TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-AAS-74-3	2. Government Accession No.	PB 238 269
4. Title and Subtitle Special Study - Safety Aspects of Emergency Evacuations From Air Carrier Aircraft		5. Report Date November 13, 1974
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Aviation Safety Washington, D. C. 20591		10. Work Unit No. 1373-A
		11. Contract or Grant No.
		13. Type of Report and Period Covered Special Study
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20591		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This study examines 10 recent U.S. air carrier accidents in which an emergency evacuation occurred. Of the aircraft accidents and incidents in the National Transportation Safety Board's files, these 10 evacuation accidents exemplify the factors most commonly identified as influencing evacuation success. The factors identified and discussed include the following: Weather, terrain, aircraft attitude, fire and smoke, evacuation slides, emergency lighting, emergency communications equipment, obstructions to egress, passenger preparedness, crewmember training, and crewmember procedures. Ten safety recommendations regarding improvements in evacuation slides, megaphones, public address systems, passenger briefings, emergency lighting,and crewmember training resulted from this study.

Emergency evacuations

17. Key Words	18. Distribution Statement
Aircraft Accident, Evacuation, Passenger Injuries, Cabin Furnishings, Crew Procedures, Crew Emergency Training, Exits, Passenger Information, Fire and Smoke, Evacuation Alarms, Evacuation Slides, Emergency Lighting, Emergency Communications.	This document is available to the public through the National Technical Information Service, Springfield, Va. 22151

19. Security Classification (of this report)	20. Security Classification (of this page)	21.
UNCLASSIFIED	UNCLASSIFIED	

NTSB Form 1765.2 (Rev. 9/74)

SPECIAL STUDY

SAFETY ASPECTS OF EMERGENCY EVACUATIONS FROM AIR CARRIER AIRCRAFT

ADOPTED: NOVEMBER 13, 1974

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591
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INTRODUCTION

In spite of the downward trend in the U. S. air carrier accident rates over the past 10 years, an examination of accidents indicates that passengers are being injured or killed during emergency evacuations following "survivable" 1/ accidents. The National Transportation Safety Board, therefore believes that corrective action is needed to provide passengers with a greater degree of safety during emergency evacuations. The Safety Board further believes that the factors which most often affect the outcome of such evacuations must be identified and assessed as a first step toward improving passenger safety.

In order to identify such factors, the Safety Board has reexamined air carrier accidents during which an emergency evacuation took place. It also examined the Federal Aviation Administration's (FAA) incident files. As a result of these examinations, 10 case histories were studied because they exemplified the most common circumstances under which emergency evacuations occur.

Since records are not kept by either the FAA or the air carriers regarding successful evacuations, the total number and types of evacuations occurring each calendar year could not be determined. In spite of incomplete data, the facts and circumstances of the 10 cases presented in this report demonstrate that problems exist which merit additional safety studies and corrective actions.

1/ The term "survivable" as used herein, refers only to aircraft crash impact forces and conditions. That is, the deceleration forces imposed on the aircraft occupants and their immediate environment during the crash sequence, up to the time the aircraft comes to rest. Impact conditions which are survivable are those in which deceleration forces experienced by occupants through their restraint systems are within human "g" tolerances and adequate restraint is provided. Of course, the occupiable area of the aircraft must remain uncompromised.

In examining the 10 case histories, numerous factors were found that influence the success or failure of emergency evacuations, and some of these factors recurred frequently regardless of the circumstances surrounding the evacuation. The Safety Board believes that the elimination or the control of these recurring factors will greatly enhance passenger safety.

FACTORS AFFECTING EMERGENCY EVACUATIONS

The various factors which affect the success of an evacuation do not appear to be associated with specific types of evacuation conditions and circumstances. (See Appendix A.) Instead, most factors can be significant in any evacuation. In addition, some factors can and have provided positive and negative influences on evacuations. These factors have been grouped into three broad categories: Environment-Related Factors, Machine-Related Factors, and Man-Related Factors.

Environment-Related Factors

The more prevalent environment-related factors are: Weather, external illumination, terrain, aircraft attitude, fire, and smoke.

Weather.--Although weather may affect the success of an evacuation in many ways, the effects of wind on evacuation slides is one of the most serious problems. The direction and velocity of the wind at an evacuation site may cause the emergency evacuation slides to deploy and inflate improperly. Improper slide deployment and inflation can severely limit the number of usable exits, as in the Pan Am 747 accident. (Case History No. 9.) Figure 1 depicts the effect of adverse wind on emergency escape slides (No. 2 on left side and No. 1 on right side.) The winds affecting the Pan Am 747 slides were about 25 knots; such wind velocities are not uncommon in normal landing situations. The longer slides on wide-bodied aircraft make them more susceptible to wind displacement.

Following the Pan Am 747 accident, the Safety Board was informed that the design of the slides was being reviewed to determine if the effects of wind on slides could be reduced. The Federal Aviation Regulations (FARs) have not been revised and wind remains a potential problem.

External Illumination.--External illumination at the scene of an accident can also affect evacuations. Initially, poor external illumination

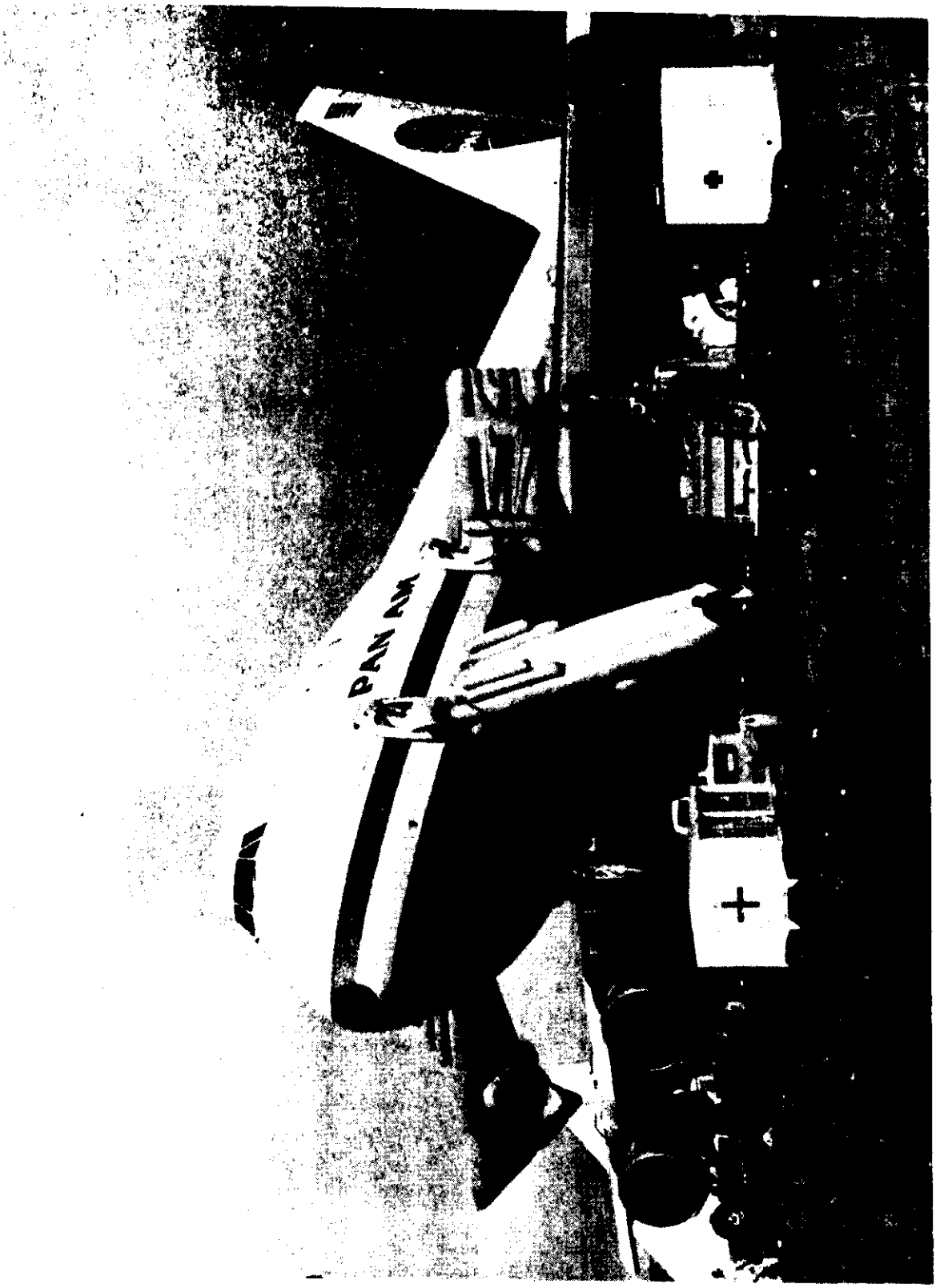

Figure 1. Wind effect on Pan American escape slide deployment

becomes a factor during the events precipitating an emergency evacuation. For example, the TWA 747 and the TWA 727 evacuations (~~Case Histories 3 and 4~~) were initiated because fire was observed outside of the aircraft. Both of these evacuations occurred during the hours of darkness, and the presence of fire was more evident. Possibly, these evacuations were unwarranted since they were initiated because of erroneous assessments of the severity of the fire.

Once an evacuation has been initiated, the lack of external illumination may prevent crewmembers from determining the adequacy of escape slide deployment and inflation, or the condition of the terrain onto which passengers will evacuate.

The FAR's contain standards for external emergency lighting systems. Current systems have an independent power source which is activated when the aircraft's power is interrupted. If the aircraft engines are operating, the systems will not be activated. For example, the TWA 747 and TWA 727 evacuations were continued for some time although the engines were running and no exterior lighting was available.

Another problem of poor external illumination is encountered after the passengers have exited. They can become disoriented, and consequently injured outside the aircraft, especially if they evacuated through overwing exits. In the TWA 727 evacuation, disorientation because of darkness was the single cause of occupant injuries. Several passengers who exited via overwing exits, were seriously injured when they inadvertantly stepped off the wing and fell to the pavement. Had the evacuation taken place during daylight or with sufficient artificial lighting, these injuries probably would have been prevented. Therefore, a better means of artificial exterior lighting would help to eliminate needless injuries resulting from poor illumination.

Terrain. --The terrain on which an evacuation occurs can influence the outcome of that evacuation. Of the 10 cases studied, eight evacuations took place within airport boundaries, and therefore, escape slides were deployed onto hard surfaces. In the American DC-10 accident, (~~Case History No. 10),~~ passengers evacuated onto pavement on one side of the aircraft, and onto grass on the other. More passengers who deplaned on the pavement side were injured than those who deplaned on the grass. In addition, in the TWA 747 accident, passengers were injured on the pavement at the bottom of the slides.

The terrain on which an evacuation must take place obviously cannot be controlled. However, better design of evacuation escape

slides may eliminate some of the injuries which occur. Additionally, assistance by passengers at the base of the slides during an evacuation has proven helpful and should be encouraged.

Aircraft Attitude. --The aircraft attitude following a survivable accident may significantly influence evacuation success. The Pan Am 747 and the Northwest 747 accidents, ~~(Case Histories No. 7 and 9)~~ clearly illustrate the influence of aircraft attitude on evacuation success. In Figure 2, the Pan Am 747 tilted back on its tail during the evacuation, and in Figure 3, the Northwest 747 came to rest with its tail high in the air. Although their attitudes were nearly opposite, the results of the evacuations were essentially the same. That is, escape slides were not usable at one end of the aircraft, because they were hanging nearly straight down. Nineteen minor and eight serious injuries were sustained by persons who evacuated the Pan Am 747, and one person who evacuated the Northwest 747 was injured slightly, because they slid down escape slides which were nearly vertical.

Federal regulations previously required that slides be long enough so that their angle with the ground is "safe and usable by an evacuee," regardless of whether one or two landing gears collapsed. However, current regulations with respect to the new wide-bodied aircraft specify that the slides be long enough for the lower end to be "self-supporting on the ground," after collapse of one or more legs of the landing gear.

Since the design of slides on wide-bodied aircraft does not provide for large attitude variations, and changes to the current designs do not appear forthcoming, the possibility that exits will be unsafe or unusable because of attitude variations will continue to be a problem for evacuating passengers. Crewmembers should be made aware of this possibility so they can redirect passengers to usable exits, if necessary.

Fire and Smoke. --Accident experience indicates that fire and smoke are the most serious environmental factors to affect an emergency evacuation. In fact, the threat of fire and smoke is the primary reason for evacuating an aircraft. The scope of this study does not include an analysis of measures to reduce or prevent the occurrence or severity of aircraft fires. Rather, the discussion is based on the assumption that within the foreseeable future, the threat of fire and smoke following a mishap will continue to be a very serious one.

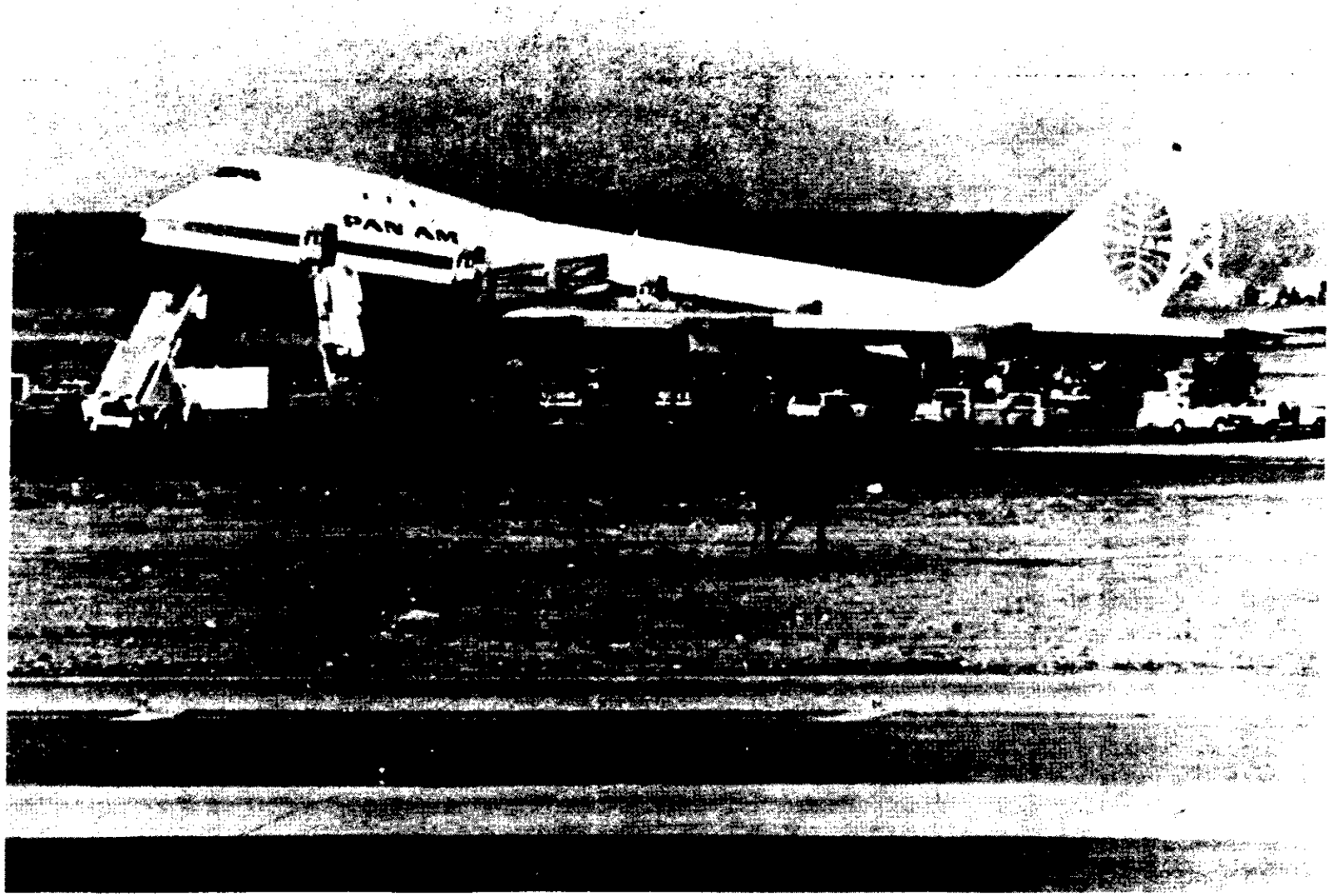

Figure 2. The Pan American 747 nose-high attitude

Figure 2. The Pan American 747 nose-high attitude

Figure 3. The Northwest 747 tail-high attitude

The aircraft fire problem has long been recognized and studied by the aviation community. Its magnitude and seriousness were illustrated in a report entitled "A Study of U. S. Air Carrier Accidents Involving Fire, 1955-1964," issued by the Civil Aeronautics Board in 1966. Work has been under way by FAA, NASA, and industry to develop improved fire resistant materials, practical fuel inerting systems, and other approaches to remedying the fuel fire hazard. Although these efforts offer promise of significant progress in the future, the Safety Board believes that implementation of the measures recommended in this report will provide more immediate improvements in the level of passenger safety.

Although fire and smoke during an evacuation involve environment-related, machine-related, and man-related factors, this study has addressed only the environmental aspects because of the extremely hostile environment created by fire and smoke. Accident data indicates that completely survivable crashes that were followed by postimpact fire, often resulted in injuries and fatalities.

Smoke during an evacuation often causes aircraft occupants to become disoriented because it causes visibility in the cabin to decrease rapidly. Smoke generated by aircraft fires is normally dense, black, and toxic. This smoke reduces cabin visibility in three ways: (1) Heat from the fires causes the smoke to rise and reduces or obscures lighting, which is normally located in the ceiling; (2) smoke eliminates or reduces external light entering through windows; and (3) smoke causes eye irritation which further reduces the occupants' ability to see.

Disorientation can cause passengers to enter areas of the aircraft from which they are unable to escape. For example, in the North Central DC-9, (Case History No. 2), fatally injured passengers were found in the lavatory area, the tailcone area, and in the cockpit. Circumstances suggest that they became disoriented because they could not see.

In the Allegheny Convair accident, (Case History No. 8), smoke significantly influenced occupant egress. All but one of the fatalities had inhaled significant amounts of smoke. According to survivors, there was considerable confusion in the dark, smoke-filled cabin. Only two passengers were able to exit successfully.

If smoke and fire are outside the aircraft when an evacuation is initiated the number of usable exits is limited. Flight attendants are trained not to open an exit which has smoke or fire immediately outside. Therefore, depending on the flight attendant's judgment, several exits may remain closed because of fire or smoke immediately outside. If a flight attendant has misjudged the situation and vitally needed exits remain closed, the evacuation may not be as timely or as efficient as it should be. (See Case Histories Nos. 2 and 5.) A fire around the engine nacelle on the left wing of the Icelandic DC-8 led to the decision not to use the overwing exits and two floor-level exits (jetescapes) on the left side of the aircraft. Fortunately, the fire did not spread to the cabin, and the passengers were able to escape.

In the North Central DC-9 accident, only two of the four available exits were opened and used. Two overwing exits, one forward door and the tailcone exit, were not opened during the evacuation. The reasons these exits were not opened could not be determined; however, fire and smoke were present shortly after the collision and may have influence the decision not to open the exits.

Smoke and fire create an environment which impairs breathing and vision in which persons can survive for only a short time, because fire propagates rapidly through an aircraft and tends to produce large quantities of toxic smoke. Numerous toxic gases are produced by aircraft fires. Two gases most frequently cited as the cause of postcrash fatalities are carbon monoxide (CO) and hydrogen cyanide (HCN). Although the individual levels of the toxic gases found in the smoke from aircraft fires are not always fatal, combinations of nonfatal levels of toxic gases can cause fatalities. 2/ In addition, the physical effects of one toxic agent can influence the effects of another. For example, inhalation of HCN causes a person to breathe more rapidly, which, in turn, leads to the ingestion of greater concentrations of other toxic gases.

In 3 of the 10 case histories examined, postcrash fatalities were attributed to inhalation of toxic gases. In the North Central DC-9 and Allegheny Convair accidents, all passenger fatalities were attributed to smoke inhalation and burns. These cases point out the need for rapid evacuations when fire or smoke is present in the evacuation environment.

2/ NTSB Docket Number SA-535, Exhibit 6-C.

Machine-Related Factors

Machine related factors affecting evacuation success include the design aspects and the crash-induced influences of aircraft contents and components. Aircraft components and items carried on board by passengers or crewmembers can influence an evacuation. In fact, some items placed on board for use in emergency evacuations, such as evacuation slides, emergency illumination devices, emergency communication devices, emergency exits, and exit location devices have adversely influenced some evacuations. Physical obstructions, which are either designed into the aircraft interior or generated by crash forces, can also influence evacuations. A discussion of each follows.

Evacuation Slides. --Evacuation slides and slide/rafts are the primary devices used for deplaning passengers during an emergency. Therefore, successful deployment and inflation of the slides is essential. 14 CFR 25.803, 25.809, 121.310, and 37.175 specify criteria for design, manufacture, installation, and inspection of emergency escape slides. Yet, past accident experience indicates that slide failures occur frequently and thereby limit exit usability. The slide problems identified in the 10 case histories examined represent the types of failures that occur and suggest that the reliability of slide systems may need to be improved.

Improper installation and maintenance of emergency evacuation slides and their activating mechanisms have caused inflation failures. When the Safety Board examined the forward entry door slide on the North Central DC-9, it discovered that the inflation lanyard was wrapped around the neck of the inflation bottle. Regardless of the force applied to the inflation lanyard, the slide could not have inflated. The inflation bottle was improperly rigged either during installation or during periodic maintenance of the system. Fortunately, the non-functioning slide did not influence the success of the evacuation, since the aircraft was resting on its belly and the slide was not essential.

The failure of the right-4 slide on the Pan Am 747 is an example of the consequences of an inadequately installed or inadequately maintained slide. The gas generator bottle had shifted in its mounts and caused the trigger mechanism to be misaligned. The bottle was free to shift because one of the two bottle retainer straps had not been fastened. Therefore, the trigger did not fire the bottle.

Although only two failures of evacuation slides were attributed to maintenance/installation problems ~~in the 10 cases~~, other accident experience has shown similar maintenance/installation problems. Accordingly, these problems merit consideration as significant influences on evacuation success. The Safety Board believes that improved quality control of the slide packing, installation, and maintenace could prevent most of the problems.

The crash forces in the Pan Am 747 accident were minor; in the Icelandic DC-8 accident, the crash forces were moderate; and in the United 737 accident, (Case History No. 6), they were quite severe. Yet, in all three cases, components of the emergency slide systems failed because of crash forces.

In the Pan Am 747 accident, one exit was rendered unusable because the entire emergency slide pack broke loose from the door to which it was mounted. (See Figure 4.) The same problem occurred in the Icelandic DC-8 accident when a slide pack broke loose at impact. The crash forces of both accidents were survivable.

In the United 737 accident, the slide pack cover came loose and prevented the exit from being opened until the cover was straightened. Failures of slide components caused by crash forces identified in these three accidents, have occurred in several other evacuation accidents. Thus, although anticipated crash forces may have been considered in the design of evacuation slides, actual accident experience indicates that under minor dynamic loads failures occur. Such failures indicate that the crash forces specified for the design of slide systems may not be entirely adequate or that in-service deterioration may occur.

As a result of these problems, the Safety Board has recommended that the FAA review the slide pack mounting design, gas generator retention design, and wheel-well mounted gas generator retention design of the B-747. The recommendation was aimed at improving the design and reliability of these components. The Boeing Company issued a service bulletin regarding these problems, but no rulemaking has been initiated.

Since wide-bodied aircraft can carry more passengers, they were designed with wider doors and double-occupancy slides. During several evacuations, passengers have lost their balance while sliding down these double-occupancy slides, even though there is a raised

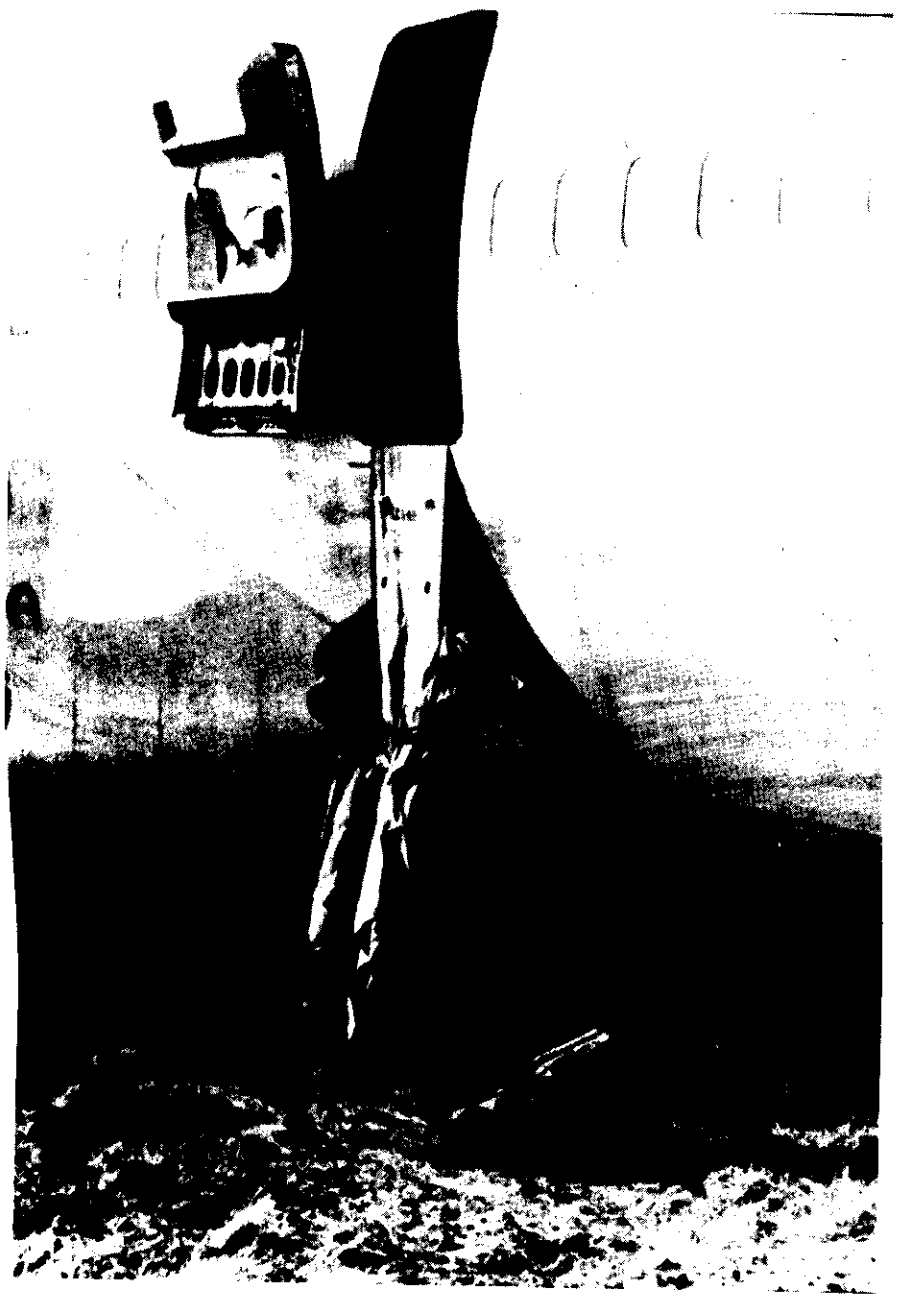

Figure 4. Evacuation Slide Failure, Pan American 747

area down the center of the slide. In the American DC-10 accident, passengers were injured because they were unable to stabilize their descent and to land "feet first." The problem indicates that design improvements may be necessary.

The FAR's specify the maximum allowable time period for slide inflation and erection. In the American DC-10 accident, passengers were ready to evacuate before the exits were available for use. In the United 737 accident, as well as other accidents, passengers were actually departing the aircraft before slides had inflated. If these incidents had taken place on a wide-bodied aircraft, they would have been disasterous. More rapid slide inflation and erection would allow evacuations to begin sooner. Although the more recently certificated aircraft are fitted with automatically inflated slides, older aircraft, such as the Boeing 737, Douglas DC-9, and Convair 580, are not. In some of these aircraft, slides are automatically deployed but must be manually inflated. This process takes time and requires that the crewmembers or passengers be knowledgeable of the system in order to operate exits. Fully automatic slides, with manual backup, afford the best opportunity for reducing the time required for slide deployment and inflation. Until aircraft are retrofitted with automatic slides, better training of the crewmembers and instructing of passengers are needed.

Emergency Lighting Systems.--Emergency lighting systems are installed in aircraft to assist evacuating passengers in locating and using emergency exits. These systems reduce the effects of poor illumination on evacuation success, since most of the current emergency lighting systems include provisions for both interior and exterior lighting. Although there is a need for both systems during night evacuations, adequate interior illumination is required for all evacuations regardless of time of day. For instance, survivors of the United 737 and Allegheny Convair accidents indicated that it was dark in the aircraft even though the accident occurred during daylight hours.

All air carrier aircraft are required by the FAR's to have some type of interior emergency lighting system installed. These systems are designed to be activated anytime that normal aircraft electrical power is not available. Since 14 CFR 25.812 requires that emergency lighting systems be independent of the main aircraft power supply, current systems operate on integral batteries. Therefore, in order for these lights to illuminate automatically during an emergency, the main aircraft electrical power must be interrupted and the emergency lighting system must be "armed."

These systems have two characteristics which frequently affect evacuation successes--light intensity and light location. 14 CFR 25.812 requires that aircraft emergency lighting systems meet certain illumination criteria. Actual observations of the cabin interiors of older, as well as more recently certificated aircraft, with only emergency lighting provided, reveal that cabin illumination levels are low. For example, in the Delta Convair 880 accident, (Case No. 1), the flight attendants had to use flashlights to examine passengers for injuries because the cabin lights were dim.

Although this low level of emergency cabin illumination may be sufficient to allow passengers to locate an emergency exit and deplane under smoke-free conditions, in a smoke-filled cabin, current ceiling-mounted emergency lighting systems do not provide adequate illumination. Since smoke eventually forces passengers to take lower positions in the cabin, supplemental emergency lighting, located on or near the floor, would be a more effective means for providing guidance to exits.

The Safety Board has made recommendations to the FAA regarding problems with emergency lighting intensity and location. The most recent of these recommended improvements both in cabin illumination levels and in passenger guidance to emergency exits. (Recommendations A-73-42 and 53.) The conditions which precipitated these recommendations still exist.

In situations involving large wide-bodied aircraft, adequate external emergency lighting is doubly important, because the distance to the ground from wide-bodied aircraft exits can cause serious injuries if an occupant attempts to use an improperly inflated slide. In the TWA 747 accident, no external emergency lighting was available during a portion of the evacuation, because the engines were running and the ship's power continued to be available. Therefore, the emergency lighting system was not energized. As a result, the flight attendants evacuated passengers without being able to determine either the condition of the slides or conditions on the ground around them. This accident and the TWA 727 accident, in which passengers inadvertantly walked off the wings in the dark, illustrate the consequences of poor external illumination. Since the activation of external emergency lighting requires interruption of normal aircraft power and proper switch settings, a more reliable system would be one activated by door opening in the emergency mode. This concept has been considered previously by the FAA in Notice of Proposed Rulemaking 66-26.

Flashlights, although not part of the aircraft lighting system, are required equipment for flight attendants. Such flashlights have been of assistance in some evacuations. In the Delta Convair 880 case, flight attendants used them to augment aircraft emergency lighting and to examine passenger injuries. However, in the United 737 case, the two flight attendants in the aft cabin had stowed their flashlights in their purses, which were stored in the aft coat closet. Although the FAR's require that a flashlight be readily available, a flashlight can be of assistance in an evacuation only if it is carried on the person who will use it. The Safety Board has urged that portable high-intensity lights be installed at flight attendant stations for use in emergency evacuations. (Recommendation A-73-41.) Such a device would provide flight attendants with a more readily available source of light.

Emergency Communication Equipment. --Emergency communication equipment includes public address (p.a.) systems, evacuation alarms, and megaphones. Although aircraft p.a. systems are not designated as emergency communications devices, they should be considered as such, since they may be used until main aircraft power is lost. On some aircraft, p.a. systems are wired to the battery bus and thus can be used after engine shutdown as long as the battery switch remains on. Unfortunately, the events precipitating evacuations often dictate shutting off all aircraft electrical power including the battery. When this occurs, only items directly wired to the battery are available for use. Therefore, p.a. systems rarely are available as emergency communication devices except possibly for evacuation initiation.

The importance of using the p.a. system for emergency communications has become more pronounced with the advent of modern, wide-bodied aircraft. The larger cabin areas and larger number of passengers require that voice commands be amplified so that evacuations can be controlled. Currently, only selfpowered megaphones are required for voice amplification. Accessibility of these devices has created a problem similar to that of the flashlights.

Currently, the FAR's require that a minimum of one or two battery-powered megaphones be carried in the passenger cabin, depending on the seating capacity. Megaphones were not used during the evacuations in any of the 10 case histories examined. In fact, records suggest that they are rarely used for directing emergency evacuations. Megaphones are probably not used because:

(1) Megaphones are not readily accessible to the flight attendants since they are stored usually in overhead hatracks or in storage bins. These locations are frequently not within reach of flight attendants at their seats (normally their evacuation duty stations). Therefore, flight attendants would have to abandon their assigned duty station in order to obtain a megaphone. In many situations, it is inconsistent with good emergency procedures to expect this to be done.

(2) Flight attendants may forget about megaphones during an emergency situation, because the devices are stowed in rather inconspicuous and inaccessible locations. Because of the problems with these emergency communications devices, megaphones should be located closer to crew evacuation duty stations or should be augmented by other means of emergency communication. For example, aircraft p.a. systems located at evacuation duty stations, if wired directly to the battery or provided with an independent power source, would assist in providing emergency communications.

(3) Many of the megaphones currently in use are large, heavy, and cumbersome to handle in a crowded cabin. Present technology would permit implementation of compact, light-weight models which would facilitate accessible stowage and use.

Evacuation alarms are another emergency communcations device which is installed on some air carrier aircraft. Although the FAR's do not require evacuation alarms, such alarms are used by some airlines to initiate emergency evacuations.

Once the decision has been made to evacuate, all aircraft occupants must be notified. In aircraft not configured with evacuation alarm systems, the fastest means of initiating an evacuation is via the p.a. system. The interphone system could also be used to alert crewmembers to evacuate. A standardized evacuation alarm system would eliminate delays in initiation such as that which occurred during the Pan Am 747 accident wherein the first officer inadvertantly broadcast the evacuation order on the VHF radio rather than on the p.a. system. The evacuation did not start until sometime later when a cockpit crewman entered the cabin. Once the forward doors were opened, the passengers and crew farther back in the cabin noticed the evacuation in progress and opened their exits.

If an evacuation alarm were installed on all air carrier aircraft, it would provide a standard system by which crewmembers could initiate

an emergency evacuation. The Safety Board has urged the FAA to amend the FAR's to require that evacuation alarms be installed. (Recommendation A-72-141.) The FAA responded that the "state-of-the-art" in evacuation alarms systems does not support rulemaking.

Obstructions to Egress.--In addition to the various emergency equipment discussed so far, there are other machine-related factors which can influence an emergency evacuation. The most important of these are components of the aircraft's interior which can obstruct the flow of occupants during an evacuation. These components are important because they often fail and shift about after a crash. Several fixtures in the cabin interior have been identified repeatedly as hazards, because they often fail and create obstacles to evacuation. They include: Ceiling panels, overhead racks, liferafts, galley components, galley supplies, movie projectors, movie screens, emergency oxygen masks, and other miscellaneous items including passenger carry-on baggage. ~~(See Figures 5 and 6.)~~

Ceiling panels are designed for quick removal or partial lowering to afford easy access to various aircraft components. All of these panels are designed to comply with FAR crashworthiness specifications. Accident circumstances, however, have demonstrated that these panels have fallen on passengers in many accidents. Besides this immediate hazard, ceiling panels also can block access to exits during emergency evacuations, such as occurred in the American DC-10 (see Figure 6) and Pan Am 747 accidents.

As a result of the Pan Am 747 ceiling-panel failures, the Safety Board recommended that the FAA review criteria for installing ceiling panels and amend requirements to insure that they stay in position during survivable impact forces. (Recommendation A-72-144.) The FAA responded that the criteria for installing ceiling panels was reviewed and found to be adequate. Recent accident experience indicates, however, that the problem still exists.

Other cabin fixtures that interfered with egress or passenger vision of exits usually failed because of inadequate latching mechanisms. In 7 of the 10 cases studied, failures of these types of components occurred although the deceleration forces, as described by survivors, were light to moderate (e.g., "normal landing, hard landing, firm touchdown").

14 CFR 25.789 specifies that: "Means must be provided to prevent each item of mass (that is part of the airplane type design)

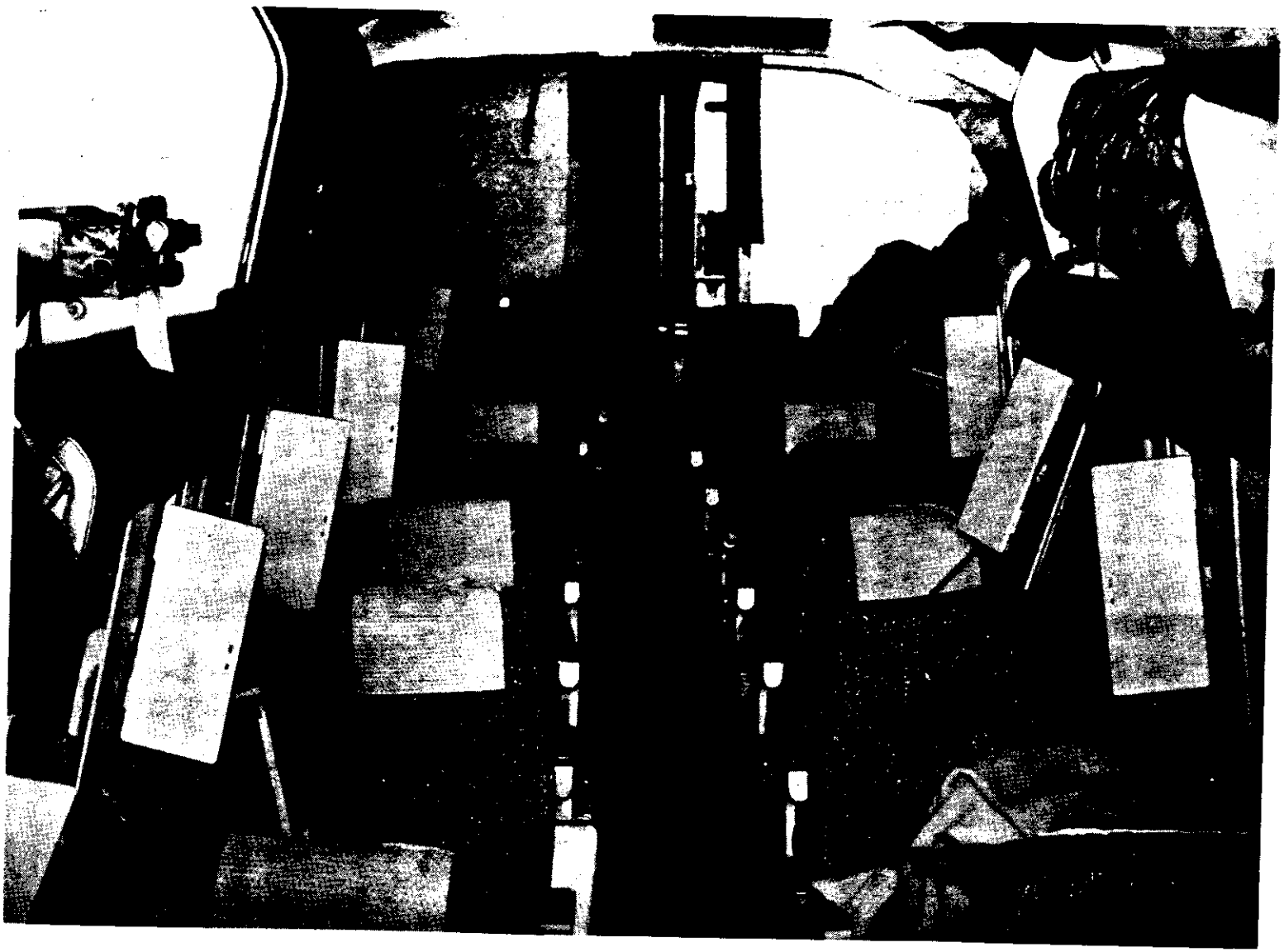

Figure 5. Interior Damage of Icelandic DC-8 Accident

Figure 5. Interior Damage of Icelandic DC-8 Accident

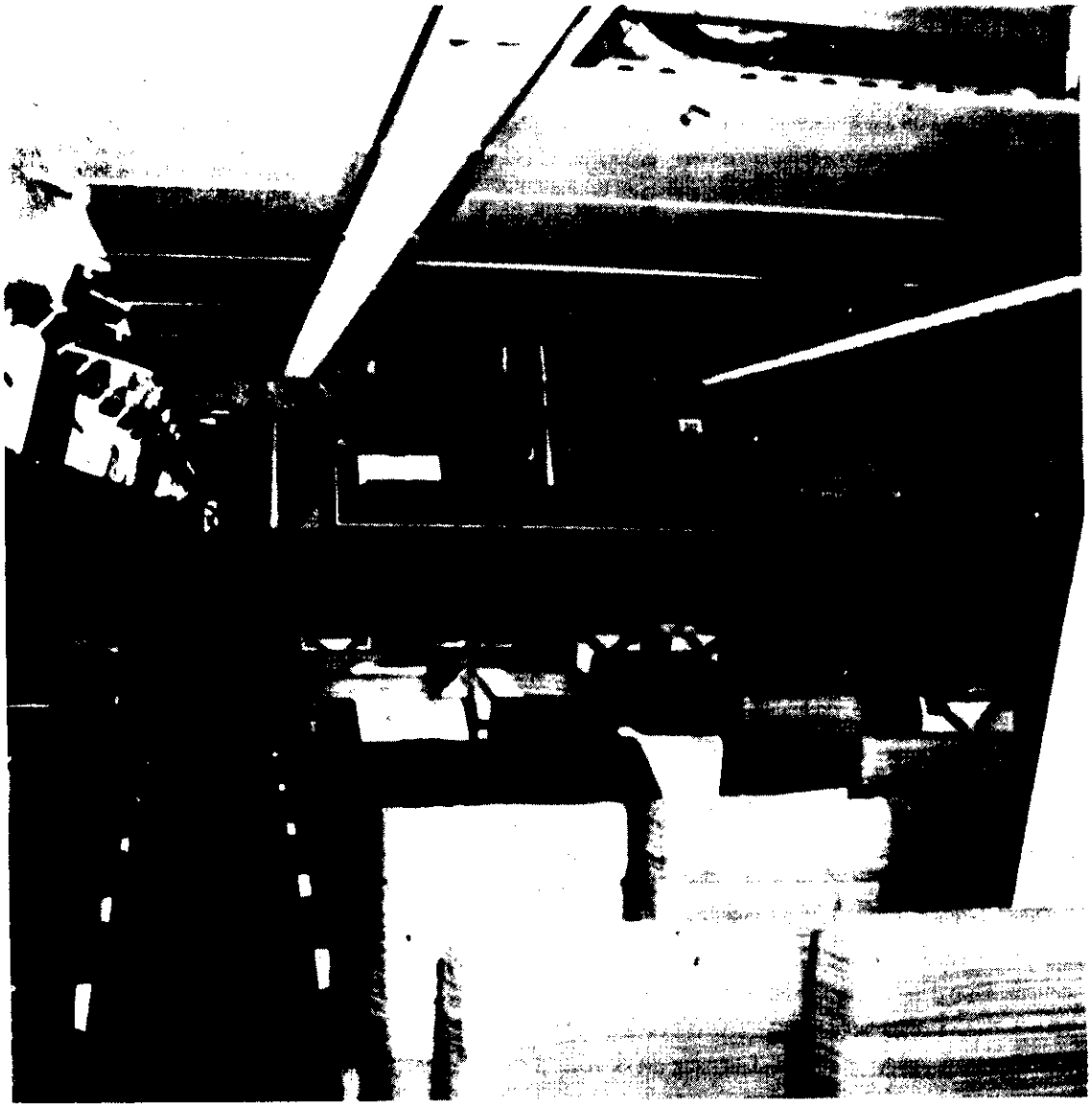

Figure 6. Interior Damage of American DC-10 Accident

in a passenger or crew compartment from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions and the emergency landing conditions of 14 CFR 25.561 (b)." Additionally, 14 CFR 25.561 paragraph (c) states that "The supporting structure must be designed to restrain, under all loads up to those specified in paragraph (b)(3) of this section, each item of mass that could injure an occupant if it came loose in a minor crash landing."

The intent of the regulations is to restrain items of mass in aircraft cabins, including all cabin fixtures previously discussed. However, in the cases studied and in other accidents, items of mass have failed and have ostructed evacuations even though the decelerations and impacts were described by survivors as "minor." Therefore, it appears that the FAR's are inadequate, the manufacturers are not giving proper attention to design detail regarding retention of secondary structures, or the intent of the FAR's is not being enforced properly by the FAA.

Features of the aircraft cabin layout also can obstruct an evacuation. Examples of these potential obstructions include the placement of fixtures such as cabin dividers, lavatories, partitions, coat closets, and galley bulkheads. These fixtures can become obstacles to evacuation if they obscure exits from view or confuse occupants during emergency evacuations. The influence of these items is subtle, and therefore difficult to document. However, in the North Central DC-9 accident, survivors recalled being temporarily confused by bulkheads while evacuating the aircraft. In large wide-bodied aircraft this problem would be more pronounced because of the greater number of dividers and bulkheads in the cabin. Since most of these fixtures cannot be eliminated, the only solution is more effective education of passengers regarding exit locations.

Additionally, problems are caused during evacuations by carry-on baggage. The FAR's require that carry-on baggage be placed beneath passenger seats, and it does not constitute a hazard if it remains there during an evacuation. However, experience shows that passengers often attempt to evacuate with their carry-on baggage. This practice has delayed evacuations and resulted in passenger injuries.

In the TWA 747 accident, evacuation obstacles were created when passengers were injured deplaning with personal belongings.

It appears that in order to prevent these problems for recurring, better methods of securing carry-on baggage must be developed. The newer type overhead storage bins and other means of retaining these articles are desirable if proper latching mechanisms are installed and maintained.

Man-Related Factors

There are many man-related factors affecting the success of evacuations. The more significant of these can be categorized into three general areas: Passenger preparedness, crewmember emergency training, and crewmember evacuation procedures. Each of these areas is discussed below.

Passenger Preparedness.--Passenger preparedness before an evacuation is dependent mainly on three sources of information--the pretakeoff briefing, the information contained in the passenger information cards, and pre-evacuation briefing (if any).

14 CFR 121.571 requires that passengers receive a pretakeoff briefing on the following: Smoking, location of exits, and use of seatbelts. The briefing must be supplemented by printed information cards which must be conveniently located for passenger use. Safety Board investigators have observed that passenger attentiveness to these briefings and information cards frequently is poor. Becker 3/ attributes this lack of attention to a feeling of powerlessness. The author maintains that the whole attitude and manner of delivery of emergency briefings tends to play down the significance of the information being presented. Therefore, the passenger gets the feeling that he has no control over his environment and thus, ignores the information being presented. Nevertheless, whether a passenger listens or not, the only meaningful evacuation information contained in a pretakeoff briefing is the location of exits. No instructions regarding operation of exits or other emergency evacuation equipment is given.

Passengers who have been involved in evacuation accidents frequently suggest that there is a need for greater dissemination of safety information. Ironically, much of the safety information

3/ Becker, M.A. "Behavioral Stress Response Related to Passengers Briefing and Emergency Warning Systems," Safe Journal, Vol. 3, No. 2 Page 6-9, 1973.

recommended is currently available, which suggests that the techniques for presenting safety information may be inadequate. The Safety Board believes that the current increased emphasis on consumer and occupational safety should also be extended to the research and development of more effective audio-visual methods of presenting safety information to air carrier passengers. The Board previously had made recommendations to the FAA and the Air Transport Association urging improvements in presentation of passenger safety information. (Recommendations A-72-67, 68, and 72.) Although the addressees expressed intent to study the problem, and some examples of improvements are evident in the air transport industry, the Board believes there still exists a need for upgraded and standardized requirements.

Passengers interviewed following aircraft accidents, frequently admit that they did not read the safety information card, and usually explain that they had read the cards previously and that all the cards contained the same information. One possible reason for the lack of passenger interest may be the design of the information card. A review of passenger safety information cards from many air carriers revealed that there have been few changes made over the years. Only recently have systematic efforts been made toward improving information card format and presentation.

Another more subtle reason the cards are not read is that they must compete with other reading material in the cabin. In addition, on many occasions, the cards are mentioned concurrently with the airline magazine, which is normally located in the same seatback pocket, and some pretakeoff briefings tend to minimize the importance of the information cards.

Past accidents have shown that when the need for an evacuation is imminent, and time is available for briefing, passengers pay close attention to the instructions. Such briefings serve several purposes--they act as a refresher of the pretakeoff briefing, they help to calm and reassure passengers, and they can be used for exchange of information and assigning of evacuation duties to the passengers. The success of the Pan Am 747 and American DC-10 evacuations supports the premise that the more safety information available to passengers, the better chance of a successful evacuation. Since the impending need for most evacuations cannot be predicted, the safety information should be presented to passengers so that it is easily understood and likely to be retained.

In an attempt to quantify the worth of safety information in pre-takeoff briefings and on safety information cards, the Safety Board analyzed passenger questionnaires which were completed by passengers involved in the TWA 747 evacuation. One hundred sixty-five questionnaires were mailed out and 114 evacuees responded. All passengers who were injured in the evacuation apparently responded to the questionnaire; however, not all injuries were sustained during the evacuation and were not related to knowledge of safety information. Therefore, only injuries determined to be related to evacuation problems were evaluated.

The questionnaires revealed that of the 114 persons responding, 72 had not read the safety information card. Of the 72 passengers who had not read the card, 40 persons were injured by evacuation-related causes. By contrast, of the 42 persons who had read the card, only 7 received evacuation-related injuries. Although these constitute a very limited sample, these data indicate that the percentage of passengers injured who had not read the safety information card was three times as great as that for those passengers who had read the card. (See Figure 7.) These data suggest that passengers who are not attentative to safety information are much more susceptible to being injured during an evacuation.

Crew Training. --Regardless of how well-informed passengers are, the actions of the aircraft's crewmembers have a far-reaching affect on an emergency evacuation. Of course, crewmember performance depends greatly upon the emergency training that each has received. Air carriers provide emergency training for their crewmembers, and the FAA is responsible for assuring that this emergency training is adequate and in compliance with the regulations. Although the programs vary somewhat, the training has tended to be more oriented toward audio-visual presentations and demonstrations rather than actual performance and practice. Although the FAR's require actual operation of the proper equipment during emergency training, deviations have been authorized, and much of the training is done by demonstrations.

In education, it has been found that a variety of training experiences increases the depth of understanding of important concepts. Therefore, to prepare crewmembers more adequately for the conditions and circumstances encountered in an evacuation, the actual

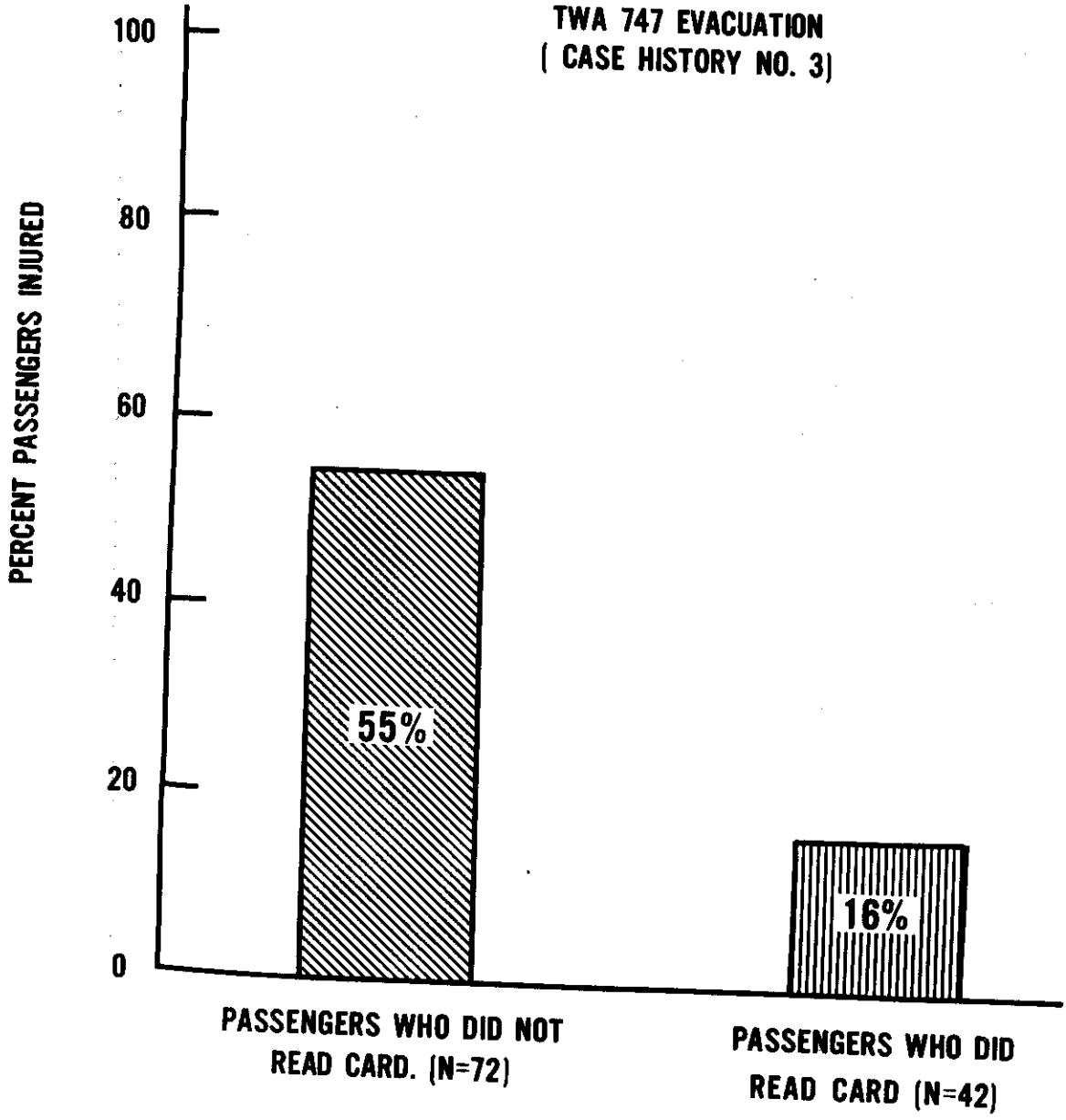

Figure 7. Comparison of Evacuation Related Injuries and Knowledge of Safety Information Card

operation of equipment and the actual performance of duties would enhance crewmember preparedness for an actual evacuation. Since the FAR's require actual performance during training, which could result in greater efficiency in an actual evacuation, training mainly through demonstration is not desirable.

The adequacy of emergency training can be measured indirectly by analyzing crewmember performance during an actual evacuation. Based on such an analysis, inadequacies in training have been revealed. In the North Central DC-9 evacuation, flight attendants and cockpit crewmembers were not fully aware of how to operate certain emergency equipment. In the TWA 747 evacuation, exits were opened and slides deployed close to a fire, and while the aircraft engines were running. There are many ~~other~~ examples of crewmember errors due to inadequate knowledge of equipment and procedures. The Safety Board reiterates its belief that more realistic initial and recurrent training would significantly increase survival and reduce injuries.

Crew Procedures.--Crew emergency evacuation procedures and adherence to these procedures repeatedly have been identified as problems. The FAR's require that air carrier operators establish emergency procedures and include them in their operations manual. In addition to proper training in such procedures, adequate procedures must be formulated and implemented if evacuations are to be successful. A review of the operations manuals of the air carriers in the 10 cases studied revealed differences in procedures for initiating evacuations and in crew responsibilities during evacuations.

Standards are deficient with regard to evacuation communication procedures. No standard means exists by which air carriers initiate evacuations. Some use evacuation alarms, some use the p.a. system, and some use verbal commands. Since an evacuation must be timely, procedures for initiating evacuations must be standardized. Evacuation initiation problems experienced in the TWA 747, TWA 727, and the North Central DC-9 cases would have been avoided had evacuation initiation procedures been standardized.

Once the decision to evacuate is made, crewmembers must complete several important tasks before passengers can begin to deplane. Crewmembers must: Determine exit availability, exit opening, slide deployment, and slide inflation, if not automatic. Exit availability should be determined before exits are opened and before passengers are allowed to egress down emergency evacuation slides. In several recent accidents, this determination was not made.

In the Pan American 747 and the Northwest 747 cases, passengers were allowed to deplane via slides that were too steep and consequently, passengers were injured. It is especially important on wide-bodied aircraft to determine exit availability and slide usability before passengers are allowed to egress. As indicated previously, the heights of these exits on new aircraft can result in severe injuries if the slides are not properly deployed and inflated.

The FAR's specify the number of cabin attendants on each passenger-carrying aircraft. The number is based on the aircraft seating capacity and not on the number of exits. Since some aircraft are operated with fewer than one cabin attendant per exit, it is possible that a passenger may be required to operate an exit. Therefore, passengers located adjacent to unmanned exits should be made aware of the operation of the exit in case of an emergency evacuation. Such information, presented in the pretakeoff briefing, would improve evacuation success by increasing exit availability.

Accident experience indicates that it is extremely important that crewmembers be at their assigned evacuation duty stations before the evacuation begins. During evacuations, passengers tend to rush to crewmembers for evacuation guidance and directions. Crewmembers, located at assigned duty stations, can be of greater assistance than when located elsewhere in the cabin, since their duty stations are usually located at exits. In the North Central DC-9 case, none of the crewmembers were at their assigned duty stations during the evacuation. As a result, crewmembers were unable to provide adequate evacuation direction or to determine that all of the passengers were out of the aircraft before exiting themselves. Accidents such as this confirm the need for crewmembers to adhere strictly to assigned tasks during an evacuation.

CONCLUSIONS

1. Because evacuation slide deployments are not reportable, the reliability of these systems cannot be determined accurately.

2. Because of the size of the wide-bodied aircraft evacuation slides, they are more susceptible to becoming unusable because of surface winds.

3. The attitude of wide-bodied aircraft following an accident may render exits unusable. Nose-high and tail-high attitudes can cause some slides to be nearly vertical.

4. Adequate external illumination is necessary to reduce the incidence of injuries in evacuations during darkness.

5. Passengers using evacuation slides are frequently injured when evacuating on to hard surfaces.

6. Smoke generated in aircraft fires rapidly reduces visibility in the cabin, causes disorientation, and can result in passengers entering areas of an aircraft from which escape is improbable.

7. Since heat causes smoke to rise, it rapidly obscures interior emergency illumination, which is located in the ceiling.

8. The amount of time available to evacuate an aircraft is reduced significantly when smoke is present, because of its debilitating effect and its toxicity.

9. Evacuation slide failures have occurred because of improper design, installation, and maintenance.

10. Passengers frequently are unable to maintain "feet first" stability on the double-occupancy slides of wide-bodied aircraft.

11. Fully automatic slides with manual backups afford the best opportunity to reduce the time required for slide deployment and inflation.

12. Requirements regarding portable flashlights do not provide for adequate auxiliary light sources.

13. P.a. systems are often used to initiate emergency evacuations; however, they are not always available when aircraft power is interrupted.

14. Megaphones are rarely used for directing emergency evacuations, because they are not stowed in locations readily accessible to flight attendants.

15. Evacuation alarm systems would provide a standardized method for rapid evacuation initiation and notification.

16. Many components of aircraft cabin interiors break loose during "survivable" impacts, causing injuries and obstructing occupant flow during evacuations.

17. FAR's to prevent items of mass in passenger cabins from becoming a hazard during minor crash landings are either inadequate, incorrectly interpreted by manufacturers, or inadequately enforced by the FAA.

18. Because of variations in cabin layouts, passengers must be well instructed about the locations of emergency exits.

19. Passengers are prepared for an unexpected evacuation mainly by the information contained in the pretakeoff briefing and on the safety information card.

20. Investigative experience indicates that passengers are generally not too attentive during pretakeoff briefings.

21. Passengers who have been involved in evacuations frequently suggest the need for additional safety information.

22. The success rate of planned evacuations suggests that passengers are more attentive to pre-evacuation briefings and are therefore better prepared for an evacuation.

23. Some of the training techniques currently used by airlines for crewmember training rely more on audio-visual demonstrations rather than actual practice.

24. There is no standard for initiating emergency evacuations. All airlines differ.

25. Some aircraft are operated with less than one crewmember per exit.

RECOMMENDATIONS

As a result of this study, the National Transportation Safety Board has made 10 recommendations to the Administrator, Federal Aviation Administration. (See Appendix B.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

William R. Haley, Member, did not participate in the adoption of this report.

November 13, 1974.

APPENDIX A

Evacuation Case Studies

The following aircraft accidents were selected to illustrate the conditions and circumstances under which evacuations can occur. The summaries point out the factors which influenced the success or failure of the evacuations.

It should be noted that some of the accidents included in this study would not have been classified as aircraft accidents had occupants not been "seriously injured" during the evacuation. This, in itself, illustrates the importance of developing means to reduce occupant injuries and death as a result of evacuations.

Case History No. 1.--Delta Airlines Convair 880, Chicago

On December 20, 1972, a Delta Airlines Convair 880 with 86 passengers and a crew of 7 was involved in a collision with a North Central Airlines DC-9 at the O'Hare International Airport. While attempting a takeoff, a North Central DC-9 collided with the Convair 880, which was taxiing across the active runway. The landing gear of the DC-9 struck the vertical stabilizer and rudder assembly which damaged the Convair 880 substantially. Two passengers aboard the Convair 880 were injured slightly in the collision. An evacuation of the Convair was initiated immediately after the collision, and all aircraft occupants were safely evacuated within 5 minutes.

Factors Influencing the Evacuation

- The evacuation occurred at night and in dense fog.
- Passengers assisted the crew in conducting the evacuation.
- Loose ceiling panels partially obstructed access to the rear exits.
- Aircraft interior emergency lighting had to be supplemented with crew flashlights.

(Reference Report No. NTSB AAR-73-15).

Case History No. 2.--North Central Airlines Douglas DC-9, Chicago

The North Central DC-9, which was involved in the collision with the Delta Airlines Convair 880, at O'Hare International Airport, contained 41 passengers and a crew of 4. The aircraft was completely

destroyed by the postcrash fire. Ten passengers were killed and nine injured seriously. None of the fatalities was attributed to deceleration injuries. All injuries were attributed to smoke inhalation and to burns.

Factors Influencing the Evacuation

- One of the flight attendants was not at her assigned seat in the rear of the aircraft during the takeoff.
- None of the crewmembers went to their assigned positions during the evacuation.
- Flight attendants exited the aircraft before the passengers.
- The cabin illumination was poor.
- The forward flight attendant jumpseat failed to retract to its stowed position and created an obstacle to persons attempting to evacuate through the forward entry door.
- Fire and smoke were present when the aircraft stopped.
- The cabin filled with dense, toxic smoke during the evacuation which forced passengers to crawl on the floor.
- The evacuation occurred at night.
- There was no specific evacuation order given.
- All exits were not available or used during the evacuation.

(Reference Report No. NTSB AAR-73-15).

Case History No. 3.--Trans World Airlines Boeing 727, Chicago

On April 1, 1971, the passengers of a Trans World Airlines Boeing 727 were involved in an accident at the Chicago O'Hare International Airport as a result of an unwarranted emergency evacuation. While taxiing to its assigned gate, the aircraft stopped momentarily because of conflicting ground traffic. The flight engineer at that time attempted to start the auxiliary power unit (APU). The start was unsuccessful and flames erupted from the APU exhaust, located at the right wing root of the aircraft. A flight attendant supervisor, not wearing a uniform, who was performing a flight check of the flight attendants, noticed the flames through the cabin windows and initiated an emergency evacuation. The cockpit crew first became aware of the evacuation when the aft door/stair warning light illuminated. Four passengers sustained serious injuries as a result of the evacuation and eight others sustained minor injuries.

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Factors Influencing the Evacuation

- The evacuation was initiated, without the knowledge of the crew, by a flight attendant supervisor who was not wearing a uniform.
- Flames from the APU exhaust precipitated an unwarranted evacuation.
- The evacuation was initiated and conducted while the engines were running.
- The evacuation was conducted at night.
- The passengers egressed on to a hard surfaced parking ramp.
- The aircraft was not configured for an evacuation as depicted on the emergency briefing cards.

(Reference NTSB Accident No. CHI-71-A-C070).

Case History No. 4.--Trans World Airlines Boeing 747, New York

On September 1, 1972, a Trans World Airlines Boeing 747 was involved in an evacuation accident at the John F. Kennedy International Airport, New York, during which 8 passengers were injured seriously and 72 were injured slightly. The evacuation was precipitated by a fire in the left body landing gear which started during taxi out for takeoff. All but about 70 of the 335 passengers evacuated the aircraft via emergency evacuation slides. Most of the injuries resulted when passengers were blown down by exhaust blast from the engines which continued to operate during a portion of the evacuation. Other injuries resulted from passengers deplaning with carry-on baggage and from passengers piling up at the bottom of the evacuation slides.

Factors Influencing the Evacuation

- An evacuation alarm was used to initiate the evacuation.
- Fire and smoke precipitated the evacuation.
- The evacuation was conducted at night.
- The evacuation was initiated and continued while the aircraft engines were running.
- The evacuation slides were not illuminated by exterior lighting.
- All evacuating passengers landed on a hard surface taxiway.

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- Several passengers attempted to deplane, and many did deplane with their carry-on baggage.
- Three of the evacuation slides were deployed close to the fire.
- Poor coordination and communication was exercised by the crewmembers during the evacuation.
- Flight attendants were not able to determine visually the condition of the emergency slides prior to sending passengers down the slides.

(Reference NTSB Accident No. NYC-73-A-N040).

Case History No. 5.--Icelandic Airlines Douglas DC-8-61, New York

On June 23, 1973, an Icelandic Airlines Douglas DC-8-61 experienced a hard landing, while executing an instrument landing system (ILS) approach to runway 31R at John F. Kennedy International Airport. At impact, the No. 1 engine broke off and a fire erupted in the engine pylon. After the aircraft stopped, it was successfully evacuated. Of the 119 persons aboard the aircraft, 30 were injured slightly and 6 were injured seriously. In addition, two flight attendants were injured seriously. All injuries were attributed to the hard landing.

Factors Influencing the Evacuation

- The overhead hat racks failed at impact, causing injuries to passengers in the cabin and creating evacuation obstructions.
- The liferafts stored in overhead compartments fell into the cabin aisleway.
- The emergency escape slide pack on the right rear service door broke loose from its mounts at impact.
- The evacuation occurred at night.
- Three doors were not opened because of fire outside of the aircraft.

(Reference Report No. NTSB AAR-73-20).

Case History No. 6.--United Air Lines Boeing 737, Chicago

On December 8, 1972, a United Air Lines Boeing 737 crashed into several houses while making an instrument approach to the Chicago

Midway Airport. Forty passengers and three crewmembers were killed as a result of the impact and postcrash fire. Fifteen passengers and two crewmembers escaped from the wreckage within 3 minutes after the crash. One other crewmember was rescued from the forward portion of the aircraft by firemen.

Factors Influencing the Evacuation

- The aircraft cabin was extremely dark after the crash.
- Portions of the aircraft were severely damaged during the crash, causing fatal and incapacitating injuries.
- The left and possibly the right window exits, and the left rear entry door, were blocked by fire.
- The contents of the rear galley spilled, creating obstacles to the only available exit in the rear of the aircraft.
- Ceiling panels and hat racks fell into the cabin area, creating obstacles to exit routes.
- The emergency escape slide pack on the right rear service door broke from its mounts during the crash, causing difficulty in opening the door.

(Reference Report No. NTSB AAR-73-16).

Case History No. 7.--Northwest Airlines Boeing 747, Miami

On December 15, 1972, the crew of a Northwest Orient Airlines Boeing 747, with 149 passengers and a crew of 11, shut down one engine and landed after birds were ingested by the engine on takeoff. During the landing roll, hydroplaning occurred and the aircraft ran off the end of the runway and struck a concrete abutment. Although the nosegear collapsed and the aircraft came to rest in a tail-high attitude, no one was injured in the crash. The aircraft was evacuated in about 2 minutes and four persons were injured slightly during the evacuation.

Factors Influencing the Evacuation

- The aircraft came to rest in a tail-high attitude, rendering the rear exits unusable.
- There was no specific order given to evacuate the aircraft.
- Damage to the floor and galley in the first-class section obstructed passengers proceeding toward the forward cabin doors.

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- The terrain on which the aircraft came to rest was a soft grassy surface.
- Failure of one evacuation slide to inflate rendered the associated exit unusable.

(Reference Report No. NTSB AAR-73-13).

Case History No. 8.--Allegheny Airlines Convair 340/440, New Haven

On June 7, 1971, an Allegheny Airlines Convair 340/440 crashed while making an instrument approach to the Tweed-New Haven, Connecticut airport. Twenty-eight passengers and a crew of three were aboard the aircraft. Only two passengers and the first officer survived the crash and postcrash fire. The impact forces were within human tolerances, but the aircraft was destroyed by fire. All of the fatally injured passengers died because of smoke inhalation and burns.

Factors Influencing the Evacuation

- There was fire and smoke from burning houses and aircraft fuel outside the aircraft.
- Smoke entered the cabin when the overwing exits were opened.
- The cabin area filled rapidly with toxic smoke.
- There was no evidence of emergency lighting in the cabin after the crash.
- The rear exit door was not opened.
- The forward exit door was not operable after the crash.
- The only flight attendant on board was probably incapacitated by the forces of the impact.

(Reference Report. No. NTSB AAR-72-20).

Case History No. 9.--Pan American World Airways Boeing 747, San Francisco

On July 30, 1971, a Pan American Boeing 747 struck an approach light structure while taking off from San Francisco International Airport. The aircraft was carrying 191 passengers and a crew of 19. After assessing the damage, dumping fuel, and briefing the passengers, the captain returned the aircraft to the airport and made an emergency landing.

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During the landing roll the aircraft veered off the runway and came to rest in an unpaved area. The passengers and crew evacuated the aircraft via emergency evacuation slides. After the aircraft had been partially evacuated, it settled onto its tail, which rendered the forward emergency evacuation slides unusable. Two passengers were injured seriously when the aircraft struck the approach lights. Eight passengers were seriously injured and 19 were injured slightly during the evacuation.

Factors Influencing the Evacuation

- There were several deadheading crewmembers onboard the aircraft who were assigned duties before the landing and evacuation.
- Passengers were briefed concerning the emergency landing and impending evacuation.
- Carry-on baggage and other loose items were stowed in lavatories before landing.
- Overhead luggage racks opened during the landing and dumped their contents into the cabin.
- A movie screen dropped from its overhead storage area and obstructed passenger view and access to an exit.
- Ceiling panels came loose and obstructed access to exits.
- An emergency evacuation slide pack broke loose from one of the doors.
- There was less than a full load of passengers onboard.
- Some evacuation slides failed to inflate and deploy properly because of mechanical problems and surface winds.
- The first officer inadvertantly transmitted the order to evacuate on the tower radio frequency rather than the public address (p.a.) system.
- A small fire erupted momentarily in the vicinity of the left landing gear during the landing roll.
- The aircraft gradually tilted rearward and settled onto its tail during the evacuation and rendered the forward slides unusable.
- Removal of injured passengers from the narrow aisles of the cabin proved difficult.

(Reference Report No. NTSB AAR-72-17).

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Case History No. 10.--American Airlines Douglas DC-10, Detroit

On June 12, 1972, an American Airlines Douglas DC-10 with 56 passengers and 11 crewmembers onboard was substantially damaged when the aft cargo door separated from the aircraft in flight. The resultant decompression caused the rear cabin floor to collapse and some engine and flight control cables to jam. Two crewmembers and one passenger were injured as a result of the decompression. An emergency landing was made at the Detroit, Michigan,Metropolitan airport. During the landing roll, the aircraft's right main landing gear ran off the runway. After the aircraft stopped, an emergency evacuation was initiated. Eight passengers received minor injuries during the evacuation.

Factors Influencing the Evacuation

- Passengers were prebriefed about the emergency landing and evacuation.
- There was less than a full load of passengers aboard the aircraft.
- An evacuation alarm was used to initiate the evacuation.
- Passengers were used to assist in the evacuation.
- Loose ceiling panels obstructed movement to some of the exits.
- Damage to the aft cabin made the rear exits unusable.

(Reference Report No. NTSB AAR-73-2).

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX B

ISSUED:

Forwarded to:

Honorable Alexander P. Butterfield
Administrator
Federal Aviation Administration
Washington, D. C. 20591

SAFETY RECOMMENDATION(S)

A-74-105 thru 114

The National Transportation Safety Board is concerned about the number of passengers who are injured or killed during emergency evacuations from air carrier aircraft. As a result, the Safety Board has conducted a study, "Safety Aspects of Evacuations from Air Carrier Aircraft," which identifies and assesses factors that most often affect emergency evacuations. The study revealed several areas in which actions are needed to make emergency evacuations safer for passengers.

During the study, the Safety Board reexamined air carrier accidents during which emergency evacuations took place and examined the Federal Aviation Administration's incident files. From these sources, 10 recent air carrier accidents were selected and discussed in the study, because they best exemplified the most common circumstances encountered during evacuations following "survivable" aircraft accidents.

The Board's study revealed several deficiencies which have occurred repeatedly and have had a detrimental effect on the success of emergency evacuations:

Evacuation Slides--. Three problem areas were found with evacuation slides. First, because deployments of evacuation slides and their failures to function properly are not reported, the reliability of evacuation slide systems cannot be evaluated. Numerous slide failures were identified in the study; however, because the total number of failures cannot be determined, the total significance of the failures identified cannot be established. Second, manually inflated evacuation slides required more time to make an exit usable than fully automatic slide

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systems. In some of the accidents examined, passengers were ready to deplane, or were deplaning, before slides were inflated. Third, it was found that nose-high or tail-high attitudes of wide-bodied aircraft may render some exits unusable, because of the nearly vertical position of the slides. In two accidents studied, slides were unsafe and unusable because of the attitude of the aircraft.

Exterior Emergency Lighting--. Evacuations during darkness require adequate external illumination to reduce the number of injuries. Current exterior lighting systems are activated when main aircraft power is interrupted. During two nighttime accidents studied, the exterior lighting systems were not activated because the aircraft engines were operating during the evacuations; passengers were injured as a result.

Emergency Communications--. Currently, the only type of emergency evacuation communications equipment required by regulation is the megaphone. Megaphones were not used to initiate or to conduct evacuations in any of the accidents or incidents studied. The storage location of megaphones does not place them in easy reach for flight attendants at their evacuation duty stations.

Although the regulations do not require public address systems for emergency communications, these systems are often used to initiate emergency evacuations. However, since the public address systems are not always connected to the emergency electrical supply, they are not always usable when aircraft power is interrupted. The study revealed that a concise evacuation order is essential, and reliable communication during the evacuation is important.

Passenger Safety Information--. While analyzing the 10 specific accidents and other accident information, shortcomings in regulations and procedures for conveying safety information to passengers of air carrier aircraft were revealed. For example, following an evacuation, passengers frequently suggest the need for more safety information, yet they could not recall having heard the pretakeoff briefing, nor had they read the safety information card. These reports are substantiated by Safety Board investigators' observations that passengers generally are not attentive to pretakeoff briefings nor do they read the safety information cards. Since these two sources are generally the only means by which passengers can become acquainted with emergency information, proper presentation of such information is of the utmost importance. Furthermore, the successes of two evacuations which were prebriefed support the conclusion that more adequate safety information must be conveyed to the air carrier passenger and his understanding assured.

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Crewmember Emergency Training--. The performance of the crewmembers during the evacuation has a great potential for causing problems. During several accidents examined, crewmembers either lacked knowledge of the aircraft emergency evacuation systems or failed to follow established procedures. These cases suggest that current crewmember emergency training may be inadequate. The Safety Board has found that the training techniques used by some airlines for crewmember emergency evacuation training rely more on audio-visual demonstrations than on actual "hands-on" training.

In view of the above, the National Transportation Safety Board recommends that the Federal Aviation Administration:

1. Require that air carriers report all emergency evacuation slide deployments, failures, and malfunctions to the FAA.

2. Develop a maintenance surveillance program to insure greater reliability of emergency evacuation slide systems.

3. Amend 14 CFR 25.809 to require that the length of the emergency evacuation slides be such that the angle with the ground renders the slide safe and usable after collapse of one leg, or more, of the landing gear, and amend 14 CFR 121.310 to require that these new slides be installed after a reasonable date.

4. Amend 14 CFR 121.310 to require, after a reasonable date, that emergency evacuation slides on all floor-level exits be automatically inflated upon deployment.

5. Amend 14 CFR 25.812 to require that exterior emergency lighting be activated automatically when exits are opened in the emergency mode, and amend 14 CFR 12.310 to require such automatic activation after some reasonable date.

6. Require that the air carriers designate the flight attendant(s) who will be responsible for use of the megaphone(s) during an evacuation, and relocate the megaphone(s) so they are within easy reach of that flight attendant(s)' seat. Consideration should be given to the installation of new, light and compact megaphones to facilitate stowage and use.

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7. Amend 14 CFR 121.318 to require after a reasonable date, that public address systems be capable of operating on a power source independent of the main aircraft power supply.

8. Require that air carrier passengers be alerted, during pretakeoff briefings, of the need to familiarize themselves with the procedures involved in the operation of emergency exits.

9. Issue an Advisory Circular which would provide standardized guidance to the air transport industry on effective methods and techniques for conveying safety information to passengers.

10. Amend 14 CFR 121.417(c)(4) to eliminate the provision which permits carriers to use demonstrations alone to train crewmembers for certain emergency situations, thus requiring performance of drills in the operation and use of emergency exits.

Representatives of our Bureau of Aviation Safety will be available for consultation in connection with this matter if desired.

REED, Chairman, McADAMS, THAYER, and BURGESS, Members, concurred in the above recommendations. HALEY, Member, did not participate.

By: John H. Reed
Chairman

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