MILITARY SPECIFICATION

PERSONAL PROTECTIVE EQUIPMENT, AIRCREW

This specification is approved for use within the Department of the Air Force, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the development requirements and verifications for aircrew personal protective equipment.

1.2 Use. This specification cannot be used for contractual purposes without supplemental information relating to the performance requirements of aircrew personal protective equipment.

1.2.1 Structure. The supplemental information required is identified by blanks within the specification.

1.2.2 Instructional handbook. The instructional handbook, which is contained in the appendix herein, provides the rationale for specified requirements, guidance for inclusion of supplemental information, and a lessons learned repository.

1.3 Deviation. Any projected design for a given application which will result in improvement of system performance, reduced life cycle cost, or reduced development cost through deviation from this specification, or where the requirements of this specification result in compromise in operational capability, shall be brought to the attention of the procuring activity for consideration of change.

2. APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these

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documents shall be those listed in the issue of the Department of Defense Index of Specification and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

Military

MIL-O-87226	Oxygen Systems, Aircraft

STANDARDS

Military

MIL-STD-846	Escape System Testing, Ground, Track, and Flight Test

(Copies of specification, standards, handbooks, drawings, publication, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.1.2 Other Government documents, drawings and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein.

PUBLICATIONS

(Copies of specifications, standards, handbooks, drawings and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issue in the current DODISS and the supplement thereto, if applicable.

(Application for copies should be addressed to (name and address of the source.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 <u>System description</u>. The personal protection systems for aircraft shall consist of:

a. Chemical and biological (CB) head/respiratory protection
b. Eye protection
c. Anti-G protection
d. High altitude protection
e. Head protection

3.2 Performance requirements

3.2.1 Chemical/biological head/respiratory protection

3.2.1.1 <u>CB personal equipment compatibility</u>. The aircrew CB head/respiratory protection system, when properly donned and worn with other personal flight ensembles, shall integrate and be compatible with the ______________ aircraft cockpit structure, environmental control system, and electrical system. There shall be no interference with the function of the following aircrew life support equipment:

a.__________ Headgear
b.__________ Oxygen mask
c.__________ Life preserver
d.__________ Eye protection device
e.__________ Parachute harness
f.__________ Survival vest
g.__________ Anti-G suit
h.__________ Oxygen regulator
i.__________ Flight coverall
j.__________ Vision enhancement device
k.__________ Escape system
l.__________ ____________________
(Specify other)

3.2.1.2 <u>CB environmental conditions</u>. The aircrew CB head/respiratory protection system shall be capable of withstanding and operating under the following environmental conditions induced by the aircraft, ground transport, or storage ______________.

3.2.1.3 <u>CB eye/respiratory protection level</u>. The eye/respiratory protection level of the aircrew CB head/respiratory protection system shall not be less than __________ for _____ percent of the USAF aircrew population. The protection level is defined as the ratio of the measured airborne concentration of test agent in ambient air surrounding the system to the concentration of test agent within the system facial region.

3.2.1.4 <u>CB communication intelligibility</u>. Voice intelligibility shall be at least _______ % in a _______ db noise environment. The aircrew CB head/respiratory protection system shall permit intelligible voice communication both in and outside the aircraft. Voice communication within the aircraft shall include interfacing with the aircraft intercommunication system.

3.2.1.5 CB ventilation/filtration. A ventilation/filtration system shall be provided to assure removal of CB agents from the breathing gas, maintain the protection level required in 3.2.1.3 and prevent lens misting during transition between collective shelter and aircraft and during flight operations.

3.2.1.6 CB permeation. The aircrew CB head/respiratory protection system shall be resistant to permeation by CB agents for a minimum of _____ hours.

3.2.1.7 CB equipment during escape. The aircrew CB head/respiratory protective system shall not loosen, tear, or otherwise fail structurally resulting in possible injury or interference with survivable crash, emergency ground egress, the emergency ejection sequence or bailout, parachute descent, ground landing, or water entry. All system disconnects shall operate properly during an ejection and shall release with an applied force not less than _________ pounds nor more than _________ pounds. The system shall prevent suffocation following water entry.

3.2.1.8 CB utilization. The following aircrew CB head/respiratory protection system use requirements shall be met:

a. Donning - The system shall be capable of being donned in ___________ minutes.

b. Doffing - The system shall be capable of being doffed in ___________ seconds.

c. Transition - The system shall be capable of being converted from ground to aircraft operational mode in _____ seconds.

d. Valsalva - The system shall permit the wearer to perform a valsalva maneuver.

e. Comfort - The aircrew member wearing the system shall not experience hot spots, pressure points, or other intolerable discomfort.

f. Drinking - The system shall enable the wearer to drink without compromising CB protection for extended time duration missions (i.e. transport aircraft).

g. Subjective use - The system shall have no objectionable performance characteristics such as objectionable odors, skin irritation, restriction of movement, tacky to the touch, or any other property that may cause discomfort or affect wearability.

3.2.1.9 CB electromagnetic emission and susceptibility. The aircrew CB head/respiratory protection system shall meet the electromagnetic emission and susceptibility requirements of ___________.

3.2.1.10 CB sustained acceleration. The aircrew CB head/respiratory protection system shall not malfunction or hinder aircrew member's ability to perform necessary tasks when acceleration forces of _________ G's for _________ seconds are encountered.

3.2.1.11 CB optical system. The CB head/respiratory protection system lens shall be of sufficient size such as not to decrease the wearer's visual field in the upward or lateral directions. The restriction of downward vision shall be no greater than ________. The viewing area shall meet or surpass the optical requirements of ________. The lens shall be capable of meeting the ballistic resistance requirement of ________ and abrasion resistance requirements of ________. When properly donned and operating, the system shall exhibit no visible lens fogging at a temperature of ______ degrees and relative humidity of ________ %.

3.2.2 Eye protection

3.2.2.1 General protection. Eye protective equipment shall be designed to provide protection against high levels of ____________ likely to be encountered in the operational environment.

3.2.2.2 Nuclear flash protection. Nuclear flash protective equipment shall be designed to protect the eyes of aircrew members against the flash blindness and retinal burn hazards associated with military operations in a nuclear environment. The device shall be designed to be fully functional in the ________ air vehicle environment and compatible with ________________.

3.2.2.3 Laser radiation protection. Eye protective equipment shall be designed to provide protection against laser radiation likely to be encountered during the aircraft mission. The device shall be designed to afford at least ________ % protection at ________ wavelengths while providing at least a visible light transmittance of ________ %.

3.2.2.4 Thermal radiation protection. The aircrew members and crew station areas of aircraft with wartime nuclear mission roles shall be provided with thermal shielding over normally transparent areas.

3.2.2.5 Eye protection personal equipment compatibility. The aircrew eye protection system, when properly donned and worn with other personal flight ensembles, shall integrate and be compatible with the __________ aircraft cockpit structure, environmental control system and electrical system. There shall be no interference with the function of the following aircrew life support equipment:

a. ____________ Headgear

b. ____________ Oxygen mask

c. ____________ Chemical and biological protective equipment

d. ____________ High altitude personal equipment

e. ____________ Vision enhancement device

f. ____________ Escape system

g. ____________ (Specify other)

3.2.2.6 **Eye protection environmental conditions.** The eye protection system shall be capable of withstanding and/or operating under the following environmental conditions induced by the aircraft, ground transport or storage: ______________.

3.2.3 **Anti-G protection**

3.2.3.1 **Anti-G personal equipment compatibility.** The anti-G garment, when properly donned and connected to the pressure source, shall integrate and be compatible with the __________ aircraft cockpit structure and environmental control system. The aircrew shall be provided an immediate warning in the event of the loss of gas pressure to the anti-g garment. There shall be no interference with the function of the following life support equipment:

a.________ Parachute harness
b.________ Flight coverall
c.________ High altitude personal equipment
d.________ Escape system
e.____________________ ____
(Specify other)

3.2.3.2 **Anti-G environmental conditions.** The anti-G protection system shall be capable of withstanding and/or operating under the following environmental conditions induced by the aircraft or storage _________.

3.2.3.3 **Anti-G pressure regulation.** The pressure regulating source shall sense change in acceleration force to provide gas pressure to the anti-G garment as specified by the following schedule _________.

3.2.3.4 **Anti-G utilization.** The following anti-G protection system use requirements shall be met:

a. Donning - The anti-G garment shall be capable of being donned and adjusted by the wearer without assistance or difficulty.

b. Comfort - The anti-G garment shall fit the ________ to ____________ percentile of aircrew members in height and weight. The aircrew member shall experience no discomfort when the garment is uninflated and shall not experience undue high pressure areas or other intolerable discomfort when the garment is inflated.

c. Subjective use - The system shall have no objectionable performance characteristics such as skin irritation, restriction of movement, or any other property that may cause excessive discomfort, affect wearability, or cause inadvertent disconnect from pressure source.

3.2.3.5 **Anti-G endurance.** The anti-G protection system shall be subjected to the following cyclic operational conditions, ________, and shall subsequently meet the requirements of 3.2.3.2 and 3.2.3.3.

3.2.3.6 **Anti-G equipment during escape.** The anti-G equipment shall not loosen, tear, or otherwise fail structurally resulting in possible injury or interference with emergency ground egress, survivable crash, the bailout or emergency ejection sequence, seat-man separation, parachute deployment and descent, ground landing, water entry or raft boarding. Disconnects shall operate properly during ejection and shall release with an applied force of not less than ________ pounds nor more than _________ pounds. Also the disconnect shall not allow water entry following water landing.

3.2.4 High altitude protection

3.2.4.1 Personal equipment compatibility. The pressure suit ensemble (PSE), when properly donned and worn with other personal flight items, shall be compatible and integrate with ___________ aircraft cockpit structure, environmental control system, and electrical system. There shall be no interference with the function of the following equipment:

a.________ Eye protection device
b.________ Chemical and biological protective equipment
c.________ Life preserver
d.________ Survival kit
e.________ Parachute harness
f.________ Survival vest
g.________ Anti-G suit
h.________ Anti-exposure suit
i.________ Thermal control suit
j.________ Vision enhancement device
k.________ ______________
(Specify other)

3.2.4.2 Environmental conditions. The PSE shall be capable of withstanding and/or operating under the following environmental conditions induced by the aircraft, ground transport or storage ________.

3.2.4.3 Speech intelligibility. Speech intelligibility shall be at least ____________ % in a _________ db noise environment. The PSE shall permit intelligible speech both inside and outside the aircraft. Speech intelligibility within the aircraft shall include interfacing with the aircraft intercommunication system. Ground communications capability shall be considered with and without the breathing compartment covered (prebreathing of 100% oxygen may require the visor to be closed).

3.2.4.4 Escape. The PSE shall remain pressurized when required and shall not loosen, tear, or otherwise fail structurally resulting in possible injury or interference with emergency ground egress, the bailout or emergency ejection sequence, parachute descent, survivable crash, ground landing, or water entry. Adequate cockpit and airframe clearance during ejection from the aircraft shall be provided with the PSE inflated and uninflated. All ensemble disconnects shall operate properly during an ejection and shall release with an applied force not less than _________ pounds nor more than ________ pounds. The PSE shall not prevent the timely operation of parachute riser releases after landing. The connectors shall be designed to prevent system contamination during connection or exposure in a CB environment and water entry in a post ejection water landing.

3.2.4.5 <u>Utilization</u>. The following PSE use requirements shall be met:

a. Donning - The PSE shall be capable of being donned in ________ minutes.

b. Doffing - The PSE shall be capable of being doffed in ________ seconds.

c. Transition - The PSE shall be capable of being converted from ground to aircraft operational mode in ________ seconds.

d. Valsalva - The PSE shall permit the wearer to perform a valsalva maneuver without degrading mission performance.

e. Comfort - The aircrew member wearing the PSE shall not experience hot spots, high pressure areas, or other intolerable discomfort.

f. Drinking and eating - The PSE shall enable the wearer to drink and eat without compromising high altitude protection.

g. Subjective use - The PSE shall have no objectionable characteristics such as objectionable odor, skin irritation, restriction of movement, tackiness to the touch, or any other property that may cause discomfort or affect wearability and the performance of the mission.

h. Urine collection - The PSE shall enable the wearer to collect urine during wear for extended periods of time or shall provide for use of the aircraft relief facility (relief tube, restroom, "piddle-pak" etc.).

i. Cockpit compatibility - The PSE shall permit the wearer to use the aircraft cockpit controls as required without undue restriction in performance of the assigned mission. PSE inflation and aircraft differences shall be considered.

3.2.4.6 <u>Impact protection and penetration resistance of helmet hardshell</u>. The impact protection and penetration resistance performance of the PSE helmet hardshell shall be as specified in 3.2.5.8 and 3.2.5.9.

3.2.4.7 <u>Oxygen system (including oxygen regulators, pressure controllers, pressure relief valves and respiratory valves)</u>. The PSE oxygen system performance shall be as specified in the "Aircraft pressure suit provisions" paragraph of MIL-O-87226.

3.2.4.8 <u>Sustained acceleration</u>. The PSE shall not malfunction or hinder aircrew member's ability to perform necessary tasks when acceleration forces of ________ G's for ________ seconds are encountered.

3.2.4.9 <u>Optical system</u>. The PSE visor shall be of sufficient size such as not to decrease the wearer's binocular visual field in the upward or lateral directions. The restriction of downward vision shall be no greater than ________ degrees. The viewing area shall meet or surpass the optical requirements of ________. The visor shall be capable of meeting the ballistic resistance requirements of ____________ and ____________ abrasion resistance requirements of ____________. When properly donned and operating, the PSE shall exhibit no visible visor fogging at a temperature of __________ degrees and relative humidity of __________ %.

3.2.4.10 **Sound attenuation.** The PSE shall provide ________ sound attenuation when tested as specified in 4.2.4.10.

3.2.4.11 **Thermal control.** A thermal control system shall be provided to prevent overheating or overcooling of the aircrew members when exposed to environmental temperature extremes of ________ and humidity of ______ percent during transition between the aircrew alert facility and aircraft and during flight operations.

3.2.4.12 **Rapid decompression.** The PSE shall provide protection against the detrimental effects of rapid decompression from ________ to ________ feet in ________ seconds when tested as specified in 4.2.4.12. The PSE shall provide altitude protection for the crewman at _______ feet mean sea level (MSL) and during descent to ________ feet MSL for a duration of ________ minutes following loss of cabin pressure or ejection.

3.2.4.13 **Breathing compartment.** The breathing compartment performance shall be __________ when tested as specified in 4.2.4.13. Provisions shall be made to prevent suffocation following water entry.

3.2.5 **Head protection**

3.2.5.1 **Protective headgear compatibility.** The protective headgear, when properly donned and worn with other personal flight items, shall integrate and be compatible with __________aircraft cockpit structure, and its environmental control and electrical system. There shall be no interference with the function of the following aircrew life support equipment:

a.__________ Oxygen mask
b.__________ Life preserver
c.__________ Eye protection device
d.__________ Parachute harness
e.__________ Survival vest
f.__________ Oxygen regulator
g.__________ Flight garment
h.__________ Vision enhancement device
i.__________ Helmet mounted device
j.__________ CB protective equipment
k.__________ (Specify other)

3.2.5.2 **Environmental conditions for headgear.** The headgear shall be capable of withstanding the following environmental conditions induced by the aircraft, ground transport or storage _________.

3.2.5.3 **Headgear during escape.** The headgear shall not loosen, tear or otherwise fail structurally resulting in possible injury or interference with the emergency ground egress and bailout or ejection sequence, parachute descent, survivable crash, ground landing, or water entry. All disconnects shall operate properly during an ejection and shall release with an applied force of not less than ________ pounds nor more than ________ pounds.

3.2.5.4 **Headgear utility.** The following headgear use requirements shall be met:

a. Valsalva - The headgear shall permit the wearer to perform a valsalva maneuver.

b. Comfort - The aircrew member wearing the headgear shall not experience hot spots, pressure points, or other intolerable discomfort. The headgear shall fit the ________ to ________ percentile of aircrew in head size.

c. Subjective use - The headgear shall have no objectionable characteristics such as objectionable odors, skin irritation, restriction of movement, tackiness, or any other property that may cause discomfort or affect wearability.

3.2.5.5 **Electromagnetic emission and susceptibility of headgear.** The headgear shall meet the electromagnetic emission and susceptibility requirements of __________.

3.2.5.6 **Sustained acceleration on headgear.** The aircrew headgear shall neither malfunction nor hinder aircrew member's ability to perform necessary tasks when acceleration forces of __________ G's for __________ seconds are encountered.

3.2.5.7 **Visibility with headgear.** The headgear visor lens shall be large enough to not decrease the wearer's visual field in the upward or lateral directions. The restriction of downward vision shall be no greater than ____________ degrees. The viewing area shall meet or surpass the optical requirements of______________. The lens shall be capable of meeting the ballistic resistance requirements of_________and abrasion resistance requirements of ____________. When properly donned and operating, the lens shall exhibit no visible fogging at a temperature of _________ degrees and relative humidity of ________ %.

3.2.5.8 **Impact protection.** The dynamic response of the headgear to impact energy shall be ________.

3.2.5.9 **Headgear penetration resistance.** The headgear penetration resistance shall be ________.

3.2.5.10 **Speech intelligibility with headgear.** Speech intelligibility shall be at least__________ % in a ________ db noise environment. The headgear shall permit intelligible speech to be heard within the aircraft. Speech intelligibility shall include interfacing with the aircraft intercommunication system.

3.2.5.11 **Headgear sound attenuation.** The headgear shall provide __________ sound attenuation when tested as specified in 4.2.5.11.

3.3 **Reliability.** The reliability requirements of the personal protection system equipment shall be as follows: ____________.

3.4 **Maintainability.** The maintainability requirements of the personal protection system equipment shall be as follows: ____________.

3.5 Open flame thermal protection. The aircrew personal protective equipment shall provide open flame protection to the wearer when he or she leaves a burning aircraft and runs through a __________ foot circle of fire as simulation tested in accordance with 4.5.

3.6 CB resistance of materials and design. Selection of materials and design of personal protective equipment shall be such that contact with CB agents in liquid or vapor form will not cause deterioration of equipment nor increased risk to the aircrew member. The equipment shall be capable of being decontaminated by __________.

4. VERIFICATIONS

4.1 General. The verifications specified herein shall verify the ability of Aircrew Personal Protective Equipment to meet the requirements of section 3 herein and shall include __________. All verifications shall be the responsibility of the contractor; the Government reserves the right to witness, or conduct, any verification. Reference made herein to "trained test subjects" relates to training with equipment being tested in addition to experience with the test method(s)/device(s) used in the test (i.e. tests where a piece of equipment is to be used during a parachute jump requires that the test subject be a trained parachutist; communications tests require subjects trained in communications and use of piece of equipment, etc).

4.2 Verification requirements. Verification requirements are subdivided into the following groups: Chemical and biological head/respiratory protection, eye protection, anti-G protection, high altitude protection, and head protection.

4.2.1 Verification of chemical/biological head/respiratory protection

4.2.1.1 CB personal equipment compatibility tests. The aircrew CB head/respiratory protection system shall be donned along with all required life support equipment by __________ aircrew test subjects. The test subjects shall enter a __________ aircraft designed or properly modified to accept the CB protection system. The CB system shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems which are considered to be detrimental to the mission shall be cause for rejection.

4.2.1.2 Verification of CB environmental conditions. The system shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in 3.2.1.2.

4.2.1.3 CB eye/respiratory protection level tests. Quantitative leakage tests shall be performed with a __________ person test panel to verify that leakage and population requirements of 3.2.1.3 can be met. The test subjects shall wear the complete aircrew CB head/respiratory protection system and other applicable life support equipment. The leakage tests shall be performed in a test chamber of adequate size to permit the simulation of all aircrew movements during transition from a collective shelter to the aircraft, during flight operations, and during transition back to the shelter. Continuous measurements of the leakage into the system shall be recorded with instruments of sufficient accuracy to measure protection levels greater than __________.

4.2.1.4 Verification of CB communication intelligibility. Voice intelligibility tests shall be conducted to verify that voice intelligibility meets the limit specified in 3.2.1.4 in a noise environment of ________ measured by ________.

4.2.1.5 Verification of CB ventilation/filtration system. The following ventilation/filtration system tests shall be performed:

a. Service life: __________
b. Subjective use: ________
c. Durability: __________
d. Output: ____________
e. __________: __________
(Specify other)

4.2.1.6 CB permeation tests. The components of the system (e.g., helmet shell, lens, seals, hoses, shrouds, and other fabrics) shall be resistant to test agent penetration when subjected to the following tests: ____________.

4.2.1.7 Verification of CB equipment during escape. The following tests shall be performed to verify the requirements of 3.2.1.7.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration)
c. Release force
d. Wind tunnel
e. High speed sled
f. Seat ejection (IAW MIL-STD-846, paragraph 3.3 as applicable)
g. Hanging harness
h. Parachute
i. Water survival
j. Ground escape
k. ____________
(Specify other)

4.2.1.8 CB utilization tests. The following tests shall be performed to verify the requirements of 3.2.1.8.

a. Donning tests - Elapsed time shall be measured from the beginning to the end of the donning sequence for each of ________ trained test subjects. An average donning time of more than ________ minutes shall be cause for rejection.

b. Doffing tests - Elapsed time shall be measured from the beginning to the end of the doffing sequence for each of ________ trained test subjects. An average doffing time of more than ________ seconds shall be cause for rejection.

c. Transition tests - Elapsed time shall be measured to make the transition from ground use chemical defense life support equipment to aircraft life support equipment for each of ________ trained test subjects. The test subject shall be seated in the ejection seat (or other seat if system is for a non ejection seat aircraft) and a crew chief or assistant may aid in the transition if this is a normal operational procedure.

d. Valsalva tests - The completely outfitted test subject shall perform a valsalva maneuver by occluding the nose as required to equalize pressure in the ears during altitude ascent and descent. Inability of tne test subject to perform the valsalva maneuver with one hand shall be cause for rejection.

e. Subjective use/comfort tests - The system shall be tested by ________ crewmembers during flight testing. Objectionable odors, tackiness to the touch, hot spots, high pressure areas, restriction of movement, or other detrimental performance characteristics of the system shall be determined by subjective evaluation. Flight crew comments shall determine whether this requirement is met. Flight crew shall be anthropometrically selected from the fifth to ninety-fifth percentile of the USAF flying population. If females do not qualify for the aircraft mission, they shall be excluded from the flying population data.

f. Drinking tests - Flight crew shall don the system and drink from a container designed to integrate with the drink tube. Flight crew comments shall determine whether this requirement is met.

4.2.1.9 CB electromagnetic interference tests. The system or its components, as applicable, shall be analyzed and tested as described in ________________, and meet the requirements of 3.2.1.9.

4.2.1.10 CB sustained acceleration tests. The man-mounted portion of the system shall be placed on a human test subject and subjected to the requirements of 3.2.1.10 using a centrifuge. The system shall be operated during the test. It shall be stable on the head and shall not show any evidence of malfunction or failure.

4.2.1.11 Verification of optical system. The following tests shall be performed to verify the requirements of 3.2.1.11.

a. Optical quality tests. Test per ________.

b. Ballistic protection tests. Test per _________.

c. Abrasion resistance tests. Test per ________.

d. Low temperature tests. A human test subject with visual acuity of __________ or better shall don the system and sit in a chamber at the temperature and humidity specified in 3.2.1.11. Acuity measurements shall be taken at __________ intervals. A reduction in the visual acuity or any lens fogging shall constitute a failure. The ventilation system shall be turned off to permit complete fogging of the lens. The emergency defogging system shall be activated and time to defog the critical lens viewing area shall not exceed the requirement of 3.2.1.11.

4.2.2 Eye protection verifications

4.2.2.1 General protection verification. The eye protective equipment shall be evaluated by examination, test, and demonstration to determine compliance with 3.2.2.1 and to verify acceptable integration characteristics with other aircrew headgear items.

4.2.2.2 **Nuclear flash protection verification.** Nuclear flash protective equipment shall be evaluated by examination, test, and demonstration to determine compliance with 3.2.2.2 and to verify acceptable integration characteristics.

4.2.2.3 **Laser radiation protection verification.** Eye protective equipment shall be evaluated by examination, test, and demonstration to determine compliance with 3.2.2.3 and to verify acceptable integration characteristics.

4.2.2.4 **Thermal radiation protection verification.** Compliance of aircraft crew station thermal protection provisions with the requirements of 3.2.2.4 shall be verified by examination and demonstration of fit and function in the intended air vehicle environment.

4.2.2.5 **Verification of eye protection equipment compatibility.** The aircrew eye protection system shall be donned along with all required life support equipment by ________ aircrew test subjects. The test subjects shall enter a ____________ aircraft designed or properly modified to accept the eye rotection system. The eye protection system shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems which are considered to be detrimental to the mission shall be cause for rejection.

4.2.2.6 **Verification or eye protection environmental conditions.** The system shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in 3.2.2.6.

4.2.3 **Anti-G protection verifications**

4.2.3.1 **Anti-G compatibility tests.** The anti-G garment shall be donned and fitted properly along with all required life support equipment by __________ aircrew test subjects. The test subjects shall enter a _________ aircraft properly modified to accept the anti-G protection system. The anti-G garment shall function properly throughout the selected mission for the aircraft. Any undue pressures, restrictions, interferences or other problems which are considered to be detrimental to the mission shall be cause for rejection.

4.2.4 **Verifications of high altitude protection**

4.2.4.1 **Personal equipment compatibility tests.** The PSE shall be donned along with all required life support equipment by _________ aircrew test subjects. The test subjects shall enter a ________ aircraft properly modified to accept the PSE. The ensemble shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems which are considered to be detrimental to the mission shall be cause for rejection of the ensemble.

4.2.4.2 **Verification of environmental conditions.** The ensemble shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in paragraph 3.2.4.2.

4.2.4.3 **Speech intelligibility tests.** Speech intelligibility tests shall be conducted to verify that the PSE meets the limit specified in 3.2.4.3 in a noise environment of ________ measured by _________.

4.2.4.4 **Verification of escape.** The following tests shall be performed to verify the requirements of 3.2.4.4.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration)
c. Release force
d. Wind tunnel
e. High speed sled
f. Seat ejection (including clearance and posture) (IAW MIL-STD-846, paragraph 3.3, as applicable)
g. Hanging harness
h. Parachute
i. Water survival (including flotation and life raft boarding)
j. ______________
(Specify other)

4.2.4.5 **Utilization tests.** The following tests shall be performed to verify the requirements of 3.2.4.5.

a. Donning tests - Elapsed time shall be measured from the beginning to the end of the donning sequence for each of ________ trained test subjects. An average donning time of more than _________ minutes shall be cause for rejection.

b. Doffing tests - Elapsed time shall be measured from the beginning to the end of the doffing sequence for each of _______ trained test subjects. An average doffing time of more than _________ seconds shall be cause for rejection.

c. Transition tests - Elapsed time shall be measured to make the transition from ground use prebreathing and body cooling life support equipment to aircraft life support equipment for each of ________ trained test subjects.

The test subject shall be seated in the ejection seat (or other seat if PSE is for a non ejection seat aircraft) and a crew chief or assistant may aid in the transition if this is a normal operational procedure.

d. Valsalva tests - The completely outfitted test subject shall perform a valsalva maneuver by occluding the nose as required to equalize pressure in the ears during altitude ascent and descent. Inability of the test subject to perform the valsalva maneuver with one hand shall be cause for rejection.

e. Subjective use/comfort tests - The PSE shall be tested by __________ crew members during flight testing. Objectionable odors, tackiness to the touch, hot spots, high pressure areas, restriction of movement, or other detrimental performance characteristics of the PSE shall be determined by subjective evaluation. Flight crew comments shall determine whether this requirement is met. Flight crew shall be anthropometrically selected from the first to ninety-ninth percentile of the USAF flying population. If females do not qualify for the aircraft mission, they shall be excluded from the flying population data.

f. Drinking and eating tests - Flight crew shall don the PSE and drink and eat from a container designed to match the drink and eat tube. Flight crew comments shall determine whether this requirement is met.

g. Urine collection - ________ male and ________ female aircrew members shall wear the urine collection device inside the PSE and use it with the PSE inflated and uninflated to a pressure of ________.

h. Cockpit compatibility - The PSE shall be fitted onto selected aircrew (who are familiar with the aircraft cockpit) and used (while inflated and uninflated) during simulated cockpit checkout and operational procedures. Any restrictions in the standard procedures caused by the PSE shall be cause for rejection. The aircrew shall also be asked to perform the same evaluation in the standard flight ensemble as a baseline comparison.

4.2.4.6 Impact protection and penetration resistance tests. The PSE helmet hardshell shall be tested for impact protection and penetration resistance as specified in 4.2.5.8 and 4.2.5.9.

4.2.4.7 Oxygen system tests. The PSE oxygen system shall be tested as specified in the "Verification of Aircraft pressure suit provisions" paragraph of the "General Specifications for Aircraft Oxygen Systems (MIL-O-87226)".

4.2.4.8 Sustained acceleration tests. The PSE shall be placed on a human test subject and subjected to the requirements of 3.2.4.8 using a centrifuge. The PSE shall be operated during the test. It shall be stable on the body and shall not show any evidence of malfunction or failure.

4.2.4.9 Optical system tests. The following tests shall be performed to verify the requirements of 3.2.4.9.

a. Optical quality tests. Test per ________.
b. Ballistic protection tests. Test per ________.
c. Abrasion resistance tests. Test per ________.
d. Low temperature tests. Test per ________.

4.2.4.10 Verification of sound attenuation. The attenuation of the PSE shall be measured in accordance with ________. The attenuation requirements shall be ________ and shall be demonstrated at ________ frequencies.

4.2.4.11 Verification of thermal control. Thermal control testing of the PSE shall be performed under simulated conditions of ________ in a laboratory.

4.2.4.12 Rapid decompression tests. Rapid decompression tests shall be conducted on the PSE by exposing it to a pressure change of ________ psi in ________ seconds to verify that it meets the requirements specified in 3.2.4.12.

4.2.4.13 Breathing compartment tests. The breathing compartment shall be tested in accordance with ________ in order to comply with the requirements of 3.2.4.13.

4.2.5 **Head protection**

4.2.5.1 **Verification of protective headgear compatibility.** The protective headgear shall be donned along with all required life support equipment by __________ aircrew test subjects. The test subjects shall enter the __________ aircraft. The headgear shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems attributed to the headgear which are considered to be detrimental to the mission shall be cause for rejection of the headgear.

4.2.5.2 **Verification of environmental conditions for headgear.** The headgear shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in paragraph 3.2.5.2.

4.2.5.3 **Verification of headgear during escape.** The following tests shall be performed to verify the requirements of 3.2.5.3.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration)
c. Wind tunnel
d. High speed sled
e. Seat ejection (IAW MIL-STD-846, paragraph 3.3, as applicable)
f. Hanging harness
g. Parachute
h. __________
(Specify other)

4.2.5.4 **Verification of headgear utility.** The following tests shall be performed to verify the requirements of 3.2.5.4.

a. Valsalva tests - The completely outfitted test subject shall perform a valsalva maneuver by occluding the nose as required to equalize pressure in the ears during altitude ascent and descent. Inability of the test subject to perform the valsalva maneuver with one hand shall be cause for rejection.

b. Subjective use/comfort test - The headgear shall be tested by __________ aircrew members during flight testing. Objectionable odors, tackiness to the touch, hot spots, high pressure areas, restriction of movement, or other detrimental performance characteristics of the headgear shall be determined by subjective evaluation. Flight crew comments shall determine whether this requirement is met. Flight crew shall be anthropometrically selected from the fifth to ninety-fifth percentile of the USAF flying population. If females do not qualify for the aircraft mission, they shall be excluded from the flying population data.

4.2.5.5 **Verification of headgear to electromagnetic emission & susceptibility.** The headgear or its components, as applicable, shall be analyzed and tested as described in __________, and meet the requirements of 3.2.5.5.

4.2.5.6 **Verification of sustained acceleration on headgear.** The headgear shall be placed on a human test subject and subjected to the requirements of 3.2.5.6 using a centrifuge. It shall be stable on the head and shall not show any evidence of malfunction or failure

4.2.5.7 <u>Verification of visibility with headgear.</u> The following tests shall be performed to verify the requirements of 3.2.5.7.

a. Optical quality tests. Tests per __________.

b. Ballistic protection tests. Test per _________.

c. Abrasion resistance tests. Test per _________.

d. Low temperature tests. A human test subject with visual acuity of _________ or better shall don the headgear and sit in a chamber at the temperature and humidity specified in 3.2.5.7. Acuity measurements shall be taken at __________ intervals. A reduction in the visual acuity or any lens fogging shall constitute a failure.

4.2.5.8 <u>Impact testing.</u> The headgear shall be tested as described in _______ and meet the requirements of 3.2.5.8.

4.2.5.9 <u>Verification of headgear penetration resistance.</u> The following tests shall be performed to verify the requirements of 3.2.5.9 __________.

4.2.5.10 <u>Verification of speech intelligibility with headgear.</u> Speech intelligibility tests shall be conducted to determine that the limit specified in 3.2.5.10 is met in a noise environment of _________ measured by _________.

4.2.5.11 <u>Headgear sound attenuation tests.</u> The attenuation of the headgear shall be measured as described in ________________. The attenuation requirements shall be ________________ and shall be demonstrated at ______________ frequencies.

4.3 <u>Reliability tests.</u> The reliability requirements of 3.3 shall be verified by the following reliability tests: _____________.

4.4 <u>Maintainability evaluation.</u> The maintainability requirements of 3.4 shall be verified by the following maintainability tests and analyses ____________.

4.5 <u>Open flame thermal protection tests.</u> The PSE shall be exposed to _________ fuel flame for a period of _________ seconds to verify that it meets the limits specified in 3.5.

5. PACKAGING

5.1 All deliverable items shall be prepared for shipment as directed by the procuring activity.

6. NOTES

6.1 <u>Intended use.</u> The personal protective equipment covered by this document is intended for use by aircrew personnel.

6.2 Responsible engineering office. The responsible engineering office (REO) for this appendix is ASD/ENECE, Wright-Patterson AFB OH 45433-6503. The individual who has been assigned the responsibility for this handbook is Kent W. Gillespie, ASD/ENECE, Wright Patterson AFB OH 45433-6503, AUTOVON 785-2165, Commercial (513) 255-2165.

Custodian
Air Force - 11

Preparing activity:
Air Force - 11

Project No. 8475-F203

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APPENDIX

PERSONAL PROTECTIVE EQUIPMENT, AIRCREW

HANDBOOK FOR

10. SCOPE

10.1 Scope. This appendix provides rationale, guidance, lessons learned, and instructions necessary to tailor sections 3 and 4 of the basic specification (MIL-P-87234) for a specific application.

10.2 Purpose. This appendix provides information to assist the government procuring activity in the use of MIL-P-87234.

10.3 Use. This appendix is designed to assist the project engineer in tailoring MIL-P-87234. The blanks of the basic specification shall be filled in to meet operational needs of the equipment being developed.

10.4 Format

10.4.1 Requirement/verification identity. Section 30 of this appendix parallels section 3 and 4 of the basic specification; paragraph titles and numbering are in the same sequence. Section 30 provides each requirement (section 3) and associated verification (section 4) as stated in the basic specification. Both the requirement and verification have sections for rationale, guidance, and lessons learned.

10.4.2 Requirement/verification package. Section 30 of this appendix has been so arranged that the requirement and associated verification is a complete package to permit addition to, or deletion from the criteria as a single requirement. A requirement is not specified without an associated verification.

10.5 Responsible engineering office. The responsible engineering office (REO) for this appendix is ASD/ENECE, Wright-Patterson AFB OH 45433-6503. The individual who has been assigned the responsibility for this handbook is Kent W. Gillespie, ASD/ENECE, Wright-Patterson AFB OH 45433-6503, AUTOVON 785-2165, Commercial (513) 255-2165.

20. APPLICABLE DOCUMENTS

20.1 References. The documents referenced in this appendix are not intended to be applied contractually. Their primary purpose is to provide background information for the Government engineers responsible for developing the most appropriate performance values (filling in the blanks) for the requirements contained in the specification proper.

20.2 Avoidance of tiering. Should it be determined that the references contained in this appendix are necessary in writing an RFP or building a contract, excessive tiering shall be avoided by calling out only those portions of the reference which have direct applicability. It is a goal of the Department of Defense that the practice of referencing documents in their entirety be eliminated in order to reduce the tiering effect.

20.3 Government documents

SPECIFICATIONS

Military

MIL-V-9370	Valve, Automatic, Pressure Regulating, Anti-G Suit
MIL-E-25670	Earphone Elements, General Specification for
MIL-S-25948	Sunglasses, HGU-4/P (with case)
MIL-M-27274	Mask, Oxygen, MBU-5/P
MIL-L-38169	Lenses, Goggle and Visor, Helmet, Optical Characteristics, General Specification for
MIL-V-43511	Visor's, Flyer's Helmet, Polycarbonate
MIL-A-83406	Anti-G Garment, Cutaway, CSU-13B/P
MIL-C-83409	Coatings, Visor, Polycarbonate, Flying Helmet
MIL-E-83425	Earcup, Sound Protective MX-8376/AR
MIL-M-87163	Mask, Oxygen MBU-12/P

STANDARDS

Federal

FED-STD-406	Plastic: Methods of Testing

Military

MIL-STD-210	Climatic Extremes for Military Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of

MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-471	Maintainability Verification/Demonstration/ Evaluation
MIL-STD-781	Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

Test Reports

AMRL-TR-79-28	Revised Height/Weight Sizing Programs for Men's Protective Flight Garments
AMRL-TR-79-35	Height/Weight Sizing Programs for Women's Protective Garments
SAM-TR-78-30	Evaluation of Laser-Protection Eyewear

Other

AFOSH-STD-161-10	Health Hazards Control for Laser Radiation
LANL Report LA-5488	Selection of Respirator Test Panels Representative of U.S. Adult Face Sizes

20.4 Non-Government documents

Acoustical Society of America

ASA-1-1975	Measurement of Real Ear Protection of Hearing Protectors and Physical Attenuation of Ear Muffs, Method for

(Application for copies should be addressed to the Acoustical Society of America, 335 East 45th Street, New York, NY 10017.)

American National Standards Institute

ANSI Z-90.1	Protective Headgear for Vehicular Users, Specification for
ANSI Z-136.1	Safe Use of Lasers

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

30. REQUIREMENTS AND VERIFICATION

3.1 System description. The pesonal protection systems for aircraft shall consist of:

a. Chemical and biological head/respiratory protection
b. Eye protection
c. Anti-G protection
d. High altitude protection
e. Head protection

The purpose of the personal protection systems is: ________.

REQUIREMENT RATIONALE (3.1)

Each item of equipment is dissimilar in design and function but is added as necessary to the aircrew ensemble to meet the mission needs of the aircrew. Most performance requirements are therefore not common for all of the individual items of equipment except where interface between items of equipment is necessary to assure compatibility. Most items of personal protective equipment are worn by the aircrew, however, some components may be aircraft mounted or ground transported by aircrew. Groups of equipment which best identify a type of personal protection to meet a typical mission need are:

a. CB head/respiratory protection
b. Eye protection
c. Anti-G protection
d. High altitude protection
e. Head protection

REQUIREMENT GUIDANCE

The type of personal protection system required must be indicated. The description of the purpose of the personal protection system must be provided. The description should be based on the following information:

a. Chemical and biological head/respiratory protection. The purpose of chemical and biological head/respiratory protective equipment is to protect the head and respiratory tract from chemical and biological agents. The most sensitive areas to agents are the eyes, respiratory tract and ears. This equipment may add to, replace, or modify the standard flight helmet and/or oxygen mask (note - oxygen requirements are addressed in MIL-O-87226, General Requirements for Aircraft Oxygen Systems). First generation chemical defense ensembles for aircrew utilize a fullface gas mask and provide no ventilation.

Protection level which is defined as the ratio of the airborne concentration of agent in ambient air surrounding the head to the concentration of agent within the eye/respiratory region is a critical design requirement. The protection level is derived from the cumulative threat. The required protection level must be provided during aircrew transit between the collective shelter and aircraft as well as throughout the mission.

Filtered ventilation airflow to the head, particularly the face, is generally considered essential for achieving a high protection level, for cooling, and to prevent misting of the viewing lens. In addition to the filtered ventilation flow to the head, the breathing gas must also be filtered or the breathing gas supply designed to assure that it is agent free.

A means of filtering the ventilation airflow to the head and filtering the respiratory airflow must be provided during aircrew transit between a collective shelter and the aircraft. Some components such as the ventilator used for ground transit could also be used to provide filtered ventilation airflow to the head during flight by mounting in the cockpit.

Compatibility with other items of life support equipment is essential in the design of chemically protective equipment. Trade offs may be necessary to provide compatibility. Degradation in aircrew performance is a critical issue since the addition of a chemically protective barrier and filtration can be expected to add unwanted weight and degrade aircrew mobility. Commonality with existing systems should also be considered to facilitate training.

b. Eye protection. Eye protection in the operational environment is of significant importance since loss or degradation of visual capability can seriously affect crew performance and accomplishment of the mission. Types of eye protection can be categorized as general, nuclear flash, laser radiation, and thermal radiation.

(1) General protection. The higher intensity of solar ultraviolet radiation which is prevalent at aircraft flight altitudes requires the use of sunglare protective devices. These devices have tinted lenses and are normally a component of the helmet assembly where head protection is required. Impact protection for the eyes as well as the surrounding facial areas is necessary to mitigate injury potential during situations such as survivable crashes, battle damage, cockpit fires and bird strike. Windblast protection for the eyes is necessary during emergency egress from high speed aircraft.

(2) Nuclear flash protection. Protection of the eyes against flash blindness and retinal burns is necessary in a nuclear warfare environment. Past studies and analyses have revealed that crew member eye hazards such as flash blindness and retinal burns prevail at greater distances from a nuclear detonation than any other weapon effect. Good vision is of paramount importance in the performance of crew duties and even a temporary loss of visual acuity can be disastrous during critical mission phases. Flash blindness and retinal hazards are greatest under conditions of low light level since the dark adapted eye is much more sensitive to sudden increases in brightness.

The type of flash blindness device most appropriate is dependent upon such factors as mission requirements, type of air vehicle, and crew member position in the air vehicle. Use of a thermal flash protective window in the air vehicle may be the preferred approach over use of a helmet mounted flash blindness protective device.

Key features of a flash blindness device are closure and opening times. Rapid closure is necessary to prevent eye injury and rapid opening is necessary to allow aircrew to perform the mission successfully. The closure and opening times are essentially based on the state-of-the-art in the development of flash blindness devices.

An eye protective device, depending upon the basic type, will have its own set of performance parameters. For example, all protective devices will have a specified transmittance value. For a fixed filter device this value will not change and for a dynamic filter device this value will change over several orders of magnitude from the open to the closed state. Other performance aspects for all types of devices are good optical quality and freedom from distortion in all transmitting states and visual field considerations. Dynamic protective devices have additional performance parameters related to triggering, density versus time in the closure mode, and ambient light level controlled reopening.

Past development efforts by the AF, Army and Navy have established performance criteria for protecting the eyes of personnel against flash blindness and retinal burn hazards associated with military operations in nuclear warfare scenarios. Typically the established criteria have been based on state-of-the-art capabilities of various eye protective device concepts rather than ultimate values to optimize visual capabilities and protective response. An effective device for protection against flash blindness and retinal burns will entail acceptance of compromise in certain technical design areas to achieve operational acceptability and compatibility with the air vehicle environment.

(3) Laser radiation protection. Recent developments in laser technology have resulted in an increase in the utilization of these devices for military applications. The increased use of these systems in military applications increases the probability of exposure of aircrew personnel to injurious effects of laser radiation. Unique eye hazards attributed to laser radiation are the high intensity, monochromaticity, directivity, and coherence of beams from laser sources resulting in eye injury potential at considerable distances. The basic protection concept relies on imposing a reflective or absorptive filter media between the eyes and the source to reduce exposure to the maximum permissible exposure (MPE) level or lower.

Laser eye protective filters can be made available in a number of different configurations dependent upon specific aspects of their intended use. To be suitable for use by aircrew personnel they must not unduly restrict peripheral vision, must be compatible with aircrew head gear and must be of acceptable optical quality. In view of these considerations aircrew spectacle or helmet visor lens configurations are preferable.

(4) Thermal radiation protection. Nuclear weapon effects, survivability, vulnerability studies conducted on many weapon systems have pointed to the need for thermal protective barriers for aircrew members operating in a wartime nuclear combat environment. These studies have shown that the crew thermal threat prevails at ranges beyond where other weapon effects such as over-pressure, nuclear radiation and airframe damage would not result in a mission kill.

An unprotected crew station transparent area exposes the aircrew members to the hazards of skin burns, debilitating eye effects, and smoke and flame from crew compartment contents at ranges from a detonation where the basic airframe could be expected to survive the blast and thermal loading effects. The basic protection concept is to shield out high thermal flux levels by placing primarily reflective materials on the in-board side of aircraft transparent areas. Potential advantages of integrated thermal and flash protective systems are unencumbered aircrew members, unhampered visual access to controls and data displays within the aircrew station and mitigation of integration problems of flash blindness protective equipment with other crew equipment or life support items which must be worn.

Basic performance parameters for aircraft thermal protective equipment are related to the thermal hardness of the materials used as the barrier, durability of the complete assembly including attachment, extension, and retraction mechanisms, time required for erection and stowage, and compatibility with other aircraft systems. Design operational concepts include manually operated, stowed inplace, automatically operated stowed in place, or manually placed with remote stowage. Feasibility and practicality of these varied concepts will depend mainly on factors such as available space and clearance for extension and retraction mechanisms, non-interference with outside vision in the retracted position, compatibility with emergency egress provisions, and aspects affecting maintainability and life cycle cost. An integrated thermal shield and flash blindness protection system, i.e., a thermal barrier with openings in various specified locations which permit protected outside vision should be considered.

c. Anti-G protection. The anti-G protection equipment installed in an aircraft must reliably aid the aircrew member in combating the effects of G forces. The level of protection provided should be at least equal to or greater than the design load limits of the aircraft. Newer fighter aircraft with their greatly improved thrust-to-weight ratios are capable of pulling up to +9 Gz (z = vertical axis) at rates-of-onset that exceed 6 Gz per second. These aircraft can sustain these high +Gz levels for periods exceeding the aircrew members capability to cope with them. The aircrew members ability to withstand high sustained +Gz (HSGz) can now be one of the limiting factors in the mission performance capabilities of new fighter weapon systems.

Exposure to high sustained +Gz (HSGz) leads to a wide variety of physiological effects on the aircrew member. The decrease in blood flow to the eyes and brain with increasing HSGz levels and onset rates has been shown to lead to not only grayout and blackout, but also to loss-of-consciousness (LOC). Inflight LOC may not be preceded by visual warning symptoms and may last 9.0-20.5 seconds (mean = 15 seconds). When the aircrew members regain consciousness, they are often unaware that LOC has occurred. Inflight LOC under HSGz seriously jeopardizes flying safety. Aircrew member tolerance to HSGz is multifactorial and varies not only from individual-to-individual but from day-to-day in a given individual. HSGz tolerance can be influenced by aircrew member selection procedures (i.e., natural tolerance level, age, motivation, overall health), by behavior change (diet, alcohol, dehydration, exercise, sleep/fatigue, not flying while ill), by training (weight training, centrifuge training, regular HSGz exposure), or by equipment design (seat back angle, G-suit characteristics, or breathing system characteristics).

Currently the Air Force provides each aircrew member of high performance aircraft with a special garment and an aircraft-installed pressurized system to combat the acceleration forces encountered during flight. This special type of clothing is referred to as an anti-G garment, or more commonly called a G-suit. The G-suit assists the aircrew member during acceleration and tends to mitigate fatigue and to reduce the likelihood of loss of consciousness for a fit and well trained crew member. Pressurization of the garment is controlled automatically by a pressure sensitive device. The garment is connected to a quick disconnect fitting installed in the aircraft, and the operation is automatic. There is no inflation during level flight since the control valve is set to operate at +1.5 to 2.0 Gz. After the valve opens, it monitors or delivers suit pressure at an increased rate of approximately 10.3 kPa (1-1/2 psi) for each +Gz encountered.

Numerous variations of the G-suit have been developed. All current suits contain bladders which are inflated with air and compress portions of the lower body to decrease pooling of blood in the legs and increase peripheral arterial resistance (leading to increased arterial pressure). G-suits which compress larger portions of the lower body surface generally increase +Gz tolerance more than suits with less surface area. The basic material of the suit is fire-resistant Nomex cloth. The suit has slide fasteners and nylon cord lacing for ease of entry and proper adjustments. The garment comes in seven sizes and is designed to be worn over flight coveralls. The garment has been designed to provide maximum coolness and adequate protection against acceleration forces. Lacing adjustments are located in the waist and thigh regions and are protected to prevent lace entanglement with aircraft installed equipment.

The G-suit is connected to the source of pressure by means of a quick-disconnect fitting. The male portion of this fitting is carried on the pressure tube of the suit and the female portion of the fitting is attached to the aircraft pressure source. The suit operates automatically when these two connections are joined. To break the connection, 20 to 90 N (5 to 20 lbf) is necessary. In aircraft with ejection seats, the connection is broken by hand when dismounting, and automatically when the ejection seat is used. The female unit of the quick-disconnect has a springloaded dust cap which automatically seals the opening when the suit is not in use.

The current anti-G valve has basically remained unchanged since the early 1950s. The valve automatically regulates the inflation pressure to the G-suit during periods of positive acceleration. The air used in this process is from aircraft engine bleed air which has been cooled and filtered and enters the valve inlet fittings at pressures from 10 to 300 psi. The valve contains a relief system which limits suit pressure to 11 psi. The current valve has an airflow rate of 15 cubic feet/minute, begins inflating the suit at 2 G's and continues pressurizing at the rate of 1.5 psi per G up to a maximum of 10.5 psi. The valve is slow to build up to the maximum pressure (approximately five seconds to reach 10 psi) in terms of today's operational aircraft which can pull up to 9 G's with rates of onset at least at the 6 G/second level.

In the 1970s the USAF School of Aerospace Medicine (USAFSAM) conducted research on a "High Flow Ready Pressure" (HFRP) anti-G valve. The concept finally selected and tested was a valve similar to the current valve with the added feature of a higher flow rate (22 CFM) and the capability to provide a ready pressure in the suit of 0.2 psi which reduced the time to inflate the suit once the aircraft was in a high-G maneuver. The data shows a reduction in the time to inflate (at the 7 psi level) of two seconds. In 1985 AAMRL transitioned to develop, test and evaluate an electronic bang-bang servovalve which is sensitive to both acceleration magnitude and rate of change. In this valve, if the Gz sensed is higher than 1.5 Gz, and the rate of change of GZ is more than 1.5 G/sec. the anti-G suit is driven to 5 psig in about 0.2 second, and subsequently to maxmum suit pressure over the next two seconds. Thereafter, the valve reverts to conventional inertial type regulation unless the trigger criteria are again fulfilled. The prototype bang-bang servovalve has been shown to provide enhanced protection to high onset rate and high sustained-G and has been well accepted by operational aircrew members who have experienced it.

A system approach to the problem of acceleration protection in high performance aircraft needs to be taken. The system should contain elements which automate all of the functions with which the pilot must now deal. Considerable physiological work has been done to define the limits of human tolerance in the +Gz and +Gx physiological axes. Considerable research must also be performed to define limits of human tolerance in the other physiological axis, Gy, for future high performance aircraft designs and to provide a cockpit restraint system that will permit aircrew to function effectively in this environment.

d. High altitude protection. Pressure suit ensembles (PSEs) are required by aircrew members in all bomber, reconnaissance, and fighter aircraft (except those equipped with capsules) having combat ceilings at or above 50,000 ft (unless waived by the MAJCOM with concurrence of the command surgeon) to provide for emergency descent (after loss of cabin pressurization) to a lower altitude or during escape from the aircraft. A PSE requirement also exists in all aircraft that must continue flight at altitudes above 25,000 ft when cabin pressurization is lost.

PSEs are devices that deliver oxygen pressure for breathing and counterpressure to all or part of the aircrew member's body surface to protect against the adverse affects of a high altitude environment. Devices that provide counterpressure for part of the body surface have, traditionally, been called partial pressure suits and devices that provide counterpressure for the entire body have been called full pressure suits. Oxygen for breathing is traditionally delivered to the aircrew member by means of an oronasal mask or a full head enclosure with a face seal or neck seal. The method selected depends upon the maximum altitude, the duration of the exposure to that altitude and the subsequent descent below the design protection altitude of 35,000 to 40,000 ft. Accordingly, the amount of body surface counterpressure will vary with the maximum altitude and exposure time.

PSE configurations may include, but are not limited to, an oronasal mask with torso counterpressure; an oronasal mask with torso and upper leg counterpressure; an oronasal mask with torso and leg counterpressure; a pressure helmet with torso, arm, and leg counterpressure; and a pressure helmet with entire body counterpressure (includes suit, gloves, and socks). Each of these configurations provide respective typical protective time and altitude envelopes from emergency descent to mission completion. A selection of the appropriate ensemble can be made based on the aircraft mission.

Body cooling may be required if the environmental temperature is high and counterpressure body surface coverage is extensive. Accordingly, if low environmental temperature (i.e., during high altitude ejection) is encountered, heating of the extremities to prevent frostbite and heating of the visor to prevent fog and/or frost, may be required.

It is essential that the PSE design be compatible with other items of life support equipment and compromise may be necessary to provide this. An alternative is to include provisions in the PSE design for the following: anti-G, flotation, anti-exposure, urine collection, flash blindness, chemical defense, etc. A PSE can be expected to add unwanted weight and mobility restrictions to encumber the aircrew and degrade performance. The usual resulting conflicts and negative response to the need for wearing PSEs can be expected unless care is taken to address this critical problem early in the design.

e. Head protection. The type of helmet assembly (protective headgear) most appropriate for a particular application is dependent upon the physical characteristics of the aircraft cockpit, equipment within the crewmember work area, the aircraft's performance characteristics, mission requirements, and the experience available with current helmet development. The latter may dictate the use of a proven conventional helmet assembly in preference to development of an unproven helmet assembly for the precise application.

It is very important to conduct an in-depth study to determine what is needed from the total system standpoint and then to design the helmet assembly with that concept in mind. Some of the current flight helmets in the field today are unsatisfactory owing to their piecemeal development over the years. Separate development of helmet hard shells, oxygen masks, visor assemblies, helmet-mounted sights/displays, etc., resulted in a single helmet assembly not optimized to satisfy the needs of the individual aircrew member, considering the aircraft and mission being flown.

Any development effort should address the weapons system in which it is being utilized and should encompass the oxygen mask, eye protective devices, helmet suspension system, mask attachment and other items such as chemical defense protection, helmet mounted sights/displays, and night vision goggles that attach to or are an integral part of the helmet hard shell. The entire effort should be addressed as a complete system and not separate design efforts.

Helmet assemblies are used in a broad spectrum of applications. Each helmet assembly must be designed for a specific application to satisfy mission profiles involving comfort, stability, communications, sound attenuation, weight, field-of-view, oxygen, impact, penetration, windblast and retention, maneuvering and load, smoke, fire and chemical protection, ballistic threat, radiation (solar), helmet mounted sights and displays, and laser threat. A further discussion of helmet capabilities required versus aircraft type follows.

(1) Fighter/attack. These are high performance, ejection seat equipped aircraft which have only one or two aircrew members, physically constrained by the gross limitations of their work area. Canopy/helmet proximity is hazardous, instrumentation is profuse, aircraft speed, attitude and G-loading are extreme, and mission demands require aircrew performance exceeding all other type aircraft. Hence, the aircrew member is potentially

vulnerable to many various hazards which could produce head trauma-buffeting during weather turbulence, sudden high performance maneuvers, canopy fragmentation from bird strike, flash fires, high noise levels, sun glare, and ejection, along with exposures to wind blast, tree entanglement upon descent and, finally, ground contact on rough terrain.

Helmet capabilities required include:

a. The helmet must fit in such a manner that it will not shift or rotate upon the head during high-G maneuvers and yet not fit so tight that comfort is sacrificed because of hot spots.

b. Adequate noise attenuation to avoid progressive, permanent hearing loss and to assure effective communications response. This is a function of good overall fit and comfortable earphone/earpad integration.

c. An integrated visor system which is easy to position, does not add unacceptable weight, bulk, or cause poor mass distribution, and provides protection from sun glare, bird strike, and windblast.

d. Impact and penetration protection to coincide with head tolerance limits and acceptable comfort levels.

e. Dependable retention during ejection.

f. Vision unobstructed by the exterior helmet configuration.

(2) Cargo/transport. This aircraft type is comprised of low-performance multi-crewmember aircraft without ejection capability. Crewmembers work in restrained, and at times in unrestrained positions, in areas which are not too physically restrictive. Buffeting to some extent during weather turbulence and ground impact during emergency landings (since the crashlanding philosophy also applies to this group) are the instances when a crewmember is vulnerable to head injury. Therefore, for this group of aircraft, it is generally accepted by the crewmember that a helmet somewhat less protective than current standard helmets, is acceptable. Because of long-duration missions, added emphasis is placed on comfort.

Helmet capabilities required include:

a. A lightweight helmet because of the long mission time.

b. Oxygen mask integration which affords an on-off position capability without a one-sided drag on the helmet.

c. Adequate noise attenuation to avoid progressive, permanent hearing loss and to assure effective communication response.

(3) Bomber. This aircraft type is unique in that it is comprised of medium-performance, multi-crewmember aircraft similar to cargo/transport but each crewmember wears a helmet and, in the case of the B-52, there exists an upward front and rear facing ejection seat and a downward front facing ejection seat, along with escape hatches. Interior configurations are confining

and equipment is extensive. Everything from overhead sextant to the hatch grill door can cause head injury. Other bombers such as the B-1 have similar characteristics from the standpoint of helmets to fighter/attack aircraft. The F-11 is unique in that it includes a capsule.

Helmet capabilities required include:

a. A lightweight helmet because of the long-duration missions.

b. Adequate noise attenuation to avoid progressive, permanent hearing loss and to assure effective communication response.

c. Dependable retention during bailout or ejection.

(4) Helicopter. This aircraft type is comprised of low-performance, multi-crewmember, non-ejection capability aircraft wherein crewmembers experience a high noise level, interior buffeting, low level flight temperatures, and are vulnerable to bird strike and small arms ground fire. An adequate helmet must therefore attenuate the noise in an environment where adequate sound attenuation is perhaps the most difficult to achieve. It must dissipate heat, provide good eye protection because of the large windscreen areas. To be compatible with the crash-landing philosophy of helicopter flying, since there are no ejection seats and even parachutes are not always available, it must be designed to absorb energy in case of repetitive head impact. Also, penetration protection from small arms fire may be required.

Helmet capabilities required include:

a. Adequate noise attenuation to avoid progressive, permanent hearing loss and to assure effective communications response. This is a function of good overall fit, comfortable earphone/earpad integration, adequate sound attenuating materials, and earcup shape.

b. An integrated visor system which is easy to position, does not add unacceptable weight, bulk, or cause poor mass distribution, and provides protection from sun glare, bird strike, and wind blast.

c. Adequate impact and penetration protection in terms of the crash landing philosophy for this group.

(5) Utility/observation. Crewmembers of this aircraft type share, to a lesser degree, all the problems encountered with the more extreme environments experienced in fighter/attack, helicopter and cargo/transport aircraft. Work areas are small and various instrumentation is in close proximity to the head. Because of its structure and the proximity of instrumentation, the crewmember is exposed to head impacts which would tend to indicate that the helmet needs to be designed to aid in absorbing some of the added energy involved in impact situations.

Helmet capabilities required include:

a. An integrated visor system which is easy to position, does not add unacceptable weight, bulk, or cause poor mass distribution, and provides protection from sun glare, bird strike, and windblast.

b. Impact and penetration protection, because in many accidents, the crewmembers remain in the aircraft.

c. Dependable retention during bailout.

REQUIREMENT LESSONS LEARNED

4.1 **General.** The verifications specified herein shall verify the ability of aircrew personal protective equipment to meet the requirements of section 3 herein and shall include ________. All verifications shall be the responsibility of the contractor; the Government reserves the right to witness, or conduct, any verification. Reference made herein to "Trained Test Subjects" relates to training with equipment being tested in addition to experience with test method(s)/device(s) used in the test (i.e. tests where a piece of equipment is to be used during a parachute jump requires that the test subject be a trained parachutist; communications tests require subjects trained in communications and use of piece of equipment, etc.).

VERIFICATION RATIONALE (4.1)

Verification of specification requirements is essential to the procuring activity such that equipment design and performance is proven or validated prior to commitment to production and aircraft installation. This ensures that properly designed aircrew personal protective equipment and associated components are delivered. Verification of the aircrew personal protective equipment design and installation will also minimize hazards to crewmembers and passengers on the aircraft.

VERIFICATION GUIDANCE

The aircrew personal protective equipment design and installation may be verified by inspection, analysis, demonstration, and/or testing. Components used in the design of the equipment may be inspected against all applicable requirements. Inspections ensure that the designer will provide to the military procuring activity all necessary components of the aircrew personal protective equipment. Verification of specified requirements by means of mathematical, logical, and functional analysis may be acceptable. To ensure that all performance oriented requirements will be met, demonstrations and testing are desirable. For example, a demonstration of the head protection provided by a piece of headgear may be verified by actually mounting the headgear into a test device and measuring the amount of protection provided.

VERIFICATION LESSONS LEARNED

3.2 Performance requirements

3.2.1 Chemical/biological head/respiratory protection

3.2.1.1 CB personal equipment compatibility. The aircrew CB head/respiratory protection system, when properly donned and worn with other personal flight ensembles, shall integrate and be compatible with the ________ aircraft cockpit structure, environmental control system, and electrical system. There shall be no interference with the function of the following aircrew life support equipment:

a. ________ Headgear
b. ________ Oxygen mask
c. ________ Life preserver
d. ________ Eye protection device
e. ________ Parachute harness
f. ________ Survival vest
g. ________ Anti-G suit
h. ________ Oxygen regulator
i. ________ Flight coverall
j. ________ Vision enhancement device
k. ________ Escape systems
l. ________ ________________ (Specify other)

REQUIREMENT RATIONALE (3.2.1.1)

Compatibility between the CB head/respiratory protection system and other personal protection systems and life support equipment is essential to mission performance and flight safety. Incompatibility between any life support system component could result in a flight safety hazard.

REQUIREMENT GUIDANCE

Each relevant item of life support equipment must be identified by model number or equivalent designation. The type of personal equipment to be worn by aircrew is dependent upon the aircraft type and Statement of Operational Need for new equipment development.

REQUIREMENT LESSONS LEARNED

Omission of any pertinent feature could lead to later costly modifications of the aircrew CB head/respiratory protection system or to the aircraft cockpit.

4.2.1.1 <u>Verification of CB personal equipment compatibility</u>. The aircrew CB head/respiratory protection system shall be donned along with all required life support equipment by _______ aircrew test subjects. The test subjects shall enter a _______ aircraft designed or properly modified to accept the CB protection system. The CB system shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems which are considered to be detrimental to the mission shall be cause for rejection.

VERIFICATION RATIONALE (4.2.1.1)

Ground simulation tests are useful and necessary precursors to the actual flight test to verify that flight safety hazards do not exist.

VERIFICATION GUIDANCE

The actual donning of the aircrew CB head/respiratory protection system by aircrew and performing a mission in the selected aircraft is the best procedure to verify the adequacy of the system. The larger the number of test subjects, the more thorough the evaluation. However, a reasonable number of test subjects to acquire adequate statistical data is six. The test subjects should be anthropometrically selected to represent as nearly as practical the USAF aircrew population. The actual aircraft selected for the test flights must be the same as the one or more types of aircraft in which the system is designed to be flown to prevent anomalies. Adequate ground testing prior to flight tests is essential to assure there are no flight safety problems. Typical tests include ground egress from an egress trainer to evaluate the emergency egress capability and a hanging harness test to evaluate potential problems during parachute descent. Water survivability should also be evaluated since the system will cover the breathing zone and this zone must be broken to outside ambient air soon after water entry. Parachute jumps by qualified test parachutists over both land and water are normal tests to be accomplished prior to flight testing. Visiting using commands is helpful since aircrew trained in the aircraft for which the equipment under development is designated can provide insight on potential problem areas.

VERIFICATION LESSONS LEARNED

During the design process it is essential to verify compatibility with the use of mockups or early prototypes of the CB head/respiratory protection system. Since chemical/biological protection requires an addition to the personal equipment normally worn, some degradation in mission performance (e.g., visibility and mobility) may be unavoidable. Continuous evaluation of compatibility as the system is under development will prove beneficial in avoiding significant mission performance degradation problems.

3.2.1.2 **CB environmental conditions.** The aircrew CB head/respiratory protection system shall be capable of withstanding and operating under the following environmental conditions induced by the aircraft, ground transport, or storage ____________________.

REQUIREMENT RATIONALE (3.2.1.2)

The system must meet the environmental performance requirements to assure that it will function satisfactorily following storage and during operational use in specified climatic conditions.

REQUIREMENT GUIDANCE

Worldwide climatic environmental conditions are enumerated in MIL-STD-210, Climatic Extremes for Military Equipment. Generally, the system or components of the system will encounter conditions less severe than the environmental levels stated in MIL-STD-210. Environmental extremes should be based on the cockpit environment, outdoor transit environment, and storage environments anticipated for the mission of the aircraft and theater of operations. Environmental conditions to consider include storage temperature extremes, operating temperature extremes, rapid changes in ambient operational temperatures, solar radiation, blowing rain, humidity during storage and operation, environmental fungus, environmental salt fog, and environmental dust. The system should also be designed to provide the required performance during and after exposure to the following induced environments: Acceleration, vibration, acoustical noise, and shock. MIL-STD-810 provides test levels which may be used as a guide for selecting the appropriate environmental performance limits for each component or assembly of the system based on its operational use.

REQUIREMENT LESSONS LEARNED

Failure potential results when all possible operational extremes are not tested.

4.2.1.2 **Verification of CB environmental conditions.** The system shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in 3.2.1.2.

VERIFICATION RATIONALE (4.2.1.2)

The system or its components, as applicable, must be tested and analyzed under all of the natural environment and induced environment extremes that will be encountered during operational use or storage.

VERIFICATION GUIDANCE

The test procedures of MIL-STD-810 may need to be modified to reflect the true requirements (see paragraph 1.2 of MIL-STD-810).

VERIFICATION LESSONS LEARNED

Lack of proper and complete verification can lead to very costly modification or replacement of equipment.

3.2.1.3 CB eye/respiratory protection level. The eye/respiratory protection level of the aircrew CB head/respiratory protection system shall not be less than _______________ for ____ percent of the USAF aircrew population. The protection level is defined as the ratio of the measured airborne concentration of a test agent in ambient air surrounding the system to the concentration of test agent within the system facial region.

REQUIREMENT RATIONALE (3.2.1.3)

A minimum protection level must be maintained within the eye/respiratory region to protect this region from injury by CB agent vapors.

REQUIREMENT GUIDANCE

The protection level is determined by threat analysis and time of exposure to the threat. The 1975 Chemical Warfare Defense Functional Analysis study, code named HAVE PLOT, provides chemical-biological threat estimations. The protection level requirements for individual protective equipment is based on this study plus current threat analysis. The current acceptable protection level is 10^4. A more realistic protection level is 10^5. The reason for selecting 10^5 is that laboratory measurements of protection level may be significantly higher than the actual protection level of the system in the field environment. Selecting 10^5 over 10^4 protection level will provide a safety margin. Time of exposure must also be considered as agent effects are dependent on cumulative exposure. Since fitting 100 percent of the USAF aircrew population is not considered possible because of the wide range of facial sizes, a more realistic and achievable requirement is 90(5-95 percentile) percent of this population. Individuals not meeting the required protection level must be identified and custom fitted. The threat to USAF/NATO bases is constantly changing and expanding as new CB agents, toxins, delivery means, employment doctrine, and tactics change. Protection level requirements must be based on the latest threat estimations.

REQUIREMENT LESSONS LEARNED

Field tests of commercial respiratory protective devices have shown that significantly lower protection levels are possible during actual industrial use than when the device is tested under laboratory conditions. A parallel can be drawn with military devices. A part of this problem is due to the low efficiency of breathing gas filters and to leakage past the facial seal since a protection level of 10^5 will permit only a very small amount of leakage.

4.2.1.3 **CB eye/respiratory protection level tests.** Quantitative leakage tests shall be performed with a ________ person test panel to verify that leakage and population reqirements of 3.2.1.3 can be met. The test subjects shall wear the complete aircrew CB head/respiratory protection system and other applicable life support equipment. The leakage tests shall be performed in a test chamber of adequate size to permit the simulation of all aircrew movements during transition from a collective shelter to the aircraft; during flight operations, and during transition back to the shelter. Continuous measurements of the leakage into the system shall be recorded with instruments of sufficient accuracy to measure protection levels greater than __________.

VERIFICATION RATIONALE (4.2.1.3)

Protection level can only be accurately determined through quantitative leakage measurements into the facial region. An anthropometrically selected human subject test panel is necessary to determine if the system facepiece or head covering will provide an acceptable seal for varying facial features and head sizes of the USAF aircrew population.

VERIFICATION GUIDANCE

If the aircrew CB head/respiratory protection system design incorporates a peripheral facial seal, the size of the test panel should be 25 persons. If the system design is basically a head covering, a significantly smaller test panel, e.g., 10 persons, is acceptable. An in-depth study was performed by the Los Alamos National Laboratory (LANL) to determine anthropometric specifications for test subjects wearing various styles of respirators. This study is documented in LANL report number LA-5488, Selection of Respirator Test Panels Representative of US Adult Facial Sizes, issued March 1974. The accuracy of test instrumentation should permit measurements of greater than 10^5 protection level. The reason for this accuracy requirement is to assure that quantifiable measurements can be acquired significantly above the minimum protection level of 10^4 to evaluate the adequacy of the system.

VERIFICATION LESSONS LEARNED

Selection of a trained test panel is a tedious process. The test subjects must be properly trained and motivated to acquire useful test data. There are a number of types of test chambers and measurement instrumentation. Of most importance are accuracy and repeatability in selecting the test system. Calculation of protection level from the raw test data can be accomplished using several techniques. The technique with the widest acceptance is based on average peak penetration. This technique uses an average of the peak simulant penetrations into the facial region recorded on a strip chart during an exercise such as moving the head from side to side.

Past testing has shown that the sampling probe should be positioned within the facial region at as many locations as is feasible to do so. The problem is that the probe may miss possible streamlining of ambient contaminant through an opening in the CB barrier. A judgement will need to be made as to adequate sampling sites for each system design. The streamlining of ambient contaminants through a small opening in the CB barrier should not be a significant problem where the nose cup fits snugly to the face since a minimum amount of air should be drawn past the nose cup during inhalation.

3.2.1.4 CB communication intelligibility. Voice intelligibility shall be at least ____________ % in a ______________________ db noise environment. The aircrew CB head/respiratory protection system shall permit intelligible voice communication both inside and outside the aircraft. Voice communication within the aircraft shall include interfacing with the aircraft intercommunication system.

REQUIREMENT RATIONALE (3.2.1.4)

Effective and efficient communication between aircrew members and also between aircrew and groundcrew members must be accomplished in the mission environment. High noise levels are distracting and fatiguing.

REQUIREMENT GUIDANCE

The aircrew CB head/respiratory protection system is a possible source of noise, and this must be considered during the design of the system. The noise level requirements are also influenced by the type and mission of the aircraft. Voice intelligibility can be assessed by placing trained test subjects wearing the system in a noise environment and determining voice intelligibility. A thorough assessment of the noise environment in which the aircrew CB protection system could be worn should be conducted. Voice intelligibility should be assessed under all possible noise environments.

REQUIREMENT LESSONS LEARNED

4.2.1.4 Verification of CB communication intelligibility. Voice intelligibility tests shall be conducted to verify that voice intelligibility meets the limit specified in 3.2.1.4 in a noise environment of __________ measured by __________.

VERIFICATION RATIONALE (4.2.1.4)

Communication intelligibility can only be verified through the use of trained human test subjects to determine whether or not speech is intelligible in the mission noise environment when wearing the aircrew CB protection system. Testing procedures and equipment have been developed to simulate actual noise environments and scientifically measure voice intelligibility.

VERIFICATION GUIDANCE

Voice intelligibility can be assessed by placing at least 10 trained test subjects wearing the aircrew CB head/respiratory protective system in a noise environment of 105 decibels (dB) sound pressure level (SPL) USASI spectrum or other SPL as appropriate to the mission and determining voice intelligiblity. The communication system is connected to an AIC-18 or AIC-25 interphone. The test subjects perform a modified Rhyme test. The test subjects should score 80 percent or better on the modified Rhyme test. In MIL-STD-1472, the paragraph entitled "Speech intelligibility" provides recommended speech intelligibility test methods with the appropriate selection being dependent upon the requirements of the test.

VERIFICATION LESSONS LEARNED

3.2.1.5 **CB ventilation/filtration.** A ventilation/filtration system shall be provided to assure removal of CB agents from the breathing gas, maintain the protection level required in 3.2.1.3, and prevent lens misting during transition between collective shelter and aircraft and during flight operations.

REQUIREMENT RATIONALE (3.2.1.5)

A ventilation/filtration system must be provided to remove liquid, particulate and vapor CB agents from breathing gas and ventilation airflow. Ventilation airflow is necessary to maintain the required protection level, prevent misting of the aircrew CB protection system lens, and reduce thermal load. The ventilation/filtration system may have various configurations including: modification of the aircraft environmental control system to add filtration and cooling as needed; separate ground use and aircraft mounted systems; or a common aircraft-use and ground-use system which may be readily mounted inside the aircraft. The breathing gas must be filtered if the aircraft oxygen supply system is not designed to assure that CB agent free breathing gas is provided to the user. (See General Specification for Aircraft Oxygen Systems MIL-O-87226.)

Both the breathing gas and the ventilation flow must be filtered as necessary to provide CB agent free gas flows continuously during transition between collective shelter and aircraft and during flight operations. Filtration downstream of the man-mounted disconnects may be necessary to assure that neither the breathing gas nor ventilation airflow will become contaminated with chemical agent vapor during transition between ground and flight modes of operation.

REQUIREMENT GUIDANCE

The ventilation system must maintain a positive pressure within the facial region to assure that a high protection level (greater than 10^4) can be maintained. Loss of this positive pressure will result in a significantly lower protection level dependent upon the design of the head enclosure. It may be acceptable to have reduced protection (10^3) during emergency situations such as ground abort and ejection. A full head enclosure with neck seal may be necessary to provide at least a 10^3 protection level in the event of failure or disconnect from of the ventilation supply system. Joint Operational Requirements (JOR) provide protective requirements for the face, eyes, and respiratory tract of the wearer in field concentrations of CB agents. These protective requirements are defined by a Joint Technical Integration Working Group (JTIWG). The JOR requires the filter system of a protective mask to be capable of withstanding a minimum of 15 attacks with nerve, choking, and blister agents under combat conditions, and to provide at least a two-attack capability against blood agents. A CB attack for the JOR attack is defined as an exposure of 20,000 mg-min per cubic meter of CB agent. The JOR may not be suitable for all USAF requirements. These protective requirements should be altered where threat data, mission analysis, including time duration or Statement of Operational Need (SON) for the system require other performance capabilities.

REQUIREMENT LESSONS LEARNED

The JOR requirements are not ideally suited to USAF aircrew needs since they are based primarily on the Army anticipated field threat. In developing the CB protection requirements for aircrew, consideration must be given to the potential airbase threat during transition between the protective shelter and the aircraft as well as potential cockpit contamination throughout the mission. Performance requirements for the ventilation/filtration system must reflect the latest threat analysis for the mission of the aircraft selected for use of the aircrew CB head/respiratory protection system.

The ventilation airflow to the head must be properly adjusted and directed to assure not only the required protection level but also to prevent eye dryness, cold spots and other physical discomforts.

If a survivable protection level of at least 10^3 is required in the event of the loss of the ventilation supply, then a neck seal and full head enclosure may be necessary. Without the neck seal, the protection level could rapidly drop to immediately hazardous levels if the ventilation supply system fails.

4.2.1.5 **Verification of CB ventilation/filtration system.** The following ventilation/filtration system tests shall be performed:

a. Service life: ____________________

b. Subjective use: ____________________

c. Durability: ____________________

d. Output: ____________________

e. ____________: ____________________
(Specify other)

VERIFICATION RATIONALE (4.2.1.5)

Ventilation/filtration system tests are necessary to assure that the system will function satisfactorily and provide adequate comfort, service life, storage life, and durability throughout its required operational life. Verification teting should apply to all components of the ventilation/filtration system (e.g., filters, air mover, hoses, etc).

VERIFICATION GUIDANCE

The JOR provides evaluation conditions and test procedures to meet the filter service life requirements established by the JTIWG. If it is determined through threat and mission analysis that service life requirements should be different from those stated in the JOR, modified filter test procedures need to be developed in consort with the US Army Chemical Research and Development Center (CRDC), Aberdeen Proving Grounds, MD since the Army has the lead service responsibility for the development of such filter evaluation criteria and test procedures.

Subjective-use testing is necessary to determine if there are any physiological detrimental performance characteristics of the ventilation/filtration system. Objectionable odors and discomfort are indications of such physiological problems. The rated airflow of the ventilation system is based on physiological response as well as the required protection level. The filter size is based on the airflow rate necessary to meet physiological needs and the required protection level.

Durability requirements should meet the stated goals/requirements of the aircraft mission and Statement of Operational Need (SON). Endurance testing of mechanical and electrical components of the ventilation system is necessary to assure an adequate service life. Rigorous wearing trials and ruggedness tests should also be conducted and selected components (e.g., filters and air movers) should have performance evaluated following such trials and tests. Durability testing should complement environmental testing.

Output testing is the evaluation of the capability of the ventilation/filtration system to deliver rated gas flows at various ambient, altitude, and induced-load conditions pertinent to the aircraft mission. Centrifuge testing and altitude chamber testing are typical types of tests to simulate actual flight operation conditions. The actual test conditions are dependent upon the aircraft mission.

VERIFICATION LESSONS LEARNED

Early installation of a mock-up of the CB protective system in the aircraft cockpits for which the system is intended will minimize cockpit integration problems.

3.2.1.6 CB permeation. The aircrew CB head/respiratory protection system shall be resistant to permeation by CB agents for a minimum of _____ hours.

REQUIREMENT RATIONALE (3.2.1.6)

All components of the system should be capable of providing skin protection if the wearer is continuously exposed to the heaviest concentration of toxic chemical agents (liquid or vapor) that can be operationally delivered.

REQUIREMENT GUIDANCE

The Statement of Operational Need should provide the time period for protection. Current requirements vary from 6 to 24 hours and are dependent upon the user's needs.

REQUIREMENT LESSONS LEARNED

Seams and cavities can contain CB agents. The need to maintain a smooth contour of the CB barrier should be emphasized.

4.2.1.6 CB permeation tests. The components of the system (e.g. helmet shell, lens, seals, hoses, shrouds, and other fabrics) shall be resistant to test agent penetration when subjected to the following tests___________.

VERIFICATION RATIONALE (4.2.1.6)

Permeation tests using chemical agents provide the best testing technique to assure that all components of the system are chemical agent resistant for the required time period specified by the user.

VERIFICATION GUIDANCE

Chemical agent resistant test methods are developed by the Army Chemical Research and Development Center (CRDC), Aberdeen Proving Grounds, MD for all three services. The Army has the lead service responsibility for the development of such test methods. The Joint Operational Requirements (JOR) provides evaluation criteria and values for permeability of mask components. The evaluation criteria and values are determined by a Joint Technical Integration Working Group (JTIWG).

In addition to the test methods described in the JOR, the Army has developed other material permeability test methods. These test methods are described in special publication CRDC-SP-84010, Laboratory Methods for Evaluating Protective Clothing Systems Against Chemical Agents.

The test methods described by the JOR or by the published CRDC test methods should be altered where threat data, mission analysis, or Statement of Operational Need (SON) for the system requires other performance capabilities.

A new test method under development with considerable promise is a chemical agent impact test. The Prins Mauritz Lab, TNO, Rijswijk, Netherlands, and the Chemical Defense Establishment (CDE), Porton Down, England are two foreign laboratories that have developed laboratory test equipment to simulate a falling agent droplet onto a fabric test sample. The Battelle Institute, Columbus, Ohio, has developed an agent impact tester under USAF funding and transitioned to the U.S. Army for evaluation. The objective of this test is to measure agent penetration in a fabric with varying droplet sizes and patterns at terminal velocity.

VERIFICATION LESSONS LEARNED

Fabric seams should be tested since agents can penetrate through seams faster than through the parent material.

3.2.1.7 <u>CB equipment during escape</u>. The aircrew CB head/respiratory protective system shall not loosen, tear, or otherwise fail structurally resulting in possible injury or interference with survivable crash, emergency ground egress, the emergency ejection sequence or bailout, parachute descent, ground landing, or water entry. All system disconnects shall operate properly during an ejection and shall release with an applied force not less than _____ pounds nor more than ________ pounds. The system shall prevent suffocation following water entry.

REQUIREMENT RATIONALE (3.2.1.7)

The system must meet escape requirements for the designated aircraft to prevent induced bodily injury by the system during bailout, an emergency ejection, survivable crash, parachute descent, ground aborts and landing on the ground or in the water. If the aircraft does not contain an ejection seat, this performance requirement should be revised accordingly.

REQUIREMENT GUIDANCE

Dynamic forces that may be encountered during a typical ejection are germane to the type of aircraft for which the system is intended. Dynamic forces include both inertial forces and windblast forces.

The intensity of the acceleration force selected for system design should meet or exceed the acceleration force imposed by the ejection seat. An acceleration force 1.25 times greater than that imposed by the ejection seat is a reasonable requirement which provides a safety factor to assure adequate performance of the system during an ejection.

Windblast forces selected should be typical of ejection velocities anticipated for the aircraft and should include those forces at the maximum velocity of the escape envelope of the aircraft. Imposing high velocity windblast requirements may result in a considerably heavier construction of the system than desired, thus degrading aircrew performance. The windblast requirement presently used for high performance aircraft flight helmets is in the range of 450 to 500 KEAS or the aircraft design requirement velocity which represents a trade-off in assuring head protection at lower ejection velocities while providing a light weight stable headgear system for optimum aircrew performance during the mission. However, it is necessary to evaluate the CB system at the maximum velocity of the escape envelope to ensure seat/aircrew compatibility even though a lower velocity is selected for the system design criterion. Ejection is possible at 600 KEAS.

Quick disconnects provide the primary connections between the aircrew and the aircraft (e.g. filtered air supply and oxygen system). These disconnects are mounted to the parachute harness to distribute the force of the ejection. The disconnects should be omnidirectional to assure against possible binding or failure to release. The disconnects should release with an applied force not less than 8 nor more than 24 pounds. This range will avoid inadvertent disconnects and minimize the induced load on the aircrew during an ejection.

For aircraft containing the ACES II ejection seat, consideration must be given to the aerodynamic design of the chemical-biological barrier around the head to prevent airflow distortion into the seat Pitot tubes. Such flow distortion would prevent appropriate seat mode selection.

REQUIREMENT LESSONS LEARNED

Selection of materials which satisfy all of the following requirements--provide a positive pressure CB barrier, be fire resistant, be flexible and lightweight so as not to restrict head movement, be structurally strong enough to withstand the windblast forces experienced during an emergency ejection, and be aerodynamically smooth so as not to disturb the airflow into the ACES II ejection seat Pitot tubes--is a difficult technical problem.

4.2.1.7 <u>Verification of CB equipment during escape</u>. The following tests shall be performed to verify the requirements of 3.2.1.7.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration)
c. Release force
d. Wind tunnel
e. High speed sled
f. Seat ejection (IAW MIL-STD-846, paragraph 3.3, as applicable)

g. Hanging harness
h. Parachute
i. Water survival
j. Ground escape
k. ____________
(Specify other)

VERIFICATION RATIONALE (4.2.1.7)

The capability of the aircrew to survive an emergency ejection, or bailout at various airspeeds, a parachute descent, survivable crash and landing on the ground or in the water must be verified through simulated and actual environment tests. Test procedures and equipment have been developed to perform such tests. Test procedures must be modified and new procedures added as necessary to suit each type of aircrew CB head/respiratory protective system and the aircraft for which it is designed.

VERIFICATION GUIDANCE

Test limits for the variety of tests required are determined by the type of aircraft, mission, Statement of Operational Need, and good judgement which weighs the severity and number of tests needed to assure that the system is flightworthy.

Windblast tests are normally performed by mounting the system on an appropriately instrumented test dummy properly restrained for ejection in an ejection seat. The dummy is exposed to windblasts of 500 KEAS (knots equivalent airspeed) or the aircraft design requirement velocity (ejection is possible at 600 KEAS) to determine the velocity at which the system will fail. A typical velocity profile is a rise time to peak velocity of 0.3 second with no dwell at maximum velocity and decay to 200 knots in 3 seconds. Although this velocity profile does not match an actual ejection, it is within the capability of available test facilities and provides a good structural test of the system. Seat attitudes should be varied in both pitch and yaw directions to simulate possible ejection positions and assure a thorough structural test.

The acceleration tests can be performed by mounting the system on a dummy properly restrained in an ejection seat, in an ejection tower (or deceleration tower) test facility. Where an ejection tower is used, separation of quick disconnects can be photographed and separation forces can be measured with appropriate instrumentation. High speed photography is used to provide evidence of any slippage, loosening or other failure which could result in bodily injury.

In addition to the quick disconnect release forces measured at an ejection tower test facility, a test rig capable of simulating and measuring release forces may be used. Possible angles of man/seat separation should be simulated.

Prior to high speed sled tests, wind tunnel tests should be performed to carefully assess the compatibility of the ejection seat and aircrew worn equipment. These tests should be accomplished at varying ejection seat pitch and yaw angles as well as varying airspeeds to cover the aircraft operational envelope.

High speed sled tests are accomplished by mounting the system on a dummy appropriately restrained in an ejection seat. The seat is mounted on a sled with the appropriate aircraft forebody or a sting device in a position to simulate the initial stages of an ejection. The sled is accelerated to a predetermined velocity (approximately 500 KEAS) or the aircraft design requirement velocity (ejection is possible at 600 KEAS). High speed photography provides the sequence of any failure. If ejection seats with pressure sensors (i.e. Aces II pitot tubes) are used, seat sensor pressures and mode switching are recorded to determine any interference with normal seat mode switching.

An ejection seat test requires a similar test setup as the high speed sled test except that the sled has a closed canopy. Failure of the ejection seat to operate in the proper mode because of pressure sensor interference (i.e. (ACES II seat pitot tubes) from the system, failure of aircrew/cockpit disconnects, or failure of the dummy to separate from the seat following the ejection would constitute a test failure.

In preparation for flight test evaluation, a hanging harness test is normally performed. A trained test subject wears the system with appropriate life support equipment and is suspended in a hanging parachute harness. The test subject must be able to perform all necessary parachute descent functions while suspended.

An actual parachute jump from an aircraft or helicopter by a trained test parachutist is normally performed prior to flight test evaluation. The test subject jumps from the aircraft onto dry land and into water. The system must not interfere with parachute opening or inhibit any descent functions. Good visibility and unrestricted arm movement are essential during descent. The test subject must satisfactorily break the chemical/biological barrier around the face after water entry within 30 seconds. The test parachutist must be able to easily release his parachute riser releases. The ability to remove the chemical/biological barrier during parachute descent should also be evaluated.

Water drag tests should be performed prior to flight testing over water. This can be accomplished from the aft end of a boat appropriately rigged. The test subject is drug in the water at various speeds simulating possible wind velocities. The test subject must demonstrate the capability of rolling over, releasing the riser quick release, and breaking the chemical/biological barrier without undue problems.

VERIFICATION LESSONS LEARNED

At 450 KEAS and above, the chin straps on current flight helmets are more apt to fail resulting in loss of helmet. Due to expense of seat ejection tests, "piggy back" tests are usually preferred.

3.2.1.8 **CB utilization.** The following aircrew CB head/respiratory protection system use requirements shall be met:

a. Donning - The system shall be capable of being donned in ___________ minutes.

b. Doffing - The system shall be capable of being doffed in ___________ seconds.

c. Transition - The system shall be capable of being converted from ground to aircraft operational mode in ______ seconds.

d. Valsalva - The system shall permit the wearer to perform a valsalva maneuver.

e. Comfort - The aircrew member wearing the system shall not experience hot spots, pressure points, or other intolerable discomfort.

f. Drinking - The system shall enable the wearer to drink without compromising CB protection for extended time duration missions (i.e. transport aircraft).

g. Subjective use - The system shall have no objectionable performance characteristics such as objectionable odors, skin irritation, restriction of movement, tacky to the touch, or any other property that may cause discomfort or affect wearability.

REQUIREMENT RATIONALE (3.2.1.8)

Utilization requirements are essential to assure the wearability of the system and the achievement of the mission requirement for the aircrew without significant performance degradation.

REQUIREMENT GUIDANCE

Utilization requirements are based upon the Statement of Operational Need for the system and previous experience in the development of similar systems.

a. Donning - A donning time, measured from the beginning to the end of the donning sequence, of 5 minutes will normally satisfy user requirements and should be attainable with a well-designed system.

b. Doffing - A doffing time should include the time to doff the entire headgear. (This doffing time is not the same as the water survivability requirement for breaking the CB barrier following water entry.) Removal of an agent contaminated system is an essential requirement to permit timely processing of aircrew through a contamination control area into a collective shelter. (This could include, for example, hook-up to aircraft supply and mounting of blower in cockpit.)

c. Transition - The system should be capable of being converted from ground to aircraft operational modes within 15 seconds. (This could include, for example, hook-up to aircraft oxygen supply and mounting of blower in cockpit.) It is essential to keep this time as low as possible to minimize delay in the start of a mission.

d. Valsalva - It is essential for the safety of the aircrew to be able to perform the valsalva maneuver through the use of the forefinger and thumb or with a mechanical device which occludes the nostrils while wearing the chemical defense glove set. The system shall be designed to prevent eye injury.

e. Comfort - Comfort is subjective and therefore difficult to quantify. Qualitative criteria are the best criteria for establishing comfort requirements.

f. Drinking - The drinking feature of the system should be flexible and adjustable to permit stowing and not be a safety hazard. The aircrew must be able to drink fluids without compromising CB protection since drinking would likely be accomplished in CB agent-contaminated environment.

g. Subjective use - Subjective use requirements are qualitative by nature. Identification of possible objectionable performance characteristics that can be subjectively evaluated is an important requirement.

REQUIREMENT LESSONS LEARNED

Valsalva performed with the forefinger and thumb is preferred over a mechanical device; however, allowance must be made for the thickness of the chemical defense glove set if worn.

4.2.1.8 CB utilization tests. The following tests shall be performed to verify the requirements of 3.2.1.8.

a. Donning tests - Elapsed time shall be measured from the beginning to the end of the donning sequence for each of ______ trained test subjects. An average donning time of more than _____ minutes shall be cause for rejection.

b. Doffing tests - Elapsed time shall be measured from the beginning to the end of the doffing sequence for each of _____ trained test subjects. An average doffing time of more than _____ seconds shall be cause for rejection.

c. Transition tests - Elapsed time shall be measured to make the transition from ground use chemical defense life support equipment to aircraft life support equipment for each of _______ trained test subjects. The test subject shall be seated in the aircraft and a crew chief or assistant may aid in the transition if this is a normal operational procedure.

d. Valsalva tests - The completely outfitted test subject shall perform a valsalva maneuver by occluding the nose as required to equalize pressure in the ears during altitude ascent and descent. Inability of the test subject to perform the valsalva maneuver with one hand shall be cause for rejection. Valsalva devices can be a hazard to the eyes if not properly designed.

e. Subjective use/comfort tests - The system shall be tested by ________ crewmembers during flight testing. Objectionable odors, tackiness to the touch, hot spots, high pressure areas, restriction of movement, or other detrimental performance characteristics of the system shall be determined by subjective evaluation. Flight crew comments shall determine whether this requirement is met. Flight crew shall be anthropometrically selected from the fifth, to ninety-fifth percentile of the USAF flying population. If females do not qualify for the aircraft mission, they shall be excluded from the flying population data.

f. Drinking tests - Flight crew shall don the system and drink from a container designed to integrate with the drink tube. Flight crew comments shall determine whether this requirement is met.

VERIFICATION RATIONALE (4.2.1.8)

Testing must be performed to assure the wearability and flight safety of the system without significant aircrew performance degradation. Testing is primarily subjective and requires trained test subjects and aircrew to provide a thorough assessment of the airworthiness of the system.

VERIFICATION GUIDANCE

Since the test requirements are subjective in nature, there are only a few test limits that can be applied and these are the donning, doffing, and transition time limits specified in 3.2.1.8. All other testing is subjective evaluation by trained test subjects. Doffing may include a determination of self contamination. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population. A minimum of six test subjects should be selected to perform any one test to acquire statistically valid test data.

VERIFICATION LESSONS LEARNED

The entire chemical defense ensemble must be worn along with all other items of required life support equipment to assure a thorough and valid subjective evaluation of the system.

3.2.1.9 <u>CB electromagnetic emission and susceptibility</u>. The aircrew CB head/respiratory protection system shall meet the electromagnetic emission and susceptibility requirements of ______________________________.

REQUIREMENT RATIONALE (3.2.1.9)

The system or its components, as applicable, must meet electromagnetic interference requirements to assure that electromagnetic emission and susceptibility levels do not interfere with the mission of the aircraft.

REQUIREMENT GUIDANCE

MIL-STD-461 establishes the documentation and design requirements for the control of the electromagnetic emission and susceptibility characteristics of electrical and electromechanical equipment. When engineering analyses reveal that the requirements in this standard are not adequate for procurement, they may be tailored by the procuring activity and incorporated into the request-for-proposal or specification. For equipment and systems in feasibility or advanced development stages of the acquisition process, this standard should be used as a guide in formulating the appropriate requirements.

REQUIREMENT LESSONS LEARNED

4.2.1.9 **CB electromagnetic interference tests.** The system or its components, as applicable, shall be analyzed and tested as described in ______________ and meet the requirements of 3.2.1.9.

VERIFICATION RATIONALE (4.2.1.9)

The system or its components, as applicable, must be tested and analyzed under all possible electromagnetic emission and susceptibility levels to assure that the system will not cause electromagnetic interference or be susceptible to such interference which may interfere with the accomplishment of the aircraft mission.

VERIFICATION GUIDANCE

MIL-STD-462, Measurement of Electromagnetic Interference Characteristics, adequately establishes techniques to be used to measure and determine the electromagnetic interference characteristics (emission and susceptibility) of the system or its components, as applicable.

VERIFICATION LESSONS LEARNED

3.2.1.10 **CB sustained acceleration.** The aircrew CB head/respiratory protection system shall not malfunction or hinder aircrew member's ability to perform necessary tasks when acceleration forces of ________ G's for ________ seconds are encountered.

REQUIREMENT RATIONALE (3.2.1.10)

Sustained acceleration requirements must be attained to assure accomplishment of aircraft mission. The Statement of Operational Need should provide this requirement.

REQUIREMENT GUIDANCE

Current requirements for tactical aircraft are up to +9 G_z and -2 G_z. This is the limit imposed by the USAF School of Aerospace Medicine, Brooks AFB, Texas, for human subject testing in a centrifuge. The aircraft mission statement or Statement of Operational Need should provide necessary information to establish this requirement.

REQUIREMENT LESSONS LEARNED

A small additional weight to the helmet can severely degrade aircrew performance. Shifting the center of gravity forward on the head will cause a high forward moment on the head.

4.2.1.10 <u>CB sustained acceleration tests</u>. The man-mounted portion of the system shall be placed on a human test subject and subjected to the requirements of 3.2.1.10 using a centrifuge. The system shall be operated during the test. It shall be stable on the head and shall not show any evidence of malfunction or failure.

VERIFICATION RATIONALE (4.2.1.10)

The capability of aircrew to perform without impairment during the sustained G-force maneuvers specified for the aircraft must be verified through simulated tests prior to actual flight tests. Test procedures and equipment have been developed to perform such tests.

VERIFICATION GUIDANCE

Test limits for the centrifuge tests are determined by the type of aircraft, mission, Statement of Operational Need, and good judgment which weighs the severity and number of tests needed to assure that the system is flightworthy. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population. The centrifuge used for testing is a man-rated centrifuge, that the contractor will have to schedule time on and pay for testing. The testing is done only with trained military volunteer subjects who participate after giving their informed consent. The testing is done under the provisions of a medico-legal document (protocol) which may have to be approved at levels as high as the office of the AFSC Surgeon General. The available centrifuges and staff for this type of testing are at USAFSAM and AAMRL.

VERIFICATION LESSONS LEARNED

Selection of trained test subjects is essential for detecting any shifting and movement of the CB barrier which would degrade aircrew performance.

3.2.1.11 CB optical system. The CB head/respiratory protection system lens shall be of sufficient size such as not to decrease the wearer's visual field in the upward or lateral directions. The restriction of downward vision shall be no greater than ____________. The viewing area shall meet or surpass the optical requirements of ____________. The lens shall be capable of meeting the ballistic resistance requirements of ______________ and abrasion resistance requirements of ____________. When properly donned and operating, the system shall exhibit no visible lens fogging at a temperature of ____________ degrees and relative humidity of _________ %.

REQUIREMENT RATIONALE (3.2.1.11)

Vision requirements are essential to assure the wearability of the system and the achievement of the mission requirement by the aircrew without significant performance degradation.

REQUIREMENT GUIDANCE

The elimination of all downward vision restriction due to protuberances such as the oxygen mask nose cup and the chemical defense barrier interface with the lens may be unavoidable. Downward restriction of at least 15° can be expected.

A reference for aircrew lens optical characteristics is MIL-L-38169. This specification will provide optical characteristics for various classes of lenses from clear to 99 percent filter. Optical requirements include prismatic deviation, luminous transmittance, optical distortion, and haze.

A material commonly used for lenses is polycarbonate. MIL-V-43511 is a specification for a flyer's helmet visor and provides impact resistance requirements. Equivalent requirements for the system lens should provide adequate ballistic protection.

Abrasion resistance requirements for a flyer's helmet polycarbonate visor is provided in MIL-C-83409. Equivalent requirements for the system lens should provide adequate abrasion resistance.

Lens fogging will most often occur when the ambient environment is cold and damp. The selection of ambient conditions of 32°F and 80% relative humidity would be an adverse lens fogging environment which is likely to occur at a NATO airbase.

Unless a requirement is provided by the Statement of Need or the user, emergency defogging within 5 seconds should be an adequate time period.

REQUIREMENT LESSONS LEARNED

Ventilation airflow must be properly directed to prevent drying of the eyes and still adequately prevent lens fogging.

4.2.1.11 **CB optical system tests.** The following tests shall be performed to verify the requirements of 3.2.1.11.

a. Optical quality tests. Test per __________.

b. Ballistic protection tests. Test per __________.

c. Abrasion resistance tests. Test per __________.

d. Low temperature tests. A human test subject with visual acuity of __________ or better shall don the system and sit in a chamber at the temperature and humidity specified in 3.2.1.11. Acuity measurements shall be taken at __________ intervals. A reduction in the visual acuity or any lens fogging shall constitute a failure. The ventilation system shall be turned off to permit complete fogging of the lens. The emergency defogging system shall be activated and time to defog the critical lens viewing area shall not exceed the requirement of 3.2.1.11.

VERIFICATION RATIONALE (4.2.1.11)

Testing must be performed to assure the wearability and flight safety of the system without significant aircrew performance degradation.

VERIFICATION GUIDANCE

MIL-L-38169 provides test methods for optical quality. These test methods cover prismatic deviation, luminous transmittance, optical distortion, and haze which are the primary optical quality tests.

MIL-V-43511 provides an impact test method for a flyer's helmet polycarbonate lens. This test method is general in nature and should be applicable to most lens designs.

Abrasive resistance test methods for plastics are provided in Federal Test Method Standard No. 406. Test Methods 1092 and 3022 of FED-STD-406 are applicable test methods. Haze and luminous transmittance should be determined before and after abrasion testing.

Selection of test subjects with eyesight of 20/20 or better is essential for the low temperature tests. Acuity measurements at 3-minute intervals should be adequate. A measureable reduction in the far or near visual acuity using the Standard Snellen Chart at a distance of 20 feet or any fogging in the lens critical area should constitute a failure. Where emergency lens defogging is provided, this system should be exercised to determine its effectiveness in clearing the lens. At least six test subjects should be selected to acquire an adequate data base.

VERIFICATION LESSONS LEARNED

3.2.2 Eye protection

3.2.2.1 General protection. Eye protective equipment shall be designed to provide protection against high levels of ________ likely to be encountered in the operational environment.

REQUIREMENT RATIONALE (3.2.2.1)

Eye protection in the aircrew operational environment is of significant importance since loss or degradation of visual capability can seriously affect crew performance and accomplishment of the mission and in some cases cause loss of the aircraft. The higher intensity of solar ultraviolet radiation which is prevalent at aircraft flight altitudes emphasizes the need for sunglare protection. Impact protection for the eyes and surrounding facial areas is necessary to mitigate injury potential during situations such as survivable crashes, battle damage, cockpit fires and bird-strike incidents. Windblast eye protection is necessary during emergency ejection from high speed aircraft.

REQUIREMENT GUIDANCE

Performance parameters for aircrew ophthalmic lenses are essentially concerned with optical characteristics such as transmittance, chromaticity, neutrality, distortion, power, haze and optical quality aspects. Requisite characteristics for ophthalmic lenses have been developed over the years based on inputs from the users, the Air Force medical community, and transparent-materials experts.

Requirements for standard military sunglasses, HGU-4/P, can be found in MIL-S-25948. General requirements for curved-eyeshield polycarbonate helmet visors, both clear and tinted, can be found in MIL-V-43511. If a polycarbonate visor lens is desired, then a protective hard coating specified in MIL-C-83409 should also be required. Optical characteristics for goggle and helmet visor lens can be found in MIL-L-38169. Aircrew ophtalmic lenses are divided into three classes based on their transmittance under specification MIL-L-38169, Class 1 lenses transmitting approximately 90% are untinted and intended for nocturnal use. Class 2 lenses transmitting approximately 15% are neutral gray tinted and intended for day time use. Class 3 lenses transmitting approximately 2% are heavily tinted and intended for day time nuclear flash protection. Polycarbonate visor lenses under specification MIL-V-43511 are divided into Classes 1, 2, and 2G for clear, neutral gray tinted, and neutral gray gradient tinted respectively.

Mechanical impact and windblast protection is dependent upon the type of head protection being employed and the specific operational mission requirements.

REQUIREMENT LESSONS LEARNED

Lens materials have been changed over the years to keep pace with changes in aircraft performance. Early visor lenses were fabricated (blow molded) from acrylic materials, however, current trends are to hard coated, injection molded polycarbonate resins to exploit the greater toughness and impact resistance of these materials. Although superior optical properties are attainable in glass lenses, inherent fragility and greater weight in comparison to plastics have limited their use to spectacles and sunglasses.

4.2.2.1 General protection verification. The eye protective equipment shall be evaluated by examination, test, and demonstration to determine compliance with 3.2.2.1 and to verify acceptable integration characteristics with other aircrew headgear items.

VERIFICATION RATIONALE (4.2.2.1)

Verification of compliance with configuration and integration requirements is best determined by examination and demonstration. Compliance with required optical characteristics can only be determined by testing.

VERIFICATION GUIDANCE

Test methods for optical characteristics are provided in MIL-L-38169. Test Method 3022 in FED-STD-406 can be used in determining luminous transmittance and haze of planar sections of transparent plastics. Demonstration tests should be specified as appropriate for the mission requirements to assure that (1) there is no significant degradation in aircrew performance and (2) that the eye protective device will integrate with the headgear and other life support equipment.

VERIFICATION LESSONS LEARNED

Maintenance of high optical quality in aircrew ophthalmic lenses is of significant importance to preserve aircrew visual capabilities. Plastic visor lenses in particular have been criticized by user activities for deficiencies in optical property aspects such as distorted vision and observed point defects. Since service use of lenses can be expected to degrade optical quality, it is very important that manufacturing defects and optical imperfections in new items not be permitted.

3.2.2.2 Nuclear flash protection. Nuclear flash protective equipment shall be designed to protect the eyes of aircrew members against flash blindness and retinal burns associated with military operations in a nuclear environment. The device shall be fully functional in the __________ air vehicle environment and compatible with _________.

REQUIREMENT RATIONALE (3.2.2.2)

Past studies and analyses have revealed that crew member eye hazards such as flash blindness and retinal burns prevail at greater ranges from a nuclear detonation than any other weapon effect. Good vision is of paramount importance in the performance of crew duties and even a temporary loss of visual acuity can be disastrous during critical mission phases. Flash blindness and retinal hazards are greatest under conditions of low light level as the dark adapted eye is much more sensitive to sudden increases in brightness.

REQUIREMENT GUIDANCE

Past development efforts by the AF, Army and Navy have established performance criteria for protecting the eyes of personnel against flash blindness and retinal burns associated with military operations in nuclear warfare scenarios. Typically the established criteria have been based on state-of-the-art capabilities of various eye protective device concepts rather than ultimate values to optimize visual capabilities and protective response. An effective device for protection against flash blindness and retinal burns will entail acceptance of compromise in certain technical design areas to achieve operational acceptability and compatibility with the air vehicle environment.

An eye protective device, depending upon the basic type, will have its own set of performance parameters. For example, all protective devices will have a specified transmittance value. For a fixed-filter device this value will not change and for a dynamic-filter device this value will change over several orders of magnitude from the open to the closed state. Other performance aspects for all types of devices are good optical quality and freedom from distortion in all transmitting states and visual field considerations. Dynamic protective devices have additional performance parameters related to triggering, density versus time in the closure mode, and ambient light level controlled reopening.

The type of flash-blindness device most appropriate is dependent upon such factors as mission requirements, type of air vehicle, and crew member position in the air vehicle. Use of a thermal-flash protective window in the air vehicle may be the preferred approach over use of a helmet-mounted flash-blindness protective device. If the helmet-mounted approach is taken, provisions to mount the device in flight may be necessary.

Key features of a flash-blindness device are closure and opening times. Rapid closure is necessary to prevent eye injury and rapid opening is necessary to allow aircrew to perform the mission successfully. The closure and opening times are essentially based on the state-of-the-art in the development of flash-blindness devices.

REQUIREMENT LESSONS LEARNED

Early operational aircrew eye protective devices consisted of monocular eye patches for use at night and gold-coated fixed filters in goggle lens and helmet visor lens configurations for daytime use. These items, while possessing many drawbacks, have been utilized by the Strategic Air Command and other nuclear strike forces since nothing better was available. Drawbacks of the eye patch are decrement of the visual field, loss of binocular vision, and degraded depth perception. The major drawback of the fixed-filter devices is their unsuitability for use at night and other low light level conditions likely to be encountered in the operational environment. Fixed-filter devices employing a thin gold coating on an absorptive plastic substrate have been found to be susceptible to abrasion damage in operational use. An absorptive fixed-filter configuration has been developed to alleviate this problem. A number of eye protective device concepts have resulted from research and development efforts sponsored by the Army, Navy and Air Force. These efforts involved directly activated photochemical filter devices, indirectly activated filter devices employing photochromic (reversible) materials, mechanical shutter techniques, and explosively deployed opaque media. Although several of these concepts progressed to the point of fabrication of hardware for operational test and evaluation by the major air commands, none were considered completely acceptable for service use. Reasons for rejection by the operational commands included factors such as inadequate visual capabilities, aircraft weight and volume penalties, high aircraft modification cost, and an expressed preference for protective equipment which does not encumber the crew member or present other problems during emergency situations.

4.2.2.2 **Nuclear flash protection verification.** Nuclear flash protective equipment shall be evaluated by examination, test, and demonstration to determine compliance with 3.2.2.2 and to verify acceptable integration characteristics.

VERIFICATION RATIONALE (4.2.2.2)

Verification of compliance with configuration and integration requirements is best determined by examination and demonstration. Compliance with required optical characteristics can only be determined by testing.

VERIFICATION GUIDANCE

Specific verification requirements are dependent upon the type of flashblindness equipment developed. Dynamic protective devices rather than passive devices are now the preferred device. Dynamic protective devices usually have performance requirements related to triggering, density versus time in the closure mode, and ambient light level controlled reopening. Optical quality and visual field requirements also need to be evaluated.

VERIFICATION LESSONS LEARNED

It is of significant importance that provisions for flash blindness protective equipment and especially those which are electrically powered be considered early in the conceptual phase of a new weapon system to assure their compatibility with other equipment, availability of necessary power, and satisfaction of mission requirements.

3.2.2.3 **Laser radiation protection.** Eye protective equipment shall be designed to provide protection against laser radiation likely to be encountered during the aircraft mission. The device shall be designed to afford at least ___________ % protection at ___________ wave lengths while providing at least a visible light transmittance of __________ %.

REQUIREMENT RATIONALE (3.2.2.3)

Recent developments in laser technology have resulted in an increase in the utilization of these devices for military applications. The increased use of these systems in military applications increases the probability of exposure of aircrew personnel to injurious effects of laser radiation. Unique eye hazards attributed to laser radiation are the high intensity, monochromaticity, directivity, and coherence of beams from laser sources resulting in eye injury potential at considerable distances. The basic protection concept relies on imposing a reflective or absorptive filter media between the eyes and the source to reduce exposure to the maximum permissible exposure (MPE) level or lower.

REQUIREMENT GUIDANCE

Laser eye protective filters can be made available in a number of different configurations dependent upon specific aspects of their intended use. To be suitable for use by aircrew personnel they must: (1) not unduly restrict peripheral vision, (2) be compatible with aircrew head gear, and (3) must be of acceptable optical quality. In view of these considerations, aircrew spectacle or helmet visor lens configurations are preferable. A comprehensive evaluation of 60 different items of laser protective eye wear is provided in USAF School of Aerospace Medicine Report SAM-TR-78-30 which covers pertinent aspects of commercially available and AF-developed items. The first blank should be filled in with the required Optical Density (OD) value dictated by the operational situation.

Protection standards such as Permissible Exposure Level (PEL) and Safe Eye Exposure Distance (SEED) are contained in AFOSH-STD-161-10. American National Standard Z 136.1-1976, "Standard for the Safe Use of Lasers" contains criteria based on laser characteristics to avoid injury from accidental exposure to their beams.

The second blank should be filled in with the specific laser wave length for which eye protection is required as dictated by the particular laser being employed. The third blank should be filled in with the required visible light transmittance value. This value should be as high as possible consistent with the required Optical Density value at the specified laser wave length to provide optimum visibility outside the required high density spectral attenuation region.

Suitability for use in the intended operational environment, durability, and resistance to environmental conditions are major performance parameters which must be considered in addition to the specified spectral attenuation and visible light transmittance characteristics.

REQUIREMENT LESSONS LEARNED

Evaluation of commercially available laser protective filters which were essentially designed for use on the ground or in a laboratory environment revealed that these items had significant limitations precluding their use by aircrews during flight operations. Major limitations included inadequate visual field, poor integration with aircrew life support equipment such as helmets and oxygen masks, and degraded visual acuity resulting from low transmissivity or excessive color distortion. These shortcomings may be minimized by proper design for the intended application.

4.2.2.3 Laser radiation protection verification. Eye protective equipment shall be evaluated by examination, test, and demonstration to determine compliance with 3.2.2.3 and to verify acceptable integration characteristics.

VERIFICATION RATIONALE (4.2.2.3)

Verification of compliance with configuration and integration requirements is best determined by examination and demonstration. Compliance with required optical characteristics can only be determined by testing.

VERIFICATION GUIDANCE

Specific verification requirements are dependent upon the type and configuration of laser eye protective device. Testing is necessary to verify existence of the specified optical density value at the specified wave length and the specified minimum visible light transmittance. Demonstration of complete suitability in the use environment is necessary to assure that field of view limitations or color distortion will not degrade operational use of the item.

VERIFICATION LESSONS LEARNED

3.2.2.4 Thermal radiation protection. The aircrew members and crew station areas of aircraft with wartime nuclear mission roles shall be provided with thermal shielding over normally transparent areas.

REQUIREMENT RATIONALE (3.2.2.4)

Thermal radiation protection for the crew and crew station areas of aircraft with nuclear warfare roles is necessary to optimize survivability and approach a balanced hardness to nuclear weapon effects. An unprotected crew station transparent area exposes the crew to the hazards of skin burns, debilitating eye effects, and smoke and flame from crew compartment contents at ranges from a detonation where the basic airframe could be expected to survive the blast and thermal loading effects. (Reference - "The Effects of Nuclear Weapons", Samuel Glasstone.) The basic protection concept is to shield out high thermal flux levels by placing primarily reflective materials on the inboard side of aircraft transparent areas. Potential advantages of integrated thermal and flash protective systems are unencumbered crew members, unhampered visual access to controls and data displays within the crew station and mitigation of integration problems of flash blindness protective equipment with other crew equipment or life support items which must be worn.

REQUIREMENT GUIDANCE

Nuclear weapon effects, survivability, and vulnerability studies conducted on many weapons systems have pointed to the need for thermal protective barriers for crew stations and crew members operating in a wartime nuclear combat environment. These studies have shown that the crew thermal threat prevails at ranges beyond where other weapon effects such as over-pressure, nuclear radiation, and airframe damage would not result in a mission kill.

Basic performance parameters for aircraft thermal protective equipment are related to the thermal hardness of the materials used as the barrier, durability of the complete assembly including attachment, extension, and retraction mechanisms, time required for erection and stowage, and compatibility with other aircraft systems. Design operational concepts include manually operated, stowed in place, automatically operated stowed in place, or manually placed with remote stowage. Feasibility and practicality of these varied concepts will depend mainly on factors such as available space and clearance for extension and retraction mechanisms, non-interference with outside vision in the retracted position, compatibility with emergency egress provisions, and aspects affecting maintainability and life cycle cost. A requirement for an integrated thermal shield and flash blindness protection system, i.e., a thermal barrier with openings in various specified locations which permit protected outside vision should also be considered.

REQUIREMENT LESSONS LEARNED

Early nuclear mission role aircraft depended heavily on flexible fabric materials for construction of thermal barriers over transparent areas even for applications where flexibility was not a design constraint and more durable and maintainable rigid materials were available. Specific examples were the early use of white cotton duck material which soiled easily and was difficult to maintain and a MIL Specification aluminized fiberglass material with silicone rubber backing which could withstand a high thermal flux level when new, but which was not sufficiently resistant to every day wear and tear and required frequent repair or replacement. New design of aircraft thermal shields such as developed for the B-1 included rigid aluminum panels with integrated thermal flash protective devices for protected outside viewing. This design concept could be improved by expenditure of effort to decrease erection and stowage time, possibly by stowage in a position adjacent to the point of use to minimize handling and alignment of individual component panels.

4.2.2.4 **Thermal radiation protection verification.** Compliance with aircraft crew station thermal protection provisions along with the requirements of 3.2.2.4 shall be verified by examination and demonstration of fit and function in the intended air vehicle environment.

VERIFICATION RATIONALE (4.2.2.4)

Verification of compliance with configuration and integration requirements is best determined by examination and demonstration.

VERIFICATION GUIDANCE

Compliance with integration and compatibility requirements can only be assured by actual demonstration and flight test in the applicable air vehicle. Preliminary functional characteristics may be checked out in a crew station mock-up. Particular attention should be taken to ensure non-interference with other crew station systems, compliance with erection and stowing time requirements, if applicable, the use of suitable thermally resistant materials, and complete blockage of direct radiation through all crew station transparent areas. Suitability of previously unqualified thermal resistant materials should be verified by thermal testing.

VERIFICATION LESSONS LEARNED

3.2.2.5 <u>Eye protection personal equipment compatibility</u>. The aircrew eye protection system, when properly donned and worn with other personal flight ensembles, shall integrate and be compatible with the ______________ aircraft cockpit structure, environmental control system and electrical system. There shall be no interference with the function of the foll"wing aircrew life support equipment:

a. ______________ Headgear

b. ______________ Oxygen mask

c. ______________ Chemical and biological protective equipment

d. ______________ High altitude personal equipment

e. ______________ Vision enhancement device

f. ______________ Escape system

g. ______________ (Specify other)

REQUIREMENT RATIONALE (3.2.2.5)

Compatibility between the aircrew eye protection system and other personal protection systems and life support equipment is essential to mission performance and flight safety. Incompatibility between any life support system components could result in a flight safety hazard.

REQUIREMENT GUIDANCE

Each relevant item of life support equipment must be identified. The type of personal equipment to be worn by aircrew is dependent upon the aircraft type and SON for new equipment development.

REQUIREMENT LESSONS LEARNED

Omission of any pertinent feature could lead to later costly modifications of the aircrew eye protection system or to the aircraft cockpit.

4.2.2.5 __Verification of eye protection equipment compatibility__. The aircrew eye protection system shall be donned along with all required life support equipment by ________ aircrew test subjects. The test subjects shall enter a ________ aircraft designed or properly modified to accept the eye protection system. The eye protection system shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences, or other problems which are considered to be detrimental to the mission shall be cause for rejection.

VERIFICATION RATIONALE (4.2.2.5)

Ground simulation tests are useful and necessary precursors to the actual flight test to verify that flight safety hazards do not exist.

VERIFICATION GUIDANCE

The actual donning of the aircrew eye protection system by aircrew and performing a mission in the selected aircraft is the best procedure to verify the adequacy of the system. The larger the number of test subjects, the more thorough the evaluation. However, a reasonable number of test subjects to acquire adequate statistical data is six. The test subjects should be anthropometrically selected to represent, as nearly as practical, the USAF aircrew population. The actual aircraft selected for the test flights must be the same as the one or more types of aircraft in which the system is designed to be flown to prevent anomalies. Adequate ground testing prior to flight tests is essential to assure there are no flight safety problems. Typical tests include ground egress from an egress trainer to evaluate the emergency egress capability (including emergency doffing if required) and a hanging harness test to evaluate potential problems during parachute descent, although it is probable that the eye protection system will be lost during ejection windblast. Water survivability should also be evaluated since the system may have to be removed soon after water entry. Parachute jumps by qualified test parachutists over both land and water are normal tests to be accomplised prior to flight testing. Visiting using commands is helpful since aircrew trained in the aircraft for which the equipment under development is designated can provide insight on potential problem areas.

VERIFICATION LESSONS LEARNED

During the design process it is essential to verify compatibility with the use of mockups or early prototypes of the eye protection system. Since eye protection requires an addition to the personal equipment normally worn, some degradation in mission performance (e.g., visual field restriction, etc.) may be unavoidable. Continual evaluation of compatibility as the system is under development will prove beneficial in avoiding significant mission performance degradation problems.

3.2.2.6 **Eye protection environmental conditions.** The eye protection system shall be capable of withstanding and/or operating under the following environmental conditions induced by the aircraft, ground transport or storage: ________________.

REQUIREMENT RATIONALE (3.2.2.6)

The system must meet the environmental performance requirements to assure that it will function satisfactorily following storage and during operational use in specified climatic conditions.

REQUIREMENT GUIDANCE

Worldwide climatic environmental conditions are enumerated in MIL-STD-210, Climatic Extremes for Military Equipment. Generally, the system or components of the system will encounter conditions less severe than the environmental levels stated in MIL-STD-210. Environmental extremes should be based on the cockpit environment, outdoor transit environment, and storage environments anticipated for the mission of the aircraft and theater of operations. Environmental conditions to consider include storage temperature extremes, operating temperature extremes, rapid changes in ambient operational termperatures, solar radiation, blowing rain, humidity during storage and operation, environmental fungus, environmental salt fog, and environmental dust. The system should also be designed to provide the required performance during and after exposure to the following induced environments: Acceleration, vibration, acoustical noise, and shock. MIL-STD-810 provides test levels which may be used as a guide for selecting the appropriate environmental performance limits for each component or assembly of the system based on its operational use.

REQUIREMENT LESSONS LEARNED

4.2.2.6 **Verification or eye protection environmental conditions.** The system shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in 3.2.2.6.

VERIFICATION RATIONALE (4.2.2.6)

The system or its components, as applicable, must be tested and analyzed under all of the natural environment and induced environment extremes that will be encountered during operational use or storage.

VERIFICATION GUIDANCE

The test procedures of MIL-STD-810 may need to be modified to reflect the true requirements (see paragraph 1.2 of MIL-STD-810).

VERIFICATION LESSONS LEARNED

Lack of proper and complete verification can lead to very costly modification or replacement of equipment.

3.2.3 Anti-G protection

4.2.3 Anti-G protection verification

3.2.3.1 **Anti-G personal equipment compatibility.** The anti-G garment, when properly donned and connected to the pressure source, shall integrate and be compatible with the ____________ aircraft cockpit structure and environmental control system. There shall be an immediate warning to the aircrew in the event of the loss of gas pressure to the anti-g garment. There shall be no interference with the function of the following life support equipment:

a.________ Parachute harness
b.________ Flight coverall
c.________ High altitude personal equipment
d.________ Escape system
e.________ ________________
(Specify other)

REQUIREMENT RATIONALE (3.2.3.1)

Compatibility between the anti-G protection system and other life support equipment is essential to mission performance and flight safety. Incompatibility between any life support system component could result in a flight safety hazard. The unknown loss of gas pressure to the anti-g garment is a life threatening situation for high performance fighter aircrew.

All relevant life support equipment and cockpit features must be identified to assure that the aircrew can perform the aircraft mission without significant degradation in performance or flight safety.

REQUIREMENT GUIDANCE

Each relevant item of life support equipment must be identified. The type of personal equipment to be worn by aircrew is dependent upon the aircraft type and Statement of Need for new equipment development.

REQUIREMENT LESSONS LEARNED

There is a need for a warning system for the loss of gas pressure to the anti-g garment. Inadvertent disconnects are too common an occurrence.

4.2.3.1 **Anti-G compatibility tests.** The Anti-G garment shall be donned and fitted properly along with all required life support equipment by ____________ aircrew test subjects. The test subjects shall enter a _____________ aircraft properly modified to accept the anti-G protection system. The anti-G garment shall function properly throughout the selected mission for the aircraft. Any undue pressures, restrictions, interferences, or other problems which are considered to be detrimental to the mission shall be cause for rejection.

VERIFICATION RATIONALE (4.2.3.1)

The actual donning of the anti-G garment by aircrew and performing a mission in the selected aircraft is the best procedure to verify the adequacy of the system. Ground simulation tests are useful and necessary precursors to the actual flight test to verify that flight safety hazards do not exist.

VERIFICATION GUIDANCE

The larger the number of test subjects, the more thorough the evaluation; however, a minimum number of test subjects to acquire an adequate data base is six. The test subjects should be anthropometrically selected to represent as nearly as practical the USAF aircrew population. The actual aircraft selected for the test flights must be the same as the one or more types of aircraft in which the system is designed to be flown to prevent anomalies. Adequate ground testing prior to flight tests is essential to assure there are no flight safety problems. Typical tests include ground egress from an egress trainer to evaluate an emergency egress and a hanging harness test to evaluate parachute descent problems. Parachute jumps by qualified test subjects over both land and water are normal tests to be accomplished prior to flight testing should a safety problem be identified.

VERIFICATION LESSONS LEARNED

3.2.3.2 **Anti-G environmental conditions.** The anti-G protection system shall be capable of withstanding and operating under the following environmental conditions induced by the aircraft or storage _________.

REQUIREMENT RATIONALE (3.2.3.2)

The system must meet the environmental performance requirements to assure that it will function satisfactorily during operational use and following storage in all climatic conditions.

REQUIREMENT GUIDANCE

Worldwide climatic environmental conditions are enumerated in MIL-STD-210, Climatic Extremes for Military Equipment. Generally, the system or components of the system will encounter conditions less severe than the environmental levels stated in MIL-STD-210. Environmental extremes should be based on the cockpit environment, outdoor transit environment, and storage environments anticipated for the mission of the aircraft and theater of operations. Environmental conditions to consider include storage temperature extremes, operating temperature extremes, rapid changes in ambient operational temperatures, solar radiation, blowing rain, humidity during storage and operation, environmental fungus, environmental salt fog, and environmental dust. The system should also be designed to provide the required performance during and after exposure to the following induced environments: Acceleration, vibration, and shock. MIL-STD-810 provides test levels which may be used as a guide for selecting the appropriate environmental performance limits for each component or assembly of the system based on its operational use.

The engineer should assure that these requirements are appropriately tailored to the operational need and are not excessive resulting in unneeded operational capability.

REQUIREMENT LESSONS LEARNED

Failure potential results when all possible operational extremes are not tested.

4.2.3.2 Anti-G environmental tests. The system shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in 3.2.3.2

VERIFICATION RATIONALE (4.2.3.2)

The system or its components, as applicable, must be tested and analyzed under all of the natural environment and induced environment extremes that will be encountered during operational use or storage.

VERIFICATION GUIDANCE

The test procedures of MIL-STD-810 may need to be modified to reflect the true requirements (see paragraph 1.2 of MIL-STD-810). For example, specification MIL-V-9370 provides environmental test requirements for the current anti-G garment automatic pressure regulating valve. A new specification for high-flow ready-pressure, pressure regulating valves is being developed which will also provide environmental test conditions to use as a guide.

VERIFICATION LESSONS LEARNED

3.2.3.3 Anti-G pressure regulation. The pressure regulating source shall sense change in acceleration force to provide gas pressure to the anti-G garment as specified by the following schedule ________.

REQUIREMENT RATIONALE (3.2.3.3)

To prevent problems associated with grey out, black out, or loss of consciousness during high-G maneuvers and high rates-of-onset of various high performance aircraft, the pressure in the anti-G garment must be automatically adjusted with the G-force present.

REQUIREMENT GUIDANCE

The current anti-G valve has basically remained unchanged since the early 1950s. The valve automatically regulates the inflation pressure to the anti-G suit during periods of positive acceleration. The air used in this process is from aircraft engine bleed air which has been cooled and filtered and enters the valve inlet fittings at pressures from 10 to 300 psi. The valve contains a relief system which limits suit pressure to 11 psi. The current valve, which has an airflow rate of 15 cubic feet/minute (CFM), begins inflating the suit at 2 Gs and continues pressurizing at the rate of 1.5 psi per G up to a maximum of 10.5 psi. The valve is slow to build up to the maximum pressure (approximately five seconds to reach 10 psi) in terms of today's operational aircraft which can pull up to 9 Gs with rates of onset at least at the 6 G/second level.

The USAF School of Aerospace Medicine (USAFSAM) conducted research on a "High-Flow Ready-Pressure" (HFRP) anti-G valve. The concept finally selected and tested was a valve similar to the current valve with the added feature of a higher flow rate (22 CFM) and a ready pressure in the suit of 0.2 psi which reduced the time to inflate the suit once the aircraft was in a high-G maneuver. The data shows a reduction in the time to inflate (at the 7 psi level) of two seconds.

Aircraft presently in service have demonstrated their capability to exceed the limits of human physiological tolerance to acceleration stress. The F-16, with its computer-limited control authority, releases pilots from the necessity of caution in approaching the airframe structural load factor limit. Since, under combat conditions, this aircraft is capable of generating acceleration onset rates of around 6 G/second, it is operating in a performance realm which is unique. This realm of performance also imposes stresses on the pilot which are unique and which are not always survivable. Both formal and anecdotal reports from the field contain information concerning incidents of sudden loss of consciousness related to high +Gz stress.

Specification MIL-V-9370 provides a performance schedule for the current valve. A new specification for the HFRP valve is being developed which will contain a performance schedule.

It is likely that electronic servo valves will be used in the near future.

REQUIREMENT LESSONS LEARNED

A systems approach to the problems of acceleration protection in high performance aircraft must be taken to assure that acceleration stress does not exceed the limits of human physilogical tolerance.

4.2.3.3 Anti-G pressure regulation tests. The anti-G protection system shall be analyzed and tested to demonstrate the capability to meet the schedule cited in 3.2.3.3

VERIFICATION RATIONALE (4.2.3.3)

The system or its components, as applicable, must be tested and analyzed under all the induced acceleration stresses that will be encountered during operational use to determine if the system will meet the schedule of performance.

VERIFICATION GUIDANCE

Tests have been developed to evaluate current anti-G protection system compenents. Specification MIL-A-83406 describes a test procedure to measure the inflation time of the CSU-13B/P anti-G garment. Specification MIL-V-9370 describes test procedures to measure minimum operating accelerating force, outlet pressure regulation, and response times for automatic pressure regulating valves. A new specification for high-flow ready-pressure valves is being developed which will also provide test procedures to use as a guide. This new specification also describes manned and unmanned centrifuge tests. By acceleration through a simulated air combat maneuver with test subjects, a subjective evaluation of the system performance can be acquired prior to a flight test evaluation.

VERIFICATION LESSONS LEARNED

Care should be taken in testing the anti-G garment since the inflation tests in the past have many times resulted in frayed or torn outer fabric.

3.2.3.4 Anti-G utilization. The following anti-G protection system use requirements shall be met:

a. Donning - The anti-G garment shall be capable of being donned and adjusted by the wearer without assistance or difficulty.

b. Comfort - The anti-G garment shall fit the ____________ to ____________ percentile of aircrew members in height and weight. The aircrew member shall experience no discomfort when the garment is uninflated and shall not experience undue high pressure areas or other intolerable discomfort when the garment is inflated.

c. Subjective use - The system shall have no objectionable performance characteristics such as skin irritation, restriction of movement, or any other property that may cause excessive discomfort, affect wearability, or cause inadvertent disconnect from pressure source.

REQUIREMENT RATIONALE (3.2.3.4)

Utilization requirements are essential to assure the wearability of the system and the achievement of the mission requirement for the aircrew without significant performance degradation.

REQUIREMENT GUIDANCE

Utilization requirements are based upon the Statement of Operational Need for the system and previous experience in the development of similar systems. Use requirements are generally qualitative by nature except where the Statement of Operational Need provides a specific quantitative requirement such as a time period for donning and fitting requirements. Identification of possible objectionable performance characteristics that can be subjectively evaluated is an important requirement. It should be recognized that some discomfort is inherent from wearing an anti-G garment due to pressures on the torso required to provide anti-G protection. Therefore, it is important that appropriate sizing criteria be used. Fitting the 1st to 99th percentile aircrew population should be attainable. Guidance can be found in USAF Reports, AMRL-TR-79-28, "Revised Height/Weight Sizing Programs for Men's Protective Flight Garments" and AMRL-TR-79-35, "Height/Weight Sizing Programs for Women's Protective Garments." Also, the Armstrong Aerospace Medical Research Laboratory (AAMRL), Human Engineering Division, should be queried for the latest anthropometric data on the aircrew population.

REQUIREMENT LESSONS LEARNED

The current CSU-13/P anti-G garment is connected to a source of pressure by means of a quick-disconnect fitting. The male portion of this fitting is carried on the pressure tube of the garment while the female portion of the connector is attached to the pressure source of the aircraft. The Tactical Air Command (TAC) reports that many inadvertent disconnects have occurred. Possible causes cited were: aircrew movement, high G's, hoses too long, and hoses too short.

During operation of console instrumentation, the hose system is inadvertently struck by hand causing disconnect.

Difficulty has been encountered in the past with a specific size of garment being capable of being fitted to all aircrew within the height-weight range for which the garment was designed. Frequently the problem was due to poor workmanship.

4.2.3.4 **Verification of anti-G utilization.** The following use tests shall be performed to verify the requirements of 3.2.3.4__________.

VERIFICATION RATIONALE (4.2.3.4)

Testing must be performed to assure the wearability and flight safety of the anti-G protection system without significant aircrew performance degradation.

VERIFICATION GUIDANCE

Since the test requirements are subjective in nature, only those test limits which have been provided by the Statement of Need or other documented user requirement can be applied. Testing is primarily subjective and requires trained test subjects and aircrew to provide a thorough assessment of the airworthiness of the system. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population so as to adequately evaluate the various sizes of anti-G garments. A minimum number of six test subjects is necessary to acquire an adequate data base, however, the larger the number of test subjects, the more thorough the evaluation.

VERIFICATION LESSONS LEARNED

The high occurrence of inadvertent disconnects between the anti-G garment and source of pressure shows the need for a thorough evaluation of aircrew human factors problems with the installation location of the pressure source. Each potential cockpit installation must be thoroughly evaluated to assess potential disconnect problems associated with length of hose, aircrew movement, high-G maneuvers, and operation of console.

3.2.3.5 Anti-G endurance. The anti-G protection system shall be subjected to the following cyclic operational conditions, __________, and shall subsequently meet the requirements of 3.2.3.2 and 3.2.3.3.

REQUIREMENT RATIONALE (3.2.3.5)

Reliability of the anti-G system must be defined to assure that the system will perform satisfactorily throughout its required service life. Cyclic stress requirements are necessary to assure the structural integrity of the system over its desired service life.

REQUIREMENT GUIDANCE

Selection of appropriate cyclic operational conditions is dependent upon the mission requirements for the system; i.e., the acceleration stress requirement and the service life requirement. Specification MIL-A-83406 provides endurance requirements for the current anti-G garment, CSU-13B/P. The endurance requirement in MIL-A-83406 is to inflate the garment 1000 times to a pressure of 15 psig. The pressure designated in this specification is approximately 50 percent above the maximum use pressure and thus adequately stresses the garment during an endurance test. The number of cycles selected should likewise exceed the anticipated cycles for normal use of the garment. Specification MIL-V-9370 provides endurance requirements for the current automatic pressure regulating valve. The requirements in this specification vary the inlet pressure, inlet air temperature, and applied force at selected numbers of cycles of operation. Since the design of the pressure source as well as the garment will vary for future aircraft, cyclic operational conditions should reflect the acceleration stresses imposed by the mission requirements for these advanced aircraft. The endurance requirements should stress the anti-G protection system significantly beyond its normal operational limits.

REQUIREMENT LESSONS LEARNED

4.2.3.5 Anti-G endurance tests. The following endurance tests shall be performed to verify the requirements of 3.2.3.5.________.

VERIFICATION RATIONALE (4.2.3.5)

The system or its components, as applicable, must be endurance tested to assure that the system will reliably perform throughout its required service life.

VERIFICATION GUIDANCE

Current specifications for the anti-G garment and the automatic pressure regulating valve, MIL-A-83406 and MIL-V-9370 respectively, provide endurance test requirements that may be used as a guide in developing new system component endurance test methods. Cyclic operation test conditions must represent the mission requirement and stress the system beyond its required service life.

VERIFICATION LESSONS LEARNED

3.2.3.6 Anti-G equipment during escape. The anti-G equipment shall not loosen, tear, or otherwise fail structurally resulting in possible injury or interference with emergency ground egress, survivable crash, the bailout or emergency ejection sequence, seat-man separation, parachute deployment and descent, ground landing, water entry or raft boarding. Disconnects shall operate properly during ejection and shall release with an applied force of not less than ________ pounds nor more than ________ pounds. Also the disconnect shall not allow water entry following water landing.

REQUIREMENT RATIONALE (3.2.3.6)

The anti-G garment must meet escape requirements for the designated aircraft to prevent induced bodily injury by the garment during an emergency ejection or bailout, parachute descent, survivable crash and landing on the ground or in the water.

REQUIREMENT GUIDANCE

Dynamic forces that may be encountered during a typical ejection are germane to the type of aircraft for which the anti-G garment is intended. Dynamic forces include both inertial forces and windblast forces. The anti-G garment should not contribute to injury of the aircrew member during ejection.

The intensity of the acceleration force selected to test the garment design for ejection injury potential should meet or exceed the acceleration force imposed by the ejection seat. An acceleration force 1.25 times greater than that imposed by the ejection seat is a reasonable requirement which provides a safety factor to assure adequate performance of the garment during an ejection.

Windblast forces selected to assess injury potential should be typical of ejection velocities anticipated for the aircraft and should include those forces at the maximum velocity of the escape envelope of the aircraft. Imposing high velocity windblast requirements may result in a considerably heavier construction of the garment than desired, thus degrading aircrew performance. However, it is necessary to evaluate the anti-G garment at the maximum velocity of the escape envelope to ensure seat/aircrew compatibility.

A quick disconnect provides the primary interface between the aircrew and the aircraft (e.g., garment bladder and gaseous system). This disconnect separates from the aircraft due to the force of the ejection. The disconnect should be omnidirectional to assure against possible binding or failure to release. The disconnect should release with an applied force not less than 8 nor more than 24 pounds. This range will avoid inadvertent disconnects and minimize the induced load on the aircrew during an ejection. Flailing of the anti-G garment hose following ejection separation from the aircraft and/or failure of the disconnect to properly separate are two major concerns which must be addressed in the design of the garment to assure safe parachute opening and descent. Of major concern is the capability to assure bleed off of the garment bladder pressure prior to water entry. Flotation should not be provided by the anti-G garment bladder.

REQUIREMENT LESSONS LEARNED

4.2.3.6 Verification of anti-G equipment during escape. The following tests shall be performed to verify the requirements of 3.2.3.6.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration)
c Release force
d. Wind tunnel
e High speed sled

f. Seat ejection (IAW MIL-STD-846, paragraph 3.3, as applicable)
g. Hanging harness
h. Parachute
i. Water survival
j. ______________________________
(Specify other)

VERIFICATION RATIONALE (4.2.3.6)

The capability of the aircrew to survive an emergency ejection or bailout at various airspeeds, a parachute descent, survivable crash and landing on the ground or in the water must be verified through simulated and actual environment tests. Test procedures and equipment have been developed to perform such tests. Test procedures must be modified and new procedures added as necessary to suit each type of aircrew anti-G garment and the aircraft for which it is designed.

VERIFICATION GUIDANCE

Test limits for the variety of tests required are determined by the type of aircraft, mission, Statement of Operational Need, and good judgement which weighs the severity and number of tests needed to assure that the system is flightworthy.

Windblast tests are normally performed by mounting the system on an appropriately instrumented test dummy properly restrained for ejection in an ejection seat. The dummy is exposed to windblasts of 500 KEAS (knots equivalent airspeed) or the aircraft design requirement (ejection is possible at velocity 600 KEAS) to determine the velocity at which the system will fail. A typical velocity profile is a rise time to peak velocity of 0.3 second with no dwell at maximum velocity and decay to 200 knots in 3 seconds. Although this velocity profile does not match an actual ejection, it is within the capability of available test facilities and provides a good structural test of the system. Seat attitudes should be varied in both pitch and yaw directions to simulate possible ejection positions and assure a thorough structural test.

The acceleration tests can be performed by mounting the system on a dummy properly restrained in an ejection seat, in an ejection tower (or deceleration tower) test facility. Where an ejection tower is used, separation of quick disconnects can be photographed and separation forces can be measured with appropriate instrumentation. High speed photography is used to provide evidence of any slippage, loosening or other failure which could result in bodily injury.

In addition to the quick disconnect release forces measured at an ejection tower test facility, a test rig capable of simulating and measuring release forces may be used. Possible angles of man/seat separation should be simulated.

Prior to high speed sled tests, wind tunnel tests should be performed to carefully assess the compatibility of the ejection seat and aircrew worn equipment. These tests should be accomplished at varying ejection seat pitch and yaw angles as well as varying airspeeds to cover the aircraft operational envelope.

High speed sled tests are accomplished by mounting the system on a dummy appropriately restrained in an ejection seat. The seat is mounted on a sled with the appropriate aircraft forebody or a sting device in a position to simulate the initial stages of an ejection. The sled is accelerated to a predetermined velocity (approximately 500 KEAS or the aircraft design requirement velocity which may be as great as 600 KEAS). High speed photography provides the sequence of any failure.

An ejection seat test requires a similar test setup as the high speed sled test except that the sled has a closed canopy. Failure of the ejection seat to operate in the proper mode because of failure of aircrew/cockpit disconnects, or failure of the dummy to separate from the seat following the ejection would constitute a test failure.

In preparation for flight test evaluation, a hanging harness test is normally performed. A trained test subject wears the system with appropriate life support equipment and is suspended in a hanging parachute harness. The test subject must be able to perform all necessary parachute descent functions while suspended.

An actual parachute jump from an aircraft or helicopter by a trained test parachutist is normally performed prior to flight test evaluation. The test subject jumps from the aircraft onto dry land and into water. The system must not interfere with parachute opening or inhibit any descent functions. Good visibility and unrestricted arm movement are essential during descent. The test parachutist must be able to easily release his parachute riser releases. The ability to check the anti-G garment bladder pressure during parachute descent should also be evaluated.

Water drag tests should be performed prior to flight testing over water. This can be accomplished from the aft end of a boat appropriately rigged. The test subject is dragged in the water at various speeds simulating possible wind velocities. The test subject must demonstrate the capability of rolling over and releasing the riser quick release without undue problems.

VERIFICATION LESSONS LEARNED

Due to expense of seat ejection tests, "piggy-back" tests are usually preferred.

3.2.4 **High altitude protection**

3.2.4.1 **Personal equipment compatibility.** The pressure suit ensemble (PSE), when properly donned and worn with other personal flight items, shall be compatible and integrate with ____________ aircraft cockpit structure, environmental control system, and electrical system. There shall be no interference with the function of the following aircrew life support equipment:

a.________ Eye protection device
b.________ Chemical and biological protective equipment
c.________ Life preserver
d.________ Survival kit
e.________ Parachute harness
f.________ Survival vest
g.________ Anti-G suit
h.________ Anti-exposure suit
i.________ Thermal control suit
j.________ Vision enhancement device
k.________ ____________
(Specify other)

REQUIREMENT RATIONALE (3.2.4.1)

Compatibility between the PSE and other personal protection systems and life support equipment is essential to mission performance and flight safety. Incompatibility between any life support system component or the cockpit could result in a flight safety hazard.

REQUIREMENT GUIDANCE

Each relevant item of life support equipment must be identified. The type of personal equipment to be worn by aircrew is dependent upon the aircraft type and statement of need for new equipment development.

REQUIREMENT LESSONS LEARNED

Past experience reveals that omission of any pertinent feature can lead to later costly modifications of the PSE.

4.2.4.1 **High altitude personal equipment compatibility tests.** The PSE shall be donned along with all required life support equipment by __________ aircrew test subjects. The test subjects shall enter a __________ aircraft properly modified to accept the PSE. The ensemble shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems which are considered to be detrimental to the mission shall be cause for rejection of the ensemble.

VERIFICATION RATIONALE (4.2.4.1)

The actual donning of the PSE by aircrew and performing of a mission in the selected aircraft is the best procedure to verify the adequacy of the ensemble. Ground simulation tests are useful and necessary precursors to the actual flight test to verify that flight safety hazards do not exist.

VERIFICATION GUIDANCE

The larger the number of test subjects, the more thorough the evaluation; however, a reasonable number of test subjects to acquire adequate statistical data is six. The test subjects should be anthropometrically selected to represent as nearly as practical the USAF aircrew population. To prevent anomalies, the actual aircraft selected for the test flights must be the same as the one or more types of aircraft for which the ensemble is designed to be flown. Typical tests include ground egress from an egress trainer to evaluate an emergency egress and a hanging harness test to evaluate parachute descent problems. Water survivability should also be evaluated since the ensemble will cover the breathing cavity which must be opened to ambient air prior to water entry. Parachute jumps by qualified test subjects wearing the ensemble pressurized and unpressurized over both land and water are normal tests to be accomplished prior to flight testing.

VERIFICATION LESSONS LEARNED

During the design process it is essential to verify compatibility with the use of mockups or early prototypes of the PSE. Visiting using commands is helpful since aircrew trained in the aircraft for which the equipment under development is designated can provide insight on potential problem areas. Since high altitude protection requires an addition to the personal equipment normally worn, some degradation in mission performance (e.g., heat, weight, bulk, visibility and mobility) may be unavoidable. Continuous evaluation of compatibility as the system is under development will prove beneficial in avoiding significant mission performance degradation problems.

3.2.4.2 **Environmental conditions.** The PSE shall be capable of withstanding and operating under the following environmental conditions induced by the aircraft, ground transport or storage ________.

REQUIREMENT RATIONALE (3.2.4.2)

The PSE must meet the environmental performance requirements to assure that it will function satisfactorily during operational use and following storage in possible climatic conditions.

REQUIREMENT GUIDANCE

Worldwide climatic environmental conditions are enumerated in MIL-STD-210, Climatic Extremes for Military Equipment. Generally the ensemble or components of the ensemble will encounter conditions less severe than the environmental levels stated in MIL-STD-210. Environmental extremes should be based on the cockpit environment, outdoor transit environment, and storage environments anticipated for the mission of the aircraft and theater of operations. Environmental conditions to consider include storage temperature extremes, operating temperature extremes, rapid changes in ambient operational temperatures, solar radiation, blowing rain, humidity during storage and operation, environmental fungus, environmental salt fog, and environmental dust. The ensemble should also be designed to provide the required performance during and after exposure to the following induced environments: acceleration, vibration, acoustical noise, and shock. MIL-STD-810 provides test levels which may be used as a guide for selecting the appropriate environmental performance limits for each component or subcomponent of the ensemble based on its operational use.

REQUIREMENT LESSONS LEARNED

The engineer should assure that these requirements are appropriately tailored to the operational need and are not excessive.

4.2.4.2 **Verification of high altitude environmental conditions.** The ensemble shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in paragraph 3.2.4.2.

VERIFICATION RATIONALE (4.2.4.2)

The ensemble or its components, as applicable, must be tested and analyzed under all of the natural-environment and induced-environment extremes that will be encountered during operational use or storage.

VERIFICATION GUIDANCE

The test procedures of MIL-STD-810 may need to be modified to reflect the true requirements (see paragraph 1.2 of MIL-STD-810).

VERIFICATION LESSONS LEARNED

Environmental conditions can affect the PSE function and the effect should be determined prior to use by aircrew members under actual conditions. Malfunction of the PSE due to environmental conditions while being worn could result in a hazardous condition which might affect the wearer's well being and safety. Environmental condition effects, when found early-on in the design, can be corrected prior to human use.

3.2.4.3 **Speech intelligibility.** Speech intelligibility shall be at least ________ % in a ________ db noise environment. The PSE shall permit intelligible speech both inside and outside the aircraft. Speech intelligibility within the aircraft shall include interfacing with the aircraft intercom system. Ground communications capability shall be considered with and without the breathing compartment covered (prebreathing of 100 percent oxygen may require the visor to be closed).

REQUIREMENT RATIONALE (3.2.4.3)

Effective and efficient communication between aircrew members and between aircrew and groundcrew members must be accomplished in the mission environment. High noise levels are distracting and fatiguing.

REQUIREMENT GUIDANCE

The PSE noise level requirements are influenced by the type and mission of the aircraft. Speech intelligibility can be assessed by placing trained test subjects wearing the PSE in a noise environment and determining speech intelligibility.

REQUIREMENT LESSONS LEARNED

A thorough assessment of the noise environment in which the PSE could be worn, should be conducted. Speech intelligibility should be assessed under all possible noise environments.

4.2.4.3 **Speech intelligibility tests.** Speech intelligibility tests shall be conducted to verify that the PSE meets the limit specified in 3.2.4.3 in a noise environment of _________ measured by __________.

VERIFICATION RATIONALE (4.2.4.3)

Speech intelligibility can only be verified through the use of trained human test subjects to determine whether or not speech is intelligible in the mission noise environment when wearing the PSE. Testing procedures and equipment have been developed to simulate actual noise environments and scientifically measure speech intelligibility.

VERIFICATION GUIDANCE

Speech intelligibility can be assessed by placing at least 10 trained test subjects wearing the PSE in a noise environment of 105 dB sound pressure level (SPL) USASI spectrum or other SPL as appropriate to the mission and to determining speech intelligibility. The communication system is connected to an AIC-18 or AIC-25 interphone. The test subjects shall perform a modified Rhyme test and should score 80 percent or better. MIL-STD-1472, paragraph 5.3.12, provides recommended speech intelligibility test methods with the appropriate selection being dependent upon the requirements of the test.

VERIFICATION LESSONS LEARNED

Use of PSEs which cause speech to be unintelligible can create communication problems during operational use. A determination must be made of such problems in order to avoid the inevitable aircrew member reaction to a piece of life support equipment that does not function as required.

3.2.4.4 Escape. The PSE shall remain pressurized when required and shall not loosen, tear, or otherwise fail structurally resulting in possible injury or interference with emergency ground egress, the bailout or emergency ejection sequence, parachute descent, survivable crash, ground landing, or water entry. Adequate cockpit and airframe clearance during ejection from the aircraft shall be provided with the PSE inflated and uninflated. All ensemble disconnects shall operate properly during an ejection and shall release with an applied force not less than ______________ pounds nor more than ____________ pounds. The PSE shall not prevent timely operation of parachute riser releases after landing. The connectors shall be designed to prevent system contamination during connection or exposure in a CB environment and water entry in a post ejection water landing.

REQUIREMENT RATIONALE (3.2.4.4)

The ensemble must meet escape requirements for the designated aircraft to prevent bodily injury induced by the ensemble during an emergency ground egress and bailout or ejection, parachute opening shock, parachute descent, survivable crash, and landing on the ground or in the water. If the aircraft does not contain an ejection seat, this performance requirement should be revised accordingly.

REQUIREMENT GUIDANCE

Dynamic forces that may be encountered during a typical ejection are germane to the type of aircraft for which the ensemble is intended. Dynamic forces include both inertial forces and windblast forces.

The intensity of the acceleration force selected for ensemble design should meet or exceed the acceleration force imposed by the ejection seat. A acceleration force 1.25 times greater than that imposed by the ejection seat is a reasonable requirement which provides a safety factor to assure adequate performance of the ensemble during an ejection.

Windblast forces selected should be typical of ejection velocities anticipated for the aircraft and should include those forces at the maximum velocity of the escape envelope of the aircraft. Imposing high velocity windblast requirements may result in a considerably heavier construction of the ensemble than desired thus degrading aircrew performance. The windblast requirement presently used for high performance aircraft flight helmets is in the range of 450 to 500 KEAS which represents a trade-off in assuring head protection at lower ejection velocities while providing a lightweight, stable headgear system for optimum aircrew performance during the mission. However, it is necessary to evaluate the PSE at the maximum velocity (or the aircraft design requirement velocity which may be as great as 600 KEAS) of the escape envelope to assure seat/aircrew compatibility even though a lower velocity is selected for the ensemble design criterion.

Quick disconnects provide the primary connections between the aircrew and the aircraft (e.g., ventilation air supply and oxygen source). These disconnects are attached to the suit and helmet or both to distribute the force of the ejection. The disconnects should be omnidirectional to prevent binding or release failure. The disconnects should release with an applied force not less than 8 nor more than 24 pounds. This range will avoid inadvertant disconnects and minimize the induced load on the aircrew during an ejection.

For aircraft containing the ACES II ejection seat, consideration must be given to the aerodynamic design of the PSE helmet and upper torso areas to prevent airflow distortion into the seat Pitot tubes. Such flow distortion could prevent appropriate seat mode selection. Cockpit and airframe clearance during ejection from the aircraft (particularly at the knees and elbows) should be provided with the PSE pressurized and unpressurized.

Entanglement of the ensemble with the parachute riser and obstruction of vision are two major concerns which must be addressed in the design of the ensemble to assure safe parachute opening and descent. Of major concern for water entry is the capability to quickly break the pressure-sealing barrier covering the breathing cavity (i.e., open the visor) prior to water entry to prevent asphyxiation.

REQUIREMENT LESSONS LEARNED

Selection of materials which will: (a) provide a positive pressure barrier, (b) provide a restraint layer, (c) be fire resistant, (d) be flexible and lightweight so as not to restrict movement, (e) be structurally strong enough to withstand the windblast forces experienced during an emergency ejection, and (f) be aerodynamically smooth so as not to disturb the airflow past the ejection seat pressure sensors (pitot tubes, etc.) are demanding requirements. Ejection clearances and posture must allow the aircrew member to eject without touching any part of the aircraft resulting in injury or ejection interference and allow the aircrew member to assume the recommended posture necessary for ejection.

4.2.4.4 <u>Verification of escape</u>. The following tests shall be performed to verify the requirements of 3.2.4.4.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration)
c. Release force
d. Wind tunnel
e. High speed sled
f. Seat ejection (including clearance and posture) IAW MIL-STD-846, para. 3.3, as applicable.
g. Hanging harness
h. Parachute
i. Water survival (including flotation and life raft boarding)
j. ______________
(Specify other)

VERIFICATION RATIONALE (4.2.4.4)

The capability of aircrew to survive during an emergency ejection or bailout at various airspeeds, a parachute descent, survivable crash, and landing on the ground or in the water must be verified through simulated and actual environment tests. Test procedures and equipment have been developed to perform such tests. Test procedures must be modified and new procedures added as necessary to suit each type of PSE and the aircraft for which it is designed.

VERIFICATION GUIDANCE

Test limits for the variety of tests required are determined by the type of aircraft, mission, Statement of Operational Need, and good judgment which weighs the severity and number of tests needed to assure that the ensemble is flightworthy.

Windblast tests are normally performed by dressing the PSE onto an appropriately instrumented test dummy properly restrained for ejection in an ejection seat. The dummy is exposed to windblasts up to or even higher than 500 KEAS (knots equivalent airspeed) or the aircraft design requirement velocity which may be as great as 600 KEAS to assure that the PSE will not fail. A typical velocity profile is a rise time to peak velocity of 0.3 second with no dwell at maximum velocity and decay to 200 knots in 3 seconds. Although this velocity profile does not match an actual ejection, it is within the capability of available test facilities and provides a good structural test of the PSE. Seat attitudes should be varied in both pitch and yaw directions to simulate possible ejection positions and assure a thorough structural test.

The acceleration tests can be performed by dressing the PSE onto a dummy properly restrained in an ejection seat, in an ejection tower (or deceleration tower) test facility. Where an ejection tower is used, separation of quick disconnects can be photographed and separation forces can be measured with appropriate instrumentation. High speed photography is used to provide evidence of any slippage, loosening, or other failure which could result in bodily injury.

Ejection clearance tests are usually conducted by placing a representative size range of subjects and PSEs into a mock up, simulator or actual aircraft. The suited subject is raised up and down the ejection seat rails with a crane while the PSE is pressurized and unpressurized. Canopy rail and instrument panel clearances during test and ability of the subject to assume the correct posture for ejection should be noted.

Prior to high speed sled tests, wind tunnel tests should be performed to carefully assess the compatibility of the ejection seat and aircrew worn equipment. These tests should be accomplished at varying ejection seat pitch and yaw angles as well as at varying airspeeds to cover the aircraft operational envelope.

In addition to the quick disconnect release forces measured at an ejection tower test facility, a test rig capable of simulating and measuring release forces may be used. Possible angles of man/seat separation should be simulated.

High speed sled tests are accomplished by dressing the PSE onto a dummy appropriately restrained in an ejection seat. The seat is mounted on a sled with the appropriate aircraft forebody or a sting device in a position to simulate the initial stages of an ejection. The sled is accelerated to a predetermined velocity (approximately 500 KEAS or the aircraft design requirement velocity which may be as great as 600 KEAS). High speed photography provides the sequence of any failure. If an ejection seat is used (which includes pressure sensors) sensor pressures and mode switching are recorded to determine any interference with normal seat mode switching.

An ejection seat test requires a test set-up similar to the high speed sled test except that the sled has a closed canopy. Failure of the ejection seat to operate in the proper mode because of pressure sensor interference (i.e. ACES II seat pitot tubes) from the PSE, failure of aircrew/cockpit disconnects, or failure of the dummy to separate from the seat would constitute a test failure.

In preparation for flight test evaluation, parachute ground training tests should be accomplished as follows (by human test subjects experienced at parachute jump testing):

a. The subject wearing the PSE, a parachute harness, and any other appropriate life support gear, should stand with his body in a typical parachute landing attitude and should fall to the ground with the corresponding typical landing fall. Any evidence of injury to the subject or hinderance to the fall test procedure should be recorded.

b. After the test in a. is successfully completed, the suited subject should stand on a platform 60-inches above the ground and step off of it in a manner to simulate a typical parachute landing and fall attitude onto the ground, thus adding vertical and horizontal velocity components to the fall. Any evidence of potential injury to the subject or hinderance to fall should be recorded.

c. A parachute harness drop test will be performed by a suited subject who will step quickly from an adjustable (ranging from 1 ft to 2.5 ft in 0.5 ft increments above the parachute harness resting hang position) platform into space and must be supported by the harness in a hanging position to simulate a nominal parachute opening. Tests are performed from each height increment, beginning at 1 ft. Subjective comments should be recorded. The subject should then remove the PSE and all other life support gear and be examined by a physician. One test series should be run with the helmet visor open and one with it closed and the PSE pressurized. Any evidence of potential injury to the subject or hinderance to the test procedure should be recorded.

d. The suited subject should be suspended in the parachute harness and required to look upward at where the actual parachute canopy area would be and downward at where the actual parachute landing area would be. The subject shall determine (based on experience and judgment) that vision in these areas would not be unduly obstructed in an actual parachute jump. Any vision restrictions should be recorded.

e. The suited subject with the PSE visor open and the flotation device actuated should be suspended in a parachute harness with his feet approximately 10 ft above the surface of the water and dropped (or by canopy release actuation) into the water using the standard "wet ditch" training procedure. He should allow himself to float and stabilize in the water. The flotation posture should be per the standard procedure and he should proceed to release his parachute and to board a one man life raft, or equal, using the standard procedures. Inadequate flotation posture or inability of the subject to board the raft would constitute failure.

An actual parachute jump from an aircraft or helicopter by a trained test subject is normally performed prior to flight test evaluation. The test subject jumps from the aircraft onto dry land and into water. The PSE must not interfere with parachute opening or inhibit any descent functions. Good visibility and unrestricted arm movement are essential during descent. The test subject must satisfactorily break the pressure barrier (i.e., open the visor) at the breathing compartment prior to water entry. The test subject must be able to easily release his parachute canopy releases after ground landing and prior to or after water landing (operation of the releases shall be possible either one at a time or simultaneously).

Water drag tests should be performed prior to jumping or flight testing over water. This can be accomplished from the aft end or side of an appropriately rigged boat. The test subject is dragged in the water at various speeds simulating possible wind velocities. The test subject must demonstrate the capability of rolling over, releasing the canopy quick releases, and performing the required water survival procedures (including flotation and life raft boarding without undue problems).

VERIFICATION LESSONS LEARNED

The use of instrumented dummies to assess the performance of the PSE during the more severe testing and human subjects for the less severe testing has provided a reasonable means to predict performance during operational use. Continued use of these evaluation techniques can serve as a basis for comparison of old and new systems.

Due to expense of seat ejection tests, "piggy-back" tests are usually preferred.

3.2.4.5 <u>Utilization</u>. The following PSE use requirements shall be met:

a. Donning - The PSE shall be capable of being donned in ________ minutes.

b. Doffing - The PSE shall be capable of being doffed in ________ seconds.

c. Transition - The PSE shall be capable of being converted from ground to aircraft operational mode in ________ seconds.

d. Valsalva - The PSE shall permit the wearer to perform a valsalva maneuver without degrading mission performance.

e. Comfort - The aircrew member wearing the PSE shall not experience hot spots, high-pressure areas, or other intolerable discomfort.

f. Drinking and eating - The PSE shall enable the wearer to drink and eat without compromising high altitude protection and CB protection, if applicable.

g. Subjective use - The PSE shall have no objectionable characteristics such as objectionable odors, skin irritation, restriction of movement, tackiness to the touch, or any other property that may cause discomfort, affect wearability and the performance of the mission.

h. Urine collection - The PSE shall enable the wearer to collect urine during wear for extended periods of time or shall provide for use of the aircraft relief facility (relief tube, restroom, "piddle pak", etc.).

i. Cockpit compatibility - The PSE shall permit the wearer to use the aircraft cockpit controls as required without undue restriction in performance of the assigned mission. PSE inflation and aircraft differences shall be considered.

REQUIREMENT RATIONALE (3.2.4.5)

Utilization requirements are essential to assure the wearability of the PSE and the achievement of the mission requirement for the aircrew without significant aircrew performance degradation.

REQUIREMENT GUIDANCE

Utilization requirements are based upon the Statement of Operational Need for the PSE and previous experience in the development of similar PSEs.

a. Donning - A donning time of five minutes, measured from the beginning to the end of the donning sequence, will normally satisfy user requirements and should be attainable with a well designed PSE.

b. Doffing - A PSE doffing time of no greater than one minute should be achievable. This doffing time is not the same as the emergency removal procedure to be followed when the wearer is being prepared for medical treatment (i.e., after injury during hard parachute landing, etc.).

c. Transition - The PSE should be capable of being converted from ground to aircraft operational modes within 15 seconds. It is essential to keep this time as low as possible to minimize delay in the start of a mission.

d. Valsalva - It is essential for the safety of the aircrew to be able to perform the valsalva maneuver through the use of the forefinger and thumb or with a mechanical or pneumatic device which occludes the nostrils.

e. Comfort - Comfort is subjective and therefore difficult to quantify. Qualitative criteria are the best criteria for establishing comfort requirements.

f. Drinking/eating - The drinking/eating features of the PSE should be flexible and adjustable to permit stowing and not be a safety hazard. The aircrew must be able to drink fluids and/or eat tube foods without compromising pressure protection since drinking/eating may be accomplished in a pressure-breathing environment.

g. Subjective use - Subjective use requirements are qualitative by nature. Identification of possible objectionable performance characteristics that can be subjectively evaluated is an important requirement.

h. Urine collection - The urine collection or relief feature should be a constant wear device or allow ease of access and use for all possible scenarios. Collection system components should be flexible and adjustable to permit stowing and not be a safety hazard.

i. Cockpit compatibility - The PSE can be designed to restrict ballooning by selecting outer layer material that will not stretch with pressure and/or selective placement of partial PSE bladders. Consideration of the cockpit control requirements and the design of the PSE with that in mind should help overcome problems that might otherwise develop. Sizing of the PSE is an important factor in this potential problem area.

REQUIREMENT LESSONS LEARNED

a. Donning - If assistance is not provided, extended donning time can both tire the wearer, and seriously degrade performance once donning is completed. Donning time reflects the training required to teach the wearer how to don the PSE. A short training time is desirable.

b. Doffing - Lengthy doffing times can create anxiety for the wearer, particularly following an extended duration mission. Lengthy doffing also creates training problems.

c. Transition - Lengthy transition time can delay the mission and will increase the time in the PSE with resultant wearer fatigue and detrimental effect on the mission.

d. Valsalva - Inability of the PSE wearer to valsalva can result in severe ear pain during descent in high performance aircraft. This could result in a delayed descent and/or reluctance to descend or to begin to descend by a wearer who routinely has ear pain during descent. Valsalva devices can be a hazard to the eyes during an ejection if not properly designed.

e. Comfort - PSE wearers require some degree of comfort or they will not use the PSE in spite of the protection provided. Degree of comfort is generally based on what the wearer is used to (i.e., if the PSE is more uncomfortable than the standard flight gear the wearer will complain accordingly).

f. Drinking and eating - The use of the PSE for extended periods of time requires that an eating and drinking capability be provided to prevent mission degradation. Physiological and psychological factors are instrumental in this important aspect of the PSE provisioning.

g. Subjective use - In order to gain maximum benefit from the outfit, the PSE wearer must (hopefully) like it or at least tolerate it. The PSE should be designed with subjective appeal to the wearer in mind.

h. Urine collection - PSEs that must be worn for extended time periods without urine collection devices can create unbearable problems. Diapers have been worn in the past under these conditions with negative reactions by the wearers, as can be expected. Provisions in anticipation of such a need is best.

i. Cockpit compatibility - The use of the PSE in the aircraft cockpit is one of the primary requirements and lack of compatibility will degrade the aircrew members performance. Excessive ballooning of the PSE can cause the wearer to activate cockpit controls inadvertently or restrict movement excessively and hamper the wearer's ability to reach controls.

4.2.4.5 <u>Utilization tests.</u> The following tests shall be performed to verify the requirements of 3.2.4.5.

a. Donning tests - Elapsed time shall be measured from the beginning to the end of the donning sequence for each of __________ trained test subjects. An average donning time of more than __________ minutes shall be cause for rejection.

b. Doffing tests - Elapsed time shall be measured from the beginning to the end of the doffing sequence for each of __________ trained test subjects. An average doffing time of more than __________ seconds shall be cause for rejection.

c. Transition tests - Elapsed time shall be measured to make the transition from ground use prebreathing and body cooling life support equipment to aircraft life support equipment for each of __________ trained test subjects. The test subject shall be seated in the ejection seat (or other seat if PSE is for a non-ejection seat aircraft) and a crew chief or assistant may aid in the transition if this is a normal operational procedure.

d. Valsalva tests - The completely outfitted test subject shall perform a valsalva maneuver by occluding the nose as required to equalize pressure in the ears during altitude ascent and descent. Inability of the test subject to perform the valsalva maneuver with one hand shall be cause for rejection.

e. Subjective use/comfort tests - The PSE shall be tested by ______ crew members during flight testing. Objectionable odors, tackiness to the touch, hot spots, high pressure areas, restriction of movement, or other detrimental performance characteristics of the PSE shall be determined by subjective evaluation. Flight crew comments shall determine whether this requirement is met. Flight crew shall be anthropometrically selected from the first to ninety-ninth percentile of the USAF flying population. If females do not qualify for the aircraft mission, they shall be excluded from the flying population data.

f. Drinking and eating tests - Flight crew shall don the PSE and drink and eat. Flight crew comments shall determine whether this requirement is met.

g. Urine collection - __________ male and __________ female aircrew members shall wear the urine collection device inside the PSE and use it with the PSE both uninflated and inflated to a pressure of __________ .

h. Cockpit compatibility - The PSE shall be fitted onto selected aircrew (who are familiar with the aircraft cockpit) and used (while inflated and uninflated) during simulated cockpit checkout and operational procedures. Any restrictions in the standard procedures caused by the PSE shall be cause for rejection. The aircrew shall also be asked to perform the same evaluation in the standard flight ensemble as a baseline comparison.

VERIFICATION RATIONALE (4.2.4.5)

Testing must be performed to assure the wearability and flight safety of the PSE without significant aircrew performance degradation. Testing is primarily subjective and requires trained test subjects to provide a thorough assessment of the airworthiness of the ensemble.

VERIFICATION GUIDANCE

Since the test requirements are subjective in nature, there are only a few test limits that can be applied and these are the donning, doffing, and transition time limits specified in 3.2.4.5. All other testing is subjective evaluation by trained test subjects. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population. A minimum of six test subjects should be selected to perform any one test to acquire statistically valid test data. Valsalva with the visor open has been accomplished where physiological considerations are permitted.

VERIFICATION LESSONS LEARNED

The use of the PSE by trained test subjects in the past has helped to assure user acceptance and made it possible to correct operational deficiencies prior to OT&E. The identification of the potential inadequacies early-on will increase the potential for success once the PSE is introduced into the field.

3.2.4.6 Impact protection and penetration resistance of helmet hardshell. The impact protection and penetration resistance of the PSE helmet hardshell shall be as specified in 3.2.5.8 and 3.2.5.9. Requirement rationale, guidance and lessons learned are as presented in 3.2.5.8 and 3.2.5.9.

4.2.4.6 Impact protection and penetration resistance tests. The PSE helmet hardshell shall be tested for impact protection and penetration resistance as specified in 4.2.5.8 and 4.2.5.9. Verification rationale, guidance and lessons learned are as presented in 4.2.5.8 and 4.2.5.9.

3.2.4.7 **Oxygen system (including oxygen regulators, pressure controllers, pressure relief valves and respiratory valves).** The PSE oxygen system performance shall be as specified in the "Aircraft pressure suit provisions" paragraph of the General Specification for Aircraft Oxygen Systems (MIL-O-87226). Requirement rationale, guidance and lessons learned are as presented in the corresponding appendix paragraph of the oxygen systems specification.

4.2.4.7 **Oxygen system tests.** The PSE oxygen system shall be tested as specified in the "Verification of aircraft pressure suit provisions" paragraph of the General Specification for Aircraft Oxygen Systems (MIL-O-87226). Verification rationale, guidance and lessons learned are as presented in the corresponding appendix paragraph of that specification.

3.2.4.8 **Sustained acceleration.** The PSE shall not malfunction or hinder aircrew member's ability to perform necessary tasks when acceleration forces of ____________ G's for _____________ seconds are encountered.

REQUIREMENT RATIONALE (3.2.4.8)

Sustained acceleration force requirements must be attained to assure accomplishment of aircraft mission. The Statement of Operational Need should provide this requirement. This may require operation of the ensemble in the pressurized and unpressurized modes.

REQUIREMENT GUIDANCE

Current requirements for tactical aircraft are up to +9 G_z and -2 G_z. This is the limit imposed by the USAF School of Aerospace Medicine, Brooks AFB TX, for human subject testing in a centrifuge. The aircraft mission statement or Statement of Operational Need should provide necessary information to establish this requirement.

REQUIREMENT LESSONS LEARNED

Sustained acceleration forces affect the ability of the aircrew member to perform as required when operating high performance aircraft. Any additional burden caused by the PSE which might further degrade performance is not tolerated when operating high performance aircraft.

4.2.4.8 **Sustained acceleration tests.** The PSE shall be placed on a human test subject and subjected to the requirements of 3.2.4.8 using a centrifuge. The PSE shall be operated during the test. It shall be stable on the body and shall not show any evidence of malfunction or failure.

VERIFICATION RATIONALE (4.2.4.8)

The capability of aircrew to perform without impairment during the sustained acceleration force maneuvers specified for the aircraft must be verified through simulated tests prior to actual flight tests. Test procedures and equipment have been developed to perform such tests (i.e. human test centrifuges at USAFSAM and AAMRL).

VERIFICATION GUIDANCE

Test limits for the centrifuge tests are determined by the type of aircraft, mission, Statement of Operational Need, and good judgment which weighs the severity and number of tests needed to assure that the PSE is flightworthy. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population.

VERIFICATION LESSONS LEARNED

Centrifuges have traditionally been used to subject aircrew members to acceleration forces, not only for indoctrination prior to actual experience in flight but also when new personal equipment is introduced and it is necessary to determine how human performance is affected. This is of particular importance for the PSE since the anti-G suit may either be an integral part of the ensemble or be required to function at the same time that the PSE is operating.

3.2.4.9 Optical system. The PSE visor shall be of sufficient size as not to decrease the wearer's binocular visual field in upward or lateral directions. The restriction on downward vision shall be no greater than ________ degrees. The viewing area shall meet or surpass the optical requirements of ________. The visor shall be capable of meeting the ballistic resistance requirements of ____________ and abrasion resistance requirements of ________. When properly donned and operating, the PSE shall exhibit no visible visor fogging at a temperature of __________ degrees and relative humidity of __________ %.

REQUIREMENT RATIONALE (3.2.4.9)

Vision requirements are essential to assure the wearability of the PSE and the achievement of the mission requirement by the aircrew without significant performance degradation.

REQUIREMENT GUIDANCE

The elimination of all downward vision restriction due to protuberances such as the pressure barrier (mask, face seal, etc.) helmet shell interface with the visor may be unavoidable. Minimal downward restriction, however, is a goal.

A reference for aircrew visor optical characteristics is in MIL-L-38169. This specification will provide optical characteristics for various classes of visors from clear to 99% filter (sun visor). Optical requirements include prismatic deviation, luminous transmittance, optical distortion, and haze.

A material commonly used for visors is polycarbonate. MIL-V-43511 is a specification for a flyer's helmet visor and provides impact resistance requirements. Equivalent requirements for the PSE visor should provide adequate ballistic protection.

Abrasion resistance requirements for a flyer's helmet polycarbonate visor is provided in MIL-C-83409. Equivalent requirements for the PSE visor should provide adequate abrasion resistance.

Visor fogging will occur most often when the ambient environment is cold and damp. The selection of ambient conditions of 32°F and 80% relative humidity would be a typically severe fogging environment which is likely to occur at a NATO airbase. More severe conditions could result in frosting of the visor. Unless a requirement is provided by the Statement of Operational Need or the user, emergency defogging within five seconds should be an adequate time period.

REQUIREMENT LESSONS LEARNED

Laboratory testing has shown conclusively that visor fogging and/or frosting will occur where warm, moist exhaled gas contacts the cold inner surface of the visor. The use of detergents or anti-fogging solutions on the inner surface of the visor or isolating the breathing compartment from the visor by use of an oronasal mask or using double-layered visors somewhat alleviates the fog; however, the only proven way has been to electrically heat the visor. The use of heating wires and conductive coatings have been effective. However, coatings tend to create reflection problems for the wearer; and wires, if too large in diameter, may cause vertigo problems.

In the past, the use of goggle style visors with oxygen masks has imposed visual field limitations on the wearer and degraded performance.

A requirement for improved ballistic protection for the visor has resulted in a change in visor materials from acrylic plastic to polycarbonate plastic. However, while polycarbonate is stronger, it is also softer and more subject to abrasion. Scratches and abrasive markings on the visor surface can distract the wearer and degrade performance.

Early flight helmets and pressure suit helmets included visors with air bubbles and other optical irregularities due to faulty fabrication techniques. These visors were unacceptable to the users who found them to cause performance degradation due to distraction and optical distortion.

4.2.4.9 Optical system tests. The following tests shall be performed to verify the requirements of 3.2.4.9.

a. Optical quality tests. Test per__________.
b. Ballistic protection tests. Test per__________.
c Abrasion resistance tests. Test per__________.
d. Low temperature tests. Test per__________.

VERIFICATION RATIONALE (4.2.4.9)

Testing must be performed to assure the wearability and flight safety of the PSE without significant aircrew performance degradation.

VERIFICATION GUIDANCE

MIL-L-83169 provides test methods for optical quality. This document covers the primary optical quality tests of prismatic deviation, luminous transmittance, optical distortion, and haze.

MIL-V-43511 provides an impact test method for a polycarbonate visor. This test method is general in nature and should be applicable to most visor designs.

Abrasion resistance test methods for plastics are provided in Federal Test Method Standard No. 406. Test Methods 1092 and 3022 of FED-STD-406 are applicable test methods. Haze and luminous transmittance should be determined before and after abrasion testing.

Low temperature operation tests:

Vision test - The test subject must have an unaided distance visual acuity (eyesight) of 20/20 or better as measured by a standard Snellen chart with 100% contrast at a distance of 20 feet. The test room should have reduced illumination. The unaided near visual acuity must be J1 as measured by a Jaeger Reading Card with 100% contrast at 2-1/2 feet. The subject dons the PSE, the visor is closed, and 100% oxygen or equivalent is provided for breathing.

Room temperature test - The suited subject's far and near baseline binocular visual acuity is measured with room temperature at 75°F (±5°F). For each determination, the illumination on the chart and card should be 10 ft candles. No fogging of the visor should occur during this test. Defogging and body cooling measures, as provided by the PSE design, may be utilized, if necessary, during test.

Systems operation heating test - Upon aircraft seat ejection (simulation may be required), the emergency heating system should actuate automatically and should satisfactorily perform its intended function by heating the visor, gloves, etc., as required. The system should be actuated manually and satisfactory performance should be demonstrated by allowing the system to operate for the period of time necessary to ensure that heating as required herein is provided.

Emergency heating subsystems test--fog/frost/ice - The suited subject is exposed to a temperature of 10°F (±5°F) for not less than 1/2 hour. The visor is to be warmed using simulated aircraft power and visual acuity tests are performed. Following this period, the suited subject is pressurized to 2.5 psi above ambient and exposed to a temperature of -65°F (±5°F) for a period of 1/2 hour (visual acuity tests should be performed during the period), followed by disconnection of the simulated aircraft power, actuation of the emergency heating system, and suspension in the parachute harness so the subjects' toes are just off the floor. The PSE pressure is reduced to zero two minutes following emergency power activation and (visual acuity tests are again performed) three minutes later the survival kit is deployed and the visor opened.

Fifteen minutes after emergency power activation, the subject simulates ground contact by standing in place relieving parachute harness tension and beginning a sequence to:

a. Release the parachute canopy.

b. Remove the parachute harness (and life preserver, if used).

c. Open survival kit, remove survival items, and utilize the PSE inherent survival features to maintain body core temperature, as required.

d. Remain at least 1/2 hour following emergency power activation and an additional two hours at an ambient temperature of -20°F (±5°F) without power but utilizing the inherent passive features of the PSE (or the emergency heating system, if available) provided body core temperature and finger tip temperature do not fall below the required minimum. Body core temperature of less than 95°F or fingertip temperature of less than 60°F or more than 92°F or failure to reach the temperature range of 60°F to 92°F within 2-1/2 minutes of actuation is cause for rejection.

VERIFICATION LESSONS LEARNED

Fogging or frosting of the PSE visor, or inadequate body heating or cooling during the required exposure to the environmental conditions specified, should demonstrate that the PSE is not providing the proper protection to the wearer. This procedure has been used in the past to successfully assess the function of the current ensembles.

The tests shown in MIL-V-43511 and MIL-L-38169 have been used to determine the acceptability of flight and PSE helmet visors and sunshades, and have demonstrated that, when the tests are passed, user acceptance is generally assured.

3.2.4.10 Sound attenuation. The PSE shall provide __________ sound attenuation when tested as specified in 4.2.4.10.

REQUIREMENT RATIONALE (3.2.4.10)

The use of aircrew personal protective equipment in and around military aircraft can expose the wearer to noise environments which can result in permanent hearing loss unless proper attenuation is provided. Aircrew members are required to wear sound protective equipment in and around military aircraft. The use of the PSE by aircrew members may preclude the use of the standard sound attenuation gear and thus require that the capability be built into the PSE.

REQUIREMENT GUIDANCE

Standard earcups for providing sound attenuation to the aircrew member are provided in flight helmets. Earcups for the PSE can be similar to the standard, however, the PSE design can also provide some sound attenuation due to possible enclosure of the ears inside a sealed helmet. This may allow the earcup design to be somewhat less sound attenuating. In addition, the PSE helmet design may include a neck ring which does not allow the helmet hardshell to be pulled away from the ears during donning and doffing. Provision will therefore have to be made for ease of donning and doffing such as soft earcups or other design changes to prevent ear discomfort. Requirement guidance for headgear (see 3.2.5.11) is also applicable to PSE helmet design.

REQUIREMENT LESSONS LEARNED

Standard flight helmets include hard or semi-rigid plastic earcups with soft, doughnut-shaped seals at the wearer's head and earcup interface. The bottom of the helmet shell is open and sound can enter into the area around the earcups. The earcup volume and seals have been designed to attenuate the noise around the cap so that which gets to the ear is less than that outside (i.e., attenuated). Pressure suit helmets that include a bladder seal at the neck and some that are sealed to a neck-bearing ring interface have been found to provide some sound attenuation during laboratory testing. PSEs that cover the entire body have been found to provide further sound attenuation.

4.2.4.10 **Verification of sound attenuation.** The attenuation of the PSE shall be measured as described in ________________. The attenuation requirements shall be ______________ and shall be demonstrated at ____________ frequencies.

VERIFICATION RATIONALE (4.2.4.10)

The use of the entire PSE during the sound attenuation tests will assure that the inherent attenuation features of the PSE (including the earcups) are considered. This will enable the test results to be compared with those using known standard earcups.

VERIFICATION GUIDANCE

A method for the measurement of real-ear protection of hearing protectors is provided in Acoustical Society of America Standard ASA 1-1975. It will be necessary to modify this standard test procedure to use the complete PSE rather than the earcups alone. The force required to seal the earcups against the subject's head to attain the specified attenuation should not exceed 4 1/2 pounds. A lesser force (3 pounds) is desirable provided the attenuation is not degraded. An H-143/AIC earphone (or equal) that conforms to MIL-E-25670 or a simulated equal mass should be installed in the earcup during the sound attenuation test. The communication cord opening in the earcup and any other opening in the PSE must be plugged during the sound attenuation test.

VERIFICATION LESSONS LEARNED

Tests conducted on PSEs in the past have shown that the sound attenuation provided by earcups alone is somewhat enhanced by full-head helmets (with neck seals) and further enhanced by ensembles that cover the whole body. The partial or full isolation of the body from the noise environment directly affects the available body skin surface and bone mass which can contribute to the noise pickup in addition to that collected by the ears.

3.2.4.11 **Thermal control.** A thermal control system shall be provided to prevent overheating or overcooling of the aircrew members when exposed to environmental temperature extremes of ________ and a humidity of ________ percent during transition between the aircrew alert facility and aircraft and during flight operations.

REQUIREMENT RATIONALE (3.2.4.11)

The inherent nature of PSEs is such that part or all of the wearer's body is isolated from the environment. Certain combinations of environmental temperature and humidity can cause overheating or overcooling of the body. This can result in discomfort which degrades performance.

REQUIREMENT GUIDANCE

The thermal control system may have various configurations including modifications of the aircraft environmental control system to add heating or cooling as needed, separate ground use and aircraft mounted systems, or a common aircraft use and ground use system which may be readily mounted inside the aircraft. Cooling of the PSE wearer in the aircrew alert facility has traditionally been provided by air conditioning of the facility, portable air conditioners or blowers, or tethering to a stationary air source in the facility. Liquid cooling systems have also been used successfully. Portable cooling units can be carried by the aircrew member in transit to and from the aircraft. Air conditioned vans are often used to transport the outfitted aircrew member to and from the aircraft. Provisioning in the aircraft for cooling include the air conditioning system and direct connection of an outfit-mounted air distribution system to the aircraft air conditioner. The use of the aforementioned liquid cooling system in the PSE could be adapted for use in the aircraft.

Electrical heating elements have been used in the glove fingers to provide short term heating during ejection at high altitude and subsequent freefall and parachute descent. Long term heating requirements are unlikely; however, if encountered, might be solved by the use of more extensive body coverage with heater wires or equal.

REQUIREMENT LESSONS LEARNED

The use of aircraft cabin air source can provide significant cooling to the PSE wearer if the gas is routed properly over the wearer's skin. The vent air can be used prior to being exhausted into the cabin area to help pressurize full PSEs, however, use of air with partial PSEs requires that the vent air be routed under the suit bladders and exhausted into the cabin. No pressure benefit is realized from the vent air used with the partial PSEs.

The limited use of liquid cooling systems with PSEs has shown it to be more efficient than air circulating systems. Certain conditions may require a combination of the two systems for maximum efficiency. The amount of the wearer's body surface area to be cooled is an important consideration in the cooling garment component design.

Consideration must also be given to the pressure points imposed on the body, particularly when the cooling garment is between the partial PSE bladders and the skin.

4.2.4.11 **Verification of thermal control.** Thermal control testing of the PSE shall be performed under simulated conditions of __________ in a laboratory.

VERIFICATION RATIONALE (4.2.4.11)

The laboratory simulation of operational conditions has traditionally been used to evaluate the performance of developmental life support equipment. The nature of life support equipment is such that the initial testing should be done under controlled conditions where the need for action to correct problems can be recognized during the use of the equipment by human test subjects and safety measures taken, if required, to assure that the subjects do not suffer the consequences of equipment failure.

VERIFICATION GUIDANCE

PSE cooling - An appropriately instrumented test subject wearing the PSE and simulating typical mission activity (e.g., intermittent tracking tasks, etc.) is placed within a test chamber conditioned at a temperature of 115°F and a relative humidity of 40% and the PSE cooling system turned on 30 minutes after chamber entry. The PSE cooling system should be capable of significantly reducing the test subjects cardiovascular strain, sudomotor response, and heat storage.

PSE heating - See 4.2.4.9 Verification Guidance.

VERIFICATION LESSONS LEARNED

Thermal control cooling tests under laboratory conditions have shown that liquid cooling systems are superior to air cooled systems. However, the support system complexity and weight of the liquid present additional problems. The advantages of the liquid systems may not warrant the additional support required.

Thermal control heating tests have shown that for short time periods, heating of the extremities (fingers and toes) may suffice. For extreme cold temperatures and longer time periods, additional cold weather clothing, sized to fit over the PSE, may be required. Survival on the ground after bailout may require that cold weather, down-filled clothing, be carried by the aircrew member in the ejection seat survival kit.

3.2.4.12 **Rapid decompression.** The PSE shall provide protection against the detrimental effects of rapid decompression from ________ to _________ feet in ________ seconds. The PSE shall provide altitude protection for the crewman at ________ feet mean sea level (MSL) and during descent to _______ feet MSL for a duration of _______ minutes following loss of cabin pressure or ejection.

REQUIREMENT RATIONALE (3.2.4.12)

High performance military aircraft aircrew compartments are pressurized when flying at high altitude to provide a pressurized environment that is tolerable to human beings. The pressure inside the compartment can, however, reduce very rapidly due to penetration or loss of the canopy, etc. The breathing compartment of protective equipment worn by the aircrew member must either vent any excessive pressure that may result or assure that the breathing pressure is equal to the counter pressure provided by the pressure suit.

REQUIREMENT GUIDANCE

When the PSE is placed on a manikin, or donned by a human subject and subjected to a decompression (pressure change) from 32,000 feet to 60,000 feet within 150 milliseconds, the pressure inside the PSE suit and breathing compartment must be as specified in the respective oxygen regulator specification. Decompressions of a greater pressure differential or at a faster rate are considered to be hazardous for human test subjects. If more severe parameters are desired, human test subjects should not be used.

REQUIRMENT LESSONS LEARNED

Laboratory testing of animals has shown that rapid decompression can cause lung damage if breathing pressure is not properly relieved and/or coordinated with counterpressure. Examination of the animals lung tissue following rapid decompression where high breathing pressures were suspected of causing damage has shown that internal bleeding and damage to the alveoli can occur.

4.2.4.12 **Rapid decompression tests.** Rapid decompression tests shall be conducted on the PSE by exposing it to a pressure change of __________ psi in _______ seconds to verify that it meets the requirements specified in 3.2.4.12.

VERIFICATION RATIONALE (4.2.4.12)

Rapid decompression protection can only be verified through the use of controlled laboratory tests using simulated test arrangements prior to any use of human subjects to prevent the unnecessary exposure of humans to hazardous conditions.

VERIFICATION GUIDANCE

The PSE should be placed on a manikin (including a simulated lung volume of approximately five liters connected to the breathing compartment) and placed in an altitude chamber. The regulated oxygen and/or airflow and pressure is preadjusted per the specific requirements peculiar to the system and with the altitude chamber at 32,000 feet. The PSE is decompressed to 60,000 feet within 150 milliseconds. The pressure in the breathing and suit compartments should automatically and without delay, compensate for lost cabin pressure during the decompression so that the required pressures in the compartments will be attained within six seconds. Pressures should be recorded during test.

VERIFICATION LESSONS LEARNED

Laboratory testing of PSEs using simulated lung volumes and manikins to predict the outcome of tests using human test subjects has shown it to be a valid procedure.

3.2.4.13 **Breathing compartment.** The breathing compartment performance shall be ____________. Provisions shall be made to prevent suffocation following water entry.

REQUIREMENT RATIONALE (3.2.4.13)

The breathing compartment is a key component of the PSE because the oxygen required for survival at altitude is delivered through the compartment and its seal and volume are considered to be a significant design consideration.

REQUIREMENT GUIDANCE

The breathing compartment performance should be equal to or better than that of the oxygen mask as specified in MIL-M-27274. Compartment design considerations will have to be related to the specification requirements. A leak-tight seal should be maintained under all breathing conditions described herein. The volume should be kept to a minimum consistent with the design. Provisions for easy removal or adjustment away from the face and integration with HGU-4/P sunglass frames are required.

The breathing compartment performance is influenced by the design which can vary from a relatively small volume oronasal mask to a large volume full head enclosure with a neck seal. The pressure differential across the seal in a mask or a neck seal outside the pressure enclosure (i.e., to ambient) is greater than that across a mask, face or neck seal inside the pressure enclosure. The higher pressure requires the use of a pressure compensated exhalation valve. However, the use of the lower pressure allows the use of a simple, spring-loaded exhalation valve and allows the seal to be more loose and comfortable to the wearer yet still effectively seal the required pressure.

REQUIREMENT LESSONS LEARNED

The volume of the breathing compartment determines the amount of dead space (rebreathable air) imposed upon the wearer. The larger the dead space, the more discomfort for the wearer when breathing at the lower pressures. The leak tightness of the breathing compartment seal is directly proportional to the high altitude protection provided by the PSE. User preference may be a factor regarding the type (i.e., neck, face or oronasal) of seal used. Face and neck seals can usually be provided in one size with a cut-to-fit option whereas the masks are required to be made in several sizes.

Obviously, mask and face seals will present more of a problem with regard to sunglass frames than neck seals. Frames may require modification in order to interface with the seals.

4.2.4.13 **Breathing compartment tests**. The breathing compartment shall be tested in accordance with __________ in order to comply with the requirements of 3.2.4.13.

VERIFICATION RATIONALE (4.2.4.13)

Specific testing of the PSE breathing compartment relates directly to sizing, sealing and interface with the PSE and other life support equipment. This requires that simulated, flight, static, dynamic, animate and inanimate testing be done.

VERIFICATION GUIDANCE

Design of the breathing compartment directly influences the testing required. MIL-M-87163, the specification for the MBU-12/P oxygen mask, can be used as a guide with allowances made as required. Testing should include but not be limited to compartment leakage, respiratory valve performance, breathing resistance, oxygen delivery-tube leakage and strength, material tear resistance and hardness, toxicity, and subjective use.

VERIFICATION LESSONS LEARNED

Breathing compartment testing is a critical phase of the overall PSE procedure. Malfunctions discovered in this part of the testing can affect related tests of the PSE since it is a primary function of the ensemble. Excessive mask leakage has been found to cause the pressure to be lower than required and/or the oxygen concentration to be less than necessary. Respiratory valve function can also cause the pressure to be less than normal and/or result in difficulty in breathing for the PSE wearer.

The oxygen delivery hose, if not made properly, can kink and reduce flow which causes discomfort due to increased inspiratory breathing resistance.

The compartment material can be too hard or too soft. The softer material is more comfortable to the wearer but more difficult to retain higher pressures without deformation or leakage. In general, the lower the pressures to retain, the softer the compartment can be. Full PSEs generally allow the breathing compartment material to be soft since the pressure differential is low.

3.2.5 **Head protection**

3.2.5.1 **Protective headgear compatibility**. The protective headgear, when properly donned and worn with other personal flight items, shall integrate and be compatible with __________ aircraft cockpit structure, and its environmental control and electrical system. There shall be no interference with the function of the following aircrew life support equipment:

a.__________ Oxygen mask
b.__________ Life preserver
c.__________ Eye protection device
d.__________ Parachute harness
e.__________ Survival vest

f.____________ Oxygen regulator
g.____________ Flight garment
h.____________ Vision enhancement device
i.____________ Headgear-mounted device
j.____________ CB protective equipment
k.____________ ____________________
(Specify other)

REQUIREMENT RATIONALE (3.2.5.1)

Compatibility between the headgear and other personal protection systems and life support equipment is essential to mission performance and flight safety. Incompatibility between any life support system component could result in a flight safety hazard.

REQUIREMENT GUIDANCE

Each relevant item of life support equipment must be identified. The type of personal equipment to be worn by aircrew is dependent upon the aircraft type and Statement of Operational Need for new equipment development.

REQUIREMENT LESSONS LEARNED

All relevant life support equipment and cockpit features must be identified to assure that the aircrew can perform the aircraft mission without significant degradation in performance or flight safety. Omission of any pertinent feature can lead to later costly modification of the protective headgear.

4.2.5.1 **Verification of protective headgear compatibility.** The protective headgear shall be donned along with all required life support equipment by ________________ aircrew test subjects. The test subjects shall enter the _______________ aircraft. The headgear shall function properly throughout the selected mission for the aircraft. Any undue restrictions, interferences or other problems attributed to the headgear which are considered to be detrimental to the mission shall be cause for rejection of the headgear.

VERIFICATION RATIONALE (4.2.5.1)

The actual donning of the headgear by aircrew and performance of a mission in the selected aircraft is the best procedure to verify the adequacy of the headgear. Ground simulation tests are useful and necessary precursors to the actual flight test to verify that flight safety hazards do not exist.

VERIFICATION GUIDANCE

The larger the number of test subjects, the more thorough the evaluation; however, a reasonable number of test subjects to acquire adequate statistical data is ten. The test subjects should be anthropometrically selected to represent as nearly as possible the USAF aircrew population. The actual aircraft selected for the test flights must be the same as the one or more types of aircraft in which the headgear is designed to be flown to prevent anomalies. Adequate ground testing prior to flight tests is essential to ensure there are no flight safety problems. Typical tests include centrifuge testing to evaluate headgear stability, ground egress from an egress trainer to evaluate an emergency egress, and a hanging harness test to evaluate parachute descent problems. Parachute jumps by qualified test subjects over both land and water should also be accomplished prior to flight testing.

VERIFICATION LESSONS LEARNED

During the design process, it is essential to verify compatibility with the use of mockups or early prototypes of the headgear. Visiting using commands is helpful since aircrew trained in the aircraft for which the equipment is designated can provide insight on potential problem areas. Continual evaluation of compatibility as the headgear is under development will prove beneficial in avoiding significant mission performance degradation problems.

3.2.5.2 **Environmental conditions for headgear.** The headgear shall be capable of withstanding and operating under the following environmental conditions induced by the aircraft, ground transport or storage ________.

REQUIREMENT RATIONALE (3.2.5.2)

The headgear shall meet the environmental performance requirements to ensure that it will function satisfactorily during operational use and following storage in varying climatic conditions.

REQUIREMENT GUIDANCE

Worldwide climatic environmental conditions are enumerated in MIL-STD-210, Climatic Extremes for Military Equipment. Generally the headgear and its components will encounter conditions less severe than the environmental levels stated in MIL-STD-210. Environmental extremes should be based on the cockpit environment, outdoor transit environment, and storage environments anticipated for the mission of the aircraft and particular theater of operations. Environmental conditions to consider include storage temperature extremes, operating temperature extremes, rapid changes in ambient operational temperatures, solar radiation, blowing rain, humidity during storage and use, environmental fungus, environmental salt fog, and environmental dust. The headgear should also be designed to provide the required performance during and after exposure to the following induced environments: acceleration, vibration, acoustical noise, and shock. MIL-STD-810 provides test levels which may be used as a guide for selecting the appropriate environmental performance limits for each component of the headgear based on its operational use.

REQUIREMENT LESSONS LEARNED

The engineer should assure that these requirements are appropriately tailored to the operational need and are not excessive resulting in unneeded operational capability.

4.2.5.2 <u>Verification of environmental conditions for headgear</u>. The headgear shall be analyzed and tested to demonstrate the capability to meet the performance requirements cited in paragraph 3.2.5.2.

VERIFICATION RATIONALE (4.2.5.2)

The headgear and its components must be tested and analyzed under all of the natural environment and induced environment extremes that will be encountered during operational use or storage.

VERIFICATION GUIDANCE

The test procedures of MIL-STD-810 may need to be modified to reflect the true requirements (see paragraph 1.2 of MIL-STD-810).

VERIFICATION LESSONS LEARNED

3.2.5.3 <u>Headgear during escape</u>. The headgear shall not loosen, tear or otherwise fail structurally resulting in possible injury or interference with the emergency ground egress and bailout or ejection sequence, parachute descent, survivable crash, ground landing, or water entry. All disconnects shall operate properly during an ejection and shall release with an applied force of not less than ________ pounds nor more than ________ pounds.

REQUIREMENT RATIONALE (3.2.5.3)

The headgear must meet escape requirements for the designated aircraft to prevent bodily injury induced by the headgear during an emergency ground egress and bailout or ejection, parachute descent, survivable crash and landing on the ground or in the water. If the aircraft does not contain an ejection seat, this performance requirement should be deleted.

REQUIREMENT GUIDANCE

Dynamic forces that may be encountered during a typical ejection are germane to the type of aircraft for which the headgear is intended. Dynamic forces include both inertial and windblast forces.

The intensity of the acceleration force selected for headgear design should meet or exceed the acceleration force imposed by the ejection seat. An acceleration force 1.25 times greater than that imposed by the ejection seat is a reasonable requirement which provides a safety factor to ensure adequate performance of the headgear during an ejection.

Windblast forces selected should be typical of ejection velocities anticipated for the aircraft. However, imposing high velocity windblast requirements may result in a considerably heavier construction of the headgear than desired thus degrading aircrew performance. The windblast requirements used for high performance aircraft headgear is in the range of 450 to 500 KEAS which represents a tradeoff in assuring head protection at lower ejection velocities while providing a lightweight stable headgear assembly for optimum aircrew performance during the mission. Ejection can occur at 600 KEAS or the aircraft design requirements velocity.

REQUIREMENT LESSONS LEARNED

Selection of materials which will be structurally strong enough to withstand the windblast forces experienced during an emergency ejection, aerodynamically smooth so as not to disturb the airflow past the ejection seat pressure sensors (pitot tubes, etc.) and of such weight and stability to permit optimum aircrew performance throughout the mission profile are demanding requirements not yet fully attained with present materials.

4.2.5.3 <u>Verification of headgear during escape</u>. The following tests shall be performed to verify the requirements of 3.2.5.3.

a. Windblast
b. Adverse acceleration environments (including vertical deceleration and/or horizontal acceleration
c. Wind tunnel
d. High speed sled
e. Seat ejection (IAW MIL-STD-846, paragraph 3.3, as applicable)
f. Hanging harness
g. Parachute
h. ______________
(Specify other)

VERIFICATION RATIONALE (4.2.5.3)

The capability of aircrew to survive during an emergency ejection or bailout at various airspeeds, a parachute descent, survivable crash, and landing on the ground or in the water must be verified through simulated and actual testing. Test procedures and equipment have been developed to perform such tests. Test procedures must be modified and new procedures added as necessary to suit each type of headgear and the aircraft for which it is designed.

VERIFICATION GUIDANCE

Test limits for the variety of tests required are determined by the type of aircraft, mission, Statement of Operational Need, and judgment which weighs the severity of tests needed to assure that the headgear is flightworthy.

a. Windblast tests are performed by mounting the headgear on an appropriately instrumented test dummy properly restrained for ejection in an ejection seat. The dummy is exposed to windblasts up to 500 KEAS or the aircraft design requirement (ejection can occur at 600 KEAS) to determine the velocity at which the system will fail. A typical velocity profile is a rise time to peak velocity of 0.3 second with dwell at maximum velocity and decay to 200 knots in three seconds. Although this velocity profile does not match an actual ejection, it is within the capability of available test facilities and provides a good structural test of the headgear. Seat attitudes should be varied in both pitch and yaw directions to simulate possible ejection positions and ensure a thorough structural test.

b. The acceleration tests can be performed by mounting the headgear on a dummy properly restrained in an ejection seat, in an ejection tower (or deceleration tower) test facility. High speed photography is used to provide evidence of any slippage, loosening, or other failure which could result in bodily injury.

c. Prior to high speed sled tests, wind tunnel tests should be performed to carefully assess the compatibility of the ejection seat and aircrew worn equipment. These tests should be accomplished at varying ejection seat pitch and yaw angles as well as varying airspeeds to cover the aircraft operational envelope.

d. High speed sled tests are accomplished by mounting the headgear on a dummy appropriately restrained in an ejection seat. The seat is mounted on a sled with the appropriate aircraft forebody or a sting device in a position to simulate the initial stages of an ejection. The sled is accelerated to a predetermined velocity (approximately 500 KEAS). High speed photography provides the sequence of any failure. If an ejection seat with pressure sensors is used (i.e. ACES II) seat pitot tube sensor pressures and mode switching are recorded to determine any interference with normal seat mode switching (ejection can occur at 600 KEAS).

e. An ejection seat test requires a similar test set-up as the high speed sled test except that the sled has a closed canopy. Failure of the ejection seat to operate in the proper mode because of Pitot tube interference (ACES II seat) from the headgear, or failure of the dummy to separate from the seat would constitute a test failure.

f. In preparation for flight test evaluation, a hanging harness test is normally performed. A trained test subject wears the headgear with appropriate life support equipment and is suspended in a hanging parachute harness. The test subject must be able to perform all necessary parachute descent functions while suspended.

g. An actual parachute jump from an aircraft or helicopter by a trained test subject is normally performed prior to flight test evaluation. The test subject jumps from the aircraft onto dry land and into water. The headgear must not interfere with parachute opening or inhibit any descent functions. Good visibility and unrestricted arm movement are essential during descent.

VERIFICATION LESSONS LEARNED

A wide helmet could disturb the air flow into the ACES II ejection seat Pitot tubes such as to prevent proper seat mode selection.

Due to expense of seat ejection tests, "piggy-back" tests are usually preferred.

3.2.5.4 __Headgear utility.__ The following headgear use requirements shall be met:

a. Valsalva - The headgear shall permit the wearer to perform a valsalva maneuver.

b. Comfort - The aircrew member wearing the headgear shall not experience hot spots, pressure points, or other intolerable discomfort. The headgear shall fit the _______ to _______ percentile of aircrew in head size.

c. Subjective use - The headgear shall have no objectionable characteristics such as objectionable odors, skin irritation, restriction of movement, tackiness, or any other property that may cause discomfort or affect wearability.

REQUIREMENT RATIONALE (3.2.5.4)

Utilization requirements are essential to assure the wearability of the headgear and the achievement of the mission requirement for the aircrew without significant aircrew performance degradation.

REQUIREMENT GUIDANCE

Utilization requirements are based upon the Statement of Operational Need for the headgear and previous experience in the development of similar headgear.

a. Valsalva - It is essential for the safety of the aircrew to be able to perform the valsalva maneuver through the use of the forefinger and thumb which occlude the nostrils.

b. Comfort - Comfort is subjective and therefore difficult to quantify. Qualitative criteria are the best criteria for establishing comfort requirements. Quantitative criteria will be necessary to provide appropriate sizing criteria to fit the desired aircrew population.

c. Subjective use - Subjective use requirements are qualitative by nature. Identification of possible objectionable performance characteristics that can be subjectively evaluated is an important requirement.

REQUIREMENT LESSONS LEARNED

4.2.5.4 **Verification of headgear utility.** The following tests shall be performed to verify the requirements of 3.2.5.4.

a. *Valsalva tests* - The completely outfitted test subject shall perform a valsalva maneuver by occluding the nose as required to equalized pressure in the ears during altitude ascent and descent. Inability of the test subject to perform the valsalva maneuver with one hand shall be cause for rejection.

b. Subjective use/comfort test - The headgear shall be tested by ________ aircrew members during flight testing. Objectionable odors, tackiness to the touch, hot spots, high pressure areas, restriction of movement, or other detrimental performance characteristics of the headgear shall be determined by subjective evaluation. Flight crew comments shall determine whether this requirement is met. Flight crew shall be anthropometrically selected from the fifth to ninety-fifth percentile of the USAF flying population. If females do not qualify for the aircraft mission, they shall be excluded from the flying population data.

VERIFICATION RATIONALE (4.2.5.4)

Testing must be performed to assure the wearability and flight safety of the headgear without a significant aircrew performance degradation. Testing is primarily subjective and requires trained test subjects and aircrew to provide a thorough assessment of the airworthiness of the headgear.

VERIFICATION GUIDANCE

All testing requires subjective evaluation by trained test subjects. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population. A minimum of six test subjects should be selected to perform any one test to acquire statistically valid test data.

VERIFICATION LESSONS LEARNED

3.2.5.5 **Electromagnetic emmission and susceptibility of headgear.** The headgear shall meet the electromagnetic emission and susceptibility requirements of ________________.

REQUIREMENT RATIONALE (3.2.5.5)

The headgear or its components, as applicable, must meet electromagnetic interference requirements to assure that electromagnetic emission and susceptibility levels do not interfere with the mission of the aircraft.

REQUIREMENT GUIDANCE

MIL-STD-461 establishes the documentation and design requirements for the control of the electromagnetic emission and susceptibility characteristics of electrical and electromechanical equipments and subsystems. When engineering analyses reveal that the requirements in this standard are not adequate for procurement, they may be tailored by the procuring activity and incorporated into the request-for-proposal or specification. For equipment in feasibility or advanced development stages of the acquisition process, this standard should be used as a guide in formulating the appropriate requirements.

REQUIREMENT LESSONS LEARNED

4.2.5.5 **Verification of headgear to electromagnetic emission & susceptibility.** The headgear or its components, as applicable, shall be analyzed and tested as described in ________ and meet the requirements of 3.2.5.5.

VERIFICATION RATIONALE (4.2.5.5)

The headgear or its components, as applicable, must be tested and analyzed under all possible electromagnetic emission and susceptibility levels to assure that it will not cause electromagnetic interference or be susceptible to such interference which may prevent accomplishment of the mission.

VERIFICATION GUIDANCE

MIL-STD-462, Measurement of Electromagnetic Interference Characteristics, adequately establishes techniques to be used to measure and determine the electromagnetic interference characteristics (emission and susceptibility) of the headgear or its components, as applicable.

VERIFICATION LESSONS LEARNED

3.2.5.6 **Sustained acceleration on headgear.** The aircrew headgear shall neither malfunction nor hinder aircrew member's ability to perform necessary tasks when acceleration forces of __________ G's for ___________ seconds are encountered.

REQUIREMENT RATIONALE (3.2.5.6)

Sustained acceleration requirements must be attained to assure accomplishment of the aircraft mission. The Statement of need should provide this requirement.

REQUIREMENT GUIDANCE

Current requirements for tactical aircraft are up to +9 G_z and -2 G_z. This is the limit imposed by the USAF School of Aerospace Medicine, Brooks AFB TX, for human subject testing in a centrifuge. The aircraft mission statement or Statement of Operational Need should provide necessary information to establish this requirement.

REQUIREMENT LESSONS LEARNED

4.2.5.6 **Verification of sustained acceleration on headgear.** The headgear shall be placed on a human test subject and subjected to the requirements of 3.2.5.6 using a centrifuge. It shall be stable on the head and shall not show any evidence of malfunction or failure.

VERIFICATION RATIONALE (4.2.5.6)

The capability of aircrew to perform without impairment during the sustained G-force maneuvers specified for the aircraft must be verified through simulated tests prior to actual flight tests. Test procedures and equipment have been developed to perform such tests.

VERIFICATION GUIDANCE

Test limits for the centrifuge tests are determined by the type of aircraft, mission, Statement of Operational Need, and good judgment which weighs the severity and number of tests needed to assure that the headgear is flightworthy. Where anthropometric differences could affect the test results, anthropometric specifications should be used to select test subjects from the aircrew population.

VERIFICATION LESSONS LEARNED

3.2.5.7 **Visibility with headgear.** The headgear visor lens shall be large enough to not decrease the wearer's visual field in the upward or lateral directions. The restriction of downward vision shall be no greater than ____________ degrees. The viewing area shall meet or surpass the optical requirements of ______________. The lens shall be capable of meeting the ballistic resistance requirements of _____________ and abrasion resistance requirements of _____________. When properly donned and operating, the lens shall exhibit no visible fogging at a temperature of __________ degrees and relative humidity of __________ %.

REQUIREMENT RATIONALE (3.2.5.7)

Vision requirements are essential to ensure the wearability of the headgear and the achievement of the mission requirement by the aircrew without significant performance degradation.

REQUIREMENT GUIDANCE

The elimination of all downward vision restriction due to protuberances such as the oxygen mask may be unavoidable. Downward restriction of at least 15° can be expected.

A reference for aircrew lens optical characteristics is MIL-L-38169. This specification will provide optical characteristics for various classes of lenses from clear to 99% filter. Optical requirements include prismatic deviation, luminous transmittance, optical distortion, and haze.

A material commonly used for lenses is polycarbonate. MIL-V-43511 is a specification for a flyer's helmet visor and provides impact resistance requirements. Equivalent requirements for the headgear lens should provide adequate ballistic protection.

Abrasion resistance requirements for a flyer's helmet polycarbonate visor is provided in MIL-C-83409. Equivalent requirements for the headgear lens should provide adequate abrasion resistance.

Lens fogging will most often occur when the ambient environment is cold and damp. The selection of ambient conditions of 32°F and 80% relative humidity would be an adverse lens fogging environment which is likely to occur at a NATO airbase.

REQUIREMENT LESSONS LEARNED

A single lens on the headgear normally does not significantly degrade the wearer's vision. The problem is with the addition or substitution of other viewing lenses, which critically degrades the wearer's vision. Such equipment as flashblindness goggle, chemical defense barrier lens, laser protective lens, and helmet mounted sight are examples of multiple viewing lenses. When such equipment is worn on the flight helmet and combined with the vision restrictions of a HUD (head-up-display) and the canopy, aircrew vision becomes unacceptably restricted and distorted.

4.2.5.7 __Verification of visibility with headgear.__ The following tests shall be performed to verify the requirements of 3.2.5.7.

a. Optical quality tests. Test per__________.

b. Ballistic protection tests. Test per___________.

c. Abrasion resistance tests. Test per__________.

d. Low temperature tests. A human test subject with visual acuity of ____________ or better shall don the headgear and sit in a chamber at the temperature and humidity specified in 3.2.5.7. Acuity measurements shall be taken at____________intervals. A reduction in the visual acuity or any lens fogging shall constitute a failure.

VERIFICATION RATIONALE (4.2.5.7)

Testing must be performed to assure the wearability and flight safety of the headgear without significant aircrew performance degradation.

VERIFICATION GUIDANCE

MIL-L-38169 provides test methods for optical quality. This document covers the primary optical quality tests of prismatic deviation, luminous transmittance, optical distortion, and haze.

MIL-V-43511 provides an impact test method for a polycarbonate lens. This test method is general in nature and should be applicable to most lens designs.

Abrasion resistance test methods for plastics are provided in Federal Test Method Standard No. 406. Test Methods 1092 and 3022 of FED-STD-406 are applicable test methods. Haze and luminous transmittance should be determined before and after abrasion testing.

Selection of test subjects with unaided distance visual acuity of 20/20 or better is essential for the low temperature tests. Acuity measurements at three-minute intervals should be adequate. A measureable reduction in the far or near visual acuity using the Standard Snellen Chart at a distance of 20 feet or any fogging in the lens critical area should constitute a failure.

A minimum number of six test subjects is necessary to acquire an adequate data base, however, the larger the number of subjects, the more thorough the evaluation.

VERIFICATION LESSONS LEARNED

3.2.5.8 Impact protection. The dynamic response of the headgear to impact energy shall be ____________.

REQUIREMENT RATIONALE (3.2.5.8)

By definition, the primary purpose of protective headgear is to provide protection against impact. Secondary considerations, which under field circumstances may be of greater importance, include use of the headgear for protection against thermal effects and hearing damage, use of the helmet as a communications platform and oxygen mask carrier, and even use as a platform for part of a weapons system. Tradeoffs may be necessary to accomplish multipurposes and such tradeoffs should be dictated by field-usage experience.

REQUIREMENT GUIDANCE

American National Standard (ANSI) Z90.1 is currently used to establish the requirements for determining the extent of protection provided by aircrew headgear. Air Force exceptions to the standard include: one impact only at each of five sites--the crown, left, right, front, and aft section. Tests are to be conducted at ambient temperatures only.

REQUIREMENT LESSONS LEARNED

ANSI Z90.1 states that a minimum impact energy of 50 foot-pounds shall limit the acceleration impacted to a test headform to the values stated in the standard. In current headgear design, the AF has reduced this value to 35 foot-pounds. This reduced level of impact protection results, however, in a lighter and more stable headgear, both highly desirable characteristics in today's high performance aircraft.

4.2.5.8 Impact testing. The headgear shall be tested as described in ____________ and meet the requirements of 3.2.5.8.

VERIFICATION RATIONALE (4.2.5.8)

Testing must be accomplished to assure the flight safety of the headgear.

VERIFICATION GUIDANCE

ANSI Z90.1 establishes techniques to determine the protective capability of the headgear. As noted, the Air Force has taken exceptions to this standard.

VERIFICATION LESSONS LEARNED

3.2.5.9 **Headgear penetration resistance.** The headgear penetration resistance shall be ___________.

REQUIREMENT RATIONALE (3.2.5.9)

Headgear must be able to provide some measure of protection against penetration by sharp objects. Even though the very sharp box corner surface is not prevalent in undamaged cockpits, accident analysis indicates that aircraft structure does sometimes break or bend into the cockpit area so that jagged sharp sections of stiff metal present a very severe penetration surface.

REQUIREMENT GUIDANCE

Requirements currently used are defined in ANSI Z90.1.

REQUIREMENT LESSONS LEARNED

4.2.5.9 **Verification of headgear penetration resistance.** The following tests shall be performed to verify the requirements of 3.2.5.9.

VERIFICATION RATIONALE (4.2.5.9)

Testing must be accomplished to assure the flight safety of the headgear without significant aircrew performance degradation.

VERIFICATION GUIDANCE

ANSI Z90.1 establishes techniques for determining penetration protection capability of the headgear.

VERIFICATION LESSONS LEARNED

3.2.5.10 **Speech intelligibility with headgear.** Speech intelligibility shall be at least __________ % in a ___________ db noise environment. The headgear shall permit intelligible speech to be heard within the aircraft. Speech intelligibility shall include interfacing with the aircraft intercommunication system.

REQUIREMENT RATIONALE (3.2.5.10)

Effective and efficient communication between aircrew members and groundcrew members must be accomplished in the mission environment. High noise levels are distracting and fatiguing.

REQUIREMENT GUIDANCE

Aircrew headgear may be a source of noise. This must be considered during the design of the headgear. The noise level requirements are also influenced by the type and mission of the aircraft. Voice intelligibility can be assessed by placing trained test subjects wearing the headgear in a noise environment and determining voice intelligibility.

REQUIREMENT LESSONS LEARNED

A thorough assessment of the noise environment in which the headgear is worn should be conducted. Voice intelligibility should be assessed under all possible noise environments.

4.2.5.10 **Verification of speech intelligibility with headgear.** Speech intelligibility tests shall be conducted to determine that the limit specified in 3.2.5.10 is met in a noise environment of _________ measured by _________.

VERIFICATION RATIONALE (4.2.5.10)

Speech intelligibility can only be verified through the use of trained human test subjects to determine whether or not speech is intelligible in the mission noise environment while wearing the headgear. Testing procedures and equipment have been developed to simulate actual noise environments and scientifically measure voice intelligibility.

VERIFICATION GUIDANCE

Voice intelligibility can be assessed by placing at least ten trained test subjects wearing the headgear in a noise environment of 105 dB sound pressure level USASI spectrum or other SPL as appropriate to the mission and determining voice intelligibility. The communication system is connected to an AIC-18 or AIC-25 interphone. The test subjects perform a modified Rhyme test. MIL-STD-1472, para 5.3.12, provides recommended speech intelligibility test methods with the appropriate selection being dependent upon the requirements of the test.

VERIFICATION LESSONS LEARNED

3.2.5.11 Headgear sound attenuation. The headgear shall provide ________ sound attenuation.

REQUIREMENT RATIONALE (3.2.5.11)

Aircrew effectiveness includes the ability of crewmembers to receive proper hearing protection throughout all phases of the flight mission. To maintain operational effectiveness, the noise in occupied areas of the aircraft must be limited to levels where significant degradation of hearing does not occur. It is essential, therefore, to consider hearing-damage risk when defining permissible noise levels for occupied areas of the aircraft.

REQUIREMENT GUIDANCE

Earcups should meet minimum frequency group attenuation requirements of MIL-E-83425. This specification covers sound protective earcup sound attenuation requirements for three different groups of frequencies for the earcups used with the HGU-26/P flight helmet and is the best reference document available to date.

REQUIREMENT LESSONS LEARNED

Standard flight helmets include hard or semi-rigid plastic earcups with soft, doughnut-shaped seals at the wearer's head and ear interface. The bottom of the helmet shell is open and sound can enter into the area around the earcups. The earcup volume and seals have been designed to attenuate the noise that is around the cup so that which gets to the ear is less than that outside (i.e., attenuated).

4.2.5.11 Headgear sound attenuation tests. The attenuation of the headgear shall be measured as described in ________. The attentuation shall be ________ and shall be demonstrated at ________ frequencies.

VERIFICATION RATIONALE (4.2.5.11)

The use of the headgear during the sound attenuation tests will assure that the inherent attenuation features of the headgear (including earcups) are considered.

VERIFICATION GUIDANCE

A method for the measurement of real-ear protection of hearing protectors is provided in Acoustical Society of America Standard ASA 1-1975. The complete headgear assembly should be utilized. The force required to seal the earcups against the subject's head to attain the specified attenuation should not exceed 3 pounds. H-143/AIC earphones or equal mass should be installed in the earcups during the sound attenuation tests. The communication cord opening in the earcups should be plugged during the sound attenuation tests.

VERIFICATION LESSONS LEARNED

Tests conducted on headgear in the past have shown, that the pinna of the ear must be fully within the earcup cushion opening to insure adequate attenuation. In addition, helmet edgerolls that are of sufficient size to be in full contact with the subject's skin also improve attenuation.

3.3 **Reliability.** The reliability requirements of the personal protection system equipment shall be as follows: ____________________ .

REQUIREMENT RATIONALE (3.3)

Reliability requirements should be specified to ensure quality and reliability of equipment necessary to meet operational requirements over the life expectancy of the equipment.

REQUIREMENT GUIDANCE

Reliability should be predicted during design, measured during testing, and maintained with continued use of the equipment. The mean-cycle-between failure (MCBF) is a significant reliability design requirement. A cycle for personal protective equipment can be defined as a sequence of events comprising a combat or training mission including such events as donning, travel to/from the aircraft, pre-flight, entering/leaving aircraft, transition to aircraft mode of operation, combat/training flight, doffing, and decontamination if (decontamination is required). Endurance life is another method of expressing a significant reliability requirement. An example would be the operational life of a filter/blower unit. Both consumer's risk and producer's risk may be stated, which are the probabilities of accepting or rejecting equipment lower or higher than the true MCBF. Along with the risk probabilities, a discrimination ratio should be stated which is a measure of the power of the reliability test in reaching a decision quickly. The decision risks, together with the discrimination ratio, are essential in defining accept/reject criteria. Guidance on the selection of these parameters can be found in MIL-STD-781, "Reliability Design Qualification and Production Acceptance tests: Exponential distribution". The project engineer should consult the reliability engineer when completing this requirement.

REQUIREMENT LESSONS LEARNED

4.3 **Reliability tests.** The reliability requirements of 3.3 shall be verified by the following reliability tests ____________ .

VERIFICATION RATIONALE (4.3)

Verification of compliance with reliability requirements is best determined by test and analysis.

VERIFICATION GUIDANCE

Detailed test requirements and accept/reject criteria are provided in MIL-STD-781. The project engineer should consult the reliability engineer when establishing test requirements.

VERIFICATION LESSONS LEARNED

3.4 **Maintainability.** The maintainability requirements of the personal protection system equipment shall be as follows: ________________.

REQUIREMENT RATIONALE (3.4)

The system should be designed for easy access and maintenance of those components that will require frequent inspection or replacement. These requirements serve to assure that both the contractor and the project engineer give proper consideration to system inspection, testing, and component replacement, both during the design of the system and during the design reviews and inspections. The system must be designed recognizing that first-term airmen may be performing the system maintenance.

REQUIREMENT GUIDANCE

In completing the maintainability requirements, the engineer should consider the following, in addition to the unique requirements of the system under consideration:

a. All components requiring frequent replacement (e.g. filters) should be designed for easy access.

b. When designing the system, recognize the possible low level of training and experience of the technician performing the maintenance.

A reference which is useful in understanding physical limitations in performing maintenance tasks is MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment and Facilities. Section 5.9 of MIL-STD-1472, Design for Maintainability, provides useful guidance in establishing maintainability requirements. Actual maintainability requirements must be tailored to the equipment being designed. Overstatement of requirements can lead to unnecessarily large and unworkable systems whereas understatement of requirements can lead to difficulty in maintaining systems.

The mean time to repair or service a system or component at lower echelons of maintenance is a key requirement that should be specified and should be commensurate with the mission requirements for the system.

REQUIREMENT LESSONS LEARNED

4.4 **Maintainability evaluation.** The maintainability requirements of 3.4 shall be verified by the following maintainability tests and analyses ________.

VERIFICATION RATIONALE (4.4)

Verification of compliance with maintainability requirements is best determined through testing, inspections, and demonstrations.

VERIFICATION GUIDANCE

Demonstration tests should be conducted close to or in a field environment using the level of trained technicians expected to maintain the system.

Common standards referenced in a Statement of Work are MIL-STD-470, Maintainability Program Requirements and MIL-STD-471, Maintainability Verification/Demonstration/Evaluation. The first standard provides requirements for establishing a maintainability program and guidelines for the preparation of a maintainability program plan. The second standard provides procedures and test methods for verification, demonstration, and evaluation of qualitative and quantitative maintainability requirements. The project engineer should consult the maintainability engineer when establishing test requirements.

VERIFICATION LESSONS LEARNED

3.5 **Open flame thermal protection.** The aircrew personal protective equipment shall provide open flame protection to the wearer when he or she leaves a burning aircraft and runs through a ________ foot circle of fire as simulation tested in accordance with 4.5.

REQUIREMENT RATIONALE 3.5

Aircrew members must be able to escape on the ground from a burning aircraft and standard flight ensembles have been designed with this requirement in mind. The aircrew personal protective equipment will replace all or part of the standard ensemble and must provide open flame protection at least as good as the standard ensemble.

REQUIREMENT GUIDANCE

Aircrew members escaping from burning aircraft quite often must run through burning aircraft fuel which can be a distance of as much as 60 feet from aircraft to the outer edge of the flames. If fire protection is not provided during this run, the escapee will receive severe burns.

REQUIREMENT LESSONS LEARNED

Aircrew members have had to escape from burning aircraft on the ground and if not provided with flame proof or flame retardant ensembles have either not survived or have been severely burned during the escape attempt. Fuel fires are hot and require special consideration from a protection standpoint.

4.5 **Open flame thermal protection tests.** The aircrew personal protective equipment shall be exposed to ________________ fuel flame for a period of ____________ seconds to verify that it meets the limits specified in 3.5.

VERIFICATION RATIONALE 4.5

Open flame thermal protection can only be verified through the use of controlled laboratory procedures that simulate operational conditions in order to prevent the unnecessary exposure of humans to hazardous conditions.

VERIFICATION GUIDANCE

Open flame thermal protection can be assessed by placing the aircrew personal protective equipment on a fiberglass epoxy coated manikin with calibrated paper temperature sensors on the outer surface. It is suspended head-up from an overhead cable and pulled, in a period of three seconds, over a fire pit of burning JP-4 fuel (1800-2300°F). Temperatures indicated on the sensors shall be recorded. The PSE must provide the thermal protection with no burn indication (maximum of 169°F skin temperature) and be flame resistance. Effects on the hair, respiratory system and injury due to melting of materials shall also be considered.

VERIFICATION LESSONS LEARNED

Inherent multilayered PSE construction techniques using flame-resistant materials have been found to substantially contribute to the aircrew member's safety durning exit from a burning aircraft on the ground.

3.6 **CB resistance of materials and design.** Selection of materials and design of personal protective equipment shall be such that contact with CB agents in liquid or vapor form will not cause deterioration of equipment nor increased risk to the aircrew member. The equipment shall be capable of being decontaminated by ___________.

REQUIREMENT RATIONALE 3.6

Aircrew personal protective equipment may be used in a CB environment and may require decontamination to enable reuse.

REQUIREMENT GUIDANCE

Mission requirements will determine the CB environment to which aircrew personal equipment will be exposed. If reuse after exposure to CB agents is required, the equipment shall be capable of being decontaminated by available decontamination techniques or special decontamination techniques developed for the aircrew equipment.

Exposure to CB agents could be from direct contact while transitioning from a shelter to the aircraft or from agents in the cockpit. Also, agent exposure could occur from transfer of agents through the environmental control system (ECS). CB agents in the ECS could therefore enter anti-G garments and PSE's through air lines to them.

REQUIREMENT LESSONS LEARNED

Cracks and crevices are collecting points for CB agents. Some available decontamination techniques can cause deterioration of materials.

4.6 **Verification of CB agent resistance.** The CB agent resistance requirements of 3.6 shall be verified by the following test and analysis ___________.

VERIFICATION RATIONALE (4.6)

Aircrew personal protective equipment, as applicable, must be tested and/or analyzed to verify that the materials and designs will not deteriorate nor increase the risk to the aircrew member and are decontaminable after exposure to CB agents.

VERIFICATION GUIDANCE

Analysis and test should be accomplished as necessary. Prior to testing, existing data bases for materials should be reviewed to determine if past testing has been accomplished. The U.S. Army Chemical Research and Development Center (RDC), Aberdeen Proving Ground, MD., should be able to provide some guidance in terms of testing to accomplish and provide available data on materials and design.

VERIFICATION LESSONS LEARNED

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