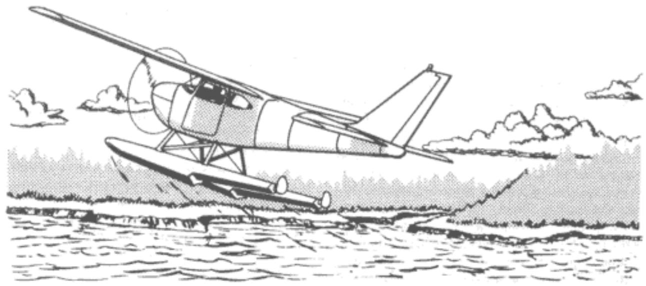

CHAPTER 15

Seaplane Operations[1]

This chapter is intended to introduce seaplane flying, as well as to provide a general review for experienced seaplane pilots. It contains general explanations of commonly accepted techniques and procedures for operating seaplanes on the water, with special emphasis on those which are different from landplane flying.

The explanations herein apply to light single-engine and multiengine seaplanes typical of those used in general aviation operations. For information regarding specific types and models of airplanes approved as seaplanes, reference should be made to that airplane's operating manual and the manufacturer's recommendations.

In addition to material contained herein, there are numerous commercially produced publications relating to water operations that contain additional valuable information. All this information used collectively with good training and practice will result in a safe and pleasurable experience during water based operations.

The operation of an airplane on water is somewhat different than operating one on land, but should be no more difficult if the pilot acquires the essential knowledge and skill in the techniques involved. This is particularly important because of the widely varying and constantly changing conditions of the water surface.

I. WATER CHARACTERISTICS

The competent seaplane pilot must be knowledgeable in the characteristics of water to understand its effects on the seaplane. Water is a fluid, and although it is much heavier than air it behaves in a manner similar to air.

Since it is a fluid, water seeks its own level and, if not disturbed, lies flat and glassy. It yields, however, if disturbed by such forces as winds, undercurrents, and objects traveling on its surface, creating waves or movements.

Because of its weight, water can exert a tremendous force. This force, a result of resistance, produces drag as the water flows around or under an object being propelled through it or on its surface. The force of drag imposed by the water increases as the square of the speed. This means that as the speed of the object traveling on the water is doubled, the force exerted is four times as great.

Forces created when operating an airplane on water are more complex than those created on land. When a landplane's wheels contact the ground, the force of friction or drag acts at a fixed point on the airplane; however, the water forces act along the entire length of a seaplane's hull or floats with the center of pressure constantly changing depending upon the pitch attitude, dynamic hull or float motion, and action of the waves.

Since the surface condition of water varies constantly, it becomes important that the seaplane pilot be able to recognize and understand the effects of these various conditions of the water surface.

Under calm wind conditions, the waveless water surface is perhaps the most dangerous to the seaplane pilot and requires precise piloting techniques. Glassy water presents a uniform mirror-like appearance from above, and with no other visual references from which to judge height, it can be extremely deceptive. Also, if waves are decaying and setting up certain patterns, or if clouds are reflected from the water surface, distortions result that are

1. Excerpted from the Flight Training Handbook (AC 61-21A), published by the US Government.

even more confusing for inexperienced as well as experienced pilots.

Wave conditions on the surface of the water are a very important factor in seaplane operation. Wind provides the force that generates waves, and the velocity of the wind governs the size of the waves or the roughness of the water surface.

Calm water resists wave motion until a wind velocity of about 2 knots is attained; then patches of ripples are formed. If the wind velocity increases to 4 knots, the ripples change to small waves that continue to persist for some time even after the wind stops blowing. If this gentle breeze diminishes, the water viscosity dampens the ripples and the surface promptly returns to a flat and glassy condition.

As the wind velocity increases above 4 knots, the water surface becomes covered with a complicated pattern of waves, the characteristics of which vary continuously between wide limits. This is referred to as the generating area. This generating area remains disarranged so long as the wind velocity is increasing. With a further increase in wind velocity, the waves become larger and travel faster. When the wind reaches a constant velocity and remains constant, waves develop into a series of equidistant parallel crests of the same height.

Table 1: Weather and Wind Conditions

Terms used by US Weather Service	Velocity (mph)	Estimating Velocities on land	Estimating Velocities on Sea	
Calm	less than 1	Smoke rises vertically	Sea like a mirror	Check your glassy water technique before water flying under these conditions
Light air	1 - 3	Smoke drifts; wind vanes unmoved	Ripples with the appearance of scales are formed but without foam crests	xx
Light breeze	4 - 7	Wind felt on face; leaves rustle; ordinary wind vane moves by wind	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break	xx
Gentle Breeze	8 - 12	Leaves and small twigs in constant motion; wind extends light flag	Large wavelets; crests begin to break. Foam of glassy appearance, perhaps scattered whitecaps	Ideal water flying characteristics in protected water
Moderate Breeze	13 - 18	Dust and loose paper raised; small branches are moved	Small waves, becoming longer; fairly frequent whitecaps	xx
Fresh Breeze	19 - 24	Small trees in leaf begin to sway; crested wavelets form in inland water	Moderate waves; taking a more pronounced long form; many whitecaps are formed, chance of some spray	This is considered rough water for seaplanes and small amphibians, especially in open water
Strong Breeze	25 - 31	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	Large waves begin to form; white foam crests are more extensive everywhere, probably some spray	xx
Moderate Gale	32 - 38	Whole trees in motion; inconvenience felt in walking against the wind	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind	This type of water condition is for emergency only in small aircraft in inland waters and for the expert pilot

An object floating on the water surface where simple waves are present will show that the water itself does not actually move along with the waves. The floating object will describe a circle in a vertical plane, moving upward as the crest approaches, forward and downward as the crest passes, and backward as the trough between the waves passes. After the passage of each wave the object stays at almost the same point at which it started. Consequently, the actual movement of the object is a vertical circle whose diameter is equal to the height of the wave. This theory must be slightly modified however, because the friction of the wind will cause a slow downwind flow of water resulting in drift. Therefore, a nearly submerged object, such as a hull or float, will slowly drift with the waves

When the wind increases to a velocity of 12 knots, waves will no longer maintain smooth curves. The waves will break at their crest and create foam - whitecaps. When the wind decreases, the whitecaps disappear. However, lines or streaks form which can be used as an accurate indication of the path of the wind. Generally, it will be found that waves generated by wind velocities up to 10 knots do not reach a height of more than one foot.

A great amount of wind energy is needed to produce large waves. When the wind ceases, the energy in the wave persists and is reduced only by a very slight internal friction in the water. As a result, the wave patterns continue for long distances from their source and diminish at a barely perceptible rate. These waves are known as swells, and gradually lengthen, becoming less high, but increase in speed.

If the wind changes direction during the diminishing process, an entirely separate wave pattern will form which is superimposed on the swell. These patterns are easily detected by the pilot from above, but are difficult to see from the surface.

Islands, shoals, and tidal currents also affect the size of waves. An island with steep shores and sharply pointed extremities allows the water at some distance from the shore to pass with little disturbance or wave motion. This creates a relatively calm surface on the lee side. If the island has rounded extremities and a shallow slope and outlying shoals where the water shallows and then becomes deep again, the waves will break and slow down. This breaking will cause a considerable loss of wave height on the lee side of the shoal. However, if the water is too deep above the shoal, the waves will not break.

When waves are generated in non-flowing water and travel into moving water such as a current, they undergo important changes. If the current is moving in the same direction as the waves, they increase in speed and length but lose their height. If the current is moving opposite to the waves, they will decrease in speed and length but will increase in height and steepness. This explains "tidal rips" which are formed where strong streams run against the waves. A current traveling at 6 miles per hour will break almost all waves traveling against it. When waves break, a considerable loss in wave height occurs to the leeward side of the breaking.

Another characteristic of water that should be mentioned is the ability of water to provide buoyancy and cause some objects to float on the surface. Some of these floating objects can be seen from the air, while others are partially submerged and are very difficult to see. Consequently, seaplane pilots must be constantly aware of the possibility of floating debris to avoid striking these objects during operation on the water.

II. Characteristics of Seaplanes

A seaplane is defined as "an airplane designed to take off from and land on water." Seaplanes can be generally classified as either flying boats or floatplanes. Those that can be operated on both land and water are called amphibians.

The floatplane is ordinarily understood to be a conventional landplane equipped with separate floats instead of wheels, as opposed to a flying boat in which the hull serves the dual purpose of providing buoyancy in the water and space for the pilot, crew, and passengers. The float type is the more common seaplane, particularly those with relatively low horsepower. It maybe equipped with either a single float or twin floats; however, most seaplanes are the twin-float variety. Though there is considerable difference between handling a floatplane and handling a flying boat, the theory on which the techniques are based is similar. Therefore, with few exceptions, the explanations given here for one type may be considered to apply to the other.

In the air the seaplane is operated and controlled in much the same manner as the landplane, since the only major difference between the floatplane and the landplane is the installation of floats instead of wheels. Generally, because of the float's greater weight, replacing wheels with floats increases the airplane's empty weight and thus decreases its useful load, and rate of climb.

On many floatplanes, the directional stability will be affected to some extent by the installation of the floats. This is caused by the length of the floats and the location of their mass in relation to the airplane's CG. To help restore directional stability, an auxiliary fin is often added to the tail. The pilot will also find that less aileron pressure is needed to hold the floatplane in a slip and holding some rudder pressure during in-flight turns is usually required. This is due to the water rudder being connected to the air rudder or rudder pedals by cables and springs which tend to prevent the air rudder from streamlining in a turn.

Research and experience have improved float and hull designs throughout the years. Figure 1 and Figure 2 illustrate the basic construction of a float and a flying boat. The primary consideration in float construction is the use of sturdy, lightweight material, designed hydrodynamically and aerodynamically for optimum performance.

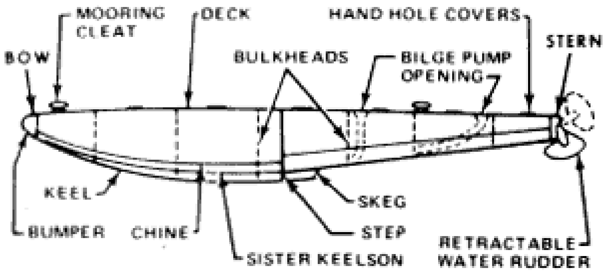

Figure 1: Float Components

All floats and hulls now being used have multiple watertight compartments which make the seaplane virtually unsinkable, and prevent the entire float or hull from becoming filled with water in the event it is ruptured at any point.

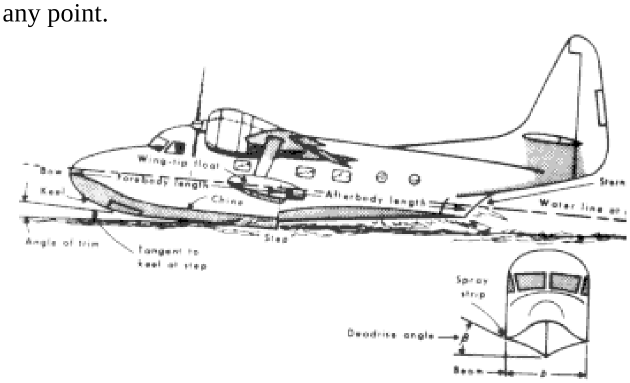

Figure 2: Hukk Components

Both the lateral and longitudinal lines of a float or hull are designed to achieve a maximum lifting force by diverting the water and the air downward. The forward bottom portion of the float (and a hull) is designed very much like the bottom surface of a speedboat. The rearward portion, however, differs significantly from a speedboat.

A speedboat is designed for travel at an almost constant pitch angle and, therefore, the contour of the entire bottom is constructed in approximately a continuous straight line. However, a seaplane float or hull must be designed to permit the seaplane to be rotated or pitched up to increase the wing's angle of attack and gain the most lift for takeoffs and landings. Thus, the underside of the float or hull has a sudden break in its longitudinal lines at the approximate point around which the seaplane rotates into the lift off attitude. This break, called a "step," also provides a means of interrupting the capillary or adhesive properties of the water. The water can then flow freely behind the step, resulting in minimum surface friction so the seaplane can lift out of the water.

The steps are located slightly behind the airplane's center of gravity, approximately at the point where the main wheels of a landplane are located. If the steps were located to far aft or forward of this point, it would be difficult, if not impossible, to rotate the airplane into a pitch-up attitude prior to planing (rising partly out of the water while moving at high speed) or lift off.

Although steps are necessary, the sharp break along the float's or hull's underside causes structural stress concentration, and in flight produces considerable drag because of the eddying turbulence it creates in the airflow.

III. Seaplane Bases

With few exceptions seaplane operations are authorized on U.S. Army Corps of Engineer lakes. Some states and cities are very liberal in the laws regarding the operation of seaplanes on their lakes and waterways, while other states and cities may impose stringent restrictions. It is recommended that before operating a seaplane on public waters, the Parks and Wildlife Department of the state, the State Aeronautics Department, or the FAA Flight Standards District Office [formerly General Aviation District Office] nearest the site of planned operation be contacted concerning the local requirements. In any case, seaplane pilots should always avoid creating a nuisance in any area, particularly in congested marine areas or near swimming or boating facilities.

The location of established seaplane bases is symbolized on aeronautical charts by depicting an anchor inside a circle. They are also listed in Airport/Facility Directories. The facilities provided at seaplane bases vary greatly, but most include a hard surface ramp for launching, servicing facilities, and an area for mooring or hangaring seaplanes. Many marinas designed for boats also provide seaplane facilities.

In many cases seaplane operations are conducted in "bush country" where regular or emergency facilities are either poor or nonexistent. The terrain is often hazardous, the waterways treacherous, and servicing must be the individual pilot's responsibility.

Too many times pilots receive their water training in the "lower 48" states where facilities are mostly excellent, and shortly after receiving a seaplane rating head north to Alaska or the north woods of Canada. The results are frequently tragic. Prior to operating in the "bush," it is recommended that pilots obtain the advice of FAA appointed Accident Prevention Counselors who are familiar with the area.

IV. Rules of the Road

In addition to Federal Aviation Regulations, the "Rules of the Road" applicable to the operation of boats, apply also to seaplane operations. "Inland Rules of the Road" apply to all vessels navigating upon certain waters inshore of the boundary line which divides the inland waterways from the high seas; "International Rules of the Road" apply to all public or private vessels navigating on the high seas outside the boundary line. The U.S. Coast Guard, of course, has jurisdiction over operations on the high seas. It is strongly recommended that seaplane pilots acquire copies of the pertinent rules, become thoroughly familiar with their contents, and comply with the requirements during all operations.

In the interest of safety, it is particularly important that seaplane pilots become familiar with such navigation aids as buoys, day and night beacons, light and sound signals, and also steering and sailing rules.

V. Preflight Inspection

Generally, with a few exceptions, the preflight inspection of a seaplane is similar to that of a landplane. The major difference is the checking of floats or hull. The manufacturer's manual or handbook should be used in conducting the inspection.

The pilot should first note how the seaplane is setting in the water prior to each flight. If the sterns of the floats are very low in the water, consideration should be given to how the seaplane is loaded. Also, if lower than normal for a given load, a rear compartment may have a leak.

Floats and hulls should be inspected for obvious or apparent defects and damage, such as loose rivets, corrosion, separation of seams, punctures, and general condition of the metal skin. Because of the rigidity of the float installation, fittings and adjacent structure should be checked for cracks, defective welds, proper attachment, alignment, and safetying. All hinged points should be examined for wear and corrosion, particularly if the seaplane is operated in salt water. If water rudders are installed, the should be inspected for free and proper movement.

It is important to check each compartment of the floats or hull for any accumulation of water before flight. Even a small amount of water, such as a cup full, is not unusual and can occur from condensation or normal leakage. All water should be removed before flight, because the water may critically affect the location of the seaplane's center of gravity.

If an excessive amount of water is found, a thorough search for the leak should be made. If drain plugs and inspection plates are installed, a systematic method of removing and reinstalling these plugs and plates securely should be used. Naturally, it is extremely important to ensure that all drain plugs and inspection plates are securely in place before launching the seaplane into the water. It is recommended that each plug and plate be counted and placed in a receptacle upon removal and counted again when reinstalled.

Float compartments, water rudders, etc., should be inspected for ice if near freezing temperatures are encountered. Airframe icing, resulting from water spray during a takeoff or landing, must also be considered. Part of the preflight inspection should include a cabin inspection. All items must be secured, such as anchors and paddles prior to takeoff. Floatation gear should be available for each occupant.

During the preflight and boarding of passengers, a thorough passenger briefing is very important. Evacuation of a seaplane causes a few problems not encountered with the landplane. Location and operation of regular and emergency exits should be known by all persons on board. The pilot should assure that all passengers are familiar with operations of seatbelts and shoulder harnesses, most especially that all persons can UNFASTEN their own seatbelts and shoulder harnesses in the event an accident occurs on the water.

Before beginning any seaplane operation, it is especially advisable to consider the existing and expected water condition, and the wind speed and direction to determine their combined effects on the operation.

VI. Taxiing

One of the major differences between the operation of a seaplane and that of a landplane is the method of maneuvering the aircraft on the surface. The landplane will usually remain motionless with the engine idling, particularly with the brakes applied, but a seaplane, since it is free-floating, will invariably move in some direction, depending upon the forces exerted by wind, water currents, propeller thrust, and inertia. Because a seaplane has no brakes, it is important that the pilot be familiar with the existing wind and water conditions, effectively plan the course of action, and mentally stay "ahead" of the aircraft.

There are three positions or attitudes in which a seaplane can be moved about on the water: (1) the "idling" position, (2) the "plowing" position, and (3) the "planing" or "on the step" position (see Figure 3).

Idling Position

When taxiing with the engine idling or at a low RPM, the seaplane will remain in what is considered a displacement condition similar to being at rest on the water (see

Figure 3). This is the "idling" position. The recommended taxi speed is usually below 6 or 7 knots so that the propeller will not pick up water spray which causes serious erosion of the propeller blades. In calm or light wind conditions, the elevator control should be held full back to raise the seaplane's nose and further reduce the possibility of water spray on the propeller, and to improve overall maneuverability of the seaplane. This is particularly true if it is equipped with water rudders because more rudder area is kept in the water. Since seaplanes have no brakes, it is especially important to taxi at this slow speed in congested or confined areas because inertia forces build up rapidly, making the seaplane vulnerable to serious damage even in minor collisions.

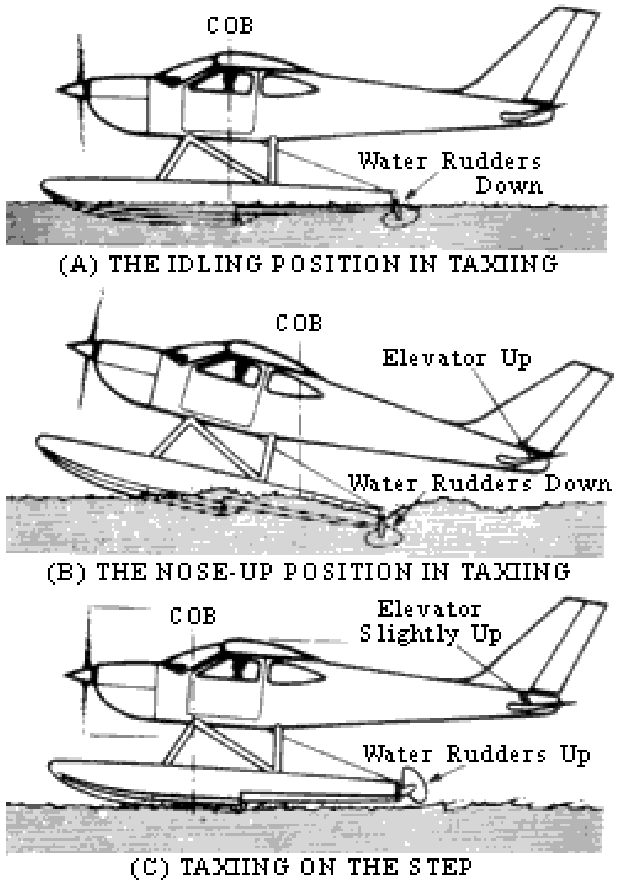

Figure 3: Taxiing

Plowing Position

When the power is increased significantly above idling, the seaplane will usually assume a nose-up or "plowing" position (see Figure 3). Most seaplane experts do not recommend the plowing position for taxiing, except in rough water when it would be desirable to raise the propeller clear of the spray, or when turning the seaplane downwind during strong wind conditions. To attain this position, full power should be applied and the elevator control held in the full aft position. Seaplanes that have a high thrust line will tend to nose down upon application of power, in which case it is imperative that the elevator control be held in the full aft position. The "plowing" position is brought about by the combination of the propeller slipstream striking the elevator and the hydrodynamic force of water exerted on the underside of the float's or hull's bow. After the planing position is attained, the power should be reduced to maintain the proper speed.

If the water conditions are favorable and there is a long distance to travel, the seaplane may be taxied at high speed "on the step." This position (see Figure 3) is reached by accelerating the seaplane to the degree that it passes through the plowing phase until the floats or hull are literally riding on the water in a level position.

Planing Position

Basically, the planing or step position is best attained by holding the elevator control full aft and advancing the throttle to full power. As the seaplane accelerates it will then gradually assume a nose-high pitch attitude, raising the bow of the float or hull and causing the weight of the seaplane to be transferred toward the aft portion of the float or hull. At the time the seaplane attains its highest pitch attitude, back pressure should be gradually relaxed, causing the weight to be transferred from the aft portion of the float or hull onto the step area. This can be compared to a speedboat's occupants moving forward in the boat to aid in attaining a planing attitude. In the seaplane we do essentially the same thing by use of aerodynamics (elevators). As a result of aerodynamic and hydrodynamic lifting, the seaplane is raised high in the water, allowing the floats or hull to ride on top of rather than in the water.

The entire process of planing a seaplane is similar to that of water skiing. The skier cannot make the transition from a submerged condition to that of being supported on the surface of the water unless a sufficiently high speed is attained and maintained.

As further acceleration takes place the flight controls become more responsive just as in the landplane and elevator deflection must be reducing in order to hold the required planing/pitch attitude. This of course is accomplished by further relaxing back pressure, increasing forward pressure, or using forward elevator trim depending on the aircraft flight characteristics.

Throughout the acceleration, the transfer of weight and the hydrodynamic lifting of the float or hull may be seen from the cockpit. When the seaplane is taxiing slowly, the water line is quite high on the floats or hull as compared to "on the step" (see Figure 2). At slow taxi speeds a small wake is created close to the bow of the float or hull and moves outward at a very shallow angle. As acceleration commences, the wake starts to move from the bow aft toward the step area and the wake now turns into an outward spray pattern. As speed and lifting action increase, the spray pattern continues to move aft toward the step position and increases in intensity, i.e., slow speed spray may be approximately one foot outboard compared to about a 20-foot outboard spray at higher speed on the step position. Some seaplane pilots use the spray pattern as an additional visual reference in aiding them in determining when the seaplane has accelerated sufficiently to start easing it over onto the step.

After the planing position has been attained, proper control pressures must be used to control the proper pitch attitude/trim angle. Usually this will be maintained with slight back pressure. As for the amount of pressure to be held, the beginner will find a very "thin line" between easing off back pressure too much or too little. It can perhaps best be described as finding the "slippery spot" on the float or hull. Too much back pressure, acceleration rate decreases. Not enough back pressure or too much forward pressure also decreases acceleration rate. So that fine line or "slippery spot" is that position between not enough or too much back pressure.

If one does not want to take off and just wants to continue to taxi on the step, a reduction in power is initiated at approximately the time the seaplane is eased over onto the step. Power requirements to maintain the proper speed with wind, load and current action will vary. More power will be required taxiing into the wind or an upcurrent or with a heavy load. However, 65 to 70 percent of maximum power can be used as a starting point.

From either the plowing or on-the-step position, if power is reduced to idle, the seaplane will decelerate quite rapidly and eventually assume the displacement or idle position. Care must be taken to use proper flight control pressures during the deceleration phase because weight is now being transferred toward the bow and drag is increasing; hence, some aircraft have a nose-over tendency. This is of course controllable by proper use of the elevator controls.

VII. Turns

If water rudders have the proper amount of movement, a seaplane can be turned within a radius less than the span of the wing during calm conditions or a light breeze. It will be found that water rudders are usually more effective at slow speeds because they are acting in comparatively undisturbed water. At high speeds, however, the stern of the float churns the adjacent water, thereby causing the water rudder to become less efficient. Furthermore, because of the high speed, the water's impact on the rudders may tend to force them to swing up or retract.

Particular attention should always be given to the risks involved in making turns in a strong wind or at high speeds. Any seaplane will tend to weathervane into a strong wind if the controls are not positioned to prevent it. In a single-engine seaplane rudder should be applied as necessary to control the turn while aileron is held into the wind. On twin-engine seaplanes this tendency can be overcome through the use of differential power - using a higher setting on the upwind side. The rate at which the seaplane turns when it weathervanes is directly proportional to the speed of the crosswind. When taxiing downwind or crosswind, the seaplane will swing into the wind as soon as the flight controls are neutralized or power is reduced.

During a high speed taxiing turn, centrifugal forces tends to tip the seaplane toward the outside of the turn (see Figure 4). Simultaneously, when turning from a downwind heading to an upwind heading, the wind force striking the fuselage and the under side of the wing increases the tendency for the seaplane to lean to the outside of the turn. If an abrupt turn is made, the combination of these two forces may be sufficient to tip the seaplane to the extent that the outside wing drags in the water, and may even tip the seaplane onto its back (see Figure 5). Obviously, the further the seaplane tips, the greater will be the effect of wind, since more wing area on the windward side is exposed to the wind force.

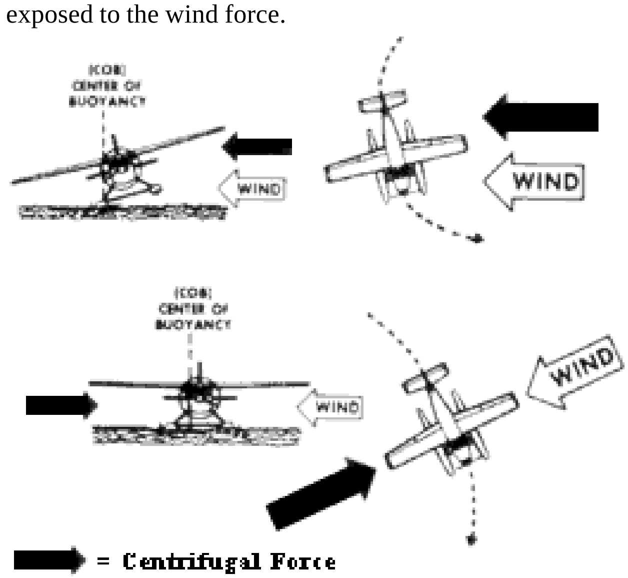

Figure 4: Effect of wind and centrifugal force

When making a turn into the wind from a crosswind condition, the air-rudder may be neutralized and the seaplane allowed to weathervane into the wind. If taxiing directly downwind, a turn into the wind may be started by deflecting the air rudder in the same direction that the turn is desired. As soon as the seaplane begins to turn, the rudder should be neutralized; if the wind is strong, some opposite rudder may be needed during the turn. The amount of opposite rudder depends upon the rate at which the seaplane turns. The greater the amount of opposite rudder, the slower the rate of turn. Normally, the power should be reduced to idle when the turn begins because with the power on the left turning tendency of the seaplane may become excessive. Short bursts of power are best for turning in a small radius, but sustained excessive power causes a buildup of speed and a larger turning radius.

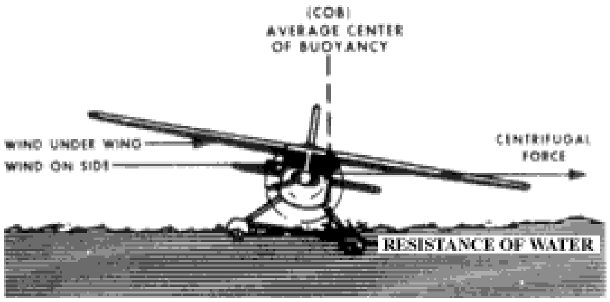

Figure 5: Effect of wind

The seaplane tends to use its center of buoyancy (COB) as a pivot point wherever it may be. Center of buoyancy moves laterally, as well as forward and aft. Each object in water has a point of center of buoyancy. In a twin-float installation the effects of wind, power and flight controls are shared by the two floats and the average COB is free to move significantly.

The center of buoyancy (COB), or average point of support, moves aft when the seaplane is placed in a nose-up or plowing position (see Figure 3). This position exposes to the wind a considerable amount of float and fuselage side area forward of the center of buoyancy. Therefore, when taxiing crosswind in this position, many seaplanes will show a tendency to turn downwind because of the wind force on the exposed area of the float and the fuselage. For this reason it is sometimes helpful to place the seaplane in a nose-up position when turning downwind, particularly if the wind velocity is high. Under high wind conditions, the throttle may be used as a turning device by increasing power to cause a nose-up position when turning downwind, and decreasing power to allow the seaplane to weathervane into the wind.

VIII. SAILING

Occasions often arise when it is advisable to move the seaplane backward or to one side because wind or water conditions, or limited space make it impractical to attempt a turn (see Figure 6). In this situation, particularly if there is a significant wind, the seaplane can be "sailed" into a space which to an inexperienced pilot might seem extremely cramped. Even if the wind is calm and the space is inadequate for making a normal turn, a paddle (which should be part of every seaplane's equipment) may be used to propel the seaplane or to turn the nose in the desired direction.

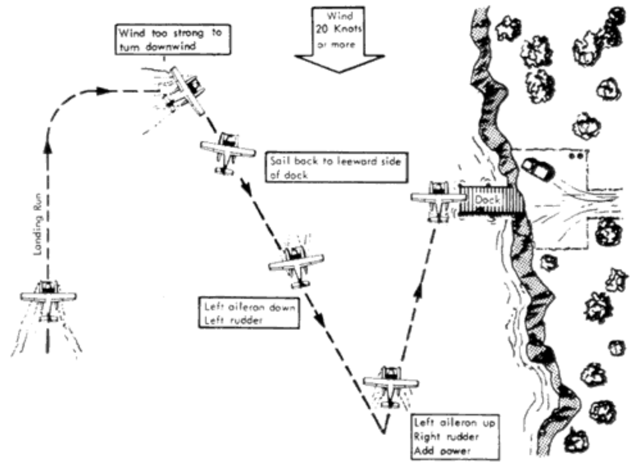

Figure 15-7: Taxiing/Sailing in Strong Wind

Figure 6: Taxiing/Sailing in strong wind

In light wind conditions with the engine idling or shut down, the seaplane will naturally weathervane into the wind and then sail in the direction the tail is pointed (see Figure 7). With a stronger wind and a slight amount of power, the seaplane will usually sail downwind toward the side in which the nose is pointed. Rudder and aileron can be deflected to create drag on the appropriate side to control the direction of movement. Positioning the controls for the desired direction of motion in light or strong winds is illustrated in Figure 7. Lowering the wing flaps and opening the cabin doors will increase the air resistance and thus add to the effect of the wind; however, the effect of the air rudder may be reduced in this configuration. Since water rudders have little or no effect in controlling direction while sailing, they should be lifted

With the engine shut down, most flying boats will sail backward and toward the side to which the nose is pointed, much as a sailboat tacks, regardless of wind velocity because the hull does not provide as much keel (side area) as do floats in proportion to the side of the seaplane. To sail directly backward in a seaplane having a hull, the controls should be released and the wind allowed to steer the seaplane.

Sailing is an essential part of seaplane operation. Since each type of seaplane has its own minor peculiarities, depending on the design of the floats or hull, it should be practiced until thorough familiarization with that particular type is gained.

During initial seaplane training, sailing should be practiced in large bodies of water such as lakes or bays, but sufficiently close to a prominent object in order to evaluate performance. Where there are strong tides or a rapidly flowing current, such as in rivers, care must be taken in observing the relative effect of both the wind and the water current. Often the force of the current will be equal to or greater than the force of the wind..

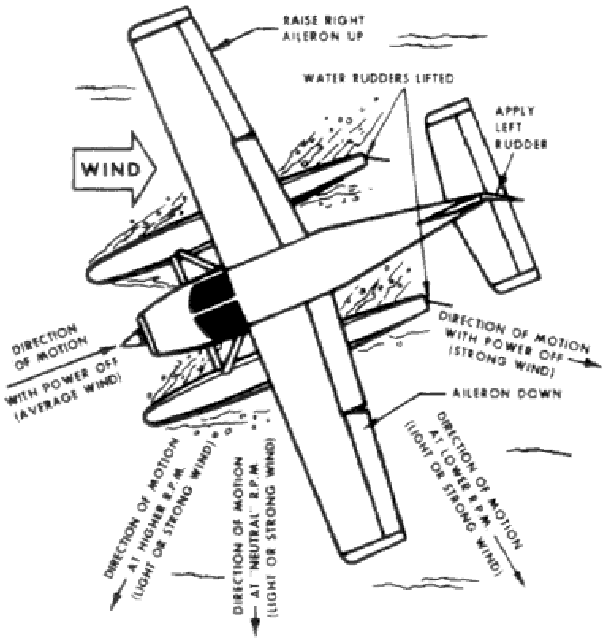

Figure 15-8: Sailing Procedures

Figure 7: Sailing procedures

Before taxiing into a confined area, the effect of wind and the current should be considered carefully. Otherwise, the seaplane may be carried into obstructions with resulting damage to the wings, tail surfaces, floats, hull, or other parts of the seaplane. Generally, with a seaplane of average size and power at idle, a water current of 5 knots will more than offset a wind velocity of 25 knots. This means that the seaplane will move against the wind.

When operating multiengine seaplanes, differential power can be used to aid in steering the seaplane along a desired course.

IX. Porpoising

Porpoising in a seaplane is much like the antics of a dolphin - a rhythmic pitching and heaving while in the water. Porpoising is a dynamic instability of the seaplane and may occur when the seaplane is moving across the water while on the step during takeoff or landing. It occurs when the angle between the float or hull, and the water surface exceeds the upper or lower limit of the seaplane's pitch angle. Improper use of the elevator, resulting in attaining too high or too low a pitch (trim angle) sets off a cyclic oscillation which steadily increases in amplitude unless the proper trim angle or pitch attitude is reestablished.

A seaplane will travel smoothly across the water while on the step, so long as the floats or hull remain within a moderately tolerant range of trim angles. If the trim angle is held too low during planing, water pressure in the form of a small crest or wall is built up under the bow or forward part of the floats or hull. As the seaplane's forward speed is increased to a certain point, the bow of the floats or hull will no longer remain behind this crest and is abruptly forced upward as the seaplane rides over the crest. As the crest passes the step and on to the stern or aft portion of the floats or hull, the bow abruptly drops into a low position. This again builds a crest or wall of water in front of the bow resulting in another oscillation. Each oscillation becomes increasingly severe, and if not corrected will cause the seaplane to nose into the water, resulting in extensive damage or possible capsizing. Porpoising can also cause a premature lift off with an extremely high angle of attack, resulting in a stall or being in the area of reverse command and unable to climb over obstructions.

Porpoising will occur during the takeoff run if the trim angle is not properly controlled with proper elevator pressure just after passing through the "hump" speed, or when the highest trim angle before the planing attitude is attained; that is, if up-elevator is held too long and the angle reaches the upper limits.

On the other hand, if the seaplane is nosed down too sharply, the lower trim range can be entered and will also result in porpoising. Usually, porpoising does not start until a degree or two after the seaplane has passed into the critical trim angle range, and does not cease until a degree or two after the seaplane has passed out of the critical range.

If porpoising does occur, it can be stopped by applying timely back pressure on the elevator control to prevent the bow of the floats or hull from digging into the water. The back pressure must be applied and maintained until porpoising is damped. If porpoising is not damped by the time the second oscillations occurs, it is recommended that the power be reduced to idle and elevator control held firmly back so the seaplane will settle onto the water with no further instability.

The correct trim angle for takeoff, planing and landing applicable to each type of seaplane must be learned by the pilot and practiced until there is no doubt as to the proper angles for the various maneuvers.

The upper and lower trim angles are established by the design of the aircraft; however, changing the seaplane's gross weight, wing flap position, and center of gravity location will also change these limits. Increased weight increases the displacement of the floats or hull and raises the lower limit considerably. Extending the wing flaps frequently trims the seaplane to the lower limit at lower speeds, and may lower the upper limit at high speeds. A forward center of gravity increases the possibility of high angle porpoising especially during landing.

X. Skipping

Skipping is a form of instability which may occur when landing with excessive speed at a nose-up trim angle. This nose-up attitude places the seaplane at the upper trim limit of stability, and causes the seaplane to enter a cyclic oscillation when touching the water, resulting in the seaplane skipping across the surface. This action may be compared to "skipping" flat stones across the water.

Skipping can also occur by crossing a boat wake while fast taxiing on the step or during a takeoff. Sometimes the new seaplane pilot will confuse a skip with a porpoise. Pilot's body feelings can quickly determine whether a skip or porpoise has been encountered. A skip will give the body vertical "G" forces, similar to bouncing a landplane. The porpoise is a rocking chair type forward and aft motion feeling.

Correction for skipping is made by first increasing back pressure on the elevator control and adding sufficient power to prevent the floats from contacting the water. Then pressure on the elevator must be adjusted to attain the proper trim angle and the power gradually reduced to allow the seaplane to settle gently onto the water.

Skipping will not continue increasing its oscillations, as in porpoising, because of the lack of forward thrust with reduced power.

XI. Takeoffs

Unlike landplane operations at airports, seaplane operations are often conducted on water areas at which other activities are permitted. Therefore, the seaplane pilot is constantly confronted with floating objects, some of which are almost submerged and difficult to see - swimmers, skiers, and a variety of watercraft. Before beginning the takeoff, it is advisable to taxi along the intended takeoff path to check for the presence of any hazardous objects or obstructions. Thorough scrutiny should be given to the area to assure not only that it is clear, but that it will remain clear throughout the takeoff. Operators of motorboats and sailboats often do not realize the hazard resulting from moving their vessels into the takeoff path of a seaplane.

To accelerate during takeoff in a landplane, propeller thrust must overcome only the surface friction of the wheels and the increasing aerodynamic drag. During a seaplane take-off, however, hydrodynamic or water drag becomes the major part of the forces resisting acceleration. This resistance reaches its peak at a speed of about 27 knots, and just before the floats or hull are placed into a planing attitude.

The hydrodynamic forces at work during a seaplane takeoff run are shown in Figure 8. The point of greatest resistance is referred to as the "hump" because the increasing and decreasing effect of water drag causes a hump in the resisting curve. After the hump is passed and the seaplane is traveling on the step, water resistance decreases.

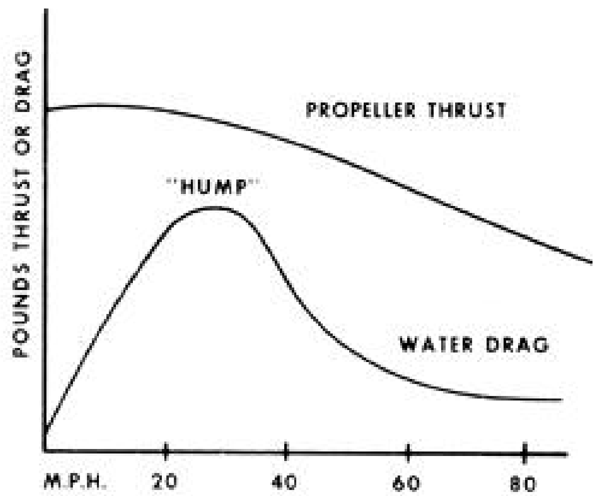

Figure 8: Water drag on take-off

Several factors greatly increase the water drag or resistance; heavy loading of the aircraft, or glassy water conditions in which no air bubbles slide under the floats or hull, as they do during a choppy water condition. In extreme cases, the drag may exceed the available thrust and prevent the seaplanes from becoming airborne. This is particularly true when operating in areas with high density altitudes (high elevations/high temperatures) where the engine cannot develop full rated power. For this reason the pilot should also practice takeoffs using only partial power to simulate the long takeoff run usually needed when operating at water areas where the density altitude is high and/or the seaplane is heavily loaded.

The seaplane takeoff may be divided into four distinct phases: (1) The "displacement" phase, (2) the "hump" or "plowing" phase, (3) the "planing" or "on the step" phase, and (4) the "lift off." The first three phases were previously described in the section on taxiing. The "lift off" is merely transferring support of the seaplane from the floats or hull to the wings by applying back elevator pressure. This results in the seaplane lifting off the water and becoming airborne. To avoid porpoising during the takeoff run, it is important to maintain the proper pitch angles. Too much back elevator pressure during the planing or lift off phases will force the stern of the floats or hull deeper into the water, creating a strong resistance and appreciably retarding the takeoff. Conversely, insufficient back elevator pressure will cause the bows to remain in the water, which also results in excessive water drag. Experience will determine the best angle to maintain during takeoff for each seaplane, and if held at this angle, the seaplane will take off smoothly.

Because the seaplane is not supported on a solid surface and the float or one side of the hull can be forced deeper into the water, right aileron control is usually required to offset the effect of torque when full power is applied during takeoff.

The spray pattern for each particular seaplane should also be considered during takeoff. During acceleration the water is increasingly sprayed upward, outward, and rearward from the bow portion of the floats or hull, and on some seaplanes will be directed into the propeller, eventually causing erosion of the blades. This water spray is greater during the hump phase. The spray can be reduced during takeoff, however, by first increasing the planing speed about 10 knots, then opening the throttle as rapidly as practical. This method shortens the time that propellers are exposed to the spray. Again, the best technique must be learned through experience with each particular seaplane. Bear in mind that a rough water condition creates more spray than does smooth water.

Glassy water takeoffs in a low-powered seaplane loaded to its maximum authorized weight presents a difficult, but not necessarily a dangerous, problem. Under these conditions the seaplane may assume a "plowing" or nose-up position, but may not "unstick" or get "on the step" because of the adhesive action of smooth water; consequently, always plan ahead and consider the possibility of aborting the takeoff. Nonetheless, if these conditions are not too excessive, the takeoff can be accomplished using the following procedure.

After the bow has risen to the highest point in the plowing position with full back elevator pressure, it should be lowered by decreasing back elevator pressure. The bow will drop if the seaplane has attained enough speed to be on the verge of attaining the step position. After a few seconds, the bow will rise again. At the instant it starts to rise, the rebound should be caught by again applying firm back elevator pressure, and as soon as the bow reaches its maximum height, the entire routine should be repeated. After several repetitions, it will be noted that the bow attains greater height and that the speed in increasing. If the elevator control is then pushed well forward and held there, the seaplane will slowly flatten out "on the step" and the controls may then be eased back to the neutral position.

Whenever the water is glassy smooth, a takeoff can be made with less difficulty by making the takeoff run across the wakes created by motorboats. If boats are not operating in the area, it is possible to create wakes by taxiing the seaplane in a circle and then taking off across these self-made wakes.

On seaplanes with twin floats water drag can be reduced by applying sufficient aileron pressure to raise the wing and lift one float out of the water after the seaplane is on the step. By allowing the seaplane to turn slightly in the direction the aileron is being held rather than holding opposite rudder to maintain a straight course, considerable aerodynamic drag is eliminated, aiding acceleration and lift off. When using this technique, great care must be exercised so as not to lift the wing to the extent that the opposite wing strikes the water. Naturally, this would result in serious consequences.

In most cases an experienced seaplane pilot can safely take off in rough water, but a beginner should not attempt to takeoff if the waves are too high. Using the proper procedure during rough water operation lessens the abuse of the floats, as well as the entire seaplane.

During rough water takeoffs, the throttle should be opened to takeoff power just as the bow is rising on a wave. This prevents the bow from digging into the water and helps keep the spray from the propeller. Slightly more back elevator pressure should be applied to the elevator than on a smooth water takeoff. This raises the bow to a higher angle.

After planing has begun, the seaplane will bounce from one wave crest to the next, raising the nose higher with each bounce, and each successive wave will be struck with increasing severity. To correct this situation and to prevent a stall, smooth elevator pressures should be used to set up a fairly constant pitch attitude that will allow the aircraft to "skim" across each successive wave as speed increases. Remember, in waves, the length of the float is very important. It is important that control pressure be maintained to prevent the bow from being pushed under the water surface or "stubbing its toes," which could result in capsizing the seaplane. Fortunately, a takeoff in rough water is accomplished within a short time because if there is sufficient wind to make water rough, the wind would also be strong enough to produce aerodynamic lift earlier and enable the seaplane to become airborne quickly.

With respect to water roughness, one condition that seaplane pilots should be aware of is the effect of a strong water current flowing against the wind. For example, if the velocity of the current is moving at 10 knots, and the wind is blowing at 15 knots, the relative velocity between the water and the wind is 25 knots. In other words, the waves will be as high as those produced in still water by a wind of 25 knots.

The advisability of canceling a proposed flight because of rough water depends upon the size of the seaplane, wing loading, power loading, and, most important, the pilot's ability. As a general rule, if the height of the waves from trough to crest is more than 20 percent of the length of the floats, takeoffs should not be attempted except by the most experienced and expert seaplane pilots.

Downwind takeoffs are possible, and at times preferable, if the wind velocity is light and normal takeoffs would involve clearing hazardous obstructions, or flying over congested areas before adequate altitude can be attained. The technique used for downwind takeoffs is almost identical to that used for upwind takeoffs. The only difference is that the elevator control should be held further aft, if possible. When downwind takeoffs are made, it should be kept in mind that more space is needed for the takeoff. If operating from a small body of water, an acceptable technique may be to begin the takeoff run while headed downwind, and then turning so as to complete the takeoff into the wind. This may be done by planing the seaplane while on a downwind heading then making a step turn into the wind to complete the takeoff. Caution must be exercised when using this technique since wind and centrifugal force will be acting in the same direction and could result in the seaplane tipping over.

Crosswind takeoff techniques will be discussed later in the chapter.

XII. LANDINGS

In comparison, the land surfaces of all airports are of firm, static matter, whereas the surface of water is changing continually as a fluid. Floating obstacles and various activities frequently present on the water surface may present serious hazards during seaplane landings, especially to the careless pilot. For these reasons, it is advisable to circle the area of intended landing and examine it thoroughly for obstructions such as buoys or floating debris, and to note the direction of movement of any boats which may be operating at the intended landing site.

Most established seaplane bases are equipped with a windsock to indicate wind direction, but if one is not available the wind can still be determined prior to landing. The following are but a few of the methods by which to determine the wind direction.

If there are no strong tides or water currents, boats lying at anchor will weathervane and automatically point into the wind. It is also true that sea gulls and other water fowl usually land facing the wind. Smoke, flags, and the set of sails on sailboats also provide the pilot with a fair approximation of the wind direction. If there is an appreciable wind velocity, streaks parallel to the wind are formed on the water. During strong winds, these streaks form distinct white lines. However, wind direction cannot always be determined from the streaks alone. If there are white caps or foam on top of the waves, the foam appears to move into the wind. This illusion is caused by the waves moving under the foam.

In seaplanes equipped with retractable landing gear (amphibians), it is extremely important to make certain that the wheels are in the retracted position when landing on water. Wherever possible, a visual check of the wheels themselves is recommended, in addition to checking the landing gear position indicating devices. A wheels-down landing on water is almost certain to capsize the seaplane, and is far more serious than landing the seaplane wheels-up on land. The water rudder should also be in the retracted position during landings.

The landing approach procedure in a seaplane is very similar to that of a landplane and is governed to a large extent by pilot preference, wind, and water conditions.

Under normal conditions a seaplane can be landed either power-off or power-on; however, power-on landings are recommended in most cases because this technique gives the pilot more positive control of the seaplane and provides a means for correcting errors in judgment during the approach and landing. So that the slowest possible airspeed can be maintained, the power-on landing should be accomplished with maximum flaps extended. The seaplane should be trimmed to the manufacturer's recommended approach speed, and the approach made similar to that of a landplane..

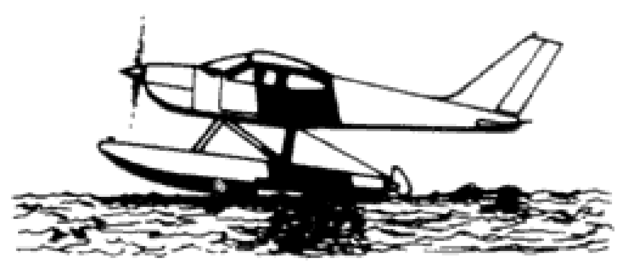

Figure 9: Touchdown attitude

Touchdown on the water should be made in a pitch attitude that is correct for taxiing "on the step," or perhaps a slightly higher attitude (see Figure 9). This attitude will result in the floats or hull first contacting the water at a point aft of the step. Once water contact is made, the throttle should be closed and back elevator pressure gradually applied. The application of back pressure reduces the tendency for the seaplane to nose down and the bows to dig in due to increased drag of the floats as they contact the water. The faster the speed at which a seaplane is landed, the more water drag is encountered, resulting in a greater nose-down attitude after touchdown. If the seaplane has a tendency to nose down excessively with full flaps extended, it is recommended that subsequent approaches and landing be made with less flaps. Remember, the objective is to land the seaplane at the slowest possible speed in a slightly nose-up attitude

After contacting the water, gradually increase back elevator pressure. It may be desirable at times to remain on the step after touchdown. To do so, merely add sufficient power and maintain the planing attitude immediately after touchdown.

Flat, calm, glassy water is perhaps the most deceptive condition that a seaplane pilot will experience. The calmness of the water has a psychological effect in that it tends to overly relax the pilot when there should be special alertness. Consequently, this surface condition is frequently the most dangerous for seaplane operation.

From above, the mirror-like appearance of smooth water looks most inviting and easy to land on but as many pilots have suddenly learned, adequate depth perception may be lacking. Even experienced pilots misjudge height above the water, making timely round-outs difficult. This results in either flying bow first into the water or stalling the seaplane at too great a height above the water. When the water is crystal clear and glassy, pilots often attempt to judge height by using the bottom of the lake as a reference, rather than the water surface.

An accurately set altimeter may be used as an aid in determining height above the glassy water. However, a more effective means is to make the approach and landing near the shoreline so it can be used as a reference for judging height above the water. Another method is to cross the shoreline on final approach at the lowest possible safe altitude so that a height reference is maintained to within a few feet of the water surface.

Glassy water landings should always be made power-on, and the need for this type of landing should be recognized in ample time to set up the proper final approach.

During the final approach the seaplane should be flown at the best nose-high attitude, using flaps as required or as recommended by the manufacturer. A power setting and pitch attitude should be established that will result in a rate of descent not to exceed 150 feet per minute and at an airspeed approximately 10 knots above stall speed. With a constant power setting and a constant pitch attitude, the airspeed will stabilize, and remain so if no changes are made. The power or pitch should be changed only if the airspeed or rate of descent deviates from that which is desired. Throughout the approach the seaplane performance should be closely monitored by cross-checking the instruments until contact is made with the water.

Upon touchdown, back elevator control pressure should be applied as necessary to maintain the same pitch attitude. Throttle should be reduced or closed only after the pilot is sure that the aircraft is firmly on the water. Several indications should be used.

1.A slight deceleration force will be felt. 2.A slight downward pitching moment will be seen. 3.The sounds of water spray striking the floats, hull, or other parts of the aircraft will be heard.

All three cues should be used because accidents have resulted from cutting the power rapidly after initially touching the water. To the pilot's surprise a skip had taken place and it was found that when the power was cut, the aircraft was 10 to 15 feet in the air and not on the water, resulting in a stall and substantial damage.

Maintaining a nose-up, wings-level attitude, at the correct speed and a small rate of descent, are imperative for a successful glassy water landing. All aspects of this approach and landing should be considered prior to its execution. Bear in mind that this type of approach and landing will usually consume considerable landing distance. Landing near unfamiliar shorelines increases the possibility of encountering submerged objects and debris.

It is impractical to describe an ideal rough water procedure because of the varying conditions of the surface. In most instances, though, the approach is made the same as for any other water landing. It may be better however, to level off just above the water surface and increase the power sufficiently to maintain a rather flat attitude until conditions appear more acceptable, and then reduce the power to touchdown. If severe bounces occur, power should be increased and a search made for a more ideal landing spot.

Generally, it is recommended that night water landing in seaplanes be avoided, since they can be extremely dangerous due to the difficulty or almost impossibility of seeing objects in the water. If it becomes necessary to land at night in a seaplane, serious consideration should be given to landing at a lighted airport. An emergency landing can be made on land in seaplanes with little or no damage to the floats or hull. Touchdown should be made with the keel of the floats or hull as nearly parallel to the surface as possible. After touchdown, full back elevator most be applied and additional power applied to lessen the rapid deceleration and nose-over tendency. Don't worry about getting stopped with additional power applied after touchdown. It will stop! The power is applied only for increasing elevator effectiveness.

XIII. Crosswind Techniques

Because of restricted or limited areas of operation, it is not always possible to take off or land the seaplane directly into the wind. Such restricted areas may be canals or narrow rivers. Therefore, skill must be acquired in crosswind techniques to enhance the safety of seaplane operation.

The forces developed by crosswinds during takeoffs or landings on water are almost the same as those developed during similar operations on land. Directional control is more difficult because of the more yielding properties of water, less surface friction, and lack of nosewheel, tailwheel, or brakes. Though a water surface is more yielding than solid land, a seaplane has no shock absorbing capability, so all the shock is absorbed by the hull or floats and transmitted to the aircraft structure.

As shown in Figure 10, a crosswind tends to push the seaplane sideways. The drifting force, acting through the seaplane's center of gravity, is opposed by the water reacting on the area of the floats or hull in contact with the water. This results in a tendency to weathervane into the wind. Once this weathervaning has started, the turn continues and is further aggravated by the addition of centrifugal force acting outward from the turn, which again is opposed by the water reaction on the floats or hull. If strong enough, the combination of the wind and centrifugal force may tip the seaplane to the point where the downwind float will submerge and subsequently the wingtip may strike the water and capsize the seaplane. This is known as a "waterloop" similar to a "groundloop" on land.

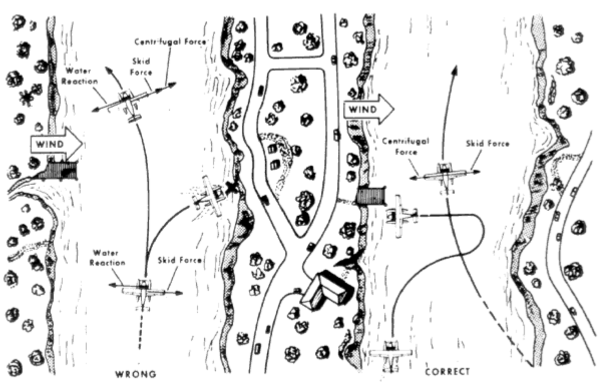

Figure 15-11: Crosswind Landing Technique

Figure 10: Crosswind landing technique

Because of the lack of clear reference lines for directional guidance, such as are found on airport runways, it is difficult to quickly detect sidedrift on water. Fortunately, early detection of sidedrift is not really essential, because the seaplane takeoff and landing can be made without maintaining a straight line while in contact with the water. A turn should be made toward the downwind side after landing. This will allow the seaplane to dissipate its forward speed prior to its weathervaning into the wind. By doing this, centrifugal force while weathervaning will be kept to a minimum and better aircraft control will result with less turnover tendency.

One technique sometimes used to compensate for crosswinds during water operations is the same as that used on land; that is, by lowering the upwind wing while holding a straight course with rudder. This creates a slip into the wind to offset the drifting tendency. The upwind wing is held in the lowered position throughout the touchdown and until completion of the landing.

Another technique used to compensate for crosswinds (preferred by many seaplane pilots) is the downwind arc method. Using this method, the pilot creates a sideward force (centrifugal force) that will offset the crosswind force. This is accomplished by steering the seaplane in a downwind arc as shown in Figure 10. The pilot merely plans an arced path and follows this arc to produce sufficient centrifugal force so that the seaplane will tend to lean outward against the wind force. During the run, the pilot can adjust the rate of turn by varying rudder pressure, thereby increasing or decreasing the centrifugal force to compensate for a changing wind force.

In practice, it is quite simple to plan sufficient curvature of the takeoff path to cancel out strong crosswinds, even on very narrow rivers. As illustrated in Figure 11, the takeoff is started at the lee side of the river with the seaplane heading slightly into the wind. The takeoff path is then gradually made in an arc away from the wind and the liftoff accomplished on the downwind edge of the river. This pattern also allows for more climbout space into the wind.

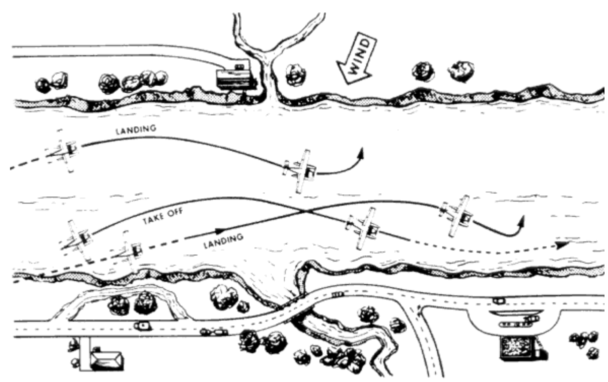

Figure 15-12: Crosswind Takeoff and Landing Technique

Figure 11: Crosswind takeoff and landing technique

It should be noted that the greatest degree of the downwind arc is during the time the seaplane is traveling at the slower speeds of takeoff or landing. At the faster speeds, the crosswind effect lessens considerably, and at very slow speeds the seaplane can weathervane into the wind with no ill effect.

Unless the current is extremely swift, crosswind or calm wind takeoffs and landings in rivers or tidal flows should be made in the same direction as the current. This reduces the water forces on the floats or hull of the seaplanes.

Again, experience will play an important part in successful operation during crosswinds. It is essential that all seaplane pilots have thorough knowledge and skill in these maneuvers.

XIV. Anchoring, Mooring, Docking and Beaching

Anchoring the seaplane is the easiest method of securing it on the water surface after a flight. The areas selected should be out of the way of moving vessels, and in water deep enough to ensure that the seaplane will not be left high and dry during low tide. The length of the anchor line should be approximately seven times the depth of the water. After dropping anchor with the seaplane headed into the wind, allow the seaplane to drift backward so the anchor is set. To determine that the anchor is holding the seaplane at the desired location, select two fixed objects nearby or on shore that are lined up, and check to assure that these objects remain aligned. If they do not, it means that the seaplane is drifting and dragging the anchor on the bottom.

The effects of a wind shift must also be considered and sufficient room should be allowed in which the seaplane can swing around without striking other anchored vessels or nearby obstacles.

If anchoring the seaplane overnight or for longer periods of time, an additional, heavier anchor should be used. This anchor should be dropped about twice as far ahead as the first anchor and about thirty degrees to one side of the seaplane.

Mooring a seaplane eliminates the problem of anchor dragging. A permanent mooring installation consists of a firmly implanted anchor or heavy weight connected by a wire or chain to a floating buoy.

A mooring should be approached at a very low speed and straight into the wind. To avoid the possibility of overrunning the mooring, the engine should be shut down early and the seaplane allowed to coast to the mooring. The engine can always be started again if needed for better positioning. Never straddle the buoy with a twin float installation. Always approach so as to have the buoy on the outside of the float to avoid damage to the propeller and underside of the fuselage. It is recommended that initial contact with the mooring be made with a boathook or a person standing on the deck of one float.

If a person is on the float, the seaplane should be taxied right or left of the mooring so that the float on which the person is standing is brought directly alongside the buoy. A short line, which has one end already secured to a strut, can then be secured to the mooring.

It is very important to exercise extreme caution whenever a person is assisting in securing a seaplane. Numerous accidents have been caused by the helper being struck by the propeller.

The procedure for docking is essentially the same as that used for mooring. Properly planning the approach to the dock under existing conditions, and skill in handling the seaplane in congested areas are essential to successful docking. Bear in mind that a seaplane is fragile and striking an obstruction could result in extensive damage to the airplane.

Beaching the seaplane is easy. Success in beaching depends primarily upon the type and firmness of the shoreline. Inspect the beach before using it. If this is impossible, the approach to the beach should be made at an oblique angle so that the seaplane can be turned out into deeper water in the event the beach is not satisfactory. The hardest packed sand is usually found near the water's edge and becomes softer further from the water's edge where it is dry. Mud bottoms are usually not desirable for beaching.