FLIGHT SAFETY NOTES

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Alcohol and Flying - It's Impact on Flight Safety

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INTRODUCTION

While alcoholic beverages are widely consumed in the modern society, we all know that driving an automobile after consuming alcohol is an offence. The adage "Don't drink when you drive and don't drive when you drink" is common everywhere. The main reason behind this is the detrimental effect of alcohol on our faculties resulting in degraded ability to drive properly and hence the risk of an accident. If this is the case of an automobile one can imagine the impact of alcohol on a complex task of flying an aircraft.

In this safety note, the faculties required for flying, the effects of alcohol on these and the impact on flight safety are detailed.

FLYING SKILLS

Flying an aircraft is a complex task requiring continuous and coordinated sensory, cognitive and motor functioning by the pilot.

Flying an aircraft requires:

- Interpretation of sensory information in the form of visual, motion, proprioceptive and aural cues.
- Cognitive evaluation of the sensory information presented.
- Performance of motor tasks in response to the perceived situation.
- Sound functioning of the higher cortical faculties responsible for planning, judgement, cognition, calculation, attention, vigilance, sequencing, and memory.

Basic faculties required for successfully flying an aircraft are:

- Adequate and unimpaired senses of vision and hearing.
- Sufficient intelligence & judgment.
- Suitable personality.
- Motor skills
  - adequate power, dexterity, & coordination to manipulate aircraft controls,
  - sufficient power & coordination of speech for radio based communication,
  - strength & agility to allow entrance-to and egress-from the aircraft.

Unlike driving an automobile, pilot is exposed to additional factors, namely,

- hypoxia of increasing altitude,
- high noise levels,
- requirement for radio communication with the outside world,
- higher accelerations during aircraft maneuvering, and
- visual-vestibular illusions with the potential for loss of three dimensional orientation.

Pilots are imparted comprehensive training to hone their skills & faculties to the task of flying aircraft.

FACTS ABOUT ALCOHOL

- Alcohol is a sedative, hypnotic, and addicting drug.
- Alcohol is rapidly absorbed from the stomach and small intestine, and transported by the blood throughout the body.
- Toxic effects of alcohol vary considerably from person to person, and are influenced by variables such as gender, body weight, rate of consumption (time), and total amount consumed.
- An average, healthy person eliminates pure alcohol at a fairly constant rate - about 1/3 to 1/2 oz. of pure alcohol per hour, which is equivalent to the amount of pure alcohol contained in any of the popular drinks as shown in the table below. This rate of elimination of alcohol is relatively constant, regardless of the total amount of alcohol consumed. In other words, whether a person consumes a few or many drinks, the rate of alcohol elimination from the body is essentially the same. Therefore, the more alcohol an individual consumes, higher will be the alcohol concentration in his blood and the longer it takes his/her body to get rid of it.

Type Beverage	Typical Serving (oz.)	Pure Alcohol Content (oz.)
Table Wine	4	.48
Light Beer	12	.48
Aperitif Liquor	1.5	.38
Champagne	4	.48
Vodka	1	.50
Whiskey	1.25	.50

- Even after complete elimination of all of the alcohol in the body, there are undesirable effects(hangover) that can last 48 to 72 hours following the last drink.

EFFECTS OF ALCOHOL

The majority of adverse effects produced by alcohol relate to the brain, the eyes, and the inner ear-three crucial organs to a pilot. Acute Intoxication produced by increase in blood alcohol concentration produces impairment of psychological functions of perception, discrimination, association, and voluntary responses. The alcohol level in blood is measured by BAC.

Blood alcohol content (BAC) or blood alcohol concentration is defined as the concentration of alcohol in blood expressed as the weight of alcohol in a fixed volume of blood. It is measured either as a percentage by mass, or by mass per volume. For example, a BAC of 0.20% means 2 grams of alcohol per 1000 grams of an individual's blood.

Approximately equivalent BAC measures		
Measurement with Units	Units also known as:	Commonly used in
0.01 g/100 mL	g/dL, % g/mL	USA
0.10 mg/mL	g/L, ‰ g/mL (permille g/mL)	Netherlands, Lithuania, Poland
10 mg/100 mL	mg/dL, % g/L, % mg/mL	Britain
0.01 g/100 g	%, percent by mass	
0.10 mg/g	‰, permille by mass, g/kg	Sweden, Norway

Note: The first three mass/volume units are not exactly equivalent to the last two mass/mass units. Because the density of blood is 1.06 g/mL, there is a very close approximation between mass/volume and volume/volume measurements. For this reason, a mg/mL is approximately the same as a mg/g. An exact conversion is 1 mg/g = 1.06 mg/mL.

General effects of various levels of concentration of alcohol in blood is summarized in the table below. The blood alcohol content values in this table overlap because of the wide variation in alcohol tolerance among individuals.

Blood Alcohol Concentration(BAC)	Effects of alcohol
0.01-0.05 (10-50 mg %)	average individual appears normal
0.03-0.12 (30-120 mg %)	mild euphoria, talkativeness, decreased inhibitions, decreased attention, impaired judgment, increased reaction time
0.09-0.25 (90-250 mg %)	emotional instability, loss of critical judgment, impairment of memory and comprehension, decreased sensory response, mild muscular incoordination
0.18-0.30 (180-300 mg %)	confusion, dizziness, exaggerated emotions (anger, fear, grief) impaired visual perception, decreased pain sensation, impaired balance, staggering gait, slurred speech, moderate muscular incoordination
0.27-0.40 (270-400 mg %)	apathy, impaired consciousness, stupor, significantly decreased response to stimulation, severe muscular incoordination, inability to stand or walk, vomiting, incontinence of urine and feces
0.35-0.50 (350-500 mg %)	unconsciousness, depressed or abolished reflexes, (abnormal body temperature, coma; possible death from respiratory paralysis (450 mg% or above)

IMPAIRMENT OF FACULTIES DUE TO ALCOHOL & THEIR CONSEQUENCES

The impairment of various faculties due to alcohol have been studied through aero medical investigations. In the following these are detailed along with the associated impact on safety.

1. Impairment of higher cortical functions
   - Complex task performance and reaction times are impaired by BAC in excess of 0.04% and 0.08% respectively.
   - Visual tracking performance during whole body motion & in non-moving individuals at BAC levels as low as 0.027%.
   - The monitoring and decision components of reaction time tasks are impaired by BAC level of 0.09%.

All these functions are crucial for safe flying and impairment to these is detrimental to flight safety.

2. Impairment of Visual and vestibular functions

   Vision is the most important sensory modality for flying and is required for monitoring and adjustment of aircraft performance. It is required for spatial orientation and navigation during both 'visual' and 'Instrument' 'meteorological' flight conditions.
   - In the absence of adequate visual stimulus, control of an aircraft is typically lost within 60 seconds.
   - The speed of the eyes, in pursuing a target, is reduced by alcohol.
   - The speed of the eye's saccadic motion, their latency times, and reaction times are impaired by BAC greater than 0.04%.
   - BAC of 0.05% and above slows down the ability of the eyes to accommodate or adjust their focus.

- Alcohol intoxication results in double vision and dilatation of the pupils leading to blurred vision.
  Any impairment to vision and increase in visual perception delays will affect adversely the flying skills and is detrimental to flight safety.
- During the angular accelerations of flight there occur reflex rapid, oscillatory eye movements called nystagmus. This tends to impair the view of objects within the aircraft and produces blurring of vision of instruments. Usually a pilot is able to suppress this nystagmus by deliberately fixating on an instrument.
  The ability to suppress this nystagmus is impaired at BAC as low as 0.02%.
- Positional Alcohol Nystagmus (PAN) results in rapid, oscillatory eye movements when the head is placed in specific positions in the absence of angular acceleration. This results in impairment of vision as well as spatial disorientation. PAN has been measured 34 hours after alcohol ingestion, long after there is no measurable alcohol in the blood.

The maintenance of correct Spatial Orientation is important for the flight. This depends primarily on vision but the vestibular apparatus and the somatic sensory organs also contribute.

- BAC greater than 0.04% impairs the function of the vestibular apparatus, and its interaction with the eyes in maintaining correct posture and balance.
- High doses of alcohol retard the suppression of post-rotatory nystagmus, an important consideration in turning aircraft.
- PAN may play a role in spatial disorientation.

Impairment of the visual system and the intimately related vestibular system by alcohol causes some degree of pilot incapacitation, which could lead to spatial disorientation and an aircraft accident.

3. Impairment of motor skills
   Flying requires coordinated, motor actions and fine dexterous movements for operation of aircraft instruments, navigation and radio communication equipment. Slight to moderate physical forces have to be applied during normal operations but significant forces may be required during emergency procedures.
   - While alcohol has little effect on muscular strength it impairs the coordination of motor functions.
   - Basic motor coordination tasks such as standing still, hand steadiness, walking, especially with the eyes closed, and a variety of sensorimotor tracking/pointing tasks are all impaired by alcohol.

Impaired coordination during sensorimotor actions could lead to degraded performance and hence compromise flight safety.

4. Effects in conjunction with altitude hypoxia
   The hypoxia produced by aviation altitude exposure will subtly or potently impair pilot performance. The degree of hypoxic impairment varies with the altitude exposure.

While alcohol and altitude hypoxia both impair pilot performance their interaction could be additive in nature.

5. Tolerance to positive radial acceleration.
   In performing a balanced turn in an aircraft the pilot is exposed to a centrifugal force due to the radial acceleration. High levels of this acceleration can result in

impairment of vision and even unconsciousness as blood is unable to reach the eyes and brain. While a high level of acceleration is not normally encountered it may result during steep turns or emergency maneuvers, or uncontrolled spiral flight. Alcohol reduces the tolerance of this acceleration. A 'moderate' dose will reduce the threshold by 0.1 - 0.4g and will intensify the severity of the symptoms produced by a given level of acceleration.

6. Interference with speech
   Speech communication is an essential component of flight. A pilot relies on radio communication for traffic and procedural information, weather and safety warnings, navigational assistance, and emergency procedures. Alcohol causes alterations of speech including 'thick, slurred speech', 'difficulty in speech', 'repetitive speech', 'low, raspy speech', and 'slow, mumbled, and incoherent' speech. Memory for words, fluency in their use, and quality of word associations are also impaired by alcohol. This impairment was found to be greater in older pilots than younger pilots.

Impairment of speech communication will jeopardize flight safety as it is crucial for intra communication within the cockpit and communication to ATC and tower.

7. Risk taking behaviour.
   The euphoria induced by alcohol as well as the impairment of judgement may cause *a pilot to undertake maneuvers that he would not normally undertake, compromising flight safety.*

8. Hangover effects.
   Post Alcohol Impairment has been defined as 'performance impairment after alcohol is no longer detectable'. This condition is the equivalent of the lay term of 'hangover'. Post Alcohol Impairment has been observed 14 hours after alcohol ingestion (to 0.08% and 0.1% blood alcohol concentration) in simulated flight tests. There are other studies that failed to demonstrate any hangover related performance deficits. There is conflicting evidence and opinion concerning whether or not there exists any consistent hangover related performance deficit that could adversely affect aviation safety. Symptoms commonly associated with a hangover are headache, dizziness, dry mouth, stuffy nose, fatigue, upset stomach, irritability, impaired judgment,

9. Alcohol induced hypoglycaemia.
   Hypoglycaemia is the state of a lower than normal blood sugar level. When the blood sugar level is lower than normal, performance may be impaired due to insufficient sugar for the central nervous system to function. Low blood sugar is not compatible with the safe piloting of an aircraft. Alcohol ingestion results in a lowering of the blood sugar levels which, in turn, leads to performance degradation.

10. Studies on the effect of alcohol on pilot performance
    - Pilots have shown impairment in their ability to fly an ILS approach or to fly IFR, and even to perform routine VFR flight tasks while under the influence of alcohol, regardless of individual flying experience.

- The number of serious errors committed by pilots dramatically increases at or above concentrations of 0.04% blood alcohol. This is not to say that problems don't occur below this value. Some studies have shown decrements in pilot performance with BAC as low as the 0.025%.

If other variables such as sleep deprivation, fatigue, medication use, or flying at night or in bad weather, the negative effects of alcohol are significantly amplified.

Regulations

The use of alcohol and drugs by pilots is regulated by FAR Part 91 – General Operating and Flight Rules. Section FAR 91.17 among other provisions states that no person may operate or attempt to operate an aircraft:

- Within 8 hours of having consumed alcohol
- While under the influence of alcohol
- With a blood alcohol content of 0.04% or greater
- While using any drug that adversely affects safety

KAC Operation Policy Manual(OPM) is more stringent than FAR Part 91. Paragraph 2.1.16.3 stipulates that no person may operate an aircraft within 12 hours of having consumed alcohol.

Recommendations to the crew

1. Do not fly while under the influence of alcohol.
2. As a minimum, adhere to the guidelines of Kuwait Airways Operation Policy Manual (OPM) which stipulates 12 hours from "bottle to throttle"
3. Do not fly while using any drug that may adversely affect safety.
4. A more conservative approach is to wait 24 hours from the last use of alcohol before flying. This is especially true if intoxication occurred or if you plan to fly IFR. Cold showers, drinking black coffee, or breathing 100% oxygen cannot speed up the elimination of alcohol from the body.
5. Consider the effects of a hangover. Eight hours from "bottle to throttle" does not mean you are in the best physical condition to fly, or that your blood alcohol concentration is below the legal limits.
6. Recognize the hazards of combining alcohol consumption and flying.
7. Use good judgment. Your life and the lives of your passengers are at risk if you drink and fly.

Ideally, total avoidance of alcohol should be a key element observed by every pilot in planning or accomplishing a flight.

Alcohol avoidance is as critical as developing a flight plan, a good preflight inspection, obeying ATC procedures, and avoiding severe weather.

CONCLUSIONS

Flying is a complex task requiring continuous and coordinated sensory, cognitive, and motor functioning by the pilot. Alcohol impairs most aspects of the flying task. Some flight related skills are adversely affected by blood alcohol levels as low as 0.025% while aircraft flight and simulator flight is clearly impaired by levels of 0.04%. Higher blood alcohol levels result in correspondingly more profound impairment of flying skills and reduction in flying safety.

The use of alcohol is a significant self-imposed stress factor that should be eliminated from the cockpit. The ability to do so is strictly within the pilot's control.

Pilots must adhere to KAC regulations which stipulate a minimum of twelve hours between bottle to throttle. Pilots should keep in mind that regulations alone are no guarantee that problems won't occur. It is far more important for pilots to understand the negative effects of alcohol and its deadly impact on flight safety.

As Dr. Dougal Watson puts it - "***Any concentration of ethanol in the living pilot is unacceptable and can contribute to aircraft accidents"***

REFERENCES:

1. Guillermo J. Salazar, Melchor J. Antuñano, "Alcohol and Flying ", Medical Facts for pilots, Publication AM-400-94/2, Aeromedical Education Division, Civil Aerospace Medical Institute Federal Aviation Administration.
2. Dougal Watson., " The effect of Alcohol on pilot performance and safety", AVMEDIA 1997, June 1997.
3. FAR Part 91 – General Operating and Flight Rules, Federal Aviation Administration.
4. Operation Policy Manual, Kuwait Airways Corporation.