Stan/Eval Newsletter
CIVIL AIR PATROL
UNITED STATES AIR FORCE AUXILIARY
105 S. Hansell Street
Maxwell AFB, AL 36112

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Braking Badly (Maj M. Banner, FLWG)

Brake misuse seems to be pervasive. In my experience as a CAP Check Pilot Examiner and civilian flight instructor for 20 years, I've observed many pilots misuse the aircraft's brakes. Some use excessive power while taxing, requiring the need to apply brakes continuously to help control the aircraft's speed, so-called "brake riding". Others inadvertently tap the brakes on takeoff. Immediately after landing, others have a misplaced urgency to exit the runway at the first taxiway. These pilots apply brakes at the moment of touchdown and/or apply brakes excessively after landing. Many check pilots and flight instructors remarked to me that they too have made similar observations. It is never appropriate to apply an aircraft's brakes as described above. Brake misuse may be due to a lack of understanding of how brake systems operate and their limitations, improper training, and apathy. Risk management (RM) controls (best/safest course of action) can be applied to mitigate brake misuse.

Brake system

Single, dual, and multiple disc brakes are used on different types of aircraft. The size, weight and landing speed of an aircraft influence the design and complexity of the disc brake system. Typically, many general aviation aircraft employ a single disc/rotor bolted to each main wheel. (Figs. 1 and 2) For a disc brake, as the wheel turns, so does the disc. Brakes for both main wheels are individually operated by pushing on the tops of floor-mounted rudder pedals at both pilot stations. When the top of the pedal is depressed, a piston inside a sealed fluid-filled chamber in a master cylinder forces hydraulic fluid through a line to the piston in the brake assembly. A disc brake uses calipers to squeeze pairs of pads against a disc/rotor to create friction when the brakes are applied. (Fig. 2) This action retards the rotation of an individual wheel, either to reduce rotational speed or to hold both main wheels stationary. When pressure on the tops of both brake pedals is removed, a spring in the master cylinder pushes the piston in the master cylinder back to the off position, hydraulic pressure against the brake piston is removed and a return spring or springs move the brake piston back to the off position, so the brake doesn't drag.

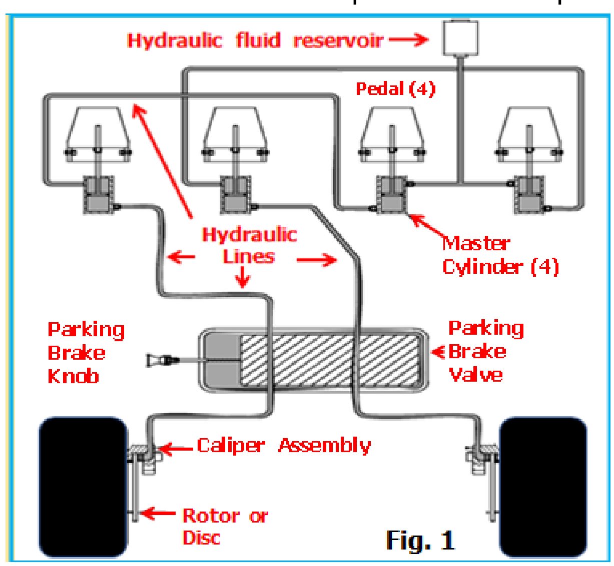

Fig. 1

A parking brake mechanism is used to hold induced hydraulic pressure on the disk brakes for parking. (Fig. 1). Some pilots incorrectly believe by simply pulling the parking brake knob the brakes will become activated, as occurs with a car. For many airplanes, setting the parking brake is a two-step process. For example, for a Cirrus SR22, first, apply brake pressure to the tops of both rudder pedals to generate hydraulic pressure within the system. Next, while holding pressure on the pedals, pull the parking brake knob; this allows poppet valves in the system to close, trapping pressure in the system and locking the brakes.

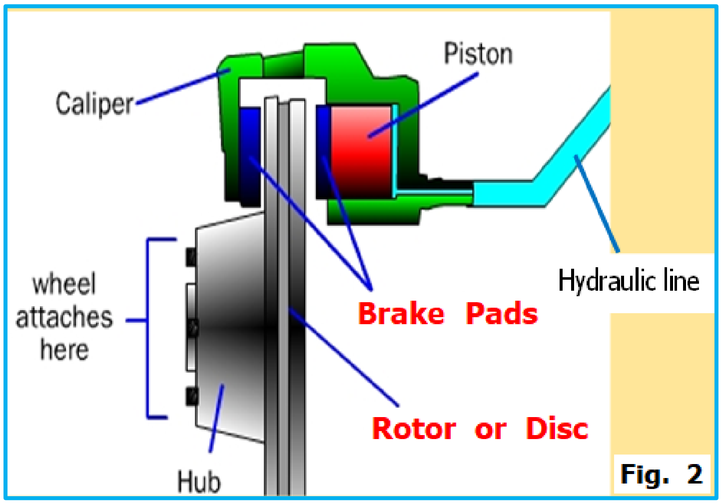

Fig. 2

Energy converters

A fundamental principle of how brakes operate is based on conservation of energy, i.e., energy is neither created nor destroyed, but can only be converted from one form to another form. Brakes may be termed as “energy converters” because they convert kinetic energy (speed/motion) into heat energy through friction between a brake pad and brake rotor/disc surface. Heat energy generated by the brakes, measured in British Thermal Units (BTU), varies directly with the aircraft’s mass (weight) and the pilot’s desired speed reduction. BTUs generated by the brake system are proportional to the amount of kinetic energy that is being converted. Kinetic energy = ½ Mass X Speed ^{2}; this means the amount of energy the brakes must convert to heat is increased significantly by doubling an airplane’s weight and quadrupled by doubling its speed! Brake heat energy is only related to the amount of kinetic energy being converted; whether the brakes are applied hard for a short time or light for a long time, the resulting heat will be the same if the desired speed reduction is the same.

As a result of the limits on how quickly heat energy can be dissipated, a brake system can sometimes build up heat faster than it can be removed. This imbalance between the heat coming into the system and the heat leaving the system is referred to as saturation. If saturation persists and the system's heat builds up to certain temperature thresholds, a brake fire may result (see brake fire below). Brakes having larger diameter rotors/discs can dissipate more heat, thus reducing the chance of overheating, while brakes with smaller diameter rotors/discs (e.g., SR20) are more predisposed to overheating if misused.

Abnormal operation

Brake fade, a reduction in stopping power that can occur after repeated or sustained application of the brakes, is associated with brake system malfunction or impending brake failure. Noisy or dragging brakes, soft or spongy pedals and excessive pedal travel characterize brake malfunction. Should any of these conditions occur at the pilot's or co-pilot's station while taxiing from the ramp to the runway, the airplane should not be flown, and the brake deficiency should be reported. *RM control: Do not taxi or land an airplane with a known brake deficiency; this is an accident waiting to happen.*

Preflight inspection

Brakes and brake systems should be evaluated during the pre-flight inspection to ensure they are free from corrosion and that all fasteners and safety wires are secure. Brake pads should have a proper amount of material remaining and be secure. Brake lines should be secure and free of signs of hydraulic fluid leaks (red colored fluid) and devoid of abrasions and cracking. Tires should also be included in all preflight inspections. The airplane may be pushed backwards a few feet while simultaneously viewing the treads for the presence of a flat-spotted or bull's-eyed tire. Landing on the exposed tire cord of a flat-spotted tire risks tire blow-out, loss of control on the ground (LOC–G), airplane damage and injuries. *RM control: If a flat-spotted tire with threads showing is found, postpone the sortie until the tire is changed.*

For some airplanes, brake temperature needs to be checked. For example, the preflight checklist for a Cirrus SR22 requires checking a brake temperature indicator sensor attached to the piston of the brake mechanism on each main wheel. This sensor can reveal if the pilot of a previous flight misused and overly heated the brakes. If overheated, the brake pads must be inspected, and O-rings may need to be replaced.

Differential braking

Brakes may be applied to the main wheels to varying degrees independent of each other; a method known as differential braking. This method may be used to assist in steering during taxiing operations. For some airplanes, a mechanical link connects the rudder pedals to the nose wheel for pivoting the wheel left or right, enabling the airplane to be steered on the ground. All our Cessna fleet has steerable nose gear reducing the need for differential braking. Differential braking can help in a turn, however. The correct procedure is to first apply pressure to the bottom of the rudder pedal in the direction of the turn, while using just enough power to taxi the airplane slowly, and, if needed, use intermittent braking by applying toe taps to the top of the pedal in the direction of the turn. For airplanes with a caster type nose wheel (wheel that swivels with no mechanism to steer, for example, Diamond DA20), differential braking and minimal power settings are applied carefully for turning. *RM control: Brakes are used to supplement directional control on the ground, and not used as the primary means for turning except for castering nose gears.*

Taxi speed

Follow manufacturer recommendations for an appropriate taxi speed. For example, the Pilots Operating Handbook for a Cessna 182 T states, “When taxiing, it is important that speed be held to a minimum . . .” (underline added). In the absence of manufacturer recommendations, follow FAA recommendations for taxi speed. As stated in the Airplane Flying Handbook (FAA – H – 8083 – 3C), “Pilots should proceed at a cautious speed . . .”, and have the “ . . . ability to stop or turn where and when desired, without undue reliance on the brakes”. RM control: Taxi speed should not be controlled by continuous application of the brakes. It is recommended to taxi no faster than a brisk walk while applying minimal power.

Brake fire

Riding the brakes while taxiing, which needlessly erodes brake pads, caused a wing fire mishap (Plane & Pilot, 2011). By employing a high-power setting and riding the brakes, the pilot of a Cirrus SR22 taxied at a quick speed (Fig. 3) from the parking area to the end of the runway for takeoff, which was 1.5 miles. As he turned the airplane onto the runway and began to align it with the centerline, the right brake failed, and he noticed smoke and flames coming from under the right wing. He reported that the airplane had been pulling to the left for several months, and he had to "drag" the right brake to taxi straight. During the taxi, he applied extra power and right brake pressure to maintain a straight taxi. The NTSB determined that the probable cause of the accident was the pilot's excessive braking during taxi that resulted in the right brake overheating and causing a fire. The pilot was also found to be negligent in operating the airplane with a known brake deficiency. Energy mismanagement may be considered as a contributing factor in this mishap, i.e., excessive taxi speed was used. RM control: While taxiing employs a lower power setting, approximately 800 RPM for most single engine airplanes, and position toes at the bottoms of the rudder pedals. (Fig. 4)

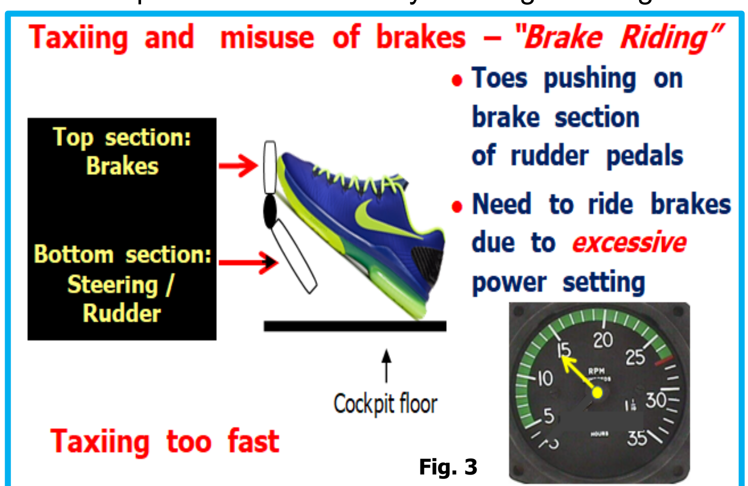

Fig. 3

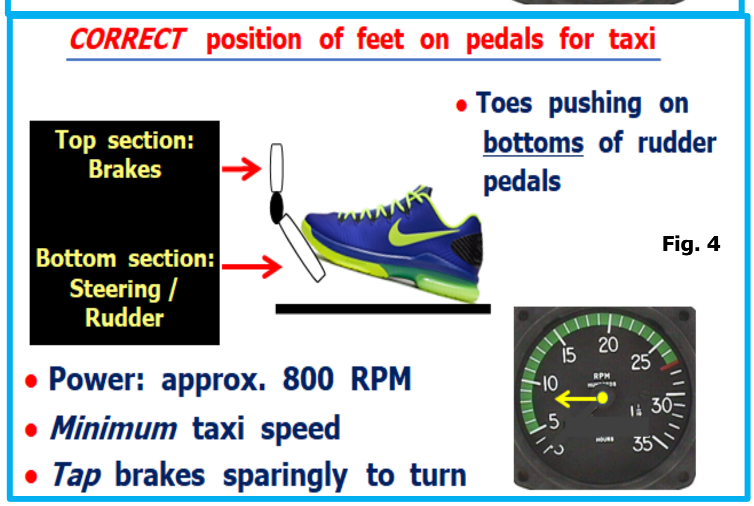

Fig. 4

Brakes and landings

As stated in the Airplane Flying Handbook for a normal landing, after touchdown and with power set to idle, put maximum weight on the main wheels by applying back pressure to the flight controls without lifting the nose wheel off the runway; this is referred to as aerodynamic braking. The raised elevator causes a negative aerodynamic load on the tail which has the effect of increasing airplane weight and, therefore, braking effectiveness. The speed of the airplane should be allowed to dissipate by the friction and drag of the tires on the runway; this allows the airplane to decelerate. If needed, brake pressure should be applied judiciously at a distance down the runway just prior to turning onto a taxiway. This method saves wear and tear on the brake pads and tires as well as money for repairs. If braking must be applied immediately following landing, as on a short runway, careful application of the brakes is initiated after the nose wheel is on the ground and directional control is established. *RM control: Maximum deceleration following landing is not achieved by "slamming on the brake pedals" with maximal force. This causes the wheels to lock and induces skidding which can cause a loss of traction. If brake pressure is aggressively applied where skidding occurs, braking becomes ineffective.*

Toes, tires and touchdown

By inappropriately pushing on the brake sections of rudder pedals at the moment of touchdown the main tires are locked in place. As a result, upon contact with the runway, a section of tread on one or both main tires can be eroded significantly causing a flat-spotted or bull's-eyed tire. (Fig. 5) To mitigate a flat-spotted tire some think by placing one's foot heals on the floor, their toes will not be pushing accidentally on the brakes prior to landing. However, as shown in Figure 6, this is not necessarily correct. Even though heels are on the floor, toes may still be pushing on the brakes. *RM control: Prior to landing or takeoff, position toes on the bottoms of the rudder pedals to mitigate the risks of pushing on the brakes, leading to a flat-spotted tire.*

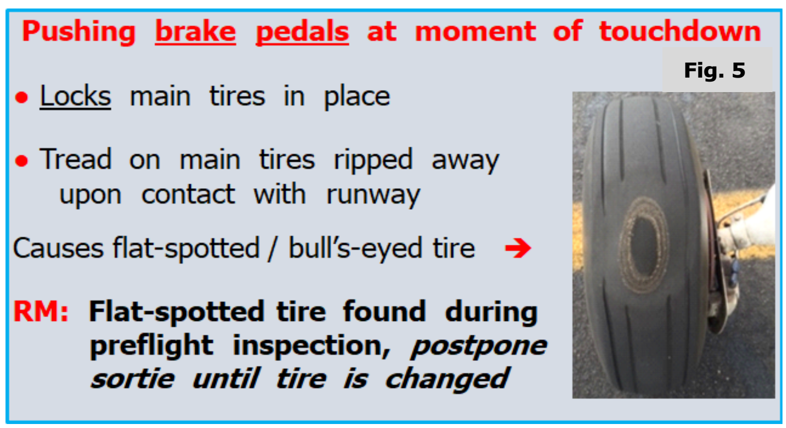

Fig. 5

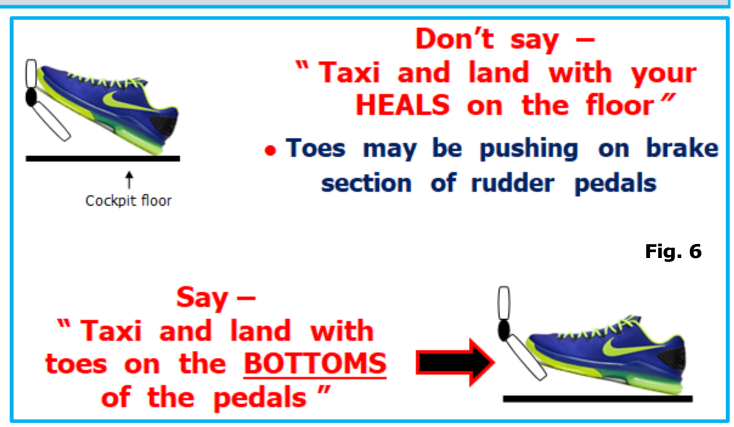

Fig. 6

Prior to landing and takeoff, ensure the parking brake knob (Fig. 1) has not been accidentally pulled back while in flight or taxiing. If landing with the parking brake valve set, brake pressure is applied at the moment of touchdown risking flat-spotted tires and tire blow-out upon landing, a potentially dangerous condition.

Brake misadventures while landing

A CAP pilot applied brakes aggressively and inappropriately while practicing a short-field approach and landing (Civil Air Patrol, Safety Beacon, 2017). Although the airplane type was not specified, it was most likely a Cessna 172 or 182. At the moment of touchdown, the pilot ". . . immediately applied strong brake pressure" which resulted in a skid causing a flat-spotted main tire, while the other main tire was worn all the way through until it went flat. Energy mismanagement is suspected in this mishap, i.e., excessive kinetic energy (airspeed) on final approach and landing, which in turn required excessive braking resulting in damage to both tires. Because the pilot was simulating a short-field landing while using a long runway, there was no need to hurry and aggressively apply brakes.

A short-field approach and landing is a precise energy management maneuver; potential energy/altitude, kinetic energy/airspeed, power, and drag need to be properly managed when flying down the glidepath for a spot-landing on the runway. *RM control: As stated in the Airplane Flying Handbook for a short-field landing, just prior to touchdown the airplane should be in approximately a pitch attitude that results in a power-off stall when the throttle is closed and, upon touchdown, use aerodynamic braking. If the proper approach airspeed is maintained (60 KIAS for a Cessna 182T), minimal float during the round-out should result and the touchdown should be made at minimal control airspeed, that would not require excessive braking.*

Another example of brake misuse following landing involved a civilian private pilot flying a Cessna Cardinal 177B at an airport where I was employed. Immediately after landing on a runway 3,009 feet long, the tower directed the pilot to exit the runway at the first taxiway with a right turn. While going too fast, the pilot immediately applied heavy braking to try to make the right turn. As a result, the right main tire skidded which caused a section of tire tread to be ripped away, resulting in a blown-out, flattened tire. The pilot should have known that the airplane's speed on the runway was too fast to make the first turn. As stated in the FAA publication Runway Safety: Best Practices, a pilot is expected to advise ATC if he/she is unable to comply with their instructions. *RM control: The pilot should have informed the tower controller, "unable to exit at first taxiway", and then slowed the airplane to a safe taxi speed before turning to exit the runway.*

Summary

Misusing brakes predisposes to ruined brakes and tires, costly airplane damage, personal injury and possible LOC–G. By keeping taxi speeds low, using brakes sparingly to turn on the ground and not misapplying brakes following landing, an aircraft's brakes will likely be available when you really need them. Learn to use brakes properly to avoid becoming a "braking news" accident.

Winter Flying

The seasons are changing and it's time to think about winter flying. (OK I hear the Alaska pilots saying winter started a couple of months ago while our Hawaii pilots are scratching their heads asking what "winter" is?). Winter flying brings enhanced performance to our fleet due to the lower density altitude. Takeoff runs will be shorter, and climbs will be faster. Here are some points to consider when flying in cold weather.

- Trying to do a leisurely but careful preflight in the biting wind and cold is a challenge. Take no shortcuts. It's also important to dress warmly in case of an off-airport landing ("Dress to Egress!"). Pilots often assume the trip will be in a nice warm airplane only to find they are facing a long freezing hike through inhospitable terrain. Make sure your crew dresses warmly as well.
- Although we should always do a thorough preflight, cold weather means that some items get special attention. Checking that the pitot-heat works in the middle of summer is probably not important unless you fly in the flight levels. However, it's critical during cold weather. Ensuring that the lights work is also important when considering the shorter days.
- Check to be sure that the CO (carbon monoxide) detectors are not expired. Look for signs of cracking or leaks in the exhaust system. In flight, it's important to check for signs of CO poisoning. Most newer aircraft have CO detectors, and some pilots also carry their own. Your body can often detect CO poisoning before any other detector though. Be alert for signs of CO poisoning in any of your crew. Headaches, nausea, and general feelings of ill health are all possible signs of carbon monoxide poisoning. Open a window and turn off the heat to see if the symptoms go away. Sporty's has a good article on CO poisoning available on their website.
- When the temperature is below freezing, pre-heat the engine unless the engine is already warm (from a previous flight or the airplane has been hangered). Starting will strain the starter so be vigilant for any signs of starter stress. Preheat doesn't heat everything. Cold weather saps battery strength resulting in fewer amps being available. Keep in mind the thickening of oil in colder temps can be a compounding factor. Pre-heating the engine doesn't do anything for your electronics so expect them to come up slowly. Engine pre-heats and deicing can be expensive. If this is a self-funded flight, there is no reimbursement so consider that before heading out to the airport. But don't skip the preheat just because you don't want to pay. The damage you do to the engine could be very expensive. CAPR 173-3 does allow reimbursement for some Air Force Funded Missions (AFAM) but is limited to actual missions. There is no reimbursement for pre heat for O-rides and other missions even if A missions.
- All contamination including frost must be removed from all flying surfaces before flight. Experience has shown that any frost on flying surfaces is a safety hazard and must be removed even on polished surfaces. In some parts of the country, frost can be an early morning problem but gone once the sun comes up. It can also help to reposition the aircraft where the sunlight can be most effective. For days when waiting isn't going to remove the frost, you will need some help to get rid of it. If it's light frost, there are solutions you can spray on. Talk to your (AMO) Aircraft Maintenance Officer about which solutions are safe to use (you could damage the paint if you use the wrong one and they are almost always bad on the windscreen). Be sure the frost is really gone. Anything other than light frost will need the FBO to de-ice the aircraft. It's good practice to remove snow (broom, soft bristle brush, leaf blower...being careful not to scratch paint) right after it accumulates, even if you are not flying soon. This takes the weight off the tail and allows more time for the sun to do its work. Check carefully to make sure that snow was not brushed into mechanical assemblies that could cause controllability problems. If the snow is heavy and icy, you will risk damaging the paint or even mechanical assemblies in trying to remove it. You could order a de-ice from the FBO, or just go home.

- Ice is not just a problem on flying surfaces. Frozen water in control linkages or other mechanical assemblies is an accident waiting to happen. Ice can get into enclosures that you can't see. Recently, some Citation jets had controllability problems when ice built up in the tail cone and started interfering with elevator control. The best way to get rid of ice is to get the aircraft somewhere warm so it will thaw out. Be sure everything is dry before you take the aircraft out again or the water will re-freeze in hard-to-get places. If you don't have access to a warm hangar, then de-icing may be your only option.
- Turn on your pitot-heat anytime the outside temperature is <4.4°C/40°F. This ensures that you don't lose your airspeed indicator. This is especially critical when you are IMC but, it's good practice in VFR as well as there could be moisture already in the pitot tube.
- Taxing, takeoff, and landing on icy surfaces can be challenging or even impossible (Ok, I hear the ski plane pilots laughing). Snow or ice on taxiways or runways may mean cancelling a flight even after the snowplows do their job. Taxiing, takeoff, and landing in a cross wind can cause loss of control due to the slick conditions. Make sure your controls are set to counteract the wind. Your tires may not provide much traction at all, and there may be little or no braking. Even if flight is possible, you will find that the ordinarily smooth runway is now very rough due to the snow and ice. The crosswind limit on CAP aircraft is 15 knots but may not be achievable on wet or contaminated surfaces. The published demonstrated cross wind was done with a dry runway.
- Our CAP airplanes are not certified for flight in icing conditions and your preflight planning should ensure you don't go there. The best way to avoid icing is to stay in above freezing temperatures. That's not always practical but should be the objective. Foreflight and other sites have some excellent resources to predict and avoid icing, including useful PIREPs. If in doubt, simply DON'T GO! No CAP pilot should ever consider launching if there is a chance of icing in flight. If you do encounter unforeseen icing in the air, you need to deal with it immediately by exiting the icing conditions as quickly as possible (easier said than done). Anything more than trace icing is hazardous, and the trace icing may be a warning of things to come. Keep your airspeed up, don't use flaps and ensure your pitot heat is on. Turn the heat/defrost on full to keep your windscreen clear if possible. Consider carb heat if you suspect induction icing. Let ATC know and don't hesitate to declare an emergency. Remember, ATC can't fly the airplane, so aviate first. Inflight icing is extremely hazardous to small GA aircraft. Before you take off, ensure there is no chance of icing, otherwise stay home.
- Flying in snow is IFR and poses a serious safety hazard. If the snow is dry, chances are you will not accumulate ice, but you need to exit the conditions as quickly as possible. If the snow is wet, you are at risk of in-flight icing.
- In extremely cold conditions, your altimeter will be in error even if set properly. The
  The following table indicates changes to approach minimums versus temperature but can also be used by a VFR pilot to estimate altimeter error due to temperature.

  It's also useful to review guidance for cold temperature barometry on the FAA website here.

TBL ENR 1.8-1

ICAO Cold Temperature Error Table

REPORTED TEMP °C	200	300	400	500	600	700	800	900	1000	1500	2000	3000	4000	5000
+10	10	10	10	10	20	20	20	20	20	30	40	60	80	90
0	20	20	30	30	40	40	50	50	60	90	120	170	230	280
-10	20	30	40	50	60	70	80	90	100	150	200	290	390	490
-20	30	50	60	70	90	100	120	130	140	210	280	420	570	710
-30	40	60	80	100	120	140	150	170	190	280	380	570	760	950
-40	50	80	100	120	150	170	190	220	240	360	480	720	970	1210
-50	60	90	120	150	180	210	240	270	300	450	590	890	1190	1500

CO Detectors (Maj J. Doyle, NVWG)

We're coming up on the time of year (January) to replace the disposable carbon monoxide (CO) detectors in all our airplanes as required by CAPR 130-2, paragraph 14.4. Since this typically only gets done once per year, here are some tips and reminders for those who are new to the process.

Detectors must be replaced no later than 12 months after they have been installed. Cards that are already in the airplane should have the month and year they were installed written on them, and the replacement due date should also appear on the CAPF 71 that's on the front cover of the Aircraft Information File (AIF). Be sure to write the installed date on a new card before attaching it to a readily visible place on the instrument panel, and then update the appropriate entry in AMRAD.

If the detector darkens during flight due to the presence of CO, open all the air vents and land as soon as practical. Ground the aircraft using the red placard in the AIF and notify your unit's AMO immediately. Do not fly the aircraft until the exhaust system has been thoroughly examined by your local aircraft maintenance facility and authorized to return to service by a logbook entry.

The detector should be checked before every flight to make sure the round sensor in the middle is a medium reddish-brown color. Certain cleaning products contain chemicals like ammonia that can damage or destroy the sensor. If the sensor has turned dark reddish brown or black, the detector is unusable and should be replaced before the aircraft is flown. If the detector is missing, the aircraft should be grounded until a new detector has been installed. Disposable detectors can be found in most local hardware stores.

Carbon monoxide is a by-product of combustion that is tasteless, colorless, and odorless. It acts on the body by displacing oxygen in the bloodstream, which leads to symptoms that progress from headache to dizziness to nausea to confusion to loss of motor control to death. If the detector senses the presence of CO in the aircraft cabin, it's an indication that there's a leak in the aircraft's exhaust system. Get the aircraft on the ground as soon as practical.

CAP requires CO detectors to be installed in our airplanes to protect pilots and their air crews and passengers from CO poisoning. It's everyone's responsibility to make sure the detectors are current and functioning properly.

How it's Done: A model for handling emergencies (AVEMCO)
The latest AVEMCO newsletter is worth a read here.

Articles for the National Stan Eval Newsletter:
These articles have been written to present ideas, techniques, and concepts of interest to CAP aircrews rather than provide any direction. The articles in this newsletter should in no way be considered CAP policy. We are always looking for brief articles of interest to CAP aircrews to include in this newsletter. CAP has many very experienced pilots and aircrew who have useful techniques, experiences, and tips to share.

Please send your contribution to stephen.hertz@vawg.cap.gov . You can view past issues here.