NATO STANDARD

AAMedP-1.4

MINIMUM REQUIREMENTS FOR G PROTECTIVE SYSTEMS

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NORTH ATLANTIC TREATY ORGANIZATION

ALLIED AEROMEDICAL PUBLICATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

13 February 2024

1. The enclosed Allied Aeromedical Publication AAMedP-1.4, Edition B, version 1, MINIMUM REQUIREMENTS FOR G PROTECTIVE SYSTEMS, which has been approved by the nations in the Military Committee Air Standardization Board, is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 3200.

2. AAMedP-1.4, Edition B, version 1, is effective upon receipt and supersedes AAMedP-1.4, Edition A, version 2, which shall be destroyed in accordance with the local procedure for the destruction of documents.

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

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Director, NATO Standardization Office

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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 Documents Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
CZE	Aircraft currently used in CZE meet the requirements for Anti-G systems in principle. The CZE Air Force is not fully equipped with the required individual Anti-G equipment. Meeting all requirements for Anti-G systems will be possible after the purchase of new aircraft and all the required individual Anti-G equipment.
FRA	France will not implement the last sentence of paragraph 1.2.2 concerning the control of pressure reduction during deflation. On some aircraft, France uses a method other than the safety valve to guarantee a maximum outlet pressure of 90 kPa.
USA	AF/JAO notes no operational or international law impediment to ratification, however, if ratified we recommend that STANAG 3200 be ratified with reservation to clarify that the U.S. will not procure equipment/systems or train personnel beyond that needed to satisfy current U.S. requirements.
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CHAPTER 1 GENERAL

1.1 CONDITIONS OF USE

1.1.1 Operational Considerations

AAMedP-1.4 sets criteria to be observed in the development, selection and use of anti-G systems; however, it is acknowledged that different combinations of acceleration protection are operationally available to member nations and that one or more may be used in different applications depending on the degree of protection required:

a. **Anti-G Straining Manoeuvre (AGSM) Only**. The AGSM alone provides adequate protection in cases of brief and infrequent exposure to levels as high as +6 Gz but protection can vary depending on the effectiveness of the individual's technique. It is the only means of G protection in some aircraft. Reliance on this method alone should be accompanied by thorough training in the technique, centrifuge training and a collateral physical conditioning programme. The requirements for training and use of the AGSM are addressed in STANAG 3827. A shortcoming is that fatigue erodes AGSM effectiveness and limits safe access to high G.

b. **Anti-G Trousers (AGT)**. AGT are broadly divided into partial coverage (or skeletal) garments comprising 5 distensible bladders, and full coverage garments which have circumferential leg bladders, although other designs also exist. The bladders are restrained by inextensible covers allowing the application of pressure to the lower limbs to increase vascular resistance, reducing leg venous pooling and supporting the diaphragm (via the abdominal bladder), thus mitigating the physiological effects of +Gz. Typically, the 5-bladder design can improve relaxed G tolerance by 1 to 1.5 G, and the full coverage design by 2 to 2.5 G. AGT are also used together with a chest counter-pressure garment (CCG) to provide high altitude protection when high levels of pressure breathing for altitude (PBA) are required. This combination is termed a partial pressure assembly.

c. **AGT with AGSM**. Anti-G trousers used in conjunction with an AGSM can enable trained individuals to achieve levels as high as +9Gz for brief periods. It is the primary means of protection in many fighter, and most attack aircraft. Reliance and use of AGSM should include centrifuge training and an appropriate physical conditioning programme.

d. **AGT with AGSM plus Pressure Breathing for G (PBG)**. By reducing the respiratory effort associated with the AGSM, PBG can reduce fatigue and enhance endurance. PBG may raise resting G-tolerance and reduce the need to perform an AGSM if it is used in combination with full coverage AGT. PBG is commonly used in aircraft platforms which operate in the +7 to +9 Gz range.

1.1.2 Performance Considerations

The anti-G system shall be required to operate under the following conditions:

a. **Environmental Pressure**. The system shall be able to provide adequate operating and inspired oxygen pressures across the full range of potential (normal and decompressed) cabin altitudes.

b. **Environmental Temperature**. The system shall function at temperatures between -26°C and +55°C and during and after exposures to temperatures between -40°C and -26°C for at least 30 minutes.

1.2 ANTI-G VALVE (AGV)

1.2.1 Anti-G Valve Schedule

The AGV may use electronic or mechanical means to sense changes in +Gz and control pressures to the AGT. It is supplied by a pressurized gas source and will deliver inflation pressure to the AGT according to the following relationship:

$P_{AGVO} = m (G_Z – G_{ZO})$,

where:

P_{AGVO} is pressure measured at the G valve outlet
m is the slope of the relationship of AGT pressure with G_Z (kPa per G)

G_Z is acceleration exerted on the sitting pilot in the direction of the head

G_{ZO} is the level of G_Z at which AGT pressurization begins, usually between 1.5 and 2.5 G_Z

Several different slopes are in use with member nations and several viable schedules have been proposed.

1.2.2 Dynamic Performance

The minimal requirement for the flow capacity of the AGV is for AGT inflation to be achieved to its nominal schedule ± 3.5 kPa (26 mmHg) within 2 seconds. It is highly desirable, especially in PBG systems that this pressure is reached within 1 second. A pilot-selectable pre-inflation (ready) pressure may be used to expedite inflation. On decreasing G, AGT pressure shall be vented by the anti-G valve. The time to deflate the AGT to 3.5 kPa (26 mmHg) following an instantaneous change from 6G to 1G should usually not exceed 3 seconds.

1.2.3 Maximum AGV Pressure

A system should limit the maximum outlet pressure of the AGV to 90 kPa (675 mmHg) under normal or failure conditions.

1.2.4 Press-To-Test

It shall be possible to verify the proper function of the system by activating a press-to-test feature. In PBG systems this should be accompanied by breathing pressure activation.

1.3 PBG BREATHING REGULATORS

The PBG regulator may either be electronically or pneumatically controlled. In addition to the requirements of STANAG 3198, the following requirements will apply.

1.3.1 PBG Schedule

Safety considerations require that it be impossible to receive PBG in the absence of adequate AGT inflation. The PBG schedule is usually a linear function of the form:

$$P_{PBG} = m\,(G_Z - G_{Z1}),$$

where:

P_{PBG} is the breathing pressure (kPa)
m is the slope (kPa per G)

G_Z is the acceleration (G)

G_{Z1} is the level at which PBG begins

Non-linear relationships are acceptable within the framework of constraints expressed below, as long as both the onset and magnitude of PBG are governed by pressures in the AGT.

1.3.1.1 Slope of the PBG Schedule

Several different slopes are in use with member nations and several viable schedules have been proposed. The only agreed constraint at this time is that in no case will the mask cavity pressure be allowed to exceed 10.7 kPa (80 mmHg).

1.3.1.2 Onset of the PBG Schedule

Onset may be the same as the onset of AGT inflation (+1.5 to +2.5 Gz) or be displaced to a higher threshold (i.e. +4 to +5 Gz).

1.3.1.3 Priority of Pressure Breathing for Altitude (PBA) and/or PBG Schedules

The PBG regulator shall deliver the higher of the PBA and/or PBG pressure schedules dictated by the cockpit environment. The PBG schedule shall not be additive with ready pressure or PBA schedules.

1.3.2 Dynamic Performance

The PBG regulator should achieve the mask cavity pressure required by the schedule ± 0.5 kPa (3.8 mmHg) within one second, whether increasing or decreasing +Gz.

1.3.3 Controls and Displays

The regulator should be equipped with a press-to-test feature (see paragraph 1.3.4 below). If the system is designed to permit use without a CCG, a PBG mode selector switch may be provided.

1.3.4 Use Without Chest Counter-Pressure

Use of chest counter-pressure is not mandatory for use with a PBG system, as studies have shown there is no increased risk of lung over-distension under increased Gz. If the PBG system is used without chest counter-pressure, it shall be designed such that mask cavity pressure cannot exceed 4 kPa (30 mmHg) when the applied acceleration is less than +6Gz. In this configuration, the press-to-test feature must not deliver more than 30 mmHg mask cavity pressure.

1.3.5 Relief Valves

A relief valve will limit the applied mask pressure as follows: increases in pressure due to head movement, hose pumping or dynamic overshoot by the regulator shall not exceed 1 kPa (7.5 mmHg) gauge. Increases during rapid decompression will be limited to 5.35 kPa (40 mmHg) if the CCG is not worn, and 10.7 kPa (80 mmHg) if it is worn.

In the latter case, a single transient in the interval from 10.7 kPa (80 mmHg) to as high as 13.3 kPa (100 mmHg) is also allowed for 250 ms or less.

1.4 AIRCREW ANTI-G ENSEMBLES

Such ensembles may be used for high altitude emergency descent protection following decompression, as described in STANAG 3198.

1.4.1 General Requirements

The following requirements apply to all anti-G ensembles:

a. **Materials and Construction**. The garments shall be made of flexible material and be comfortable to wear both inside and outside the aircraft. Heat stress to the aircrew should be minimized. The restraint layer shall be designed to minimize inflated growth, and burst pressure shall be at least 1.5 times the maximum operating pressure. Flame retardant materials should be used wherever possible, and no hazardous or toxic smoke, fumes or gases shall be produced as a result of burning or heating the garments.

b. **Fit**. The garment should be easily adjustable to fit snugly, but should not limit the range of motion necessary for normal ground and flight operations, cockpit ingress or emergency egress. Fit is critical for proper function.

c. **Don/Doff**. The design should allow quick and easy donning and doffing without assistance. Where appropriate, comfort zippers may be provided so that the garment may be worn loosely for non-flying activities and tightened quickly to achieve a proper fit.

d. **Integration**. The garment must be compatible with other items in the aircrew equipment ensemble and the working cockpit environment. When inflated it shall not interfere with normal operation or visibility of the primary controls and displays in the cockpit.

e. **Connectors**. Whenever the AGT is disconnected from the AGV outlet, PBG should be disabled. Quick release connectors shall be designed to prevent inadvertent disconnection. A disconnect warning is desirable.

f. **Interoperability**. Participating nations will provide information to one another on request in order to adapt anti-G ensembles to other aircraft types.

1.4.2 Anti-G Trousers (AGT)

a. **Coverage**. At a minimum, AGTs shall provide counter-pressure to the abdomen (below the lower level of the ribs) and the thighs and calves. The restraint layer may be used to extend pressure application beyond the bladder margin, or bladder coverage may be applied to a greater area of the lower body through the use of extended or full-coverage AGTs. Full or extended coverage AGTs provide enhanced protection and are preferable in PBG systems.

b. **Supply Hoses**. AGT supply hoses shall be of anti-kink and non-crushable materials and construction to prevent flow restriction.

1.4.3 Chest Counter-pressure Garments (CCG)

a. **Coverage**. The CCG should cover the entire upper torso above the upper margin of the AGT. Its bladder coverage should include the diaphragm and anterior chest wall. Adjustments should be included to ensure that the restraint layer conveys counter-pressure beyond the limits of bladder coverage.

b. **Supply Hoses**. CCG supply hoses shall be of anti-kink and non-crushable materials and construction to prevent flow restriction.

ANNEX A DEFINITIONS

The following definitions shall be employed when implementing the provisions of this document:

The symbol “G”	The ratio of the acceleration in m/sec^2 measured at a point in space, to the acceleration of gravity at the surface of the earth (approximately 9.81m/sec^2). Multiples of this are experienced in manoeuvring flight. Subscripts *x*, *y*, and *z* are used to describe accelerations applied to the shortest (front-to-back), intermediate (lateral) and longest (spinal) axes of the body. Gz is the axis that routinely impacts pilot and aircraft performance and, therefore, aircrew often simply refer to “G” when referring to Gz.
Anti-G System	The airframe-mounted, seat mounted and personal equipment required to implement G protection for aircrew. Personal equipment includes the anti-G valve, anti-G garment, and Pressure Breathing for G (PBG) system (if equipped).
Anti-G Straining Manoeuvre (AGSM)	A method for raising blood pressure and total peripheral resistance in order to increase tolerance to +Gz acceleration by voluntary isometric contraction of the skeletal muscles of the limbs and abdomen while simultaneously exhaling against a closed or partially closed glottis to raise the intrathoracic and blood pressure. The manoeuvre is interrupted every 3 to 4 seconds by a short rapid air exchange.
Anti-G Trousers (AGT)	A trouser-like garment designed to apply pressure to the abdomen and legs of the wearer to counteract the tendency of blood to pool in the lower parts of the body during +Gz exposure and consequently to maintain cerebral blood pressure during +Gz. The amount of coverage of the AGT may vary from a five-bladder design to full coverage. Some alternative AGT designs may be utilized by some nations.
Pressure Breathing for G (PBG)	Delivery of breathing gas to the respiratory system under positive pressure; PBG reduces the effort required in performing the inspiratory portion of an AGSM and may enhance G protection by raising intra-thoracic and thus arterial pressure.
Pressure Breathing for Altitude (PBA)	A method of maintaining alveolar pressure required to maintain sufficient alveolar PO2 above 40,000 ft to mitigate high altitude hypoxia.

Chest Counter-pressure Garment (CCG) A garment which applies counter-pressure to the upper torso. It is not required to limit lung distension under increased Gz but is required when it forms part of a partial pressure assembly to protect against the respiratory effects of PBA during high levels of altitude exposure.

Aircrew Anti-G System The equipment worn by the crewmember to increase G tolerance. The anti-G system will always include an AGT, but may also include a capability for PBG with or without a CCG.

Anti-G Valve (AGV) A pressure-regulating valve that controls the pressure inside a pneumatic AGT as a function of the applied +Gz acceleration. It may also signal the breathing regulator to command pressure breathing.

G Tolerance The term G tolerance is usually used to describe the level of G that a crewmember can tolerate before experiencing G-related symptoms (eg grey-out, blackout, or loss of consciousness). When assessing G protective equipment, relaxed G tolerance is commonly measured. This is the level of G that an individual, who is sitting relaxed without muscle tensing, sees a 60 degree reduction in their peripheral vision. When operational matters are relevant, straining G tolerance is more commonly used. Straining G tolerance can be measured both in terms of absolute G level and also in endurance to a series of repeated G profiles; it is less repeatable due to variations in individual straining effort.

Pressure Schedule The relationship between the pressure applied by an AGV or PBG regulator and the applied +Gz acceleration, usually described as a slope (kPa or mmHg per G).

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