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Helicopter Crew Members Immersion Suits

1 Introduction

1.1 The Air Navigation Order requires for certain categories of helicopter operation, that crew be equipped with survival suits. In such cases the suits are required to be approved by the Civil Aviation Authority.

1.2 This Specification details the requirements for a dry coverall type of immersion suit for continuous wear by crew when operating a helicopter.

Other types of garment which provide equivalent performance may be approved by the Authority.

2 Applicability

This Specification prescribes the minimum standards of design and performance for immersion suits submitted to the CAA for approval in accordance with the provisions of the ANO Schedule 4 Scale I.

3 General

3.1 Approval of an immersion suit to this Specification shall take into account the compatibility between the suit and any CAA approved lifejacket and sprayhood that is intended to be worn with it.

3.2 The immersion suit and any attached equipment should be capable of being donned without assistance and shall be capable of being sealed and adjusted by the wearer without assistance when in flight.

Air retained inside the suit after sealing which could adversely affect the maneuverability or flotation attitude shall be capable of being exhausted, either automatically or by the wearer, from the garment.

3.3 The immersion suit, and its attached equipment including the appropriate CAA-approved life-jacket and sprayhood shall be designed, and the materials used in their construction chosen, to have no features which would be likely to have any detrimental effect on the operation of any helicopter or its equipment. In particular, any part of the suit or lifejacket which might pose a snagging hazard during flight or emergency egress shall be suitably covered, protected or restrained.

The immersion suit should not jeopardise safety by causing discomfort which could result in degradation of crew performance. The immersion suit should be of a design and construction such that the wearer is afforded the optimum standard of thermal comfort practicable with particular attention to long into-sun flights in summer.

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3.4 Any attached equipment shall not compromise the basic survival function of the immersion suit by causing puncturing, fretting or distortion of the material, or changes in its mechanical properties.

3.5 The immersion suit shall be tailored to a standard which will allow the wearer to carry out all normal and emergency functions and movements necessary for the operation of a helicopter and its equipment.

3.6 The design of the immersion suit shall allow tailoring to fit the individual wearer or, where suits are not individually tailored, the size range must be fully satisfactory for all wearers whose significant body dimensions range from the 5th percentile female to the 95th percentile male and adequate for most of the 5% at each extreme.

The significant body dimensions to be taken into account shall include at least the following:-

Total Height	:	from ground to top of head
Chest girth	:	
Waist girth	:	
Hips	:	
Sitting height	:	neck seam to crotch seam
Inner leg	:	crotch seam to normal length of trouser
Sleeve length	:	shoulder seam over elbow to cuff (arm bent at 90º)
Boot size	:	

3.7 Gloves or mittens shall be provided and they should be stowed so that they can be retrieved and donned when the wearer is in the water and wearing an inflated lifejacket.

3.8 If the immersion suit is a multi-layer garment such that the immersion suit is required to be protected by an outer garment, then the combined use of the garments shall be specified in the manufacturer's manual.

4 Sealing

Where the immersion suit is designed to be worn unsealed in flight, it shall be capable of being correctly sealed by the wearer within 10 seconds. This action shall be possible when seated at the wearer's normal position in a helicopter with harness fastened and wearing an uninflated lifejacket. This action must not compromise control of the helicopter in a normal or emergency situation (see Appendix 1 Al.5).

5 Sprayhood

5.1 A sprayhood shall be provided. This shall be easily deployed by the survivor wearing an immersion suit and inflated lifejacket when in or out of the water. Deployment of the sprayhood shall be possible within 20 seconds in calm conditions.

NOTE 1: The sprayhood may form part of the immersion suit, lifejacket or be a separate item.

NOTE 2: The sprayhood, whether stowed or deployed, should not cause inconvenience during winching operations, or when deployed it should be capable of being easily discarded during such operations.

5.2 The sprayhood shall meet the applicable requirements of CAA Life-jacket Specification No. 5.

6 Insulation and Water Ingress

6.1 Not more than 200g of water shall leak into the suit when the test of paragraph 9.5 is carried out.

6.2 Means shall be provided to protect the head of the survivor from heat loss. The head covering shall have a minimum insulation value of 2 clo when the survivor is in the water. This insulation value may be achieved by the sprayhood alone or in combination with any head protection provided as part of the immersion suit.

NOTE: One do is defined as an insulation value of 0.16 °CM^2/W.

7 Flotation and Maneuverability

7.1 A person wearing the suit correctly vented and the appropriate properly donned and inflated approved lifejacket shall be able to adopt a safe flotation attitude. Passive self-righting from any other attitude to the face-up position shall occur within 5 seconds, remaining stable in that position with the mouth at least 120 mm above the waterline (see Section 9). The angle of the body shall not be greater than 600 from the horizontal (see Section 9).

7.2 The immersion suit shall be designed to provide the wearer sufficient freedom of movement in or out of the water to perform all required actions as detailed in paragraphs 9.4 and 9.5.

7.2.1 In particular the wearer shall be able to climb into a liferaft fitted with boarding facilities, without undue effort and without assistance, with the suit sealed, the sprayhood deployed and the lifejacket inflated.

7.2.2 A male subject with 95th percentile (large) bi-deltoid width, wearing the immersion suit, its attached equipment and the uninflated appropriate approved lifejacket, shall be able to exit the helicopter through any Emergency Exit of at least Type 4 size. This action shall be possible in air or under water.

8 Materials

8.1 To facilitate search operations, those parts of the equipment which will be visible when in the water shall be of a highly conspicuous colour. They shall be made of materials with a minimum factor of luminosity of 0.6 according to BS 4610:1970(3) (or acceptable equivalent) and there shall be patches of reflective tape fitted to the hood, as well as to the approved lifejacket and sprayhood. The total area of these patches must amount to at least 0.03lm^2 (48 in^2).

Conspicuous materials shall be located where they will not cause reflections which would interfere with the operation of the helicopter.

NOTE: Retro reflective materials to D.o.T. Specification MSC 57/27/ADD2 Annex 14 are considered an acceptable standard.

8.2 All materials used shall be to an acceptable Specification which shows the material to be suitable for its intended application and compatible with materials used in the construction of any approved lifejacket, sprayhood or liferaft.

8.3 The choice of materials and protective treatments shall be such that, during the period between inspections, corrosion or time-related degradation will not render the immersion suit or its attached equipment unserviceable.

9 Type Evaluation Tests

9.1 General

9.1.1 A Type Test Schedule is required to be submitted by the design organisation to the CAA for approval. The schedule shall be such that suits complying with it will satisfy the design and performance requirements described in this Specification. The schedule shall include at least the performance tests described below.

9.1.2 The type tests fall into two categories: those in which the suit alone is tested (i.e. 'unmanned') and those in which the suit is tested with a wearer (i.e. 'manned').

9.1.3 The tests in the first category are:

- Fuel resistance
- Temperature cycling
- Flammability

9.1.4 In order to test the water tightness of the suit after it has been subjected to some use, the 'manned' tests shall be carried out in the following order and using the same suit and lifejacket without rectification of defects for the whole sequence:

- Manoeuvrability and performance in water
- Water ingress

9.1.5 All tests on the suit type shall be carried out at a test facility acceptable to the Authority. The tests shall be carried out on a representative sample of suits produced to the manufacturer's specification.

9.2 Unmanned Tests

9.2.1 Fuel resistance

This test will be carried out on all suits which are designed to be used as single layer garments. Immersion suits designed as an inner layer of a multi-layer garment need not be tested in accordance with this paragraph.

After all apertures have been sealed, a suit shall be immersed under a 100 mm head of aviation kerosene for 30 minutes at normal room temperature (a nominal 20°C). The surface fluid will then be wiped off and the suit shall show no signs of damage that may affect its waterproof qualities. An approved water leakage test will then be carried out.

In the case of immersion suits of unconventional design, alternative means of demonstrating resistance to fuel contamination may be agreed with the Authority.

9.2.2 Temperature cycling

A suit shall be alternately submitted to ambient temperatures of -30°C and +40°C for 10 cycles with a period of 8 hours at each temperature. The alternating exposures need not follow immediately after each other and the following procedure is acceptable:

- an 8-hour exposure at +40°C to be completed in one day
- the suit removed from the warming chamber on the same day and left exposed under ordinary room conditions until the next day
- an 8-hour exposure at -30°C to be completed in one day
- the suit removed from the cold chamber that same day and left exposed under ordinary room conditions until the next day
- the above procedure repeated a further nine times

On completion of the 10 cycles, the suit shall show no sign of damage such as shrinking, cracking, swelling, dissolution or changes of mechanical properties.

9.2.3 **Flammability**

The outer cloth fabric used in the construction of the suit shall be of low flammability. This fabric should not have a burn rate greater than 100 mm/mm (4 in/mm) when tested in accordance with the horizontal test of CAA Specification No. 8 Issue 2 or other approved equivalent method.

The flammability test should be applied to the outermost layer which is intended to form part of the immersion suit.

9.3 **Manned Tests - Test Subjects**

The tests described in this Section shall be carried out using at least six people each wearing an immersion suit tailored in accordance with paragraph 3.6 as near as possible to the following heights and weights:-

Height	Weight
1.40 m - 1.60 m	1 person under 60 kg and 1 person over 60 kg;
1.60 m - 1.80 m	1 person under 75 kg and 1 person over 75 kg;
1.80 m - 2.00 m	1 person under 90 kg and 1 person over 90 kg.

They should be capable of relaxing when in water out of their depth and be able to swim for 20 minutes and cover a distance of 350m with the aid of a life-jacket. They should be suitably fit as determined by a medical examination undertaken before the tests commence.

Throughout all the following tests, except where otherwise stated, they shall wear clothing under the immersion suit to ensure an immersed do value of 0.5 (see Appendix 2) and the appropriate approved lifejacket shall be worn over the suit. If the suit is designed to be worn with hard-soled footwear, such footwear shall be worn.

9.4 **Buoyancy and Manoeuvrability in Water**

Maneuverability evaluation in the water consists of the following:

a) Swimming and boarding

b) Buoyancy

c) Floating position

d) Dexterity

e) Escape test underwater

as detailed in the following paragraphs.

9.4.1 **Swimming and Boarding**

Each test subject shall swim 25 metres wearing the suit and inflated lifejacket. The subject shall then attempt to board an approved helicopter liferaft without assistance. The test must be carried out in a pool filled with fresh water and of a size and depth that prevents assistance from any firm surface.

9.4.2 **Buoyancy**

The buoyancy of each test subject shall be measured vertically immersed when wearing the test clothing and suit but, for this test, no life jacket. Suits that are not equipped with automatic venting should be tested manually vented in accordance with the manufacturer's instructions and approved drills. The trapped buoyancy due to the suit and clothing with the suit fully vented shall be no more than 15 kg.

9.4.3 **Floating position**

Each test subject, wearing the test clothing, the suit and lifejacket (inflated) shall fall face down into the test pool. Passive self-righting (face-up floating position) shall occur within 5 seconds.

Tests shall be conducted with the subject's legs together and arms by the sides. After a period of 5 minutes it shall be established that this position is stable by depressing each shoulder in turn, so as to turn the body through 90°, and checking that the subject returns to the face-up position and does not invert.

The height of the mouth above the waterline shall be measured and recorded and should be at least 120 mm. It shall be established visually that the nose freeboard is not less than the mouth freeboard.

The angle of the test subject's body shall be measured by an appropriate method. The angle between the body and the horizontal shall be recorded and shall not be greater than 60°.

9.4.4 **Dexterity**

Each test subject, wearing the immersion suit with the appropriate clothing providing insulation as specified in IAM Aircrew Equipment Report No. 568 to take account of the water temperature and the wearer's physique and give a survival time of 3 hours, shall demonstrate the ability to retrieve from stowage and don mittens after immersion in water at a temperature no higher than 10°C for a period of 3 minutes.

9.4.5 **Escape test underwater**

Each test subject shall be required to swim through an opening not greater than 19 inches wide and 26 inches high (Type IV Emergency Exit), positioned with the top of the opening 36 inches below the surface of the water wearing the suit and uninflated lifejacket. At least one of the subjects for this test shall be required to have a bi-deltoid width measurement at least equal to the male 95th percentile (large) figure.

9.5 **Water Ingress**

9.5.1 Where necessary the suit shall be vented of excess air prior to this test. Each test subject, wearing the suit and lifejacket over the test clothing, shall enter the water of a swimming pool with a water temperature up to 20°C and remain there for 2 minutes in order to completely pre-wet the suit. He/she shall then climb out, remove the lifejacket and any over-suit and stand for 1 minute to permit excess water to run off the exterior of the suit and remove any free water from the hood and be weighed in order to establish his/her gross weight before the leak tests start.

9.5.2 Immediately after the 'pre-wetting' and weighing, the subject shall cross one arm over the top of the lifejacket and cover the mouth and nose with the other hand, then jump vertically, feet first, into the pool from a height of 3 m. The lifejacket should be deflated for this test. The suit shall not be damaged or dislodged in any way by the jump.

9.5.3 After jumping into the pool the subject shall swim on his/her back for 20 minutes, covering a distance of at least 350 m in this time. The hands and arms shall be kept in the water even if not being used for propulsion.

9.5.4 After the swim the subject shall climb out, remove the lifejacket and any over-suit and stand for 1 minute, remove any free water from the hood and be weighed. The subject's weight shall not have increased by more than 200 g over the gross weight before the jump and the swim.

9.5.5 Any other equivalent method of evaluating the sealing capability of the immersion suit may be agreed with the Authority.

10 Inspection Testing and Repair

10.1 The procedure for inspecting, testing and repairing immersion suits shall be established and shall be capable of ensuring that all suits satisfy the requirements of this Specification throughout their service lives.

As part of the procedure, suits shall be inspected at intervals to ensure they are always ready for immediate and effective use in the water. Special attention should be paid to seals and fasteners. Suits shall be required to be immediately removed from service for repair or replacement if damage or deterioration is discovered that may lead to the suit failing to satisfy a routine leak test when one is next carried out. (see 10.2)

10.2 Repairs to the immersion suit shall be carried out by the manufacturer of the suit or a suitably approved organisation to carry out the repair. After the repair the suit shall be subjected to the routine leak test specified in the manufacturer's maintenance manual to check the integrity of the repair.

10.3 The procedures for servicing, inspection, repair and testing shall be described in the manufacturer's manual.

10.4 The frequency of servicing and inspections shall be agreed between the Authority and the manufacturer holding design approval for the suit.

11 Marking

11.1 Each detachable part of the immersion suit assembly shall, where practicable, be marked with:

a) The manufacturer's approved inspection stamp

b) The Part Number

c) Date of manufacture or batch record

11.2 The immersion suit shall be marked with:

a) The name of the crew member to whom it has been allocated

b) Rank of crew member marked externally, e.g. epaulettes

c) Garment Model designation

d) The manufacturer's name and address

e) Date of manufacture/Serial Number

f) Date at which next scheduled service and overhaul are due

g) Modification standard

11.3 When marking is not practicable, alternative means must be agreed with the authority.

Appendix 1

Operational Considerations

A1.1 Although immersion suit manufacturers are not required to address the immersion suit/ aircraft interface in detail, it is envisaged that the manufacturer will normally co-operate with the operator to ensure that the requirements of this Appendix and the Appendices 2 and 3 are satisfied, and will design the equipment with this in view.

A1.2 Approval of the application of an immersion suit for a particular helicopter type and crew function must be obtained before the immersion suit may enter service. Procedures for obtaining this approval are described in Appendix 3.

A1.3 The achievement of an acceptable standard of body insulation depends' on the wearing of recommended clothing in conjunction with the immersion suit. Operators must provide means for underclothing of the correct insulation value to be worn with the immersion suit taking account of the body characteristics of the crew member and the expected sea temperature. Operators must advise crew members of the necessity for correct underclothing to be worn by means of a statement in their Operations Manuals (see Appendix 2).

A1.4 Any flying overall or other garment worn over the immersion suit shall be chosen so as not to compromise in any way the basic survival functions of the suit or the requirements of flight safety. Choice of such clothing must be addressed in the Operations Manual.

A1.5 If the immersion suit is designed to be worn unsealed in flight, it may be inadvisable to expect crews to spend time re-sealing suits in conditions of high workload, even though the suit satisfies the requirements of Paragraph 4 of this Specification. Operational procedures should therefore specify the conditions in which flying unsealed is permissible

A1.6 Operators should note that since the function of an immersion suit is to preserve the insulation of the crew member in severe conditions, there is a consequent possibility of over-insulation in exceptionally warm conditions. This can lead to extreme discomfort and heavy perspiration with an attendant risk of dehydration or cramp in exceptional cases. The human factors consequences of operation for long periods in such conditions, while difficult to quantify, should not be disregarded. In such circumstances, when the wearing of an immersion suit is not required by the ANO, it is possible that the flight safety disadvantages of the wearing of such a garment could outweigh the benefit of its survival value in the water.

If operators choose to require crews to wear survival suits in conditions when they are not required by the ANO, account must be taken of the above and the operator must take all reasonable precautions to ensure that flight safety is not unnecessarily compromised.

Appendix 2

Insulation and Under Clothing

Although thermal insulation characteristics for an immersion suit are not specified, it is expected that immersion suits will have little inherent heat insulation, and therefore they should be worn with sufficient clothing underneath to protect the wearer from hypothermia while in the water. The main contribution of the suit is to keep dry the clothing worn underneath and thus to preserve its insulating properties. The suit and clothing together should maintain the deep body temperature of the 10th percentile thin man (as per Doc Ref. Institute of Aviation Medicine, Report Ref. AEG 517 dated 1985 (MOD Airforce Department)) at a level above 34°C for 3 hours.

Although it will vary with skinfold thickness, a hydrostatically compressed insulation value of 0.5 do over the trunk, arms, legs and feet satisfies this requirement for an average man in a sea temperature of 5°C. An example of clothing which will normally provide 0.5 do when under hydrostatic pressure is:

Cotton underwear

Long sleeved heavy cotton shirt

Cotton or corduroy trousers

Woollen socks

Military type long sleeved pullover

There is no test proposed to check that the suit and any clothes worn under it will provide the wearer with 3 hours protection against hypothermia when immersed in the sea. A suit satisfying the water leakage test described in paragraph 9.5 of this Specification and worn with the correct clothing will provide the necessary protection.

Compliance with the requirements of Appendix 1 paragraph A1.3 may be achieved either by means of data placed in the Operations Manual, or by issuing the underclothing.

An acceptable scheme for estimating the correct insulation is described in IAM Aircrew Equipment Report No. 568.

Appendix 3

Procedures for Obtaining Approval of an Immersion Suit for a Particular Helicopter Type and Crew Function

In order to obtain approval for the application of an immersion suit to a particular helicopter type and crew function, the following capabilities must be demonstrated for each crew member on representative rotorcraft:

1) the ability to operate throughout their ranges all the normal and emergency controls of the helicopter type/s and crew function for which approval is sought, when seated in the appropriate crew position/s with harness secured and wearing the suit and specified lifejacket uninflated. The suit shall not snag or cause restriction to the operation of any controls nor shall it restrict the head movement or field of vision in any way;

2) where the suit is designed to be worn unsealed in flight, the ability to seal the suit fully within 10 seconds while secured in the appropriate crew seat. The sealing action must be possible without compromising control of the helicopter; and

3) the ability to abandon the helicopter type/s for which approval is sought using the drills specified in the appropriate aircrew evacuation and survival procedure and while wearing the suit and uninflated lifejacket.

These demonstrations must be carried out to the satisfaction of the Authority on an aircraft identical to the type for which approval is sought in respect of crew station seats, trim, furnishings, controls, instruments and equipment which is likely to affect crew mobility or vision at the crew station.