NATO STANDARD

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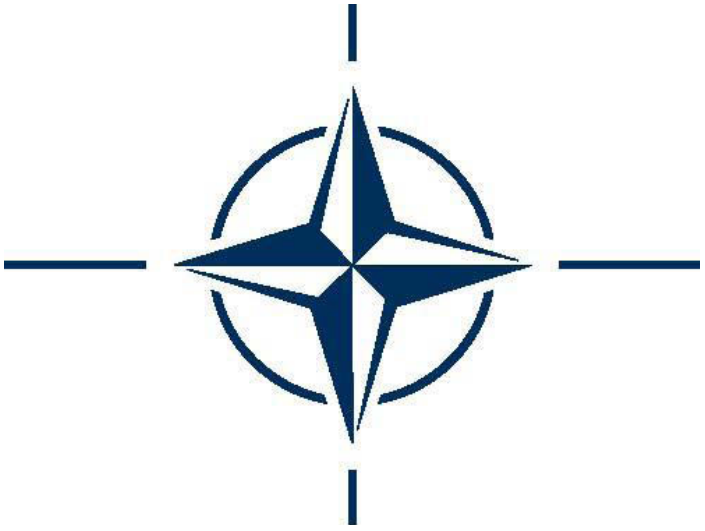
TECHNICAL AND MEDICAL STANDARDS AND REQUIREMENTS FOR SUBMARINE SURVIVAL AND ESCAPE

Edition A Version 1

JULY 2014



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NATO LETTER OF PROMULGATION

28 July 2014

1. The enclosed Allied/Multinational Naval Engineering Publication ANEP/MNEP-86, Edition A, Version 1, TECHNICAL AND MEDICAL STANDARDS AND REQUIREMENTS FOR SUBMARINE SURVIVAL AND ESCAPE, which has been approved by the nations in the Military Committee Maritime Standardization Board (MCMSB), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 1476.

2. ANEP/MNEP-86, Edition A, Version 1, is effective upon receipt.

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

Edvardas MAŽEIKIS
Major General, LTUAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS

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

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RECORD OF SPECIFIC RESERVATIONS

Nation	Detail of reservation

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

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RECORD OF CHANGES

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RELATED PUBLICATIONS

ATP/MTP-57	THE SUBMARINE SEARCH AND RESCUE MANUAL
ANEP/MNEP-85	MATERIAL INTEROPERABILITY REQUIREMENTS FOR SUBMARINE ESCAPE AND RESCUE

CHAPTER 1 - MINIMUM CONDITIONS FOR SURVIVAL IN A DISTRESSED SUBMARINE (DISSUB) PRIOR TO ESCAPE OR RESCUE

1.1. PURPOSE

a. Identify the important physiological and environmental factors that influence survival in a DISSUB pending escape or rescue.

b. Where possible, quantify these factors (in terms of minimum/maximum acceptable levels) and thus ensure that both the physical and mental functions of the survivors remain at a level necessary to enable them to effect an escape or rescue.

1.2. DEFINITIONS

The following terms and definitions are used for the purpose of this agreement:

a. 1 bar is approximately equivalent to: 1 ATA; 100 kPa; 10 msw; 33 fsw; 760 mmHg; 760 Torr.

b. Standard Temperature & Pressure (STP) is 0°C and 760 Torr.

c. Normal constituent of air:

(1) Nitrogen: 78% by volume (0.78 bar partial pressure at 1bar)

(2) Oxygen: 21% by volume (0.21 bar partial pressure at 1bar)

(3) Carbon Dioxide: 0.04 % by volume (0.0004 bar partial pressure at 1bar)

d. High concentrations are normally expressed in volume percent (Vol.%). i.e. 1 part of a substance in 100 parts of air. Air consists of 21 Vol.% oxygen. (i.e. 100 parts of air contain 21 parts of oxygen).

e. In smaller concentrations the engineering unit 'parts per million' is used (ppm). The concentration ppm means 1 part of a substance in 1 million parts of air. 1 Vol.% = 10,000 ppm.

f. Partial Pressure: the pressure a gas would exert if it alone occupied the same volume as the whole gas mixture.

1.3. GENERAL DETAILS

Survivors in a DISSUB are faced with determining the best method of returning to the surface. The safest way may be to await rescue and be transferred to the surface in a rescue vehicle. Alternatively, escape may be the best option, particularly if conditions within the DISSUB are deteriorating or the sinking is in a remote area. Escape necessitates the survivors exposing themselves to the external environment in what is essentially a bounce dive, possibly superimposed over a saturation decompression obligation.

The longer the survivors spend in the DISSUB the more likely the environmental conditions will deteriorate and result in adverse affects on the physical and mental wellbeing of the survivors. These in turn affect the capability of undertaking an escape or continuing to await rescue. Many of the DISSUB environmental factors are inter-related and time dependant. The way in which these factors interrelate is largely unknown.

This chapter identifies the important physiological and environmental factors that affect survival in the DISSUB. The technical information is located in the Annex. There are 3 major sections:

- THE DISSUB INTERNAL PRESSURE
- THE DISSUB ATMOSPHERE
- TEMPERATURE, HYDRATION AND NUTRITION

ANNEX 1.A. CONDITIONS FOR SURVIVAL IN A DISSUB SCENARIO

1.A.1. THE DISSUB INTERNAL PRESSURE

1. Rescue considerations. Past experience has demonstrated that a DISSUB is invariably pressurised to a certain degree. If exposed to a pressure of 1.7 bar or above for a period of time the DISSUB survivors have a decompression obligation once rescued. Survival for up to 1 week at an internal pressure of around 5 bar is considered possible, however it should be noted that this has never been proven scientifically. This magnitude of exposure will result in a deterioration of lung function due to pulmonary oxygen toxicity that gets progressively worse above an oxygen partial pressure of 0.5 bar. Above 5 bar mental ability rapidly deteriorates due to nitrogen narcosis and cerebral oxygen toxicity (above an oxygen partial pressure of 1.6 bar).

2. Escape considerations. The safety of escape is dependant on the type of escape system being used (national variation), the depth of the DISSUB and the internal pressure within the DISSUB. Laboratory experiments have demonstrated that return to surface pressure from a DISSUB internal pressure of 1.7 bar or less results in a low incidence of decompression illness(i). Further and more detailed information is provided in A/MTP 57.

1.A.2. THE DISSUB ATMOSPHERE

1.A.2.1. OXYGEN

3. Oxygen is a colourless, odourless gas that supports combustion and life. It is a major factor to be considered during survival in the DISSUB. Oxygen sources in the DISSUB include ambient air, compressed oxygen cylinders, oxygen-generating chemicals and for some systems even LOX (liquid oxygen).

a. Oxygen Consumption. In a DISSUB, it is expected that the survivors will be at a minimal activity level, since complete rest minimises oxygen consumption (and CO_2 production). Oxygen consumption in a DISSUB has been shown to range from 20 to 40 litres/man/hour at STP(ii).

b. The following value should be used in the calculation of life support stores requirements and stay times prior to submarine escape or rescue:

Oxygen usage: 27 litres/man/hour at STP(iii)

c. Physiological Constraints. It is the partial pressure of oxygen that is important physiologically. The partial pressure of O_2 in the tissues is 0.07 bar and the normal partial pressure of oxygen in air at STP is 0.2 bar. If this gradient is reduced too much, the tissues become deficient in oxygen and ill health effects ensue (the effects of hypoxia). Table 1.A-1 illustrates the acute affects of hypoxia caused by a sudden reduction in the partial pressure of oxygen.

Table 1.A-1 The acute effects of hypoxia

P.Pressure of Oxygen in inspired air (bar)	Health Effects
0.2	Normal
0.18	Lowest acceptable limit for normal submarine
0.17	Earliest signs: loss of night vision; dilated pupils
0.15	Concentration on and reliability of tasks slightly impaired[(iv)]
0.13	Co-ordination affected; respiratory effects stimulated by hypoxia
0.11	Unconsciousness
0.06	Death

d. It is important to note that a gradual reduction in the partial pressure of oxygen will result in some acclimatisation to the effects of hypoxia (in the 0.18 - 0.13 bar range). Thus, the survivors may remain sufficiently alert to enable them to assist during the rescue procedures down to partial pressure of around 0.13 bar (however note para. 4.b. regarding escape).

e. A raised partial pressure of oxygen can also be harmful. The signs and symptoms of pulmonary oxygen toxicity become progressively worse above an O_2 partial pressure of 0.5 bar. Pulmonary oxygen toxicity increases the risks involved during escape and rescue. Cerebral oxygen toxicity may occur if the partial pressure of O_2 exceeds 1.6 bar; the most obvious manifestation of this is convulsions.

f. Above a fractional concentration of 23% oxygen becomes a significant fire hazard within the DISSUB and Rescue Submersible.

Advice on Oxygen

4. Onboard the DISSUB:

a. Whenever possible both following parameters should be maintained for as long as possible

- oxygen partial pressure between 0.15 bar and 0.5 bar (physiological matters);
- oxygen concentration lower than 23% volume (fire hazard matters).

b. When oxygen regeneration sources have been exhausted, the oxygen partial pressure will fall. In the absence of instructions from the surface, escape should be planned such that the partial pressure of oxygen does not fall below 0.13 bar at the end of the escape procedure.

c. It is acceptable to await rescue down to a partial pressure of 0.13 bar.

1.A.2.2. CARBON DIOXIDE

5. Carbon dioxide is a colourless and odourless gas at normal temperatures and pressures. Denser than air, it may accumulate in low areas. It is a dangerous product of combustion. It is also a product of respiration and is directly related to the amount of oxygen consumed by the body. Carbon dioxide production is minimised by complete rest, but can readily double with physical activity:

a. CO_2 production. In a DISSUB, it is expected that the crew will be at a minimal activity level. The following minimum value should be used in the calculation of life support stores requirements and stay times prior to submarine escape or rescue.

Carbon Dioxide production: 23 litres/man/hour at STP[iii]

b. Physiological Constraints. As with oxygen it is the partial pressure of CO_2 that is important physiologically. The partial pressure of CO_2 in the tissues is 0.07 bar and the normal partial pressure of CO_2 in air at 1 bar is 0.0003 bar. If this gradient is sufficiently reduced the tissues retain excessive amounts of CO_2 (hypercapnoea) and ill health effects ensue.

c. In the DISSUB scenario a rising CO_2 partial pressure is likely to become a limiting physiological factor well in advance of any problems with falling oxygen. The partial pressure of CO_2 may rise suddenly due to rapid pressurisation or a fire. Alternatively the survivors may be subjected to a gradual increase in the partial pressure as they await rescue. The physiological response to the two scenarios is different as there is some adaptation to chronic exposure. Table 1.A-2 and Table 1.A-3 illustrate the differences.

Table 1.A-2 Acute effects of CO_2 from short term exposure

Partial Pressure of CO_2 (bar)	Health Effects
0.01 - 0.02	Slight increase in depth of respiration; headache & fatigue after several hours
0.03	Severe headache; diffuse sweating; laboured or difficult respiration
0.04	Flushing of face; palpitations
0.05	Mental impairment
0.06	Hard work impossible; visual disturbance
0.08	Tremors; convulsions
0.12	Unconsciousness

Table 1.A-3 Effects of CO_2 from chronic exposure

Partial Pressure of CO_2 (bar)	Health Effects
0.03	Threshold for dyspnoea at rest
0.03 - 0.04	Headaches but likely to subside
0.03 - 0.06	Increasing incidence of dyspnea
0.05	Lower limit for reduced intellectual and cognitive capacity
0.06	Dyspnoea at rest
> 0.08	Expect tremors/convulsions/loss of consciousness

When CO_2 removal resources have been exhausted, the CO_2 partial pressure will rise making the escape procedure more hazardous. A CO_2 partial pressure of 0.05 bar is the maximum acceptable for escape. There is some evidence that hypercapnoea increases carbon monoxide(CO) toxicity (see CO section) and central nervous system oxygen toxicity.

Advice on Carbon Dioxide

6. Onboard the DISSUB the carbon dioxide partial pressure should be kept below the following limit for as long as possible:

a. Less than or equal to 0.03 bar

b. In the absence of instructions from the surface, escape should be planned such that the partial pressure of carbon dioxide does not exceed 0.05 bar at the end of the escape.

1.A.2.3. CARBON MONOXIDE

7. Carbon Monoxide (CO) is a dangerous product of incomplete combustion. It is a colourless, tasteless, odourless gas with a density almost equal to that of air. CO competes with oxygen for the haemoglobin molecules within the blood stream (the haemoglobin molecule transports oxygen to the body tissues). Carbon Monoxide's affinity for haemoglobin is some 200 times greater than that of oxygen. Consequently, carbon monoxide attaches to the haemoglobin in preference to the oxygen and produces an insidious hypoxia (lack of oxygen) within the body tissues. There is a dose dependant reaction.

8. CO poisoning not only reduces the oxygen carrying capacity of blood but also exerts toxic effects directly on the cell by blocking a critical enzyme (cytochrome a3 oxidase). Victims surviving the immediate intoxication may experience long term health effects (e.g. memory and mood disturbances, headache) due to damage of cells in the nervous system. Little is known of low concentration/long duration exposure to CO. Table 1.A-4 demonstrates the consequences of inhaling CO when breathing contaminated air (partial pressure of oxygen 0.2 bar) at 1 bar.

9. Table 1.A-4 indicates expected levels of toxicity based on normoxia and it is important to note that any reduction in the oxygen partial pressure will worsen and hasten symptoms of CO toxicity. Conversely, a raised oxygen partial pressure (greater the 0.2 bar) will lessen the production of carboxyhaemoglobin and thus delay development of CO toxicity. An increased partial pressure of CO_2 is believed to facilitate the toxic effects of CO.

10. Therefore, within the DISSUB the ambient pressure (assumed boundaries of 1 - 5 bar), the partial pressure of oxygen, CO and CO_2 will all act as independent but interrelated variables with the body tissues. As a consequence of this complexity, the provision of advice as to what constitutes a safe level of exposure to CO whilst considering escape or rescue is difficult.

Table 1.A-4 Acute effects of carbon monoxide

Conc. in inhaled air (ppm) at 1 bar	CO % saturation of the haemoglobin	Symptoms
25	0 – 5	Safe for all individuals
50	0 – 10	None
100	10 – 20	Tightness across forehead, slight headache. Approx. upper limit of continuous exposure with minor symptoms only
200	20 – 30	Headache and throbbing in temples. Mild symptoms for 8 hour exposure; moderate symptoms for continuous exposure
300	30 – 40	Severe headache, weakness, disorientation, confusion and collapse
500	40 – 50	Same as above but earlier - after 3 - 4 hours exposure.
1000	60 – 70	Immediately dangerous - severe symptoms after minutes exposure: coma, intermittent convulsions; depressed heart action; possible death
2000	80 – 90	Death in less than 1 hour
4000	90 – 100	Death in few minutes

Advice on Carbon Monoxide

11. Advice on escape and rescue must be extrapolated from the known effects produced by short term exposures. As such the advice is, at best, very rudimentary.

a. Advice on Escape. Escaping from a submarine with moderate or severe symptoms would impose a significant risk due to the decreased physical and mental capacity. Thus symptoms may be used as a crude measure of toxicity. However, it should be noted that similar symptoms due to CO_2 intoxication and other contaminants might further confuse the picture.

(1) Mild Symptoms: headache; dizziness; exertion dyspnoea; decreased visual acuity; some impairment of higher cerebral function.

(2) Moderate Symptoms: severe headache; irritability; reduced judgement; nausea; worsening dizziness.

(3) Severe Symptoms: fainting; convulsions; paralysis; coma; respiratory and cardiac arrest.

b. Advice on Rescue. A continuous exposure of up to 200 ppm may still allow survivors to undertake the required DISSUB tasks to effect a rescue within 7 days. Above this level the acute effects will severely reduce physical and mental abilities. Some long-term health complications are to be expected.

1.A.2.4. CHLORINE

12. Chlorine[vi] is produced as a result of electrolysis of sodium chloride containing solutions. Any uninsulated voltage underwater, like flooding above the submarine batteries, may produce Cl_2 gas. Chlorine gas is heavier than air therefore it may be confined to the lower levels of the escape compartment.

13. Chlorine is a simple irritant and has no metabolic effect within the body. The main danger is damage to the lower respiratory tract due to the irritant action. This will ultimately result in life threatening pulmonary oedema. The effects on the human body are well understood. Table 1.A-5 summarizes the results from numerous experimental and industrial studies.

Table 1.A-5 Acute effects of chlorine

Chlorine concentration at 1 bar (ppm)	Health Effects
0.2 - 0.4	The odour threshold.
0.5	No change in pulmonary function after 8 hr. exposure.
1.0	Tolerable for 8 hrs but some significant changes in pulmonary function.
2.0	A 2 hr. exposure produced no statistically significant changes in pulmonary function.
3 – 6	Severe irritant to eyes, nose, throat and upper respiratory tract.
15	Lowest conc. causing respiratory distress.
14 – 20	Exposure for 1 hour reported as dangerous.
100	Tolerable for a maximum of 1 minute.
430	Lowest lethal conc. for a 30 min. exposure.
1000	Usually lethal after a few good breaths.

14. If the presence of chlorine is suspected it should be measured for on a regular basis. The survivors must balance the risk of chlorine exposure against the risks of escape (depth, pressure, surface conditions) and awaiting rescue. Some chlorine induced lung damage may be acceptable in the knowledge that the rescue vehicle is expected. Conversely, lung damage may reduce the survivor's ability to escape and survive on the surface.

<u>Advice on Chlorine</u>

15.

Table 1.A-6 provides a guideline for exposure management within the DISSUB:

Table 1.A-6 Acute exposure guidelines for chlorine

Chlorine concentration at 1 bar (ppm)	Effects when breathed
0.5	Safe to breathe and await rescue. Above this level don coveralls to protect skin
1	Safe to breathe for 6 hours Above this level wear hood if available to protect face and eyes
2	Safe to breathe for 3 hours
5	Dangerous after approximately 1 hour
10	Dangerous - do not breathe

1.A.2.5. CONSIDERATION SHOULD BE GIVEN TO MONITOR THE FOLLOWING GASES

a.	Hydrogen chloride	HCl
b.	Hydrogen sulfide	H_2S
c.	Ammonia	NH_3
d.	Oxides of Nitrogen	NO_x
e.	Hydrogen cyanide	HCN
f.	Hydrocarbons	$C_xH_x(X)$
g.	Hydrogen	H_2
h.	Humidity	H_2O
i.	Refrigerant gases.	

1.A.3. TEMPERATURE, HYDRATION AND NUTRITION

16. Traditionally it was considered that over a period of days the DISSUB internal temperature will tend to approach the surrounding sea water temperature[(vii)(viii)(ix)]. However a number of recent SURVIVEXs have cast doubt on this view and have shown that either the fall in DISSUB temperature is significantly slower[(x)] or indeed there may actually be a rise in temperature as result of metabolic heat production by the crew and heat produced as a result of the exothermic reaction when lithium hydroxide or soda-lime (both widely used as CO_2 absorbents) absorb CO_2 and O_2 candles. Thus there is some doubt as to what might actually happen and this will also be dependent on ambient sea temperatures.

17. Low temperatures may cause hypothermia (core temperature of 35°C or below) and non-freezing cold injury to the skin. Wet clothing will exacerbate the problem. Shivering will increase oxygen consumption, carbon dioxide production and consequently decrease DISSUB survival

time. Additional thermal protection, extra to the normal working clothing, is required to prevent hypothermia and non freezing cold injury in cold conditions[xi]. Hypothermic patients should be placed in upper bunks if facilities and patient monitoring allows, as the vertical atmospheric temperature gradient may be significant.

18. High temperatures will cause hyperthermia. The body will attempt to lower core temperature by increased sweating; this mechanism will be impaired if the humidity is also elevated, which is considered to be highly likely. Increased sweating will result eventually in dehydration; this can be prevented by allowing survivors to drink as much water as is possible. Additionally attempts should be made to cool hyperthermic survivors, this can be achieved relatively effectively by immersing extremities in cool water, sea water should provide a plentiful supply.

19. Surviving on meagre rations has been shown to cause hypoglycaemia, starvation diarrhoea, headache, backache, low urine output leading to renal failure and exacerbate the effects of hypothermia. Furthermore, the ability to perform an escape or rescue procedure is severely restricted by the lack of adequate fluid and calorific intake. Consequently, the minimum fluid intake should be 1 litre per day per man and the minimum calorific intake should be 1250kcal per day per man. In addition, 1000kcal should be available to be eaten just prior to escape[xi].

20. Attention must be paid to hygiene issues to prevent the spread of infectious disease. If at all possible hand washing should be performed prior to eating, handling food and after defaecation. Faecal material must be isolated in plastic bags. A gastrointestinal infection, in combination with other DISSUB stress factors, may make participation in any rescue procedure impossible due to hypovolaemia and hypoglycaemia. Each escape compartment should contain medical stores to deal with the conditions envisaged. The provision of antiseptic wipes (non-alcohol based) should be considered as a means of improving personal hygiene.

1.A.4. BIBLIOGRAPHY

[i] Islander 1. An investigation of direct decompression from oxygen/nitrogen saturation to 1 bar. Bell PY, English MS, Harris DJ et al. Environmental Science Division, ARE Alverstoke, Gosport UK

[ii] Personnel communication Jan Risberg SURVIVEX 2002

[iii] House CM et al. Findings from a simulated disabled submarine survival trial. Undersea and Hyperbaric Medicine 27:4 pp175 - 183 (survivors at rest with minimal or no activity)

[iv] Gustafsson C, Gennser M, Ornhagen H, Derefeldt G. Aviat Space Environ Med. 1997 Nov; 68(11): 985-92.

[v] Wong, KL.B3 Carbon Dioxide. In: Subcommittee on Spacecraft Maximum Allowable Concentration, National Research Council: Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants: Volume 2, 105-188, National academy press, Washington DC, 1996

[vi] Dean M R Surgeon Commander. Chlorine levels in submarines. Review for the UK Standing Committee on Submarine Escape and Rescue. Institute of Naval Medicine's 253/103 dated 24 October 1994

[vii] Wilson J, McGill T and Williams R H (1996) Los Angeles class forward compartment disabled submarine ambient temperature final report. Electric Boat Corporation, Groton, Connecticut. Report N° 470: JW/600827/1.7

[viii] Panet, Bodalis and Radziszewski (1991) Survivex. Survival in refuge compartments of submarines. Commission of submarine practical studies N° 183 CEPSM/DR

[ix] Loncar M and Ornhagen H (1996). Environmental parameters in a simulated disabled Vastergotland submarine. FOA Naval Medicine Division PM 541:33, 960117

[x] Risberg J, Ostberg C, Svensson T, Norfleet W, Ornhagen H, Mjaavatten O, Juvik T. Atmospheric changes and physiological responses during a 6-day “Disabled Submarine” exercise. Aviation,Space and Environmental Medicine Vol 75, No2 Feb 2004 138-149.

[xi] CM Windle 1997. Survival in a Disabled Submarine Thermal Considerations. Institute of Naval Medicine Report N° 97012

CHAPTER 2 - SUBMARINE ESCAPE AND SURFACE SURVIVAL PERSONNEL EQUIPMENT (SESSPE)

2.1. PURPOSE

This chapter defines the minimum requirements for SESSPE to enable a submarine escapee to make a safe ascent from a DISSUB and survive on the surface pending rescue.

2.2. GENERAL

The primary function of the SESSPE is to enable the user to make a safe ascent from the DISSUB to the surface.

Secondary functions include the provision of:

a. Adequate buoyancy, stability, self righting and wave-splash protection to prevent drowning.

b. Adequate design to enable the user to vomit without aspiration, if seasick on the surface.

c. Seals at wrists and face/neck to minimize ingress of seawater.

d. Sufficient insulation to minimize the incidence of hypothermia and cold injury in cold sea and weather conditions.

e. Suitable location aids to enable detection by surface ships and aircraft.

f. To reduce the incidence of hypothermia, the suit shall have means of minimizing fluid accumulation within the SESSPE due to urine production, both for men and women.

2.3. DETAILS

The SESSPE should be:

a. of universal size to fit all users,

b. worn in conjunction with additional clothing to slow the onset of general hypothermia,

c. The suit or its associated life raft should be fitted with a battery operated SOLAS approved light to aid in the detection of survivors,

d. packaged to prevent degradation during storage in as small a presentation as possible,

e. fully usable within 5 minutes of withdrawal from storage and must not immobilize the wearer,

f. functionally safe to the maximum escape depth that a human body can handle.

The SESSPE must be conspicuous and brightly coloured to aid visual detection. During ascent:

a. the wearer must be able to breath air normally,

b. the SESSPE must be provided with a reliable system for venting excess air from the suit and from the built-in buoyancy,

c. stability should not be compromised by design features.

There should be a means of:

a. minimizing fluid accumulation within the SESSPE due to urine production,

b. grasping the survivor to facilitate removing him from the water.

If the SESSPE is fitted with a life raft, the life raft should have the following requirements:

a. adequate buoyancy, stability and wave-splash protection,

b. sufficient insulation to minimise the incidence of hypothermia and cold injury in cold sea and weather conditions,

c. suitable location aids to enable detection by surface ships and aircraft.

The life raft should be:

a. of universal size to fit all users,

b. fitted with a battery operated SOLAS approved luminous beacon to aid in the detection of survivors,

c. packaged to prevent degradation during storage and must not immobilize the wearer to allow easy access into the escape tower,

d. maximum inflation time to be no longer than 90 seconds and fitted with a manual secondary inflation system. Manual water removal system is also to be fitted,

e. equipped with a drogue,

f. the life raft must be conspicuous and brightly coloured to aid visual detection,

g. life rafts fitted with protective canopies must provide a ventilation system to avoid CO2 build up,

h. life raft must be capable of being manually “re-righted”.

CHAPTER 3 - MEDICAL STANDARD FOR SUBMARINE ESCAPE TRAINING TANK CANDIDATES

3.1. PURPOSE

This chapter defines the minimum requirements to ensure that foreign students being trained in a submarine escape training tank are medically fit for such training.

3.2. DETAILS

a. The requirements cover training in submarine escape training tank (SET), but not escape training from a submerged submarine.
b. Definitions: The host nation is the nation providing SET training. The client nation is the nation requesting SET training.
c. The host nation holds overall responsibility for the safety of the SET training.
d. The client nation has the responsibility for assessment of medical fitness according to the host nation standards. However, the medical authority of the host nation has the privilege to re-assess the candidate's medical fitness and may disqualify the candidate for training if he/she is found medically unfit.
e. The decision of medical fitness should be based on the assumption that no underlying disorder exists which may represent a risk for the candidate during SET training. The objective of this chapter is not to define examination applicable for submarine service in general.
f. The decision of medical fitness should be based on a thorough medical investigation and subsequent assessment. The minimum extent of such investigation is detailed in ANNEX 3.A, but this should be expanded as considered necessary by the client nation medical authority. Dependent on the nature of the SET training, national military or civilian regulations applicable for the host nation or development of medical knowledge, the host nation may require extension of the examinations beyond what is identified in ANNEX 3.A.
g. The decision of medical fitness for SET training should be signed by a service physician trained in diving medicine. The physician should be authorized by an appropriate national medical authorisation agency for such responsibility. Host nation may request copy of such letter of approval. Details of the content of the medical certificate are given in ANNEX 3.B.
h. A certificate of medical fitness for SET training has a maximum validity of three months following the examination unless otherwise agreed between host and client nation.
i. Pass/fail criteria for the medical examination is detailed in ANNEX 3.C. As described in Serial e above this should be decided on the candidate's ability to perform training in a safe manner. If the examining physician considers the candidate fit for SET training, in spite of the guidance provided in ANNEX 3.C, this should be detailed on the medical certificate. The client nation has the responsibility to bring details of such a decision to the attention and final approval of the host nation at the earliest opportunity.

ANNEX 3.A. MEDICAL EXAMINATION OF SET CANDIDATES

3.A.1. GENERAL

1. The examination should include assessment of the medical history, a clinical examination and additional examinations as detailed in this document. The examining physician has the responsibility to investigate the candidate on an individual basis, extending the examinations listed below as considered necessary.
2. The medical information should be filed in writing or electronic format in agreement with national regulations. The host nation may request a copy of the results.

3.A.2. MEDICAL HISTORY

3. The medical history should be addressed by a questionnaire as well as a personal interview by the examining physician. The questionnaire and interview shall address the social relationships and service history, family medical history, malformations, previous illnesses and injuries, present complaints, use of recreational drugs, alcohol and tobacco as well as medication and allergies. In specific any problems related with previous diving and SET training should be addressed.
4. The medical history is considered the most important part of the medical examination and should be investigated and documented in detail.

3.A.3. CLINICAL EXAMINATION

5. As a minimum these clinical examinations should be completed:
   - Height, weight.
   - Blood pressure, Pulse.
   - Examination of ear, nose and throat. Assessment of air flow through both nostrils, intact eardrums and normal movement of the eardrum by insufflation of air and active equilibration (Valsalva).
   - Examination of lungs and heart (auscultation).
   - Thorough neurological exam.

3.A.4. INVESTIGATIONS

6. These investigations should be included:
   - Haemoglobin concentration and urine chemistry (as a minimum including examination for protein, glucose, blood – e.g. dipstix).
   - Dynamic spirometry as a minimum including FVC, FEV1 and PEF completed with instrumentation and procedures complying with accepted international clinical standards for spirometric examinations.
   - Pure tone audiometry with threshold assessment for each ear as a minimum including frequencies 500, 1000, 2000, 4000 and 6000 Hz.
   - Dental examination not older than 12 months.
   - Chest X-ray, inspiration, PA not older than 12 months.

ANNEX 3.B. MEDICAL CERTIFICATE CONTENTS

1. The medical certificate should be written in English (other additional language may be used as needed).
2. The form should be signed in person by the examining physician (signature stamp not accepted).
3. The medical certificate should contain at least these elements
   - Name, rank and DOB of person examined
   - Standard to which the subject has been examined (present standard and any other relevant national or international standard)
   - Date of examination
   - Result of examination (fit, unfit or fit with restriction)
   - Comment (a person considered fit in spite of non-compliance with guidelines attached as Annex C should have details of the condition/disorder detailed here)
   - Period of validity (3 months maximum)
4. A sample form is attached at the next page.

MEDICAL CERTIFICATE FOR SET CANDIDATES

Name:
Rank:
DOB:

has been examined by me in compliance with ANEP/MNEP-86 Chapter 3.

In addition he/she has been examined according to:
☐ Not applicable ☐ Other (please detail):

I confirm that I am authorized by my national head of submarine medicine to issue certificate of medical fitness for SET candidates.

Based on my examination I consider the subject:
- ☐ Fit for SET training, no restriction
- ☐ Fit for SET training, but a condition considered a contraindication for SET training as per Annex C has been identified and is detailed in “Comments” field below.
- ☐ Unfit for SET training
- ☐ Fit for SET training with these limitations:

Comment:

Period of validity: 3 months after date of issuing

Place/Date

Examining physicians name, signature and official stamp
Address, telephone and e-mail address of examining physician

ANNEX 3.C. GUIDELINE FOR ASSESSMENT OF MEDICAL FITNESS FOR SET TRAINING (PASS/FAIL CRITERIA)

3.C.1. INTRODUCTION

1. The investigation of candidates with conditions which might make them unfit is to be initiated by the examining physician of the client nation, with specialist opinions sought as appropriate. The candidate is to be considered temporarily medically unfit until a definitive decision is made.
2. If investigation fails to resolve the issue of fitness, the examining physician of the client nation should send all relevant information to the medical authority of the host nation for review. The medical authority of the host nation may overrule a decision of medical fitness issued by the client nation.
3. It is important to consider fitness for SET training whenever these personnel attend for a medical consultation, whether in a primary or secondary care setting. A relevant medical condition will have an immediate effect on the fitness for pressure exposure - and, although prospective submarine escape candidates might not be due to attend for pressurised training for some considerable time, they can face unnecessary delay if assessment is not initiated at the earliest possible opportunity.

3.C.2. MEDICAL STANDARDS

4. A decision of medical fitness for SET training should be based on the candidate’s ability to perform the training in a safe manner, not exposing him/herself or instructors to risk due to pre-existing medical disorder.
5. Candidates must be physically and mentally fit and be without evidence of emotional instability. There is no upper age limit, but the discretion of the examining physician should be exercised when assessing the level of general fitness.

3.C.3. CONDITIONS INFLUENCING FITNESS FOR SUBMARINE ESCAPE TRAINING

6. It is not possible to provide a comprehensive list of conditions which permanently exclude a candidate. Frequently, a decision is based on the extent of the abnormality or the severity of disease and the individual response to treatment. Conditions which have a bearing on fitness for diving and submarine escape are listed below. By scrutiny of medical documents, direct questioning and physical examination, the following conditions must be excluded. Where positively elicited or identified, these conditions are normally grounds for rejection. However, in cases of doubt, the condition should be discussed with the medical authority of the host nation.

3.C.4. GENERAL

7. Candidates’ age must be consistent with host nation regulations.
8. Hearing and eyesight must be to the General Service standard of the appropriate branch.
9. There are no specific height or weight restrictions to submarine escape training. The trainee's size must not be so extreme as to prevent donning a Submarine Escape Immersion Suit or from negotiating the escape tower without risk of becoming stuck. Potential candidates taller than 2 metres should have the opportunity of trying a suit for size at the earliest opportunity in order to avoid nugatory training.

3.C.5. DERMATOLOGICAL CONDITIONS

10. Chronic or acute skin disorder, including the cutaneous manifestations of systemic disease, other than mild, localised conditions, may disqualify a candidate. A decision of fitness or unfitness should be based on the risk of skin infections and whether water exposure may worsen the disorder.

3.C.6. EARS, NOSE AND THROAT CONDITIONS

11. The following conditions render a candidate unfit for pressure exposures:
    a. Chronic or recurrent sinusitis.
    b. Chronic or recurrent outer or middle ear discharge.
    c. Severe allergic conditions of the upper respiratory tract.
    d. Meniere's Disease
    e. Previous stapes surgery.
    f. Perforation of the tympanic membrane, unless adequately healed or surgically corrected.
12. The following conditions render a candidate, or qualified diver, temporarily unfit for pressure exposures and should be referred to an ENT Specialist:
    a. Viral labyrinthitis.
    b. A history of ENT surgery.
13. Hearing should be examined by pure tone audiometry to a standard acceptable to the host nations. The tympanic membrane must be clearly seen on examination with evidence of satisfactory Eustachian tube function and adequate ear-clearing by observing the ear drum to be mobile while a Valsalva manoeuvre is performed. Where doubt exists and in the absence of an upper respiratory infection or inflammation, a cautious exposure to pressure should be carried out in a compression chamber. Continued failure to clear ears should be cause for referral to an ENT consultant for formal assessment of Eustachian tube function.
14. Exostoses are acceptable provided they do not occlude the external auditory canal.

3.C.7. RESPIRATORY DISORDERS

15. Pulmonary function test (PFT), as a minimum dynamic spirometry measuring FVC, FEV1 and PEF, should be completed with an accuracy and methodology meeting current standard of the European Respiratory Society or other recognized international professional society for pulmonary medicine.
16. FVC and FEV1 should not be less than the threshold limit. The threshold limit is defined as two standard deviations (SD) lower than the expected value based on applicable population reference values. If the estimation the exact threshold value (Ref.value – 2 SD) is impractical, 80% of reference value may be used. FEV1/FVC should exceed 75%. If these values are not reached, the candidate should be reassessed, and if the values continue to remain less than threshold values, the patient should be referred to a chest physician.
17. The following conditions will render a candidate unfit for pressurised SET training:
    a. Symptomatic asthma or other form of recurring bronchospasm.
    b. Chronic obstructive airways disease or areas of potential air trapping such as lung cysts, bullae and blebs; pleural effusion; lung fistula; bronchiectasis; pulmonary fibrosis; neoplasm and unresolved pneumothorax; moderate or severe lung emphysema.

c. Pulmonary tuberculosis - unless limited to an isolated healed and calcified peripheral primary focus (Ghon focus). Such lesions are not necessarily an automatic bar to submarine escape training.
d. Active sarcoidosis or other restrictive pulmonary condition.
e. Any lung disease, abnormality or penetrating chest injury likely to result in areas of altered lung compliance and / or pleural adhesions. Candidates with a history of pneumonia with x-ray changes should be presented to and discussed with the medical authority of the host nation.

18. Candidates with a past history of reversible, obstructive airways disease are judged on an individual basis. Isolated attacks of bronchospasm in association with frank chest infections should be discussed with the medical authority of the host nation. It is very important to identify any tendency to recurring obstructive airways disease. A current history consistent with bronchoconstriction on exercise or in a cold environment is an absolute contra-indication to pressure exposure - the candidate should be made unfit for SET training.
19. Candidates with the following histories should be investigated by a chest physician or as a minimum asked to keep a PEF diary:
    a. past history consistent with reversible bronchoconstriction,
    b. current history of questionable significance,
    c. allergen-mediated bronchoconstriction.
20. The PEF diary should be kept for 28 days, recording best of 3 efforts:
    a. on waking and at 1800 each day,
    b. pre- and post-exercise, making a note of this on the diary,
    c. if the candidate feels wheezy or short of breath, making a note of this on the diary.
21. If an occupational exposure is suspected then readings should be taken every 4 hours while awake and every 2 hours while at work, with careful notes of circumstances at each reading. If variability that is not attributable to occupational exposure is 15 % or greater then the candidate should be made unfit for SET training.
22. If the specialist laboratory shows no evidence of abnormal bronchial lability in response to a challenge or bronchodilator then the candidate may be found fit for pressure exposures.
23. A history of perforating chest injury or open chest surgery may disqualify if there is evidence of residual pulmonary or pleural scarring. The reason for the surgery is to be established. All such cases should be discussed with the medical authority of the host nation.
24. Pneumothorax, other than spontaneous, may be acceptable providing at least three months have elapsed since resolution and it has been determined by detailed pulmonary function assessment that no residual impairment remains. All such cases should be discussed with the medical authority of the host nation.
25. A history of spontaneous pneumothorax usually precludes pressure exposures. Individuals who have been recurrence-free for at least five years and in whom it has been determined by detailed pulmonary function assessment that no residual impairment remains may, in exceptional circumstances, be permitted to undergo SET training. All such cases should be reviewed by the medical authority of the host nation.

3.C.8. CARDIOVASCULAR CONDITIONS

26. The following conditions will render a candidate unfit:
    a. Any organic heart disease.

b. Coarctation of the aorta.

27. The following conditions must be referred for specialist cardiological opinion prior to review by the host nation medical authority.
    a. Significant atrial or ventricular septal defects, or other potential right to left shunts. These conditions are usually incompatible with pressure exposure unless surgically corrected. Primary screening for right to left shunts, however, is not currently considered justifiable.
    b. Cases of valvular stenosis or regurgitation.
    c. Any history of coronary insufficiency or myocardial ischaemia, even if treated by coronary bypass grafting.
    d. Cardiomegaly unless it is established by specialist investigation to be the consequence of athletic training.
    e. All arrhythmias except sinus arrhythmias and ventricular extrasystoles which disappear with increasing heart rate.
    f. Conduction defects. Right bundle branch block may not require specialist referral if considered an isolated finding.
28. Abnormalities found on cardiovascular examination, such as murmurs, and on ECG must be investigated to an appropriate extent before a decision on fitness is made.

3.C.9. ALIMENTARY SYSTEM CONDITIONS

29. The following condition will render the candidate unfit:
    a. Abdominal wall herniation unless adequately repaired.
30. The following conditions must be referred for specialist opinion prior to review by the host nation medical authority.
    a. Chronic inflammatory bowel disease.
    b. Acute or chronic active hepatic disease.
    c. History of pancreatitis.

3.C.10. MUSCULO-SKELETAL CONDITIONS

31. Candidates must have unimpeded mobility and dexterity. Any limitation should be assessed on the basis of the candidate's ability to perform his work or undertake training and, particularly, its possible impact on safety.
32. The presence of juxta-articular ('A') lesions of dysbaric osteonecrosis precludes further pressure exposures.
33. Successful surgery for prolapsed intervertebral disc may be acceptable provided neurological examination is normal and there is no functional impairment.
34. Musculoskeletal, or referred, pain that might mimic decompression illness must be assessed carefully. If any doubt exists, the case should be discussed with the medical authority of the host nation.

3.C.11. NERVOUS SYSTEM CONDITIONS

35. Neurological abnormalities should merit specialist referral.
36. Conditions with the potential to preclude pressure exposure are as follows:
    a. Epilepsy, including petit mal and partial seizures, and irrespective of any treatment. Febrile convulsions up to the age of five years should not be considered a bar to pressure exposure. Individuals who have suffered an isolated seizure but who are not

considered to be suffering from epilepsy, should be reviewed by the medical authority of the host nation.

b. Intracranial surgery.
c. Severe speech impediment.
d. Severe motion sickness.
e. Migraine unless mild and unaccompanied by visual, speech, motor or sensory disturbance.

37. Head injury accompanied by skull fracture or resulting in loss of consciousness or post-traumatic amnesia may result in increased risk of convulsion. This may be further increased by high inspired partial pressures of oxygen. A history of severe head injury is a permanent bar. Candidates with a history of a moderate head injury may be considered fit for pressure exposure after a period of 1 year without sequelae but will require referral to a Diving Medicine Specialist and will be assessed on an individual basis . Candidates with a history of mild head injury may be considered fit for pressure exposure after a period of 1 month without sequelae but will require referral a Diving Medicine Specialist and will be assessed on an individual basis.

a. Severe head injuries have one or more of the following features:

- brain contusion (diagnosed on the basis of observation during surgery or focal neurological symptoms),
- intracranial haematoma,
- loss of consciousness or post-traumatic amnesia for more than 24 hours.

b. Moderate head injuries have one or more of the following features:

- loss of consciousness or post-traumatic amnesia lasting 30 minutes to 24 hours.
- skull fracture.

c. Mild head injuries have

- an absence of fracture,
- loss of consciousness or post-traumatic amnesia for less than 30 minutes.

d. Candidates whose severe head injury occurred more than 10 years prior to the medical and in whom there is no evidence of neurological sequelae may, in exceptional circumstances, be permitted to undertake SET, but all such cases must be referred to a Diving Medicine Specialist.

38. A history of bacterial or viral meningitis or encephalitis is compatible with pressure exposure provided that the candidate has been asymptomatic for 12 months and there is no evidence of neurological sequelae.

3.C.12.MENTAL HEALTH

39. Psychiatric illness other than minor reactive or transient non-recurring conditions. A history of past or present psychiatric or psychological disorder, including abuse of alcohol or drugs, should be considered a contraindication to pressure exposures unless the examining physician is content, having taken specialist advice if indicated, that it is of a minor nature and unlikely to recur. Past or present evidence of alcohol or drug abuse is not suitable for SET training unless a consultant psychiatric opinion is favourable. These latter cases should be reviewed by the medical authority of the host nation.

3.C.13. GENITO-URINARY CONDITIONS

40. Renal calculi and malformations of the urinary system will be cause for rejection unless adequately treated.
41. Sexually transmitted diseases will disqualify until successfully treated. Although specific testing does not form part of a routine medical examination, HIV positive candidates should be dealt with in accordance with host and client nations policies.

3.C.14. ENDOCRINE DISORDERS

42. Detailed specialist investigation of endocrine conditions is not normally required. However, where abnormalities are detected clinically, these should be investigated.
43. Diabetes mellitus requiring insulin and/or oral hypoglycaemic agents is an absolute contraindication. Subjects with diabetes mellitus controlled by diet alone are usually considered fit for SET training unless end-organ injury or a history of other complication exists.

3.C.15. HAEMATOLOGICAL CONDITIONS

44. Abnormalities revealed should be referred for specialist assessment.
45. Asymptomatic sickle cell trait is not a contraindication to pressure exposure and individuals with frank sickle cell disease will be unfit for entry into military service. Routine testing for sickle cell disease is thus not required. Haemoglobin electrophoresis may be carried out if required at the initial medical.

3.C.16. DENTAL STANDARDS

46. Candidates require a high standard of dental fitness. Teeth should be sound or adequately restored (no caries) and the gum and supporting bones should be healthy.
47. Crowns and fixed bridgework must be scrutinised annually. If in doubt as to a candidate's dental fitness, the examining physician should seek the opinion of a dental officer.

3.C.17. GENDER

48. These standards apply to both genders. Pregnancy is a contraindication for SET training. Post-partum candidates should be evaluated against host and client nations regulations.