CHAPTER 6

NOXIOUS SUBSTANCES IN AVIATION

CONTENTS

Introduction

1. The list of noxious substances encountered in aviation is now very lengthy and is likely to go on increasing as new techniques are developed. These are substances which under certain circumstances and in certain concentrations are harmful to the human body. The main potentially dangerous substances will be considered in separate groups.

Fuels and Propellants

2. This is now a very large group due to the introduction of jet engines and rocket propellants.

a. *Petrol (AVGAS).*

(1) The principal constituents of AVGAS are aliphatic and aromatic hydro-carbons. Petrol vapour can produce symptoms in non-flammable concentrations. It is narcotic and anaesthetic, producing effects on the central nervous system. Its anaesthetic effect on the lining of the nose brings with it the additional hazard of dulling the sense of smell, so that individuals are not aware of the continued danger of exposure. It also irritates the eyes and throat and, in 10% - 20% of cases, the intestines. The usual symptoms are headache, nausea, excitement, blurring of vision, mental confusion and inco-ordination. If the concentration is high enough, unconsciousness and death can result. Concentrations of 0·26% inhaled for a period of one hour can produce a "drunken" state.

(2) Petrol has a local irritant effect on the skin and repeated contact can set up a skin sensitivity.

(3) Exposure to petrol vapour in aircraft cockpits is not very common. The greatest hazard is to ground personnel cleaning out petrol storage tanks, a situation which is aggravated by the dulling effect on the sense of smell.

(4) Tetra-ethyl lead is an additive to petrol. It is a volatile substance which is therefore absorbed by the body *via* the lungs. Its effects are on the central nervous system producing general weakness, muscular inco-ordination and mental disturbances. It is an unlikely hazard in flight but poisoning can occur due to prolonged exposure during fuel tank cleaning.

b. *Gas Turbine Fuels.*

(1) A gas turbine engine can operate with a fairly wide variety of fuels but owing to various practical considerations only petroleum hydro-carbons are used. The early gas turbine engines were developed on AVTUR but for reasons of production AVTAG was introduced. AVTUR is a kerosene-type of fuel, whereas AVTAG is a wide-cut gasoline.

(2) Kerosenes affect the central nervous system, gaining entry to the body *via* the lungs.

(3) The harmful effects of gas turbine fuels and their handling problems are not essentially different from those associated with ordinary aviation fuel.

c. *Rocket Propellants and Oxidizing Agents.*

(1) The constituents of rocket fuels are usually toxic. Aniline, for example, which is used in some liquid propellant mixtures,

has a pleasant, non-irritant odour, but is dangerous. It is absorbed *via* the lungs and the skin and causes shortage of breath, weakness, dizziness, bowel disturbances, muscular inco-ordination and mental disturbances.

(2) Liquid oxygen, fuming nitric acid and hydrogen peroxide are used in various liquid propellants as oxidizers. Liquid oxygen is liquid at –183°C and can give rise to frostbite and burns. Vapour trapped in clothing can lead to explosive fires and organic materials may detonate readily after contact with liquid oxygen. Nitric acid causes severe burning on contact with skin as does hydrogen peroxide. The vapour causes marked irritation of the eyes and respiratory tract.

Products of Combustion

3. Carbon monoxide is the most important product of combustion. It is the most dangerous of all noxious agents due to the insidious nature of the onset of toxic symptoms and the fact that it is practically odourless. It is almost always present in varying concentrations in exhaust gases or indeed as a product of combustion of practically any material in an aircraft in the event of fire. Carbon monoxide contamination of the cockpit was commonly found in single piston engine aircraft due to defective bulkhead sealing. Exhaust gases are often used to provide cabin heating through a heat exchanger and should a defect occur in the mechanism, exhaust gases are able to contaminate the hot air supply to the cabin.

4. When carbon monoxide is inhaled into the alveoli of the lungs, it passes through their walls into the blood stream. In the blood, it enters the red blood cells and combines with the haemoglobin in the same way as oxygen. There is a very important difference, however, between oxygen and carbon monoxide in their ability to combine with haemoglobin, in that carbon monoxide does so about 200 times more easily.

5. The effects of absorbing carbon monoxide are caused by two factors:

a. Due to its greater affinity for carbon monoxide, haemoglobin is converted into carboxyhaemoglobin. This conversion produces the same effect as a decreasing oxygen saturation due to hypoxia. Altitude tolerance is decreased therefore by the absorption of carbon monoxide.

b. Carboxyhaemoglobin has an effect upon the circulating blood whereby it decreases its ability to release the oxygen it is carrying to the tissues. This becomes very critical during periods of increased demand for oxygen, such as during exercise or at a time when there is a shortage of oxygen anyway, as in hypoxia in flight.

6. If an individual, breathing air at 6,000 ft, has a 10% carboxyhaemoglobin concentration in his blood he is in the same position physiologically as someone breathing air at 12,000 ft with no carbon monoxide in his system. The effect of 10% carboxyhaemoglobin on a person breathing oxygen at 36,000 ft is to raise his "physiological altitude" to over 40,000 ft.

7. The symptoms of carbon monoxide poisoning related to various blood saturations are shown in the following table. These apply to sea level and not to the situation at altitude. If an individual is exposed to the same concentration of carbon monoxide at altitude as at sea level, the degree of saturation of the blood with carbon monoxide will be the same assuming all other factors are constant except the partial pressure of oxygen. The signs and symptoms, however, will be more pronounced at altitude, mainly due to the result of increasing hypoxia caused by the decreasing partial pressure of oxygen with altitude.

SYMPTOMS ARISING FROM VARIOUS CONCENTRATIONS OF CARBON MONOXIDE (CO) IN THE BLOOD

% CO in the blood	Symptoms
0–10	None noticeable, but night vision is affected
10–20	Tightness across forehead and possibly slight headache
20–30	Headache and throbbing of the temples; breathlessness on exertion and perhaps nausea and weakness
30–40	Severe headache, weakness, dizziness, dimness of vision, nausea and vomiting, collapse
Over 40	Increasing likelihood of collapse, increasing pulse rate, irregular respiration, coma, convulsions, respiratory failure, death

8. In a case of known or suspected exposure to carbon monoxide, the most significant finding is the carbon monoxide content in the blood. It is imperative therefore that the individual is seen by the nearest medical officer as soon as possible. The immediate treatment of carbon monoxide poisoning is the restoration of normal breathing and the abatement of shock. The patient requires as much fresh air as possible and oxygen if available. If the breathing is not satisfactory and the patient is unconscious, artificial respiration should be carried out. The patient should be kept at "room temperature" and not over-heated.

Fire Extinguishing Agents

9. There is no ideal fire extinguishing agent for use in aircraft. In the first place there is the problem of finding an extinguisher which can deal with a fire irrespective of the nature of the burning material. Secondly it should be non-toxic not only in its normal state but also in its decomposed form when in use. Many efficient extinguishing substances are particularly dangerous when exposed to the heat of a fire. Finally, it should be effective in as small a bulk as possible.

10. The toxicity of a number of fire extinguishing agents will now be considered:

a. *Methyl Bromide*.

(1) This is a most effective fire extinguishing agent, but highly toxic. The acute poisoning may have a delayed onset of up to six hours in milder cases, but sleepiness, double vision, headache and sickness, paralysis and convulsions may lead to a fatal result. In poisoning due to chronic exposure there may be headache, lethargy and brain damage.

(2) Methyl bromide is no longer used where there is any danger of its gaining access to the aircraft cabin or cockpit.

(3) Two other similar substances are also used as fire extinguishing agents namely, chlorbromethane and carbon tetrachloride.

b. *Carbon Dioxide*. Carbon dioxide has been used extensively as a fire fighting agent, but it is not very effective in dealing with combustible material such as paper and cloth. From the toxic point of view it should not be used in enclosed spaces. At concentrations of 20-25% most people would become unconscious in about 1½ minutes, due to the onset of hypoxia.

Hydraulic Fluids

11. Hydraulic fluid formerly had a castor oil base, but it is now a mineral base. These fluids are not very volatile. Exposure to these fluids causes mild irritation of the eyes and respiratory passages, some nausea and anaesthesia.

Lubricating Oils

12. Oil leaks on to hot surfaces produce aldehydes as break-down products. The smoke which is produced is irritant to the upper respiratory tract.

De-icing Fluids

13. De-icing fluids consist of various mixtures of ethylalcohol, methyl alcohol, propylene or ethylene glycol and water. These substances are not very toxic. Exposure to de-icing fluid in an aircraft is usually due to the fracture of a pipe carrying the fluid, permitting a fine spray to enter the cabin interior. This may produce irritation of the eyes and nose and also some headache and nausea. The symptoms are not usually severe.

Refrigerants

14. Refrigerant gases, such as Freon and Arcton are in themselves usually safe, but decomposition by heat leads to the production of dangerous gases such as chlorine, fluorine and phosgene.

Ozone

15. Ozone is tri-atomic oxygen (O_3) and is formed by the shorter range of ultra-violet being absorbed by oxygen. Most of the ozone is formed between 50,000 and 140,000 ft, the maximum concentration being at about 75,000 ft —the ozone layer. It is highly toxic when inhaled, even in small quantities, and has a destructive effect on rubber which would be badly affected if exposed in the ozone layer. If the ozone is not broken down by heat in the pressurization system, and toxic concentrations are built up in the pressure cabin, the use of 100% oxygen will prevent the inhalation of this substance.

Action in the Event of Cockpit Contamination

16. In the event of contamination of the crew compartment with noxious substances, the appropriate action to be taken to prevent the inhalation of the contaminant will vary according to the particular oxygen system. In the case of the economizer system, EMERGENCY should be selected on the regulator. If the aircraft is fitted with a demand regulator EMERGENCY should be selected and the air-mix control closed (100%); as an extra precaution the mask toggle could be rolled down. Any possible action to prevent irritation to the eyes should be taken. Although not as useful as goggles in this

respect, the vizor can prevent direct contamination.

17. Any action possible to stop further contamination of the crew compartment should also be taken, as well as any measures to improve ventilation—if such a procedure is possible without aggravating the situation.