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AIR—AIRMANSHP

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TRANSPORT CANADA AERONAUTICAL INFORMATION MANUAL (TC AIM)
EXPLANATION OF CHANGES
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NOTES:

1. Editorial and format changes were made throughout the TC AIM where necessary, and those that were deemed insignificant in nature were not included in the “Explanation of Changes.”
2. The blue highlights in the manual represent the changes described in this section.

AIR

- (1) [AIR 2.11.1 – General](#)
Information was added regarding the Collision Regulations, including a Web site link.
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AIR—AIRMANSHIP

1.0 GENERAL INFORMATION

1.1 GENERAL

Airmanship is the application of flying knowledge, skill and experience which fosters safe and efficient flying operations. Airmanship is acquired through experience and knowledge. This section contains information and advice on various topics which help to increase knowledge.

1.2 PILOT VITAL ACTION CHECKLISTS

A number of aircraft accidents have been directly attributed to the lack of proper vital action checks by the pilots concerned. It is essential that pretakeoff, prelanding and other necessary vital action checks be performed with care.

While Transport Canada does not prescribe standard checks to be performed by pilots, it is strongly recommended that owners equip their aircraft with the manufacturer's recommended checklists. For any specific type of aircraft, only relevant items should be included in the checklists which should be arranged in an orderly sequence having regard to the cockpit layout.

1.3 AVIATION FUELS

1.3.1 Fuel Grades

The use of aviation fuel other than specified is contrary to a condition of the Certificate of Airworthiness and, therefore, a contravention of regulations. A fuel which does not meet the specifications recommended for the aircraft may seriously damage the engine and result in an in-flight failure. In Canada, fuels are controlled by government specifications. Aviation fuel can usually be identified by its colour.

Table 1.1—Fuel Grades and Colours

FUEL	COLOUR
AVGAS 80/87	red
AVGAS 100/130	green
100 LL	blue
Aviation Turbine Fuels	straw-coloured or
MOGAS P 87-90 (see NOTE 2)	undyed
MOGAS R 84-87 (see NOTE 2)	green
	undyed

NOTES:

- Good airmanship ensures that positive identification of the type and grade of aviation fuel is established before fuelling.
- Transport Canada now approves the use of automotive gasoline for certain aircraft types under specific conditions. For additional information, refer to TP 10737E – *Use of Automotive Gasoline (MOGAS) for General Aviation Aircraft*, available from your TC Airworthiness Regional office. (See GEN 1.1.2 for addresses.)

1.3.2 Aviation Fuel Handling

A company supplying aviation fuel for use in civil aircraft is responsible for the quality and specifications of its products up to the point of actual delivery. Following delivery, the operator is responsible for the correct storage, handling, and usage of aviation fuel. A fuel dispensing system must have an approved filter, water separator or monitor to prevent water or sediment from entering aircraft fuel tanks. The use of temporary fuelling facilities such as drums or cans is discouraged. However, if such facilities are necessary, always filter aviation fuel using a proper filter and water separator with a portable pump bonded to the drum before bungs are removed.

The aircraft and fuelling equipment through which fuel passes all require bonding. The hose nozzle must be bonded to the aircraft before the tank cap is removed in over-wing fuelling. All funnels or filters used in fuelling are to be bonded together with the aircraft. Bonding prevents sparks by equalizing or draining the electric potentials.

During the pre-flight check, a reasonable quantity of fuel should be drawn from the lowest point in the fuel system into a clear glass jar. A “clear and bright” visual test should be made to establish that the fuel is completely free of visible solid contamination and water (including any resting on the bottom or sides of the container), and that the fuel possesses an inherent brilliance and sparkle in the presence of light. Cloudy or hazy fuel is usually caused by free and dispersed water, but can also occur because of finely divided dirt particles. Free water may also be detected by the use of water-finding paste available from oil companies. If there is any suspicion that water exists in an aircraft's fuel system detailed checking of the entire system should be carried out until it is proven clear of contamination. Analysis by an approved laboratory is the only way to ensure positive proof of compliance if doubt exists.

1.3.3 Fuel Anti-Icing Additives

All aviation fuels absorb moisture from the air and contain water in both suspended particles and liquid form. The amount of suspended particles varies with the temperature of the fuel. When the temperature of the fuel is decreased, some of the suspended particles are drawn out of the solution and slowly fall to the bottom on the tank. When the temperature of the fuel increases, water particles from the atmosphere are absorbed to maintain a saturated solution.

As stated in AIR 1.3.2, water should be drained from aircraft fuel systems before flight. However, even with this precaution water particles in suspension will remain in the fuel. While this is not normally a problem it becomes so when fuel cools to the freezing level of water and the water particles change to ice crystals. These may accumulate in fuel filters, bends in fuel lines, and in some fuel-selectors and eventually may block the fuel line causing an engine stoppage. Fuel anti-icing additives will inhibit ice crystal formation. Manufacturer approved additives, such as ethylene-glycol-monomethyl-ether (EGME), used in the prescribed manner have proven quite successful. The aircraft manufacturer's instructions for the use of anti-icing fuel additives should therefore be consulted and carefully followed.

1.3.4 Refuelling—Fires and Explosions

Pound for pound, aviation fuel is more explosive than dynamite. It has different properties than automotive fuel so the rules you follow when filling your car at the pump are not enough to keep you safe when fuelling your aircraft. AVGAS used in piston engines is also very different from jet fuel.

1.3.4.1 Understanding Flashpoint, Static and Auto-ignition

The flashpoint of a volatile material is the lowest temperature at which it can vaporize to form an ignitable mixture in air. The flashpoint of AVGAS is well below freezing, making it extremely flammable. To be explosive, the mixture must contain one to six percent fuel vapour by volume when combined with air. Mixtures below this range are too lean and those above are too rich to ignite. The mixture in the space above the fuel in a gas-tight compartment is usually too rich for combustion; but in extremely cold conditions, the mixture may be lean enough to be explosive. Regardless of the temperature or type of fuel, it is essential that aircraft be properly bonded to the refuelling equipment and grounded to avoid the risk of a spark igniting the fuel vapour when the fuel nozzle nears the fuel tank. All other possible sources of ignition—smoking, portable electronics—should also be controlled. Do not refuel when thunderstorms are in the vicinity.

For very light aircraft that may be refuelled using portable tanks, it is also important to understand that plastic jerry cans cannot be easily grounded, and that fuel vapours remaining in empty tanks can be highly flammable.

The flashpoint of jet fuel is 38°C, so flammable fuel vapours are present only at high ambient temperatures. It is less flammable than AVGAS but has other characteristics critical to refuelling operations. All fuels generate static charges from agitation during fuelling as well as from movement through fuel pumps, filters and lines. Jet fuel accumulates more static charges than AVGAS. Jet fuel, particularly Jet A-1, has low electrical conductivity and requires time at rest to dissipate accumulated static charges. Anti-static additives make jet fuel more conductive. The additives do not reduce the generation of static charges, but allow the charges to be dissipated faster. Proper bonding/grounding does not eliminate the static charges accumulated in jet fuel.

Jet A-1 also has a low auto-ignition temperature (220°C), which is the lowest temperature at which it will spontaneously ignite in a normal atmosphere without an external source of ignition (such as a flame or spark). Jet A-1 fuel spills onto hot surfaces such as exhaust pipes or brakes can result in spontaneous ignition.

NOTES:

1. Incidents of fuelling in enclosed spaces and/or with inadequate bonding have resulted in death or injury. At low temperature and humidity, a blower heater could cause statically charged dust particles to build up and combine with fuel vapours leading to catastrophic results.
2. Plastic fuel containers cannot be properly bonded or grounded, which increases the chance of explosion and fire.

1.4 AIRCRAFT HAND FIRE EXTINGUISHERS

1.4.1 General

When selecting a hand fire extinguisher for use in aircraft, consider the most appropriate extinguishing agent for the type and location of fires likely to be encountered. Take account of the agent’s toxicity, extinguishing ability, corrosive properties, freezing point, etc.

The toxicity ratings listed by the Underwriters’ Laboratories for some of the commonly known fire extinguisher chemicals are as follows:

- Bromotrifluoromethane (Halon 1301) – Group 6
- Bromochlorodifluoromethane (Halon 1211) – Group 5a
- Carbon dioxide – Group 5a
- Common Dry Chemicals – Group 5a
- Dibromodifluoromethane (Halon 1202) – Group 4*
- Bromochloromethane (Halon 1011) – Group 4*
- Carbon Tetrachloride (Halon 104) – Group 3*
- Methyl bromide (Halon 1001) – Group 2*

**Should not be installed in an aircraft*

It is generally realized that virtually any fire extinguishing agent is a compromise between the hazards of fire, smoke, fumes and a possible increase in hazard due to the toxicity of the extinguishing agent used. Hand fire extinguishers using agents having a rating in toxicity Groups 2 to 4 inclusive should not be installed in aircraft. Extinguishers in some of the older types of aircraft do not meet this standard and for such aircraft it is recommended that hand fire extinguishers employing agents in toxicity Group 5 or above be installed when renewing or replacing units and that they be of a type and group approved by the Underwriters’ Laboratories. It is further recommended that instruction in the proper use, care and cautions to be followed be obtained from the manufacturer and the local fire protection agency.

1.4.2 Classification of Fires

Table 1.2—Fire Classification

<i>Class A fires:</i>	Fires in ordinary combustible materials. On these, water or solutions containing large percentages of water are most effective.
<i>Class B fires:</i>	Fires in flammable liquids, greases, etc. On these a blanketing effect is essential.
<i>Class C fires:</i>	Fires in electrical equipment. On these the use of a nonconducting extinguishing agent is of first importance.

1.4.3 Types of Extinguishers

Carbon Dioxide Extinguishers: Carbon dioxide extinguishers are acceptable when the principal hazard is a Class B or Class C fire. Carbon dioxide portable installations should not exceed five pounds of agent per unit to ensure extinguisher portability and to minimize crew compartment CO2 concentrations.

Water Extinguishers: Water extinguishers are acceptable when the principal hazard is a Class A fire and where a fire might smolder if attacked solely by such agents as carbon dioxide or dry chemical. If water extinguishers will be subject to temperatures below freezing, the water extinguisher must be winterized by addition of a suitable anti-freeze.

Vaporizing Liquid Extinguishers: Vaporizing liquid type fire extinguishers are acceptable when the principal hazard is a Class B or Class C fire.

Dry Chemical Extinguishers: Dry chemical extinguishers using a bi-carbonate of sodium extinguishing agent or potassium bi-carbonate powder are acceptable where the principal hazard is a Class B or Class C fire.

Dry chemical extinguishers using a so-called All Purpose Monoammonium Phosphate are acceptable where the hazard includes a Class A fire as well as Class B and Class C.

The size of the dry chemical extinguisher should not be less than two lb. Only an extinguisher with a nozzle that can be operated either intermittently or totally by the operator should be installed.

Some abrasion or corrosion of the insulation on electrical instruments, contacts or wiring may take place as a result of using this extinguisher. Cleaning and inspection of components should be carried out as soon as possible.

Care should be taken when using this extinguisher in crew compartments because the chemical can interfere with visibility while it is being used and because the nonconductive powders may be deposited on electrical contacts not involved in the fire. This can cause equipment failure.

Halon Extinguishers: Halon 1211 is a colourless liquefied gas which evaporates rapidly, does not freeze or cause cold burn, does not stain fabrics nor cause corrosive damage. It is equally effective on an A, B or C class fire and has proven to be the most effective extinguishant on gasoline based upholstery fires. The size of a Halon 1211 extinguisher for a given cubic space should not result in a concentration of more than 5%. Halon 1211 is at least twice as effective as CO₂ and is heavier than air (so it “sinks”). Decomposed Halon 1211 “stinks” so it is not likely to be breathed unknowingly.

Halon 1301 is less toxic than Halon 1211 but it is also less effective and is excellent for B or C class fires. A short-coming appears to be the lack of a visible “stream” on discharge; Halon 1301 turns into an invisible gas as it discharges.

1.5 PRESSURE ALTIMETER

1.5.1 General

The pressure altimeter used in aircraft is a relatively accurate instrument for measuring flight level pressure but the altitude information indicated by an altimeter, although technically “correct” as a measure of pressure, may differ greatly from the actual height of the aircraft above mean sea level or above ground. In instances of aircraft flying high above the earth’s surface, knowledge of the actual distance between the aircraft and the earth’s surface is of little immediate value to the pilot except,

perhaps, when navigating by pressure pattern techniques. In instances of aircraft operating close to the ground or above the highest obstacle en route, especially when on instruments, knowledge of actual ground separation or of “error” in the altimeter indication, is of prime importance if such separation is less than what would be assumed from the indicated altitude.

An aircraft altimeter which has the current altimeter setting applied to the subscale should not have an error of more than ± 50 feet when compared on the ground against a known aerodrome or runway elevation. If the error is more than ± 50 feet, the altimeter should be checked by maintenance as referenced in AIR 1.5.2.

1.5.2 Calibration of the Pressure Altimeter

Pressure altimeters are calibrated to indicate the “true” altitude in the ICAO Standard Atmosphere. The maximum allowable tolerance is ± 20 feet at sea level for a calibrated altimeter. This tolerance increases with altitude.

The ICAO Standard Atmosphere conditions are:

- (a) air is a perfectly dry gas;
- (b) mean sea level pressure of 29.92 inches of mercury;
- (c) mean sea level temperature of 15°C; and
- (d) rate of decrease of temperature with height is 1.98°C per 1 000 feet to the height at which the temperature becomes -56.5°C and then remains constant.

1.5.3 Incorrect Setting on the Subscale of the Altimeter

Although altimeters are calibrated using the Standard Atmosphere sea level pressure of 29.92 inches of mercury, the actual sea level pressure varies hour to hour, and place to place. To enable the “zero” reference to be correctly set for sea level at any pressure within a range of 28.0 to 31.0 inches of mercury, altimeters incorporate a controllable device and subscale. Whether a pilot inadvertently sets an incorrect pressure on the altimeter subscale or sets the correct pressure for one area and then, without altering the setting, flies to an area where the pressure differs, the result is the same – the “zero” reference to the altimeter will not be where it should be but will be “displaced” by an amount proportional to 1 000 feet indicated altitude per 1 inch of mercury that the subscale setting is in error. As pressure decreases with altitude, a subscale setting that is higher than it should be will “start” the altimeter at a lower level, therefore, A TOO HIGH SUBSCALE SETTING MEANS A TOO HIGH ALTIMETER READING, that is the aircraft would be at a level lower than the altimeter indicates; A TOO LOW SUBSCALE SETTING MEANS A TOO LOW ALTIMETER READING, that is the aircraft would be at a level higher than the altimeter indicates. As the first instance is the more dangerous, an example follows:

A pilot at Airport A, 500 feet ASL, sets the altimeter to the airport’s altimeter setting of 29.80 inches of mercury prior to departure for Airport B, 1 000 feet ASL, some 400 NM away. A flight altitude of 6 000 feet is selected for the westbound flight so as to clear a 4 800-foot mountain ridge lying across track about 40 NM from B.

The pilot does not change the altimeter subscale reading until he makes radio contact with B when 25 NM out and receives an altimeter setting of 29.20 inches of mercury. Ignoring other possible errors (see below), when the aircraft crossed the mountain ridge the actual ground clearance was only 600 feet, not 1 200 feet as expected by the pilot. This illustrates the importance of having the altimeter setting of the nearest airport along the route set on the instrument.

1.5.4 Non-Standard Temperatures

The only time that an altimeter will indicate the “true” altitude of an aircraft at all levels is when ICAO Standard Atmosphere conditions exist.

When the current altimeter setting of an airport is set on the subscale of an altimeter, the only time a pilot can be certain that the altimeter indicates the “true” altitude is when the aircraft is on the ground at that airport.

When 29.92 inches of mercury is set on the subscale of an altimeter within the Standard Pressure Setting Region, the altimeter will indicate “true” altitude if ICAO Standard Atmosphere conditions exist or if the aircraft is flying at that particular level for which 29.92 inches of mercury would be the altimeter setting.

In general, it can be assumed that the altitude indication of an altimeter is always in error due to temperature when an aircraft is in flight.

The amount of error will be approximately 4% of the indicated altitude for every 11°C that the average temperature of the air column between the aircraft and the “ground” differs from the average temperature of the Standard Atmosphere for the same air column. In practice, the average temperature of the air column is not known and “true” altitude is arrived at from knowledge of the outside air temperature (OAT) at flight level and use of a computer. The “true” altitude found by this method will be reasonably accurate when the actual lapse rate is, or is near, that of the Standard Atmosphere, i.e. 2°C per 1 000 feet. During the winter when “strong” inversions in the lower levels are likely and altimeters “habitually” over-read, in any situation where ground separation is marginal, a pilot would be well advised to increase the altimeter error found using flight level temperature by 50%. Consider the aircraft in the above example; assume that the OAT at flight level in the vicinity of the mountain ridge was -20°C; what was the likely “true” altitude of the aircraft over the mountain ridge?

To calculate “true” altitude using a computer, the pressure altitude is required. In this case, the altimeter indicates 6 000 feet with 29.80 inches of mercury set on the subscale, therefore, if the pilot altered the subscale to 29.92 inches of mercury momentarily, the pilot would read a pressure altitude of 6 120 feet. Although the indicated altitude is 6 000 feet, if the altimeter setting of the nearest airport (B) was set, the indicated altitude would be 5 400 feet. With 29.20 inches of mercury set on the altimeter subscale if the aircraft was on the ground at B, the altimeter would indicate the “true” altitude of 1 000 feet; assuming no pressure difference, it can be taken that the altimeter set to 29.20 inches of mercury would indicate the 1 000-foot level at the mountain with no error due to temperature, therefore

temperature error will occur only between the 1 000-foot level and the 5 400-foot level, i.e. 4 400 feet of airspace.

- (a) Set pressure altitude, 6 120 feet, against OAT, -20°C, in the appropriate computer window.
- (b) Opposite 4 400 feet (44) on the inner scale read 4 020 feet (40.2) on the outer scale.
- (c) Add the 1 000 feet previously deducted as being errorless and find the “true” altitude of 4 020 feet + 1 000 feet = 5 020 feet ASL. The margin of safety is now just over 200 feet, but this does not take into account variables which may prevail as outlined immediately above and due to mountain effect as explained below.

1.5.5 Standard Pressure Region

When flying within this region, the altimeter must be reset, momentarily, to the altimeter setting of the nearest airport along the route to obtain indicated altitude, or indicated altitude calculated from the altimeter setting, and the steps given above followed, or, when over large expanses of water or barren lands where there are no airports, the forecast mean sea level pressure for the time and place must be used to get indicated altitude. In the other instance, “airport” level would be zero, therefore subtraction and addition of airport elevation would not be done. The “true” altitude determined in such a case would be “true” only if the forecast pressure used approximates the actual sea level pressure. (If sea level pressure is not known and pressure altitude is used also as indicated altitude, the resultant “true” altitude will be the “true” altitude above the 29.92 level, wherever it may be in relation to actual mean sea level).

1.5.6 Effect of Mountains

Winds which are deflected around large single mountain peaks or through the valleys of mountain ranges tend to increase speed which results in a local decrease in pressure (Bernoulli’s Principle). A pressure altimeter within such an airflow would be subject to an increased error in altitude indication by reason of this decrease in pressure. This error will be present until the airflow returns to “normal” speed some distance away from the mountain or mountain range.

Winds blowing over a mountain range at speeds in excess of about 50 kt and in a direction perpendicular (within 30°) to the main axis of the mountain range often create the phenomena known as “Mountain” or “Standing Wave”. The effect of a mountain wave often extends as far as 100 NM downwind of the mountains and to altitudes many times higher than the mountain elevation. Although most likely to occur in the vicinity of high mountain ranges such as the Rockies, mountain waves have occurred in the Appalachians, elevation about 4 500 feet ASL (the height of the ridge of our example).

Aware and the Air Command Weather Manual (TP 9352E) cover the mountain wave phenomena in some detail; however, aspects directly affecting aircraft “altitude” follow.

1.5.7 Downdraft and Turbulence

Downdrafts are most severe near a mountain and at about the same height as the top of the summit. These downdrafts may reach an intensity of about 83 ft/s (5 000 ft/min) to the lee of high mountain ranges, such as the Rockies. Although mountain waves often generate severe turbulence, at times flight through waves may be remarkably “smooth” even when the intensity of downdrafts and updrafts is considerable. As these smooth conditions may occur at night, or when an overcast exists, or when no distinctive cloud has formed, the danger to aircraft is enhanced by the lack of warning of the unusual flight conditions.

Consider the circumstances of an aircraft flying parallel to a mountain ridge on the downwind side and entering a smooth downdraft. Although the aircraft starts descending because of the downdraft, as a result of the local drop in pressure associated with the wave, both the rate of climb indicator and the altimeter will not indicate a descent until the aircraft actually descends through a layer equal to the altimeter error caused by the mountain wave, and, in fact, both instruments may actually indicate a “climb” for part of this descent; thus the fact that the aircraft is in a downdraft may not be recognized until after the aircraft passes through the original flight pressure level which, in the downdraft, is closer to the ground than previous to entering the wave.

1.5.8 Pressure Drop

The “drop” in pressure associated with the increase in wind speeds extends throughout the mountain wave, that is downwind and to “heights” well above the mountains. Isolating the altimeter error caused solely by the mountain wave from error caused by non-standard temperatures would be of little value to a pilot. Of main importance is that the combination of mountain waves and non-standard temperature may result IN AN ALTIMETER OVERREADING BY AS MUCH AS 3 000 FT. If the aircraft in our example had been flying upwind on a windy day, the actual ground separation on passing over the crest of the ridge may well have been very small.

1.5.9 Abnormally High Altimeter Settings

Cold dry air masses can produce barometric pressures in excess of 31.00 in. of mercury. Because barometric readings of 31.00 in. of mercury or higher rarely occur, most standard altimeters do not permit setting of barometric pressures above that level and are not calibrated to indicate accurate aircraft altitude above 31.00 in. of mercury. As a result, most aircraft altimeters cannot be set to provide accurate altitude readouts to the pilot in these situations.

When aircraft operate in areas where the altimeter setting is in excess of 31.00 in. of mercury and the aircraft altimeter cannot be set above 31.00 in. of mercury, the true altitude of the aircraft will be HIGHER than the indicated altitude.

Procedures for conducting flight operations in areas of abnormally high altimeter settings are detailed in *AIP Canada* ENR 1.7.

1.6 CANADIAN RUNWAY FRICTION INDEX (CRFI)

1.6.1 General

The following paragraphs discuss the slippery runway problem and suggest methods of applying runway coefficient of friction information to aircraft flight manual (AFM) data.

1.6.2 Reduced Runway Coefficients of Friction and Aircraft Performance

The accelerate-stop distance, landing distance and crosswind limitations (if applicable) contained in the aircraft flight manual (AFM) are demonstrated in accordance with specified performance criteria on runways that are bare, dry, and that have high surface friction characteristics. Unless some factor has been applied, these distances are only valid under similar runway conditions. Whenever a contaminant—such as water, snow or ice—is introduced to the runway surface, the effective coefficient of friction between the aircraft tire and runway is substantially reduced. The stop portion of the accelerate-stop distance will increase, the landing distance will increase and a crosswind may present directional control difficulties. The problem has been to identify, with some accuracy, the effect that the contaminant has had on reducing the runway coefficient of friction and to provide meaningful information to the pilot, e.g. how much more runway is needed to stop and what maximum crosswind can be accepted.

1.6.3 Description of Canadian Runway Friction Index (CRFI) and Method of Measurement

The decelerometer is an instrument mounted in a test vehicle that measures the decelerating forces acting on the vehicle when the brakes are applied. The instrument is graduated in increments from 0 to 1, the highest number being equivalent to the theoretical maximum decelerating capability of the vehicle on a dry surface. These numbers are referred to as the CRFI. It is evident that small numbers represent low braking coefficients of friction while numbers on the order of 0.8 and above indicate the braking coefficients to be expected on dry runways.

The brakes are applied on the test vehicle at 300-m (1 000-ft) intervals along the runway within a distance of 10 m (30 ft) from each side of the runway centreline at that distance from the centreline where the majority of aircraft operations take place at each given site. The readings taken are averaged and reported as the CRFI number.

1.6.4 Description of Canadian Runway Friction Index (CRFI) Reporting Method

Where an airport receives aeroplane operations in an air transport service under Subpart 5 of Part VII of the CARs, CRFI is reported by runway thirds for runways greater than or equal to 1 829 m (6 000 ft) in length.

CRFI may be reported by runway thirds for runways less than 1 829 m (6 000 ft) in length where the aerodrome is equipped to do so; however, CRFI will be reported by full runway lengths as a default.

The aerodrome's airport winter maintenance plan should be consulted for the latest information on CRFI reporting methodology for a given runway.

1.6.5 Aircraft Movement Surface Condition Reports (AMSCR)

AMSCRs are issued to alert pilots of natural surface contaminants—such as snow, ice or slush—that could affect aircraft braking performance. The RSC section of the report provides information about runway conditions in plain language, while the CRFI section describes braking action quantitatively using the numerical format described in AIR 1.6.3.

Where runway information is reported in thirds, a runway condition code (RWYCC) is reported for each third. RWYCCs are on a scale of 0 to 6, where 0 represents the most slippery conditions and 6 represents dry runway performance.

AMSCRs are issued when contaminants are present on a movement area as follows:

- (a) at the commencement of published AMSCR hours;
- (b) a minimum of once every eight hours thereafter;
- (c) when a significant change in a runway surface condition occurs;
- (d) following every accident or incident in which winter conditions may have been a factor; and
- (e) whenever the cleared width of the runway falls below full width.

When available, a CRFI reading will be issued along with the RSC in order to provide an overall descriptive picture of the runway condition and to quantify braking action. Due to mechanical and operational limitations, the runway friction readings produced by decelerometers may be inaccurate under certain surface conditions. As a result, runway friction readings will be taken and a CRFI will be provided to ATS or to pilots only when any of the following conditions are present:

- (a) ice;
- (b) wet ice consisting of a thin film of water on ice;
- (c) compacted snow;
- (d) slush on ice;
- (e) dry snow not exceeding 2.5 cm (1 in.) in depth;
- (f) de-icing chemical solution or sand on ice; or
- (g) frost.

An RSC report must be issued for each CRFI measurement provided.

The following changes relating to runway conditions are considered significant:

- (a) any change in the RWYCC (if applicable);
- (b) a CRFI change of 0.05 or more;
- (c) any change in the contaminant type;
- (d) any change of 20% or more in the reportable contaminant coverage;

- (e) any change in contaminant depth of $\frac{1}{8}$ in. for standing water and slush, $\frac{1}{4}$ in. for wet snow, and $\frac{3}{4}$ in. for dry snow; and
- (f) any other information that, according to assessment techniques, is considered to be significant, for example following the application or removal of sand or chemicals; following snow removal or sweeping; or following changes in conditions caused by rapid increases or decreases in temperature.

The depth of deposit is expressed in inches or feet or both. When the depth is above 2 in., whole values are used. When the depth is less than 2 in., fractions are used. The accepted fraction values are $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and $1\frac{1}{2}$; however, caution has to be exercised as these values could be confused with CRFI measurements. When the depth of deposit is below $\frac{1}{8}$ in., the accepted depth is reported as $\frac{1}{8}$ in.

When clearing is not underway or expected to begin within the next 30 minutes, a notation such as "Clearing expected to start at (time in UTC)" will be added to the RSC report. When the meteorological conditions cause runway surface conditions to change frequently, the RSC NOTAM will include the agency and telephone number to contact for the current runway conditions.

The full range of RSC/CRFI information will be available as a voice advisory from the control tower at controlled aerodromes and from the FSS at uncontrolled aerodromes.

Each new RSC NOTAM (AMSCR report) issued supersedes the previous report for that aerodrome. An RSC NOTAM is valid for 8 hours or 24 hours, based on the most recent observation of either the RSC or CRFI, after which time it is removed from the database. An RSC NOTAM may also be cancelled if the reporting requirements are no longer met or the RSC NOTAM was issued in error.

NOTE:

The absence of an RSC NOTAM in no way indicates that runway conditions are acceptable for operations.

The CRFI portion of the report is titled ADDN NON-GRF/TALPA INFO: and is in the following format: title (CRFI), runway number, temperature (in degrees Celsius), runway CRFI reading by full runway length or by runway thirds, and the observation time of the report using the 10-digit date-time group format in UTC (YYMMDDHHMM).

An RSC NOTAM is issued based on reporting requirements rather than on dissemination criteria. Therefore, conditions such as "dry" or "wet" will be disseminated if reported.

Information on taxiways and aprons, although not mandatory, can be disseminated in an RSC NOTAM if deemed to have an impact on safe operations.

1.6.6 Wet Runways

Runway friction values are currently not provided during the summer and when it is raining. Consequently, some discussion of wet runways is in order to assist pilots in developing handling procedures when these conditions are encountered.

A packed-snow or ice condition at a fixed temperature presents a relatively constant coefficient of friction with speed, but this is not the case for a liquid (water or slush) state. This is because water cannot be completely squeezed out from between the tire and the runway and, as a result, there is only partial tire-to-runway contact. As the aircraft speed is increased, the time in contact is reduced further, thus braking friction coefficients on wet surfaces fall as the speed increases, i.e. the conditions in effect become relatively more slippery, but will improve again as the aircraft slows down. The situation is further complicated by the susceptibility of aircraft tires to hydroplane on wet runways.

Hydroplaning is a function of the water depth, tire pressure and speed. Moreover, the minimum speed at which a non-rotating tire will begin to hydroplane is lower than the speed at which a rotating tire will begin to hydroplane because a build up of water under the non-rotating tire increases the hydroplaning effect. Pilots should therefore be aware of this since it will result in a substantial difference between the take-off and landing roll aircraft performance under the same runway conditions. The minimum speed, in knots, at which hydroplaning will commence can be calculated by multiplying the square root of the tire pressure (PSI) by 7.7 for a non-rotating tire, or by 9 for a rotating tire.

This equation gives an approximation of the minimum speed necessary to hydroplane on a smooth, wet surface with tires that are bald or have no tread. For example, the minimum hydroplaning speeds for an aircraft with tires inflated to 49 PSI are calculated as:

Non-rotating tire: $7.7 \times \sqrt{49} = 54 \text{ kt}$; or

Rotating tire: $9 \times \sqrt{49} = 63 \text{ kt}$

When hydroplaning occurs, the aircraft's tires are completely separated from the actual runway surface by a thin water film and they will continue to hydroplane until a reduction in speed permits the tires to regain contact with the runway. This speed will be considerably lower than the speed at which hydroplaning commences. Under these conditions, the tire traction drops to almost negligible values, and in some cases, the wheel will stop rotating entirely. The tires will provide no braking capability and will not contribute to the directional control of the aircraft. The resultant increase in stopping distance is impossible to predict accurately, but it has been estimated to increase as much as 700 percent. Further, it is known that a 10-kt crosswind will drift an aircraft off the side of a 200-ft wide runway in approximately 7 sec under hydroplaning conditions.

Notwithstanding the fact that friction values cannot be given for a wet runway and that hydroplaning can cause pilots serious difficulties, it has been found that, under light or moderate rain conditions, well-drained runways seldom accumulate sufficient standing water for hydroplaning to occur.

1.6.7 Canadian Runway Friction Index (CRFI) Application to Aircraft Performance

The information contained in Tables 1.3 and 1.4 has been compiled and is considered to be the best data available at this time because it is based upon extensive field test performance data of aircraft braking on winter-contaminated surfaces. The information should provide a useful guide to pilots when estimating aircraft

performance under adverse runway conditions. The onus for the production of information, guidance or advice on the operation of aircraft on a wet and/or contaminated runway rests with the aircraft manufacturer. The information published in the TC AIM does not change, create any additional, authorize changes in, or permit deviations from regulatory requirements. These Tables are intended to be used at the pilot's discretion.

Because of the many variables associated with computing accelerate-stop distances and balanced field lengths, it has not been possible to reduce the available data to the point where CRFI corrections can be provided, which would be applicable to all types of operations. Consequently, only corrections for landing distances and crosswinds are included pending further study of the take-off problem.

It should be noted that in all cases the Tables are based on corrections to aircraft flight manual (AFM) dry runway data and that the certification criteria does not allow consideration of the extra decelerating forces provided by reverse thrust or propeller reversing. On dry runways, thrust reversers provide only a small portion of the total decelerating forces when compared to wheel braking. However, as wheel braking becomes less effective, the portion of the stopping distance attributable to thrust reversing becomes greater. For this reason, if reversing is employed when a low CRFI is reported, a comparison of the actual stopping distance with that shown in Table 1.3 will make the estimates appear overly conservative. Nevertheless, there are circumstances—such as crosswind conditions, engine out situations or reverser malfunctions—that may preclude their use.

Landing distances recommended in Table 1.3 are intended to be used for aeroplanes with no discing and/or reverse thrust capability and are based on statistical variation measured during actual flight tests.

Notwithstanding the above comments on the use of discing and/or reverse thrust, Table 1.4 may be used for aeroplanes with discing and/or reverse thrust capability and is based on the landing distances recommended in Table 1.3 with additional calculations that give credit for discing and/or reverse thrust. In calculating the distances in Table 1.4, the air distance from the screen height of 50 ft to touchdown and the delay distance from touchdown to the application of full braking remain unchanged from Table 1.3. The effects of discing and/or reverse thrust were used only to reduce the stopping distance from the application of full braking to a complete stop. The recommended landing distances stated in Table 1.4 take into account the reduction in landing distances obtained with the use of discing and/or reverse thrust capability for a turboprop-powered aeroplane and with the use of reverse thrust for a turbojet-powered aeroplane. Representative low values of discing and/or reverse thrust effect have been assumed and, therefore, the data may be conservative for properly executed landings by some aeroplanes with highly effective discing and/or thrust reversing systems.

The crosswind limits for CRFI shown in Figure 1.1 contain a slightly different display range of runway friction index values from those listed in Tables 1.3 and 1.4. However, the CRFI values used for Figure 1.1 are exactly the same as those used for Tables 1.3 and 1.4 and are appropriate for the index value increments indicated.

Table 1.3—CRFI Recommended Landing Distances (No Discing/Reverse Thrust)

Reported Canadian Runway Friction Index (CRFI)														
Landing Distance (Feet) Dry	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.27	0.25	0.22	0.20	0.18	Landing Field Length (Feet) Dry	Landing Field Length (Feet) Dry
Unfactored	Recommended Landing Distances (no Discing/Reverse Thrust)												60% Factor	70% Factor
1 800	3 120	3 200	3 300	3 410	3 540	3 700	3 900	4 040	4 150	4 330	4 470	4 620	3 000	2 571
2 000	3 480	3 580	3 690	3 830	3 980	4 170	4 410	4 570	4 700	4 910	5 070	5 250	3 333	2 857
2 200	3 720	3 830	3 960	4 110	4 280	4 500	4 750	4 940	5 080	5 310	5 490	5 700	3 667	3 143
2 400	4 100	4 230	4 370	4 540	4 740	4 980	5 260	5 470	5 620	5 880	6 080	6 300	4 000	3 429
2 600	4 450	4 590	4 750	4 940	5 160	5 420	5 740	5 960	6 130	6 410	6 630	6 870	4 333	3 714
2 800	4 760	4 910	5 090	5 290	5 530	5 810	6 150	6 390	6 570	6 880	7 110	7 360	4 667	4 000
3 000	5 070	5 240	5 430	5 650	5 910	6 220	6 590	6 860	7 060	7 390	7 640	7 920	5 000	4 286
3 200	5 450	5 630	5 840	6 090	6 370	6 720	7 130	7 420	7 640	8 010	8 290	8 600	5 333	4 571
3 400	5 740	5 940	6 170	6 430	6 740	7 110	7 550	7 870	8 100	8 500	8 800	9 130	5 667	4 857
3 600	6 050	6 260	6 500	6 780	7 120	7 510	7 990	8 330	8 580	9 000	9 320	9 680	6 000	5 143
3 800	6 340	6 570	6 830	7 130	7 480	7 900	8 410	8 770	9 040	9 490	9 840	10 220	6 333	5 429
4 000	6 550	6 780	7 050	7 370	7 730	8 170	8 700	9 080	9 360	9 830	10 180	10 580	6 667	5 714

Application of the CRFI

The recommended landing distances in Table 1.3 are based on a 95 percent level of confidence. A 95 percent level of confidence means that in more than 19 landings out of 20, the stated distance in Table 1.3 will be conservative for properly executed landings with all systems serviceable on runway surfaces with the reported CRFI.

Table 1.3 will also be conservative for turbojet- and turboprop-powered aeroplanes with reverse thrust, and additionally, in the case of turboprop-powered aeroplanes, with the effect obtained from discing.

The recommended landing distances in CRFI Table 1.3 are based on standard pilot techniques for the minimum distance landings from 50 ft, including a stabilized approach at V_{Ref} using a glide slope of 3° to 50 ft or lower, a firm touchdown, minimum delay to nose lowering, minimum delay time to deployment of ground lift dump devices and application of brakes, and sustained maximum antiskid braking until stopped.

Landing field length is the landing distance divided by 0.6 (turbojets) or 0.7 (turboprops). If the aircraft flight manual (AFM) expresses landing performance in terms of landing distance, enter the Table from the left-hand column. However, if the AFM expresses landing performance in terms of landing field length, enter the Table from one of the right-hand columns, after first verifying which factor has been used in the AFM.

Table 1.4—CRFI Recommended Landing Distances (Discing/Reverse Thrust)

Reported Canadian Runway Friction Index (CRFI)														
Landing Distance (Feet) Dry	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.27	0.25	0.22	0.20	0.18	Landing Field Length (Feet) Dry	Landing Field Length (Feet) Dry
Unfactored	Recommended Landing Distances (Discing/Reverse Thrust)												60% Factor	70% Factor
1 200	2 000	2 040	2 080	2 120	2 170	2 220	2 280	2 340	2 380	2 440	2 490	2 540	2 000	1 714
1 400	2 340	2 390	2 440	2 500	2 580	2 660	2 750	2 820	2 870	2 950	3 010	3 080	2 333	2 000
1 600	2 670	2 730	2 800	2 880	2 970	3 070	3 190	3 280	3 360	3 460	3 540	3 630	2 667	2 286
1 800	3 010	3 080	3 160	3 250	3 350	3 480	3 630	3 730	3 810	3 930	4 030	4 130	3 000	2 571
2 000	3 340	3 420	3 520	3 620	3 740	3 880	4 050	4 170	4 260	4 400	4 510	4 630	3 333	2 857
2 200	3 570	3 660	3 760	3 880	4 020	4 170	4 360	4 490	4 590	4 750	4 870	5 000	3 667	3 143
2 400	3 900	4 000	4 110	4 230	4 380	4 550	4 750	4 880	4 980	5 150	5 270	5 410	4 000	3 429
2 600	4 200	4 300	4 420	4 560	4 710	4 890	5 100	5 240	5 350	5 520	5 650	5 790	4 333	3 714
2 800	4 460	4 570	4 700	4 840	5 000	5 190	5 410	5 560	5 670	5 850	5 980	6 130	4 667	4 000
3 000	4 740	4 860	5 000	5 160	5 340	5 550	5 790	5 950	6 070	6 270	6 420	6 580	5 000	4 286
3 200	5 080	5 220	5 370	5 550	5 740	5 970	6 240	6 420	6 560	6 770	6 940	7 110	5 333	4 571
3 400	5 350	5 500	5 660	5 850	6 060	6 310	6 590	6 790	6 930	7 170	7 340	7 530	5 667	4 857
3 600	5 620	5 780	5 960	6 160	6 390	6 650	6 960	7 170	7 320	7 570	7 750	7 950	6 000	5 143
3 800	5 890	6 060	6 250	6 460	6 700	6 980	7 310	7 540	7 700	7 970	8 160	8 380	6 333	5 429
4 000	6 070	6 250	6 440	6 660	6 910	7 210	7 540	7 780	7 950	8 220	8 430	8 650	6 667	5 714

Application of the CRFI

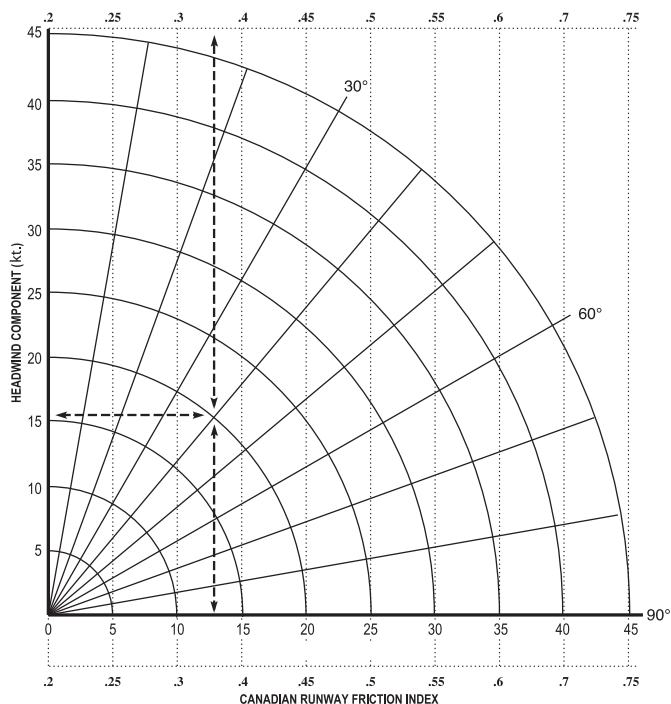
The recommended landing distances in Table 1.4 are based on a 95 percent level of confidence. A 95 percent level of confidence means that in more than 19 landings out of 20, the stated distance in Table 1.4 will be conservative for properly executed landings with all systems serviceable on runway surfaces with the reported CRFI.

The recommended landing distances in Table 1.4 take into account the reduction in landing distances obtained with the use of discing and/or reverse thrust capability for a turboprop-powered aeroplane and with the use of reverse thrust for a turbojet-powered aeroplane. Table 1.4 is based on the landing distances recommended in Table 1.3 with additional calculations that give credit for discing and/or reverse thrust. Representative low values of discing and/or reverse thrust effect have been assumed, hence the data will be conservative for properly executed landings by some aeroplanes with highly effective discing and/or thrust reversing systems.

The recommended landing distances in CRFI Table 1.4 are based on standard pilot techniques for the minimum distance landings from 50 ft, including a stabilized approach at V_{Ref} using a glide slope of 3° to 50 ft or lower, a firm touchdown, minimum delay to nose lowering, minimum delay time to deployment of ground lift dump devices and application of brakes and discing and/or reverse thrust, and sustained maximum antiskid braking until stopped. In Table 1.4, the air distance from the screen height of 50 ft to touchdown and the delay distance from touchdown to the application of full braking remain unchanged from Table 1.3. The effects of discing/reverse thrust were used only to reduce the stopping distance from the application of full braking to a complete stop.

Landing field length is the landing distance divided by 0.6 (turbojets) or 0.7 (turboprops). If the AFM expresses landing performance in terms of landing distance, enter the Table from the left-hand column. However, if the AFM expresses landing performance in terms of landing field length, enter the Table from one of the right-hand columns, after first verifying which factor has been used in the AFM.

Figure 1.1—Crosswind Limits for CRFI



This chart provides information for calculating headwind and crosswind components. The vertical lines indicate the recommended maximum crosswind component for reported CRFI.

Example:

CYOW CRFI 07/25 -4C .30 1201191200

Tower Wind 110° 20 kt.

The wind is 40° off the runway heading and produces a headwind component of 15 kt and a crosswind component of 13 kt. The recommended minimum CRFI for a 13-kt crosswind component is .35. A takeoff or landing with a CRFI of .3 could result in uncontrollable drifting and yawing.

The CRFI depends on the surface type, as shown in Table 1.5(a) a. It should be noted that:

- (a) the CRFI values given in Table 1.5(a) are applicable to all temperatures. Extensive measurements have shown that there is no correlation between the CRFI and the surface temperature. The case where the surface temperature is just at the melting point (i.e. about 0°C) may be an exception, as a water film may form from surface melting, which could induce slippery conditions with CRFIs less than those in Table 1.5(a).
- (b) the CRFI may span a range of values for various reasons, such as variations in texture among surfaces within a given surface class. The expected maximum and minimum CRFIs for various surfaces are listed in Table 1.5(b). Note that these values are based on a combination of analyses of extensive measurements and sound engineering judgment.
- (c) the largest range in CRFI is to be expected for a thin layer (3 mm or less in thickness) of dry snow on pavement (Table 1.5(a)). This variation may occur due to:
 - (i) non-uniform snow coverage; and/or
 - (ii) the tires breaking through the thin layer.

In either case, the surface presented to the aircraft may range from snow to pavement.

Table 1.5(a)—Expected Range of CRFI by Surface Type

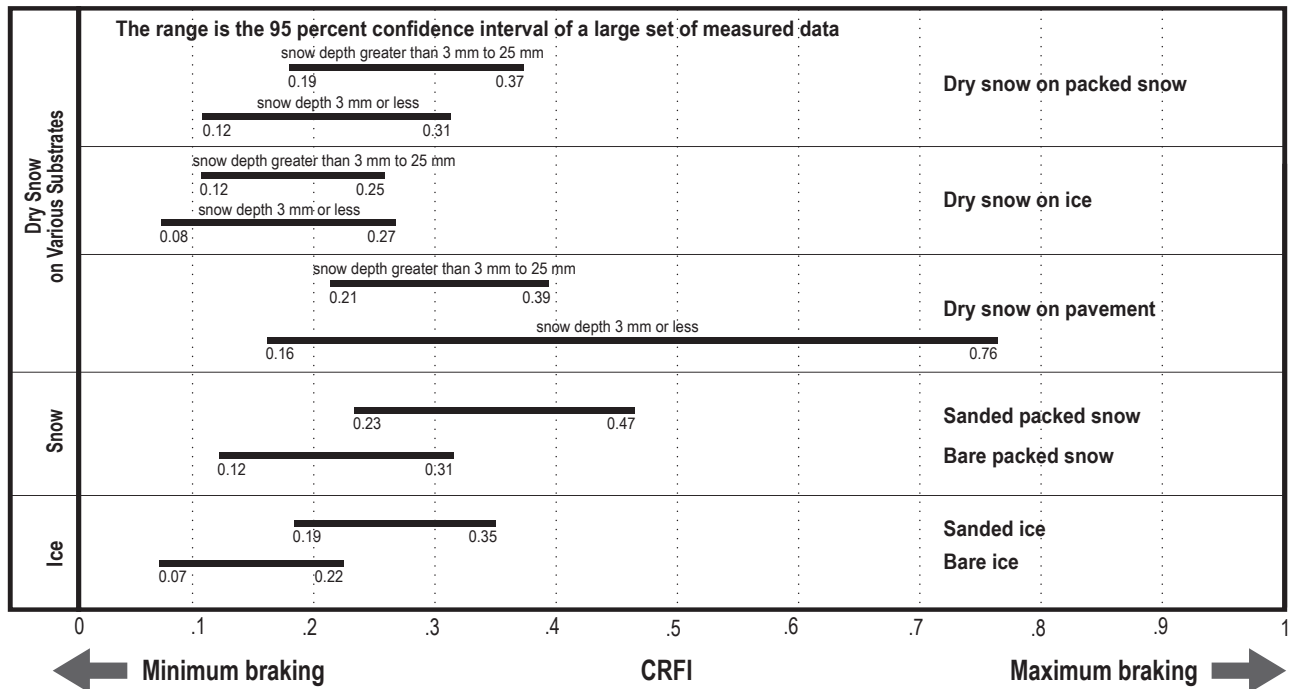


Table 1.5(b)—Minimum and Maximum CRFI for Various Surfaces

SURFACE	LOWER CRFI LIMIT	UPPER CRFI LIMIT
Bare Ice	No Limit	0.3
Bare Packed Snow	0.1	0.4
Sanded Ice	0.1	0.4
Sanded Packed Snow	0.1	0.5
Dry Snow on Ice (depth 3 mm or less)	No Limit	0.4
Dry Snow on Ice (depth 3 to 25 mm)	No Limit	0.4
Dry Snow on Packed Snow (depth 3 mm or less)	0.1	0.4
Dry Snow on Packed Snow (depth 3 to 25 mm)	0.1	0.4
Dry Snow on Pavement (depth 3 mm or less)	0.1	Dry Pavement
Dry Snow on Pavement (depth 3 mm to 25 mm)	0.1	Dry Pavement

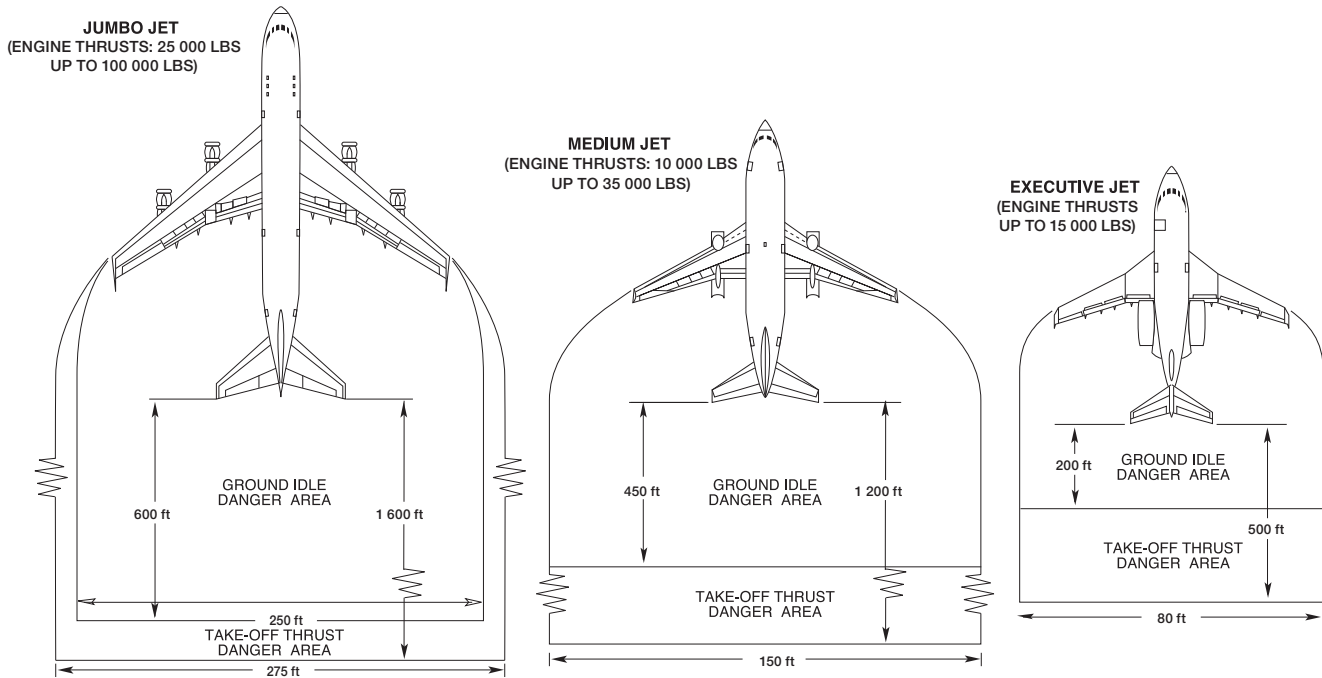
1.7 JET AND PROPELLER BLAST DANGER

Jet aircraft are classified into three categories according to engine size. The danger areas are similar to those shown in Figure 1.1 and are used by ground control personnel and pilots. The danger areas have been determined for ground idle and take-off thrust settings associated with each category.

As newer aircraft are designed to handle more weight, larger engines are being used. Executive jets may have thrusts of up to 15 000 lb; medium jets may have thrusts of up to 35 000 lb; and some jumbo jets now have thrusts in excess of 100 000 lb. Therefore, caution should be used when interpreting the danger areas for ground idle and take-off thrust settings, as some of the distances

shown in Figure 1.1 may need to be increased significantly. Pilots should exercise caution when operating near active runways and taxiways. With the use of intersecting runways, there is an increased possibility of jet blast or propeller wash affecting other aircraft at the aerodrome. This can occur while both aircraft are on the ground or about to take off or land. Pilots taxiing in close proximity to active runways should be careful when their jet blast or propeller wash is directed towards an active runway. Pilots operating behind a large aircraft, whether on the ground or in the take-off or landing phase, should be aware of the possibility of encountering localized high wind velocities.

Figure 1.2—Jet Blast Danger Areas (Not To Scale)



No information is available for supersonic transport aircraft or for military jet aircraft. Many of these aircraft are pure-jet aircraft with high exhaust velocities for their size, and may or may not use afterburner during the take-off phase. Thus, great caution should be used when operating near these aircraft.

Lastly, it should be noted that light aircraft with high wings and narrow-track undercarriages are more susceptible to jet blast and propeller wash related hazards than heavier aircraft with low wings and wide-track undercarriages.

The following is a Table showing the expected speed of the blast created by large turbo-prop aeroplanes:

Table 1.6—Expected Large Turbo-Prop Blast Speed

DISTANCE BEHIND PROPELLERS	LEAVING PARKED AREA	TAXIING	TAKING OFF
ft	kt	kt	kt
60	59	45	—
80	47	36	60–70
100	47	36	50–60
120	36	28	40–50
140	36	28	35–45
180	—	—	20–30


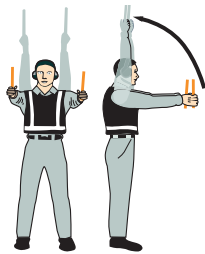



1.8 MARSHALLING SIGNALS

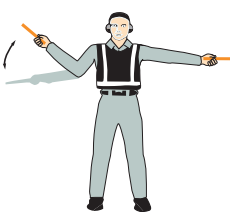
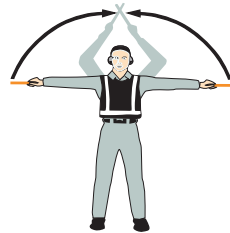




Marshalling signals for the guidance of aircraft on the ground are set out in section 5 of ICAO Annex 2. These signals should be used in order to standardize signalling between ground and flight personnel when required for aircraft entering, departing or manoeuvring within the movement area of an aerodrome.



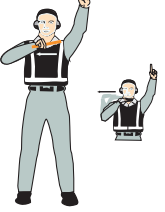
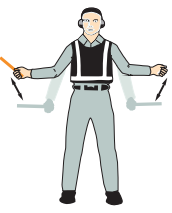
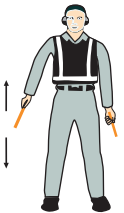

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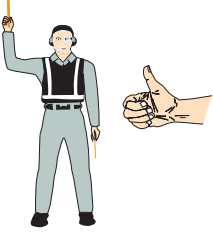
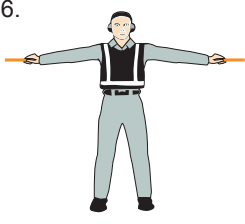
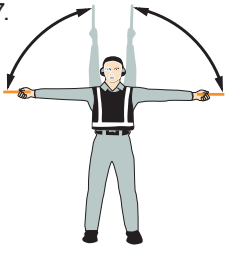
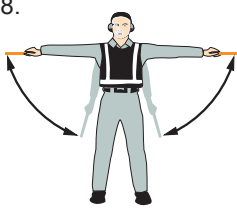
- Marshalling signals are designed for use by the marshaller, with hands illuminated as necessary to facilitate observation by the pilot, and facing the aircraft in a position:
 - for fixed-wing aircraft, on the left side of the aircraft, where best seen by the pilot; and
 - for helicopters, where the marshaller can best be seen by the pilot.
- The aircraft engines are numbered from left to right, with the No. 1 engine being the left outer engine. That is right to left for a marshaller facing the aircraft.
- Signals marked with an asterisk (*) are designed for use with hovering helicopters.

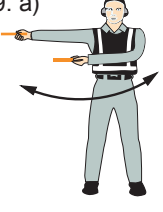
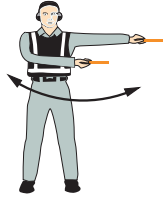

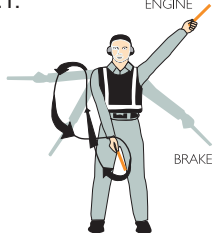



Marshalling Signals Diagram

Signal	Description
<p>1.</p> 	<p>Wingwalker/guide Raise right hand above head level with wand pointing up; move left-hand wand pointing down toward body. NOTE: This signal provides an indication by a person positioned at the aircraft wing tip, to the pilot/ marshaller/ push-back operator, that the aircraft movement on/off a parking position would be unobstructed.</p>
<p>2.</p> 	<p>Identify gate Raise fully extended arms straight above head with wands pointing up.</p>
<p>3.</p> 	<p>Proceed to next marshaller as directed by tower/ground control Point both arms upward; move and extend arms outward to sides of body and point with wands to direction of next marshaller or taxi area.</p>
<p>4.</p> 	<p>Straight ahead Bend extended arms at elbows and move wands up and down from chest height to head.</p>
<p>5. a)</p> 	<p>Turn left (from pilot's point of view) With right arm and wand extended at a 90-degree angle to body, make "come ahead" signal with left hand. The rate of signal motion indicates to pilot the rate of aircraft turn.</p>

Signal	Description
<p>5. b)</p> 	<p>Turn right (from pilot's point of view) With left arm and wand extended at a 90-degree angle to body, make "come ahead" signal with right hand. The rate of signal motion indicates to pilot the rate of aircraft turn.</p>
<p>6. a)</p> 	<p>Normal stop Fully extend arms and wands at a 90-degree angle to sides and slowly move to above head until wands cross.</p>
<p>6. b)</p> 	<p>Emergency stop Abruptly extend arms and wands to top of head, crossing wands.</p>
<p>7. a)</p> 	<p>Set brakes Raise hand just above shoulder height with open palm. Ensuring eye contact with flight crew, close hand into a fist. Do not move until receipt of "thumbs up" acknowledgement from flight crew.</p>
<p>7. b)</p> 	<p>Release brakes Raise hand just above shoulder height with hand closed in a fist. Ensuring eye contact with flight crew, open palm. Do not move until receipt of "thumbs up" acknowledgement from flight crew.</p>
<p>8. a)</p> 	<p>Chocks inserted With arms and wands fully extended above head, move wands inward in a "jabbing" motion until wands touch. Ensure acknowledgement is received from flight crew.</p>

Signal	Description
8. b) 	Chocks removed With arms and wands fully extended above head, move wands outward in a "jabbing" motion. Do not remove chocks until authorized by flight crew.
9. 	Start engine(s) Raise right arm to head level with wand pointing up and start a circular motion with hand; at the same time, with left arm raised above head level, point to engine to be started.
10. 	Cut engines Extend arm with wand forward of body at shoulder level; move hand and wand to top of left shoulder and draw wand to top of right shoulder in a slicing motion across throat.
11. 	Slow down Move extended arms downwards in a "patting" gesture, moving wands up and down from waist to knees.
12. 	Slow down engine(s) on indicated side With arms down and wands toward ground, wave either right or left wand up and down indicating engine(s) on left or right side respectively should be slowed down.
13. 	Move back With arms in front of body at waist height, rotate arms in a forward motion. To stop rearward movement, use signal 6.a) or 6.b).

Signal	Description
14. a) 	Turns while backing (for tail to starboard) Point left arm with wand down and bring right arm from overhead vertical position to horizontal forward position, repeating right-arm movement.
14. b) 	Turns while backing (for tail to port) Point right arm with wand down and bring left arm from overhead vertical position to horizontal forward position, repeating left-arm movement.
15. 	Affirmative/all clear Raise right arm to head level with wand pointing up or display hand with "thumbs up"; left arm remains at side by knee. <i>NOTE: This signal is also used as a technical/servicing communication signal.</i>
*16. 	Hover Fully extend arms and wands at a 90-degree angle to sides.
*17. 	Move upwards Fully extend arms and wands at a 90-degree angle to sides and, with palms turned up, move hands upwards. Speed of movement indicates rate of ascent.
*18. 	Move downwards Fully extend arms and wands at a 90-degree angle to sides and, with palms turned down, move hands down-wards. Speed of movement indicates rate of descent.

Signal	Description
*19. a) 	Move horizontally left (from pilot's point of view) Extend arm horizontally at a 90-degree angle to right side of body. Move other arm in same direction in a sweeping motion.
*19. b) 	Move horizontally right (from pilot's point of view) Extend arm horizontally at a 90-degree angle to left side of body. Move other arm in same direction in a sweeping motion.
*20. 	Land Cross arms with wands downwards and in front of body.
21. 	Fire Move right-hand wand in a "fanning" motion from shoulder to knee, while at the same time pointing with left-hand wand to area of fire.
22. 	Hold position/stand by Fully extend arms and wands downwards at a 45-degree angle to sides. Hold position until aircraft is clear for next manoeuvre.
23. 	Dispatch aircraft Perform a standard salute with right hand and/or wand to dispatch the aircraft. Maintain eye contact with flight crew until aircraft has begun to taxi.
24. 	Do not touch controls (technical/servicing communication signal) Extend right arm fully above head and close fist or hold wand in horizontal position; left arm remains at side by knee.

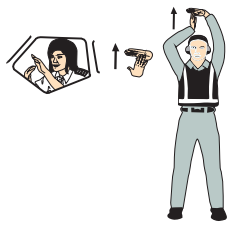

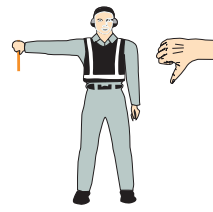


Signal	Description
25. 	Connect ground power (technical/servicing communication signal) Hold arms fully extended above head; open left hand horizontally and move finger tips of right hand into and touch open palm of left hand (forming a "T"). At night, illuminated wands can also be used to form the "T" above head.
26. 	Disconnect power (technical/servicing communication signal) Hold arms fully extended above head with finger tips of right hand touching open horizontal palm of left hand (forming a "T"); then move right hand away from the left. Do not disconnect power until authorized by flight crew. At night, illuminated wands can also be used to form the "T" above head.
27. 	Negative (technical/servicing communication signal) Hold right arm straight out at 90 degrees from shoulder and point wand down to ground or display hand with "thumbs down"; left hand remains at side by knee.
28. 	Establish communication via interphone (technical/servicing communication signal) Extend both arms at 90 degrees from body and move hands to cup both ears.
29. 	Open/close stairs (technical/servicing communication signal) With right arm at side and left arm raised above head at a 45-degree angle, move right arm in a sweeping motion towards top of left shoulder. NOTE: This signal is intended mainly for aircraft with the set of integral stairs at the front.

Table 1.7—Aircraft Pilot Marshalling Signals to a Marshaller

Meaning of Signal	Description of Signal
Brakes engaged	Raise arm and hand, with fingers extended, horizontally in front of face, then clench fist.
Brakes released	Raise arm, with fist clenched, horizontally in front of face, then extend fingers.
Insert chocks	Arms extended, palms outwards, move hands inwards to cross in front of face.
Remove chocks	Hands crossed in front of face, palms outwards, move arms outwards.
Ready to start the engine(s)	Raise the appropriate number of fingers on one hand indicating the number of the engine to be started.

2.0 FLIGHT OPERATIONS

2.1 GENERAL

This section provides airmanship information on various flight operations subjects.

2.2 CROSSWIND LANDING LIMITATIONS

Approximately 10% of all aircraft accidents involving light aircraft in Canada are attributed to pilot failure to compensate for crosswind conditions on landing.

Light aircraft manufactured in the United States are designed to withstand, on landing, 90° crosswinds up to a velocity equal to 0.2 (20%) of their stalling speed.

This information in conjunction with the known stalling speed of a particular aircraft makes it possible to use the following crosswind component graph to derive a “general rule” for most light aircraft manufactured in the United States. The aircraft owner’s manual may give higher or limiting crosswinds. Examples follow.

Figure 2.1—Crosswind Landing Limitations

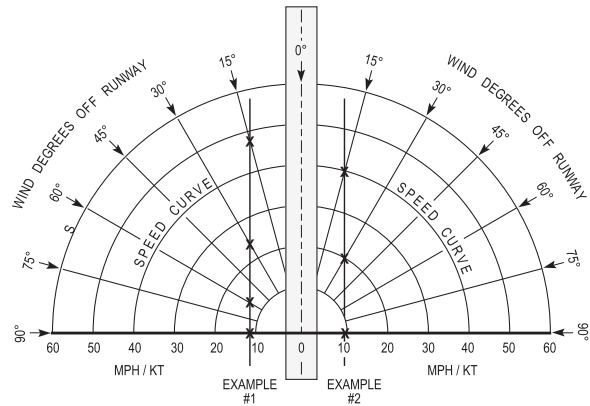


Table 2.1—Example of an Aircraft With a Stalling Speed of 60 MPH

WIND-DEGREE	PERMISSIBLE WIND SPEEDS
90°	(0.2 x 60 MPH stalling speed) 12 MPH
60°	using crosswind component graph 14 MPH
30°	using crosswind component graph 24 MPH
15°	using crosswind component graph 48 MPH

Table 2.2—Example of an Aircraft With a Stalling Speed of 50 KIAS

WIND-DEGREE	PERMISSIBLE WIND SPEEDS
90°	(0.2 x 50 kt stalling speed) 10 kt
60°	using crosswind component graph 12 kt
30°	using crosswind component graph 20 kt
15°	using crosswind component graph 40 kt

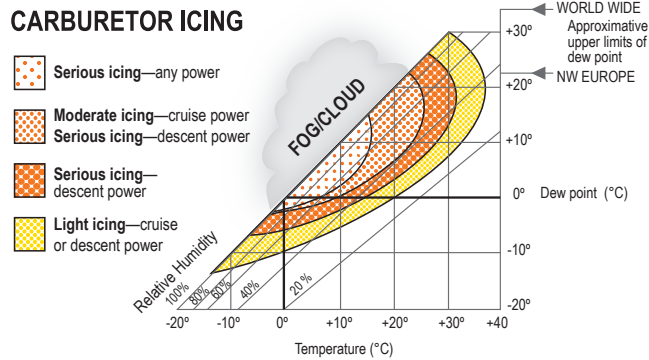
2.3 CARBURETOR ICING

Carburetor icing is a common cause of general aviation accidents. Fuel injected engines have very few induction system icing accidents, but otherwise no aeroplane and engine combination stands out. Most carburetor icing related engine failure happens during normal cruise. Possibly, this is a result of decreased pilot awareness that carburetor icing will occur at high power settings as well as during descents with reduced power.

In most accidents involving carburetor icing, the pilot has not fully understood the carburetor heat system of the aircraft and what occurs when it is selected. Moreover, it is difficult to understand the countermeasures unless the process of ice formation in the carburetor is understood. Detailed descriptions of this process are available in most good aviation reference publications and any AME employed on type can readily explain the carburetor heat system. The latter is especially important because of differences in systems. The pilot must learn to accept a rough-running engine for a minute or so as the heat melts and loosens the ice which is then ingested into the engine.

Figure 2.2—Carburetor Icing

The following chart provides the range of temperature and relative humidity which could induce carburetor icing.



NOTE:

This chart is not valid when operating on MOGAS. Due to its higher volatility, MOGAS is more susceptible to the formation of carburetor icing. In severe cases, ice may form at OATs up to 20°C higher than with AVGAS.

2.4 LOW FLYING

Warning—Intentional low flying is hazardous. Transport Canada advises pilots that low flying, especially for weather avoidance, is a high-risk activity.

Before conducting any low flying, the pilot should be clear about the purpose and legality of the exercise. Accordingly, all preparations in terms of assessment of the terrain to be overflown, obstacles along the flight path, weather conditions, aircraft performance, and selection of appropriate charts are important for safe completion of the flight.

Normally, 300 ft AGL high objects or more (or lower ones if deemed hazardous) are depicted on visual navigational charts. However, because there is only limited knowledge over the erection of man-made objects, there can be no guarantee that all such structures are known. Also, an object which is known may not yet be included for the amendment cycle of the chart. Thus, an additional risk is added to the already hazardous practice of low flying.

Furthermore, even though structures assessed as potential hazards to air navigation are required to be marked, including special high-intensity strobe lighting for all structures 500 ft AGL and higher, the majority of aircraft collisions with man-made structures occur at levels below 300 ft AGL (see AGA 6.0).

Low flying can imply a constrained situation in which it may be difficult to take the normal evasive action to widely avoid an obstacle. In such an instance, guy wires that can be up to 45° from a tower become of importance. There have been incidents in which the tower itself was avoided, but a guy wire was struck by the aircraft.

2.4.1 Birds and Sensitive Fauna

Birds usually fly relatively low, and most birds fly below 500 ft. However, during migration, birds may climb to higher altitudes and can often be seen around 2 500 to 3 000 ft, although some may even climb up to 20 000 ft. While takeoff and landing are considered to have the highest rate of wildlife strikes and damage, en route aircraft have also reported damage from hitting birds. The speed at which the aircraft is travelling affects the amount of damage that the bird may cause, and it is recommended that aircraft do not travel at low altitudes when possible to decrease this potential risk.

Conversely, low flying can also pose a danger to wildlife and farm animals. Refer to *AIP Canada ENR* paragraphs 5.6.5 and 5.6.6.

2.4.2 Remotely Piloted Aircraft (RPA)

Pilots need to be aware that RPA present a new hazard at low altitudes. RPA are difficult to see at distances necessary to avoid collision with other aircraft because they are relatively small and for the most part present low contrast against the available background. Several collisions with other aircraft have occurred despite the requirement for RPA pilots to give way to traditional aircraft that are typically travelling at a much higher speed.

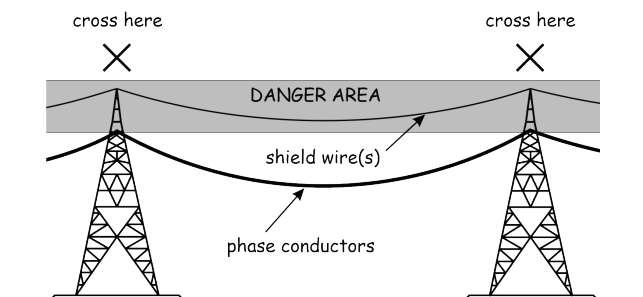
Because it is low flying, the RPA is exposed to the same hazards identified herein and increasingly so with the introduction of beyond visual line-of-sight (BVLOS) operations such as power transmission line inspection and pipeline inspection. But RPA have additional hazards in the form of objects (e.g. buildings) that can result in loss of visual contact or disruption of the radio link. Refer to RPA 3.2.11.2.

2.4.3 Flying Near High-Voltage Power Lines

Wire-strikes account for a significant number of low flying accidents. A number of these accidents occur over level terrain, in good weather, and at very low altitudes.

The line of structures of high voltage powerlines are easy to see, but when flying in their vicinity, pilots must take the time to look for what is really there and use safe procedures. The human eye has limitations, so if the background landscape does not provide sufficient contrast, pilots will not see a wire or cable. Although hydro structures are big and generally quite visible, a hidden danger exists in the wires between them.

Figure 2.3—Flying Near Powerlines



AIR

The figure shown above emphasizes this point. The bundle of current-carrying phase conductors is made up of several heavy wires. These heavy, sagging phase conductors are about 2 in. in diameter and are relatively visible, so they tend to distract pilots from seeing the upper shield or lightning protection wires, which are of much smaller diameter and may not be visible.

The shield wires do not sag the way the phase conductors do and are difficult to pick out even in good visibility. The only way to be safe is to avoid the span portion of the line and **always cross at a tower**, maintaining a safe altitude and as much clearance as possible.

- (a) When following power lines, remain on the right-hand side relative to the direction of the flight and watch for other crossing powerlines and guy cables. Note that sometimes only one side of the powerline is available to fly along safely (due to trees, obstacles, rising terrain, etc.).
- (b) Expect radio and electrical interference in the vicinity of powerlines.
- (c) For operational low flying, do an overflight and map check first.
- (d) Leave yourself an “out”—cross at 45° to the line.
- (e) Reduce speed in lower visibilities.

2.4.4 Transmission Line Catenaries

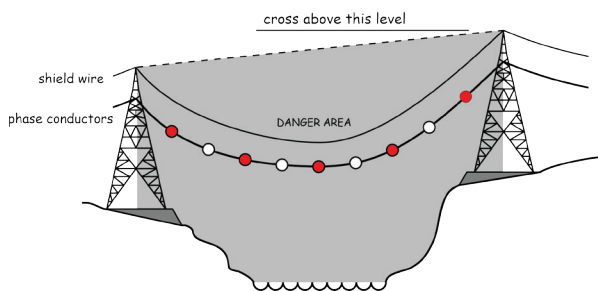
Transmission line catenaries pose a particular risk to low flying aircraft.

In contrast to distribution powerlines, which are usually of low voltage and tend to follow a roadway, transmission powerlines are typically high voltage (more than 69 kV) and extend across the countryside from a generating source to a distant load centre. In the process, they cross over major roadways, rivers, valleys, or straits for which the wires may or may not be marked depending on height and local air traffic conditions. Pilots operating at low altitudes must make themselves aware of these crossings and exercise extreme caution.

Where markers are provided, they are usually placed on the highest line, which is the shield wire for lightning protection. However, because of design issues, the markers may be located on the lower phase conductors. The purpose of the markers is not to indicate the height of the catenary, but rather the presence of an obstacle, as shown in Figure 2.4 below.

As in the case of flying near powerlines (2.4.1), the pilot should always fly **above the height of the support structures**.

Figure 2.4—Flying Over Catenaries

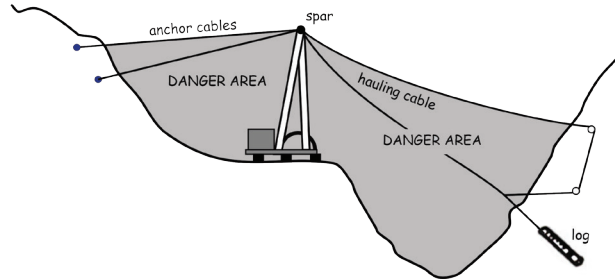


2.4.5 Logging Operations

Extensive use is made in logging operations of equipment potentially hazardous to aircraft operations. These include highlead spars, grapple yarders and skyline cranes.

When highlead spars or grapple yarders are used, hauling and guyline cables radiate from the top of the spar or boom. Cables may cross small valleys or be anchored on side hills behind the spar. While spars generally do not exceed 130 ft AGL and are conspicuously painted, the cable system may be difficult to see. This type of equipment operates from a series of logging roads.

Figure 2.5—Highlead Spar



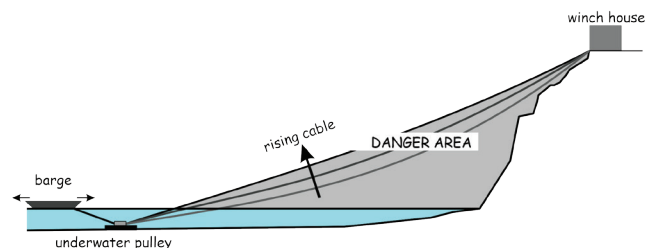
By contrast, skyline cranes consist of a single skyline cable anchored at the top and bottom of a long slope and supported by one or several intermediate poles. This cable generally follows the slope contour about 100 ft AGL but may also cross draws and gullies and may be at heights in excess of 100 ft AGL. Skyline cables are virtually invisible from the air. Their presence is indicated by active or recently completed logging and the absence of a defined series of logging roads, although a few roads may be present.

Pilots operating in areas where logging is prevalent must be aware when operating below 300 ft AGL that these types of equipment exist and do not always carry standard obstacle paint markings.

2.4.6 Hydrokinetic Energy System

A situation similar to logging occurs for a hydrokinetic energy system for which energy is produced by a barge carried by incoming and outgoing tides. The cable runs through an underwater pulley base to a winch house located on the side of the estuary. As the barge is pulled with the tide, the cable is placed in tension and is exposed away from a cliff side, as shown in Figure 2.6. Only the winch house may be marked. Pilots should take care when flying in areas that may have such energy systems installed.

Figure 2.6—Hydrokinetic Energy System



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2.4.7 Wind Farms with a Dimming System

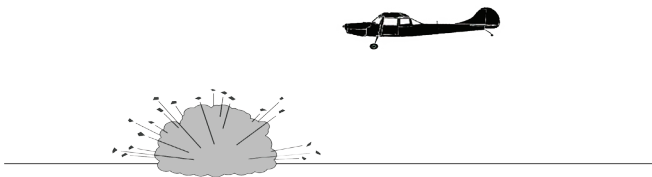
Some wind farms may have a dimming system that changes the intensity of the wind-turbine lighting according to measured visibility. This is for the purpose of addressing residential complaints about the glare received from beacon lights on the nacelle. As visibility improves, lighting intensity is reduced. The wind farm has numerous visibility sensors installed on selected wind turbines so that the intensity reduction is not dependent upon a single sensor. The determined intensity is that associated with the worst reported visibility amongst the community of visibility sensors.

Pilots should note that there can be a rare situation when the weather condition they are flying in has not yet reached a sensor on the wind farm. In short, the windfarm might be sensing, at its location, a higher visibility than that of the pilot. In such a situation, the reduced intensity of lights at the wind farm should still be sufficient to provide adequate acquisition distance for avoidance when flying at the night minimum of 3 statute miles (SM). However, choosing to fly at significantly below minimum visibility can result in inadequate acquisition distance being available. Therefore, pilots should avoid flying in reduced visibility in areas that may have a wind farm.

2.4.8 Blasting Operations

Blasting operations such as those associated with the logging industry, mining, and construction are also a concern when it comes to low flying. The trajectory of debris from blasting varies with the type of explosive, the material being excavated, and any tree canopies, if any. These blasting activities may not be advertised by a NOTAM.

Figure 2.7—Blasting Operations



2.5 FLIGHT OPERATIONS IN RAIN

An error in vision can occur when flying in rain. The presence of rain on the windscreen, in addition to causing poor visibility, introduces a refraction error. This error is because of two things: firstly, the reduced transparency of the rain-covered windscreen causes the eye to see a horizon below the true one (because of the eye response to the relative brightness of the upper bright part and the lower dark part); and secondly, the shape and pattern of the ripples formed on the windscreen, particularly on sloping ones, which cause objects to appear lower. The error may be present as a result of one or other of the two causes, or of both, in which case it is cumulative and is of the order of about 5° in angle. Therefore, a hilltop or peak 1/2 NM ahead of an aircraft could appear to be approximately 260 ft lower, (230 ft lower at 1/2 SM) than it actually is.

Pilots should remember this additional hazard when flying in conditions of low visibility in rain and should maintain sufficient altitude and take other precautions, as necessary, to allow for the presence of this error. Also, pilots should ensure proper terrain clearance during en route flight and on final approach to landing.

2.6 FLIGHT OPERATIONS IN VOLCANIC ASH

Flight operations in volcanic ash are hazardous. Experience has shown that damage can occur to aircraft surfaces, windshields and powerplants. Aircraft heat and vent systems, as well as hydraulic and electronic systems, can also be contaminated. Powerplant failures are a common result of flight in volcanic ash, with turbine engines being particularly susceptible. Simultaneous power loss in all engines has occurred. In addition, volcanic ash is normally very heavy; accumulations of it within the wings and tail section have been encountered, with adverse effects on aircraft weight and balance.

Aviation ATS surveillance is not effective in detecting volcanic ash clouds. There is no reliable information regarding volcanic ash concentrations which might be minimally acceptable for flight. Recent data suggests that “old” volcanic ash still represents a considerable hazard to safety of flight. Pilots are cautioned that ash from volcanic eruptions can rapidly reach heights in excess of FL 600 and be blown downwind of the source for considerable distances. Encounters affecting aircraft performance have occurred 2 400 NM from the ash source and up to 72 hours after an eruption.

Therefore: if an ash cloud is visible to a pilot, entry into the cloud must be avoided.

The risk of entering ash in IMC or night conditions is particularly dangerous, owing to the absence of a clear visual warning.

Therefore: if PIREPs, SIGMETs (see MET 6.0), NOTAM (see MAP 3.0), and analysis of satellite imagery and/or ash cloud trajectory forecasts indicate that ash might be present within a given airspace, that airspace must be avoided until it can be determined to be safe for entry.

St. Elmo’s fire is usually a telltale sign of a night encounter, although rapid onset of engine problems may be the first indication. Pilots should exit the cloud expeditiously while following any engine handling instructions provided in the aircraft flight manuals for such circumstances.

Pilots should be aware that they may be the first line of volcanic eruptions detection in more remote areas. In the initial phase of any eruption there may be little or no information available to advise pilots of the new ash hazard. If an eruption or ash cloud is observed, an urgent PIREP (see MET 2.5 and 2.1.1) should be filed with the nearest ATS unit.

2.7 FLIGHT OPERATION NEAR THUNDERSTORMS

2.7.1 General

Thunderstorms are capable of containing nearly all weather hazards known to aviation. These include tornadoes, turbulence, squall line, microburst, heavy updrafts and downdrafts, icing, hail, lightning, precipitation static, heavy precipitation, low ceiling and visibility.

There is no useful correlation between the external visual appearance of a thunderstorm and the severity or amount of turbulence or hail within it. The visible thunderstorm cloud is only a portion of a turbulent system of updrafts and downdrafts that often extend far beyond. Severe turbulence may extend up to 20 NM from severe thunderstorms.

Airborne or ground based weather radar will normally reflect areas of precipitation. The frequency and severity of turbulence associated with the areas of high water content generally increases the radar return. No flight path, through an area of strong or very strong radar echoes separated by 40 NM or less, can be considered free of severe turbulence.

Turbulence beneath a thunderstorm should not be underestimated. This is especially true when the relative humidity is low. There may be nothing to see until you enter strong out-flowing winds and severe turbulence.

The probability of lightning strikes occurring to aircraft is greatest when operating at altitudes where temperatures are between -5°C and 5°C. Lightning can strike aircraft flying in clear air in the vicinity of a thunderstorm. Lightning can puncture the skin of an aircraft, damage electronic equipment, cause engine failure and induce permanent error in magnetic compasses.

Engine Water Ingestion

If the updraft velocity in the thunderstorm approaches or exceeds the terminal falling velocity of the falling raindrops, very high concentrations of water may occur. It is possible that these concentrations may exceed the quantity of water that a turbine engine is capable of ingesting. Therefore, severe thunderstorms may contain areas of high water concentration which could result in a flameout or structural failure of one or more engines. Note that lightning can also cause compressor stalls or flameouts.

PIREP

Remember, a timely PIREP will allow you and others to make the right decision earlier.

2.7.2 Considerations

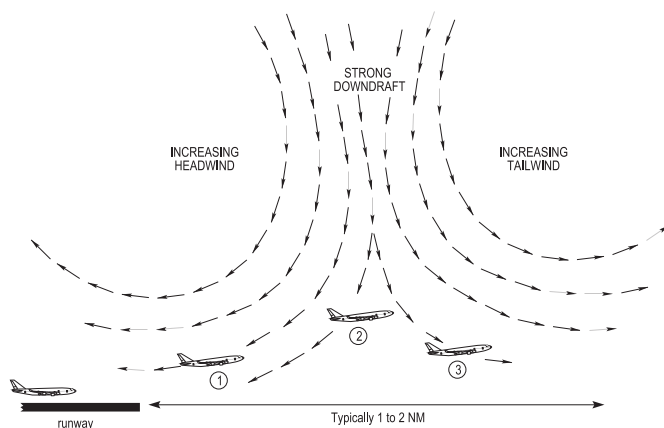
- (a) Above all, never think of a thunderstorm as “light” even though the radar shows echoes of light intensity. Avoiding thunderstorms is the best policy. Remember that vivid and frequent lightning indicates a severe activity in the thunderstorm and that any thunderstorm with tops 35 000 ft or higher is severe. Whenever possible:
 - (i) don’t land or take off when a thunderstorm is approaching. The sudden wind shift of the gust front or low-level turbulence could result in loss of control;
 - (ii) don’t attempt to fly under a thunderstorm even when you can see through to the other side. Turbulence under the storm could be disastrous;
 - (iii) avoid any area where thunderstorms are covering 5/8 or more of that area;
 - (iv) don’t fly into a cloud mass containing embedded thunderstorms without airborne radar;
 - (v) avoid by at least 20 NM any thunderstorm identified as severe or giving intense radar returns. This includes the anvil of a large cumulonimbus; and
 - (vi) clear the top of a known or suspected severe thunderstorm by at least 1 000 ft altitude for each 10 kt of wind speed at the cloud top.
- (b) If you cannot avoid an area of thunderstorms, consider these points:
 - (i) Tighten your seat belt and shoulder harness; secure all loose objects.
 - (ii) Plan a course that will take you through the storm area in a minimum time and hold it.
 - (iii) Avoid the most critical icing areas, by penetrating at an altitude below the freezing level or above the level of -15°C.
 - (iv) Check that pitot, carburetor or jet inlet heat are on. Icing can be rapid and may result in almost instantaneous power failure or airspeed indication loss.
 - (v) Set the power settings for turbulence penetration airspeed recommended in your aircraft manual.
 - (vi) Turn up cockpit lights to its highest intensity to minimize temporary blindness from lightning.
 - (vii) When using the auto-pilot, disengage the altitude hold mode and the speed hold mode. The automatic altitude and speed controls will increase manoeuvres of the aircraft, thus increasing structural stresses.
 - (viii) Tilt the airborne radar antenna up and down occasionally. This may detect hail or a growing thunderstorm cell.
- (c) If you enter a thunderstorm:
 - (i) Concentrate on your instruments; looking outside increases the danger of temporary blindness from lightning.

- (ii) Don't change power settings; maintain the settings for turbulence penetration airspeed.
- (iii) Don't attempt to keep a constant rigid altitude; let the aircraft "ride the waves". Manoeuvres in trying to maintain constant altitude increases stress on the aircraft. If altitude cannot be maintained, inform ATC as soon as possible.
- (iv) Don't turn back once you have entered a thunderstorm. Maintaining heading through the storm will get you out of the storm faster than a turn. In addition, turning manoeuvres increases stress on the aircraft

2.8 LOW-LEVEL WIND SHEAR (WS)

Relatively recent meteorological studies have confirmed the existence of the "burst" phenomena. These are small-scale, intense downdrafts which, on reaching the surface, spread outward from the downflow centre. This causes the presence of both vertical and horizontal wind shear (WS) that can be extremely hazardous to all types and categories of aircraft.

Figure 2.8—Low-Level Wind Shear



Wind shear may create a severe hazard for aircraft within 1 000 ft AGL, particularly during the approach to landing and in the takeoff phases. On takeoff, this aircraft may encounter a headwind (performance increasing) (1) followed by a downdraft (2), and tailwind (3) (both performance decreasing).

Pilots should heed wind shear pilot weather reports (PIREPs) as a previous pilot's encounter with a wind shear may be the only warning. Alternate actions should be considered when a wind shear has been reported.

Characteristics of microbursts include:

- (a) **Size** - Approximately 1 NM in diameter at 2 000 ft AGL with a horizontal extent at the surface of approximately 2 to 2 1/2 NM.
- (b) **Intensity** - Vertical winds as high as 6 000 ft/min. Horizontal winds giving as much as 45 kt at the surface (i.e. 90 kt shear).
- (c) **Types** - microbursts are normally accompanied by heavy rain in areas where the air is very humid. However, in drier areas, falling raindrops may have sufficient time and distance to evaporate before reaching the ground. This is known as VIRGA.
- (d) **Duration** - The life-cycle of a microburst from the initial downburst to dissipation will seldom be longer than 15 minutes with maximum intensity winds lasting approximately 2 - 4 minutes. Sometimes microbursts are concentrated into a line structure and under these conditions, activity may continue for as long as an hour. Once microburst activity starts, multiple microbursts in the same general area are common and should be expected.

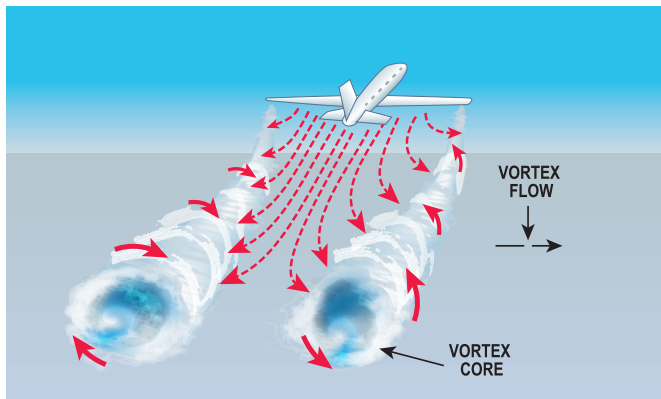
The best defence against wind shear is to avoid it altogether because it could be beyond your capabilities or those of your aircraft. However, if you do recognize WS, prompt action is required. In all aircraft, the recovery could require full power and a pitch attitude consistent with the maximum angle of attack for your aircraft. Aircraft equipped with wind shear detection and warning systems may be provided with guidance to escape WS or, in the case of Predictive Wind Shear Systems (PWSs), to avoid it (see MET 2.3). For more information on WS, consult the *Air Command Weather Manual* (TP 9352E).

If you experience WS, advise air traffic services (ATS) (see RAC 6.1) and warn others, as soon as possible, by sending a PIREP to the ground facility.

2.9 WAKE TURBULENCE

Wake turbulence is caused by wing-tip vortices and is a by-product of lift. The higher air pressure under the wings tries to move to the lower air pressure on top of the wings by flowing towards the wing tips, where it rotates and flows into the lower pressure on top of the wings. This results in a twisting rotary motion that is very pronounced at the wing tips and continues to spill over the top in a downward spiral. Therefore, the wake consists of two counter-rotating cylindrical vortices.

Figure 2.9—Wake Turbulence



Vortex Strength

The strength of these vortices is governed by the shape of the wings, and the weight and speed of the aircraft; the most significant factor is weight. The greatest vortex strength occurs under conditions of *heavy* weight, *clean* configuration, and slow speed. The strength of the vortex shows little dissipation at altitude within 2 min of the time of initial formation. Beyond 2 min, varying degrees of dissipation occur along the vortex path; first in one vortex and then in the other. The break-up of vortices is affected by atmospheric turbulence; the greater the turbulence, the more rapid the dissipation of the vortices.

Induced Roll

Aircraft flying directly into the core of a vortex will tend to roll with the vortex. The capability of counteracting the roll depends on the wing span and control responsiveness of the aircraft. When the wing span and ailerons of a larger aircraft extend beyond the vortex, counter-roll control is usually effective, and the effect of the induced roll can be minimized. Pilots of short wing span aircraft must be especially alert to vortex situations, even though their aircraft are of the high-performance type.

Helicopter Vortices

In the case of a helicopter, similar vortices are created by the rotor blades. However, the problems created are potentially greater than those caused by a fixed-wing aircraft because the helicopter's lower operating speeds produce more concentrated wakes than fixed-wing aircraft.

Helicopters produce a pair of high-velocity trailing vortices similar to wingtip vortices of large fixed-wing aircraft; the heavier the helicopter, the more intense the wake turbulence. These vortices not only affect the air behind a helicopter but can also spread over a large area and drift with the wind. Pilots of small aircraft should use caution and adjust their trajectory when operating or crossing behind helicopters. Helicopter pilots must be aware that their wake turbulence can be fatal for lighter aircraft nearby and slightly below the flight path. Helicopter pilots should adapt their trajectory if their wake turbulence can reach another aircraft.

Vortex Avoidance

Avoid the area below and behind other aircraft, especially at low altitude, where even a momentary wake turbulence encounter could be disastrous.

2.9.1 Vortex Characteristics

General

Trailing vortices have characteristics which, when known, will help a pilot visualize the wake location and thereby take avoidance precautions. Vortex generation starts with rotation (lifting off of the nosewheel) and will be severe in that airspace immediately following the point of rotation. Vortex generation ends when the nosewheel of a landing aircraft touches down.

Because of ground effect and wind, a vortex produced within about 200 feet AGL tends to be subject to lateral drift movements and may return to where it started. Below 100 feet AGL, the vortices tend to separate laterally and break up more rapidly than vortex systems at higher altitude. The vortex sink rate and levelling off process result in little operational effect between an aircraft in level flight and other aircraft separated by 1 000 feet vertically. Pilots should fly at or above a heavy jet's flight path, altering course as necessary to avoid the area behind and below the generating aircraft. Vortices start to descend immediately after formation and descend at the rate of 400 to 500 feet per minute for large heavy aircraft and at a lesser rate for smaller aircraft, but in all cases, descending less than 1 000 feet in total in 2 minutes.

Vortices spread out at a speed of about 5 kt. Therefore, a crosswind will decrease the lateral movement of the upwind vortex and increase the movement of the downwind vortex. Thus, a light wind of 3 to 7 kt could result in the upwind vortex remaining in the touchdown zone for a period of time or hasten the drift of the downwind vortex toward another runway. Similarly, a tail wind condition can move the vortices of the preceding landing aircraft forward into the touchdown zone.

Since vortex cores can produce a roll rate of 80° per second or twice the capabilities of some light aircraft and a downdraft of 1 500 feet per minute which exceeds the rate of climb of many aircraft, the following precautions are recommended.

Pilots should be particularly alert in calm or light wind conditions where the vortices could:

- (a) remain in the touchdown area;
- (b) drift from aircraft operating on a nearby runway;
- (c) sink into takeoff or landing path from a crossing runway;
- (d) sink into the traffic pattern from other runway operations;
- (e) sink into the flight path of VFR flights at 500 feet AGL and below.

2.9.2 Considerations

On the ground

Before requesting clearance to cross a live runway, wait a few minutes when a large aircraft has just taken off or landed.

When holding near a runway, expect wake turbulence.

Takeoff

When cleared to takeoff following the departure of a large aircraft, plan to become airborne prior to the point of rotation of the preceding aircraft and stay above the departure path or request a turn to avoid the departure path.

When cleared to takeoff following the landing of a large aircraft, plan to become airborne after the point of touchdown of the landing aircraft

En route VFR

Avoid flight below and behind a large aircraft. If a large aircraft is observed along the same track (meeting or overtaking), adjust position laterally preferably upwind.

Landing

When cleared to land behind a departing aircraft, plan to touchdown prior to reaching the rotation point of the departing aircraft.

When behind a large aircraft landing on the same runway, stay at or above the preceding aircraft's final approach flight path, note the touchdown point and land beyond this point if it is safe to do so.

When cleared to land behind a large aircraft on a low approach or on a missed approach on the same runway, beware of vortices that could exist between the other aircraft's flight path and the runway surface.

When landing after a large aircraft on a parallel runway closer than 2 500 feet, beware of possible drifting of the vortex on to your runway. Stay at or above the large aircraft's final approach flight path, note his touchdown point and land beyond if it is safe to do so.

When landing after a large aircraft has departed from a crossing runway, note the rotation point. If it is past the intersection, continue the approach and land before the intersection. If the large aircraft rotates prior to the intersection, avoid flight below the large aircraft's flight path. Abandon the approach unless a landing is assured well before reaching the intersection.

ATC will use the words "CAUTION – WAKE TURBULENCE" to alert pilots to the possibility of wake turbulence. It is the pilots' responsibility to adjust their operations and flight path to avoid wake turbulence.

Air traffic controllers apply separation minima between aircraft. See RAC 4.1.1 for these procedures which are intended to minimize the hazards of wake turbulence.

An aircraft conducting an IFR final approach should remain on glide path as the normally supplied separation should provide an adequate wake turbulence buffer. However, arriving VFR

aircraft, while aiming to land beyond the touchdown point of a preceding heavy aircraft, should be careful to remain above its flight path. If extending flight path, so as to increase the distance behind an arriving aircraft, one should avoid the tendency to develop a dragged-in final approach. Pilots should remember to apply whatever power is required to maintain altitude until reaching a normal descent path. The largest number of dangerous encounters have been reported in the last half mile of the final approach.

Be alert to adjacent large aircraft operations particularly upwind of your runway. If an intersection takeoff clearance is received, or parallel and cross runway operations are in progress, avoid subsequent heading which will result in your aircraft crossing below and behind a large aircraft.

NOTES:

1. If any of the procedures are not possible and you are on the ground, WAIT! (2 minutes are usually sufficient). If on an approach, consider going around for an other approach.
2. See AIR 1.7 for Jet and Propeller Blast Danger.

2.10 CLEAR AIR TURBULENCE (CAT)

These rules of thumb are given to assist pilots in avoiding clear air turbulence (CAT). They apply to westerly jet streams. The *Air Command Weather Manual* (TP 9352E) available from Transport Canada discusses this subject more thoroughly.

Jet streams stronger than 110 kt (at the core) have areas of significant turbulence near them in the sloping tropopause above the core, in the jet stream front below the core and on the low-pressure side of the core.

Wind shear and its accompanying CAT in jet streams is more intense above and to the lee of mountain ranges. For this reason, CAT should be anticipated whenever the flight path crosses a strong jet stream in the vicinity of a mountain range.

On charts for standard isobaric surfaces such as the 250 mbs charts, 30 kt isotachs spaced closer than 90 NM indicate sufficient horizontal shear for CAT. This area is normally on the north (low-pressure) side of the jet stream axis, but in unusual cases may occur on the south side.

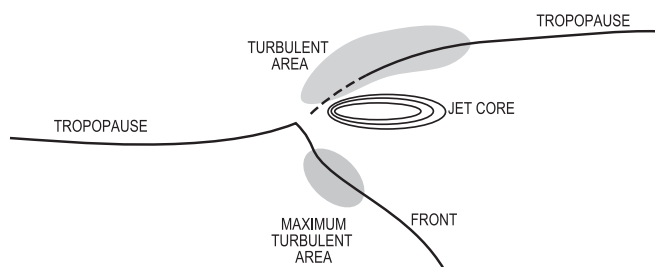
CAT is also related to vertical shear. From the wind-aloft charts or reports, compute the vertical shear in knots-per-thousand feet. Turbulence is likely when the shear is greater than 5 kt per thousand feet. Since vertical shear is related to horizontal temperature gradient, the spacing of isotherms on an upper air chart is significant. If the 5°C isotherms are closer together than 2° of latitude (120 NM), there is usually sufficient vertical shear for turbulence.

Curving jet streams are more apt to have turbulent edges than straight ones, especially jet streams which curve around a deep pressure trough.

Wind-shift areas associated with troughs are frequently turbulent. The sharpness of the wind-shift is the important factor. Also, ridge lines may also have rough air.

In an area where significant CAT has been reported or is forecast, it is suggested that the pilot adjust the airspeed to the recommended turbulent air penetration speed for the aircraft upon encountering the first ripple, since the intensity of such turbulence may build up rapidly. In areas where moderate or severe CAT is expected, it is desirable to adjust the airspeed prior to encountering turbulence.

Figure 2.10—Clear Air Turbulence



If jet stream turbulence is encountered with direct tailwinds or headwinds, a change of flight level or course should be initiated since these turbulent areas are elongated with the wind but are shallow and narrow. A turn to the south in the Northern Hemisphere will place the aircraft in a more favourable area. If a turn is not feasible because of airway restrictions, a climb or descent to the next flight level will usually result in smoother air.

When jet stream turbulence is encountered in a crosswind situation, pilots wanting to cross the CAT area more quickly should, either climb or descend based on temperature change. If temperature is rising – climb; if temperature is falling - descend. This will prevent following the sloping tropopause or frontal surface and staying in the turbulent area. If the temperature remains constant, either climb or descend.

If turbulence is encountered with an abrupt wind-shift associated with a sharp pressure trough, a course should be established to cross the trough rather than to fly parallel to it. A change in flight level is not as likely to reduce turbulence.

If turbulence is expected because of penetration of a sloping tropopause, pilots should refer to the temperature. The tropopause is where the temperature stops decreasing. Turbulence will be most pronounced in the temperature-change zone on the stratospheric side of the sloping tropopause.

Both vertical and horizontal wind shear are greatly intensified in mountain wave conditions. Therefore, when the flight path crosses a mountain wave, it is desirable to fly at turbulence-penetration speed and avoid flight over areas where the terrain drops abruptly. There may be no lenticular clouds associated with the mountain wave.

PIREP

Clear air turbulence can be a very serious operational factor to flight operations at all levels and especially to jet traffic flying above 15 000 feet. The best available information comes from pilots via a PIREP. Any pilot encountering CAT is urgently requested to report the time, location and intensity (light,

moderate or severe per MET 2.2.2) to the facility with which they are maintaining radio contact. (See MET 1.1.6.)

2.11 FLIGHT OPERATIONS ON WATER

2.11.1 General

Pilots are reminded that when aircraft are being operated on the waters of harbours, ports, lakes or other navigable waterways, they are considered to be a vessel and must abide by the applicable marine regulations and the provisions of CAR 602.20 (see chapter 1.8 of the RAC).

The attention of all pilots and aircraft owners is drawn to the *Canada Shipping Act, 2001*, the *Canada Marine Act* and the *Collision Regulations*. The *Canada Marine Act* provides harbour commissions and port authorities, with the authority to restrict vessel operations on the bodies of water that are in their jurisdiction. The *Collision Regulations* apply to every seaplane on or over Canadian waters and to the owner, the charterer and the operator of a seaplane and the person in charge of a seaplane. A seaplane includes any aircraft designed to manoeuvre on the water. Rule 18 states that “a seaplane on the water shall, in general, keep well clear of all vessels and avoid impeding their navigation. In circumstances, however, where risk of collision exists, she shall comply with the Rules of this Part.” The *Collision Regulations* may be accessed at https://laws-lois.justice.gc.ca/eng/regulations/c.r.c.,_c._1416/index.html.

Restrictions established by the above authorities relating to vessels apply to aircraft underway or at rest on the water of a harbour, and operators are advised to furnish themselves with copies of the appropriate regulations as published by such harbour commissions or port authorities.

In addition, the *Canada Shipping Act, 2001*, through the *Vessel Operation Restriction Regulations*, prohibits or imposes restrictions on the operation of vessels on certain lakes and waterways within Canada. The bodies of water affected, and applicable restrictions, may be found in the schedules to the *Vessel Operation Restriction Regulations* at <https://laws-lois.justice.gc.ca/eng/regulations/SOR-2008-120/index.html>.

2.11.2 Ditching

When flying over water, a pilot must always consider the possibility of ditching. Aircraft operating handbooks usually contain instructions on ditching that are applicable to the type of aircraft. Also, the *Flight Training Manual* (TP 1102E) discusses this topic.

Before flying over water, pilots should be aware of the regulatory requirements, some of which are outlined in AIR 2.11.3.

On the high seas, it is best to ditch parallel and on top of the primary swell system, except in high wind conditions. The primary swell is usually recognized first because it is easier to see from a higher altitude while secondary systems may only be visible at a lower altitude. Wind effect may only be discernible at a much lower altitude from the appearance of the white caps. It is possible for the primary swell system to disappear from view once lower altitudes are reached as it becomes hidden by secondary systems

and the wind chop.

Some guidelines can be adopted:

- (a) Never land into the face of a primary swell system unless the winds are extremely high. The best ditching heading is usually parallel to the primary swell system.
- (b) In strong winds it may be desirable to compromise by ditching more into the wind and slightly across the swell system.

Decide as early as possible that ditching is inevitable, so that power can be used to achieve the optimum impact conditions. This would permit a stabilized approach at a low rate of descent at the applicable ditching speed.

Communicate. Initially, broadcast on the last frequency in use, then switch to 121.5 as many air carriers at high altitude have a VHF radio set on 121.5. Set off the ELT if able; SARSAT has a very good chance of picking up the signal. Set your transponder to 7700. Many coastal radars will detect the signal at extremely long ranges over the water.

Surviving a ditching is one thing, but immersion and the time spent in the cold water is possibly even more hazardous. Ensure that all equipment needed for flotation and the prevention of hypothermia from a lengthy exposure to cold water is on board and available. Brief passengers on their expected actions including their responsibilities for the handling of emergency equipment, once the aircraft has stopped in the water.

2.11.3 Life-Saving Equipment For Aircraft Operating Over Water

Life jackets suitable for each person on board are required to be carried on all aircraft taking off from and landing on water, and on all single-engine aircraft flown over water beyond gliding distance from shore. Complete requirements are contained in CARs 602.62 and 602.63.

2.11.4 Landing Seaplanes on Glassy Water

It is practically impossible to judge altitude when landing a seaplane or skiplane under certain conditions of surface and light. The following procedure should be adopted when such conditions exist.

Power assisted approaches and landings should be used although considerably more space will be required. The landing should be made as close to the shoreline as possible, and parallel to it, the height of the aircraft above the surface being judged from observation of the shoreline. Objects on the surface such as weeds and weed beds can be used for judging height. The recommended practice is to make an approach down to 200 ft (300 ft to 400 ft where visual aids for judgement of height are not available) and then place the aircraft in a slightly nose high attitude. Adjust power to maintain a minimum rate of descent, maintaining the recommended approach speed for the type until the aircraft is in contact with the surface. Do not “feel for the surface”. At the point of contact, the throttle should be eased off gently while maintaining back pressure on the control column to hold a nose high attitude which will prevent the floats from digging in as

the aircraft settles into the water. Care must be taken to trim the aircraft properly to ensure that there is no slip or skid at the point of contact.

This procedure should be practised to give the pilot full confidence. It is recommended that the same procedure be used for unbroken snow conditions.

2.12 FLIGHT OPERATIONS IN WINTER

General

The continuing number of accidents involving all types and classes of aircraft indicates that misconceptions exist regarding the effect on performance of frost, snow or ice accumulation on aircraft.

Most commercial transport aircraft, as well as some other aircraft types, have demonstrated some capability to fly in icing conditions and have been so certified. This capacity is provided by installing de-icing or anti-icing equipment on or in critical areas of equipment, such as the leading edges of the wings and empennage, engine cowls, compressor inlets, propellers, stall warning devices, windshields and pitots. However, this equipment does not provide any means of de-icing or anti-icing the wings or empennage of an aircraft that is on the ground.

2.12.1 Fan Blade Ice Shedding Procedure

General

Ice intake on high bypass jet engines has the potential to cause significant fan blade damage.

The Fan Blade Ice Shedding Procedure may be applied by aircrew during conditions of freezing rain, freezing drizzle, freezing fog or heavy snow.

Weather conditions of 1 SM visibility or less in snow or blowing snow are considered high risk blade damage conditions.

If icing conditions exceed 30 min or if significant engine vibration occurs, the engines may be accelerated for approximately 30 s prior to higher thrust operations. This may occur just prior to takeoff to check engine parameters and ensure normal engine operation.

Pilot Requirements

It is imperative that aircrew inform ATS of the intent to perform this procedure, prior to entering an active runway.

Prior to approaching the active runway holding position, pilots should advise ATS that they will require extra time on the runway threshold for ice shedding or any other potential delay.

This information is required to ensure a timely departure and to prevent an arriving flight from conducting an unplanned missed approach.

2.12.2 Aircraft Contamination on the Ground – Frost, Ice or Snow

General Information: Where frost, ice or snow may reasonably be expected to adhere to the aircraft, the *Canadian Aviation*

Regulations require that an inspection or inspections be made before takeoff or attempted takeoff. The type and minimum number of inspections is indicated by the regulations, and depends on whether or not the operator has an approved Operator's Ground Icing Operations Program using the Ground Icing Operations Standard as specified in CAR 602.11 – *Operating and Flight Rules Standards*.

The reasons for the regulations are straightforward. The degradation in aircraft performance and changes in flight characteristics when frozen contaminants are present are wide ranging and unpredictable. Contamination makes no distinction between large aircraft, small aircraft or helicopters, the performance penalties and dangers are just as real.

The significance of these effects are such that takeoff should not be attempted unless the pilot-in-command has determined, as required by the CARs, that frost ice or snow contamination is not adhering to any aircraft critical surfaces.

Critical Surfaces: Critical surfaces of an aircraft mean the wings, control surfaces, rotors, propellers, horizontal stabilizers, vertical stabilizers or any other stabilizing surface of an aircraft which, in the case of an aircraft that has rear-mounted engines, includes the upper surface of its fuselage.

Flight safety during ground operations in conditions conducive to frost, ice or snow contamination requires a knowledge of:

- (a) adverse effects of frost, ice or snow on aircraft performance and flight characteristics, which are generally reflected in the form of decreased thrust, decreased lift, increased drag, increased stall speed, trim changes, altered stall characteristics and handling qualities;
- (b) various procedures available for aircraft ground de-icing and anti-icing, and the capabilities and limitations of these procedures in various weather conditions, including the use and effectiveness of freezing point depressant (FPD) fluids;
- (c) holdover time, which is the estimated time that an application of an approved de-icing/anti-icing fluid is effective in preventing frost, ice, or snow from adhering to treated surfaces. Holdover time is calculated as beginning at the start of the final application of an approved de-icing/anti-icing fluid and as expiring when the fluid is no longer effective. The fluid is no longer effective when its ability to absorb more precipitation has been exceeded. This produces a visible surface build-up of contamination. Recognition that final assurance of a safe takeoff rests in the pre-takeoff inspection.

The Clean Aircraft Concept: CARs prohibit takeoff when frost, ice or snow is adhering to any critical surface of the aircraft. This is referred to as “The Clean Aircraft Concept”.

It is imperative that takeoff not be attempted in any aircraft unless the pilot-in-command has determined that all critical components of the aircraft are free of frost, ice or snow contamination. This requirement may be met if the pilot-in-command obtains verification from properly trained and qualified personnel that the aircraft is ready for flight.

Frozen Contaminants: Test data indicate that frost, ice or snow formations having a thickness and surface roughness similar to medium or coarse sandpaper, on the leading edge and upper surface of a wing, can reduce wing lift by as much as 30% and increase drag by 40%. Even small amounts of contaminants have caused (and continue to cause) aircraft accidents which result in substantial damage and loss of life. A significant part of the loss of lift can be attributed to leading edge contamination. The changes in lift and drag significantly increase stall speed, reduce controllability, and alter aircraft flight characteristics. Thicker or rougher frozen contaminants can have increasing effects on lift, drag, stall speed, stability and control.

More than 30 factors have been identified that can influence whether frost, ice or snow will accumulate, cause surface roughness on an aircraft and affect the anti-icing properties of freezing point depressant fluids. These factors include ambient temperature; aircraft surface temperature; the de-icing and anti-icing fluid type, temperature and concentration; relative humidity; and wind speed and direction. Because many factors affect the accumulation of frozen contaminants on the aircraft surface, holdover times for freezing point depressant fluids should be considered as guidelines only, unless the operator's ground icing operations program allows otherwise.

The type of frost, ice or snow that can accumulate on an aircraft while on the ground is a key factor in determining the type of de-icing/anti-icing procedures that should be used.

Where conditions are such that ice or snow may reasonably be expected to adhere to the aircraft, it must be removed before takeoff. Dry, powdery snow can be removed by blowing cold air or compressed nitrogen gas across the aircraft surface. In some circumstances, a shop broom could be employed to clean certain areas accessible from the ground. Heavy, wet snow or ice can be removed by placing the aircraft in a heated hangar, by using solutions of heated freezing point depressant fluids and water, by mechanical means (such as brooms or squeegees), or a combination of all three methods. Should the aircraft be placed in a heated hangar, ensure it is completely dry when moved outside; otherwise, pooled water may refreeze in critical areas or on critical surfaces.

A frost that forms overnight must be removed from the critical surfaces before takeoff. Frost can be removed by placing the aircraft in a heated hangar or by other normal de-icing procedures.

The Cold-Soaking Phenomenon: Where fuel tanks are located in the wings of aircraft, the temperature of the fuel greatly affects the temperature of the wing surface above and below these tanks. After a flight, the temperature of an aircraft and the fuel carried in the wing tanks may be considerably colder than the ambient temperature. An aircraft's cold-soaked wings conduct heat away from precipitation so that, depending on a number of factors, clear ice may form on some aircraft, particularly on wing areas above the fuel tanks. Such ice is difficult to see and, in many instances, cannot be detected other than by touch with the bare hand or by means of a special purpose ice detector.

Clear ice formations could break loose at rotation or during flight, causing engine damage on some aircraft types, primarily those with rear-mounted engines. A layer of slush on the wing can also hide a dangerous sheet of ice beneath.

The formation of ice on the wing is dependent on the type, depth and liquid content of precipitation, ambient air temperature and wing surface temperature. The following factors contribute to the formation intensity and the final thickness of the clear ice layer:

- (a) low temperature of the fuel uplifted by the aircraft during a ground stop and/or the long airborne time of the previous flight, resulting in a situation that the remaining fuel in the wing tanks is subzero. Fuel temperature drops of up to 18°C have been recorded after a flight of two hours;
- (b) an abnormally large amount of cold fuel remaining in the wing tanks causing fuel to come in contact with the wing upper surface panels, especially in the wing root area;
- (c) weather conditions at the ground stop, wet snow, drizzle or rain with the ambient temperature around 0°C is very critical. Heavy freezing has been reported during drizzle or rain even in a temperature range between +8° to +14°C.

As well, cold-soaking can cause frost to form on the upper and lower wing under conditions of high relative humidity. This is one type of contamination that can occur in above-freezing weather at airports where there is normally no need for de-icing equipment, or where the equipment is deactivated for the summer. This contamination typically occurs where the fuel in the wing tanks becomes cold-soaked to below-freezing temperatures because of low temperature fuel uplifted during the previous stop, or cruising at altitudes where low temperatures are encountered, or both, and a normal descent is made into a region of high humidity.

In such instances, frost will form on the under and upper sides of the fuel tank region during the ground turn-around time, and tends to re-form quickly even when removed.

Frost initially forms as individual grains about 0.004 of an inch in diameter. Additional build-up comes through grain growth from 0.010 to 0.015 of an inch in diameter, grain layering, and the formation of frost needles. Available test data indicate that this roughness on the wing lower surface will have no significant effect on lift, but it may increase drag and thereby decrease climb gradient capability which results in a second segment limiting weight penalty.

Skin temperature should be increased to preclude formation of ice or frost prior to take-off. This is often possible by refuelling with warm fuel or using hot freezing point depressant fluids, or both.

In any case, ice or frost formations on upper or lower wing surfaces must be removed prior to takeoff. The exception is that takeoff may be made with frost adhering to the underside of the wings provided it is conducted in accordance with the aircraft manufacturer's instructions.

De-Icing and Anti-Icing Fluids: Frozen contaminants are most often removed in commercial operations by using freezing point depressant fluids. There are a number of freezing point depressant fluids available for use on commercial aircraft and, to a lesser extent, on general aviation aircraft. De-icing and anti-icing fluids should not be used unless approved by the aircraft manufacturer.

Although freezing point depressant fluids are highly soluble in water, they absorb or melt ice slowly. If frost, ice or snow is adhering to an aircraft surface, the accumulation can be melted by repeated application of proper quantities of freezing point depressant fluid. As the ice melts, the freezing point depressant mixes with the water, thereby diluting the freezing point depressant. As dilution occurs, the resulting mixture may begin to run off the aircraft. If all the ice is not melted, additional application of freezing point depressant becomes necessary until the fluid penetrates to the aircraft surface. When all the ice has melted, the remaining liquid residue is a mixture of freezing point depressant and water at an unknown concentration. The resulting film could freeze (begin to crystallize) rapidly with only a slight temperature decrease. If the freezing point of the film is found to be insufficient, the de-icing procedure must be repeated until the freezing point of the remaining film is sufficient to ensure safe operation.

The de-icing process can be sped up considerably by using the thermal energy of heated fluids and the physical energy of high-pressure spray equipment, as is the common practice.

SAE and ISO Type I Fluids: These fluids in the concentrated form contain a minimum of 80% glycol and are considered "unthickened" because of their relatively low viscosity. These fluids are used for de-icing or anti-icing, but provide very limited anti-icing protection.

SAE and ISO Type II Fluids: Fluids, such as those identified as SAE Type II and ISO Type II, will last longer in conditions of precipitation. They afford greater margins of safety if they are used in accordance with aircraft manufacturers' recommendations.

Flight tests performed by manufacturers of transport category aircraft have shown that most SAE and ISO Type II fluids flow off lifting surfaces by rotation speeds (V_r), although some large aircraft do experience performance degradation and may require weight or other takeoff compensation. Therefore, SAE and ISO Type II fluids should be used on aircraft with rotation speeds (V_r) above 100 KIAS. Degradation could be significant on aeroplanes with rotation speeds below this figure.

As with any de-icing or anti-icing fluid, SAE and ISO Type II fluids should not be applied unless the aircraft manufacturer has approved their use, regardless of rotation speed. Aircraft manufacturers' manuals may give further guidance on the acceptability of SAE and ISO Type II fluids for specific aircraft.

Some fluid residue may remain throughout the flight. The aircraft manufacturer should have determined that this residue would have little or no effect on aircraft performance or handling qualities in aerodynamically quiet areas; however, this residue should be cleaned periodically.

SAE and ISO Type II fluids contain no less than 50% glycol and have a minimum freeze point of -32°C. They are considered “thickened” because of added thickening agents that enable the fluid to be deposited in a thicker film and to remain on the aircraft surfaces until the time of takeoff. These fluids are used for de-icing (when heated) and anti-icing. Type II fluids provide greater protection (holdover time) than do Type I fluids against frost, ice or snow formation in conditions conducive to aircraft icing on the ground.

These fluids are effective anti-icers because of their high viscosity and pseudoplastic behaviour. They are designed to remain on the wings of an aircraft during ground operations or short-term storage, thereby providing some anti-icing protection and will readily flow off the wings during takeoff. When these fluids are subjected to shear stress (such as that experienced during a takeoff run), their viscosity decreases drastically, allowing the fluids to flow off the wings and causing little adverse effect on the aircraft’s aerodynamic performance.

The pseudoplastic behaviour of SAE and ISO Type II fluids can be altered by improper de-icing/anti-icing equipment or handling. Therefore, some North American airlines have updated de-icing and anti-icing equipment, fluid storage facilities, de-icing and anti-icing procedures, quality control procedures, and training programs to accommodate these distinct characteristics. Testing indicates that SAE and ISO Type II fluids, if applied with improper equipment, may lose 20% to 60% of their anti-icing performance.

All Type II fluids are not necessarily compatible with all Type I fluids; therefore, you should refer to the fluid manufacturer or supplier for further information. As well, the use of Type II fluid over badly contaminated Type I fluid will reduce the effectiveness of the Type II fluid.

SAE and ISO Type II fluids were introduced in North America in 1985, with widespread use beginning to occur in 1990. Similar fluids, but with slight differences in characteristics, have been developed, introduced, and used in Canada.

Type III Fluids: Type III is a thickened freezing point depressant fluid which has properties that lie between Types I and II. Therefore, it provides a longer holdover time than Type I, but less than Type II. Its shearing and flow-off characteristics are designed for aircraft that have a shorter time to the rotation point. This should make it acceptable for some aircraft that have a V_T of less than 100 KIAS.

The SAE had approved a specification in AMS1428A for Type III anti-icing fluids that can be used on those aircraft with rotation speeds significantly lower than the large jet rotation speeds, which are 100 KIAS or greater. No fluid has yet been identified that can meet the entire Type III fluid specification. Pending publication of a Type III Holdover Time Table and availability of suitable fluids, the Union Carbide Type IV fluid in 75/25 dilution may be used for anti-icing purposes on low rotation speed aircraft, but only in accordance with aircraft and fluid manufacturer’s instructions.

Type IV Fluids: A significant advance is Type IV anti-icing fluid. These fluids meet the same fluid specifications as the Type II fluids and in addition have a significantly longer holdover time. In recognition of the above, Holdover Time Tables are available for Type IV.

The product is dyed green as it is believed that the green product will provide for application of a more consistent layer of fluid to the aircraft and will reduce the likelihood that fluid will be mistaken for ice. However, as these fluids do not flow as readily as conventional Type II fluid, caution should be exercised to ensure that enough fluid is used to give uniform coverage.

Research indicates that the effectiveness of a Type IV fluid can be seriously diminished if proper procedures are not followed when applying it over Type I fluid.

All fluid users are advised to ensure that these fluids are applied evenly and thoroughly and that an adequate thickness has been applied in accordance with the manufacturer’s recommendations. Particular attention should be paid to the leading edge area of the wing and horizontal stabilizer.

Further information on aircraft critical surface contamination may be found in When in Doubt... Small and Large Aircraft—Aircraft Critical Surface Contamination Training for Aircrew and Groundcrew (TP 10643), a TC publication available online at <<https://tc.canada.ca/en/aviation/publications/when-doubt-small-large-aircraft-aircraft-critical-surface-contamination-training-tp-10643>>. A CD-ROM, with the same title and an accompanying workbook, is also available for order. The priced CD-ROM and workbook may be ordered from the TC Publications Order Desk using one of the methods listed below.

Transport Canada Publications Order Desk
Operational Support Services (AAFBD)
2655 Lancaster Road
Ottawa ON K1B 4L5

Tel. (toll-free in North America):1-888-830-4911
.....613-991-4071
Fax: 613-991-1653
Email: publications@tc.gc.ca
Web site: <https://tc.canada.ca/en/corporate-services/publications-how-order>

2.12.3 Aircraft Contamination in Flight – In-flight Airframe Icing

Airframe icing can be a serious weather hazard to fixed and rotary wing aircraft in flight. Icing will result in a loss of performance in the following areas:

- (a) ice accretion on lifting surfaces will change their aerodynamic properties resulting in a reduction in lift, increase in drag and weight with a resultant increase in stalling speed and a reduction in the stalling angle of attack. Therefore, an aerodynamic stall can occur before the stall warning systems activate;
- (b) ice adhering to propellers will drastically affect their efficiency and may cause an imbalance with resultant vibration;
- (c) ice adhering to rotor blades will degrade their aerodynamic efficiency. This means that an increase in power will be required to produce an equivalent amount of lift. Therefore, during an autorotation this increase can only come from a higher than normal rate of descent. In fact, it may not be

- possible to maintain safe rotor RPM's during the descent and flare due to ice contamination;
- (d) ice on the windshield or canopy will reduce or block vision from the flight deck or cockpit;
- (e) carburetor icing, see AIR 2.3; and
- (f) airframe ice may detach and be ingested into jet engine intakes causing compressor stalls, loss of thrust and flame out.

2.12.3.1 Types of Ice

There are three types of ice which pilots must contend with in flight: Rime Ice, Clear Ice and Frost (see MET 2.4). For any ice to form the OAT must be at or below freezing with the presence of visible moisture.

Rime ice commonly found in stratiform clouds is granular, opaque and pebbly and adheres to the leading edges of antennas and windshields. Rime ice forms in low temperatures with a low concentration of small super-cooled droplets. It has little tendency to spread and can easily be removed by aircraft de-icing systems.

Clear ice commonly found in cumuliform clouds is glassy, smooth and hard, and tends to spread back from the area of impingement. Clear ice forms at temperatures at or just below 0°C with a high concentration of large super-cooled droplets. It is the most serious form of icing because it adheres firmly and is difficult to remove.

Frost may form on an aircraft in flight when descent is made from below-freezing conditions to a layer of warm, moist air. In these circumstances, vision may be restricted as frost forms on the windshield or canopy.

Additional references on icing include MET 2.4 and the *Air Command Weather Manual* (TP 9352E).

2.12.3.2 Aerodynamic Effects of Airborne Icing

Commercial pilots are familiar with the classic aerodynamic effects of ice accumulation on an aeroplane in flight. These can include:

- (a) reduced lift accompanied by significant increases in drag and increases in weight;
- (b) increases in stall speed and reduced stall angle of attack as ice alters the shape of an airfoil and disrupts airflow;
- (c) reduced thrust due to ice disrupting the airflow to the engine and/or degrading propeller efficiency. Ice ingested into a jet engine may induce a compressor stall and/or a flame out;
- (d) control restrictions due to water flowing back into control surfaces and freezing;
- (e) ice adhering to rotor blades will degrade their aerodynamic efficiency. This means that an increase in power will be required to produce an equivalent amount of lift. Therefore, during an autorotation this increase can only come from a higher than normal rate of descent. In fact, it may not be possible to maintain safe rotor RPM during the descent and flare due to ice contamination;

- (f) ice on the windshield or canopy will reduce or block vision from the flight deck or cockpit; and
- (g) carburetor icing (see AIR 2.3).

2.12.3.3 Roll Upset

Roll upset describes an uncommanded and possibly uncontrollable rolling moment caused by airflow separation in front of the ailerons, resulting in self-deflection of unpowered control surfaces. It is associated with flight in icing conditions in which water droplets flow back behind the protected surfaces before freezing and form ridges that cannot be removed by de-icing equipment. Roll upset has recently been associated with icing conditions involving large super-cooled droplets; however, it theoretically can also occur in conventional icing conditions when temperatures are just slightly below 0°C.

The roll upset can occur well before the normal symptoms of ice accretion are evident to the pilot, and control forces may be physically beyond the pilot's ability to overcome. Pilots may receive a warning of incipient roll upset if abnormal or sloppy aileron control forces are experienced after the autopilot is disconnected when operating in icing conditions.

Corrective Actions

If severe icing conditions are inadvertently encountered, pilots should consider the following actions to avoid a roll upset:

- (a) Disengage the autopilot. The autopilot may mask important clues or may self disconnect when control forces exceed limits, presenting the pilot with abrupt unusual attitudes and control forces.
- (b) Reduce the angle of attack by increasing speed. If turning, roll wings level.
- (c) If flaps are extended, do not retract them unless it can be determined that the upper surface of the wing is clear of ice. Retracting the flaps will increase the angle of attack at any given airspeed, possibly leading to the onset of roll upset.
- (d) Set appropriate power and monitor airspeed /angle of attack.
- (e) Verify that wing ice protection is functioning symmetrically by visual observation if possible. If not, follow the procedures in the aircraft flight manual.

2.12.3.4 Tail Plane Stall

As the rate at which ice accumulates on an airfoil is related to the shape of the airfoil, with thinner airfoils having a higher collection efficiency than thicker ones, ice may accumulate on the horizontal stabilizer at a higher rate than on the wings. A tail plane stall occurs when its critical angle of attack is exceeded. Because the horizontal stabilizer produces a downward force to counter the nose-down tendency caused by the centre of lift on the wing, stall of the tail plane will lead to a rapid pitch down. Application of flaps, which may reduce or increase downwash on the tail plane depending on the configuration of the empennage (i.e. low set horizontal stabilizer, mid-set, or T-tail), can aggravate or initiate the stall. Therefore, pilots should be very cautious in lowering flaps if tail plane icing is suspected. Abrupt nose-down pitching movements should also be avoided, since these increase

the tail plane angle of attack and may cause a contaminated tail plane to stall.

A tail plane stall can occur at relatively high speeds, well above the normal 1G stall speed. The pitch down may occur without warning and be uncontrollable. It is more likely to occur when the flaps are selected to the landing position, after a nose-down pitching manoeuvre, during airspeed changes following flap extension, or during flight through wind gusts.

Symptoms of incipient tail plane stall may include:

- (a) abnormal elevator control forces, pulsing, oscillation, or vibration;
- (b) an abnormal nose-down trim change (may not be detected if autopilot engaged);
- (c) any other abnormal or unusual pitch anomalies (possibly leading to pilot induced oscillations);
- (d) reduction or loss of elevator effectiveness (may not be detected if the autopilot is engaged);
- (e) sudden change in elevator force (control would move down if not restrained); and/or
- (f) a sudden, uncommanded nose-down pitch.

Corrective Actions

If any of the above symptoms occur, the pilot should consider the following actions unless the aircraft flight manual dictates otherwise:

- (a) Plan approaches in icing conditions with minimum flap settings for the conditions. Fly the approach on speed for the configuration.
- (b) If symptoms occur shortly after flap extension, immediately retract the flaps to the previous setting. Increase airspeed as appropriate to the reduced setting.
- (c) Apply sufficient power for the configuration and conditions. Observe the manufacturer's recommendations concerning power settings. High power settings may aggravate tail plane stall in some designs.
- (d) Make any nose-down pitch changes slowly, even in gusting conditions, if circumstance allow.
- (e) If equipped with a pneumatic de-icing system, operate several times to attempt to clear ice from the tail plane.

WARNINGS

- (a) At any flap setting, airspeed in excess of the manufacturer's recommendations for the configuration and environmental conditions, accompanied by uncleared ice on the tail plane, may result in a tail plane stall and an uncontrollable nose-down pitch.
- (b) Improper identity of the event and application of the wrong recovery procedure will make an already critical situation even worse. This information concerning roll upset and tail plane stall is necessarily general in nature, and may not be applicable to all aircraft configurations. Pilots must consult their aircraft flight manual to determine type specific procedures for these phenomena.

2.12.3.5 Freezing Rain, Freezing Drizzle, and Large Super-Cooled Droplets

The classical mechanism producing freezing rain and/or freezing drizzle aloft involves a layer of warm air overlaying a layer of cold air. Snow falling through the warm layer melts, falls into the cold air, becomes supercooled, and freezes on contact with an aircraft flying through the cold air. Freezing rain and freezing drizzle are therefore typically found near warm fronts and troughs, both of which cause warm air to overlay cold air. Freezing rain or freezing drizzle may also occur at cold fronts, but are less common and would have a lesser horizontal extent due to the steeper slope of the frontal surface. The presence of warm air above has always provided a possible escape route to pilots who have encountered classical freezing precipitation aloft through a climb into the warm air.

Recent research has revealed that there are other non-classical mechanisms that produce freezing precipitation aloft. Flights by research aircraft have encountered freezing drizzle at temperatures down to -10°C at altitudes up to 15000 feet ASL. There was no temperature inversion—that is, no warm air aloft—present in either case. Pilots must be aware that severe icing may be encountered in conditions unrelated to warm air aloft. They must also understand that, if non-classical freezing drizzle is encountered in flight, the escape route of a climb into warmer air may not be immediately available; however, climbing remains the preferred escape route. It should allow the aircraft to reach an altitude above the formation region, while a descent may keep the aircraft in freezing precipitation. It should be noted that, while ascending, the aircraft might get closer to the source region with smaller droplets, higher liquid water content and conventional icing.

2.12.3.6 Detecting Large Super-Cooled Droplets Conditions in Flight

Visible clues to flight crew that the aircraft is operating in large super-cooled droplets conditions will vary from type to type. Manufacturers should be consulted to assist operators in identifying the visible clues particular to the type operated. There are, however, some general clues of which pilots should be aware:

- (a) ice visible on the upper or lower surface of the wing aft of the area protected by de-icing equipment (irregular or jagged lines of ice or pieces that are self-shedding);
- (b) ice adhering to non-heated propeller spinners farther aft than normal;
- (c) granular dispersed ice crystals or total translucent or opaque coverage of the unheated portions of front or side windows. This may be accompanied by other ice patterns on the windows such as ridges. Such patterns may occur within a few seconds to one half minute after exposure to large super-cooled droplets;
- (d) unusually extensive coverage of ice, visible ice fingers or ice feathers on parts of the airframe on which ice does not normally appear; and
- (e) significant differences between airspeed or rate of climb expected and that attained at a given power setting.

Additional clues significant at temperatures near freezing:

- (a) visible rain consisting of very large droplets. In reduced visibility selection of landing or taxi lights “on” occasionally will aid detection. Rain may also be detected by the audible impact of droplets on the fuselage;
- (b) droplets splashing or splattering on the windscreen. The 40 to 50 micron droplets covered by Appendix C to Chapter 525 of the Airworthiness Manual icing criteria (Appendix C lists the certification standard for all transport category aeroplanes for flight in known icing), are so small that they cannot usually be detected; however freezing drizzle droplets can reach sizes of 0.2 to 0.5 mm and can be seen when they hit the windscreen;
- (c) water droplets or rivulets streaming on windows, either heated or unheated. Streaming droplets or rivulets are indicators of high liquid water content in any sized droplet; and/or
- (d) weather radar returns showing precipitation. Whenever the radar indicates precipitation in temperatures near freezing, pilots should be alert for other clues of large super-cooled droplets.

2.12.3.7 Flight Planning or Reporting

Pilots should take advantage of all information available to avoid or, at the very least, to plan a safe flight through known icing conditions. As well as FAs, TAFs, and METARs, pilots should ask for pertinent SIGMETs and any PIREPs received along the planned route of flight. Significant Weather Prognostic Charts should be studied, if available. Weather information should be analyzed to predict where icing is likely to be found, and to determine possible safe exit procedures should severe icing be encountered. Pilots should routinely pass detailed PIREPs whenever icing conditions are encountered.

2.12.4 Landing Wheel-Equipped Light Aircraft on Snow Covered Surfaces

During the course of each winter, a number of aircraft accidents have occurred due to pilots attempting to land wheel-equipped aircraft on surfaces covered with deep snow. This has almost invariably resulted in the aircraft nosing over.

Light aircraft should not be landed on surfaces covered with snow unless it has previously been determined that the amount of snow will not constitute a hazard.

2.12.5 Use of Seaplanes on Snow Surfaces

The operation of float-equipped aircraft or flying boats from snow covered surfaces will be permitted by Transport Canada under the following conditions:

- (a) the pilot and operator will be held responsible for confining all flights to those snow conditions found to be satisfactory as a result of previous tests or experimental flights in that type of aircraft;
- (b) passengers should not be carried; and
- (c) a thorough inspection of the float or hull bottom, all struts

and fittings, all wing fittings, bracing, wing tip floats and fittings should be carried out after every flight to ensure that the aircraft is airworthy.

Seaplanes should not be landing on, or taking off from, snow surfaces except under conditions of deep firm snow, which should not be drifted or heavily crusted.

Flights should not be attempted if there is any adhesion of ice or snow to the under surface of the float or hull. When landing or forced landing a ski or float equipped aeroplane on unbroken snow surfaces, the procedure in AIR 2.11.4 is recommended.

2.12.6 Landing Seaplanes on Unbroken Snow Conditions

It has been found practically impossible to judge altitude when landing a skiplane or seaplane under certain conditions of surface and light. Under such conditions the procedures for landing seaplanes on glassy water should be used (see AIR 2.11.4).

2.12.7 Whiteout

Whiteout (also called milky weather) is defined in the *Glossary of Meteorology* (published by the American Meteorological Society) as:

“An atmospheric optical phenomenon of the polar regions in which the observer appears to be engulfed in a uniformly white glow. Neither shadows, horizon, nor clouds are discernible; sense of depth and orientation is lost; only very dark, nearby objects can be seen. Whiteout occurs over an unbroken snow cover and beneath a uniformly overcast sky, when with the aid of the snowblink effect, the light from the sky is about equal to that from the snow surface. Blowing snow may be an additional cause.”

Light carries depth perception messages to the brain in the form of colour, glare, shadows, and so on. These elements have one thing in common, namely, they are all modified by the direction of the light and changes in light intensity. For example, when shadows occur on one side of objects, we subconsciously become aware that the light is coming from the other. Thus, nature provides many visual clues to assist us in discerning objects and judging distances. What happens if these clues are removed? Let’s suppose that these objects on the ground and the ground itself are all white. Add to that, a diffused light source through an overcast layer which is reflected back in all directions by the white surface so that shadows disappear. The terrain is now virtually devoid of visual clues and the eye no longer discerns the surface or terrain features.

Since the light is so diffused, it is likely that the sky and terrain will blend imperceptibly into each other, obliterating the horizon. The real hazard in whiteout is the pilot not suspecting the phenomenon because the pilot is in clear air. In numerous whiteout accidents, pilots have flown into snow-covered surfaces unaware that they have been descending and confident that they could “see” the ground.

Consequently, whenever a pilot encounters the whiteout conditions described above, or even a suspicion of them, the pilot should immediately climb if at low level, or level off and

turn towards an area where sharp terrain features exist. The flight should not proceed unless the pilot is prepared and competent to traverse the whiteout area on instruments.

In addition, the following phenomena are known to cause whiteout and should be avoided if at all possible:

- (a) water-fog whiteout resulting from thin clouds of super-cooled water droplets in contact with the cold snow surface. Depending on the size and distribution of the water droplets, visibility may be minimal or nil in such conditions.
- (b) blowing snow whiteout resulting from fine snow being plucked from the surface by winds of 20 kt or more. Sunlight is reflected and diffused resulting in a nil visibility whiteout condition.
- (c) precipitation whiteout resulting from small wind-driven snow crystals falling from low clouds above which the sun is shining. Light reflection complicated by spectral reflection from the snow flakes and obscuration of land marks by falling snow can reduce visibility and depth perception to nil in such conditions.

If at all possible, pilots should avoid such conditions unless they have the suitable instruments in the aircraft and are sufficiently experienced to use a low-speed and minima rate of descent technique to land the aircraft safely.

2.12.8 Flat-Light Conditions

Flat light is an optical illusion, also known as “sector or partial white out.” It is not as severe as “white out,” but the condition causes pilots to lose their depth of field and contrast in vision. Flat-light conditions are usually accompanied by overcast skies inhibiting any good visual clues. Such conditions can occur anywhere in the world, primarily in snow covered areas but can occur in dust, sand, mud flats, or on glassy water. Flat light can completely obscure features of the terrain, creating an inability to distinguish distances and closure rates. As a result of this reflected light, it can give pilots the illusion of ascending or descending when actually flying level. However, with good judgment and proper training and planning, it is possible to safely operate an aircraft in flat-light conditions.

2.13 FLIGHT OPERATIONS IN MOUNTAINOUS AREAS

The importance of proper training, procedures and pre-flight planning when flying in mountainous regions is emphasized.

In the Pacific area, the combined effect of the great mountain system and the adjacent Pacific Ocean lead to extremely changeable weather conditions and a variety of weather patterns. Some of the factors to be taken into consideration regarding the effect on aircraft performance when operating under these conditions include the following:

- (a) elevation of the airport;
- (b) temperature and pressure;
- (c) turbulence and wind effect; and
- (d) determination of safe takeoff procedures to ensure clearance over obstacles and intervening high ground.

In the western mountainous region VFR routes may be marked by diamonds on visual navigation charts. The routes are marked for convenience to assist pilots with pre-flight planning. The diamond marks do not imply any special level of facilities and services along the route. Pilots are cautioned that the use of the marked routes does not absolve them from proper pre-flight planning or the exercising of good airmanship practices during the proposed flight. Alternative unmarked routes are always available, the choice of a suitable route for the intended flight and conditions remains the sole responsibility of the pilot-in-command.

2.14 FLIGHT OPERATIONS IN SPARSELY SETTLED AREAS OF CANADA

(See *AIP Canada* GEN 1.5)

2.14.1 Single-Engine Aircraft Operations in Northern Canada

(See *AIP Canada* GEN 1.5)

2.15 FLIGHT OPERATIONS AT NIGHT

There are many risks associated with operating aircraft in dark-night conditions where maintaining orientation, navigation and weather avoidance may become extremely difficult. Takeoff and landing may be particularly dangerous for both VFR and IFR pilots.

A variety of illusions may result at night because of a lack of outside visual cues. Your best defense, if you do not hold an instrument rating, is to receive some instrument training, and to be aware of the illusions and their counter measures.

2.16 VERTICAL PATH CONTROL ON NON-PRECISION APPROACHES (NPAS)

2.16.1 Controlled Flight Into Terrain (CFIT)

Controlled Flights Into Terrain (CFIT) continue to be a major threat to civil aviation safety in Canada. A stabilized final approach during an NPA has been recognized by the ICAO CFIT Task Force as an aid to prevent CFIT. The step-down technique presumed by NPA procedure design may have been appropriate for early piston transport aircraft, but it is less suited to larger jet transport aircraft.

When using the step-down technique, the aircraft flies a series of vertical descents during the final approach segment as it descends and levels off at the minimum IFR altitudes published for each segment of the approach. The successive descents and level-offs result in significant changes in power settings and pitch attitudes and for some aircraft, may prevent the landing configuration from being established until landing is assured. Using the step-down technique, the aircraft may have to be flown at minimum IFR altitudes for each segment of the approach and consequently be exposed to reduced obstacle separation for extended periods of time. A premature descent or a missed level-off could render the aircraft vulnerable to a CFIT accident.

Many air operators require their flight crews to use a stabilized approach technique which is entirely different from that envisaged in the original NPA procedure design. The stabilized approach is calculated to achieve a constant rate of descent at an approximate 3° flight path angle with stable airspeed, power setting, and attitude, and also with the aircraft configured for landing. The safety benefits derived from the stabilized final approach have been recognized by many organizations including ICAO, the FAA and TCCA. Those air operators not already doing so are encouraged to incorporate stabilized approach procedures into their SOPs and training syllabi.

CAUTION:

Caution should be exercised when descending below the MDA while following an FMS-generated vertical path. Unlike vertically guided approaches, which have their OCSs verified below the DA, OCSs on LNAV procedures below the MDA have NOT been assessed. As a result, obstacles may penetrate the computer-generated flight path. Pilots are reminded to visually scan for obstacles before descending below the MDA.

VASI and PAPI are calibrated for a defined geometric vertical path angle. In cold temperatures, a non-temperature compensated barometric FMS-generated vertical path may be lower than that of a calibrated VASI or PAPI. In high temperatures, a barometric FMS-generated vertical path will be higher than that of a calibrated VASI or PAPI. Pilots should be aware of this limitation and operate accordingly.

2.16.2 Stabilized Approach

An approach is considered stabilized when it satisfies the associated conditions, typically defined by an air operator in their company operations manual (COM) or SOPs, as they may relate to the:

- (a) range of speeds specific to the aircraft type;
- (b) power setting(s) specific to the aircraft type;
- (c) range of attitudes specific to the aircraft type;
- (d) configuration(s) specific to the aircraft type;
- (e) crossing altitude deviation tolerances;
- (f) sink rate; and
- (g) completion of checklists and flight crew briefings.

Stabilized approach procedures should be defined for all approaches and may include the following:

- (a) a flight profile should be stabilized at an altitude not lower than 1 000 ft above the threshold when in IMC;
- (b) a flight profile should be stabilized at an altitude not lower than 500 ft above the threshold;
- (c) a flight profile should remain stabilized until landing;
- (d) a go-around is required if a flight profile is not stabilized in accordance with these requirements or if the flight profile subsequently becomes destabilized.

2.16.3 Vertical Path Control Techniques

There are typically three vertical path control techniques available for an NPA:

- (a) step-down;
- (b) constant descent angle; or
- (c) stabilized constant descent angle (SCDA).

NOTE:

Constant descent angle is equivalent to ICAO's constant angle descent, and SCDA is considered a form of ICAO's continuous descent final approach (CDFA). In the interest of respecting terminology already in use in the Canadian civil aviation industry and standardization with NAV CANADA charting, the above terminology has been adopted.

While NPA procedures themselves are not inherently unsafe, the use of the step-down descent technique to conduct an NPA is prone to error and is therefore discouraged where other methods are available. When using the step-down technique during the final approach segment, the flight crew member flies an unstable vertical profile by descending and levelling off at the minimum altitudes published for each segment of the approach and then, if the required visual references have been acquired, descending from the MDA to a landing.

The risks associated with conducting an NPA can be mitigated by using an angular vertical profile instead of the step-down technique described above. The use of an angular vertical profile increases the likelihood of the approach being conducted in a stabilized manner. When conducting an NPA using an angular vertical profile, the vertical path may be intercepted prior to the FAF at a higher altitude.

Ideally, the angle to be used for an angular vertical path is obtained from the approach chart. If the approach chart does not contain a published constant descent angle, the angle may be calculated using an approved method provided to the flight crew in the air operator's SOPs or by using tables such as those found in Appendix 1 of Advisory Circular (AC) 700-028. Flight crew members must be aware of the risks associated with manually calculating the descent angle as a calculation error could lead to the use of the wrong descent angle. It is strongly recommended that flight crew members become proficient with manually calculating the descent angle before doing so under high workload conditions.

Regardless of the type of vertical path control technique used on an NPA, the lateral "turning" portion of the missed approach may not be executed prior to the MAP. However, the climb portion of a missed approach procedure may be commenced at any point along the final approach. In addition, during cold weather operations, a temperature correction must be applied to all minimum altitudes, no matter what type of vertical control path technique is used.

Except in the case of an air operator conducting operations in accordance with an exemption to Paragraph 602.128(2)(b) of the CARs, a flight crew member may not descend below the MDA if the visual references required to land have not been acquired. A correction to the MDA may be required to ensure that the aircraft does not descend below the MDA during the

transition from a descent to the climb required by a missed approach procedure.

In 2013, NAV CANADA will begin the publication of approach charts which include constant descent angle information in a tabular form and in the profile view. The inclusion of this information is intended to facilitate the use of the stabilized approach techniques described in AC 700-028 and to reduce the possibility of calculation errors.

To facilitate the stabilized descent, some avionics, such as baro-VNAV-capable (barometric vertical navigation) and WAAS-capable (wide area augmentation system) systems, generate a calculated vertical profile and the guidance to follow this profile. When conducting an NPA, the vertical guidance generated by the navigation system is advisory only. Flight crew members must use the barometric altimeter as the primary altitude reference to ensure compliance with any and all altitude restrictions. Special consideration is required when using advisory vertical guidance generated by WAAS-capable equipment. Flight crew members should refer to the manufacturer's operating guides or limitations.

Further information and descriptions of the techniques available for conducting the vertical portion of an NPA are contained in AC 700-028. <<https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-700-028>>

3.0 MEDICAL INFORMATION

3.1 GENERAL HEALTH

A healthy pilot is as essential to a safe flight as a mechanically sound aircraft. There is no precise regulation that tells pilots whether they are fit to fly and there is no pre-flight inspection to ensure fitness. Therefore, individuals must base their decision to fly on common sense, good judgement, and training prior to each flight. While flying an aircraft, a pilot must not have any condition that impairs alertness, reaction time or decision-making ability. Persons with conditions that could result in sudden or subtle incapacitation, such as epilepsy, heart disease, diabetes requiring insulin, or psychiatric illnesses, cannot be medically certified until their case is reviewed by the Civil Aviation Medicine Branch. Conditions such as anaemia, acute infections and gastrointestinal illnesses are temporarily disqualifying. When there is any doubt about their health, pilots should consult their physician or Civil Aviation Medical Examiner (CAME).

3.1.1 Mandatory Medical Reporting

Pilots are reminded that section 6.5 of the *Aeronautics Act* requires them to identify themselves as the holder of a pilot's licence prior to the commencement of any examination by a physician or optometrist. Section 6.5 further requires that the attending physician or optometrist notify the Minister of any finding that may constitute a hazard to aviation safety.

Section 6.5 also deems the pilot to have consented to the release of aviation-related findings by the physician or optometrist to the Minister.

3.2 SPECIFIC AEROMEDICAL FACTORS

3.2.1 Hypoxia

The literal definition of hypoxia is "low oxygen". Therefore, hypoxia implies a lack of sufficient oxygen for the body to operate normally. Its onset is insidious and may be accompanied by a feeling of well being, known as euphoria. Even minor hypoxia impairs night vision and slows reaction time. More serious hypoxia interferes with reasoning, gives rise to unusual fatigue and, finally, results in a loss of consciousness. Hypoxia is classified into four different types; all are relevant to pilots and merit consideration.

Hypoxic hypoxia

Hypoxic hypoxia is the result of low oxygen levels in the bloodstream. In pilots, this most often occurs with exposure to altitude (hypobaric hypoxia). At low altitudes, the partial pressure of oxygen in the atmosphere is adequate to maintain brain function at peak efficiency. Atmospheric pressure and the partial pressure of oxygen both decline at higher altitudes. At 8 000 ft ASL (2 440 m), some people may notice a slight increase in heart rate and speed of breathing (respiratory rate). By 10 000 ft ASL (3 030 m), the partial pressure of oxygen is low enough that all pilots will experience mild hypoxia and some will become symptomatic. Pilots operating at this altitude or higher should be alert for unusual difficulty completing routine calculations and should take corrective action if difficulties are noted. To avoid hypoxia, do not fly above 10 000 ft ASL (3 050 m) without supplemental oxygen or cabin pressurization.

Anaemic hypoxia

Oxygen in blood is carried by haemoglobin, which is found in red blood cells. When the red blood cell count decreases, or the haemoglobin does not function properly, less oxygen can be carried by the blood. This can occur in conditions such as heavy bleeding, some cancers, sickle cell anaemia, or carbon monoxide poisoning, to name a few. A person suffering from anaemia may notice symptoms such as breathlessness, fatigue, or chest pain, and symptoms will worsen at higher altitudes, as the effects of hypoxia and anaemia are additive.

Ischaemic hypoxia/stagnant hypoxia

The term ischaemia refers to inadequate supply of blood, and ischaemic hypoxia occurs when there is inadequate blood flow to body tissues. This can occur with constriction of blood vessels (for example, this is often seen in fingers and toes exposed to cold) as well as in situations of low blood pressure and cardiac output such as fainting, or during exposure to high sustained accelerations (stagnant hypoxia). Oxygen therapy is not very helpful in this form of hypoxia. The best remedy is to correct the underlying cause.

Histotoxic hypoxia

Histotoxic hypoxia refers to an inability of the cells of the body to use the oxygen available. This type of hypoxia is rare in pilots, but it can occur with certain conditions such

as cyanide poisoning, chemical poisoning, and intoxication with certain drugs. Histotoxic hypoxia can also be caused by high blood alcohol levels.

3.2.2 Carbon Monoxide

Carbon monoxide is a colourless, odourless, tasteless gas that is a product of incomplete combustion. Haemoglobin, the oxygen-carrying chemical in the blood, picks up carbon monoxide over 200 times more readily than it picks up oxygen. Thus, even minute quantities in the cockpit (often from improperly vented exhaust fumes) may result in pilot incapacitation.

The symptoms of carbon monoxide poisoning are insidious. Initially, there is an inability to concentrate, thinking becomes blurred, and subsequently dizziness and headache develop. If any of these symptoms are noticed, pilots should turn off the heater, open the air ventilators and descend to a lower altitude if it is safe to do so. If oxygen is available, it should be used. If an exhaust leak is suspected, the pilot should land the aircraft as soon as possible.

Smoking is a source of carbon monoxide. Smokers carry some carbon monoxide in their blood all the time, and may have 5 to 10 percent of their haemoglobin saturated with carbon monoxide. This reduces the oxygen-carrying capacity of the blood and smokers may become hypoxic at altitudes below 10 000 ft ASL (3 050 m).

Catalytic heaters consume oxygen and can produce carbon monoxide. For this reason they should not be used on an aircraft.

3.2.3 Hyperventilation

Hyperventilation most commonly occurs in association with anxiety, fear, or during intense concentration on a difficult task, such as performing a complicated approach procedure. Normally, the rate of breathing is controlled by the amount of carbon dioxide in the lungs and in the blood. In hyperventilation, carbon dioxide is blown off and the level of carbon dioxide in the blood drops below normal. Pilots may notice dizziness, a feeling of coldness, a sensation like a tight band around the head and pins and needles in the hands and feet, and cramping and spasms of the hands and feet. Paradoxically, they will often feel as though they cannot get enough air. Continued hyperventilation may result in a loss of consciousness. The symptoms of hyperventilation, particularly the shortness of breath, are not unlike those of hypoxia, so rather than trying to make the diagnosis, follow the procedure below:

- (a) Breathe oxygen, if available, at 100 percent. If hypoxia is the cause, the symptoms will improve markedly after three or four breaths.
- (b) If the symptoms persist, consciously slow the rate of breathing to 10–12 breaths per minute and do not breathe deeply. Breathing slowly and deeply into a paper bag is helpful, although obviously not always practical during flight. Keep the respiratory rate slow until the symptoms disappear. If below 8 000 ft ASL (2 440 m), hypoxia is unlikely to be the cause of the problem.

3.3 DECOMPRESSION SICKNESS

At ground level, the body tissues are saturated with nitrogen, the inert gas that makes up 80 percent of our atmosphere. During a rapid ascent, the rapid lowering of the external barometric pressure allows the nitrogen gas to form small bubbles (an example of this phenomenon is the bubbles formed when a bottle of pop is opened). The nitrogen bubbles form in and around blood vessels, joints and muscles, causing pain and cramps (the bends). They can also form under the skin, causing itching and tingling (the creeps), or in the lung, causing chest pain and shortness of breath (the chokes). Severe cases may result in a loss of consciousness. The risks associated with decompression sickness increase with high rates of climb, age, obesity, physical activity and low temperatures. Flight operations above a cabin altitude of 20 000 ft ASL (6 100 m) should not be attempted unless crew members and passengers have completed specialized high-altitude indoctrination training. When decompression sickness is encountered, an immediate descent to a lower altitude is required.

3.4 SCUBA DIVING

Although normally decompression sickness does not occur below 20 000 ft ASL (6 100 m), people who fly after scuba diving may develop the symptoms at much lower altitudes. Atmospheric pressure beneath the water increases by one atmosphere for every 33 ft (10 m) of descent. Divers who breathe pressurized air for more than a few minutes supersaturate their tissues with nitrogen. For this reason, as the aircraft ascends, nitrogen bubble formation may take place, causing the bends. After dives of less than 33 ft (1 atmosphere pressure), where decompression stops were not required, flights up to altitudes of 8 000 ft ASL (2 440 m) should be avoided for 12 hr. Where decompression stops have been required while returning to the surface, the interval should be 24 hr. For flights above 8 000 ft ASL (2 440 m), the interval is 24 hr regardless of the type of dive, as even pressurized aircraft may lose cabin pressurization.

3.5 VISION

The retina of the eye is more sensitive to hypoxia than any part of the body; one of the first symptoms of hypoxia is a decrease in night vision. For this reason, pilots flying at night are advised to use oxygen, if available, from the ground up.

Many factors affect vision. Hypoxia, carbon monoxide poisoning, alcohol, drugs, fatigue and smoking are only a few of these. After time spent in bright sunlight, the eye is slow to adapt to darkness and this may reduce night vision. To improve dark adaptation, pilots should use sunglasses during the day to avoid eye fatigue. At night, cockpit lights should be kept low to maintain the dark adaptation needed to see clearly outside the cockpit.

Despite modern electronics, pilots still fly in a “see-and-be seen” world. For best results, good vision is only one of the requirements. In the cockpit, it must be reinforced with good visual scan practices, especially at night. Such practices are an acquired, not an inherent, skill. In performing a visual scan, the eyes should be focused at a range that will ensure detection of traffic while there is still time to take avoiding action. This requires that pilots take an object on the horizon, focus on it and then scan all sectors

of the sky, refocusing as needed to avoid “empty-field myopia” (empty-sky myopia), which can result from gazing at a featureless landscape or cloudscape. Conscientious scanning of all sections of the sky, interspersed with brief interludes of focusing on distant objects, will improve a pilot’s ability to detect distant aircraft. A clean canopy is also essential, particularly with bright sunlight. Spots on the windshield easily lead to dazzle glare and can interfere with long-range focus.

The same scan is required at night, with one difference: the part of the eye that is best suited for night vision is not in the centre. An object detected in barely adequate light will disappear if viewed directly, but will often reappear if one looks 10 to 15° to one side of the object.

Technological changes and medical experience has brought forward a proliferation in the availability and options in eye surgery directed at improving visual acuity. The Civil Aviation Medicine Branch continues to monitor this progress and has adapted the medical guidelines regarding certification for flight to reflect the growing body of knowledge and experience in this important area. The most recent information and recommendations on eye surgery can be found on the following Civil Aviation Medicine Web site:

<<https://tc.canada.ca/en/aviation/medical-fitness-aviation/assessing-medical-fitness-pilots-air-traffic-controllers/refractive-eye-surgery>>.

3.6 MIDDLE-EAR AND SINUS DISCOMFORT OR PAIN

The middle ear is similar to a box: closed at one end by a flexible cover (the ear drum) and drained at the other end by a thin, straight tube (the Eustachian tube). As the aircraft climbs, air in the body cavities expands as the barometric pressure decreases. Normally, air will escape from the middle ear and the sinuses and pilots will only notice their ears “popping”. The outlet of the Eustachian tubes, however, is narrow and, if the pilot has a head cold or a throat infection, local swelling may narrow it. On ascent, air may still be able to escape, but on descent—particularly at high rates—the outlet may close like a flap, preventing air from re-entering the middle-ear cavity. The increasing ambient air pressure will then force the eardrum inward. This can lead to severe pain and decreased hearing.

Pressure in the ears can be equalized by opening and closing the mouth, swallowing, yawning, chewing gum or by holding the nostrils shut while gently blowing the nose. If the pressure in the ears (or sinuses) cannot be relieved by these manoeuvres, it is best to climb back to the original altitude or to a higher level (if this is necessary, ATC should of course be kept informed). The ears should then be cleared and a gradual descent made, clearing the ears frequently on the way down. Sometimes, the pressure in the middle ear on descent is so low relative to the external pressure that the eardrum can bleed and even rupture. This is known as barotrauma. If barotrauma occurs, a physician familiar with aeromedical conditions should be seen for treatment as soon as possible after landing.

The best advice to pilots or passengers who are suffering from head colds, sore throats or allergies is to wait until the inflammation

has subsided before flying. Nasal sprays can help provide relief, but this is only temporary. A cold lasts only a few days, but a blown eardrum may take weeks to recover!

3.7 DISORIENTATION

Pilots sometimes refer to disorientation as “vertigo”, by which they mean not knowing which way is up. On the ground, spatial orientation is sensed by the combination of vision, muscle sense, and specialized organs in the inner ear that sense accelerations and position. Vision is the strongest of the orienting senses. However, in a whiteout or when flying in cloud, it is sometimes impossible to orient oneself by reference to the horizon. Under these conditions, the pilot is completely dependent upon the flight instruments and learned flying skills for control of the aircraft. Under no circumstances should the pilot rely upon his senses alone for orientation.

Although the organs of balance in the inner ear give useful information on the ground, they can give rise to dangerously false information in the air. For example, once a turn has been entered and is being maintained at a steady rate, the sensation of turning will disappear. Upon recovering from the turn, pilots may feel as though they are turning in the opposite direction and erroneously re-enter the turn, even causing the aircraft to enter into a spin or a spiral. This has been responsible for many accidents. False impressions of position may also be encountered if pilots align the aircraft with a sloping cloudbank or when the horizon is distorted or apparently bent by the Northern Lights. The rule of survival when disorientated is RELY ON YOUR FLIGHT INSTRUMENTS!

In their training, all pilots should be exposed to disorientation by their instructors and should have had experience in recovering from unusual attitudes. Such experience will help overcome subsequent, unexpected instances of disorientation. Pilots without instrument flight training must maintain a visual horizon at all times and should never flight plan VFR into areas where bad weather or low visibility may be encountered. An instrument rating does not prevent disorientation, but the training required to obtain the rating provides the pilot with the ability to overcome it.

3.8 FATIGUE

Fatigue slows reaction time, reduces concentration and leads to errors of attention. The most common causes are insufficient rest, lack of sleep, and overexertion. Fatigue can also be aggravated by other stresses such as business pressures and financial or family problems as well as common illnesses, such as anaemia, sleep apnoea, influenza, and head colds. Pilots should be aware of the subtle effects that acute or chronic fatigue can have on motor skills and judgement, and avoid flying when either of these are present. Pilots should also practice good sleep hygiene to prevent fatigue. Pilots who find that they are often troubled by fatigue or drowsiness, even while not flying, should see their health-care provider for a thorough medical evaluation.

Boredom and fatigue aggravate each other. One method of overcoming boredom is to keep busy by making frequent ground-

speed and fuel-consumption checks, and staying mentally active. Planning for diversion to alternates or studying relevant airfield charts are also helpful.

3.9 ALCOHOL

Never fly while under the influence of alcohol. It is best to allow at least 24 hours between the last drink and take-off time. Alcohol is selectively concentrated by the body into certain areas and can remain in the fluid of the inner ear even after all traces of alcohol in the blood have disappeared. This accounts for the difficulty in balance that is experienced in a hangover. Even small amounts of alcohol (0.05 percent) have been shown in simulators to reduce piloting skills. The body metabolizes alcohol at a fixed rate and no amount of coffee, medication or oxygen will alter this rate. ALCOHOL AND FLYING DO NOT MIX.

If you find that you are drinking excessively or encountering problems related to alcohol, you must refrain from flying and seek assistance. Transport Canada has a policy and pathway to return to flying with the appropriate treatment and monitoring. Early intervention and active engagement are best for long-term success.

3.10 MEDICATIONS, NATURAL HEALTH PRODUCTS, CANNABIS, AND OTHER RECREATIONAL DRUGS

Taking medicine in any form immediately before or while flying can be hazardous. Over-the-counter medications, including sedating antihistamines, herbal remedies (also known as natural health products), cough medicines, sleeping pills, and appetite suppressants may cause drowsiness, decrease mental alertness, and seriously impair the judgment and coordination needed by the pilot. A condition for which medicine is required may impair a pilot's proficiency, even though the symptoms are masked by medicine. Unless cleared by a Civil Aviation Medical Examiner (CAME), pilots should not fly under the influence of prescription or over-the-counter drugs or herbal remedies any more than they should fly under the influence of alcohol.

Air traffic controllers may be particularly susceptible to sedative side effects due to the need to perform repetitive tasks over prolonged periods, often in a low-light environment. The same restrictions applied to the pilot must be observed. Additionally, since controllers are more likely to report for work while suffering from a cold than pilots are, the effects of over-the-counter treatments must be stressed.

It should go without saying that recreational drug use has no place in aviation and illicit drug use may result in the refusal to issue, refusal to renew, or suspension of a medical certificate.

Cannabis became legal, for both recreational and medical purposes, in Canada in October 2018 by virtue of the *Cannabis Act*. On June 3, 2019, Transport Canada announced the Civil Aviation Medicine Cannabis Policy (<<https://tc.canada.ca/en/aviation/general-operating-flight-rules/better-pilot-decision-making/cannabis-legalization>>).

Transport Canada defines “cannabis use” as the use of any cannabis product, including cannabidiol (CBD), by any method

(including smoking, vaping, eating or applying to the skin) for any purpose (including medical, recreational or other non-medical reasons).

Whether it is used recreationally or medically, cannabis has the potential to cause impairment and adversely affect aviation safety.

All pilots, flight engineers, and air traffic controllers must abstain from cannabis use for at least 28 days before reporting for duty. The 28-day cannabis prohibition policy provides an additional layer of safety to existing approaches which requires no impairment, no diagnosis of a substance use disorder, no patterns of problematic substance use likely to affect aviation safety, and no cannabis use in the last 28 days.

This policy neither prevents Canadian air operators from implementing more stringent prohibitions for their employees nor removes the responsibility from aviation industry employers and employees to ensure that all personnel are fit for duty at every duty interval. Flight crew and controllers must continue to self-ground in the event that they might not be fit for duty. Pilots, flight engineers, and air traffic controllers are also responsible for complying with the applicable laws or regulations of other countries where they might operate.

The cannabis policy is subject to change based on new research and information on cannabis that may emerge.

NOTE:

The regulation specific to the use of alcohol or drugs by crew members is included in the RAC chapter, Annex 2.0, *Canadian Aviation Regulations*, 602.03 (<<https://lois-laws.justice.gc.ca/eng/regulations/SOR-96-433/FullText.html#s-602.03>>).

3.11 ANAESTHETICS

Questions are often asked about flying after anaesthetics. With spinal or general anaesthetics, or with serious operations, pilots should not fly until their doctor says it is safe to do so. It is difficult to generalize about local anaesthetics used in minor operations or dental work. Allergic reactions to these, if they occur, are early and by the time the anaesthetic has worn off the risk of side effects has passed. However, after extensive procedures (such as the removal of several wisdom teeth), common sense suggests waiting at least 24 hr before flying.

3.12 BLOOD DONATION

In a completely healthy individual, the fluid reduction caused by donating one unit of blood is replaced within several hours. In some people, however, the loss of blood causes disturbances to the circulation that may last for several days. While the effects at ground level are minimal, flying during this period may entail a risk. Generally, active pilots should not donate blood, but if blood has been donated they should wait at least 48 hr before flying.

3.13 IMMUNIZATIONS

After receiving routine immunizations, such as flu shots or tetanus shots, pilots should remain at the clinic for the amount of time recommended by their health-care provider. In general,

this ranges from 15 to 30 min after the immunization. If the pilot feels well and there is no evidence of an adverse reaction, they may resume flying immediately without restriction. If they feel unwell or experience an adverse reaction, they should wait for 24 hr and be assessed by a health-care provider prior to flying. The Civil Aviation Medicine Branch will monitor any new immunization developments and guidelines, and recommendations will be provided as needed.

3.14 PREGNANCY

Pilots may continue to fly up to 30 weeks into their pregnancy, provided the pregnancy is normal and without complications. However, there are certain physiological changes that may affect flight safety, and the foetus may be exposed to potentially hazardous conditions. Pilots should be aware of the hazards so that they can make informed decisions on whether they choose to fly or not.

As soon as a pilot realizes that she is pregnant, she should seek prenatal care from a qualified physician or midwife and she should ensure that her maternity-care provider is aware that she is a pilot. Should problems develop with the pregnancy before the 30th week, the Regional Aviation Medical Officer (RAMO) must be notified.

In the first trimester, nausea and vomiting are common and may be worsened by turbulence, engine fumes and G forces. In the first and second trimester, there is an increased likelihood of fainting, but this is uncommon in a sitting position. However, G tolerance may be reduced. A relative anaemia may occur after the second trimester and may affect the pilot's susceptibility to hypoxia. Hypoxia is not a problem for the foetus below 10 000 ft ASL (3 050 m).

Cosmic radiation is of particular concern because of the unborn child's susceptibility to ionizing radiation. Dose equivalent is the measure of the biological harmfulness of ionizing radiation, and the present international unit of dose equivalent is the sievert (Sv). One sievert is equal to 1 000 millisieverts (mSv). The current recommendation is that the foetus should be exposed to no more than 1 mSv during the entire pregnancy, and no more than 0.5 mSv in any given month of pregnancy. For comparative purposes, the recommended annual limit for occupational ionizing radiation exposure for an adult is 50 mSv, with a 5-year average of no more than 20 mSv per year.

Cosmic radiation is greater at the poles than at the equator and increases with altitude. On transpolar flights at 41 000 ft ASL (12 505 m), the estimated exposure is about 0.012 mSv/h, although in a solar flare this can increase by a factor of 10. The exposure at the equator is about one-half of this. A flight from Athens to New York at 41 000 ft ASL (12 505 m) would expose a pilot to approximately 0.09 mSv. A pilot flying 500 hours per year at 35 000 ft ASL (10 675 m) between 60° and 90° latitude would be exposed to 1.73 mSv annually. Although the radiation risk to the foetus is small, it does still exist. The decision to expose the foetus to this minimal degree of radiation rests with the pilot. In general, flying shorter flights at lower latitudes will decrease exposure to ionizing radiation. Further information can be obtained from the Regional Medical Office or from the

FAA Advisory Circular (AC) 120-61B, dated November 21, 2014: <https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1026386>.

Pilots with a normal pregnancy are considered temporarily unfit and should cease flying after the 30th week of pregnancy. The pilot may resume her flying privileges six weeks after delivery if there are no significant medical issues. A brief medical report from her attending physician should be forwarded to the RAMO. Air traffic controllers may work until the onset of labour, and may resume their duties six weeks after delivery. A medical report of fitness should be forwarded to the regional office.

3.15 POSITIVE AND NEGATIVE G

Many pilots think that unless they are performing aerobatics, knowledge about acceleration (G) is unnecessary. However, this force affects pilots in all aircraft—from the smallest ultralight to the biggest jet.

3.15.1 What is G?

G is the symbol for the rate of change of velocity and so represents both a force and a direction. The most common example is the force of gravity (g), which is 32 ft/s². This means a body in a vacuum would fall at a speed that increases by 32 ft/s in each second of the fall. By international convention, G is described in three planes relative to the body. These are transverse (G_x), lateral (G_y), and longitudinal (G_z) (see Figure 3.1).

Convention also requires an indication of whether the force is positive (+) or negative (-). For example, acceleration from the feet to the head is positive G_z and from the head to the feet is negative G_z. The effect of acceleration on the body is due to the displacement of blood and tissues. It is important to realize that the displacement is caused by the inertia of the tissues and this will be opposite in direction to the acceleration force. If you were fired into the air from a cannon, the acceleration would be upward, but inertia would result in a relative downward displacement of your organs and blood.

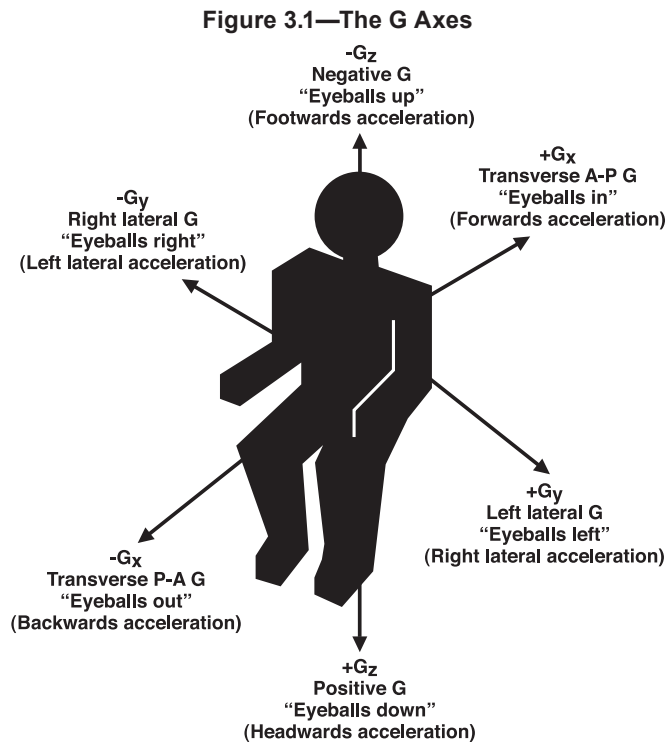
Only G_x and G_z are of practical significance to civilian pilots and the most significant result of G_x is disorientation; thus, when we speak of positive or negative G, we are referring to G_z unless otherwise noted.

3.15.2 The Effects of G

G tolerance varies greatly with the individual. Because the symptoms are caused by the displacement of blood and tissues, we would expect that a pilot with good muscle tone would have a better tolerance. This is correct. Tolerance is lowered by obesity, ill health, low blood pressure, pregnancy and many medications. It may vary from day to day in relation to fatigue, smoking, hypoxia or hangovers.

In absolute figures, G tolerance is affected by the peak value, the duration of the G force and the rate of onset. If the rate of onset is very high, positive G can result in unconsciousness, known as G-loss of consciousness (G-LOC), without any other symptoms.

The increased weight of limbs and organs interferes with movement, and forces greater than +3G make it almost impossible to escape from an aircraft in uncontrolled flight. Fine movements are less affected. Heavy equipment such as a protective helmet can cause problems with increasing G. At about +6G a pilot's head would be flexed on the chest by the increased weight of a crash helmet.



The most serious effect of positive G is the draining of blood away from the head toward the feet, causing (stagnant) hypoxia of the brain; the first symptom is vision deterioration. As G forces are experienced, the blood pressure to the retina decreases because the weight of the column of blood between the heart and the eye (and therefore the work of the heart) increases. Therefore, the retinal blood supply decreases. Vision, beginning in the periphery, starts to become dim and colourless; this is called "grey-out." As the G forces increase further, the blood flow in the back of the eye will be completely interrupted and "black-out" (temporary loss of vision) will occur, although the pilot remains conscious. There is a delay of 5–7 s between the onset of G and the visual changes because of the oxygen dissolved in the fluids of the eyeball. If G forces stabilize, there may be an improvement in the visual symptoms after 10–12 s because the body's reflexes automatically increase blood pressure.

Grey-out begins at about +2G and black-out is usually complete at +4G in the relaxed, unprotected pilot. As the G force increases, hypoxia of the brain develops and consciousness is usually lost in the unprotected pilot at over +6G (G-LOC). When the G forces decline, consciousness is quickly recovered, but there is always a brief period of confusion on awakening.

Negative G is poorly tolerated. Here, because the acceleration is from feet to head, blood pressure in the eyes and the brain is increased so "red-out" (a red haze in the vision) is experienced. Negative G in excess of -5G may cause rupture of small blood vessels in the eyes and prolonged negative G may cause brain damage. Negative G is experienced in a push-over or "bunt" and in an outside loop.

Transverse G is well tolerated; this is why astronauts recline on blastoff. Levels of up to +50 G_x can be tolerated for short intervals without tissue damage, although the acceleration interferes with breathing. In current aircraft, G_y is not a significant problem.

3.15.3 G Straining Manoeuvres

Valsalva's manoeuvre consists of bearing down against a closed glottis (the trap door between the throat and chest) while holding the nose. The same procedure, without holding the nose but with the mouth held closed, elevates the blood pressure and increases G tolerance temporarily. This manoeuvre is widely used by acrobatic pilots and may increase G tolerance by about +2G. Valsalva's manoeuvre is the original anti-G straining manoeuvre, but it is difficult to maintain.

3.15.4 Dealing with G

G tolerance is affected by diet and good physical conditioning. High tolerance requires adequate hydration and normal blood sugar; hypoglycaemia (low blood sugar) markedly lowers tolerance. Tensing the muscles in the calves and thighs to reduce blood pooling and squatting down in the seat or leaning slightly forward while tensing the abdominal muscles, all reduce the distance between the heart and the brain and increase blood pressure. Physical training can be beneficial, but pilots who wish to develop high G tolerance do best with a weight-lifting program rather than intensive aerobic training. Moderate aerobic training—20–30 min daily—and running distances less than 5 km is helpful, but long-distance running decreases G tolerance by slowing the resting heart rate, which increases the chance of sudden loss of consciousness (G-LOC). A well-trained, experienced pilot can tolerate up to 9G for as long as 30 s, but there is a lot of individual variation. Acrobatic pilots who regularly fly high G manoeuvres develop high tolerance, but quickly lose it if they are no longer exposed.

4.0 MISCELLANEOUS

4.1 AIR TIME AND FLIGHT TIME

Air Time is the period of time commencing when the aircraft leaves the supporting surface and terminating when it touches the supporting surface at the next point of landing.

Flight Time is the total time from the moment an aircraft first moves under its own power for the purpose of taking off until the moment it comes to rest at the end of the flight. This should be recorded in all Pilot Log Books.

NOTE:

Air Time and Flight Time should be recorded to the nearest 5 minutes, or to the nearest 6 minutes when using the decimal system as follows:

Table 4.1—Rounding of Air Time and Flight Time

0 to 02 = .0	03 to 08 = .1	09 to 14 = .2
15 to 20 = .3	21 to 26 = .4	27 to 32 = .5
33 to 38 = .6	39 to 44 = .7	45 to 50 = .8
51 to 56 = .9	57 to 60 = 1.0	

4.2 CONDUCT OF EXPERIMENTAL TEST FLIGHTS

The C of A requires that aircraft be maintained and operated in accordance with the aircraft type certificate, Weight and Balance Report and Aircraft Flight Manual. If, for test demonstration or experimentation, an aircraft is to be flown outside of the approved Aircraft Flight Manual envelope, with unapproved equipment installed, with equipment intentionally disabled, or with inoperative equipment not covered by an approved Minimum Equipment List or maintenance deferral action, the C of A will be invalid. In these cases, flights may only be authorized through a Flight Permit issued by TC.

It must be emphasized that experimentation beyond the limitations imposed by the aircraft certification documentation (type certificate, C of A, Aircraft Flight Manual, Minimum Equipment List) may be hazardous as it can reduce the safety margins designed into the aircraft and, thus, jeopardize the safety of the crew. Consequently, experimental or developmental flight testing should normally be conducted only under controlled conditions by specifically qualified aircrew after adequate engineering analysis and planning have taken place.

Before a test flight, the determinations of the conditions and limits of testing, normal and emergency procedures specific to the test, and expected aircraft handling characteristics are essential if risks are to be minimized. If companies or individuals wish to conduct a flight test program, they should apply for a Flight Permit and consult with the aircraft manufacturer and TC, who can help them to assess the risks and their capability to conduct the tests safely.

Careful planning, covering all foreseeable exigencies, is critical to safe testing.

4.3 PRACTICE SPINS

Intentional practice spins conducted at low altitudes have resulted in fatal accidents. All practice spin recoveries should be completed no less than 2 000 feet AGL, or at a height recommended by the manufacturer, whichever is the greater.

4.4 CARGO RESTRAINT

4.4.1 General

Regulations, guidelines, and references have been established to assist commercial air carriers to obtain appropriate airworthiness approval and develop suitable operational procedures to ensure adequate restraint for cargo in aircraft.

4.4.2 Regulations

Canadian Aviation Regulations (CARs) 602.86, 703.37, 704.32, and 705.39 and the associated standards, govern the requirement for proper weight and balance procedures to ensure the load is properly distributed in accordance with the C of A or flight permit.

The intent of these regulations is to ensure that the loading and restraint of cargo are such that the aircraft conforms to a configuration which is in compliance with the applicable airworthiness standards at all times. If the approved C of G or floor load limits are not adhered to the aircraft is unairworthy. Similarly, if the configuration of the restraint system does not meet the standards of the basis of certification or approval for the aircraft type, the aircraft is also unairworthy.

In this context it should be understood that the term “flight” includes all phases of operation of the aircraft including the applicable emergency landing conditions. These emergency landing conditions are defined in the various airworthiness standards and are an integral part of any basis of certification or approval.

4.4.3 Guidelines

Aircraft data is normally considered to be material provided by the aircraft manufacturer, and should include identification of hardpoints, floor loads, C of G travel and related limits. Capacity of hardpoints and floor loads takes into account the properly factored gust, manoeuvre and emergency landing loads specified in the type approval of the aircraft.

The air carrier, through his flight crew and persons responsible for loading aircraft, must ensure that the cargo, as loaded, does not cause the aircraft to be unairworthy. Examples of typical loads and capacities may be provided by the aircraft manufacturer, given the calculated strength of ropes, belts, nets and containers. Unusual loads (pipe lengths, drill rod, fuel barrels, etc.) present unique problems and are likely to require specific approval of the restraint system. Where doubt exists as to the adequacy of the proposed method of restraint, the air carrier must submit a substantiating load and strength analysis to the Regional Manager of Airworthiness for engineering approval against the requirements of the aircraft certification or approval basis.

4.4.4 References

The air carrier is responsible to acquire and review the following Cargo Restraint Reference Material prior to submitting application to a region.

- Airworthiness Manual, Chapters
 - 523.561
 - 525.561
 - 527.561
 - 529.561
 - 523.787
 - 525.787
 - 527.787
 - 599.787
- FAA Advisory Circular 43.13-2A (a general guide useful in preparing initial application to the RMA for engineering approval. It includes critical static test load factors for FAR 23, 25, 27 and 29 aircraft)
- FAA Advisory Circular 121-27
- CAR 3.392 Cargo Compartments
- CAR 4b.359 Cargo Compartments
- FAR 23.787 Cargo Compartments
- FAR 25.787 Stowage Compartments
- FAR 27.787 Cargo and Baggage Compartments
- FAR 29.787 Cargo and Baggage Compartments
- FAR 91.203 Carriage of Cargo
- FAR 121.285 Carriage of Cargo in Passenger Compartments
- FAR 121.287 Carriage of Cargo in Cargo Compartment
- ICAO/IATA Training Manual, Book 4, Load Planners and Cargo Handlers

4.4.5 Approval

Because of the magnitude in variety, the complexity of cargo loads and the aircraft restraints involved, the following is only a generalized approval process and requires review by the Regional Managers, Aircraft Maintenance and Commercial and Business Aviation.

The carrier (applicant) reviews the preceding regulations, aircraft data and reference material, relates that to type(s) of aircraft involved and submits application to the Regional Manager, Aircraft Maintenance for engineering approval. (Application includes manufacturer's aircraft data and type approval or certificated data, sample typical loads and proposed methods of restraint.)

Concurrently, the carrier submits an application to the Regional Manager, Air Carrier concerning operational procedures for each aircraft type involved (including training) in an amendment to the Operations Manual.

Following joint review, the Regional Manager, Aircraft Maintenance may issue engineering approval of the application and the Regional Manager, Commercial and Business Aviation may process the Operations Manual amendment. These are then both forwarded to the carrier. The air operator issues the amendment to the Operations Manual.

4.5 COLLISION AVOIDANCE – USE OF LANDING LIGHTS

Several operators have for some time been using a landing light(s) when flying at the lower altitudes and within terminal areas, both during daylight hours and at night. Pilots have confirmed that the use of the landing light(s) greatly enhances the probability of the aircraft being seen. An important side benefit for improved safety is that birds seem to see aircraft showing lights in time to take avoidance action. Therefore, it is recommended that all aircraft show a landing light(s) during the takeoff and landing phases and when flying below 2000 feet AGL within terminal areas and aerodrome traffic zones.

4.6 USE OF STROBE LIGHTS

The use of high intensity strobe lights while taxiing or awaiting takeoff holding short of the active runway can be very distracting, particularly to pilots in the final stages of approach or during the initial landing phase.

It is recommended that high intensity strobe lights not be used while the aircraft is on the ground when they adversely affect ground personnel or other pilots. Circumstances permitting, high intensity strobe lights should be activated anytime the aircraft is occupying an active runway, including awaiting takeoff clearance while holding on the active runway. They should be extinguished after landing once clear of the active runway.

High intensity strobe lights should not be used in-flight when there is an adverse reflection from clouds or other weather phenomena.

4.7 MANNED FREE BALLOON OPERATIONS

Pilots and owners of balloons, like all other aircraft pilots and owners, must comply with the CARs with respect to crew licensing, aircraft registration and operating procedures.

4.7.1 Balloon Operations with Fare-Paying Passengers

CAR 603.17 states, "No person shall operate a balloon under this Division unless the person complies with the provisions of a special flight operations certificate - balloons issued by the Minister pursuant to Section 603.18."

To qualify for a special flight operations certificate to permit the operation of balloons with fare-paying passengers, operators must:

- (a) maintain balloons in accordance with the requirements of CAR 605;
- (b) ensure that the balloons are properly equipped for the area and type of operation; and
- (c) employ flight crew members who meet the requirements of CAR 623.21, namely, who:
 - (i) are at least eighteen years of age,
 - (ii) hold a Balloon Pilot Licence issued by Transport Canada,

- (iii) hold a Medical Certificate, Category 1 or 3,
- (iv) have accumulated a minimum of 50 hours flight-time in untethered balloons or are the holder of a Canadian Balloon Licence with a valid Flight Instructor Rating - Balloon Category, and
- (v) demonstrate annually a satisfactory level of knowledge and ability to perform normal and emergency operating procedures on the specific AX class of balloon to be operated.

4.8 PARACHUTE JUMPING/SKYDIVING

Parachuting or skydiving is a high-risk activity that can result in death or serious injury. As such, any individual participating in this activity must take full responsibility for their personal safety.

Transport Canada **does not** regulate the sport of parachuting directly. Transport Canada **does not** regulate or have licensing or certification requirements for parachute equipment, parachute packers/riggers, parachuting instructors or coaches.

It is strongly recommended that persons participating in parachuting activities be conversant with the procedures and standards established by associations representing parachuting activities. In Canada, that association is:

Canadian Sport Parachuting Association (CSPA)
 204-1468 Laurier Street
 Rockland ON K4K 1C7
 Tel.: 613-419-0908

Transport Canada regulations pertaining to parachuting are in place to ensure the safety and efficiency of the air navigation system in which parachuting takes place and to ensure the safety of persons and property on the ground.

CAR 602.26 states, “Except where permitted in accordance with section 603.37, no pilot-in-command of an aircraft shall permit, and no person shall conduct, a parachute descent from the aircraft

- (a) in or into controlled airspace or an air route; or
- (b) over or into a built-up area or an open-air assembly of persons.”

CAR 603.37 states, “... a pilot-in-command may permit and a person may conduct a parachute descent under this Division if the person complies with the provisions of a special flight operations certificate - parachuting issued by the Minister pursuant to Section 603.38.”

4.9 HANG GLIDER AND PARAGLIDER OPERATIONS

Hang gliders and paragliders are not required to be registered or to bear identification marks. There are no airworthiness standards or requirements imposed by the CARs. The CARs do not impose any training requirements for hang glider or paraglider pilots, and the regulations do not require these pilots to hold any pilot licence or permit to operate their aircraft. There is, however, a requirement to successfully complete a written examination before piloting hang gliders and paragliders in controlled airspace. Section 602.29 of the CARs outlines airspace

requirements for hang gliders and paragliders. Hang glider operators may use an ultralight aeroplane to tow a hang glider. Before doing so, these operators are required to notify Transport Canada.

The Hang Gliding and Paragliding Association of Canada (HPAC) has developed standards for pilot ratings, competitions, setting records, safety procedures and reporting, as well as for solo and two-place pilot instruction. Information regarding HPAC operations and procedures may be obtained from:

Margit Nance
 Executive Director
 Hang Gliding and Paragliding Association of
 Canada (HPAC)
 308-1978 Vine Street
 Vancouver BC V6K 4S1
 E-mail: admin@hpac.ca
 Tel.: 877-370-2078

4.10 ULTRA-LIGHT AEROPLANE

Pilots interested in flying ultralight aeroplanes or advanced ultralight aeroplanes are encouraged to contact their Transport Canada regional office for information on regulation and licence requirements. See GEN 1.1.1 for addresses and telephone numbers.

Pending amendment of the CARs, the *Ultra-light Aeroplane Transition Strategy* outlines requirements for the operation of ultralight aeroplanes in Canada. This document can be obtained from Transport Canada offices or viewed online at: <www.tc.gc.ca/eng/civilaviation/standards/general-recavi-ultralight-menu-2457.htm>.

A copy of the *Study and Reference Guide—Pilot Permit—Ultra-light Aeroplane* (TP 14453E) is available at: <www.tc.gc.ca/eng/civilaviation/publications/menu.htm>.

4.11 CIRCUIT BREAKERS AND ALERTING DEVICES

Automatic protective devices (circuit breakers) are provided within aircraft systems to minimize distress to the electrical system and hazard to the aircraft in the event of wiring faults or serious malfunction of a system or connected equipment. Alerting devices provide the pilot with a visual and/or aural alarm to direct the pilot’s attention to a situation that may require an immediate intervention by the pilot.

Good operating practices suggest a popped circuit breaker can indicate that there is a potential problem being protected. The practice of attempting one reset should only be considered if the equipment rendered unusable is considered essential for the continued safety of the flight. Depending on the amperage of the circuit breaker and its location within the circuit being protected, resetting a popped circuit breaker may create a more adverse situation than simply leaving the circuit breaker out. Indiscriminately resetting popped circuit breakers should be avoided.

Crew members are cautioned against pulling circuit breakers on board an aircraft in order to silence an alerting or warning

device that may in fact be providing a valid warning or alarm. Examples of such alarms include landing gear warning horn with certain flap/slat combinations, overspeed warnings, ground proximity warning system alerts and washroom smoke detectors. Deactivating the alerting or warning device by pulling circuit breakers compromises or may compromise the safety of flight. Exceptions would be acceptable for an obvious malfunction resulting in continuous erroneous warnings. In these cases, a defect entry in the aircraft journey log book must be made.

4.12 DESIGN EYE REFERENCE POINT

Some aircraft manufacturers provide reference points which the pilot uses while making the seat adjustments. These reference points could be something as simple as two balls affixed to the glare shield which the pilot must line up visually. In a two-pilot aircraft the reference points could be formed by three balls in a triangle and each pilot would adjust the seat until the respective reference balls line up. The intent, of course, is to have the pilot adjust the seat in order for the eyes of the pilot to be at the optimum location for visibility, inside and outside the cockpit, as well as the correct position for access to the cockpit switches and knobs. The engineering that results in the manufacturer placing these balls on the glare shield is called ERGONOMICS. This optimum position for the pilot's eyes is referred to as the Design Eye Reference Point.

If there is no information on the design eye reference point in the aircraft operating manual, then it is suggested that the pilot could write the manufacturer and request the information. Failing that, the following guidelines should be considered when attempting to locate the correct seat placement (height, as well as fore and aft placement):

- all flight controls must be free of restriction throughout the full travel of the controls;
- flight instruments and warning lights must be visible to the pilot without being obscured by items such as the top of the glare shield;
- forward out-of-the-cockpit visibility should be sufficient to ensure that things such as the nose of the aircraft do not block the view of the pilot, especially during a normal approach and landing; and
- the chosen seat position should be comfortable for the pilot.

4.13 FIRST AID KITS ON PRIVATELY OWNED AND OPERATED AIRCRAFT

CAR 602.60 requires a first aid kit to be carried on board every power-driven aircraft, other than an ultra-light aeroplane. For a list of recommended items that should be carried in a first aid kit on board aircraft that are privately owned and operated, refer to Part 9—First Aid of the *Aviation Occupational Health and Safety Regulations* (SOR/2011-87). <<https://laws-lois.justice.gc.ca/eng/regulations/sor-2011-87/page-10.html#h-781458>>

4.14 SURVIVAL ADVISORY INFORMATION

A basic survival manual should be carried, appropriate to the area of flight.

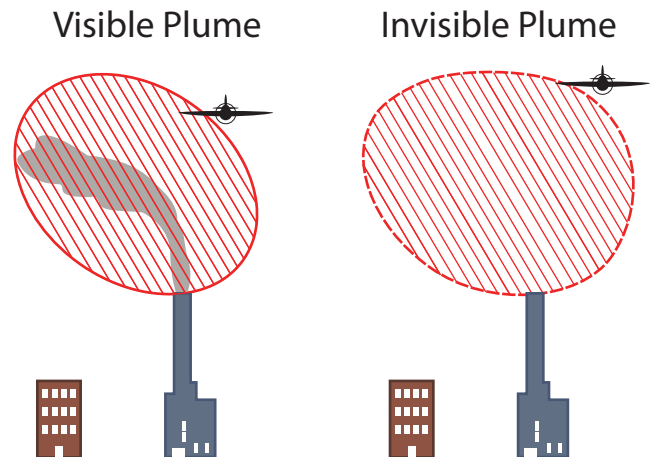
Private pilots should obtain some training in certain aspects of survival if they have never spent time in the bush in winter or summer. Those planning to fly above the tree line should obtain more specialized training.

Locating and saving people in aeronautical emergencies has been greatly improved by the changes implemented by the SARSAT/COSPAS members. Today the SARSAT/COSPAS system provides global detection capability by satellite. The improvements in reliability of ELTs in conjunction with the global application SARSAT/COSPAS systems has greatly increased the chances of early detection and location of crash survivors. The carriage of food is no longer a critical item in survival and is left as a personal choice of the individual operator. (See *AIP Canada* GEN 1.5)

4.15 POTENTIAL FLIGHT HAZARDS FOR AIRCRAFT

4.15.1 Avoid Flight in the Vicinity of Exhaust Plumes

Figure 4.1—Visible and Invisible Plumes



Exhaust plumes are defined as visible or invisible emissions from power plants, industrial production facilities or other industrial systems that release large amounts of vertically directed unstable gases. High temperature exhaust plumes may cause significant air disturbances, such as turbulence and vertical shear. Other identified potential hazards include, but are not necessarily limited to, reduced visibility, oxygen depletion, engine particulate contamination, exposure to gaseous oxides, and/or icing.

When able, pilots should fly upwind of possible exhaust plumes. Encountering a plume may result in airframe damage, aircraft upset, and/or engine damage/failure. These hazards are most critical during low altitude flight in calm and cold air, especially in and around approach and departure corridors or in airport traffic areas.

When a plume is visible via smoke or a condensation cloud, remain clear and realize that a plume may have both visible and

invisible characteristics. Exhaust stacks without visible plumes may still be in full operation, and airspace in the vicinity should be treated with caution. As with mountain wave turbulence or CAT, an invisible plume may be encountered unexpectedly.

Whether plumes are visible or invisible, the total extent of their turbulent effect is difficult to ascertain. Some studies predict that the significant turbulent effects of a thermal plume can extend over 1 000 ft above the top of the stack or cooling tower. Any effects will be more pronounced where the plume is very hot and the surrounding air is calm, stable and cold. Fortunately, studies also predict that crosswinds help dissipate the effects. However, the size of the tower or stack is not a good indicator of the plume's predicted effect. The effects are primarily related to the heat or size of the plume effluent, the ambient air temperature, and the wind speed affecting the plume. Smaller aircraft can expect to be affected at a higher altitude than heavier aircraft.

Pilots are encouraged to reference the CFS for the location of structure(s) emitting exhaust plumes, such as cooling towers, power plant stacks, exhaust fans and other similar structures.

Pilots encountering hazardous plume conditions should report time, location and intensity (light, moderate, severe or extreme) to the facility with which they are maintaining radio contact.

4.15.2 Pilot Procedures When Exposed to Laser and Other Directed Bright Light Sources

4.15.2.1 General

Directed bright light sources projected near airports or into any navigable airspace can cause potential flight control disruptions and/or eye injury to pilots, crew members, and passengers. The number of laser illuminations affecting aircraft has significantly increased during the past few years. In particular, the number of laser incidents reported involving law enforcement helicopters has substantially increased.

Canada and the USA have both recorded numerous instances of laser exposures that have been disruptive to flight operations. Flight crews may be startled; they may be affected by glare, flash blindness and/or afterimage due to laser occurrences.

Directed bright light sources, particularly laser beams, projected near airports or into any navigable airspace can cause two flight safety concerns:

- (a) The primary concern is when non-injurious, bright, directed light unexpectedly enters the cockpit. Depending on the brightness level, the light could startle (a) flight crew member(s); cause glare, making it difficult to see out the windscreen; or cause temporary vision impairment (flash blindness and/or afterimage). The illumination and glare may be short—one or a few bright flashes—but the startle and afterimage effects could persist for many seconds or even minutes.
- (b) A secondary concern is a laser beam so powerful that it causes temporary or permanent eye injury to pilots, crew members, or passengers. Fortunately, this is only a remote possibility because the laser power required to cause eye

injury greatly exceeds that of lasers in common use today.

Therefore, the most likely in-flight safety hazard is a bright non-injurious flash causing disruption in the cockpit workflow. This disruption poses significant flight safety hazards when the cockpit workload increases below 10 000 ft AGL, such as during critical phases of flight (approach and landing); in dense traffic areas (terminal environment and en route areas); and in proximity to airports.

Even laser pointers can cause pilots to become distracted from their immediate tasks. Reports of pilots exposed to persons using laser pointers have been increasing in number. Pilots flying law enforcement helicopters have been particularly targeted by lasers.

4.15.2.2 Procedures

The primary purpose of this subsection is to outline preventive measures and incident procedures that pilots can follow to either prevent potential illuminations or minimize cockpit disruption. For simplicity, the following procedures refer to laser illumination incidents; however, the same procedures should be applied regardless of the source, whether it is a laser or any other directed bright light, such as a searchlight.

4.15.2.2.1 Preventive Procedures

During aircraft operations into navigable airspace where laser illuminations are anticipated, flight crews should:

- (a) Consult NOTAMs for temporary laser activity. The NOTAM should include the location and time of the laser operations.
 - Avoid known permanent laser displays (e.g. Disney World). In the USA, these sites are published in the *Airport/Facility Directory*, a Federal Aviation Administration (FAA) publication available at <www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/>. Currently, there is only one permanent laser display site in Canada, located at the Shaw Millennium Park in Calgary, Alta., (510258N 1140530W 5 NM SW AIRPORT) but it is only being used for special events (e.g. Canada Day). A NOTAM is published on those specific days.
- (b) Turn on additional exterior lights to help ground laser safety observers locate the aircraft, so they can respond by turning off the laser beam.
- (c) Turn on thunderstorm lights to minimize cockpit illumination effects.
- (d) Engage the autopilot.
- (e) Have one flight crew member stay on the instruments to minimize the effects of a possible illumination while in the area of expected laser activity.
- (f) Consider using notch filter eye spectacles that protect against 514- and 532-nanometre laser wavelengths, if flying a helicopter engaged in surveillance or medical evacuation.

4.15.2.2.2 Incident Procedures

If a laser beam illuminates a pilot in flight, the pilot should:

- (a) Immediately look away from the laser source or try to shield their eyes with their hand or a hand-held object to avoid, if possible, looking directly at the laser beam.
- (b) Immediately alert the other flight crew member(s) and advise them of the illumination and its effect on their vision.
- (c) If vision is impaired, immediately transfer control of the aircraft to the other flight crew member. If other flight crew members have been illuminated, engage the autopilot (if equipped).
- (d) Be very cautious of spatial disorientation effects (e.g. the leans). After regaining vision, they should check cockpit instruments for proper flight status.
- (e) Resist the urge to rub their eyes after a laser illumination, as this action may cause further eye irritation or damage.
- (f) Contact ATC and advise of a “LASER ILLUMINATION”. Use this terminology for all laser incident/accident reports. If the situation dictates, declare an emergency.
- (g) When time permits, provide ATC with an incident report that includes the laser location, direction, and beam colour as well as the length of exposure (flash or intentional tracking) and the effect on the crew.

NOTE:

To ensure that TC has sufficient information to analyze and investigate occurrences, please complete the “Directed Bright

Light Illumination Incident Report/Questionnaire” at <http://wwwapps.tc.gc.ca/wwwdocs/Forms/26-0751E_1405-03_E_X.pdf> and send the completed form to <services@tc.gc.ca>.

4.15.2.2.3 Medical Follow-up Procedures After an In-flight Illumination

A crew member who has been subjected to a significant illumination and who experiences persistent symptoms, such as pain or visual abnormalities (e.g. flash blindness and/or afterimage), should seek immediate medical attention. In addition, they should contact a RAMO or an aviation medical officer at the earliest opportunity. The medical officer will provide assistance in locating the nearest ophthalmologist or medical facility with experience in evaluating laser injuries. If outside Canada, contact the Civil Aviation Medicine Branch in Ottawa. An eye damaged by a laser beam starts to repair itself immediately. Therefore, it is strongly recommended that an ophthalmologist, familiar with laser injury examination requirements, evaluate the crew member within five hours of the exposure to determine the nature of the injury and if further follow-up action is needed.

NOTE:

Because diagnosis can be difficult, especially for medical personnel who rarely, if ever, see laser eye injuries, it should not be automatically assumed that a particular symptom, abnormality or injury was caused by a given laser exposure.

For assistance, please contact one of the following.

Table 4.2—Civil Aviation Medicine Branch Offices

HEADQUARTERS	ATLANTIC REGION
<p>Civil Aviation Medicine Transport Canada 330 Sparks Street Place de Ville, Tower C, Room 617 Ottawa ON K1A 0N8</p> <p>Tel.: 613-990-1311 Fax: 613-990-6623</p>	<p>New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador</p> <p>Civil Aviation Medicine Transport Canada 330 Sparks Street Place de Ville, Tower C, Room 617 Ottawa ON K1A 0N8</p> <p>Tel.: 1-800-305-2059 Fax: 613-990-6623</p>
QUEBEC REGION	ONTARIO REGION
<p>Quebec</p> <p>Civil Aviation Medicine Transport Canada 330 Sparks Street Place de Ville, Tower C, Room 617 Ottawa ON K1A 0N8</p> <p>Tel.: 1-800-305-2059 Fax: 613-990-6623</p>	<p>Ontario</p> <p>Civil Aviation Medicine Transport Canada 4900 Yonge Street, 4th Floor North York ON M2N 6A5</p> <p>Tel.: 1-800-305-2059 Fax: 416-952-0569</p>
PRAIRIE AND NORTHERN REGION	PACIFIC REGION
<p>Alberta, Yukon, Manitoba, Saskatchewan, Northwest Territories and Nunavut</p> <p>Civil Aviation Medicine Transport Canada 1140-9700 Jasper Avenue Edmonton AB T5J 4C3</p> <p>Tel.: 1-800-305-2059 Fax: 780-495-4905</p>	<p>British Columbia</p> <p>Civil Aviation Medicine Transport Canada 800 Burrard Street, Room 620 Vancouver BC V6Z 2J8</p> <p>Tel.: 1-800-305-2059 Fax: 604-666-0145</p>

4.16 REMOTELY PILOTED AIRCRAFT (RPA)

Remotely piloted aircraft (RPA), otherwise known as drones, have become increasingly popular over the last several years. Advances in technology have made aircraft like these a good tool for conducting inspections, taking photographs, and responding to emergencies but, like any change to a system, the introduction of remotely piloted aircraft systems (RPASs) to the National Civil Air Transportation System (NCATS) has created new risks.

To mitigate the risks associated with the growing number of RPAS operations, Transport Canada developed Part IX of the *Canadian Aviation Regulations* (CARs), which governs the use of small RPA less than 25 kg and operated within visual line of sight. Part IX of the regulations came into force on June 1, 2019, and created requirements for RPAS operations, including registration, pilot certification, and two operating environments, basic and advanced. All small RPA (250 g–25 kg) are required to be registered and marked, and all small RPA pilots are required

to write an exam and obtain an RPA pilot certificate. Advanced pilots also need to pass a flight review. Micro RPA of less than 250 g do not require registration or a pilot certificate, but they must fly in a way that does not pose a risk to aviation or people on the ground. One fundamental change from other parts of the CARs is the elimination of the distinction between commercial and recreational users. Part IX of the RPAS rules applies to every RPA pilot, regardless of the purpose of their mission.

Pilots are responsible for managing risk. RPA are a relatively new entrant into the National Civil Air Transportation System (NCATS) and have created a new risk: collisions between RPA and other aircraft. RPA pilots are responsible for remaining clear of areas where traditional aircraft are operated, but pilots of traditional aircraft should understand the operating environment that Part IX creates for RPA pilots so they can plan their flights in a way that further reduces the risks.

Here is a simplified version of the two operating environments:

Table 4.3—RPAS Operating Environment

	Basic environment	Advanced environment
Maximum altitude	400 ft AGL, or 100 ft above any building or structure, if below 200 ft horizontally	400 ft AGL, or 100 ft above any building or structure, if below 200 ft horizontally, or as approved by air traffic control (if within controlled airspace)
Controlled airspace	outside of controlled airspace	within controlled airspace with authorization**
Other airspace	outside restricted airspace outside emergency security perimeter outside special aviation event outside advertised event 3 NM from military aerodromes	outside restricted airspace outside emergency security perimeter outside special aviation event outside advertised event 3 NM from military aerodromes
Proximity to other people	more than 100 ft (30 m) away	more than 16.4 ft (5 m) away*
Over people	no	yes*
Proximity to airports	more than 3 NM	at or near airports***
Proximity to heliports	more than 1 NM	at or near heliports***
Proximity to uncertified aerodromes	at or near uncertified aerodromes	at or near uncertified aerodromes
Night operations	with sufficient position lights	with sufficient position lights

*The RPAS must meet Standard 922—*RPAS Safety Assurance* to fly near people or over people.
 **The RPAS must meet Standard 922—*RPAS Safety Assurance* to fly in controlled airspace and the pilot must have authorization from NAV CANADA.
 ***Advanced RPA pilots flying at or near certified airports and certified heliports must follow the applicable established procedure for RPAS operations

All RPA pilots, regardless of the operating environment they are in, are responsible for keeping their drone under control and within visual line of sight so that when another aircraft is detected, they will be able to take immediate action to give way. Avoiding a collision is the shared responsibility of all pilots. To further minimize the risk of collision, pilots of traditional aircraft should exercise caution when conducting flights below 400 ft AGL in uncontrolled airspace and take additional care to fly standard circuits at uncertified aerodromes because that is where other airspace users are going to expect aircraft to be.

For more information on drones and drone safety, see the Transport Canada drone safety Web site: <<https://tc.canada.ca/en/aviation/drone-safety>>.