in getting to the aft window exit between rows 2 and 3, once the exit was removed. However, it was opened approximately 32 seconds after the forward exit and evacuation flow was constant. There was a waiting line of passengers for both exits until all were out.

When the forward stewardess re-entered the forward cabin, heavy smoke had filled the area, making it necessary for her to feel her way. Most passengers were outside by this time. The stewardess then found an "injured" man in the front right aisle seat and shouted for the aft stewardess to help. Because of the heavy smoke and lack of visibility, the forward stewardess found the loose end of the seat belt and thought it was unfastened. She attempted lifting the man but realized the belt was still fastened. It took both hands to unfasten the belt, "...while I needed one hand free to hold him back from slumping over it," she stated. The aft stewardess arrived quickly and the two struggled with the man for approximately 22 seconds. The stewardessess felt that his weight (210 pounds) was the prime reason they could not move him. They left him and went out the forward window exit. The stewardesses were last out of the aircraft except the "dead man" in three minutes and 6½ seconds.

The dependence of passengers on the action of the stewardesses is noteworthy in this test. Aisle debris was quickly kicked out of the way and seemed to cause very little trouble to passengers on their way out.

The outside emergency lights suddenly went out just before the aft door was opened and evacuation started. In spite of power failure the evacuation was successfully completed using the rotating beacon from the fire truck and flashlights.

The only injury experienced was one bruised and scraped left hand by a male passenger who helped remove two "injured" and assisted with a third. This passenger scraped his hand on the door sill or floor in the scurry.

A high-speed, infra-red, sensitive film (HIR) was used for documenting the night tests (II and IV) and was run at approximately five frames per second. Camera locations for this test are shown in Figure 3.

Analysis and further details are included in Test Results Section.

CRITIQUE SESSION

On Wednesday, April 7, 1964, a session was held to discuss Tests I and II. It was agreed that five items could be changed or included in Tests III and IV which would add to information gained from the tests. These changes were:

1. Obstacles placed in the aisles before tests were being observed by the passengers and plans were apparently made to get them out of the way. Therefore, the stewardess responsible for aisle debris was asked to delay placing these obstacles in the aisle until just before the starting signal.
2. The Captain's announcement on the sound tape was revised to provide a five-minute interval between his announcement and the crash sounds. The comments were also changed to delete remarks relative to nose gear trouble. A regular landing announcement was substituted and referred to local weather conditions and five-minutes until landing. The one minute interval previously used created some confusion among the stewardesses whether the emergency was considered to be a planned or unplanned event. Also, one minute did not allow stewardesses sufficient time to brief the passengers and be in their seats at "impact."
3. The cruising engine sound time was decreased from 15 minutes to about ten minutes or less.

4. More stewardess instruction time was provided, especially for procedural seat belt checks and passenger briefing.
5. Ropes were installed in the overwing exits to obtain additional evaluations on the use of the ropes.

TEST III

Stewardesses for the test were shown how to open the aft door, the galley door and the overwing exits. Similar to the instructions given the stewardesses in the previous tests, they were told to evacuate the aircraft as quickly as possible at the end of the crash sounds. They were instructed to direct passengers to use the ropes at the overwing exits. They were also asked to make a regular seat belt check before landing.

Fore-aft seat spacing was 32 inches, providing eight rows of five-abreast seats forward. There were five double seats aft of the galley with 32-inch spacing.

The change in the Captain's announcement gave this crew no warning of an impending crash. When crash sounds came, there was no advice from the flight deck to help the stewardesses in their decisions.

Forty-five passengers were boarded through the aft right door and were seated. Two infant dolls (13 pounds) were also boarded, one in the aft cabin, first row, right window seat and one in the forward cabin, fifth row, right window seat. A fifty-pound doll was placed in the second row, left aisle seat in the aft cabin. The same four "injured" passengers were anonymously boarded, one in the aft cabin in the last row window seat, two side-by-side in the two seats just forward of the galley on the right side, and the fourth in a window seat on the right side, fourth row. Representatives of the news media were invited aboard before test time and were allowed about twenty minutes for their interviews and pictures.

Following the meal, the sound-effects tape was played through an outside speaker additionally mounted on top of the fuselage for observers outside the aircraft. Since the Captain's announcement had been changed for this test, the stewardesses did not at first associate the crash sounds with an emergency. However, the aft stewardess opened the aft exit in 2.9 seconds. The first passenger was on the ground in eleven seconds. Smoke was introduced into the cabin almost immediately, but the evacuation continued with a reasonably steady flow (Figure 7). The aft stewardess guided the evacuation quite efficiently. Her requests to passengers for help with "injured" and "come this way" were made in a controlled voice which was recorded over the unexpected low noise level by the aft microphone on the left hat rack. Most of the time she stood back of the aft exit giving passengers directions. Twenty-one persons, including three "injured" and two dolls, cleared the aft exit in one minute, 35.9 seconds.

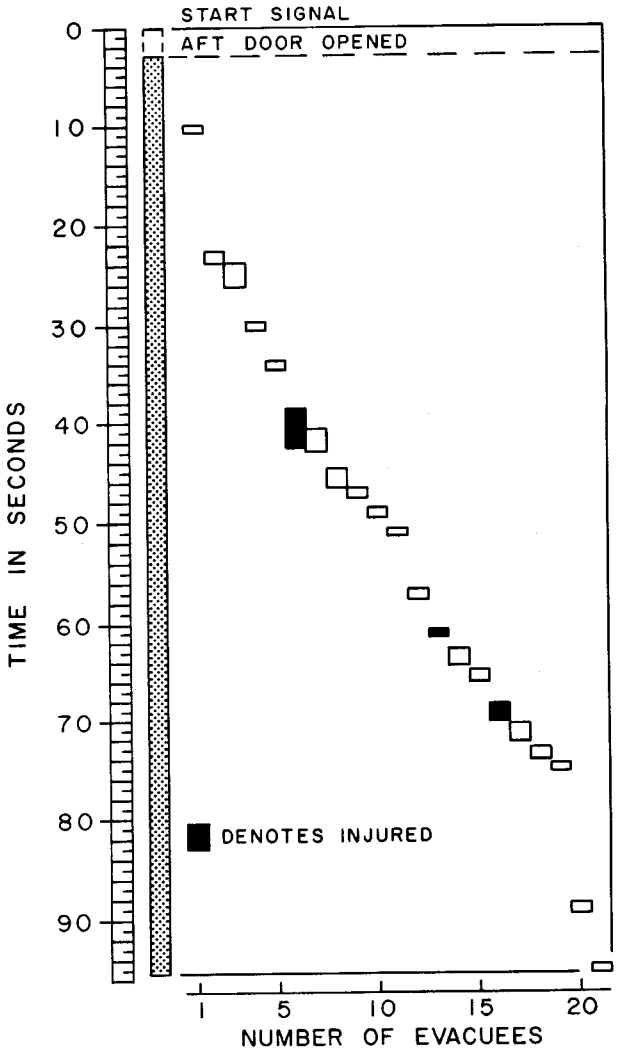

FIGURE 7.—Individual evacuation flow from the right aft door in Test III. Rectangular blocks represent each of the 21 persons and show the time the exit was in use by each individual.

The forward stewardess at the start of the test first tried opening the galley door, then gave the command to "Unfasten seat belts. Go out back.

Watch incline." She discovered the "injured" promptly after she saw passengers opening the right overwing exits. At the direction of this stewardess, two men helped evacuate the "injured" female through the aft door from the right seat, first row, in front of the galley. Another man evacuated the "injured" man who was sitting to the woman's right through the aft door. The forward stewardess then moved toward the overwing exits giving commands to "hurry," "go this way," and "leg-body-leg." Smoke then began filling the forward cabin while only eight or nine passengers still remained. The stewardess requested help for an "injured" man in the fourth row. The helper used a fireman's carry and quickly delivered him to the forward exit feet first. The help of a male passenger from outside on the wing enhanced removal of the injured. The forward stewardess called for the aft stewardess to come forward and check the seats to assure that all passengers were out. After this check the aft stewardess quickly went out the aft door.

In the forward cabin, there was a period of 12½ seconds after the test started before the first attempt was made to open either overwing exit. The forward exit was opened and the first person was on the wing in 23.75 seconds. The first person was on the wing from the aft overwing exit at 41.75 seconds from the start.

The 32-inch seat spacing provided two conditions to be evaluated during Tests III and IV. One condition was the minimum spacing for effects on the passenger flow to the exits. The second condition was the placement of a passenger seat back, when in the upright position, abreast of the center of the aft overwing exit window. This condition caused delays by partially blocking removal of the inward opening plug type exit by the passengers.

Following removal of the exit, at first there was a vying for approach to the exit opening from both the second and third rows. Two men were first out from the second row, followed by a women and two children (seven and nine years old) from the third row. Another female passenger and three males continued steadily from the third row followed by the forward stewardess who was last out of this exit. Individual escape times from both overwing exits are shown in Figure 8.

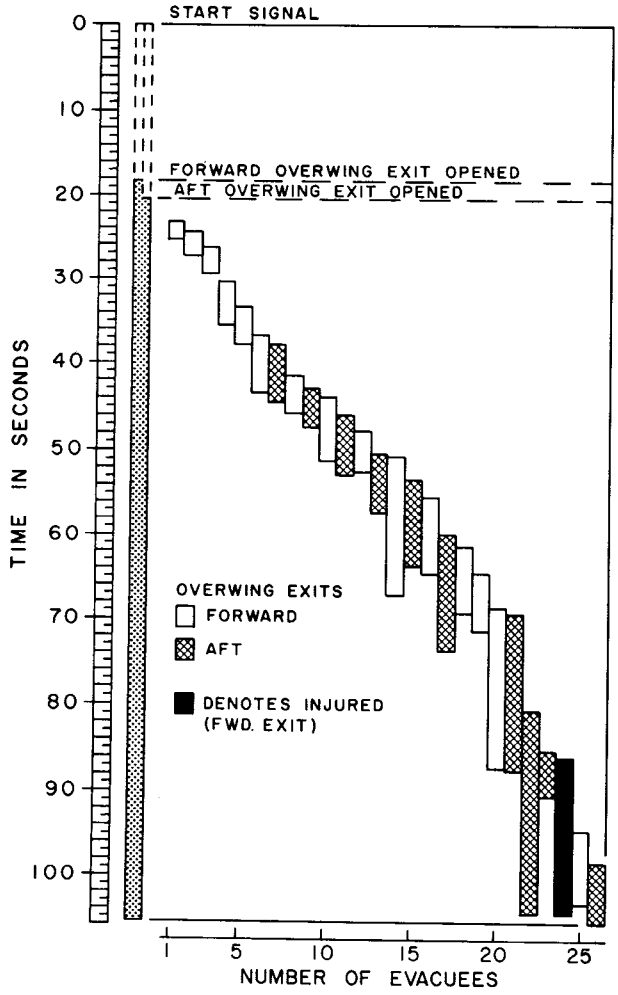

FIGURE 8.—Individual evacuation flow from the right forward and aft overwing exits in Test III. Rectangles represent each person and the time the exit was in use by them.

The forward stewardess didn't remember seeing strobe lights except that "it seemed red"—this probably being the strobe light installation in the forward right exit window. An adult male from the front-row, left aisle seat waited for a time, observing the overwing exits, and finally decided to leave by way of the aft exit door in the rear cabin.

The "injured" man, who was "fireman-carried," and his benefactor were on the wing as the stewardess stepped out of the aft window exit. The stewardess cleared the window in one minute and 42.7 seconds and was last to clear the aircraft wing in one minute and 45.8 seconds. The right overwing exit ropes were never pulled out during the action.

Minor bruises were incurred by three persons, including two of the "injured."

The camera coverage was in color, tken from locations shown in Figure 4. Tape recordings were obtained from the three microphones in the cabin.

TEST IV

The two stewardesses for this test were shown how to operate the exits soon after Test III was completed. They were instructed "to perform the evacuation consistent with their training as the crash sounds stopped, check that seat belts were fastened before landing and unfastened after the crash, have deadheading stewardess get the exit ropes out and the window exits open." The stewardesses were standing by during Test III and were aware that "injured" would be aboard and that the galley door was not operable.

Aisle obstacles were placed on the hat racks and discharged into the cabin at random by pull-strings when the evacuation began. Two blankets, five pillows, three small boxes and two briefcases were ejected into the aisle and onto passengers to effect realism as compared to other tests.

Forty-nine passengers were boarded through the galley door. Two infant dolls and a fifty-pound doll were randomly placed among the passengers. One infant doll was held by a lady in the right window seat, first row, aft cabin. The other infant was held by a man in the left window seat, fifth row, forward cabin. The fifty-pound doll occupied the right aisle seat, third row in the forward cabin.

The passenger instructions and Captain's announcement used in Tests I and II were used in this test because of volume discrepancies in the revised tape announcement used for Test III. The engine cruise sound was run for eight minutes.

At the end of the crash sounds, the cabin lights were turned out. The .05 foot-candle emergency lights remained on. The flash bulbs were set off, the bell rang, and the aisle debris tumbled from the hat racks. The deadheading stewardess in the fourth row, right aisle seat, darted toward the forward overwing exit, opened it, set the window on the floor, and was on the wing in approximately twenty-one seconds. She groped for the rope and had difficulty in getting the rope in position for use. The forward stewardess moved quickly to the forward overwing exit before the second person was out, giving commands to "get those exits open." She helped an elderly lady sitting next to the right forward exit who had difficulty with her seat belt. This delayed passenger flow through this exit. This elderly lady went out, followed by her husband and the line of waiting passengers. Three persons were out of the aft door as the first person was on the wing from the forward overwing exit. Observations on the use of the rope will be described later under Test Results.

Heavy smoke penetrated the cabin from aft forward in approximately 1.75 minutes.

Removal of the aft right overwing exit was delayed. The second row seat back was positioned in the center of the exit as in Test III. Once this exit was opened, there was a back and forth pushing on the seat back as passengers fought to obtain exit clearance from one row, then the other. Flow was continuous, but could have been faster had all the passengers used the same seat row to approach the exit opening. The emergency rope in this exit was never deployed.

The forward stewardess remained in the forward exit area and gave continuous commands, "move-move," "leg-body-leg." The passengers pushed each other in eagerness to get out while in line. The forward stewardess also shouted for those in the rear of the cabin to use the back door. The two male passengers in the right third row reported difficulty in releasing the seat belt on the fifty-pound doll in the aisle seat to their left because the doll's seat back was pushed forward on the doll. The "injured" male in the left second row window seat was helped by direction of the stewardess and was taken out very efficiently by a man who reached in the forward exit from outside, taking him out feet first. The inside helper then left the cabin and was followed by one other person. Evacuation time for the forward overwing exit was two minutes and 39 seconds. The stewardess monitored the exits until all the passengers were out, then checked all seats with her pen light and by feel on her way aft because the smoke had obscured almost all visibility.

In the aft cabin, the stewardess had the door started open in seven seconds, having to feel for the handle when the lights went out, and accidentally set the 46½ pound door on her left foot. She continuously commanded "Come this way," etc. Directions were also given to help the "injured" in the aft cabin while standing aft of the

exit and ushering passengers out. There was a crippled man in the aisle seat, left side, first row, aft cabin, who made his way without aid, on crutches, with slight difficulty. When the aft cabin was empty, the stewardess went forward through the galley where she met a man with an "injured" girl. The stewardess said, "I'll take her," and dragged her by an underarm hold to the aft cabin door. A passenger outside took the "injured" and laid her on the ground. The stewardess moved back up the aisle and led an elderly couple from the rear of the forward cabin. She was followed by a man dragging an "injured" man who was pushed out of the door to a helper outside. The two stewardesses followed the "injured" and helper out of the exit. The last person was out of the aft door in three minutes and 7.6 seconds.

The excitement in the cabin during the test was intensified by noises of a log chain thrown on top of the aircraft, a gun fired from the flight deck area, pounding on the fuselage from outside, gelled fuel set on fire on the left side, dense theatrical smoke in the cabin, the fire truck siren, wailing whistle and the low-level lighting.

Camera locations for Test IV are shown in Figure 4. Tape recordings of the cabin activity were obtained.

V. Test Results.

QUESTIONNAIRE SUMMARY

A basic questionnaire was prepared for the tests to gather information from passengers but was slightly revised for the last two tests to clarify some of the questions and include emergency lighting. A detailed summation of passenger comments is presented in Appendix 1. Answers to these forms revealed that approximately half the passengers felt the tests to be realistic; an average of 27.6% felt realism to some extent. The two night tests apparently created more apprehension than the day evacuations, the smoke, lighting and noises being the greatest contributing factors.

The slope of the floor did not cause as much difficulty as predicted. More than one-third (40%) stated that they had no trouble with the floor angles. The 18% who noted "much" difficulty were primarily those assisting the "injured." There were at least four groups who fell or ended up against the aft bulkhead in the aft cabin, all helping "injured." Getting out of the seats was another problem noted by about 10% of the passengers. Approximately half stated they developed panic feelings at different stages of the evacuation. Smoke, siren and low illumination were the main causes of these feelings.

Of the total 132 passengers, excluding the "injured" seated in the forward cabin during the four tests, 65 (49%) stated they were aware of the strobe light in the right aft window exit. It must be kept in mind that a few may have interpreted this as meaning the photo-flash bulb set off with the starting signal. There were no comments indicating objections to the brilliant flash emitted by the strobe. The exit windows containing the strobe lights were removed and either placed in seats or on the floor of the cabin, and the flashing was not noted as being in these positions, probably because of attention toward getting out of the aircraft.

Some passengers stated they did not know the purpose of the strobe light. Approximately 18% on the day tests and 30% on the night tests stated they thought the strobe light would aid them in escape.

Seventy-five per cent of the passengers stated, in the questionnaire, that aisle obstacles did not handicap them in escape. Many comments noted "people" got in the way; as well as the seat backs in line with the window exits. Aisle debris in Test IV was "rained" down from hat racks into the cabin, but did not hadicap passengers any more than in Tests I and II wherein the debris was pre-placed in the aisle. However, one adult male stated he felt panic when struck by one of the falling articles.

There was interest in whether passengers sought their route of entry for escape. Of the subjects in the two day tests, 20.5% (Tests I) and 34% (Test III) stated they sought to evacuate via the door through which they had entered. During the night tests, 5% (Test II) and 7% (Test IV) sought their route of entry.

The question concerning the adequacy of the .05 foot-candle interior emergency lighting was excluded in the questionnaire for Test II (Night), but it was agreed among the coordinators that the question should be added for the next night test. However, of the passengers in Test IV (Night), 53% responded that lighting was adequate and 45% said that lighting was inadquate for escape. Smoke was introduced in these tests, obscuring

vision and overall illumination. Consequently, many passengers commented further on the lack of adequate exit markers over windows and doors. A study of light penetration in smoke is found in recommendations.

In answer to what changes in procedures and equipment would be recommended, passengers listed many items. In most cases, however, no specific suggestion or clarification of their recommendation was noted in detail. A listing of these comments by tests is found in Appendix 4. Items receiving the most response are noted below:

1. Larger and more exits.
2. Exit-opening instructions placed on back of seats in exit area; i.e., how they operate—pull inward or push outward, and more pre-crash crew instructions on how exits operate and how to get out.
3. Larger exit markers and more light near exit areas.
4. Remove seats in front of exits.
5. More space between seats at exits.
6. A public address system or megaphone for crew to instruct passengers.
7. Wider aisles, galley forms obstacle in this aircraft.
8. Stewardess should point out strobe lights and explain their purpose.
9. Automatic exit opening, but no specific suggestion as to how it might be accomplished.
10. Flashlights furnished for passengers to use near exits.

STEWARDESS QUESTIONNAIRES

Although the questionnaire was designed for passengers, the stewardesses were asked to fill out the questionnaire form. Appendix 2 lists the detailed answers of the eight stewardesses.

Their general reactions indicated that the tests were realistic. The introduction of "injured" passengers and the smoke aboard provided the feeling of a real emergency. Most stewardesses commented they did not know whether to consider the emergency as a planned or unplanned condition. This caused them to hesitate making seat checks and giving pre-crash instructions for fear of being out of their seats at the time of impact. On Test III, however, the emergency was unplanned with no indication of difficulty. Emergency lighting seemed adequate to them until smoke obscured visibility. One aft stewardess had difficulty with the 32° slope of the floor and fell against the aft bulkhead "at least twice." Others had little or no trouble in the aft cabin.

The stewardesses were debriefed more thoroughly than were the passengers after each test and elaborated more on events which occurred during their respective tests. A verbatum listing of events in Appendix 3 documents the apprehension, excitement and conditions which were encountered. The aft stewardess had to cope with smoke from the start, stating they "could not see two rows." In the forward cabin, the general concern was for the "injured" forward of the galley. The comments also demonstrate control of evacuations by shouting or normal voice communication.

PASSENGER REACTION

The introduction of smoke, sound effects and stewardess commands were motivating factors to the passengers. Most of the children from seven to thirteen years of age were apparently "shaken" by the realism. Test film, sound recordings, and questionnaires showed that passengers performed in a calm manner generally, some more apprehensively than others, some stating that motion or vibration would have caused more concern to get out.

From the overwing exit area, once on the wing, there was a tendency for evacuees to follow the people in front of them. When the first man out of an exit went forward over the leading edge of the wing, others followed. This same tendency was evident inside the cabin. People with poor visibility conditions depended on the persons in front of them for directional guidance, and were able to follow those passengers making sounds or talking.

Results of Test II in which the starting signal was delayed, and of Test III in which no emergency was expected showed that passengers waited clues from the crew. Passengers anticipated and expected more guidance, and were vehement in their stating that more instructions should have been given. This was evident in Test III, for while the forward stewardess was trying to open the galley door, 12.5 seconds elapsed before any attempts were made by the passengers to open the overwing exits.

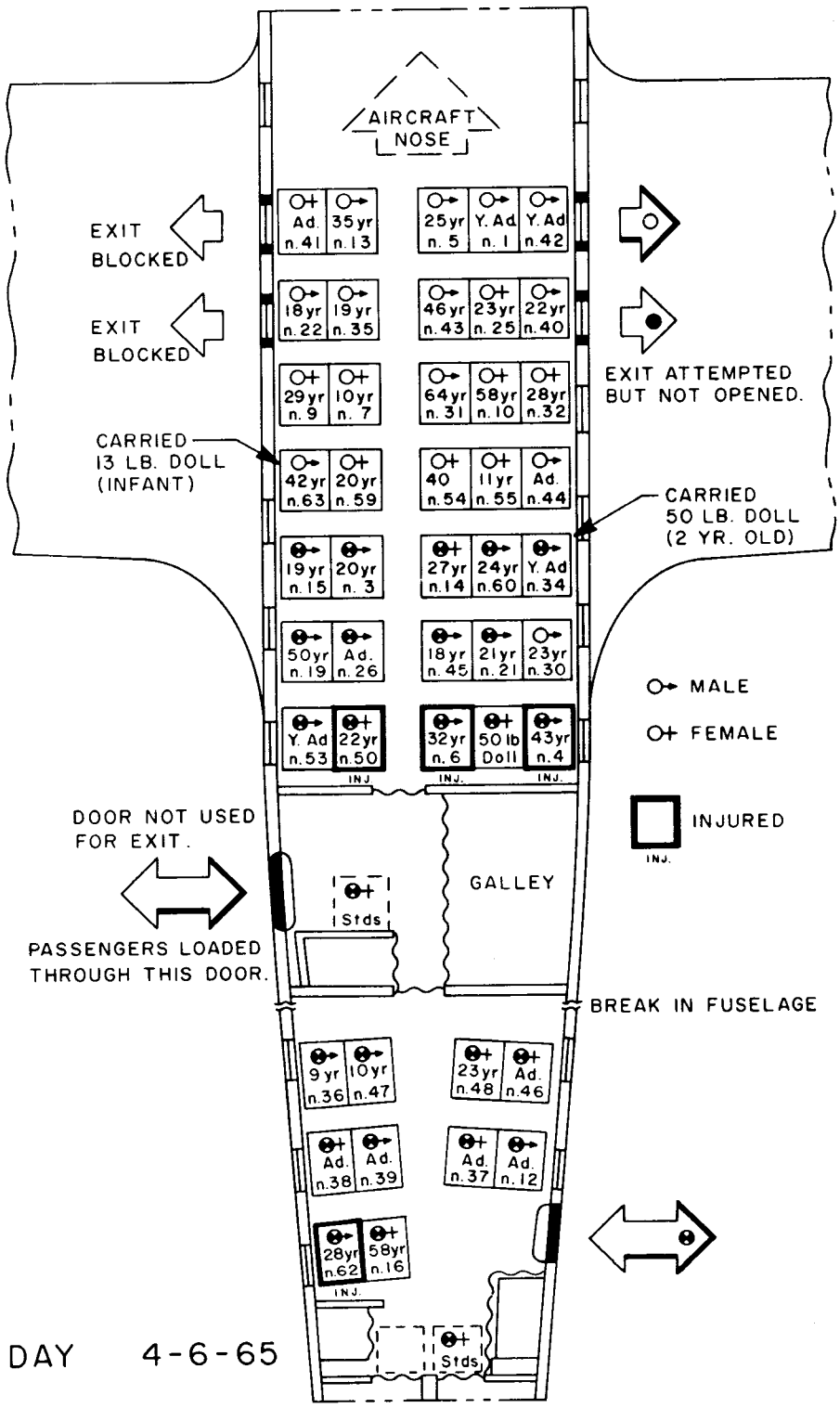

FIGURE 9.—The general seating configuration and exit usage diagram is shown for Test I. Each seat block contains the age and jacket number worn by the occupant. Where age is not known, adult (Ad) or young adult (Y.Ad) is used. The small circle of the sex symbol also designates the exit used by relating to the appropriate circle in the exit arrows.

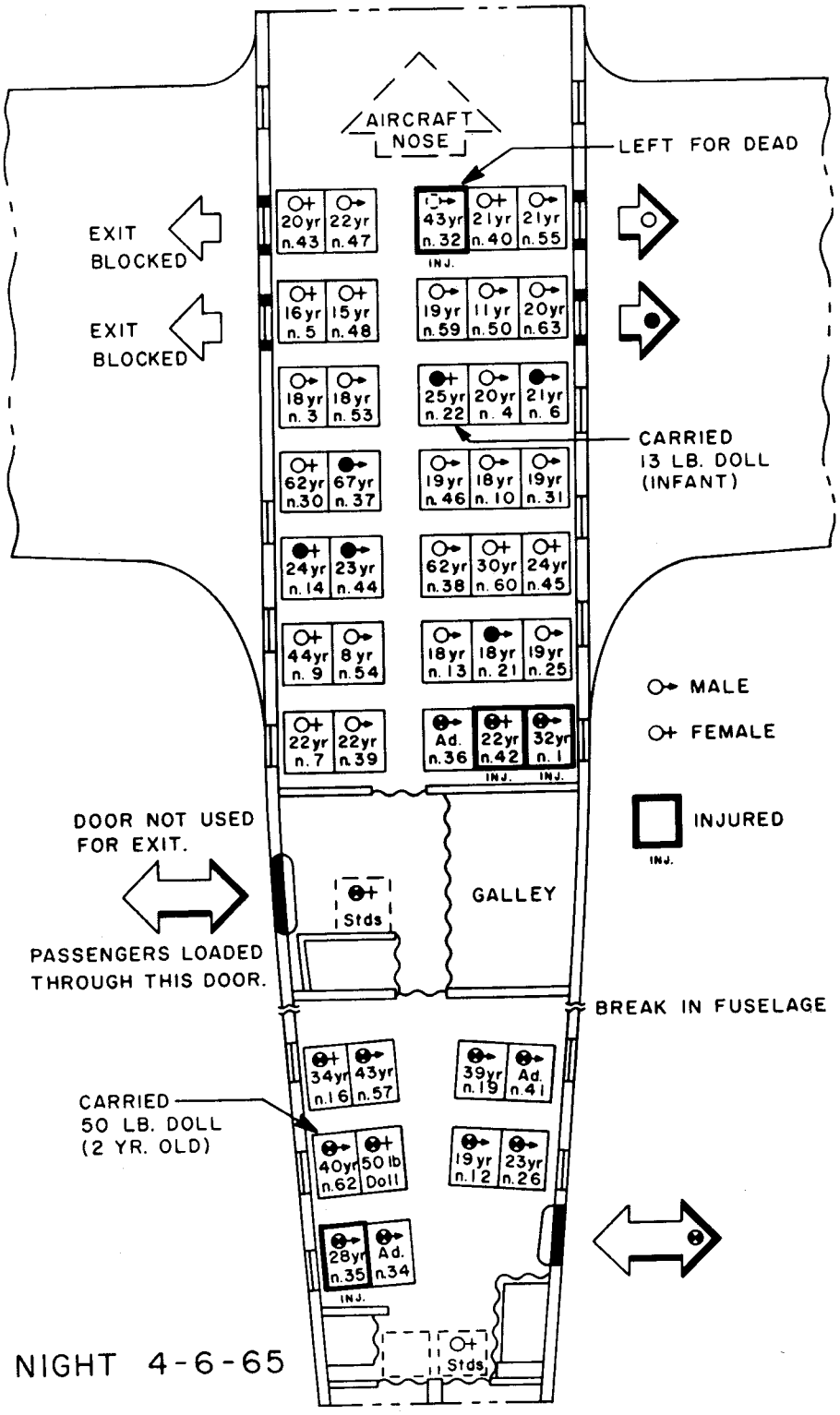

FIGURE 10.—The general seating configuration and exit usage diagram is shown for Test II. Each seat block contains the age, sex and jacket number worn by the occupant. Where age is not known, adult (Ad) or young adult (Y.Ad) is used. The small circle of the sex symbol also designates the exit used by relating to the appropriate circle in the exit arrows.

There was no attempt by passengers to take command of the evacuations from the crews in these tests. We especially looked for this in tests in which the stewardesses were busy with the "injured" or instructions were made in voices that did not penetrate through the cabin.

FLOW PATTERNS

Exits used by persons aboard the aircraft in Test I are shown in Figure 9. Figures 5 and 6 show times and flow through the forward overwing exit and aft right door respectively.

The aft door in Test I was in constant use only 46% of the time from appearance of the first person until the last person was out of the door (Figure 6). Inefficient use of this exit was mostly the result of exit and aisle blockage by removal of an "injured" causing a lapse of twenty-seven seconds. Three other "injured" were brought out this same door with very little time loss. When the aisle and exit were clear, flow continued at a steady pace. The forward overwing exit was in use 82% of the time from the first person's appearance until the last person was out of the exit, not including exit opening time, averaging three seconds per person. These exit percentages provide a general analysis of the total time an exit is being occupied by a person in the process of escaping from an aircraft beginning with the first person to appear. Percentage time losses, therefore, indicate intervals between evacuees when the exit was empty and available for escape.

In Test II, which was filmed in low-level lighting, it was not possible to determine exit usage for each individual. From questionnaires and with the help of film coverage, the exits used, as well as the number of passengers moving through each exit, could be established. Figure 10 shows the seating and exits used for this evacuation. The heaviest blanket of smoke of all the tests filled the aircraft during this test. Comments from the stewardesses pointed out how important it was for people to keep talking or making sounds so others could follow and be guided to exits.

For Test III (Day), the evacuation pattern is presented in Figure 11. Generally, passengers went to the nearest available exit unless they were guided to another by a stewardess. In this test, one passenger from the front row decided to go all the way aft to get out. Figure 7 presents the individual time plots of evacuation through the right aft door in Test III. This exit was in use 54.5% of the total time it was available. Flow was interrupted because of two "injured" being transported through the galley and the "injured" in the aft cabin. The forward overwing exit was in use 85% of the total time, including an "injury" carry-out. The aft overwing, once opened, was also in use 85% of the time although it took longer for each individual to go through the window. This is attributed to the greater step-down distance outside. A chart of the two overwing exits shows individual escape times in Figure 8.

After the initial delay while the stewardess released the seat belt of an elderly lady sitting in the exit window seat, escape continued at a steady pace from the overwing exits until passengers started using the escape rope from the forward exit. This rope was pulled across the aft exit partially blocking escape. The aft right door evacuation flow was steady except for slight interruptions when "injured" were removed. The exit pattern of Test IV is shown in Figure 12.

TOTAL TEST TIMES

The total elapsed times of these tests were of secondary importance. Some results gained, however, indicate the effects on evacuation of nighttime environmental conditions with the addition of smoke. Other specific events during the evacuations were observed for time losses or efficiency of operation, such as exit usage and various methods of removal of "injured." Figure 13 presents the four tests for a general survey of times involved on the evacuations.

SEAT SPACING

The two different fore-aft seat spacings used in the four tests did not have significantly different effects on the evacuation flow. This effect of seat spacing on evacuation flow and time should be studied further on a statistical design basis.

Aisle widths in the aircraft with five-abreast seating in the forward cabin (two left side, three right side) were measured between arm rests as follows:

Forward Cabin	*Aft Cabin*
Row 1 — 16 inches	Row 1 — 17 inches
Row 2 — 16 inches	Row 2 — 12½ inches (aircraft taper effect)
Row 3 — 18 inches	
Row 4 — 17 inches	
Row 5 — 16 inches	
Row 6 — 16 inches	
Row 7 — 18 inches	

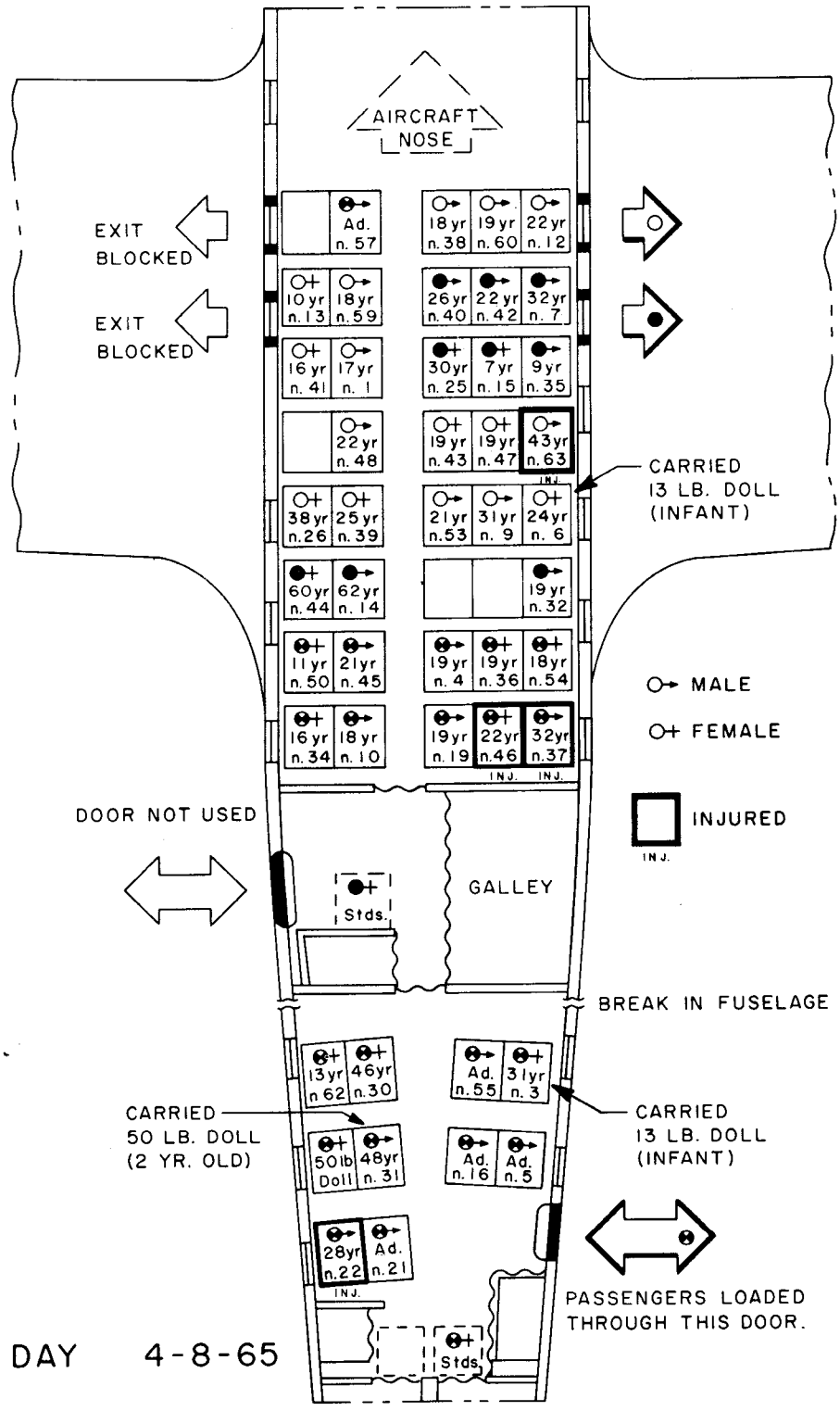

FIGURE 11.—The general seating configuration and exit usage diagram is shown for Test III. Each seat block contains the age, sex and jacket number worn by the occupant. Where age is not known adult (Ad) or young adult (Y.Ad) is used. The small circle of the sex symbol also disignates the exit used by relating to the appropriate circle in the exit arrows.

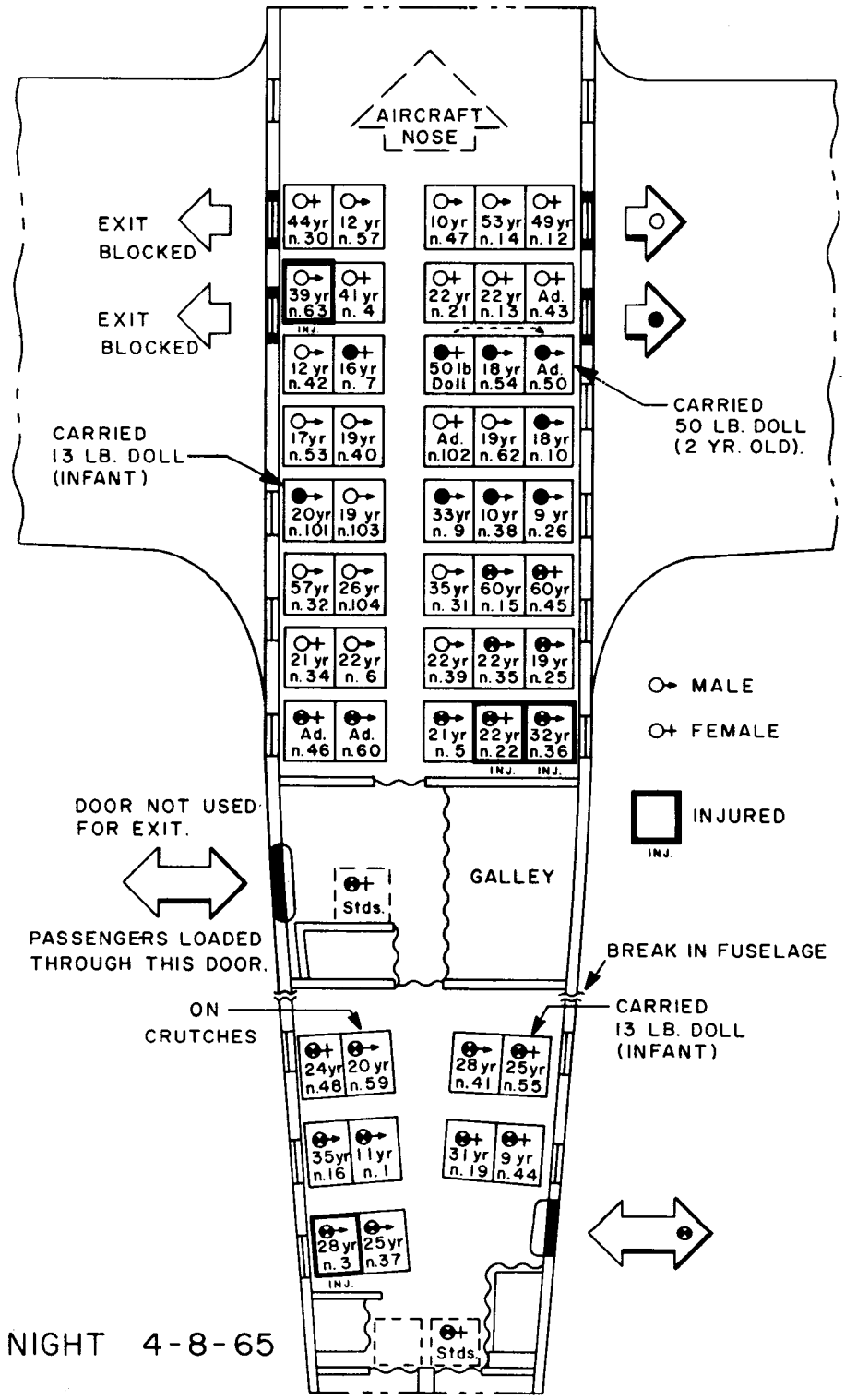

FIGURE 12.—The general seating configuration and exit usage diagram is shown for Test IV. Each seat block contains the age, sex and jacket number worn by the occupant. Where age is not known, adult (Ad) or young adult (Y.Ad) is used. The small circle of the sex symbol also designates the exit used by relating to the appropriate circle in the exit arrows.

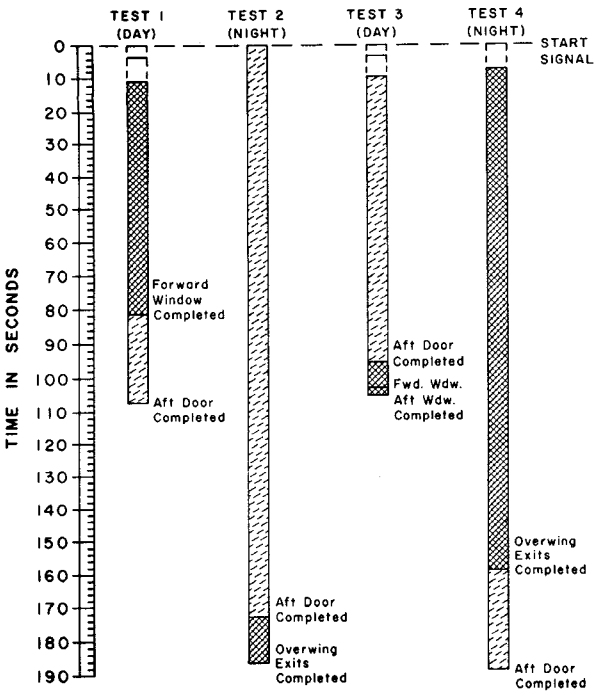

FIGURE 13.—A general time summary chart of the four evacuation tests.

ESCAPE ROPES

Escape ropes were installed in the spaces provided in a compartment above each right overwing exit. The end of each rope protruded through a hole in the top of each exit window frame.

During Test IV a "deadheading" stewardess pulled the escape rope in the forward overwing exit. She stated she had difficulty finding the rope and was delayed in pulling it out. As she cleared the wing, the rope was left trailing aft and at first no one used it. The fourth passenger from the forward exit slipped and rolled off the wing onto the ground. All of the rest of the participants from this exit then used the rope. As a result, they were closely grouped in single file and slowly moved off the wing. The rope blocked the aft window exit and seriously delayed evacuation through both overwing exits. During the action the aft exit rope was never deployed.

Four comments concerning the rope were obtained from persons aboard:

1. "Climbed out window, held on to frame, then used rope."
2. "Hurry up, hang on to the rope." (This was a command heard by one passenger.)
3. "Rope good idea." (This man was carrying a 50-pound doll.)
4. "Knew where it was but was delayed trying to find it and pull it out." (Deadheading stewardess who deployed the rope.)

EXIT SIGNS

During these tests, exit placards were not available for the left overwing exits. Since smoke was introduced in all tests, visibility of all placards was diminished quite soon, reaching the overwing exits last.

In the forward cabin, two exit placards with two arrows each pointing 45° downward were mounted, one in the ceiling and one midway between the two right overwing window exits. Usually an exit sign is mounted over each window exit. However, a shortage of available placards necessitated use of a double-arrow placard which pointed to each exit. Since smoke reached the forward area last, effectiveness of these placards was sought before smoke obscured them. Although the questionnaires did not include questions on the placard, thirty-three persons from the four tests in the forward cabin were queried about placards. Sixteen of them noticed the placards but were guided by the persons in front of them to a greater extent. Three responded they were more conscious of the exit itself than they were of the placards, and two stated they glanced at the placard which directed their attention to the exit.

The galley and right aft cabin doors each had an exit placard (without arrows) over the top door frames. The galley door placard was visible to the forward stewardess and passengers using the aisle in this area. This door was obscured by smoke eight to twelve seconds after the start signal. None, other than the forward stewardess, is known to have used the galley placard during tests. The aft door placard was obscured quickly by smoke and two aft stewardesses had to feel for the door handle.

CARRYING OF INJURED

Many methods were used to deliver the "injured" to the exits. Time loss, especially in Test I, very vividly pointed out the effect of random time-consuming ways of removing "injured" passengers.

A good technique inside the aircraft for carrying the "injured" seemed to be the fireman's carry, above seats, providing the person carrying the "injured" was physically capable. Another more practical method was catching an "injured" under the arms from behind and dragging or carrying. These methods facilitate movement through aisles and through the exit opening without prolonged interruption of continuous motion. The most efficient "injury" removals were accomplished by the underarm drag with the helper walking backwards to the aft exit and then stepping out on the ground (a 32-inch drop).

SEAT BELTS

Friction-snubbing type seat belts were used aboard this aircraft. In many instances the buckle, with the belt tightened, ended up too far on the right side to be easily released. Passengers, who were holding the dolls and had only one free hand, particularly noted difficulty in releasing their seat belts. Belt buckle design and engagement should not confront passengers with belt release problems.

In general, the most optimum belt buckle location laterally was found to be over the center of the lower abdomen with the belt snug.

CHILD CARRY

Passengers carrying dolls simulating small children seemed to have only slight difficulties in evacuating the aircraft. The only comments apparently were the one-handed release of safety belts noted previously and the additional weight of the dolls combined with the one-hand operation of getting out of seats on the floor incline of the aircraft.

VI. Conclusions.

1. Unindoctrinated passengers looked for and expected instructions from crew members before they took action on their own to escape.
2. In smoke-filled cabins, crew commands or other audible sounds aided passengers in finding exit locations.
3. Floor slopes of up to 32° did not cause a great deal of difficulty except to those handling incapacitated passengers.
4. Crewmembers can maintain command of an evacuation by using a wide range of voice volumes, but the voices should be loud enough for passengers to recognize them over the ambient noise. It is also possible to creat a great deal of anxiety and motivation in passengers by appropriate exiting type commands.
5. Seat backs located in line with overwing exits impede removal and use of these exits. Current requirements for emergency exit access are considered in FAR 25.813, but the condition is reiterated here for emphasis.
6. The brilliant flash of the strobe light was not objectionable, but an explanation to passengers of its purpose would be required. The strobe light did not furnish significant illumination to aid in passenger escape.
7. Pre-placed aisle debris caused minimum difficulty in evacuations, although the raining down of articles caused panic feelings for an instant.
8. Exits should be well-marked and should include brief and conspicuous operating instructions.
9. Emergency evacuations at night will take longer than evacuations under similar conditions in the daytime.
10. Seating of an elderly or incapacitated person directly adjacent to an exit could delay use of the exit for a few seconds while help is rendered.
11. The effect on evacuation speed of the two seat spacings of 32 and 39 inches used in these four tests were not conclusive. Speed through the exits was the determining factor.
12. Elderly passengers may require aid in release of seat belts.
13. Belt buckle design and engagement should not confront passengers with seat belt release problems.
14. The post crash site, as prepared, did not cause significant delays in escape time.
15. Time-consuming handling of incapacitated persons can be minimized if crews are shown the most practical "carry-out" methods by which to direct help when necessary.

VII. Recommendations.

1. Further investigations of the efficiency of lights (exit) in smoke are recommended as follows:

   a. Exterior emergency lighting: spot type or flood type, optimize intensity.
   b. Install markers or identifying objects which locate the seat rows leading to emergency window exits under low visibility conditions.
   c. Mounting locations on aircraft of high intensity strobe type light if they are considered as a locator device for rescue personnel. The strobe light is not recommended for cabin interior illumination as a result of these tests.
   d. Optimum aisle width to best facilitate the removal of injured.

2. A study is recommended which would compare evacuations in actual emergencies with simulated tests of this kind, including experience derived from evacuation demonstrations.

3. A suggested study would be to explore the illumination at or over all exits. The .05 foot-candle emergency lighting is considered an adequate minimum for intra-cabin illumination, but the value decreases to around .02 foot-candle at the sides. Whether or not more lighting directly on exits would enhance evacuations in poor visibility conditions significantly beyond present provisions is the question proposed. Other devices such as sound are suggested to be explored for drawing attention to location of exits.

4. Escape chutes were not used in these tests due to the aircraft resting on the ground with relatively short step-down distances. With the current use of door-mounted chutes, trials should be made with inflatable escape chutes deployed in gear-up conditions. One actual aircraft incident is known in which this condition was used successfully when fire was not involved.

APPENDIX 1

SUMMARY OF PASSENGER COMMENTS

1. Did you have much of the feeling of a real emergency?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	46.0%	60.0%	52.5%	62.0%
No	23.0	12.5	26.5	7.0
To Some Extent	31.0	27.5	21.0	31.0
Contributing Factors:				
Smoke	8.0%	12.5%	13.0%	6.6%
After Lights Out	—	5.0	5.0	8.8
Sirens	—	—	2.6	2.2
Noise	—	—	5.0	—
Debris	—	—	—	4.4

Two passengers noted that lack of vibration caused an unreal condition.

2. How much difficulty did you have with the sloping floor?

	Test I	*Test II*	*Test III*	*Test IV*
None	31.0%	37.5%	39.5%	51.0%
Little	46.0	32.5	39.5	47.0*
Much	23.0	30.0	16.0	2.0
Unknown	—	—	5.0	—

* One man carrying 50-lb. doll.

Contributing Factors:				
Getting Out of Seat	8.0%	7.5%	—	—
Helping Others Out	5.0	—	—	—
High-Heeled Shoes	2.5	—	—	—
Slipped Upon Standing	—	—	2.5%	—

3. Do you think you would have acted any differently had you been aboard this aircraft when it crashed?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	40.0%	40.0%	45.0%	47.0%
No	40.0	40.0	37.0	24.0
Not Much	10.0	10.0	3.0	—
Possibly or Probably Not	7.5	7.5	15.0	22.0
Don't Know	2.5	2.5	—	7.0

4. Were there panic feelings at anytime?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	56.0%	50.0%	47.5%	46.7%
No	44.0	50.0	52.5	53.3
Contributing Factors:				
Light	2.5%	10.0%	5.0%	2.0%

Siren	2.5	5.0	—	—
Door Wouldn't Open	2.5	—	—	—
Smoke	—	—	5.0	11.0
Pilot Indicated Trouble	—	2.5	—	—
Other	—	—	—	13.0

5. Did you observe evidence of panic in others?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	—	—	44.5%	39.5%
No	—	—	38.0	39.5
To Some Extent	—	—	15.5	13.0
No Answer	—	—	2.0	8.0

6. Have you ever been in a real emergency situation?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	41.0%	40.0%	31.6%	35.5%
No	59.0	60.0	68.4	64.5
Type Emergency:				
Car	18.0%	15.0%	8.0%	8.8%
Plane	2.5	2.5	—	4.4
Boat	—	2.5	—	—
War	—	—	2.6	—
Train	—	—	2.6	—
Apt. Fire	—	—	2.6	—

7. What were your reactions in this test as compared to a real emergency?

	Test I	*Test II*	*Test III*	*Test IV*
Same/Similar	18.5%	23.7%	10.6%	13.3%
Greater Fear Here	8.0	2.5	2.6	4.5
Greater Fear in Emergency	13.0	10.5	5.3	6.7
No Answer	60.5	63.5	78.9	69.0
Differently	—	—	2.6	6.5

8. What is your estimate of your probable reactions under an emergency situation similar to this test?

	Test I	*Test II*	*Test III*	*Test IV*
Same/Similar	74.5%	50.0%	—	—
More Panic	13.0	32.5	—	—
Would Move Faster	10.0	5.0	—	—
Wonldn't Panic So Soon	—	2.5	—	—
Don't Know/No Answer	2.5	10.0	—	—

9. Were the stewardesses instructions clear?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	69.0%	75.0%	39.5%	62.0%
No	31.0	25.0	47.5	38.0
Part of the Time	—	—	13.0	—

10. Could you hear them? (Reference Question 9)

	Test I	*Test II*	*Test III*	*Test IV*
Yes	72.0%	92.5%	52.6%	71.0%
No	18.0	7.5	47.4	29.0
No Answer	10.0	—	—	—

11. Did you expect more instructions in this case from crew members?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	56.0%	45.0%	80.0%	47.0%
No	44.0	50.0	18.0	51.0
Don't Know	—	5.0	2.0	2.0

12. Were you aware of the flashing lights in the overwing exits?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	51.0%	60.0%	42.0%	44.0%
No	49.0	40.0	58.0	47.0
No Answer	—	—	—	9.0

13. Do you think these flashing lights would aid in your escape?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	18.0%	30.0%	18.5%	31.0%
No	23.0	22.5	21.0	9.0
Maybe	26.0	17.5	2.5	—
No Answer	28.0	30.0	58.0	60.0
Confuse More	5.0	—	—	—

14. Did the aisle obstacles handicap you in your escape?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	23.0%	25.0%	2.6%	20.0%
No	74.5	75.0	79.0	73.0
People	2.5	—	5.3	7.0
No Answer	—	—	2.6	—
Seat in Way of Hatch	—	—	10.5	—

15. To what extent? (Reference Question 14)

	Test I	*Test II*	*Test III*	*Test IV*
None	79.5%	75.0%	76.5%	73.0%
Little	18.0	20.0	21.0	27.0
Much	2.5	5.0	—	—
No Answer	—	—	2.5	—

16. As a result of this experience, what do you think about the advisability of people taking carry-on baggage or packages with them on an actual flight?

	Test I	*Test II*	*Test III*	*Test IV*
No Packages	49.0%	35.0%	50.0%	53.0%
Packages O.K.	5.0	20.0	8.0	16.0
Better Place for Packages, Limited, Small Secured, No O/H	33.0	30.0	23.5	22.0
Handbag, Brief Cases, Wraps, Pillows Only	8.0	2.5	5.3	2.0
No Opinion	5.0	12.5	13.2	7.0

17. Did you hear passengers give commands or try helping guide people out?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	49.0%	75.0%	63.0%	40.0%
No	51.0	25.0	37.0	58.0
Don't Remember	—	—	—	2.0

18. Can you recall commands other than those of the stewardess?*

	Test I	*Test II*	*Test III*	*Test IV*
Yes	36.0%	45.0%	42.0%	27.0%
No	64.0	55.0	53.0	11.0
No Answer	—	—	5.0	62.0

19. Which exit did you use?

	Test I	*Test II*	*Test III*	*Test IV*
Forward Overwing	49.0%	55.0%	39.5%	49.0%
Rear Cabin Door	51.0	17.5	39.5	40.0
Aft Overwing	—	12.5	21.0	9.0
No Answer	—	—	—	2.0
Overwing (Which or Unknown)	—	—	15.0	—

20. Was there a closer exit than the one you used?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	23.0%	17.5%	18.0%	22.0%
No	77.0	82.5	82.0	73.0
No Answer	—	—	—	5.0

21. Did you try to leave the same way you came in?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	20.5%	5.0%	34.0%	7.0%
No	77.0	95.0	63.0	91.0
No Answer	2.5	—	—	2.0
Not at Start	—	—	3.0	—

22. Did you start toward an exit that turned out not to be useable?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	23.0%	20.0%	10.5%	7.0%
No	77.0	77.5	87.0	91.0
No Answer	—	2.5	2.5	2.0

23. Did you find the light level adequate after the flourescent lights went out?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	—	—	21.0%	53.0%
No	—	—	2.0	47.0
No Answer	—	—	74.0	—
Don't Remember	—	—	3.0	—

Comments:

Test III—"Foggy, smoky, not good."
Test IV—Smoke 11%.

24. Would you say much confusion was apparent?

	Test I	*Test II*	*Test III*	*Test IV*
Yes	33.0%	35.0%	31.5%	36.0%
No	36.0	27.5	37.0	33.0
No Answer	—	—	2.5	2.0
Somewhat Part Time	31.0	30.0	29.0	29.0
Don't Know	—	7.5	—	—
Contributing Factors:				
Smoke	—	5.0%	—	—
"Caused by Stewardess"	5.0%	—	—	—

*See "Commands Recalled" at end of Appendix 1.

*COMMANDS RECALLED

TEST I

"Help that man out, will you?" "Take care of him." (Command) "I'll take care of you." (Reply to previous command) "Keep it moving." Someone said, "Go out this door," but the door was locked. "Leave the dead ones behind," and how do you know they were dead? "Let's go; let's go." Someone pulled on scuff of neck. "Leave him alone." Directions to exits. Request for help to carry out an injured. Indirect urging from other passengers. Direction giving (in general). Guy in front seat said to hand him the door up and another said to push out on an exit. Instructions to go out back door.

TEST II

"Turn right." (This led to window, not exit and delayed us—turned between two exits.) "This way to window." "Don't push and help a girl." "Don't shove." "You hold the seat while I pull." "Turn right." Yank on window." Get seat forward." Cried for help in back. Person in front told me to move seat forward because of exit. Commands from people on ground to watch step off wing. Directions to get out of window. Directions to door. Directions on how forward and how far to come.

TEST III

"Use the window." "Push window out, not pull it inside." "Get out," "Don't bother injured man." "Hand me that door." "Here, this way." "This way." "Hurry, hurry." "Come towards window." "Get out as quickly as possible." "Let the women go first." Told to get out window. Instructions as to which exit to take. Instructions to children to get out open exit. Instructions between two passengers helping injured man out. Boy next to girl said, "Come on," "Follow me," and then let her evacuate first.

TEST IV

"I should go back." "Hurry up; hang on to rope." "Open second window." "Go this way; it's closer." "There's an unconsious man in corner; get him." Instructions to man carrying baby. Commands to help evacuate injured. Man at door said, "Hurry up; get out." Instructions to use other exits. Father instructing mother (Child) Father's instructions. (Child) Stewardesses asked for help to handle someone, telling which way to go. We started front; were told to come out front. Heard everybody saying, "Hurry up."

APPENDIX 2

SUMMATION OF STEWARDESSES' RESPONSE TO QUESTIONNAIRES

Question	*Test NR*	*AFT Stewardess*	*Forward Stewardess*
1. Did you have much of the feel-feeling of a real emergency?	I	"After it got started—quite a bit."	"Close as you can come—not as much noise as expected—heard siren near back at galley."
	II	"Yes—at times. (2) times. (1)thought girl was hurt; (2) when couldn't see."	"Yes—sort of a battle—vascillating emergency test, etc."
	III	"Not until smoke started."	"When people appeared hurt."
	IV	"Yes."	"Yes."
2. How much difficulty did you have with the sloping floor?	I	"None."	"Not too aware except carrying girl out."
	II	"Very much—particularly injured removal."	"Didn't notice any—(always forward)."
	III	"Some—if anyone had fallen there may have been a pile-up.	"None—Trouble in directing pax-to watch sloping floor."
	IV	"Very definitely—fell at least twice (backwards)."	"Not that I remember."
3a. Do you think you would have acted any differently had you been aboard this aircraft when it crashed?	I	"No."	"May have screamed louder."
	II	"Yes—probably been nore energetic in moving people—probably by hair."	"Probably—might not have tried harder—reality arrested from time to time."
	III	"No."	"Yes—Might have tried longer to to open door (galley)."
	IV	"Probably would have done more briefing and considered slide use."	"If had one minute—might have given more instruction in use of exits and maybe have reseated pax."
3b. In what way? (Reference Question 3)	III	NO COMMENT	"Was aware that aviation people aboard and hesirated to recruit their assistance—getting majority out who looked like they were moving fairly well."
	IV	NO COMMENT	"Put more able-bodied into strategic locations."
4 Did you experience panic feelings at anytime?	I	"Wanted to get out."	"Didn't see any—No."
	II	"Yes—more of frustration trying to move man."	"No."
	III	"No—No time to."	"Yes—At first when the lady collapsed—boy was frightened."
	IV	"At time door was an foot—when fell back with one injured pax."	"No."
5 Did you observe evidence of panic in others?	III	"No—Except maybe for little girls"	"Not real panic—disturbed by not getting injured out."
	IV	"Yes—concerned—for—elderly couple—appear frightened."	"No."
6. Have you ever been in a real emergency situation?	I	"No."	"No."
	II	"No."	"No."
	III	"No." "(Auto Accident)"	"No."

Question	*Test NR*	*AFT Stewardess*	*Forward Stewardess*
	IV	"No—Sailboat—Atlantic	"No."
7. (If Yes) How did you react as compared to your reactions in this test? (Reference Question 6)	I	NO ANSWER	NO ANSWER
	II	NO ANSWER	"No problem until it was over—then shaken."
	III	"Didn't panic in auto crash—windshield knocked out down hill, rocks, dirt."	NO ANSWER
	IV	"Very quiet—busy in this experiment."	"About same."
8 What is your estimate of your probable reactions under an emergency condition similar to this test?	I	"Would react same way'."	"May be more aware—Looking for second exit" Forgot 'heels off'."
	II	"Too hard to answer—re: frustration—not being able to see—no answers from pax—might have had to leave them."	NO ANSWER
9 Were the instructions of the stewardess clear?	I	"Other girl's voice came through loud and clear."	"At beginning—she took on where I left off."
	II	"In aft cabin, Yes—No response in forward cabin."	"Heard her telling people to come back."
	III	"None heard—didn't have to yell."	"Could not hear."
	IV	"Sending people back—clear—loud voice."	"None heard."
10 Could you hear the instructions of the stewardess?	I	"and interefered with separate instructions from flight deck."	"Yes—belts—backs up—grab ankles."
	I		
	II	NO ANSWER	NO ANSWER
	III	SEE ANSWER 9	SEE ANSWER 9
	IV	SEE ANSWER 9	SEE ANSWER 9
11 Did you expect more Instructions from crew members than you received in this case?	I	"No—trained."	"No"
	II	"Yes"	"No —not with the time involved."
	III	"No—confused by not making ing earlier instructed announcement."	"Yes."
	IV	NO ANSWER	NO ANSWER
12 Were you aware of the flashing light in the right overwing exit?	I	"No."	"No."
	II	"No"	"No."
	III	"No—Knew there were lights to start cameras, etc."	"Flash bulbs at impact only."
	IV	"Never—saw—any—something flashed at very beginning."	"No."
13 Do you think they were there to aid in your escape? (Reference Question 12)	I	NO ANSWER	"Unknown—Trail edge of wing—might if drawn to."
	II	NO ANSWER	NO ANSWER
	III	NO ANSWER	NO ANSWER
	IV	NO ANSWER	NO ANSWER
14 Did the aisle obstacles handicap you in your escape?	I	"No."	"No."
	II	"Yes—in moving injured people out."	"When dragging Don out—on hangar bag."
	III	"No—Just the two men and girl (injured)."	"Just people."
	IV	"Saw them come down—not into doorway area."	"One box fell—No."
15 To what extent did the aisle obstacles handicap you in your escape?	I	"Didn't even know they were there—kicked door,"	NO ANSWER
	II	"Pillows and blankets moved OK, OK, but not boxes".	NO ANSWER
	III	NO ANSWER	"None found,"
	IV	"No bother after that."	NO ANSWER

Question	*Test NR*	*AFT Stewardess*	*Forward Stewardess*
16. As a result of this experience, what do you think about the advisability of people taking carry-on baggage or packages with them on an actual flight?	I	"Didn't present too many problems."	"Dead set against it. (heavy articles) had to move buffet clutter helped by volunteer pax."
	II	"Each pax should be allowed to carry one package which will fit under seat."	"Don't think they should be on, but not because of what happened tonight—TEST: People took care of obstacles."
	III	"Not advisable."	"No—If A*C were tilted these might tend to block exits."
	IV	"It this test—no problems. If too much could be problems."	"Yes—if they were in aisle defi nitely hinder evacuation."
17. Did you hear passengers give commands or try helping people out?	I	"No commands Too much help in assisting incap pax."	"No—pax helping each other."
	II	"One man asked if help needed."	"No commands heard—One man helped both man and woman in last right forward seat cabin."
	III	"Saw pax helping each other (Didn't hear anyone giving commands)."	"Saw people helping each other (Didn't hear anyone giving commands)."
	IV	"Yes, help guide people out—No commands heard."	"Yes (Command man to stop on wing)—No "
18. (If Yes) Can you recall any commands other than those of the stewardesses?	I	"No others."	"No "
	II	"Didn't hear any."	"No."
	III	NO ANSWER	NO ANSWER
	IV	NO ANSWER	"No."
19. Which exit did you use?	I	"Rear door."	"Aft door."
	II	"Overwing."	"Overwing."
	III	"Right aft door."	"Right aft overwing."
	IV	"Right aft door."	"Right aft door."
20. Was there a closer exit than the one you used?	I	"No—ran forward and back to exit rear was down-hill."	"Yes—decided when assured all out."
	II	"Could have used aft door but went forward (Couldn't tell where Linda was)."	"No—Could have taken another but as long as she was there she went."
	III	"No."	"Could have taken either over wing exit."
	IV	"No."	NO ANSWER
21. Did you try to leave the same way you came in?	I	"No."	"Yes—Tried to open—Stuck."
	II	"Galley door not attempted for use due to precondition."	NO ANSWER
	III	NO ANSWER	"No."
	IV	NO ANSWER	"NO."
22. Did you start toward an exit that turned out not to be useable?	I	"NO."	"People in front all moving fast—Seat back blocked."
	II	"Only used aft door."	"Galley door."
	III	"No—My door worked OK right away and people were moving OK."	"Galley exit unusable."
	IV	"No."	"No—Knew galley door not to be used—ignored."
23. Did you find the light level adequate after the fluorescent lights went out?	III	"No Because of the smoke."	"Yes."
	IV	"Not very good—disturbed—couldn't see door handle from beginning."	"Yes—before smoke hit—then couldn't see except for forms."
24. Would you say much confusion was apparent?	I	"Confused—later aft group out"	"Where injured pax was on way out (Forward by window took (TIME)."

Question	*Test NR*	*AFT Stewardess*	*Forward Stewardess*
	II	"Not in rear."	"Very calm."
	III	"No, I thought it was good."	"Yes, when they didn't move at first; moving injured main con fusion."
	IV	"No, except for first man out. Smelled smoke right away."	"Only in trying to get aft overwing exit open."
25 What changes in procedures and equipmant would you recommend to help speed escape of passengers?	I	NO ANSWER	"Seat backs—Some people said couldn't hear" Larger exit would have helped—Space to direct exit activity might help—may have slowed people by virtue of own presence "
	II	"Wider aisles mainly (re: injured pax removal) Aft door sharp edge "	"Didn't see any emergency evacuation lights Try to know names of pax by emergency instructions "
	III	"More important to get help to get injured pax out and equally important to keep moving pax moving "	"Could have used more aisle space restriction to movement "
	IV	"Needed more light)(More light would have helped Biggest problem Tilted floor gave some problem Stewardesses are not generelly strong enough to carry adult (Dead Weight)-Help is needed "	"Placement of seat back*exit location "

APPENDIX 3

STEWARDESS COMMENTS

TEST I

Aft Stewardess

First Indication: Noise. Captain announces alarm—Yes.

First Event: First moved when noise stopped. Open rear door. No trouble. People were up. Grabbed man—white short. Out. Old Lady. Moving pretty well. Don't recall pile-up. Pax self-motivated. Anyone try to open main door?—"No." Incapacitated pax seen. Pulled forward people to rear because of pile-up in front. Two into buffet—2 more to rear.

Second Event: Returned to rear. Pax helped incapacitated out.

Third Event: Went forward to see if any left. Double. No one left. Out back door. Megaphone help—No.

Forward Stewardess

First Indication: Captain announces—Emergency Equipment. Talking stopped. Instructed belts fastened and seats forward. "Buddy system instructions."
Shouted, Spoke Loudly: Heard responsive Comments.

First Event:

1. Unfasten belts.
2. Tried to open buffet door.
   Removed clutter.
3. Aft pax—"Go back" (first 3 rows forward of galley) in forward section.

Pax separated — Opening of exits: "Open exits." No activity to open second exit. Forward right side seat backs pushed over exit. "Push seat forward."

Second Event: People not all going out "leg-body-leg." Located aisle and seat space area. Fairly calm. Lot of smoke coming from rear. Forward was clear. Ordered to bend down. People bending low. Last people going out. Re-checked cabin.

Third Event: Buffet—PAX (2) men carrying girl. They fell—3–4 times, then tried to lift her out. Other stewardess forward. *All Clear.*

TEST II

Aft Stewardess

First Event: Captain announcement.
Not clear on role to be played in test.
Discussed with Ed Burggraf. Would have yelled at pax to put head down and take care of child because no instructions came from flight deck. Remained at station. So unreal re: gear trouble. Assumed we weren't to say anything.

Forward Stewardess

First Event: Bump/crackling sound. Captain on P.A. Thought first—Try to get up and do something, but not enough time. Didn't want to get caught up. Thought about mother and girl on left about three rows forward of galley. Told her to follow others and take girl out forward exit. (Pointed forward.)

Something wrong. Sirens sounding. On approach. Then scraping sound. All lights on. Think smoke started about that time. Metal scraping stopped. Lights still on. Confused. Assumed stopped.

"Unfasten seat belt and come to rear," yelled while opening door. When door was at wall one pax at door jumped, "Come to rear—Come back here." Aft cabin cleared out about 6 or 8—8 at most. Couldn't see up forward. Went to galley. Called. Somebody being carried. Man carrying girl. Started falling aft of galley in aisle. Few helped. Ended up at aft bulkhead and Don Carroll showed up.

Second Event: Girl pinned in doorway. About 3 or 4 pax and self got Don and girl out. Other man reached back in to help. Could see only at doorway. Incapacitated pax in last left window seat was then helped out. Could see only red lights—pink glow. Not aware of other aircraft activity. Started forward front again. Aft cabin clear. All debris in aisle still there. *No one would answer.* "People here? Answer me!"

Called for Linda. She said, "There are people up here." Went forward. Couldn't see. Only shadow of obstacle 2–3″ only. Could see outline of the exit. Darkness of seats. Think could see pax outline silhouette in first two rows. She had found somebody. Someone came in from back (Joe Haley?) asked if help needed.

Third Event: Linda called, "Another one up here." Man in seat—discussing inability to move pax. Have to let him die. (Never thought of seat belt). Had to leave man in seat. Call from outside, "Anyone in here?" Then got out window followed by Linda. Could see exit outline.

Sat down—Kept thinking should get in crash position, but because test didn't. Indecision because of siren (possibly after P.A. announcement).

Lights all on.

Second Event: Heard crashing—Expected lights to go out. They didn't. Got up and yelled, "Young and Bird—Open those windows next to you." "Put windows in seat." They started opening. Everybody up. "Out window foot first then head then foot." Told people in front of me to "Go to the back." (In galley area.)

Third Event: Lights went out. (Women there in front of me) told everyone (shouting) to hurry up. Smoke just coming from behind—Moving forward. Man asked shouldn't we open this door (galley). He was going aft. Not aware of aft section. (Prior arrangement to handle areas—forward/aft—looked out window. No fire out there.) Another man asked same question: "No." Repeated forward move. Foot first (etc.) (in here). Heard woman moaning. Turned around. Pulled out armrest to get to seat belt. Man behind me said, "Can I help you?" Picked her up—gave her to man. He took her. Couldn't see. No light. Lifted a man (Don Carroll) from seat and dragged him aft behind galley in aisle. Asked Carol if anyone could get him out. Went up forward. Feeling in seats. Boxes in aisle. Recognized

window exit by feel. Got to front row and found man. Right side aisle seat. (Carol shouting, "Everybody out?") Checked other seats. Nobody. Called for help from Carol right behind tugged (had already taken seat belt off). Couldn't lift a man (by arms). Seemed like awful long time. Carol said, "He's dead." "We're going to have to leave him." "Let's get out." Pushed Carol. Could see wing. Lights outside no problem out exit. Notice any fire? Out galley door. (Seemed like reddish glow sometime). Heard man on wing, "Do you need any help?" "No." Went out. Didn't hear siren at that time or after got out.

TEST III

Aft Stewardess

First Event: Announcement. In back section. Checked seat belts. Routine. Thought more information would come. Very realistic w/o.

Second Event: Screeching sound and silence. Smoke started. Couldn't see past galley bulkhead.

Forward Stewardess

First Event: No activity. All seated after announcement. Noise. Loud bang. Lights went off. Silence. Tried to open galley door. Looked to see back door open. When open— Yelled (to pax forward): "Unfasten seat belts and go out back and watch incline." Didn't unfasten belts right away—just sat there. Didn't see too much in aft because of smoke.

Forward—Right side aft row of forward cabin woman and man. Woman was helped out—Two fellows carrying her. (1 seated next to her voluntarily.)

Boy handed man to Bobbie, "I can't hold him—too heavy—You take him." Went forward. No one in back of me then. Up forward— Dragging a man over the seat to the aisle over man's back.

Second Event: Both exits were opened on own initiative by pax. Telling pax to hurry up— Shouting: "Go this way,"—"Come on."— "Over here." Never went aft of galley. "Leg-body-leg," two or three times. Visibility fairly good. Would never have sent anybody back except Mary was talking in back as though everything was good in aft cabin. Mary came forward to see if everyone out. "We're out back here."

Man was pushed out window. Another pax and I went out. Pax—forward overwing exit; self—aft door.

Had been over every inch— assumed everyone out.

Third Event: Opened door—Trouble lifting it up. Was previously instructed. Nobody seemed overly excited—Went to get two men out. One wouldn't move. Went to get two other men to help. Told them to "Help him."—No shouting needed. They did. Man with baby near rear. Two men on ground helped him. No screaming—Heard sirens almost immediately upon opening door. Wasn't too concerned about siren. Pushing people out door. Didn't slow up. Pax were coming from forward. Two men and girl came by—Slowed up exit. Couldn't see any more people—"What do I do now?" Went forward through smoke up to front. Could see seats. Asked Bobbie if she had everyone out. Last one going out. Came all way back and out aft door.
(Was standing aft of cabin door.)

After Crash: Silence—aft—saw smoke. Noises of people. Heard siren. Don't remember when—Prior to time reached forward cabin. Don't remember when siren stopped—Except it was after getting out.
Lights—Don't remember especially, but if there were any, it seems they were red.

TEST IV

Aft Stewardess

First Event: Announce. Checked last two rows forward cabin and aft cabin for seat belts. Took position at aft bulkhead. "Don't worry," to a girl in aft cabin. "Dead man"—asked if there would be any briefing. "No." One minute— couldn't see pax. Quiet except for outside noise.

Second Event: Lights out. Difficult to see door handle. Went for door. By feel. Opened door. Landed on top of left foot. Hollered for people to "Come out this way." (Door was on foot. Facing aft. Then lifted door off.) Cabin was reasonably quite.
First man out. Asked him to stay. Shadowy figure. He came back on aircraft.
Then saw dead man. Last row left side incapacitated man came out. Helped by pax. Visibility—Poor. Restricted by smoke/light level.

Third Event: Sounds—Aware but only nose. Heard siren but not at that time. Think more were still in aft cabin. Conscious of more people around in area. Crippled man came out and held up evacuation a bit. Using crutches. "Doing alright?" "Yes."
Delay in approaching door. Crippled man. Attention on "Dead Man." Two pax having difficulties getting him out of seat. Were

Forward Stewardess

First Event: Started up aisle. Seat belts. No smoking. Very calm. No alarm. No apprehension. Anticipated. Came back. Normally in brace position.

Second Event: Sound of crash. No one seemed to move. Started for exit. Overwing exits were responsibility. Elderly lady at exit on right side forward. She couldn't get seat belt open. Two people went over to her. Believe TWA girl opened exit. Don't know for sure. Knew galley exit wasn't to be used. Weren't checked out on it.

Third Event: Unfastened elderly lady's seat belt. Out exit. Her husband went out behind her. Asked that he stay there to help. He said, "okay." Looking at exit behind it to see if it was open and being used. It was.
Location—In front aisle waving 2 penlites—leg first.
Sounds—Yelling so loud didn't notice any sounds. "Move—Let's go—Unfasten seat

going to take out arm-rest, but couldn't get to it. Started to be eased out. Fell against Kay. Told men to grab him under shoulders. Slant of floor knocked Kay into door.

belts." No problem getting to forward cabin. One box fell into aisle. Put it back. People in aisle. No problem getting forward. Don't remember siren sound. Forward—flashlights at impact. Don't remember any other flashing light. Gunshots. Heard siren—When outside door—Couldn't see other than people lining at exits. Couldn't see or tell what was going on elsewhere. Heard no commands. Couldn't tell if man on wing was helping. Incapacitated man—Pax said, "Do you want help?" "Yes." Two men helped remove injured man from second or third row on left—forward window.

Checked with flashlight in seats plus feeling seats to see if everybody out. Smoke not so bad on floor.

Fourth Event: Heard Bea up forward once—Directing people aft. Couldn't see beyond two rows. Could see exit area. Light on ground. Door was clear. Dead man got outside. Pulled to door by Kay. He got out. Another injured (girl) being brought back. "I'll take her." Had her. She was fairly heavy. Nobody at door to help. A shadowy figure came from outside to help her. Elderly couple in buffet area. Took his hand and led hand in hand. He went out and helped her. Last helped out getting pretty empty.

Bea was back aft. "Is everyone off?" "Yes—let's go." Bea followed Kay out. Sounds seemed consistent throughout. No changes.

Clearer outside.

First man outside misunderstood and came back in.

Fourth Event: To aft of galley. Injured man in aisle. Being taken out by another man. Kay was in lead out back door. Kay asked, "Everyone out from front?" "Yes." When got to door no one was outside. Shouted loudly for help from outside to get injured man out. Seemed like could see better in back—less smoke. Told Kay to jump. Kay went behind helper for injured. Then I jumped out. Heard sirens at time jumped out. Aware of lights outside? "No."

Determine what was holding up second aft overwing exit? "Pax were wrestling for this exit. Seat back was blocking it. Told boy to open, but seat back blocked. Emergency exit between seats resist exit? Not that I could tell. Smoke blocked vision of exit.

APPENDIX 4

PASSENGER RECOMMENDATIONS OF PROCEDURES AND EQUIPMENT

TEST I

Exits:

1. Larger exits.
2. Stewardess should have space to direct exit activity.
3. Escape windows should be more clearly marked.
4. More escape hatches and cut out third seat.
5. Exits should not be directly behind seats.
6. Exiting should be staggered instead of everyone being told to get out at once.
7. Parallel handles at the door inside of the aircraft.
8. Dip in center of exit (or some other method) to get leg out.
9. Open door prior to impact.
10. Automatic opening exits upon impact.

Instructions:

1. Better instructions on use of exits prior to impact.
2. Better all-around instructions on emergency evacuation.
3. More than one announcement of crash and instructions as to what to do by the captain.
4. Megaphones or PA systems to aid stewardesses in giving instructions.
5. Instructions for emergency should be given before impact.

Lighting:

1. Flashing lights over exits.
2. Have a visual guide.
3. Stewardesses should have a light.

Equipment:

1. Metal to metal safety belt locks, seat belts.
2. Wider aisles.
3. Better place to keep packages.

Miscellaneous:

1. Stewardess should be calmer.
2. Women should not wear tight skirts.
3. No packages should be permitted.

TEST II

1. Instructions to open exits should be screwed to the back of seats—You can't miss reading them.
2. Better working of exits.
3. More and larger exits.
4. Exits should go out, not in.
5. Exit locator sign should be larger.
6. Eliminate seats that block exits.
7. All windows available for exits.
8. Lights on exit seat corners.
9. Stronger exit lights.
10. Seats that will fold out of the way at exit points.
11. Widen seat spacing at exit.
12. Have exits on side with double seats.

Instructions:

1. More instructions maybe more info on use of emergency exits.
2. "I should think stewardesses would be trained enough to help passengers get out or make people aware of how to get out."
3. Tell people about light over window if you want them to notice it.
4. Instructions as to how for to ground.
5. Instructions to open exits should be screwed to the back of seats—You can't miss reading them.

Lighting:

1. Lighting—night emergency not inertia lights—good emergency lighting system need—strobe light would be helpful if stewardess would let you know it was there (Frank Malone—CAB).
2. Permanent lighting.
3. Flashlights available for emergencies.
4. Smoke elimination.
5. Need emergency lights inside of aircraft.
6. More light.
7. Lights on exit seat corners.
8. Stronger exit lights.

Equipment:

1. Seat belt took too long to separate—strap too long.
2. Something to push seat up and tunnel people through one channel rather than present seat pattern.
3. Galley forms an obstacle if going out the rear—eliminate?
4. Better padding of back of seat to prevent injury during crash.
5. Eliminate three-abreast seating.
6. Make it easier to shove seats forward.
7. Improve seat backs.

Miscellaneous:

1. Tell women to take off high-heeled shoes.
2. Difficulty with tight skirts—no tight skirts aboard aircraft?
3. Place stewardesses in front of exits to assist people to move faster.
4. Eliminate baggage where it is loose.

TEST III

Exits:

1. Nine (9) exits—More exits.
2. Move all seats clear of hatches.
3. Directions to pull hatch in.
4. Larger exits.
5. Exit windows need to be easier to get off.
6. Windows should open out, not in.

Instructions:

1. More instructions and information from stewardesses and crew.
2. Passengers should be informed of emergency procedures.
3. Better PA systems to transmit instructions.
4. More instructions before takeoff.
5. Crew members or stewardesses up front to direct exit and procedures for opening exits.
6. Exit lights should be bigger.

Lighting:

No comments concerning lights.

Equipment:

No comments concerning equipment.

Miscellaneous:

1. Ground emergency crew available and informed at actual emergency.

TEST IV

Exits:

1. More space between seats at exit.
2. Eliminate seats obstructing exits.
3. Bigger exits.
4. Exits should be marked.
5. Larger emergency exits.
6. More exits.
7. Openings larger and lower.
8. Light over escape hatches and information in advance about them.
9. Should have lighter exits.
10. Exit sign lights should be on at all times.
11. Exits easier to open.
12. More exits—split them up.

Instructions:

1. More instructions from stewardesses.
2. More explicit instructions from stewardesses.
3. More knowledge of exit locations very important—Instructions from persons in command are very important since people will follow in emergency.
4. More adequate instructions from stewardess before take-off.
5. Light over escape hatches and information in advance about them.
6. Stewardess instructions louder.
7. Stewardess—explain opening operation of window exits prior to take-off.

Lighting:

1. Better emergency lighting.
2. More lighting.
3. Light over escape hatches and information in advance about them.
4. Need more flood lights leading to exits.
5. Exit sign lights should be on at all times.
6. Better smoke elimination.

Equipment:

1. More space needed between seats.
2. Inflatable restraint in front of seats.
3. Seat belt should open when you hit it.
4. Wider aisles.
5. Seat belts metal to metal.

Miscellaneous:

1. Debris hampered evacuation.
2. Someone to aid in evacuating.
3. Stewardess in way.

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