NATO STANDARD

AAMedP-1.16

PHYSIOLOGICAL REQUIREMENTS FOR AIRCREW CBRN DEFENCE ASSEMBLIES USED IN FLIGHT

Edition A Version 1

JULY 2018

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED AEROMEDICAL PUBLICATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

17 July 2018

1. The enclosed Allied Aeromedical Publication AAMedP-1.16, Edition A, Version 1, PHYSIOLOGICAL REQUIREMENTS FOR AIRCREW CBRN DEFENCE ASSEMBLIES USED IN FLIGHT, which has been approved by the nations in the Military Committee Air Standardization Board (MCASB), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 3943.

2. AAMedP-1.16, Edition A, Version 1, is effective upon receipt.

4. This publication shall be handled in accordance with C-M(2002)60.

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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RESERVED FOR NATIONAL LETTER OF PROMULGATION

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
SVN	SVN currently does not have required equipment to protect the aircrew engaged in flight operations in a nuclear, biological and chemical warfare environment.
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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CHAPTER 1 DETAILS OF THE AGREEMENT

1.1 AIM

The aim of this standard is to define the minimum physiological and performance requirements for protective assemblies used by aircrew engaged in flight operations in a chemical, biological, radiological and nuclear environment (CBRN).

1.2 DEFINITIONS

1.2.1 Atmospheric Temperature And Pressure, Dry (ATPD)

The volume of gas expressed as a dry gas at the prevailing atmospheric pressure and temperature. In the context of this standard, the atmospheric pressure is the absolute pressure of the gas within the oronasal compartment of the respirator assembly and the temperature is constant at 15ºC.

1.2.2 Body Temperature And Pressure, Saturated (BTPS)

The volume of gas expressed at normal human body temperature (37ºC), saturated with water vapour ($P_{water\ vapour}$ = 6.251 kPa (47 mm Hg)) at the prevailing atmospheric pressure. In the context of this standard, the atmospheric pressure is the absolute pressure of the gas within the oronasal compartment of the respirator assembly.

1.2.3 Protection Factor (PF)

The PF is the ratio of the concentration of toxic agent in the immediate environment external to the headgear (C_o), to the total concentration of the toxic agent in the specified compartment of the respirator assembly (C_i) that is achieved under actual field conditions.

$$PF = \frac{C_o}{C_i} \text{ (actual agent)}$$

1.2.4 Chemically Clean Gas Or Filtered Gas

Gas employed for breathing or ventilation which has been filtered or otherwise processed to remove CBRN agents to below the no effects level. (Note: The term “filtered gas” shall be taken to mean gas which is free of CBRN agents, even if the method of cleaning the gas is different from filtration).

1.2.5 Aircrew Respirator

The aircrew respirator is that part of the aircrew ensemble which is required to provide continuous eye and respiratory protection against the toxic effects of CBRN agents.

1.2.6 Aircrew Protective Headgear

Those portions of the aircrew protective assembly worn on the head. These include items required for head, neck, eye and respiratory protection.

1.2.7 Aircrew Protective Assembly

The aircrew protective assembly consists of those components of the protective system required for eye and respiratory protection. It includes CBRN protective clothing, man-mounted equipment and aircraft equipment required to protect the crew during air operations and during normal and emergency egress from the aircraft.

1.2.8 Protective System

The protective system consists of the aircrew protective assembly and auxiliary assemblies, equipment and procedures required to protect the head, neck, eyes and respiratory tract of the aircrew member against the effects of CBRN agents during both ground and air operations. It includes specific transport systems, protective equipment for ground use, contamination avoidance procedures, additional clothing employed to avoid contamination of the aircrew protective assembly with agents whilst on the ground, and procedures employed to remove contaminants and to allow the crew member to safely don and doff the aircrew protective assembly.

1.3 DESIGN PHILOSOPHY

1.3.1 General

The aircrew respirator is a critical sub-component in the protective system designed to allow combat operations to continue in a toxic CBRN environment. The respirator design for a particular aircraft and crew position should be appropriate to the crew member’s primary job and should reflect the nature of the threat, risk and possible duration of toxic agent exposure pertinent to the aircraft mission role. Risk-weighted trade-offs between protection and utility may be appropriate for certain air missions with unique personnel mobility or visibility requirements. Thus, respirator designs may vary with aircraft type or from nation to nation. There are, however, certain guidelines which apply to all eye and respiratory protection for aircrew, regardless of design details. Within the sphere of operations of the participating nations, protective systems may be employed in lieu of protective assemblies if the PF of the protective system is

at least 10^4. The purpose of this standard is to ensure that these minimum guidelines are met by protective systems fielded for operational use by the participating nations.

1.3.2 Basis Of The Fit And Protection Standard

The impairment of vision produced by very low doses of nerve agents sets the standard for eye and respiratory protection required of aircrew respirators. The maximum acceptable cumulative dose of nerve agents to the eyes taken together with the worst case dose to which the aircrew may be exposed sets the "risk free" standard of protection for a respirator. Relevant data for air operations from NATO bases in Europe show that to ensure significant miosis will not occur, even under the worst case attack, the PF provided to the eyes and respiratory tract must be at least 10^4. There are many risk factors which affect the probability of exposure to the worst case threat. Other scenarios within the operational spheres of participating nations may generate requirements which exceed a 10^4 PF.

a. Airborne Agents. A PF of 10^4 against toxic agents in vapour, aerosol and particulate forms and against radioactive particulate matter can only currently be ensured by an aircrew respirator which has the following characteristics:

   (1) The respirator completely isolates the eyes, nose and mouth from the environment.

   (2) The oronasal and eye compartments are continuously ventilated with chemically clean gas.

   (3) If powered ventilators are used, the pressures in the oronasal and eye compartments are greater than that of the environment.

b. Liquid and Solid Agent. The most effective protection against toxic agent in the liquid and solid states is avoidance. Short term permeation of contaminated respirators by toxic agents in liquid or solid forms can be prevented by constructing the exposed portions of respirators from materials which are highly resistant to penetration by liquid or solid agent.

1.3.3 Classes of CBRN Respirators

At least two types of respirators designed for aircrew use can be recognized based upon the relationships of the pressures within the respirator to that of the environment.

a. **Lung Powered Respirators**. Respirators in which filtered gas is drawn through the eye compartment into the oronasal compartment during inspiration by the reduction of pressure in the latter below the pressure of the environment. Face sealing, lung powered respirators may not consistently provide a PF of 10^4.

b. **Positively Ventilated Respirator**. Respirators in which filtered gas is supplied to both the respiratory and eye compartments at pressures greater than that of the environment. It is highly desirable that pressures in both compartments remain above the environment throughout the entire respiratory cycle under all conditions of use.

c. **Hybrid Respirators**. Respirators which have the characteristics of a lung-powered respirator when used on the ground, but which are normally positively ventilated in flight.

1.4 GENERAL REQUIREMENTS (ALL AIRCRAFT TYPES)

1. The aircrew protective assembly shall be comfortable to wear and shall produce minimal interference with the ability of the wearer to perform the activities essential to the operational task, both in-flight and on the ground. The aircrew protective assembly must integrate and be compatible with the crew station in all normal and emergency mission environments encountered in the aircraft for which it is designed.

2. The CBRN aircrew protective assembly shall not compromise ejection, parachute deployment, subsequent descent and landing, nor shall it interfere with survival on land or on water entry. In addition, the CBRN protective assembly shall not compromise the safe egress from an aircraft in the event of an emergency landing or ditching including underwater egress. When applicable, it is desirable that the CBRN respirator be compatible with the standard flying helmet and that no change of suspension or fit be required for mission-to-mission change between chemical defence respirator assemblies and the normal issue oxygen masks.

3. The protective assembly and its associated systems shall also provide:

a. Intercommunication capability during both air and ground operations.

b. Noise attenuation.

c. Protection against hypoxia when used in concert with O2 supply systems.

d. Protection against birdstrike, wind blast and impact.

e. Drinking capability to allow intake of hot and cold liquids.

f. Compatibility with corrective and protective lenses, visors and electro-optical devices. Protection of visual properties of respirator by prevention of fogging or freezing of the visor/lens under all operating conditions.

g. Fire protection.

h. Capability to eliminate mucous or vomitus. This should not compromise CBRN protection.

i. Facility to equalize pressure in ears and paranasal sinuses.

j. Cold injury protection.

k. Nuclear thermal radiation protection.

1.5 DEGREE OF PROTECTION

The aircrew protective assembly shall provide, under all operational conditions, a PF to the eyes and respiratory tract of at least 10^4 against airborne agents. It shall be possible to use the respirator as part of an aircrew protective assembly or personnel protection system (including procedures and auxiliary personal protective assemblies) in the presence of liquid agent without degrading the vapour PF. Where the aircrew respirator provides primary protection against liquid or solid agents, it shall prevent agent in liquid or solid form from gaining access to the skin for at least 12 hours. The respirator must also provide a PF of at least 10^3 to the respiratory tract and eyes in the event of a failure of the positive pressure supply of chemically clean gas to the respirator.

1.6 CONDITIONS OF USE

1. Although not directly measurable in every case, the aircrew protective assembly shall meet the performance required by this standard during and after all the following general conditions of use:

a. Continuous wear for periods up to at least 12 hours of flight and/or routine ground use (not survival).

b. On the ground and on the flight deck of ships, including: standby in aircraft; areas of collective protection; and in the open (with auxiliary protection, if necessary).

c. At reduced ambient pressures:

(1) In aircraft not fitted with oxygen supplies, up to 3960 m (13,000 feet).

(2) In aircraft fitted with oxygen supplies, up to at least 12,200 m (40,000 feet).

d. At temperatures between -26ºC and +55ºC for at least 12 hours.

e. At sustained +3 Gz for periods of at least 30 seconds.

f. During and after rapid ground egress from aircraft.

g. Ideally provide protection following airborne escape from an aircraft.

h. It is desirable that it be possible to safely don and doff the aircrew protective assembly in-flight, if the aircraft is not contaminated.

2. In addition to the general conditions of use, the aircrew protective assembly shall meet the following conditions of use in high performance aircraft:

a. During sustained + Gz accelerations of up to at least +8 Gz for periods of up to at least 30 seconds. For carrier based aircraft during accelerations of +6.5 Gx and -3.5 Gx for periods of up to 2 seconds.

b. During and after escape from ejection seat equipped aircraft. (The specified performance need not be met during the high acceleration phases of the escape sequence, ie greater than 10 G). The aircrew protective assembly must not interfere with the operation of the ejection seat or adversely affect the mode selection, attitude, orientation or trajectory of the seat before man-seat separation. The aircrew protective assembly must not be damaged or deranged nor must it cause or contribute to injury of the crew member during or following an ejection at up to 450 knots effective airspeed.

c. When employed in aircraft which operate above 7,620 m (25,000 feet), the assembly must meet the performance required by this standard at temperatures between -40ºC and -26ºC for at least 5 minutes at wind speeds of up to 7.5 m sec^{-1} (15 knots).

3. In addition to the general conditions of use, when employed in rotary wing and utility aircraft operating with open cockpits, the protective system shall meet the performance required by this standard (with the use of insulating covers or heated ventilation, if required) at temperatures between -40ºC and -26ºC for at least 30 minutes at wind speeds of up to 7.5 m sec^{-1} (15 knots). It is desirable that it be possible to safely don and doff the aircrew protective assembly in-flight, if the aircraft is not contaminated.

1.7 WEIGHT, SIZE AND MATERIALS

The aircrew protective headgear shall be as small and as lightweight as possible. The weight shall be distributed evenly over the head and should not have a significant effect on the centre of gravity of the head. The aircrew protective assembly shall be sized to fit at least 90% of the aircrew population. It should be possible with custom fitting to fit the entire aircrew population. Those parts of the assembly which come into contact with the skin of the head and neck shall be made of materials which do not irritate the skin and are not toxic to it. The aircrew protective assembly shall be flame retardant to the maximum extent consistent with its primary function.

1.8 DONNING AND DOFFING

1. It shall be possible for the wearer to don and doff a contaminated aircrew protective assembly while processing through a Contamination Control Area (CCA) without contaminating the skin, eyes or respiratory tract with toxic agents in liquid or particulate form, and without toxic agent in any form gaining access to the eyes or respiratory tract. It is highly desirable that the wearer be able to completely don and doff the assembly without assistance. Where CCA procedures include an exchange of the mission respirator for a clean transit respirator, the breath-holding and eye-closure time requirements of the exchange shall be less than 30 seconds. It is highly desirable that the emergency doffing time be less than 15 seconds.

2. It shall be possible to decontaminate the aircrew respirator repeatedly for reuse or safely use the assembly in a contaminated state. Decontamination and disinfection shall not adversely affect the component materials or PF of the respirator. The PF of the respirator shall not be adversely affected by currently employed decontamination agents.

1.9 RESPIRATORY PERFORMANCE

1. **General Requirements for All Aircraft**:

   a. **Impedance to Respiration**. The aircrew protective assembly shall be capable of meeting peak inspiratory and expiratory flows of up to 3.3 litre (ATPD) sec^{-1}. The assembly shall impose the minimum of impedance to respiration. It is highly desirable that the impedance to respiration imposed at ground level and at any altitude up to 12,200 m (40,000 feet) does not exceed the values given in Tables 1 and 2.

   b. **Composition of Inspired Gas**. The gas delivered by the protective assembly on the ground and in aircraft not fitted with oxygen supplies shall be chemically clean air.

c. **Added Respiratory Dead Space**. To prevent under-ventilation of the pulmonary alveoli, the effective respiratory dead space of the respirator shall not be greater than 0.2 L (BTPS).

d. **Positive Pressure**. With the ventilation system operating, it is desirable that the pressure in the eye compartment and, depending on the system, in the oronasal compartment be greater than that of the environment at inspiratory flows of up to at least 1.5 litre (ATPD) sec^{-1}.

e. **Anti-suffocation and Anti-drown Protection**. It shall be possible to breathe filtered ambient air in the event of loss of the breathing gas supply and ambient air in the event of occlusion of the mask tube or of water entry (but with the head above the surface). It is highly desirable that anti-suffocation and anti-drown protection be provided without breaching the chemical integrity of the aircrew protective assembly. It is further desirable that the respirator be compatible with an underwater breathing system when used in a helicopter.

2. **Aircraft Fitted with Individual Oxygen Equipment**. The respiratory components of the aircrew protective assembly shall meet the requirements of STANAG 3198, and of STANAG 3865 where applicable.

1.10 EQUALIZATION OF PRESSURE IN MIDDLE EARS AND SINUSES

An aircrew protective assembly which is to be used at altitudes greater than 300 m (1,000 feet) above ground level shall provide the means whereby the wearer can occlude his nostrils in order to perform the Frenzel or Valsalva manoeuvres to introduce air into the middle ears and paranasal sinuses during descent from altitude. In-flight, it shall be possible to perform this manoeuvre with one hand while wearing CBRN gloves.

1.11 VISION

1.11.1 Optical Quality

The aircrew protective assembly shall produce minimal interference with vision. The optical characteristics of the visor shall meet the requirements of either MOD (UK) DTD Specification N/ 1218 or US MIL-V-43511B. The visor shall be free from misting or icing under all environmental conditions specified. The optical qualities of the visor must not be degraded by contact with CBRN agents, decontamination or disinfection. It is highly desirable that the limitations of the fixed binocular field of view imposed by the assembly shall be no greater than that imposed by the current aircrew protective helmet and oronasal mask. The assembly shall also produce minimal restriction of head movement, particularly within the confines of the cockpit.

1.11.2 Vision Protection

Where the respirator visor substitutes for the standard flying visor, it shall provide those protective functions, such as wind-blast, birdstrike and solar glare protection, normally provided by the standard visor. When appropriate, the assembly shall integrate with electro-optical devices, including nuclear flash blindness protective visors and night vision devices, as well as laser eye protection.

1.11.3 Corrective Lenses

It is highly desirable that the assembly shall integrate with the standard flying spectacles. In any case, the assembly shall provide for the incorporation of corrective lenses.

1.11.4 Anti-Mist/Anti-Fog

The assembly shall prevent condensation of moisture on the visual surface. If anti-fog coatings are used, it is highly desirable that these are permanent and no moisture obscures the vision within the operating temperature range of the equipment. Where the demist function is provided by ventilating gas, a method of backup demist shall be incorporated in the system.

1.12 RELIABILITY AND MAINTAINABILITY

1.12.1 Reliability

It is desirable that the system have a minimum mean time between failures not less than the standard flying equipment it supplants.

1.12.2 Maintainability

The respirator assembly shall be repairable by the same technicians employed to maintain the equipment the respiratory assembly supplants, preferably without extensive additional special training. The mean time to repair or replace system components shall not be greater than 30 minutes. It is highly desirable that the system's CBRN protection be verifiable by a "pass/fail" test which assures the respirator will provide a PF of at least 10^4.

1.12.3 Shelf And Service Life

It is desirable that the aircrew respirator have a shelf life of 10 years and a service life of 5 years (uncontaminated).

1.13 INTEGRATION AND INTEROPERABILITY

1.13.1 Aircrew Equipment Assemblies

The assembly shall to the maximum extent feasible integrate with existing aircrew equipment assemblies. It is desirable that sub-components of aircrew protective assemblies be interchangeable with standard aircrew equipment, for example oronasal mask.

1.13.2 Cockpit Systems

CBRN personal protective assemblies shall be compatible with the primary function of the aircrew member at his crew station. Different variants of a single aircrew respirator design or entirely different protective systems may be required to optimise CBRN protection across the air fleet.

1.13.3 Interoperability

Participating nations shall, on request, notify other participating nations of interface connections required to adapt aircrew respirators to aircraft oxygen systems, filter-blower units and communication systems. This will allow participating nations to provide the necessary adaptors to aircrews so that they may use aircraft oxygen systems and filtered air sources of other nations in accordance with STANAG 4155.

ANNEX A RECOMMENDED MAXIMUM RESPIRATORY IMPEDANCE (1) (HIGH PERFORMANCE AND ROTARY WING AIRCRAFT)

Suggested values for the maximum impedance to respiration imposed by CBRN protective assemblies at all altitudes from ground level to 12,200 m (40,000 feet):

Peak Inspiratory and Expiratory Flow [litre (ATPD) sec^{-1}]	Oronasal Compartment Pressures [kPa (inch water gauge)]		
	Maximum Swing (2)	Minimum (gauge to ambient)	Maximum (3)
NORMAL OPERATING MODES			
0.5 1.5 2.5 3.3	0.50 (2.0) 0.85 (3.4) 1.75 (7.0) 3.00 (12.0)	-0.48 (-1.9) -0.90 (-3.6) -1,65 (-6.6) -2.50 (-10.0)	+0.88 (+3.5) +0.95 (+3.8) +1.25 (+5.0) +1.75 (+7.0)
FOLLOWING FAILURE OF PRIMARY SOURCE OF FORCED VENTILATION			
0.5 1.5 2.5	0.75 (3.0) 1.60 (6.4) 2.50 (10.0)	-0.55 (-2.2) -1.00 (-4.0) -2.15 (-8.6)	+0.88 (+3.5) +1.10 (+4.4) +1.38 (+5.5)

Notes:

(1) Respiratory Impedance, defined as the complex ratio between the applied pressure and the resulting volumetric flow rate at the frequencies contained in the forcing signal.

(2) The swing of oronasal compartment pressure is the difference between minimum and maximum pressures during the respiratory cycle.

(3) Measured relative to ambient pressure.

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ANNEX B RECOMMENDED MAXIMUM RESPIRATORY IMPEDANCE (1) (ALL AIRCRAFT EXCEPT HIGH PERFORMANCE AND ROTARY WING AIRCRAFT)

Suggested values for the maximum impedance to respiration imposed by CBRN protective assembles at all altitudes from ground level to 12,200 m (40,000 feet):

Peak Inspiratory and Expiratory Flow [litre (ATPD) sec^{-1}]	Oronasal Compartment Pressures [kPa (inch water gauge)]		
	Maximum Swing (2)	Minimum (gauge to ambient)	Maximum (3)
NORMAL OPERATING MODES			
0.5 1.5 2.5	0.50 (2.0) 0.85 (3.4) 1.75 (7.0)	-0.48 (-1.9) -0.90 (-3.6) -1.65 (-6.6)	+0.88 (+3.5) +0.95 (+3.8) +1.25 (+5.0)
FOLLOWING FAILURE OF PRIMARY SOURCE OF FORCED VENTILATION			
0.5 1.5	0.75 (3.0) 1.60 (6.4)	Not Specified Not Specified	+0.88 (+3.5) +1.10 (+4.4)

Notes:

(1) Respiratory Impedance, defined as the complex ratio between the applied pressure and the resulting volumetric flow rate at the frequencies contained in the forcing signal.

(2) The swing of oronasal compartment pressure is the difference between minimum and maximum pressures during the respiratory cycle.

(3) Measured relative to ambient pressure.

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