PART 1 : SECTION 7

CHAPTER 4

# AUTOMATIC PRESSURE-DEMAND OXYGEN SYSTEMS

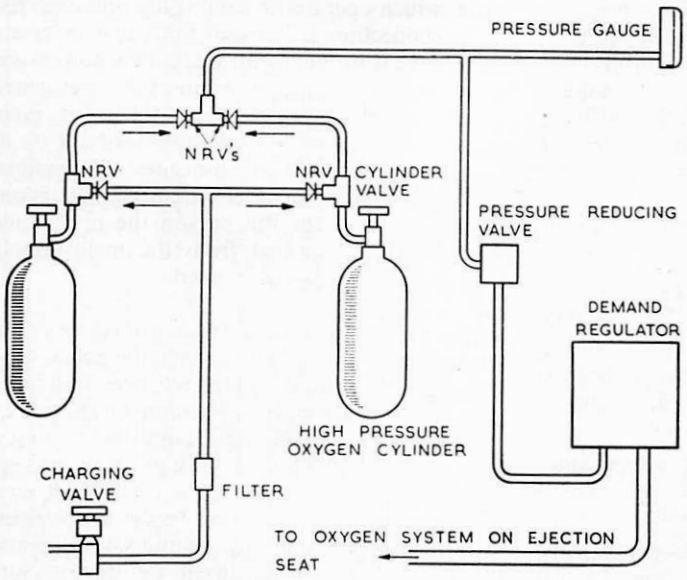


Fig. 1. Typical Automatic Pressure-Demand System.

On U.S.A.F. aircraft, the oxygen cylinder pressure is usually only 450 lbs./sq. in. The regulator (Fig. 2) is fitted with :—

(*a*) An ON/OFF valve.

(*b*) An air-dilution switch whereby 100 per cent. oxygen can be breathed at any height.

(*c*) A blinker which indicates when oxygen flows to the user.

(*d*) A pressure gauge. This shows only the reduced pressure, not the contents of the main supply system.

## Introduction

1. The automatic pressure-demand oxygen system (Fig. 1) has been introduced for use at 42,000 feet for long periods, 43,000 feet for not more than 30 minutes, and 44,000 feet for not more than 15 minutes. It also permits a safe descent in pressurized aircraft from 50,000 feet aircraft altitude in the event of pressure cabin failure. The Mk. 17, Mk. 17B, or Mk. 17C regulators are used to supply oxygen in this system. The Mk. 17 is of British manufacture ; the Mk. 17B is American made and modified to the same standard as the Mk. 17. The Mk. 17C is similar to the Mk. 17, but is fitted with a remote blinker additional to the normal blinker.

## Mk. 17 Regulator

2. The Mk. 17 regulator is fitted with an ON/OFF control which is wired ON, and all functions such as air dilution and pressurization are carried out automatically. The regulator is designed for 450 lbs./sq. in. pressure, and on British aircraft is supplied, through a reducing valve, from the 1,800 lbs./sq. in. supply cylinder.

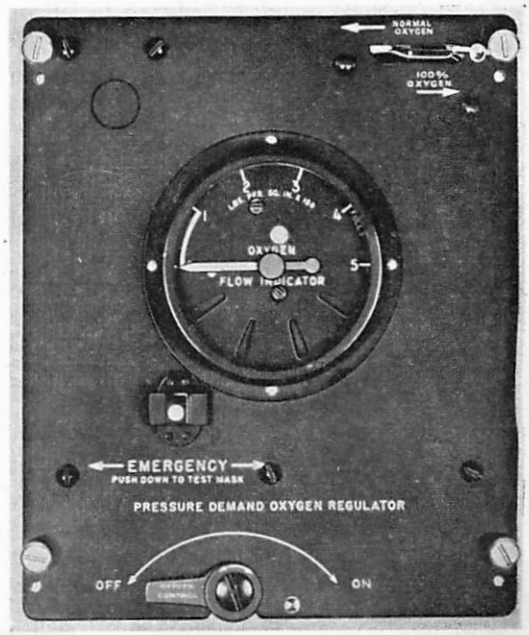


Fig. 2. Pressure-Demand Oxygen Regulator, Mk. 17.

(*e*) An EMERGENCY switch, which gives a choice of two pressures to the mask. Deflection of the switch to the left or right gives the lower (EMERGENCY) pressure which is for use at any time when prevention of inward leakage (*e.g.* fumes) to the mask is essential or in any other emergency. Pressing the switch inwards gives the higher *mask test* pressure, used to check that the mask fit is suitable for pressure-breathing. The more firmly the switch is depressed, the greater is the oxygen pressure. When the switch is depressed fully, the pressure is five times as great as when the switch is in either of the side positions.

3. The Mk. 17 regulator has the following advantages :—

(*a*) It supplies oxygen *automatically* in accordance with the user's demand, from sea level to 50,000 feet.

(*b*) It is provided with a positive indication that oxygen flows to the user each time he inhales.

(*c*) It delivers oxygen under pressure automatically for pressure-breathing at heights above about 40,000 feet.

(*d*) One hundred per cent. oxygen can be obtained at any time by operating the air-dilution switch.

(*e*) It supplies oxygen at a slightly positive pressure, for emergency use, whenever the EMERGENCY switch is deflected to left or right.

(*f*) In the event of explosive decompression of a pressurized cabin, the regulator adjusts itself immediately to the new cabin pressure.

(*g*) Any failure of the bellows produces reactions in the direction of safety, *e.g.* failure of the air inlet bellows results in the supply of 100 per cent. oxygen.

A separate regulator is required for each crew station, but this is offset by the fact that no economizer is necessary with the Mk. 17 regulator.

## Type A-13A and Type A-13A/1 Masks

4. Masks of types A-13A and A-13A/1 (Fig. 3) consist of a face-piece complete with mask tube assembly The face-piece contains two inlet check valves, a compensated outlet valve, and a microphone. Attachment to the helmet is by an adjustable webbing harness. The flexible corrugated rubber tube from the face-piece is fitted with a quick-release plug which connects to the main oxygen supply, and provision is made for connection to the emergency oxygen supply by a small bayonet connection. This connection is fitted with a self-closing valve so that when the emergency oxygen is not connected, there is no loss of oxygen. The connection to the main supply is fitted with a combined non-return and relief valve, which operates during baling out when the main connection is broken and the emergency oxygen set is brought into use. This non-return valve prevents oxygen from the emergency oxygen set being wasted, and the relief valve operates when a pre-set pressure has built up in the mask. Thus some measure of pressure-breathing is given whenever the emergency oxygen set is used, and for this reason the mask tube should be disconnected from the main supply when emergency oxygen is used.

5. Oxygen, or at low altitudes a mixture of air and oxygen, is inhaled through the mask tube and then through the inlet passages and inlet valves of the face-piece. The outlet valve, which is mounted on a diaphragm supported by a light spring, is subjected to incoming pressure through a small tube which projects into the duct conveying the breathing mixture to the inlet valves. Under pressure-breathing conditions, the pressure inside the mask is equalized by the pressure applied to the underside of the diaphragm and the outlet valve remains closed. When the user exhales, however, the inlet valves close and enable a small additional pressure to be built up to overcome the spring load and open the outlet valve.

6. The A-13A mask is fitted with an American carbon microphone for use with the American A.R.3 radio set in F.86E aircraft. The A-13A/1 mask is fitted with a British electro-magnetic microphone for use with British radio sets.

## Fitting the Mask

7. **Selection of Correct Sized Mask.** It is important that a mask of the correct size is selected. When properly fitted, the inside flap should be tight all round and the mask should not ride too high on the nose.

8. **Trimming the Cheek Flaps.** If desired, the cheek flaps may be trimmed so that they extend about $\frac{1}{4}$ in. under the forward edge of the helmet. The cheek flaps should not fit tightly, since they are intended only for protection against extreme cold and flash burns. The chin cup may be worn up to $\frac{1}{2}$ in. below the chin without affecting the mask fit. If irritation is caused by sweat between

the cheek or chin flaps and the skin, the flaps may be cut back to the edge of the mask without endangering the fit.

9. **Hooking the Mask on to the Helmet.** Proper location of the fasteners is important. The mask should be held on the face in the most comfortable position, then the top webbing strap should be carried back towards the ear lobes and all the fasteners hooked on to their appropriate attachments. The mask should then be secured comfortably by the webbing adjusters.

10. **Hints on Reducing Mask Discomfort.** To hold the higher pressures the mask must be held firmly against the face. This may result in painful pressure, especially on the bridge of the nose. Therefore :—

(*a*) Do not try to maintain greater tension on the mask than that necessary to hold the pressure. Adjust the strap tension just sufficiently to balance the pressure requirements.

(*b*) Do not let the cheek flaps jam against the edges of the helmet. This tends to counteract the strap tension and necessitates drawing the mask up more tightly against the nose. Trim the flaps as necessary.

*Note.*—With the A-13A mask, some discomfort may arise from the strap which lies across the upper lip, but it will be found that this discomfort disappears after a brief interval. For greatest pressure-holding efficiency the lip strap should not be removed.

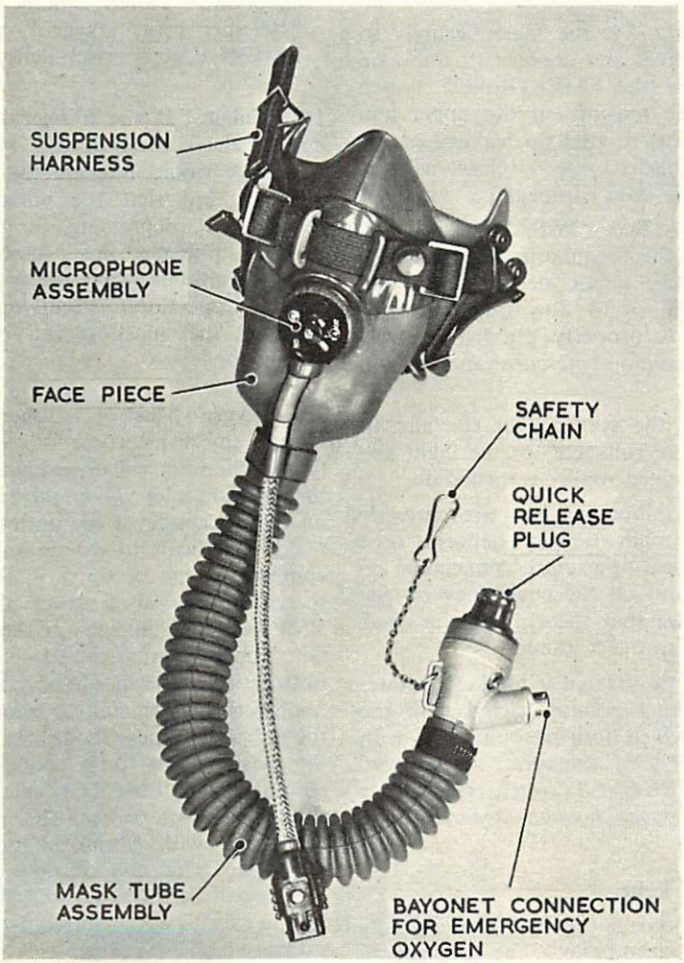


Fig. 3. Oxygen Mask, Type A–13A/1.

## Pre-Flight Checks

11. Before flight the following checks should be completed :—

(*a*) *General.* Ensure that all parts of the mask are securely in place. Ensure that the inlet check valves are covered by the plastic shields and that the arrows point downwards. (The shields are designed to keep moisture away from the inlet check valves and prevent icing.)

(*b*) *Inlet Check Valves.* Compress the mask tube by forcing the corrugations close together, then block the quick-release end with the thumb and allow the mask to hang from the thumb. The inlet check valves should hold the tube in compression. If the mask tube extends or releases from the thumb, inspect the valve seats for proper insertion and for dirt on the seat.

(*c*) *Pressure Test.* Fit the mask securely to the face and helmet and connect to the main supply. Depress the EMERGENCY switch and increase the tension on the upper and lower mask straps so that no leakage occurs during the respiratory cycle. Release as soon as adjustment has been completed.

(*d*) *Outlet Valve Test.* With the mask still connected to the regulator, depress the emergency switch, inhale deeply and hold. If oxygen continues to flow (and provided that the mask is properly fitted) the outlet valve is not holding pressure and is unserviceable.

(*e*) Ensure that the contents of the aircraft oxygen system are sufficient for the flight and that the main oxygen supply is turned on.

(*f*) Ensure that all connections are correctly made on the main oxygen delivery tube (including the seat-to-aircraft connection on ejection seats) and on the emergency oxygen supply tube. See that the clip on the mask tube is attached to the clothing.

(*g*) Ensure that the regulator blinker operates and that breathing is unrestricted with the air-dilution switch in both positions, and with the EMERGENCY pressure turned on. *When the EMERGENCY switch is turned on the additional pressure should be apparent.*

## Use in Normal Flight

12. Once the regulator is turned ON, the supply of oxygen is fully automatic. The user should keep a check on the main supply pressure gauge, which is a separate gauge, and in British aircraft is not the lower pressure indicated on the regulator dial. In addition, a check should be made to ensure that the blinker is functioning correctly.

## Use in Emergency

13. The air-dilution switch should be used in the "100 per cent. Oxygen" position in the following circumstances :—

(*a*) *When special provision has been made for pre-oxygenization so that, in a possible subsequent emergency, the risk of decompression sickness is reduced.* This is permissible only if the aircraft oxygen system is capable of maintaining the supply of oxygen for the prescribed period. (See Table 1 in para. 20.)

(*b*) *If the cockpit is contaminated with toxic fumes or noxious gases.* In this event, the air-dilution switch should be moved to the "100 per cent. Oxygen" position and the EMERGENCY switch deflected to either side.

14. **Blinker.** If the blinker ceases to operate, depress the EMERGENCY switch. A flow to the mask would indicate that oxygen is being supplied, but that the blinker mechanism is suspect. If depressing the switch does not produce pressure flow, descend immediately to a safe altitude where the system may be given a visual inspection for faults such as a disconnection of the mask-to-seat or seat-to-aircraft connections.

15. **Oxygen Mask — Emergency Procedure.** Should any dirt particle lodge beneath the valve flap of the inlet valves, exhaled breath will pass through the inlet valve and build up a pressure on the underside of the outlet valve. This will make it difficult to exhale and may cause discomfort. The bottom of the mask should, therefore, be raised from the face and the EMERGENCY switch on the regulator should be depressed momentarily to blow out the obstruction ; this should be repeated if necessary. Should this action fail to clear the obstruction, the webbing harness should be slackened off until the mask is just loose enough for exhaling in comfort, and EMERGENCY selected. Care should be taken to keep the mask as tight as is consistent with comfort (to reduce oxygen wastage). The rate of flow under these conditions will be much greater than normal, therefore, a careful watch should be kept on the high-pressure contents gauge.

*Note.*—The use of 100 per cent. oxygen increases the consumption of oxygen in inverse

proportion to the altitude. It is, therefore, imperative that this setting should be used with great caution, particularly at lower altitudes, and that the remaining oxygen supply, as indicated by the high-pressure contents gauge, should be watched carefully.

16. **Ditching.** Before ditching, the air-dilution switch should be set to deliver 100 per cent. oxygen, and the emergency switch turned ON. The equipment will then act as an efficient submarine breathing-apparatus and facilitate preparation for escape from a submerging or submerged aircraft. The following vital precautions should be observed while under water:—

(*a*) The temptation to fill the lungs to the maximum before disconnecting the oxygen tube must be resisted.

(*b*) It is essential to breathe out steadily and continuously while ascending. A satisfactory rate of " venting " surplus air is by whistling.

(*c*) The ascent should be regulated so as not to overtake the bubbles of exhaled air.

(*d*) The life-saving jacket must be inflated.

17. The Mk. 17 series regulators should not be used for escape in deep water without previous underwater experience. They should also not be used in poor visibility and rough sea, *e.g.* during catapult take-offs particularly at night ; the reason being that in such conditions it is difficult to control the breathing and impossible to see the bubbles. Unless the user is confident of his ability to follow the vital instructions (para. 16 (*a*) to (*d*)) he should rely on the time given by a good lungful of normal air drawn in just before submerging.

18. The air drawn in from the regulator while submerged, and just before disconnecting the oxygen tube, is supplied at a pressure proportional to the water pressure. During the ascent this air expands in the lungs as the balancing water pressure falls and unless the excess air is vented off in the controlled manner suggested in para. 16(*b*) the excessive pressure may cause severe damage to the lungs—with little or no warning of the approaching injury. It has been proved in practice that a normal breath of oxygen at the appropriate mask pressure will enable a successful ascent to be made from a considerable depth when using the correct technique ; there is no desire, or need, to breathe in.

## Emergency Oxygen Sets

19. When pressure-breathing masks Type A-13A or A-13A/1 are used with the emergency supply, exhalation is difficult. It is essential that the crew member disconnects the main mask tube connector if it becomes necessary to use the emergency oxygen set in the aircraft, but this will be done automatically on ejection.

## Vacating a Crew-Position During Flight

20. Pressure-demand regulators provide a slight pressurization at heights above 10,000 feet, and, therefore, *if a crew-position is vacated during flight, the end of the delivery tube must be closed by a blanking plug or a socket incorporating a shut-off valve.* If this is not done, a considerable oxygen wastage occurs from the vacated crew-position. The method of sealing delivery tubes with dummy plugs is an interim measure until sockets incorporating automatic shut-off valves are fitted. Oxygen should be allowed to flow through the hose before connecting to the mask after a dummy plug is removed.

## Regulators Not Used in Flight

21. In addition to sealing delivery tubes with dummy plugs, a regulator not in use must have its air-dilution switch in the NORMAL position, otherwise the regulator diaphragm may burst during descent.

## Endurance

22. Table 1 gives the endurance of one full 750-litre cylinder per man using the pressure-demand regulators Mk. 17, and Mks. 17B and C.

TABLE 1

(*a*) *Air-Dilution Switch at NORMAL Oxygen.*

| *Height in Thousands of Feet* | *Endurance* | |
|---|---|---|
| | *Hours* | *Mins.* |
| 0 | 2 | 30 |
| 5 | 3 | 50 |
| 10 | 4 | 45 |
| 11–14 | 4 | 30 |
| 15–19 | 3 | 25 |
| 20–24 | 2 | 50 |
| 25–29 | 3 | 00 |
| 30–34 | 2 | 45 |
| 35–39 | 1 | 55 |
| 40–44 | 1 | 55 |
| 45–50 | 1 | 55 |

(*b*) *Air-Dilution Switch at* 100 *Per Cent. Oxygen for Emergency and Pre-Oxygenization Only.*

| *Height in Thousands of Feet* | *Endurance* | |
|---|---|---|
| | *Hours* | *Mins.* |
| 0 | | 55 |
| 5 | 1 | 00 |
| 10 | 1 | 15 |
| 11–14 | 1 | 25 |
| 15–19 | 1 | 45 |
| 20–24 | 2 | 15 |
| 25–29 | 3 | 00 |
| 30–34, 35–39, 40–44, 45–50 | As shown in sub-para. (*a*) | |

## SUMMARY OF OXYGEN SYSTEMS AND ASSOCIATED EQUIPMENT

23. Table 2 outlines the various systems and their limitations. For further details, reference should be made to the appropriate chapter in this section.

(*Table* 2 *appears overleaf.*)

TABLE 2

| TYPE OF OXYGEN SYSTEM | MASK TYPE | REGULATOR | PRESSURIZED AIRCRAFT | UNPRESSURIZED AIRCRAFT | MOVING CREW MEMBER—MAX. CABIN ALTITUDE | USE IN EMERGENCY | EMERGENCY OXYGEN |
|---|---|---|---|---|---|---|---|
| ECONOMIZER | H | Mk. 10A series<br>Mk. 11 series<br>Mk. 16 series | Max. aircraft altitude 43,000 feet. Immediate descent to be made on loss of cabin pressure. | Max. aircraft altitude 40,000 feet. (Well fitting mask to be worn.) | With :—<br>Mk. 1B walk-around oxygen set—25,000 feet.<br>Mk. 3 walk-around oxygen set—30,000 feet.<br>Economizer with long lead—30,000 feet. | EMERGENCY flow to be selected or regulator set to EMERGENCY. | TO BE CARRIED ON ALL NORMAL FLIGHTS ABOVE 25,000 FEET AIRCRAFT ALTITUDE. |
| PRESSURE-BREATHING | J or M | Mk. 10A series<br>Mk. 11 series<br>Mk. 16 series | Max. aircraft altitude 48,000 feet. On loss of cabin pressure, mask setting must be set to HIGH and descent started at max. rate. | Max. aircraft altitude 44,000 feet. Time limit 15 minutes. | Using pressure-breathing equipment set at HIGH pressure with a long lead—37,000 feet.<br>Using pressure-breathing equipment set at HIGH pressure, with walk-around oxygen set Mk. 1B—37,000 feet.<br>With torn waistcoat disconnected; oxygen flow set to EMERGENCY or as high as possible—25,000 feet. | If waistcoat is torn, disconnect the oxygen line to the waistcoat ; turn oxygen flow to EMERGENCY or as high as possible. Descend to 30,000 feet cabin altitude. Oxygen regulator is to be set to HIGH. | TO BE CARRIED ON ALL NORMAL FLIGHTS ABOVE 25,000 FEET AIRCRAFT ALTITUDE. |
| AUTOMATIC PRESSURE-DEMAND | A13A or A13A/1 or N | Mk. 17 series | Max. aircraft altitude 50,000 feet. On loss of cabin pressure, height to be reduced to below 40,000 feet aircraft altitude. | Max. aircraft altitude 44,000 feet. Time limit 15 minutes. | Extension tubes provided. May be used up to 40,000 feet. | Set air dilution switch to 100 per cent. oxygen and deflect EMERGENCY switch to either left or right. | TO BE CARRIED ON ALL NORMAL FLIGHTS ABOVE 25,000 FEET AIRCRAFT ALTITUDE. |

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