AIRCRAFT
EMERGENCY PROCEDURES
OVER WATER

UNITED STATES COAST GUARD
CG 306

DEPARTMENT OF THE AIR FORCE
AFM 64-6

DEPARTMENT OF THE NAVY
OPNAV INST 3730.4A

DEPARTMENT OF THE ARMY
FM 20-151

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $1.00

Chapter 4

BASIC DITCHING PROCEDURES AND TECHNIQUES

400 GENERAL

A successful aircraft ditching is dependent on three primary factors. In order of importance they are:

1. Sea conditions and wind.
2. Type of aircraft.
3. Skill and technique of pilot.

401 SEA CONDITIONS AND WIND

The behavior of an aircraft on making contact with the water will vary within wide limits according to the state of the sea. If landed parallel to a single swell system, the behavior of the aircraft may approximate that to be expected on a smooth sea. If landed into a heavy swell or into a confused sea, the deceleration forces may be extremely greet--resulting in breaking up of the aircraft. Within certain limits, the pilot is able to minimize these forces by proper sea evaluation and selection of ditching heading using the techniques described in Chapter 3.

402 TYPE AIRCRAFT

The pilot has no choice of the type aircraft he is forced to ditch. By knowing the characteristics of the aircraft, however, and its expected behavior on the water, certain steps can be taken to insure best ditching performance. Data on ditching characteristics of most aircraft are available from controlled tests on models or from studies of actual ditchings. It is impossible to list each individual aircraft's characteristics here.

For illustration, general ditching performance of several types of aircraft will be discussed here, with reference to specific models when pertinent.

Other factors being equal, the larger the aircraft, the better are its ditching characteristics. Fighter aircraft, due to their high landing speeds and smaller size, often react violently on ditching. Standard procedure in fighter type aircraft is to eject and descend by parachute rather than ditch. This is true also of most modern bombers.

Transport aircraft are generally better in ditching than combatant types. Transport aircraft bottoms, where most failures can be expected to occur, are stronger than those found in bomber aircraft. The bomber is greatly weakened by large bomb bay doors, and failure of these doors can result in violent behavior of the aircraft on runout. Chance of survival of personnel stationed aft of the bomb bay is reduced by the rush of water through it into the after part of the fuselage. Most of the damage to the bottom of the fuselage of any aircraft may be expected to occur in the critical mid-section. The behavior of the aircraft on runout is dependent on the damage suffered, and is more violent if damage to the fuselage occurs on first impact. In most aircraft, bottom damage may be expected. Double deck aircraft will probably suffer rapid flooding of the lower deck, but the upper deck is a relatively safe location. Aircraft equipped with cabin pressurization have good inherent water-tight integrity and, if the fuselage is intact, affort better protection against rapid flooding than non-pressurized types. In all cases, however, the aircraft must be depressurized before ditching. Glass in the nose section of aircraft with bow turret or bow lookout station may be shattered during ditching with a resultant inflow of water. Nose-wheel doors may also collapse.

On many aircraft with long afterbodies, the fuselage may break a few feet forward of the tail--especially when ditching in a fully stalled altitude into the face of a swell system. In several military patrol-type ditchings, the after-end of the aircraft separated entirely from the remainder of the fuselage. Low-wing aircraft, due to the floatation support derived from the wings, are safer for ditching than high-wing types. The high-wing aircraft tends to sink rapidly after impact until the wings settle in the water. As a result, most of the fuselage is under water soon after the aircraft comes to rest.

External protuberances exert varying effects on the ditching characteristics. The landing gear must be retracted; failure to do so will result in extremely violent behavior and deceleration--often flipping the aircraft on its back or causing it to dive radically. Low-wing aircraft with large engine nacelles, or underslung nacelles, if landed wing low, may dig one nacelle first, causing a waterloop. This rotation around the vertical axis may also cause structural failure of the after fuselage. Flaps in most aircraft may be expected to carry away on initial impact. If the flaps are unusually strong and withstand the impact, some diving tendency may result. The paramount importance of flaps in slowing down the aircraft on the approach makes their use mandatory. Auxiliary fuel tanks located beneath the wing or fuselage will adversely affect the ditching characteristics. They should be jettisoned prior to touchdown. Wingtip tanks have no marked adverse effect, and if empty, provide additional floatation.

The advent of jet-engined aircraft has introduced some, as yet, unknown factors to the problems of ditching. The higher landing speeds, the large jet intakes and (in some cases) the underslung engines are the elements which produce these factors.

In their first years of operation, large jet-engined aircraft have demonstrated a dependability in flight which has considerably reduced the probability of ditching. As a result, there is no accumulated data of actual ditchings on which to base expected behavior in a ditching situation. Engineering design and model tests must be used in forecasting probable ditching characteristics.

The increased landing speed of jets will increase the deceleration forces of ditching. However, this may be off-set by the strengthened fuselage. The large jet intakes increase the inflow of water at high speed, the exact reaction of which is not known. It is expected that the water hitting a hot engine would cause the engine to seize, but the result of the deceleration forces introduced is problematical. Some of the underslung engines on jet transports may be expected to break away from the wing assembly under water loads, as indicated by model tests on at least one type. If the engines do not break away, a diving moment must be expected.

DECELERATION FORCES

Before examining the pilot technique involved in a successful ditching, it is well to consider some of the technical aspects of the deceleration forces that are encountered. An understanding of these forces is necessary in applying the recommended technique.

An aircraft in flight contains kinetic energy that must be fully expended before the aircraft can come to rest. This energy is determined by the formula:

$$E = \frac{1}{2} MV^2$$

where: E = energy
M = the mass of the aircraft
V = velocity

It becomes apparent that to reduce the energy to be expended and, thereby reduce damage to the aircraft and personnel involved, the aircraft must be made as light as possible by dumping fuel and cargo, and landing speed must be as slow as possible consistent with good control. This emphasizes the need for a power approach, if power is available, since this will appreciably lower the touchdown speed.

To illustrate the forces involved, and the performance to be expected, data was obtained from the scale model tests of five transport aircraft. These are of the propeller driven, reciprocating engine type. The data are based on CALM water ditchings. A maximum altitude of 12 degrees nose-up for four of the aircraft, and 9 degrees for the fifth, was used. Flap settings varied between 40 and 50 degrees. Average touchdown speed was 81 knots. The length of run after touchdown varied between 250 and 700 feet, with the average being 450 feet. Maximum linear decelerations varied berween 1.5 and 4 "g", with the mean being 2.1 "g". The average linear deceleration varied between 0.5 and 1.5 "g", with the mean being 0.7 "g". These figures apply to a composite aircraft which ditched without sustaining damage. In case of substantial damage, the runout was generally about 35% shorter, with maximum deceleration about 100% greater.

When ditching in rough water or into the face of a swell, much greater forces are to be expected. The length of runout will depend on whether or not the aircraft is swamped or thrown back into the air by contact with a swell. Landings made parallel to a major swell system will more nearly approximate those to be expected on calm water.

An interesting illustration of the forces involved in deceleration in smooth versus rough water can be obtained by a study of numerous sea-plane landings. In a series of landings, a Coast Guard sea-plane, equipped with reverse pitch propellers, was stalled in at 63 knots in smooth water. Reverse pitch was immediately applied. The average runout distance after touchdown was approximately 350 feet--or about that to be expected on an undamaged transport in smooth water. No discomfort was felt by any of the crew. This, of course, was a smooth linear deceleration.

When landing in a moderate sea with the same seaplane, the deceleration forces are uncomfortable but not of such severity as to injure personnel.

The hull of a seaplane is conducive to fairly smooth linear deceleration, even in rough water. A landplane, due to its shape and probable damage incurred on impact, may be subjected to irregular deceleration, with one or more severe jolts. Vertical forces also prove severe if the aircraft is stalled from too high an altitude, or drops heavily after being thrown back into the air with insufficient airspeed. A DC7C ditched under favorable weather and sea conditions, using full flap, at 95 kts. Initial water contact was smooth and was quickly followed by two impacts, the first light, the second heavier. The resulting deceleration forces caused the life raft, that had been berth-stowed during the preparation of the cabin for ditching, and the food trays to become dislodged. However, no one was injured in the ditching. The aircraft, on coming to a stop, floated high in the water with no visible damage other than bent propeller blades. It remained afloat for 24 minutes. This was one of the most successful ditchings within recent years and was carried out under the most favorable circumstances.

404 PILOT SKILL AND TECHNIQUE

In a landplane ditching, probably the least important of the controlling factors after touchdown is the skill of the pilot. The pilot's task is essentially to set the aircraft down on a proper heading in the right spot at the best combination of attitude and speed. The importance of a low touchdown speed must be appreciated. The energy of the moving aircraft, which must be dissipated during the runout, is directly proportional to the square of the speed. Touchdown should be at the lowest speed and rate of descent which permit safe handling and optimum nose up attitude on impact. Once first impact has been made, there is often little the pilot can do to control a landplane--especially if the control surfaces are carried away. In a seaplane, however, the skill of the pilot is a very important factor; he is normally able to control the aircraft through the runout.

Once pre-ditching preparations are completed, the pilot should turn to the ditching heading and commence letdown. Procedures for the pre-ditching phase are contained in Chapter 8. The aircraft should be dragged low over the water, and slowed down until ten knots or so above stall. At this point, additional power should be used to overcome the increased drag caused by the noseup attitude. When a smooth stretch of water appears ahead, cut power, and touchdown at the best recommended speed as fully stalled as possible. By cutting power when approaching a relatively smooth area, the pilot will prevent over shooting and will touchdown with less chance of planing off into a second uncontrolled landing. Most experienced seaplane pilots prefer to make contact with the water in a semi-stalled attitude, cutting power as the tail makes contact. This technique eliminates the chance of misjudging altitude with a resultant heavy drop in a fully stalled condition. Care must be taken not to drop the aircraft from too high an altitude, or to balloon due to excessive speed. The altitude above water depends on the aircraft. Over glassy smooth water, or at night without sufficient light, it is very easy for even the most experienced pilots to misjudge altitude by 50 feet or more. Under such conditions, carry enough power to maintain nine to twelve degrees noseup attitude, and 10 to 20% over stalling speed until contact is made with the water. The proper use of power on the approach is of great importance. If power is available on one side only, a little power should be used to flatten the approach; however, the engine should not be used to such an extent that the aircraft cannot be turned against the good engines right down to the stall with a margin of rudder movement available. When near the stall, sudden application of excessive unbalanced power may result in loss of directional control. If power is available on one side only, a slightly higher than normal glide approach speed should be used. This will insure good control and some margin of speed after leveling off without excessive use of power. The use of power in ditching is so important that when it is certain that the coast cannot be reached, the pilot should, if possible, ditch before fuel is exhausted. The use of power in a night or instrument ditching is far more essential than under daylight contact conditions. If no power is available, a greater than normal approach speed should be used down to the flare-out. This speed margin will allow the glide to be broken early and more gradually, thereby giving the pilot time and distance to feel for the surface--decreasing the possibility of stalling high or flying into the water. When landing parallel to a swell system, little difference is noted between landing on top of a crest or in the trough. If the wings of the aircraft are trimmed to the surface of the sea rather than the horizon, there is little need to worry about a wing hitting a swell crest. The actual slope of a swell is very gradual. If forced to land into a swell, touchdown should be made just after passage of the crest. If contact is made on the face of the swell, the aircraft may be swamped or thrown violently into the air, dropping heavily into the next swell. This may prove disastrous, particularly if the control surfaces are damaged or carried away on first impact. If control surfaces remain intact, the pilot should attempt to maintain the proper nose attitude by rapid and positive use of the yoke.

In most cases drift caused by crosswind can be ignored; the forces acting on the aircraft after touchdown are of such magnitude that drift will be only a secondary consideration. If the aircraft is under good control, the "crab" may be kicked out with rudder just prior to touchdown. This is more important with high wing aircraft, for they are laterally unstable on the water in a crosswind, and may roll to the side in ditching.

Figure 4-1

A Navy P2V sinking after ditching on Ocean Station ECHO. This ditching occurred with high winds and seas. The ditching was made into the wind and swell due to the 40-knot winds. Note the breakage point of the fuselage aft of the wings, and part of the left wing flap which did not carry away. Personnel can be seen over the left wing in a life raft. Despite the fact the aircraft sank less than two minutes after ditching, all hands were evacuated and saved.

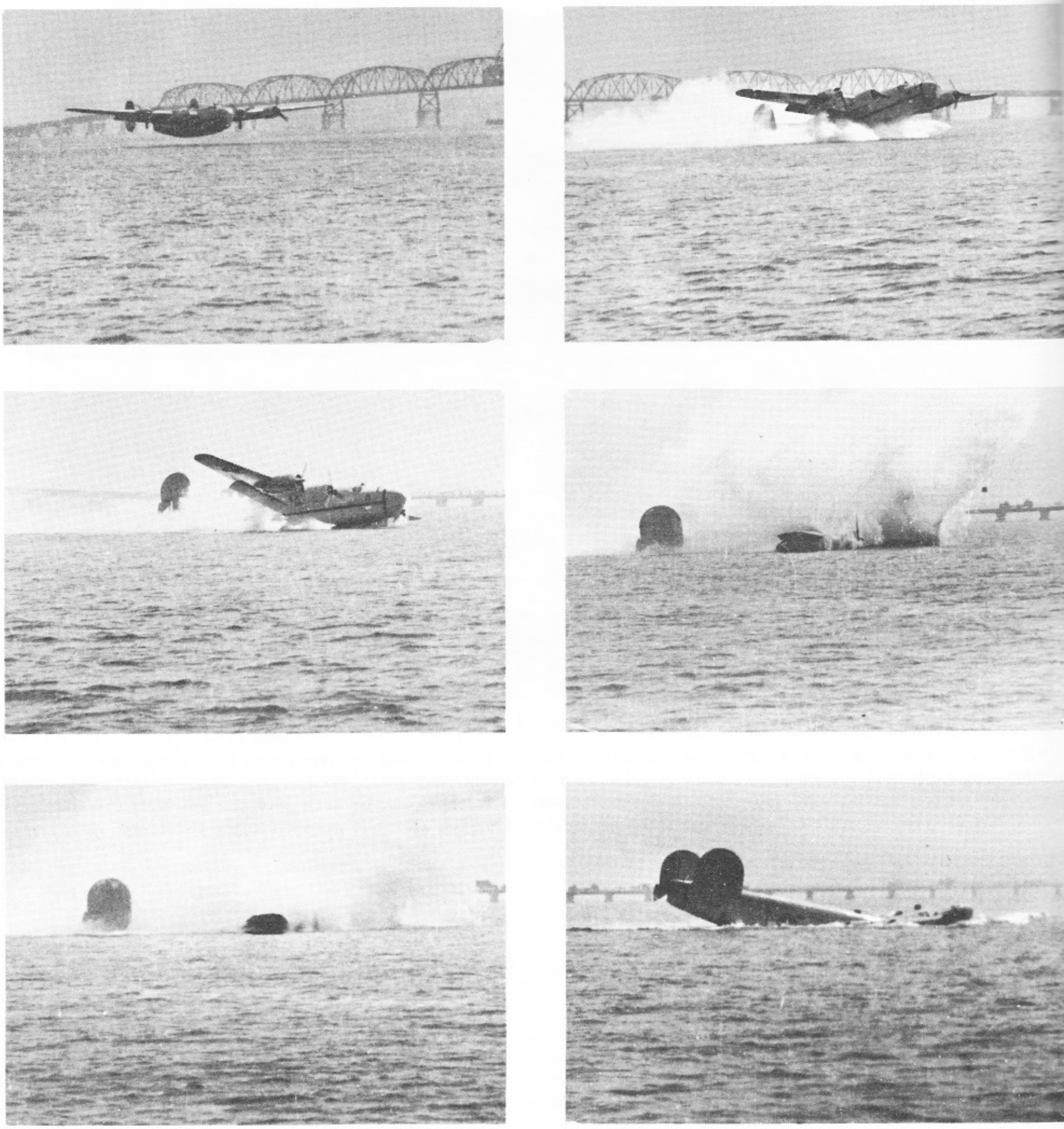

Figure 4-2

B-24 especially reenforced being ditched during tests in the James River. This aircraft had a reputation with pilots as a poor ditcher. Note the position of the fuselage after coming to rest. This is typical of high wing aircraft. (Official NASA photographs)

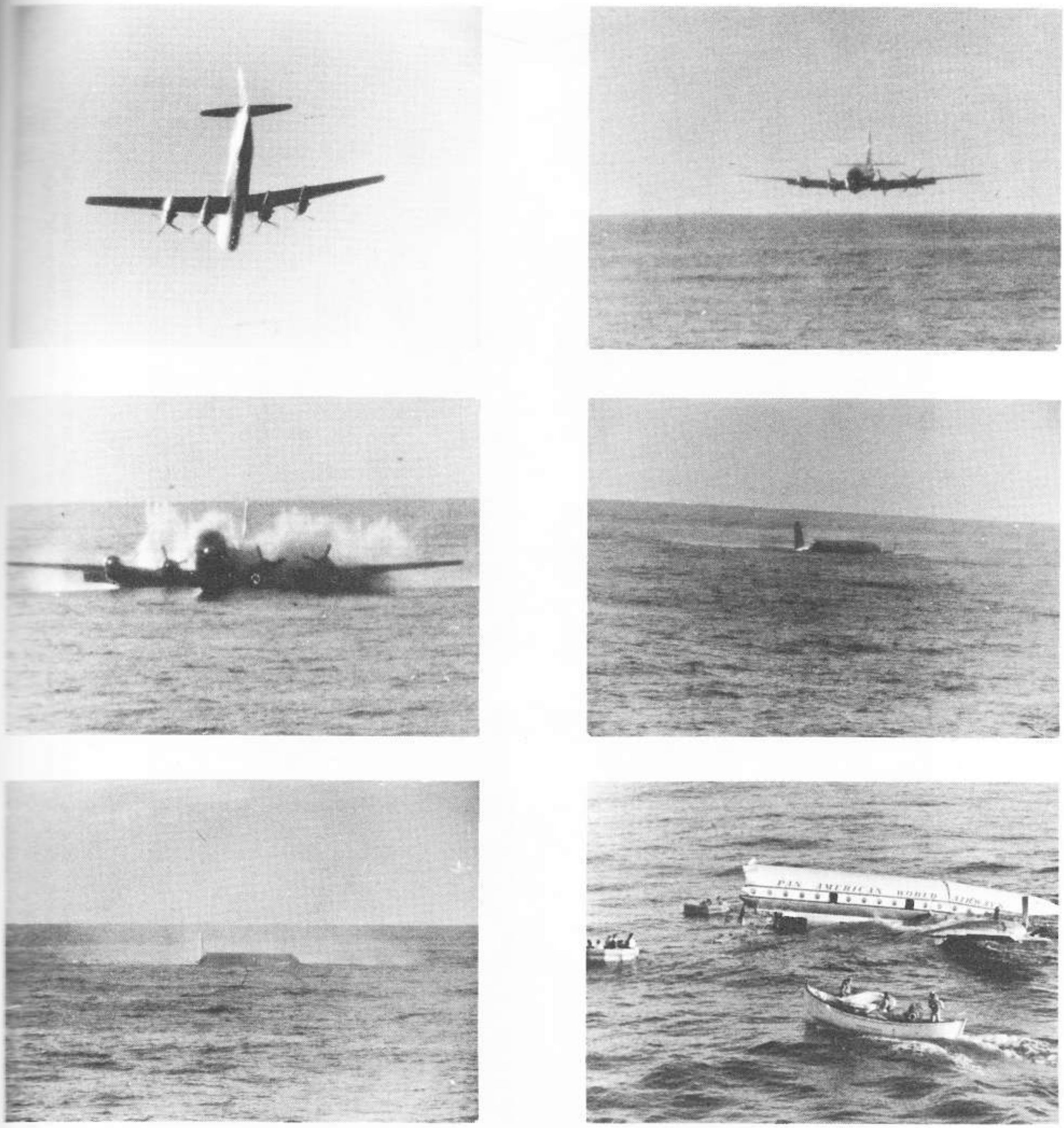

Figure 4-3

Sequential photographs of the actual ditching of Pan American "Sovereign of the Skies", a Boeing Stratocruiser that ditched at Ocean Station November during October 1956. All thirty-one persons aboard were rescued and safe aboard ship within twenty minutes after ditching. (Official U.S. Coast Guard photos).