

CHAPTER 3

NUCLEAR BIOLOGICAL AND CHEMICAL PROTECTIVE FLYING CLOTHING

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Introduction

1. Very effective personal NBC equipment has been issued to the UK Armed Forces over the last decade. This equipment, however, is designed primarily for use by ground personnel and it is unsuitable in a number of respects for the different needs of aircrew, particularly those operating in high performance aircraft. Acknowledging the need for special aircrew NBC equipment, it was decided to provide specific on-ground and in-flight protection against toxic chemical, biological and particulate nuclear agents.

2. All the major items of this equipment have now been developed and are being issued to aircrew. This chapter describes the main features of the aircrew NBC equipment and its support systems together with the associated procedures and ground facilities which are required to ensure maintenance of air operations in the presence of chemical warfare (CW) agents. To set the scene, the CW threat, its physiological and operational implications for aircrew and the philosophy of personal protection are summarised.

The Chemical Warfare Threat

3. The Soviets are known to have considerable stocks of CW agents and an effective delivery capability. Fixed air bases in particular are considered to be prime targets for early and repeated chemical attack in the event of even a limited conflict. Chemical Warfare agents provide a very effective means of inhibiting or preventing air operations without the need to destroy or damage aircraft, equipment or ground installations with high explosive weapons.

4. No differentiation is made here between the specific hazards associated with each of the different types of CW agents; all are lethal and their presence requires common protective measures. These agents, either in vapour or liquid form, may be absorbed into the body by a variety of routes. In vapour form they present an immediate severe hazard to the respiratory tract and eyes and, if in high concentrations, to exposed skin. In liquid form they present a hazard to the eyes, exposed skin and, via the mouth, to the gastro-intestinal tract. Even momentary exposure to the nerve agents can produce effects varying from

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mild impairment of performance to incapacitation and death.

5. The duration of the toxic hazard after an attack with CW weapons depends upon the type of agent used, the method of deployment and local meteorological conditions. A single attack involving the use of persistent liquid CW agent could produce a residual hazard for a period of days. Furthermore, the time interval between warning of an attack and the presence of CW agents could be only a few seconds; thus personnel must be wearing their personal protective equipment before an attack occurs. Indeed, it is envisaged that the aircrew NBC assemblies will be the normal wear equipment for many aircrew in the event of a conflict, and that this equipment will be worn for all missions from an appropriate stage of alert. Chemical warfare agents cause very little or no material damage to aircraft, ground support equipment or aircrew personal equipment; air operations can continue under a CW challenge provided that all personnel are adequately protected and the use of the protective equipment does not seriously degrade performance. Additional information on CW agents, their effects etc, is given in AP 3395.

Protection Philosophy

6. **Collective Protection.** Although the primary defence for aircrew against chemical warfare is individual personal protection, the personal NBC equipment assembly can only be worn continuously for a limited period of time (of the order of 12-18 hours). Therefore, its use must be complemented by collective protection in which the personal equipment may be removed and where all personnel can obtain rest and relief. The collective protection facility consists of leak-proof accommodation which is continuously ventilated with clean filtered air and is maintained at a slight over-pressure. It is fitted with entry and exit airlocks and a Contamination Control Area (CCA) external to the airlocks where special drills are used to ensure that personnel can safely

remove and re-don contaminated items of their NBC aircrew equipment assembly, and safely proceed into the area of collective protection. Collective protection can be provided as on-base hardened structures, ship-board Citadels, "Marshall" cabins or specially lined buildings or tentage. In certain circumstances, for example some helicopter operations, it may be possible for aircrew to deploy to an area which is free from contamination in order to obtain rest and relief; here too, however, appropriate equipment donning and doffing procedures are essential.

7. **Personal Protection.** The need for special NBC equipment for aircrew, and the requirement for its total-mission wear, are dictated by the following factors:

a. Conventional respirators of the face-sealing suction type, such as the S6, will not prevent, in a proportion of individuals, the development of miosis (constriction of the eye pupils) on exposure to high concentrations of nerve agent. Whilst miosis may be of little or no consequence to the vast majority of ground personnel, it impairs vision at low levels of illumination and this is unacceptable in aircrew operating under twilight conditions or at night. Other features of the S6 type of respirator which make it unsuitable for use in flight are restriction and distortion of vision, absence of a microphone, incompatibility with aircrew helmets, relatively high resistance to breathing, expansion of face-seal air at altitude, lack of stability under g, incompatibility with vision aids and optical sights and fogging and freezing on exposure to low temperatures.

b. The overgarment NBC protective suits for ground personnel have the disadvantages in the context of wear by aircrew, especially in small cockpits, that they are bulky, restrict movement and overlie essential facilities normally provided on the outer layers of the flying clothing.

c. In the event of a chemical attack it must be assumed that all open areas of a

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base, sheltered areas such as Hardened Aircraft Shelters and Contamination Control Areas, ground equipment and aircraft will become contaminated.

d. It will be impossible in practice to prevent CW agents being carried into aircraft during aircrew entry and during servicing by ground personnel. Furthermore, CW agents may also gain access to the cabins by way of the cabin conditioning system and indeed may condense out and remain within the system only to evaporate and pass into the cabin later during flight. The size and weight of the filter required make it impracticable to filter cabin conditioning air.

e. In any intensive war in which CW agents are employed it would not be practicable in terms of time or manpower to decontaminate either aircraft or associated ground equipment before use.

f. The standard of leaktightness achieved in current oxygen regulators even when the regulator is set to "100% oxygen" and "Emergency", are such that the oxygen delivered to the current mask cannot, in a CW environment, be guaranteed free of toxic contamination.

Aircrew NBC Equipment Assemblies

General Philosophy

8. In addition to the NBC protection requirement, equal importance in the design and development of aircrew NBC equipment has been given to the need for unobtrusive integration with all other items of aircrew protective equipment and aircraft crew stations, thus ensuring that there would be the minimum of changes to standard equipment and aircraft. The aim has been to provide aircrew with effective NBC protection which enables them to continue to perform all their flight and ground tasks with the minimum reduction of efficiency and the minimum increase in discomfort, fatigue and heat load.

9. Although the requirements of the integrated aircrew NBC equipment assemblies vary in relation to specific aircraft types and roles, every effort has been made to standardise the items of the assemblies which provide protection to the skin of the trunk, limbs, hands and feet. This objective of standardisation has also been met, as far as is practicable, with the Aircrew Respirator NBC No 5 (AR 5) where the different requirements (air or oxygen breathing and mode of attachment to the Aircrew Equipment Assembly (AEA)) have been met by a single common respirator and two variants of the respirator supply manifold.

Below-the-Neck Protective Assemblies

10. **Inner Coverall NBC Mk 1.** Investigations of the shortcomings, in the context of flight operations, of the protective overgarment used by ground personnel led to the adoption for aircrew of an NBC protective undergarment which is worn directly beneath the outer layer of the current "normal" clothing assembly. This garment, the Inner Coverall Aircrew NBC Mk 1, shown in Fig 1, is a ventile one-piece garment available in nine sizes and constructed from the standard CB fabric which is coated on its inside surface with activated charcoal. The NBC Inner Coverall has been designed and sized to ensure compatibility with all standard outer flying clothing (coveralls, cold weather flying suits, combat suits and ventile immersion overalls) AND IN COMBINATION WITH THESE GARMENTS provides protection for up to 24 hours continuous wear after exposure to liquid CW agents. However, the activated charcoal lining of the NBC Inner Coverall is degraded by direct contact with sweating skin and a minimum of one layer of clothing comprising long limbed fine cotton ribbed underwear must be worn beneath the NBC Inner Coverall. When low environmental temperatures or survival considerations dictate the wearing of additional thermal insulative garments such as the Coverall, Inner Mk 2, these garments also must be worn BENEATH the NBC Inner Coverall.

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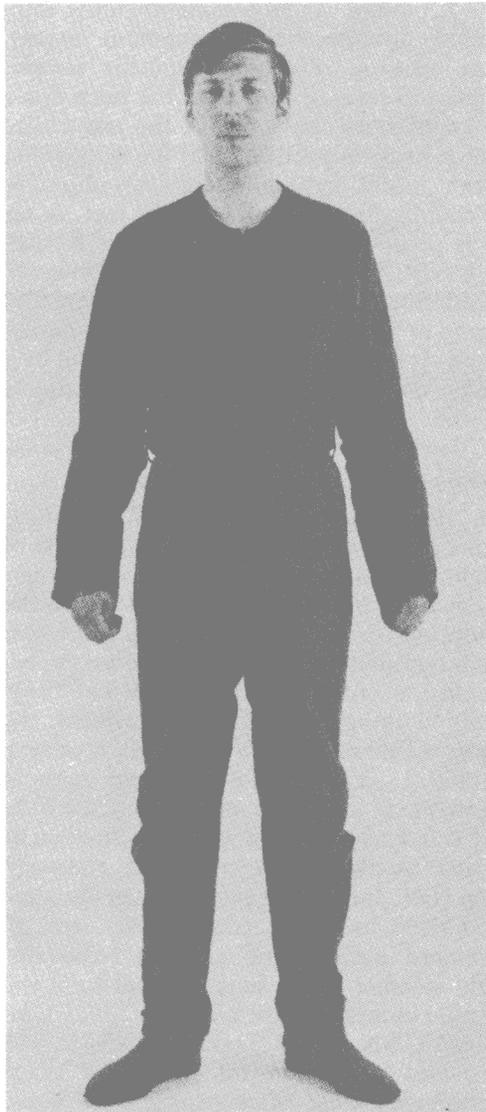


Fig 1. Inner Coverall, Aircrew, NBC Mk 1 and Socks, Aircrew, NBC Mk 1

11. Although the ventile fabric of the Immersion Coverall Mk 10 can be used as the outer layer of the AEA to protect the skin against CW agents, the method of donning and doffing that coverall, which involves passing the circular neck seal over the head and neck, cannot be used safely if the Immersion Coverall is contaminated.

Special donning and doffing procedures have been formulated to enable the Mk 10 Immersion Coverall to be used during peacetime NBC training, pending the development of a new Immersion Coverall which meets all the NBC requirements.

12. **Socks, Aircrew, NBC Mk 1/2.** The concept of undergarment body and limb protection has been extended to foot protection. This is provided by CB fabric socks (Socks, Aircrew, NBC Mks 1 and 2), which are worn over standard aircrew socks and beneath the standard aircrew boots. These NBC socks are made in eight sizes which coincide with UK male shoe sizes 5 to 12. The earlier Mk 1 socks are manufactured in left and right versions and have a reinforced heel. The Mk 2 version is a "uni-sock" and the reinforced heel has been omitted.

13. Tests have shown that the protection afforded by the complete footwear assembly against liquid CW agents is adequate with all current RAF/RN/Army Aircrew Boots. However, to supplement the protective footwear and to avoid the gross spread of contaminant to aircraft cockpits and Contamination Control Areas (CCAs), disposable latex overboots are being provided for wear over the aircrew boot whilst aircrew are in transit to or from the collective protection area and their aircraft. These overboots will be doffed at the aircraft steps or CCA entrance as appropriate.

14. **NBC Gloves.** The best compromise found to date between comfort, dexterity and adequate CW agent protection for hands is the combination of a neoprene glove (Glove, Aircrew, NBC Mk 1) worn beneath the standard aircrew cape leather glove. The Mk 1 NBC glove is made of neoprene with a cotton flock lining bonded to it by means of a thin latex interlayer. The cuffs are sufficiently long to ensure generous overlap when positioned over the cuffs of the NBC Inner Coverall. On a small percentage of individuals the glove cuffs are insufficiently tight over the coverall cuffs to prevent slippage and wrist exposure;

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to avoid this the glove cuff has to be tensioned with a folded pleat and taped locally with adhesive tape. A Mk 2 glove is being developed to overcome this problem by providing an inward tapering cone on the cuff end. The NBC gloves when worn with the aircrew cape leather gloves provide at least 8 hours protection after contamination by liquid CW agents. This period can be extended to at least 18 hours by replacing, with appropriate drills, the NBC gloves and re-donning the contaminated cape leather gloves.

15. **Dressing.** The order in which the items comprising the aircrew NBC AEA are layered over the body is of considerable importance since it affects the physiological protection provided by garments such as anti-g trousers and the ability of the wearer safely to doff and don contaminated items. Outer items of the normal AEA are donned on top of the NBC garments in the order in which they are normally worn (ie in non-NBC conditions). Thus internal g-trousers are worn directly over the NBC Inner Coverall and beneath the Aircrew Coverall and items such as Lifepreservers are donned over the Aircrew Coverall.

16. By adopting the undergarment protection approach it is accepted that in a CW environment all outer items of the aircrew NBC AEA will become contaminated and for logistic and cost reasons will have to be doffed, stored and subsequently re-donned in the contaminated state. The ground operating procedures and CCA facilities cater for these requirements. In a CW environment a new set of NBC garments is to be worn for each departure from collective protection.

Above-the-Neck Protective Assemblies

17. **Aircrew Respirator NBC No 5 (AR5) and Associated Supply Systems.** Early in the development of aircrew respirators in the UK it was decided that the required standard of protection for aircrew could be achieved consistently and continuously only

by ventilation of the respiratory and eye compartments of the respirator with clean filtered air supplemented where required by oxygen so that a positive pressure is maintained in the respirator under all normal conditions. In these circumstances no toxic agent can gain access to the lungs or eyes since the gas flow from any leak will be outward and consist of clean gas from the respirator. In addition, in order to provide adequate protection for a period of 30 minutes in the event of failure of the positive pressure ventilation, early research indicated that the head would have to be totally isolated from the environment.

18. The Aircrew Respirator NBC No 5 (AR5) shown in Fig 2 was developed to meet these requirements. Its main features are that it comprises an oronasal mask enclosed within a close fitting shaped polycarbonate face plate, to the edge of which is attached an elastic rubber head cowl which is worn immediately over the head, beneath



Fig 2. Front View Photograph of AR5

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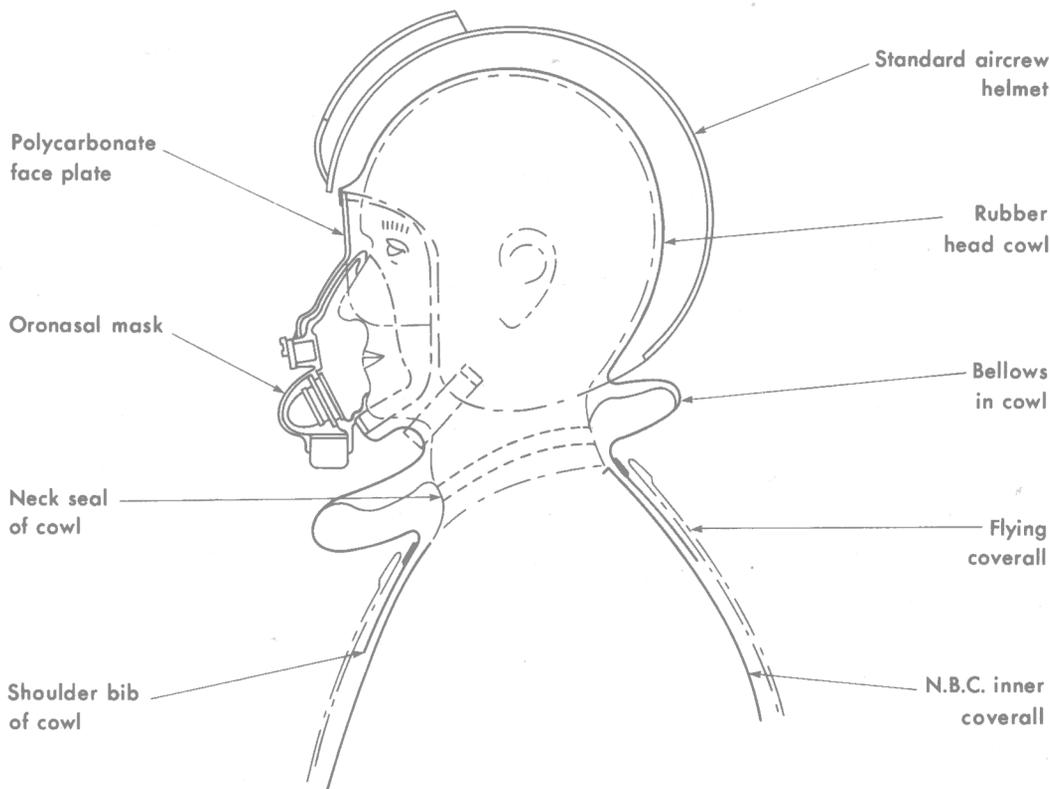


Fig 3. A Schematic Diagram of the Respirator, Aircrew, NBC No 5 (AR5)

the aircrew protective helmet. Two marks of manifold are available for use with the AR5; the Mark 1, used with medium pressure oxygen systems and filtered air and the Mark 2, used with filtered air alone. A schematic diagram of the AR5 is shown in Fig 3.

19. The respirator consists of an impervious neoprene or butyl rubber hood which covers the head and extends down to form a protective bib which overlies the neckline of the NBC Inner Coverall. The neck area is formed as a bellows to cater for head mobility and incorporates a neck seal of the type used on the Mk 10 Immersion Coverall. This seal isolates the respirator hood compartment from the environment. Sealed into the front of the hood is an injection moulded faceplate the

upper part of which provides the visual area and the lower part external support for an integrated type P or Q oronasal mask which isolates the respiratory gas from the visor compartment. The periphery of the faceplate is sized and contoured to fit within the facial openings of all sizes of protective helmet (Type G, Mk 2, 3 and 4) beneath which the respirator must be worn (Fig 4). The lower area of the faceplate is pierced by ports for the passage of hood inlet air, hood outlet air, mask inlet gas, mask exhalate, nose occluder device (Fig 5) (to permit nose pinching to aid in "clearing ears") and microphone assembly. The faceplate also carries the standard mask suspension attachments by which the respirator is secured to the aircrew helmet. The hood is supplied in two sizes which, together

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Fig 4. Side View of Aircrew Protective Helmet Mk 3c Worn Over AR5

with the two sizes of mask (type P or Q), gives a total of four, sizes of Aircrew Respirator. Special corrective lens spectacles which can be accommodated within the respirator are in production and work is at an advanced stage to provide a "safe" drinking facility in the aircrew respirator.

20. The mask and visor compartments of the respirator are supplied separately with clean filtered air from a portable or aircraft mounted electrically driven fan/filter unit by way of a chest-mounted manifold connected to the respirator by a pair of delivery tubes. At the mask tube inlet to the faceplate an anti-drowning connector is incorporated which can be broken in an escape-into-water emergency. In addition to providing a positive hood pressure, the visor compartment ventilating air prevents misting or frosting of the internal surface of the optical area of the respirator and, by flowing across the exposed areas of the face and neck, reduces the discomfort inherent in wearing the respirator in warm or hot environments. To

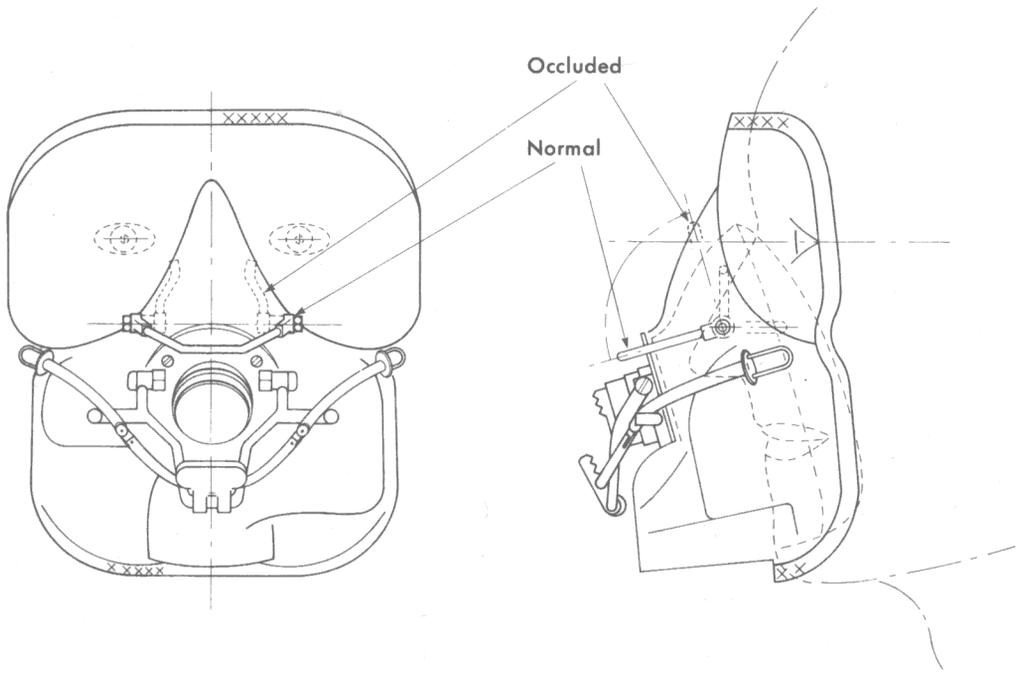


Fig 5. Diagram of the Nose Occlusion Facility of AR5

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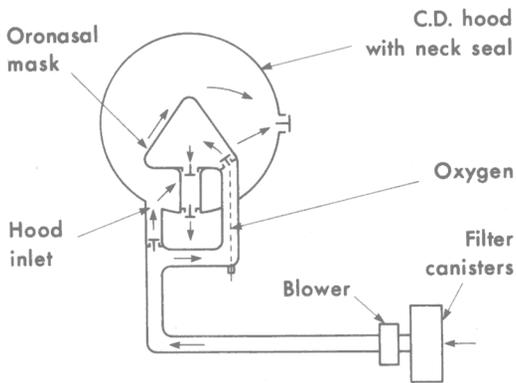


Fig 6. Filtered Air Flow Through AR5

further reduce the risk of misting or sweat contamination of the internal surface of the visual area a brow band or skull cap should be worn and the internal surface of the faceplate treated with an antimist liquid prior to donning the respirator. Aircrew should also reduce the pace at which they exercise whilst wearing the AR5 to assist in the prevention of misting and sweat contamination. A schematic diagram of the Aircrew Respirator No 5 showing a filtered air flow from a fixed ventilator (filter canisters and blower) through the respirator supply manifold to the mask and hood compartments is at Fig 6. The broken line indicates the continuous flow oxygen system.

21. On the ground, while transiting to and from the aircraft etc, the AR5 is supplied with filtered air from a portable ventilator which is battery powered. When changing from the portable ventilator to the aircraft system (where this is different), the aircraft system should be switched on for 15 seconds to purge the lines prior to attaching the AR5. The wearer should hold his breath during the change over period. In the aircraft the AR5 is fed air/oxygen by one of

four types of supply system depending on the aircraft classification.

22. **Fast Jet Aircraft with Medium Pressure Oxygen Supply.** In this group of aircraft the AR5 is used in conjunction with the Manifold and Hose Assembly Mk 1/1A.

a. *Manifold and Hose Assembly Mk 1/1A.*

This form of manifold carries filtered air supplied by a ventilator to the mask and hood compartments of the respirator together with oxygen from a medium pressure (70 psi) supply. The manifold consists of a chamber into which is connected the air inlet, mask inlet and hood inlet hoses and an oxygen block (Fig 7). The air inlet hose opens directly into the chamber and the mask hose opens directly out of it. There is, however, a non-return valve between the chamber and the outlet to the hood hose. This valve (the hood inlet valve) consists of a stepped rubber disc and seat. When air is delivered at positive pressure to the manifold the resistance to flow through the hood inlet valve (the hood hose and hood inlet adaptor) maintains safety pressure in the mask relative to the hood compartment during inspiration. The hood inlet valve also prevents air being drawn back from the hood compartment and inspired through the mask hose on failure of the blown air supply. Butyl anti-kink hoses are fitted to the manifold, the air inlet hose ending in a bayonet plug Mk 7. Restraint cords prevent overextension of the mask and hood hoses under high g or windblast forces. The inlet to the oxygen block of the manifold carries a length of butyl medium pressure hose which is fitted with the male portion of a QR (Circlex) connector. A pressure opening valve which is leakproof until the pressure difference across it exceeds 2 psi is incorporated in this inlet hose in order to prevent contaminated environmental air being drawn through the oxygen supply hose when the latter is not connected to the aircraft oxygen system.

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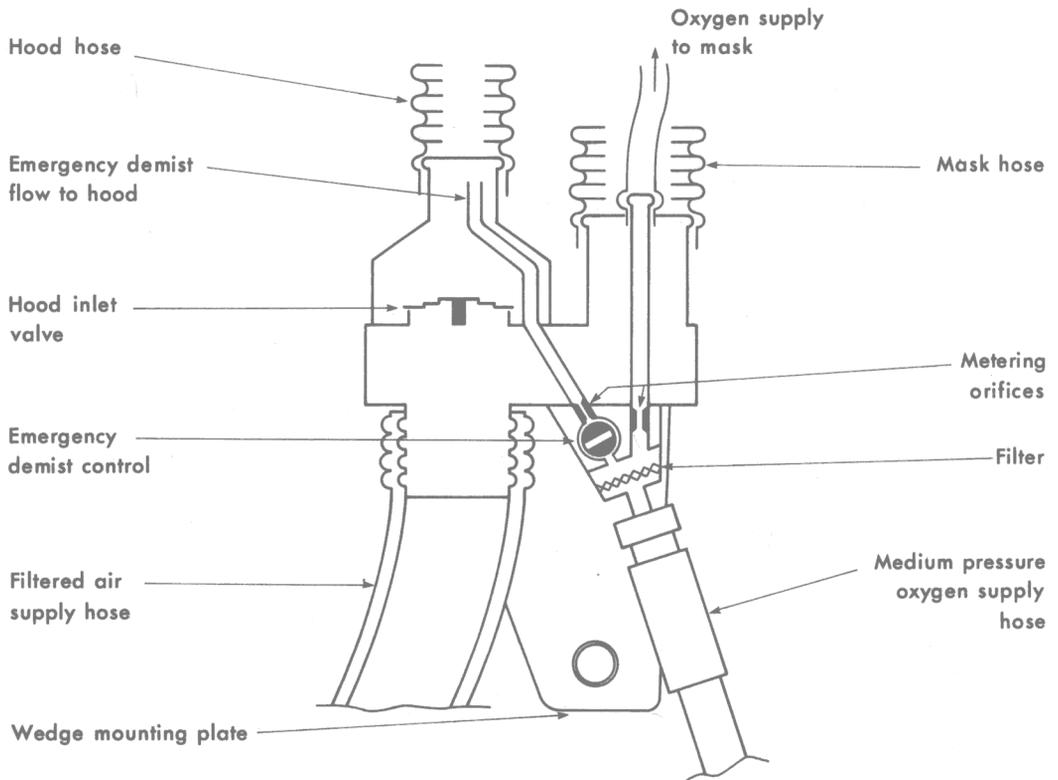


Fig 7. Diagram of Supply Manifold Mk 1 for AR5

b. Filtered Air Supply. As the Portable Ventilator cannot be used in fast jet aircraft, a fixed filter/fan assembly is mounted on the airframe or ejection seat of this type of aircraft to supply filtered clean air to the AR5. Figure 8 is a schematic diagram of the filtered air and medium pressure oxygen supplies to the AR5 in a typical high performance combat aircraft. Air from the cabin is drawn through two standard canisters (canisters NBC S6 No 2 Mk 1) by a fan driven by a motor powered from the aircraft 28 volt DC supply (Emergency battery bus bar). The clean air is delivered by way of flexible butyl antikink hose and a suitable connector system to provide automatic separation during the ejection sequence. In some aircraft the air ventilated suit supply port of the Personal Equipment

Connector (PEC) is used to carry the supply of filtered air to the AR5.

The end of the personal NBC air supply hose is fitted with a bayonet socket Mk 7 to which is connected the air inlet hose of the manifold of the AR5. Since the S6 canisters are not mounted on the crewmember protection against CW agents is lost on ejection and on rapid egress from the cockpit on the ground. In the long term it is intended however that a small compact emergency portable canister or canister-blower unit which can be stowed in the cockpit will be developed to provide NBC protection on rapid ground egress from the cockpit. Such a miniature filtered air supply unit would also be used for transit between aircraft and an area of collective protection when a standard

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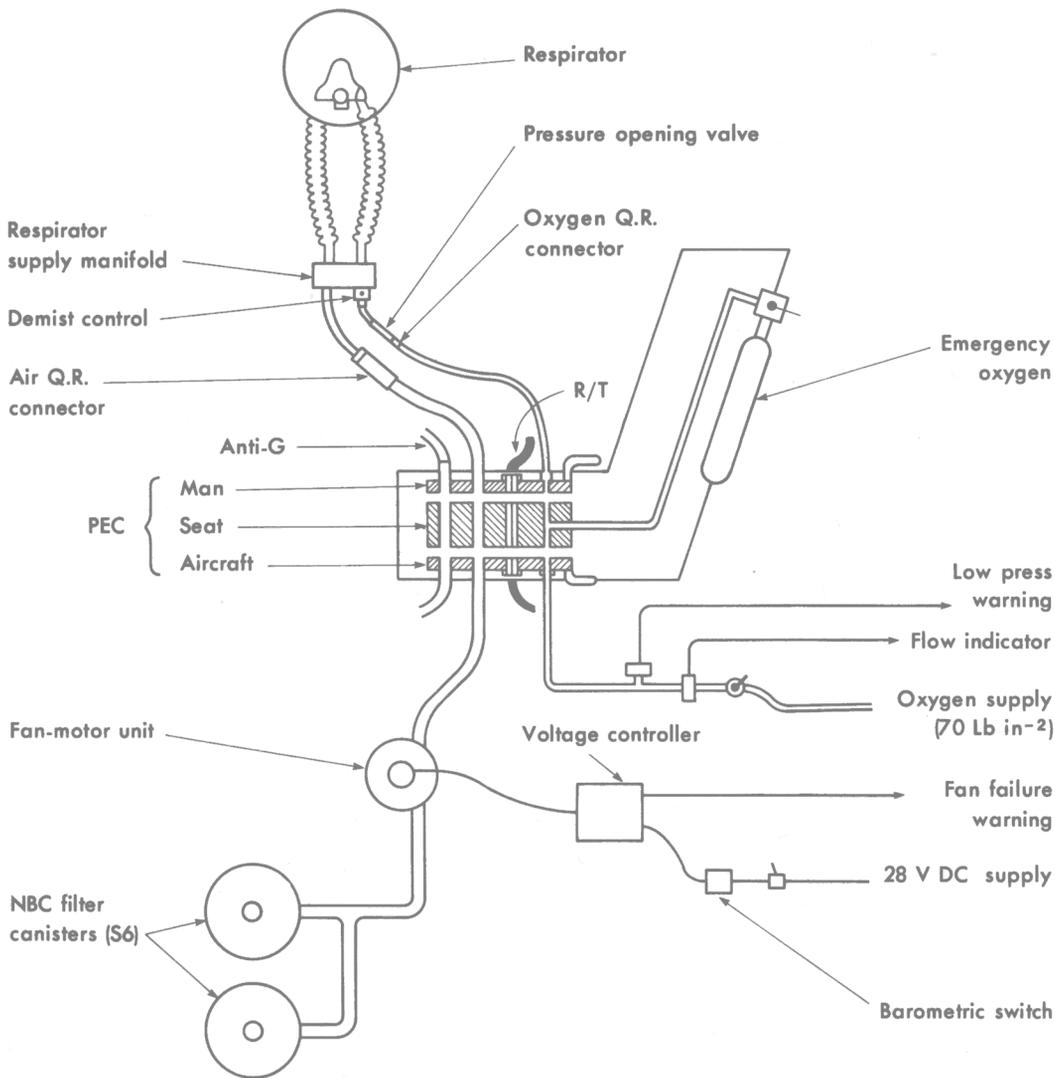


Fig 8. Schematic Diagram of Air/Oxygen Supplies to AR5 in a Typical Combat Aircraft

Portable Ventilator NBC is unavailable eg at an Allied Air Force Base. The canister holders are mounted in the cockpit or on the ejection seat in positions in which the ground crew can change the S6 canisters with relative ease. In a war, the S6 canisters would be changed daily. The motor of the fan unit is connected through an on/off switch and a voltage controller to the aircraft 28 volt DC supply. The

voltage controller allows the speed of the fan to be adjusted so that the delivery pressure-flow characteristics of the complete Fixed Ventilator are within the required limits, in spite of differences in resistance to flow because of variations in length and run of the hoses connecting the various components. A warning device is fitted to the fan electrical system. This illuminates a red caption labelled NBC

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FN in the centralised warning systems when the electrical supply to the fan fails or when no current flows through the fan motor because the fan is stalled. The device will also operate in the event of the cabin altitude exceeding 20,000 to 25,000 feet (depending on specific aircraft type) and a barometric switch coming into play to switch off the fan as explained in sub-para c below.

c. *Oxygen Supply.* A constant flow of oxygen (approximately 8 litre (NTP) min^{-1}) passes into the mask hose through a metering orifice in the oxygen block of the manifold and thence through an inner tube which opens into the mask hose just upstream of the inlet non-return valve of the mask. During expiration the oxygen fills the mask hose which thus acts as a reservoir so that on inspiration this oxygen is drawn into the lungs followed by air together with the continuous flow of oxygen. This oxygen system will prevent hypoxia at altitudes between ground level and 25,000 feet. Above a cabin altitude of 25,000 feet, however, the volume of the reservoir must be increased in order to avoid hypoxia. This is achieved by switching off the aircraft fixed ventilator automatically by a barometric switch. Since loss of ventilation of the hood compartment of the respirator can result in certain circumstances in rapid misting of the visor and hence impairment of vision, an alternative supply of gas to purge the compartment is provided through the oxygen block of the manifold. In the event of failure of the blown air supply in flight, a flow of oxygen (10–12 litre (NTP) min^{-1}) can be delivered into the hood hose (down stream of the hood inlet valve) by operating the EMERGENCY DEMIST control which is mounted on the front surface of the respirator supply manifold (figure 7). This flow of oxygen will prevent misting of the visor. The EMERGENCY DEMIST control must be operated immediately the cabin altitude exceeds 22,000 – 25,000 feet. Since this oxygen system does not provide pressure breathing the use of the AR 5 is

limited to a maximum aircraft altitude of 43,000 feet.

d. *Mark 1/1A Difference.* The two versions of this manifold differ in the method of attachment to the flying clothing. The Mk 1 manifold is fitted with a blade for insertion in an adaptor attached to the closure plate of the torso harness-life-preservers (Mk 10 and 12). The Mk 1A version has a pair of vertical prongs mounted on each side of the manifold. For attachment to life-preservers, mounting patches consisting of vertical pockets for the prongs of the manifold are sewn onto the blastproof covers of the stoles. Vertical pockets for use with aircrew coveralls etc are mounted on stiffened fabric flaps which can be attached when required by press studs to the coverall, combat suit etc.

23. **Helicopters and Transports without Oxygen Systems.** In these groups of aircraft the AR 5 is used in conjunction with the Manifold and Hose Assembly Mk 2/2A and the Portable Ventilator, both on the ground and in the air.

a. *Manifold and Hose Assembly Mk 2/2A.* This form of the manifold carries filtered air from the air inlet hose to the mask and hood hoses. The air passages of this manifold are similar to those of the Mk 1/1A manifold. The oxygen block is omitted from the Mk 2 manifold, as it is used in applications where only air is required for breathing or where filtered oxygen from a pressure demand oxygen regulator is used to supply the respirator (Fig 10). The Mk 2 manifold is fitted with a pair of vertical prongs as used in the Mk 1A manifold for attachment to the flying clothing. The Mk 2A manifold itself is similar to the Mk 2 version. It is however fitted with a blade similar to that of the Mk 1 manifold by which it can be attached to the closure plate of a torso harness lifepreserver.

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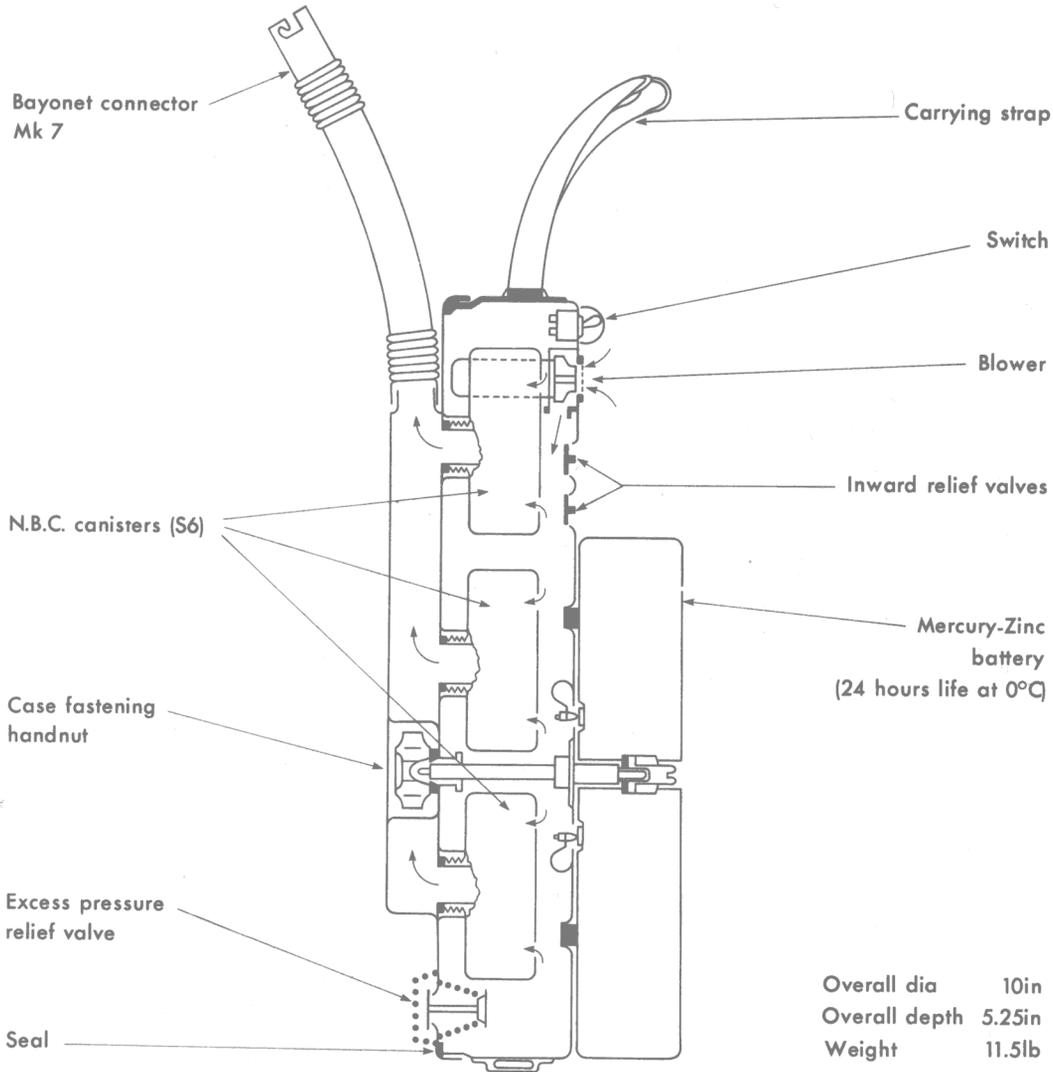


Fig 9. Portable Ventilator NBC Mk 1

b. *Filtered Air Supply.* The Mk 2/2A manifold is supplied with clean filtered air by a Portable Ventilator. The Portable Ventilator NBC Mk 1 (Fig 9) is battery powered and incorporates three standard filter canisters (Canisters NBC S6 No 2 Mk 1) arranged in parallel. Later models of the ventilator will include a facility to

permit operation from the 28V DC aircraft supply. Under CW operating conditions the battery and filter canisters will be changed at 24 hour intervals. In aircraft in which the Portable Ventilator is used in flight simple box stowages are fitted at each crew station. A schematic diagram showing the supplies to the AR5,

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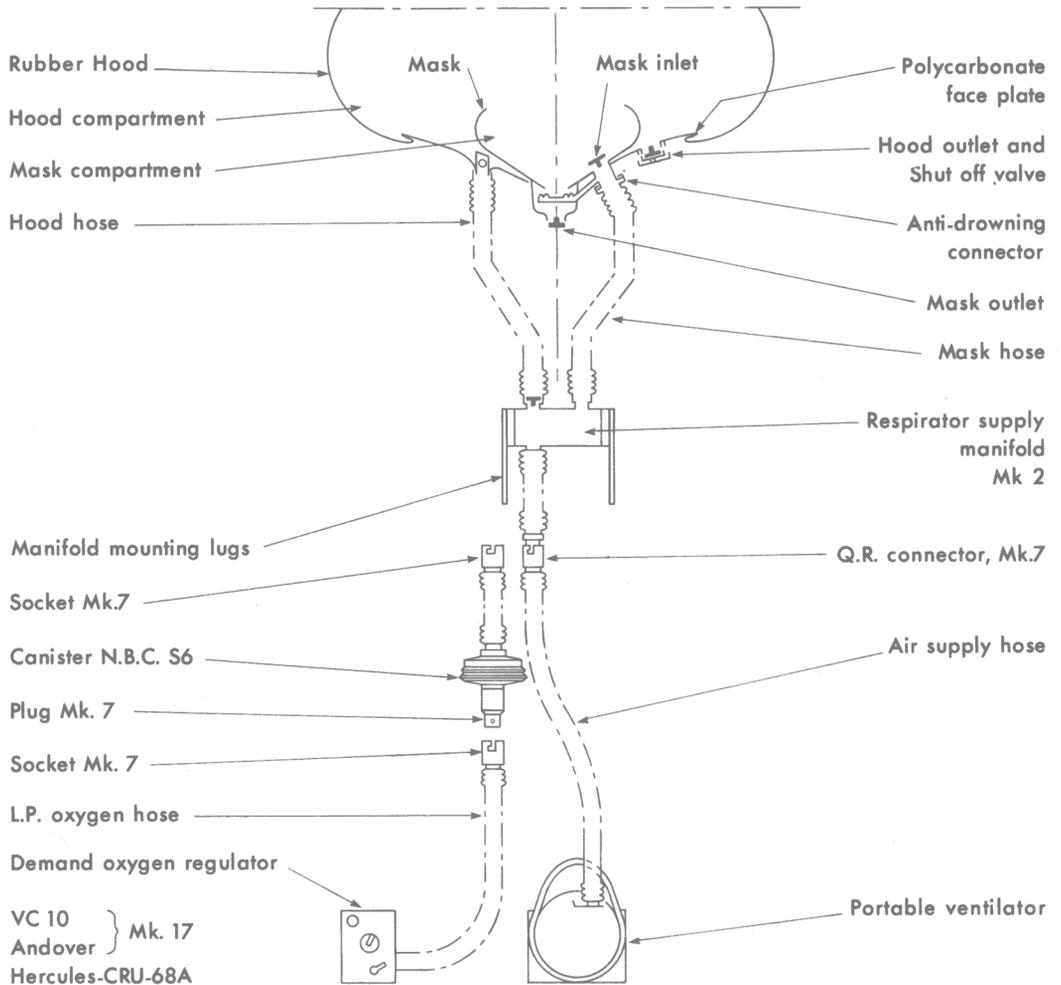


Fig 10. Schematic Diagram Showing Supplies to the AR5 Mk 2 (Oxygen Supply shown bottom left for Transport Aircraft equipped with oxygen)

Mk 2, as used in transport aircraft is given in Fig 10. In aircraft with only one pilot, two Portable Ventilators are connected to the inlet hose of the pilots AR5. This arrangement provides an immediately available alternative source of blown filtered air in the event of failure of the Portable Ventilator in use. A spare Portable Ventilator is also carried in all aircraft carrying 3 or more crew. A carrying harness has been developed for the Portable Ventilator which allows the wearer to strap the unit close to his body

when moving around inside and outside the aircraft.

24. Transport Aircraft Fitted with Oxygen Systems. The aircrew wear the AR5 with the Manifold and hose Assembly Mk 2 which is supplied by the Portable Ventilator NBC both on the ground and in routine flight. A simple stowage for the Portable Ventilator is fitted at each crew station and a spare Portable Ventilator is carried. The system is similar to that described above for transport aircraft not fitted with oxygen. It is used in

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the same way until cabin decompression or toxic fumes require that oxygen be used. Then the AR5 is supplied with oxygen from the aircraft pressure demand regulator. A single canister NBC S6 and holder is routinely connected to the delivery hose from each panel mounted regulator (Figure 10). In the event of the need to use oxygen the aircrew member will disconnect the hose from the Portable Ventilator and connect that from the oxygen regulator and NBC canister (holding his breath whilst he makes the change). He will select 100% oxygen and EMERGENCY pressure on the pressure demand regulator which will ensure that safety pressure is maintained in the mask and hood compartments of the AR5 and that the latter is adequately ventilated.

25. Multiseat (5 crew) Bomber and Tanker Aircraft. The medium pressure oxygen and fixed ventilator supply systems will be fitted at the pilots' positions in these aircraft and the pilots will wear the AR5 connected to the Mk 1A manifold and Hose assembly in the same way as aircrew in fast jet aircraft, as outlined in para 22. In order to avoid large airframe modifications and the development of new connector systems compatible with rapid emergency escape in flight, the rearcrew will use the AR5 connected to the Mk 2 Manifold and Hose Assembly. This will be supplied throughout flight with an oxygen-air mixture from the pressure demand oxygen regulator set to airmix ('normal' oxygen) and emergency pressure. This gas will pass through a pair of canisters NBC S6 arranged in parallel upstream of the manifold of the respirator. The canisters NBC S6 will be mounted in a sealed chamber inserted in the oxygen supply hose on the airframe. The system is similar to that used in oxygen breathing conditions in transport aircraft which is shown in Fig 10 and outlined in para 24.

26. Interim Supply System for the AR5. Since the Fixed Ventilator supply system will not be installed in all squadron aircraft for some time, an interim supply system

has been developed for immediate use in aircraft fitted with a medium pressure oxygen supply. In the interim arrangement oxygen is used to ventilate the hood compartment of the AR5, as well as to prevent hypoxia. The flow of oxygen into the hood compartment is obtained by placing the EMERGENCY DEMIST selector control in the open position. This demist flow is adequate under virtually all conditions of use to prevent any misting of the internal surface of the optical area. It also maintains safety pressure in the hood compartment, thus preventing any inboard leakage of contaminated atmosphere into the hood compartment or the oronasal mask (through a leak between the seal of the mask and the skin of the face). A single canister NBC S6 is attached by an adaptor to the air inlet hose of the manifold of the AR5 so that when air is drawn in by the inspiratory flow exceeding the flow of oxygen into the mask hose, CW agent is removed by the filter. The NBC canister and adaptor are mounted on the lifepreserver. The protection against CW agents provided by this interim supply system is only slightly less than that of the AR5 when supplied by the Fixed or Portable Ventilator. The disadvantages of this interim supply system are the high rate of consumption of the aircraft oxygen store, the absence of a secondary supply of gas to demist the optical area of the AR5 in the event of a failure of the oxygen supply and the increase in the thermal load produced by wearing the equipment. It has been decided that this form of interim supply system will be used in fast jet aircraft (other than the Buccaneer) until Fixed Ventilators are installed. Failure of the oxygen supply to the AR5 could, however, result in rapid impairment of vision due to misting of the internal surface of the optical area of the respirator. In peacetime, therefore, the interim supply system will only be used in dual control versions of the fast jet aircraft – so that a safety pilot will be available. In war, the interim supply system would be used in all fast jet aircraft until they are fitted with the Fixed Ventilator. An aircraft

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specific interim supply system employing the aircraft oxygen regulators Mk 17 and a single NBC S6 canister in the personal NBC hose assembly to supply the AR5 Mk 2A has been adopted for the Buccaneer.

27. **Pre-Flight Checks.** The checks of the respirator which should be performed after donning the complete aircrew NBC assembly and before departing the CCA (or crew room) prior to flight are listed below:

- a. Check that the supply manifold of the respirator is securely attached to the flying clothing (lifepreserver or coverall as appropriate).
- b. Check that the supply hoses to the manifold of the respirator (from the Portable Ventilator and, where appropriate, the medium pressure oxygen hose from the PEC) are securely connected.
- c. Check that the antidrowning connector attaching the mask hose to the mask inlet in the faceplate is securely locked (Shear pin intact.)
- d. Check that the hood outlet valve is in the open position.
- e. Check that the nostrils are closed by operation of the nose occluder bow.
- f. Check that there is no detectable leakage between the mask and the face by temporarily occluding the hood hose with the breath held and that the resistance to quiet and heavy breathing is within normal limits. If a mask seal leak is present, reposition the mask on the face and, if necessary, readjust the length of the suspension harness.
- g. Check, using a NBC Intercommunication Unit or a test set, that the transmitting and receiving components of the AR5 helmet assembly are working correctly.

28. **In-Flight Checks.** The checks of the respirator and its supply which should be performed on entry to the cockpit and at

regular intervals throughout flight are listed below::

a. *AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower-filter unit).*

- (1) Check connections at PEC, to respirator manifold and of mask hose at the antidrowning disconnect.
- (2) Check oxygen contents and pressure are adequate.
- (3) Check oxygen MI is showing continuous white.
- (4) Check seal of mask to the face.
- (5) Check that Fixed Ventilator warning caption (NBC FN) is not illuminated.
- (6) Check operation of EMERGENCY DEMIST (preflight cockpit check only) by turning off Fixed Ventilator, selecting EMERGENCY DEMIST and noting flow of oxygen across the face. Check that NBC FN caption is illuminated. Turn off EMERGENCY DEMIST and turn on Fixed Ventilator. Check that NBC FN caption is not illuminated.

b. *AR5 with Interim Supply System.*

- (1) Check connections at PEC, to respirator manifold and of mask hose at the antidrowning disconnect.
- (2) Check oxygen contents and pressure are adequate.
- (3) Check oxygen MI is showing continuous white.
- (4) Check EMERGENCY DEMIST is selected.
- (5) Check oxygen flow to mask and hood compartment by noting increase in noise on inspiration (mask flow) and flow of gas across face (hood flow) (preflight cockpit check only unless indicated in flight).

c. *AR5 Mk 2 supplied by Mk 17 or 21 Oxygen Regulator.*

- (1) Check connections at PEC, to respirator manifold and of mask hose at the antidrowning disconnect.

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(2) Check oxygen contents and pressure are adequate.

(3) Check oxygen MI is showing continuous white.

(4) Check that oxygen regulator Mk 17 is set to deliver NORMAL oxygen and EMERGENCY.

(5) Check that there is no leakage between the mask and the face by determining that the oxygen MI shows continuous black when the hood hose is occluded with the breath held.

d. *AR5 Mk 2 supplied with Portable Ventilator*

(1) Check connection to respirator manifold and of mask hose at the antidrowning disconnect.

(2) Check that Portable Ventilator is securely stowed.

(3) Check absence of leakage between mask and face by temporarily occluding the hood hose (preflight cockpit check only unless indicated in flight).

29. **In-Flight Emergencies.** The in-flight malfunctions and emergencies which can occur when wearing the respirator and the drills which should be followed when they occur are summarised below:

a. *Suspected Hypoxia – AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower – filter unit) or Interim Supply System.*

(1) Check mask seal.

(2) Check connections at PEC, in oxygen hose to manifold and at antidrowning disconnect at the faceplate.

(3) Pull emergency oxygen.

(4) Descend to below 10,000 feet cabin altitude. Note: see sub-para 29x

b. *Suspected Hypoxia – AR5 Mk 2 supplied by Mk 17 or 21 Oxygen Regulator.*

(1) Check mask seal.

(2) Check connections in oxygen supply to manifold and at antidrowning disconnect at the faceplate.

(3) Pull emergency oxygen (where available).

(4) Descend to below 10,000 feet cabin altitude.

c. *Oxygen MI Continuous Black – AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower-filter unit) or Interim Supply System.*

(1) Check connections at PEC and in oxygen hose to manifold.

(2) Pull emergency oxygen.

(3) Descend to below 10,000 feet cabin altitude. Note: see sub-para 29x.

d. *Oxygen MI Continuous Black – AR5 Mk 2 supplied by Mk 17 or 21 Oxygen Regulator.*

(1) Check oxygen connections in oxygen supply to manifold.

(2) Check oxygen regulator set to EMERGENCY.

(3) Pull emergency oxygen (where available).

(4) Descend to below 10,000 feet cabin altitude. Note: see sub-para 29x.

e. *Low Oxygen Contents and/or Pressure – AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower-filter unit) or Interim Supply System.*

(1) Check oxygen connections at PEC and in oxygen hose to manifold.

(2) Pull emergency oxygen.

(3) Descend to below 10,000 feet cabin altitude. Note: see sub-para 29x.

f. *Low Oxygen Contents and/or Pressure – AR5 Mk 2 supplied by Mk 17 or 21 Oxygen Regulator.*

(1) Check connections in oxygen supply to manifold.

(2) Pull emergency oxygen (where available).

(3) Descend to below 10,000 feet cabin altitude. Note: see sub-para 29x.

g. *Suspected Oxygen Contamination.*

(1) Pull emergency oxygen.

(2) Turn main supply off.

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- (3) Descend to below 10,000 feet cabin altitude.
 - (4) Check no toxic fumes in cabin air.
Note: see sub-para 29x.
- h. *Failure of Blown Air Supply – AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower – filter unit).*
- (1) Select EMERGENCY DEMIST.
 - (2) Check connections at PEC, in oxygen and air hoses to manifold and at antidrowning disconnect at the faceplate. Note: rate of consumption of the aircraft oxygen supply will be increased.
- j. *Failure of Blown Air Supply – AR5 Mk 2 supplied by Portable Ventilator.*
- (1) Check connection of Portable Ventilator to manifold.
 - (2) Check Portable Ventilator is switched on.
 - (3) Check hood outlet valve is open.
 - (4) Either (A) switch on or connect to standby Portable Ventilator or (B) connect delivery hose from oxygen regulator through S6 canister adaptor to inlet hose of manifold and set oxygen regulator to EMERGENCY. Check seal of mask to face.
- k. *Fogging of Inside of Visual Area of Respirator – AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower-filter unit).*
- (1) Select EMERGENCY DEMIST
 - (2) Check connections of PEC, and in hoses to manifold.
 - (3) Check hood outlet valve is open.
 - (4) Check seal of mask to face. Note: rate of consumption of aircraft oxygen supply will be increased.
- l. *Fogging of Inside of Visual Area of Respirator – AR5 Mk 1 with Interim Supply System.*
- (1) Check oxygen MI is showing continuous white.
 - (2) Check oxygen contents and pressure.
- (3) Check connections at PEC and in oxygen hose to manifold.
 - (4) Check seal of mask to face.
 - (5) If the only pilot able to control aircraft is affected prepare for crew to abandon aircraft in event of unacceptable impairment of vision.
- m. *Fogging of Inside of Visual Area of Respirator – AR5 Mk 2 supplied by Mk 17 or Mk 21 Regulator.*
- (1) Check oxygen connections to the manifold of respirator and of mask hose at antidrowning disconnect.
 - (2) Check that the oxygen regulator is set to EMERGENCY and oxygen MI is indicating continuous white.
 - (3) Check seal of mask to face.
 - (4) Pull emergency oxygen (if available).
 - (5) Descend to below 10,000 feet cabin altitude.
 - (6) If the only pilot able to control aircraft is affected prepare for crew to abandon aircraft in event of unacceptable impairment of vision.
- n. *Fogging of inside of Visual Area of Respirator – AR5 Mk 2 supplied by Portable Ventilator.*
- (1) Check connection of Portable Ventilator to manifold.
 - (2) Check Portable Ventilator is switched ON.
 - (3) Check hood outlet valve is open.
 - (4) Check seal of mask to face.
 - (5) Either (A) switch on or connect to standby Portable Ventilator or (B) connect delivery hose from oxygen regulator through S6 canister adaptor to inlet hose of manifold and set oxygen regulator to EMERGENCY.
- p. *Inadvertent Loss of Cabin Pressurisation – AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted blower-filter unit).*
- (1) Select EMERGENCY DEMIST.
 - (2) Descend to below 18,000 feet cabin altitude.

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(3) Check Fixed Ventilator operating and turn EMERGENCY DEMIST off.

q. *Inadvertent Loss of Cabin Pressurisation - AR5 Mk 1 with Interim Supply System.*

(1) Descend to below 18,000 feet cabin altitude.

r. *Inadvertent Loss of Cabin Pressurisation - AR5 supplied by Mk 17 or Mk 21 Regulator.*

(1) Descend to below 18,000 feet cabin altitude.

s. *Inadvertent Loss of Cabin Pressurisation - AR5 Mk 2 supplied by Portable Ventilator in aircraft fitted with Mk 17 Regulator.*

(1) Disconnect hose of Portable Ventilator from inlet hose of manifold.

(2) Connect delivery hose from oxygen regulator through S6 Canister adaptor to inlet hose of manifold.

(3) Set oxygen regulator to deliver EMERGENCY and 100% oxygen.

(4) Descend to below 10,000 feet cabin altitude.

(5) Revert to Portable Ventilator supply.

t. *Fumes/Smoke in the cabin - AR5 Mk 1 supplied by Fixed Ventilator (airframe mounted filter-blower unit) or Interim Supply System.*

(1) Depressurise cabin and select RAM air.

(2) Descend.

u. *Fumes/Smoke in the Cabin - AR5 Mk 2 supplied by Mk 17 or Mk 21 Regulator.*

(1) Select 100% oxygen.

(2) Check EMERGENCY selected.

(3) Depressurise cabin and select RAM air, if necessary.

v. *Fumes/Smoke in the Cabin - AR5 Mk 2 supplied by Portable Ventilator in aircraft fitted with Mk 17 Oxygen Regulator.*

(1) Disconnect hose of Portable Ventilator from inlet hose of manifold.

(2) Connect delivery hose from oxygen regulator through S6 canister adaptor to inlet hose of manifold.

(3) Set oxygen regulator to deliver EMERGENCY and 100% oxygen.

(4) Depressurise cabin and select RAM air, if necessary and acceptable.

w. *Fumes/Smoke in the Cabin - AR5 Mk 2 supplied by Portable Ventilator in aircraft not fitted with oxygen regulators.*

(1) Ventilate cabin with clean air - in pressurised aircraft, depressurise cabin and select RAM air,

x. *Note:* The duration of the oxygen flow when the emergency oxygen supply is selected is limited to between 3 and 6 minutes. In situations in which there is either no air flow from the Fixed Ventilator (failure of the Fixed Ventilator) or of oxygen from the Mk 17 or Mk 21 regulator exhaustion of the emergency oxygen supply may result in misting of the internal surface of the visual area of the respirator. If the only pilot able to control the aircraft is affected then it may be necessary for him and other crew to abandon the aircraft.

30. **Aircraft Escape/Sea Survival.** Following escape from an aircraft while wearing the AR5, air and/or oxygen will be breathed in from the air supply hose and the emergency oxygen supply. On entry into water, however, the air inlet will be beneath the surface of the water even when the stole of the lifepreserver is inflated. The mask hose can however be removed by rotating the knurled locking ring of the anti-drowning disconnect (breaking the shear pin) and pulling firmly down on the mask hose. The disconnection of the mask hose from the respirator will raise the air inlet hole to the level of the face. Closing the hood outlet valve will prevent water rapidly entering the hood compartment of the respirator, and interfering with vision. The post ejection drill following separation from the ejection seat to be completed before

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entry into water is as follows (in order of importance, the most important being first):

- (a) Inflate lifepreserver.
- b. Unlock antidrowning connector and pull mask hose away from faceplate (1).
- c. Shut hood outlet valve.
- d. Check PSP connections.
- e. Lower PSP just before water entry.

Notes: (1) A firm pull downwards is required to separate the mask hose from the faceplate of the respirator.

(2) The inlet port to the mask when the mask hose has been disconnected may possibly be obstructed by the inflated stole of the lifepreserver. The obstruction to breathing can be relieved by either simply turning the head slightly to the right or depressing the stole in the region of the mask inlet with the hand.

Should water be drawn into the mask on water entry it should be blown out through the expiratory valve before a further breath is taken. If difficulty in avoiding breathing water persists then release the toggle of the suspension harness of the respirator and lift the faceplate and mask off the face. This will provide a small additional volume of air for breathing to allow further time to bring the head above water. Once the liferaft has been entered, the protective helmet and aircrew respirator should be removed (as the visor of the respirator will almost certainly fog up) by:

- a. Disconnect inlet hose to the respirator manifold.
- b. Remove protective helmet.
- c. Disconnect respirator manifold from socket on the closure plate of the lifepreserver.
- d. Remove respirator.
- e. Re-don protective helmet.

When parachuting onto dry land the standard post ejection and landing drills should be employed. The protective helmet and aircrew respirator are removed after arriving on the ground.

Complete Aircrew Equipment Assembly

31. Modifications to standard items of the AEA to provide compatibility with NBC components are limited to the addition of manifold attachment "pockets" on outer garments such as coveralls and lifepreservers, the use of larger aperture, foam sealed earpads in standard helmets and the removal of some of the leather and padding in the helmet frontal aperture. Fig 11 shows a typical high performance combat aircraft aircrew NBC assembly. It consists of an Aircrew Coverall Mk 11, g-Trousers, Lifepreserver Mk 10, Aircrew Protective Helmet Mk 3c and the NBC Protective Assembly described in the previous paragraphs. The AR 5 is supplied by a Portable Ventilator NBC Mk 1 and a Phantom Personal NBC Hose Assembly is attached to the left hand side of the lifepreserver.

Effect of Aircrew NBC Assemblies on Aircraft Operations

32. In order to keep the heat load on aircrew within acceptable limits it is important that extra time is allowed for manning aircraft when planning sorties which will be flown in Aircrew NBC Assemblies. Aircrew must pace the donning of NBC clothing and their subsequent tasks (eg external aircraft inspections, strapping in, etc) in order to prevent overheating to an extent which would affect their performance. As most of the heat load is incurred when donning the equipment, it is important to keep the dressing area cool and to reduce the frequency of changing clothing to the minimum. Anything which can be done to avoid unnecessary physical activity will improve comfort and save time. When available, motor transport should be used to reduce the heat load and risk of picking up liquid contamination.

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Fig 11. Typical Aircrew NBC Assembly to Phantom

personal protective equipment whilst exposed to CW agents on the ground and to provide a supply of pretreatment tablets in the event of a diversion to a base where these are not available.

Aircrew NBC Ground Operating Procedures

34. All external flying clothing will be contaminated on exposure to CW agents and thus it must be doffed, stored and redonned in the contaminated state. Drills whereby the complete Aircrew NBC Assembly can be doffed and donned with safety, even when contaminated, have been evolved as part of the development of this equipment. No item of clothing or equipment, which has been worn outside and may have been contaminated, is allowed to pass into the toxic free area of the collective protection facility. The doffing and donning drills for the Aircrew NBC Assembly dictate the layout of, and the fitting required in, the Contamination Control Area (CCA) external to the entry and exit airlocks of the Pilot Briefing Facility (and any other area of collective protection which may be used by aircrew). The CCA is divided into two distinct areas: an outer in which liquid agent may be present (Liquid Hazard Area) and an inner, adjacent to the airlocks of the Pilot Briefing Facility, where only a vapour hazard exists (the Vapour Hazard Area). Contaminated flying clothing is kept in the outer Liquid Hazard area and the external surface of any item to be carried by incoming personnel into the Vapour Hazard Area of the CCA is decontaminated before the area is entered by liberal dusting with fuller's earth.

Aircrew CD First Aid Pack

33. An Aircrew CD First Aid Pack has been designed for carriage in a pocket of the coverall. It contains autojet syringes, a supply of pretreatment tablets and four fuller's earth pads (Decontamination Kit Personal Mk 1). The primary purposes of this pack are to provide immediate self treatment in the event of a failure of the

35. Fuller's earth is a clay mineral. It has a high absorptive capacity and an exceptional bonding power for CW agents. It removes liquid from contaminated surfaces and holds it in a harmless condition. It is important that it is used as soon as possible after contamination by CW agents. Fuller's earth has proved to be very effective as a decontaminant when liberally applied and rubbed in. It is supplied as free powder, in sachets

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which contain a cloth pad filled with the earth, and in plastic puffer bottles.

36. **Donning Drills.** The major steps in the donning drill for contaminated NBC Assemblies are as follows:

- a. Preparatory to Entering the Exit Airlock.
 - (1) Don (if not already wearing) Underwear, NBC Socks, Aircrew NBC Inner Coverall, NBC Gloves, S6 (Transit) Respirator, and NBC Overboots.
- b. In the Vapour Hazard Area of the CCA.
 - (1) Switch on Portable Ventilator.
 - (2) With aid, discard S6 (transit) Respirator and don AR5.
- c. In the Liquid Hazard Area of the CCA.
 - (1) Don Cape Leather Gloves.
 - (2) Don and secure Aircrew Protective Helmet and remainder of AEA including Aircrew Coverall and Aircrew Boots, redon NBC Overboots.
 - (3) Connect hoses when appropriate to man portion PEC.
 - (4) Carry out pre-flight checks of AR5 and Protective Helmet.
 - (5) Depart CCA for aircraft.

37. **Doffing Drills.** The major steps in the doffing drill for Aircrew NBC Assemblies are as follows:

- a. On entry to the CCA.
 - (1) Remove NBC Overboots.
- b. In the Liquid Hazard Area of the CCA.
 - (1) Decontaminate the Portable Blower-Filter Unit.
 - (2) Remove the external items of AEA eg Lifepreserver, Aircrew Boots, Leg Garters, Aircrew Coverall and g-Trousers, hanging each item, as it is doffed, on the Clothing Rack.
 - (3) Decontaminate the external surface of the Aircrew Protective Helmet and then remove the Helmet and hang it on the Clothing Rack.
 - (4) Decontaminate the external surfaces of the AR5, manifold and hoses.

(5) Remove Cape Leather Gloves.

(6) Walk into the fullers earth sump at the entrance to the Vapour Hazard Area of the CCA and repeat the decontamination of the external surfaces of the Portable Ventilator and NBC Socks.

- c. In the Vapour Hazard Area of the CCA.
 - (1) With help, remove the AR5 and don the S6 (transit) Respirator.
 - (2) Stow the AR5 and switch off the Portable Ventilator.
 - (3) With help, discard the NBC Inner Coverall.
 - (4) An assistant removes each NBC Sock as the aircrewmember steps onto a clean floor area immediately adjacent to the entry airlock.
 - (5) An assistant removes the NBC Gloves.
 - (6) Pass into entry airlock.
- d. In the Clean Filtered Toxic Free Area.
 - (1) Within the clean filtered toxic free area the aircrew will probably wear cotton ribbed underwear, NBC Inner Coverall, NBC Socks and Overboots and carry S6 Respirators and NBC Gloves.

38. **Contamination Control Area.** The internal layout and fittings of the Contamination Control Area of the Aircrew Briefing Facility have been determined by trials of the donning and doffing procedures outlined above. A diagram of a typical layout, and the aircrew routes through it, are given in Fig 12. The carriage of liquid contamination from one area to another of the CCA is prevented by thorough decontamination with fuller's earth and the placing of fuller's earth sumps at the entrance proper to the CCA. A lean-to Annex, external to the entrance proper to the CCA, provides shelter for personnel waiting to enter the CCA. Racks or Pedestals on which the outer flying clothing is hung as it is removed are fitted in the Liquid Hazard Area (each crew-member has a position on a rack allocated to him).

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Mirrors by the help of which the individual aircrew don and adjust their headgear and clothing are mounted on the walls of the Liquid Hazard Area of the CCA. A separate passageway is provided through the Liquid Hazard Area for personnel wearing NBC overgarments. This passage is fitted with special facilities to allow the safe removal of the NBC suit (blouse and trousers). The handling, preparation for use, and storage of both AR5 and S6 (transit) respirators is

eased by the provision of separate side racks for the two types of respirator (the Portable Ventilators being stored with the AR5's) and a central rack on which the aircrew hang their discarded Respirator on entry to and exit from the Aircrew Briefing Facility. The clean floor region of the Vapour Hazard Area immediately adjacent to the entry airlock, where personnel can walk safely without an NBC covering to their feet, is demarcated by a low step-over rail.

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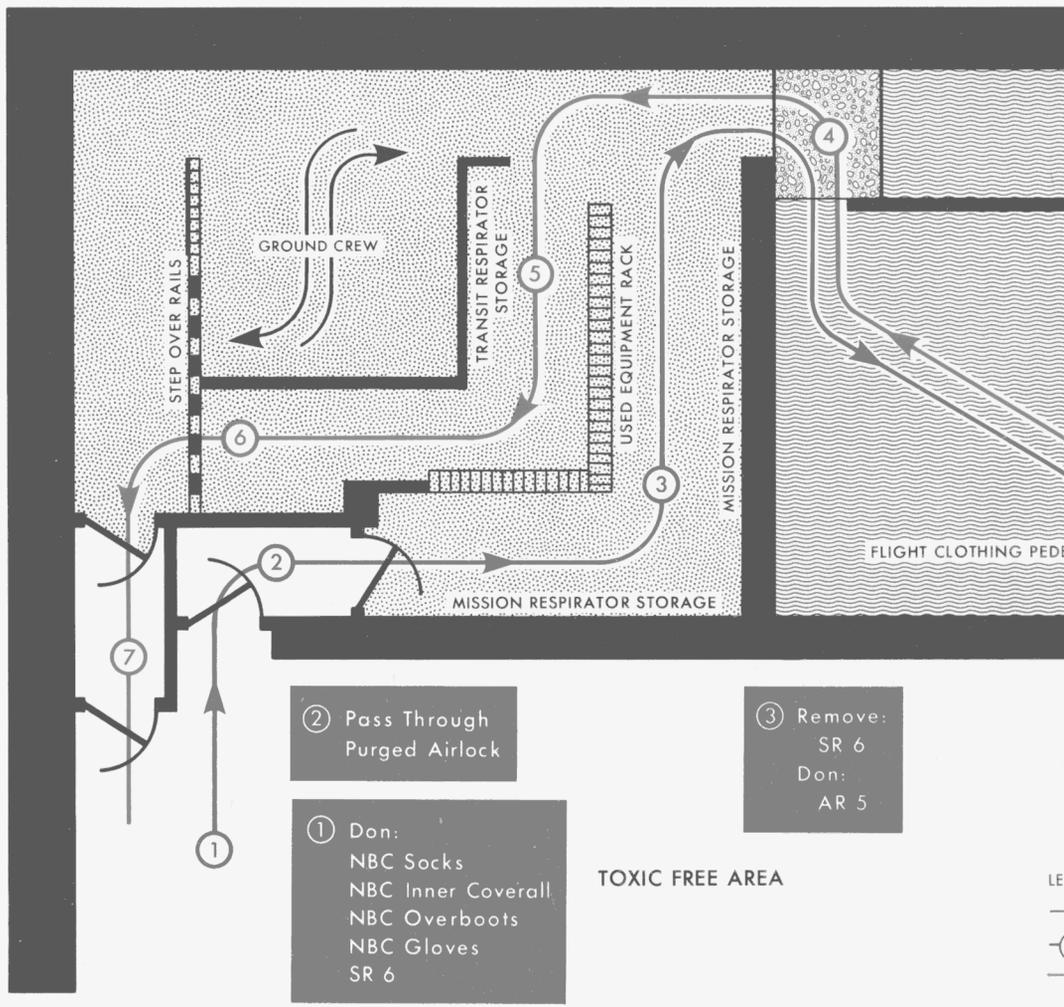
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⑦ Dwell
in Lock

⑥ Remove:
NBC Inner Coverall
NBC Socks
NBC Gloves

⑤ Remove:
AR 5
Don:
SR 6

④ Decontaminate
Ventilator and
NBC Socks



② Pass Through
Purged Airlock

③ Remove:
SR 6
Don:
AR 5

① Don:
NBC Socks
NBC Inner Coverall
NBC Overboots
NBC Gloves
SR 6

TOXIC FREE AREA

Fig 12 Typical Layout of a Contamination Control Area

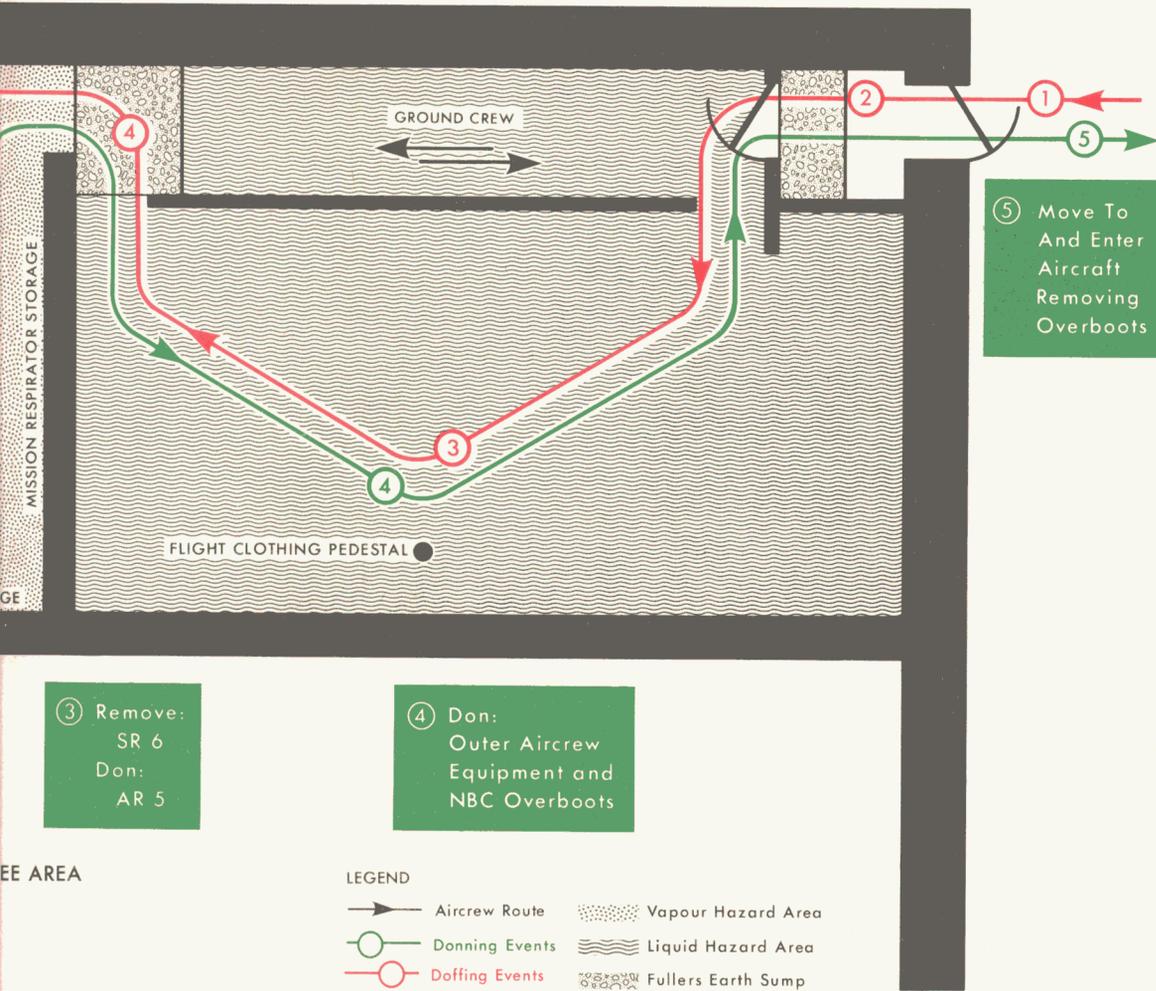
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④ Decontaminate Ventilator and NBC Socks

③ Remove: Outer Aircrew Equipment and decontaminate

② Remove: Overboots

① Exit Aircraft Donning Overboots



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g 12 Typical Layout of a Contamination Control Area

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