TECHNICAL NOTE

Smoke/Fumes in the Cockpit

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During the period 1970–80, there were reported in USAF 89 incidents of smoke/fumes in the cockpit during flight. The origin of the fumes in most cases was organic petroleum derivatives, which caused a multitude of symptoms including CNS dysfunction and mucous membrane irritation. Flight surgeons should be well-read in aerospace toxicology because of the threat to flying safety posed by the many fluids and substances necessary for the operation of today's modern aircraft.

DURING THE PERIOD 1970–80, there were reported in USAF 89 incidents of smoke/fumes in the cockpit during flight. Undoubtedly, many more occurred which, for various reasons, were never reported. Synopses of the reported incidents obtained from the repository at the Air Force Inspection and Safety Center, Norton AFB, CA, were reviewed by the authors.

The 89 incidents occurred in a variety of USAF aircraft—fighter (26), transport (21), trainer (17), bomber (16), helicopter (4), other (5)—at various phases of flight from takeoff to landing. The seriousness of smoke/fumes in the cockpit can be appreciated by noting that the crew nearly always aborted the mission by landing as soon as possible at the nearest airfield. Only in a few instances was the mission completed in spite of smoke or fumes. Furthermore, six times the crew opted to eject because of incipient incapacitating symptoms.

In most instances, the crew detected smoke/fumes either visually or by an odor described as either strong or faint, acrid or sweet, or unusual, or like something burning. Although most pilots could not identify the odor, others unmistakably identified, for example, oil, JP 4 fuel, or hydraulic fluid.

There were reported a broad spectrum of symptoms caused by the smoke/fumes, although most were due to CNS dysfunction and irritation of the mucous membranes and conjunctiva. Many were incapacitating to some degree (Table I).

TABLE I. SYMPTOMS CAUSED BY SMOKE/FUMES IN THE COCKPIT 1970–80.*

Symptom	
dizzy, lightheaded	42
irritated eyes and mucous membranes	31
nausea/vomiting	31
confusion, disorientation, performance decrement	23
headache	22
visual acuity	10
paresthesias	8
chest pain, heaviness	6
respiratory distress	5
loss of consciousness	4
cough	2

* Most crewmembers reported more than one symptom.

The cause of smoke/fumes in most of the incidents was due to mechanical malfunction or electrical fire. However, fire extinguisher leakage, contamination of the cockpit by chemicals, spillage of hazardous cargo, and contamination of the oxygen system by paints, solvents, and other impurities were sometimes cited.

The chemicals or substances which caused the fumes were usually identified by investigation (Table II), although the exact origin of the smoke/fumes was never conclusively determined in 36. Note that the substances identified, for the most part, were organic hydrocarbons which have well-known toxic properties.

DISCUSSION

Aerospace toxicologists are well aware of the many toxic substances and fluids necessary for operating today's modern aircraft. The list of principal potential contaminants is long and includes oil, hydraulic fluid, fuels, fire extinguisher fluids, exhaust gases, solvents, paints, coolants, battery

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TABLE II. ORIGIN OF COCKPIT SMOKE/FUMES 1970–80.*

Substance	*No.*
unknown	36
oil	23
fuel	7
paint	5
hydraulic fluid	4
chlorobromomethane	4
carbon monoxide	3
KOH	2
PD-680	2
epoxys	2
trichlorethane	2
toluene	1
acetone	1
freon	1
nitrous oxide	1
diesel fuel	1
aluminum/magnesium	1
methane	1
B&B chemical 3100	1
GE silicone	1
carbon disulfide	1
zinc chromate	1

* More than one substance was identified in some incidents.

fluids, sealants, pyrolysis products, and impurities in the oxygen system. All of these toxic substances have acute and long-term effects. It is the acute effects which are of particular concern to the flight surgeon because of the immediate threat to flying safety. Many of these substances consist of organic petroleum derivatives, the fumes of which cause narcotic or anesthetizing effects eventually leading to drowsiness, CNS depression, unconsciousness, and death (1). Less severe symptoms include mucous membrane/conjunctival irritation as well as headache, nausea, vomiting, and vertigo.

It is clear how serious the acute effects of in-flight smoke/fumes in the cockpit can be. Not only must one be concerned with incapacitating CNS dysfunction and mucous membrane irritation, but also simple asphyxia as well as obscured vision due to intense smoke. Furthermore, it is quite possible that the effects of smoke/fumes could be further aggravated by the stresses of flight, such as acceleration, high cockpit temperatures, and any degree of hypoxia.

Cockpit smoke/fumes can be particularly critical at lower altitudes, such as at a gunnery range or during low-level flights, since even momentary distraction or inability to see outside the cockpit could be courting disaster. Although USAF pilots apparently are well aware of the potential seriousness of cockpit fumes, since most aborted the mission, the threat is clearly there.

The symptoms compiled in Table I were, for the most part, predictable; they are those commonly associated with inhaling organic substances of the petroleum derivative family. Practically all of them are incapacitating to some degree. Note that 23 of the crewman reported confusion and performance decrement, which is particularly worrisome.

Chlorobromomethane (CBM) is a chemical used for firefighting. In several instances, its fumes were dispersed throughout the cockpit due to leakage from a portable fire extinguisher. If the extinguishers are not properly secured and sealed, fumes may be given off into the small cockpit space, which can cause not only skin irritation and mucous membrane irritation but also uncoordination, confusion, and dizziness (2).

In addition, several cockpits were contaminated by various cleaning agents and chemicals containing solvents, which were either improperly used or clearly unauthorized. As a result, a residue emitted fumes in the cockpit which, in turn, caused undesirable symptoms.

Contamination of oxygen systems must always be suspect whenever crewmembers report unusual fumes. Ideally, breathing oxygen should be 99.5% pure, although the USAF accepts very small amounts of other substances such as CO_2, methane, ethane, and other hydrocarbons. (The limits for these substances can be found in USAF technical orders.) However, should these impurities exceed acceptable limits, significant CNS symptoms may well occur. The proper maintenance and periodic purging of oxygen systems should obviate such problems.

Besides impurities in the oxygen itself, oxygen hoses are sometimes inadvertently sprayed with paints, solvents, or other chemicals used in the cockpit. Therefore, maintenance personnel should take extra care when working in the cockpit in proximity to oxygen systems.

The release of fumes or mists from hydraulic fluids, oils, and gasoline is always a potential danger. Hydraulic fluids, like oils, are petroleum products which can cause irritation of the eyes and respiratory tract as well as headaches, nausea, vomiting, and chemical pneumonitis. USAF aircraft, depending on the type, are fueled by aviation gas or jet fuel, the JPs. Aviation gasoline contains aliphatic and aromatic hydrocarbons with tetraethyl-lead. Acute exposure can cause depression of the central nervous system with possible loss of consciousness. Furthermore, there can be mucous membrane irritation with increased lacrimation. A particular danger is carbon monoxide, which is a byproduct of aviation gasoline. With faulty exhaust, aviation gasoline exhaust fumes can enter the cockpit causing attendant symptoms. The jet fuels are basically a mixture of kerosene and gasoline but contain no lead. In general, their exhaust will generate less carbon monoxide than aviation gasoline, although their vapors can cause a narcotic effect as well as mucous membrane irritation.

In the event of an electrical fire, the major problem is burning insulating material, which is most often made of plastics with various additives. The signs and symptoms caused by these fumes depend upon what additives are in the plastic. For example, vinyl chloride can cause a narcotic effect. In any event, any electrical fire will produce some type of toxic fumes.

Besides the danger from those substances and the fluids required for aircraft operation, there is an additional threat of toxic fumes from hazardous cargo. It is not unusual for fuels, fluids, and other toxic substances to be transported. Fumes have been reported because of spills in the cargo compartment, for example, of diesel fuel, trichlorethane, and gasoline. Therefore, it is important that such potentially hazardous cargo be properly identified prior to flight and properly secured.

CONCLUSIONS/RECOMMENDATIONS

Smoke/fumes in the cockpit is not a rare event and is a clear threat to flying safety because of acute toxic effects. If smoke/fumes are detected, crewmembers should immediately follow established emergency procedures which might include lowering the helmet visor, breathing 100% oxygen, dumping cabin pressure, and descending and landing. Flight surgeons should fully participate in the investigation of such

incidents, not only by obtaining a history and physical of the crew, but also obtaining air samples for analysis from the cockpit. (If carbon monoxide is suspected, a blood specimen should be immediately drawn, in the cockpit if necessary, for a carboxyhaemoglobin level.) Every effort should be expended to determine the type of fumes in the cockpit and their origin. In the event of possible contamination of the oxygen systems, the flight surgeon should see to it that the LOX is analysed, not only from the aircraft systems, but also from the service carts. Sometimes a simple sniff test of the LOX on the spot will give some indication by odor that there is a contamination problem. Because of the possibility of in-flight smoke/fumes and because of their potential danger, all flight surgeons should be well read in aerospace toxicology.

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