# Chapter 2

(Completely revised)

## OXYGEN EQUIPMENT

List of Contents



List of Illustrations



### GENERAL

1. This chapter is intended as a guide to aircraft oxygen systems and oxygen equipment; more detailed information will be found in A.P.129, Vol.1, Part 1, Sect.7, and in the other publications mentioned.

2. To enable it to function properly, the human body relies upon oxygen which is extracted from the air passing into the lungs during breathing. The oxygen enters the blood stream and is conveyed to every part of the body, eventually being extracted as required; the degree of oxygenation of the blood is dependent upon the pressure of oxygen in the lungs.

3. For all practical purposes, air may be considered as a mixture of 21 per cent oxygen and 79 per cent nitrogen and inert gases, this ratio remaining constant at all heights. During an ascent, oxygen pressure falls in proportion to the drop in atmospheric pressure, thereby reducing the oxygen content of the blood and giving rise to symptoms of anoxia (the medical term used to denote lack of oxygen).

4. The effects of decreasing pressure during the ascent are counteracted by the aircraft oxygen system which supplies air enriched with oxygen, the proportion of oxygen being increased gradually with height until at approx. 30,000 ft. pure oxygen is being supplied. The pressure exerted by the pure oxygen at this height is sufficient to provide full oxygenation of the blood. As the ascent is continued, however, the pressure continues to fall until at approx. 38,000 ft., there is insufficient pressure to obtain adequate oxygenation even when breathing pure oxygen and some means of increasing the pressure must be provided; this may be either a pressure cabin or pressure breathing (or a combination of both).

5. The effects of anoxia vary from person to person but the following information may be taken as representative of an aircrew member in average physical condition.

Note...
Before flying in high-altitude aircraft, all aircrew should have experienced anoxia in a decompression chamber where their resultant behaviour can be observed without endangering the safety of an aircraft. It is a wise precaution to make use of the decompression chamber periodically to see if their reactions have changed with the passage of time.

6. The most important result of anoxia is its effect upon the brain. Loss of judgement occurs without the knowledge of the individual concerned and in many ways, the effects of anoxia are similar to those resulting from excessive intake of alcohol. At between 10,000 and 18,000 ft. a steady increase in errors of performance occurs; at between 18,000 and 25,000 ft., dangerous changes in mental outlook occur, errors of performance being reinforced by hilarity and irresponsibility or by sleepiness and stupor followed by unconciousness. At heights of more than 25,000 ft., unconciousness follows very quickly if the oxygen supply fails, and at 30,000 ft., it may occur within 10 sec. It should be noted that these figures are average values and that there may be very large variations between persons.

7. The effects of cold upon the body are intensified when a person is suffering from anoxia. The tissues are already suffering from a lack of oxygen; the cold contracts the blood vessels, cutting down the supply of blood and thereby reducing the oxygen supply still further.

8. Night vision is the first faculty to be affected by anoxia, becoming impaired at heights above 4,000 ft., when breathing ambient air. Further effects of anoxia are reduction of resistance to fatigue and an increased liability to air-sickness.

## AIRCRAFT OXYGEN SYSTEMS

9. The early oxygen systems used in aircraft gave a continuous flow and, as oxygen was still being supplied as the user exhaled, much of the available supply was wasted. Later systems are designed to avoid this waste and are divided into three distinct types:-

(1) Economiser system.

(2) Pressure-breathing system.

(3) Pressure demand system.

### ECONOMISER SYSTEM

10. An economiser is a device which converts the continuous flow of oxygen from the regulator to the intermittent flow required during respiration, thereby achieving a saving of some 50 per cent without the user receiving any less. Below about 25,000 ft., the regulator delivers an amount of oxygen which only partially fills the economiser bag. As the user inhales, he exhausts the bag and the oxygen mask inspiratory valve opens to admit air, enabling the user to fill his lungs. Above 25,000 ft., the regulator delivers sufficient oxygen to fill the bag and the user inhales pure oxygen. At normal respirations, the economiser bag is replenished at the same rate at which the user empties it; no oxygen is supplied, therefore, during exhalation.

11. The oxygen masks used with the economiser system are either the Type H or Type L (for use of passengers in transport aircraft).

12. The maximum permissible aircraft altitude when using the economiser system is 38,000 ft. if the cabin is unpressurised or 43,000 ft. if the cabin is pressurised. If the cabin pressure system fails, an immediate rapid descent must be made to 40,000 ft. followed by a further descent to 30,000 ft. within four minutes (fig.1).

### PRESSURE-BREATHING SYSTEM

13. The pressure-breathing system consists of a pressure-breathing waistcoat and a Type M, Mk.2 oxygen mask connected to the economiser system in such a manner that the economiser is by-passed; it is used primarily as a "get-you-down" aid, giving protection to the crew of a pressurised aircraft during an emergency descent following loss of cabin pressure. The limiting altitude for this equipment is 48,000 ft. in a pressurised aircraft or 44,000 ft. if the aircraft is unpressurised.

WARNING

THE PRESSURE-BREATHING/ECONOMISER SELECTOR VALVE MUST BE WIRELOCKED IN THE "PRESSURE-BREATHING" POSITION WHEN IT IS DESIRED TO USE THE EQUIPMENT. PRESSURE-BREATHING EQUIPMENT MUST NEVER BE USED WITH AN ECONOMISER, NOR MAY THE TYPE M, MK.2 OXYGEN MASK BE USED WITHOUT A PRESSURE-BREATHING WAISTCOAT.

14. The pressure-breathing waistcoat is worn over all other items of flying clothing except the life jacket.

PRESSURE DEMAND SYSTEM

15. The pressure demand system has the following advantages over the earlier systems:-

(1) It supplies oxygen automatically in accordance with the user's demands.

(2) It provides a positive indication of oxygen flow each time the user inhales and automatically provides the correct oxygen and air mixture or pure oxygen required for any altitude.

(3) It delivers oxygen under pressure automatically for pressure breathing at cabin altitudes exceeding 40,000 ft.

(4) 100 per cent oxygen can be obtained at any time by operation of the air dilution switch.

Note...
At present, the air dilution switch is locked in the "100 per cent oxygen" position.

(5) It supplies oxygen at a positive pressure, for emergency use, when EMERGENCY is selected on the regulator.

(6) In the event of loss of cabin pressure, the oxygen supply is adjusted automatically to suit the new cabin pressure.

16. The oxygen masks and regulators used with a pressure demand system, are as follows:-

(1) Oxygen masks
Type A13A series: Type P series: Type Q series: Partial pressure helmet: Type R (Britannia aircrew only).

(2) Oxygen regulators
Mk.17D and 17E: Mk.20 and 20A: Mk.21 and 21A: Type A12A (Britannia aircrew only).

The limiting altitudes of the various combinations of mask, pressure clothing and regulator are shown in fig.1; reference is also to be made to the information which will be included in the appropriate section and chapter of this publication, dealing with specific aircraft types and marks.

17. A full description of all oxygen systems and their components will be found in A.P.1275G, Vol.1; oxygen masks and pressure clothing are dealt with in A.P.1182E, Vol.1.

LIQUID OXYGEN SYSTEMS

18. Aircraft oxygen cylinders, being both bulky and heavy, impose a severe restriction on aircraft performance, particularly on the more modern aircraft which require to fly at high altitude for long periods and thus need to carry considerable quantities of oxygen. A further disadvantage is that as the cylinders are charged to a very high pressure (1800 lb.in.$^2$), any battle damage may result in an explosion. These problems are being overcome by the use of liquid oxygen systems.

19. The liquid oxygen is carried in insulated, double-walled converters and is converted to gaseous oxygen before reaching the regulator. The weight and space saving is considerable; for example, in a long range aircraft which normally carries nine 2,250-litre cylinders, these can be replaced by one 25 litre converter, showing a weight and space saving of some 70 per cent. Furthermore, as the system operates at low pressure (150-200 lb.in.$^2$), the risk of explosion following battle damage is negligible.

EMERGENCY OXYGEN SETS

20. An emergency oxygen set provides an emergency supply of oxygen for use during a high-altitude bale-out or when the aircraft main oxygen supply fails; the set can be attached to the parachute harness, the personal survival pack or the ejection seat.

21. The main components are:-

(1) A small storage cylinder.

(2) A regulator.

(3) A supply tube.

(4) An operating cable.

22. The cylinder contains 55 litres of oxygen, compressed to 1800 $lb.in.^2$. The rate of flow of oxygen from the earlier sets is controlled by a fixed-jet regulator screwed to the neck of the cylinder. The set has an endurance of approx. 10 minutes; if, therefore, it is used because of failure of the main oxygen supply, it is essential to descend to below 10,000 ft. as soon as possible. If the set is being used after a high-altitude bale-out, a delayed drop to at least 20,000 ft. is advisable.

23. There are several types of emergency oxygen sets in service; full details will be found in A.P.1275G, Vol.1.

## WALK-AROUND OXYGEN SETS

24. Walk-around oxygen sets are provided for the use of aircrew members who may need to vacate their normal position in the aircraft in flight and move to some other position. There are three types in service, details of which will be found in A.P.1275G, Vol.1, and in A.P.129.

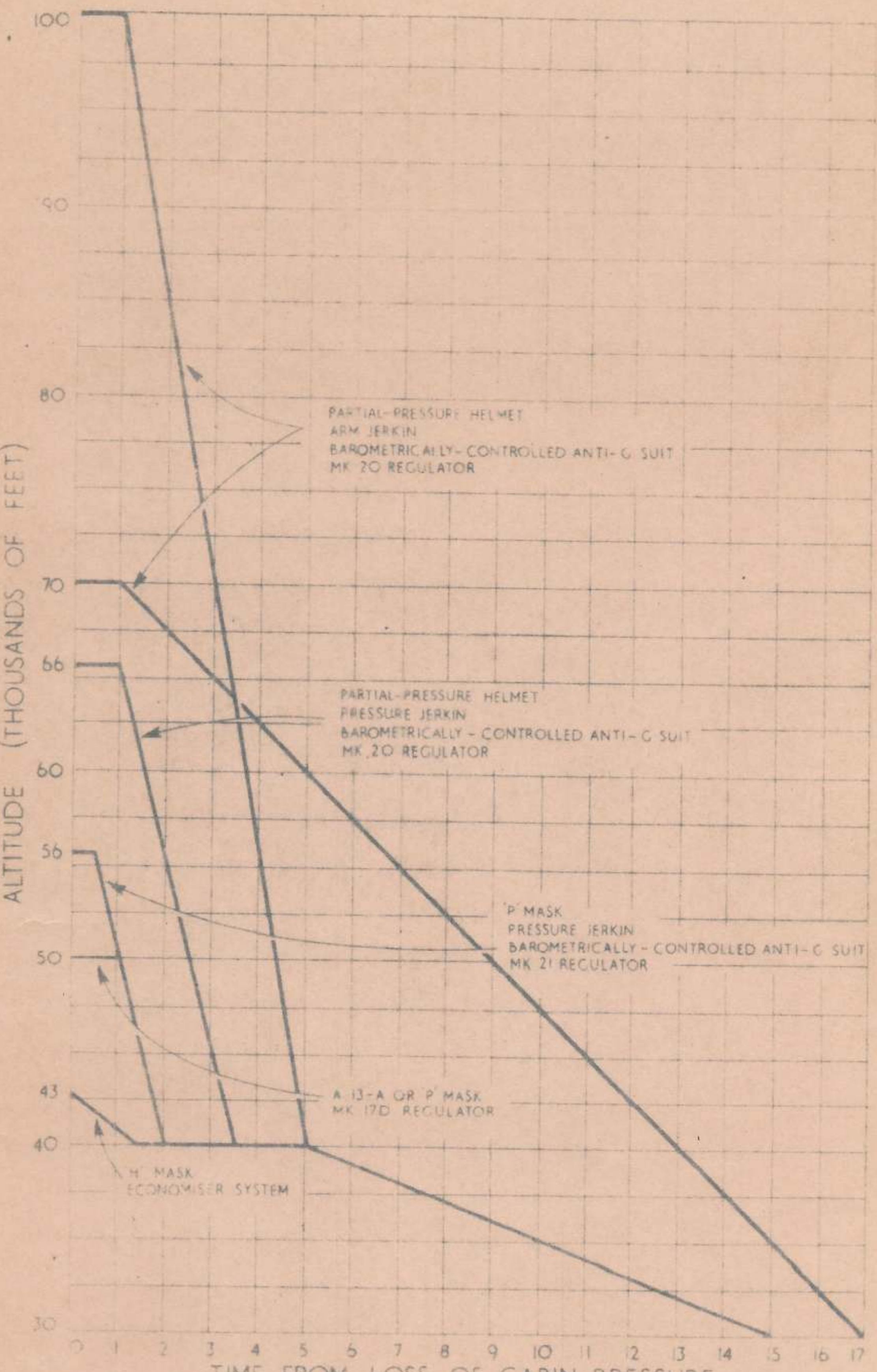


FIG.1. ALTITUDE/TIME LIMITS AFTER CABIN PRESSURE FAILURE


18
18