INTERNATIONAL STANDARD

ISO 15027-3

Second edition
2012-11-01

Immersion suits —

Part 3: **Test methods**

Combinaisons de protection thermique en cas d'immersion —

Partie 3: Méthodes d'essai

Reference number
ISO 15027-3:2012(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15027-3 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 162, *Protective clothing including hand and arm protection and lifejackets*, in collaboration with Technical Committee ISO/TC 188, *Small craft*, Subcommittee SC 1, *Personal safety equipment*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 15027-3:2002), which has been technically revised.

The main technical changes are:

a) clarification that test subjects are human test subjects;

b) addition of two sites for skin temperature measurement;

c) revision of field of vision test;

d) merger of 3.10 and 3.11 into one clause and renumbering of consecutive clauses;

e) mean body temperature deleted;

f) clarification that underclothing shall be specified by the manufacturer

g) revision of requirements regarding the testing of a Class D suit.

ISO 15027 consists of the following parts, under the general title *Immersion suits*:

— *Part 1: Constant wear suits, requirements including safety*

— *Part 2: Abandonment suits, requirements including safety*

— *Part 3: Test methods*

Immersion suits —

Part 3: Test methods

1 Scope

This part of ISO 15027 specifies the test methods for constant wear suits, including helicopter transit suits, and abandonment suits.

Requirements for constant wear suits are given in ISO 15027-1:2012 and requirements for abandonment suits are given in ISO 15027-2:2012.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 590, *Automotive fuels — Diesel — Requirements and test methods*

ISO 811, *Textile fabrics — Determination of resistance to water penetration — Hydrostatic pressure test*

ISO 12402 (all parts), *Personal flotation devices*

ISO 13935-2, *Textiles — Seam tensile properties of fabrics and made-up textile articles — Part 2: Determination of maximum force to seam rupture using the grab method*

ISO 15027-1:2012, *Immersion suits — Part 1: Constant wear suits, requirements including safety*

ISO 15027-2:2012, *Immersion suits — Part 2: Abandonment suits, requirements including safety*

3 Testing of the device

3.1 General

Requirements, for which no special test methods are given in this part of ISO 15027, shall be tested in one of the following ways:

a) by tests referred to in ISO 15027-1 and ISO 15027-2; or

b) by measurement; or

c) by visual assessment; or

d) by functional test.

Prior to testing, materials and components shall be conditioned for (24 ± 0,1) h under standard atmosphere. The temperature cycling test and the rotating shock bin test shall be carried out as pre-conditioning before any other tests are carried out.

3.2 Sampling

Where materials and components are common to a range of suits, it is permitted to test just one sample of each material or component, unless specified otherwise by the relevant test procedure.

3.3 Human test subjects

3.3.1 Instruction and selection

All human test subjects shall be familiar with the use of the suit under test. They shall be informed and instructed on the potential hazards of the tests. The human test subjects shall have a medical check-up to prove their medical fitness for completing the test. See also 3.8.

NOTE Attention is drawn to the principles of the Declaration of Helsinki (World Medical Association, 1964) as amended at Edinburgh 2000.

3.3.2 Number and sizes of human test subjects

Where tests call for the use of human test subjects, unless otherwise specified, six people shall be used, each wearing a suit of a size category suitable for their build. Their body sizes shall be within the heights and masses shown in Table 1.

Table 1 — Human test subject sizes

Height mm	**Mass** kg
1 400 to 1 600	1 person under 60 1 person over 60
> 1 600 to 1 800	1 person under 70 1 person over 70
> 1 800	1 person under 80 1 person over 80

3.3.3 Gender of human test subjects

At least one and not more than three of the persons should be females.

3.3.4 Fitness of human test subjects

The persons complying with the criteria of 3.3.1 shall be capable of relaxing when in water out of their depth, be able to swim for 20 min and cover a distance of 350 m with the aid of an approved personal flotation device as recommended by the manufacturer and, after sufficient rest, board the platform specified in 3.10.6.6.

3.3.5 Dress of human test subjects

Throughout the following tests, unless otherwise specified, the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3 shall be worn by each human test subject.

3.3.6 Pass/fail criteria

All samples shall pass all objective tests for the entire device to meet the requirements of ISO 15027-1:2012 or ISO 15027-2:2012. However, due to the high variability between human test subjects and the difficulty in assessing some subjective measures, it is permitted that a device does not completely meet the requirements of the following subjective tests[1)] in a single sample and in no more than one human test subject. In these

1) For the purpose of this clause, “subjective tests” includes all tests that require the participation of human test subjects.

circumstances, two other human test subjects within the same weight category and with the same gender, wearing the same size of suit should be subjected to the same test and before the same test panel as at 3.10.3. If this additional test is still not clearly passed as required in ISO 15027-1:2012 or ISO 15027-2:2012, then the device shall be deemed to have failed, whilst if it is clearly passed by the additional two subjects, the test panel may deem that the device has passed the test overall.

3.4 Fuel resistance test

Place three samples each of all exterior fabrics, typical seams, apertures and components in a suitable container and submerge them under a 100 mm head of diesel according to EN 590 at a temperature of (20 ± 2) °C for 24 h. After removal from the container, remove the surface oil by wiping. Subject the samples to a hydrostatic test according to ISO 811 with a speed of 10 cm/min until 1 000 mm water head and then carry out a tensile seam strength test according to ISO 13935-2.

3.5 Flammability test

3.5.1 Principle

The test suit is passed over a test pan with burning test fuel to determine if the suit burns or continues to melt after removal.

3.5.2 Apparatus

Test pan, (300 ± 20) mm × (350 ± 20) mm × (65 ± 5) mm.

Test fuel: petrol or n-heptane.

3.5.3 Sampling

One suit system shall be subjected to the flammability test.

3.5.4 Procedure

Place the test pan in a draught-free area so that the suit, which is folded so that the neck part and feet are even, travels freely across the diagonal distance of the test pan.

Fill the test pan with water to a depth of 10 mm, followed by enough petrol or n-heptane to make a minimum total depth of 40 mm.

Ignite the petrol or n-heptane and allow to burn freely for 30 s.

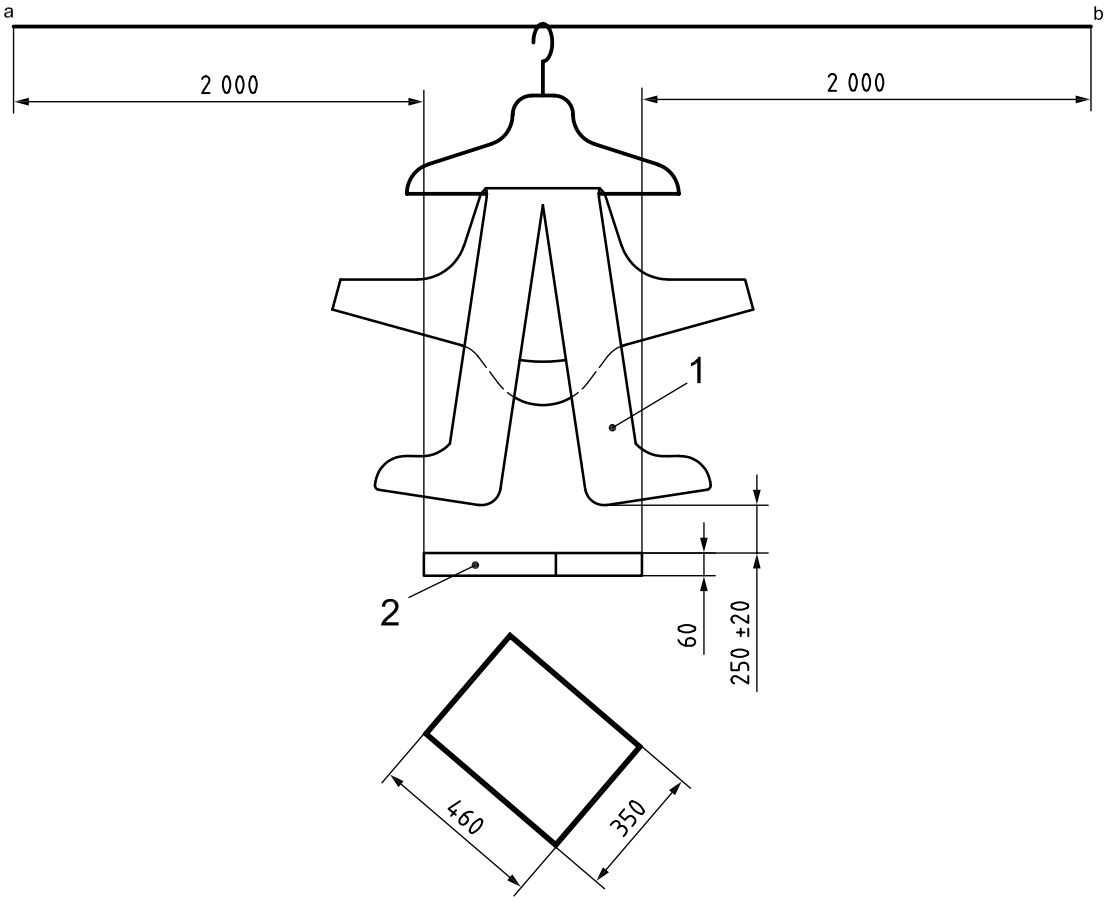
Drape the suit over a suitable hanger, folded at the waist with the front outward. The bottom of the suit shall be (250 ± 20) mm from the top edge of the test pan, see Figure 1. Secure loose parts above the lower part of the suit.

Then expose the suit with a constant speed of 0,29 m/s through the flames for 2 s. The suit shall start and finish the test 2 m away from the closest edge of the test pan.

3.5.5 Evaluation

It shall be reported if the suit is destroyed by the flames. It shall be reported whether the suit sustains burning or continues melting 6 s after being removed from the flames.

Dimensions in millimetres



Key

1 suit
2 test pan

a Start.
b Finish.

Figure 1 — Flammability test

3.6 Rotating shock bin test

3.6.1 General

The rotating shock bin test shall be carried out as a preconditioning before all other tests.

3.6.2 Apparatus

The equipment used shall be that shown in Figure 2, consisting of a box of specific design made from plywood board, the inside surface of which shall be coated with hard plastic laminate or similar. The bearing of the bin shall be in the centre of the mass and permit the bin to be rotated freely.

3.6.3 Procedure

Place a test sample in the bin through a flush panel in one of the bin's faces, then close and secure it. The bin shall be operated for a total of 150 rotations at a steady rate of 6 rotations per minute.

3.6.4 Evaluation

On completion of the rotations, the test sample shall be removed from the bin and examined by the panel for signs of wear and tear, and for any signs that the thermal insulation material has migrated.

Dimensions in millimetres

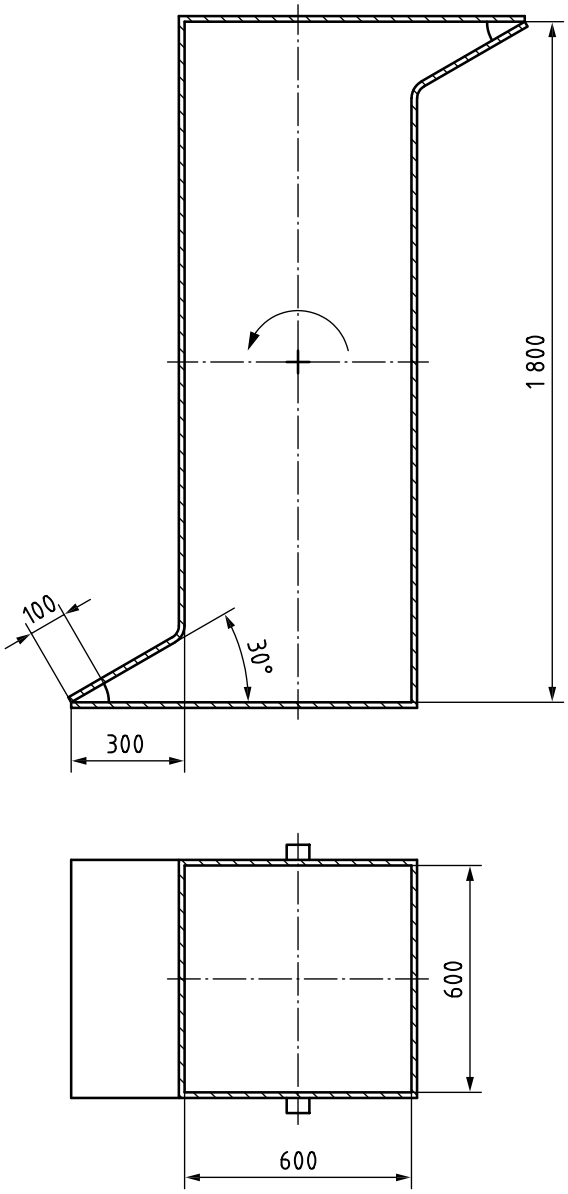


Figure 2 — Design of rotation shock bin apparatus

3.7 Leakage measurement

3.7.1 Leakage measurement for jumping

3.7.1.1 Clean the suit samples in accordance with the manufacturer's cleaning instructions to condition them prior to leakage measurement and thermal testing. The number of cleaning cycles recommended by the manufacturer or five cleaning cycles shall be undertaken.

NOTE The amount of leakage will be used as the threshold value for the thermal test.

3.7.1.2 Each human test subject shall wear the suit system with the standard underclothing as specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3. The human test subject shall carefully enter the pool using the pool ladder and remain there for 2 min in order to completely pre-wet the suit. The suit shall be vented of excess air prior to this test according to the instructions of the manufacturer. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test.

3.7.1.3 The human test subject shall then climb out using the pool ladder, crouch, stretch, shake limbs and then stand to permit excess water to run off the exterior of the suit and to remove the water from all trapped areas. After 1 min the human test subject shall be weighed, in order to establish the human test subject's gross weight before the leak test starts. The weighing scales shall have a capacity up to 150 kg, and a resolution of 0,02 kg or better.

3.7.1.4 Immediately after the "pre-wetting" and weighing, a PFD shall be donned and inflated if required. The human test subject shall then cover the mouth and nose with one hand and cross the other arm over the top, grasping the shoulder of the suit or of the PFD. The human test subject shall then jump vertically, feet first, into the pool from a height of $(4{,}5\ ^{+0{,}5}_{0})$ m.

3.7.1.5 After the jump, the human test subject shall climb out using the pool ladder, remove the PFD if used, crouch, stretch, shake limbs and then stand to remove free water from all trapped areas. After 1 min the human test subject shall be weighed again. The increase in weight shall be recorded, to be used together with the amount of leakage from swimming (see 3.7.2.4) as the amount of leakage for the thermal test according to 3.8. The suit shall then be removed to record the location of leakage in the suit and the areas of wetted underclothing.

3.7.2 Leakage measurement for swimming

3.7.2.1 Following the leakage measurement for jumping, the human test subject shall re-don the suit system using a dry set of underclothing and vent the suit. The human test subject shall then carefully enter the pool using the pool ladder and remain there for 2 min in order to completely pre-wet the suit.

3.7.2.2 The human test subject shall then climb out using the pool ladder, crouch, stretch, shake limbs and then stand to permit excess water to run off the exterior of the suit and to remove the water from all trapped areas. After 1 min the human test subject shall be weighed in order to establish the human test subject's gross weight before the swim starts.

3.7.2.3 Immediately after the "pre-wetting" and weighing, any hand protection provided with the suit shall be donned and a PFD shall be donned and inflated if required. The human test subject shall then carefully re-enter the pool using the pool ladder and swim on the back for 20 min, 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.

3.7.2.4 After the swim, the human test subject shall climb out using the pool ladder, remove the hand protection and PFD if used, crouch, stretch, shake limbs and then stand to remove free water from all trapped areas. After 1 min the human test subject shall be weighed again. The increase in weight shall be recorded, to be used together with the amount of leakage from jumping (see 3.7.1.5) as the amount of leakage for the thermal test according to 3.8. The suit shall then be removed to record the location of leakage in the suit and the areas of wetted underclothing.

3.8 Thermal test

3.8.1 Using a thermal manikin

3.8.1.1 General

The test house shall validate that the thermal manikin used is able to provide thermal insulation values for immersion suits which are within ± 10 % of the values obtained from human subject testing of the suits.

NOTE The validation should be accompanied by an exchange of experience between the manikin testing laboratories, round robin testing, and the correlation of results between the tests with human subject and manikin.

3.8.1.2 Apparatus

A thermal manikin shall be constructed so that it

a) has a surface area and shape similar to that of a 50th percentile man and at least 9 segments representing the head, upper torso, right and left arms, hip, right and left thigh, and right and left lower legs;

b) can be dressed in the underclothing specified by the manufacturer or in standard underclothing according to 3.8.1.3;

c) is capable of being heated to and controlled at a programmable uniform temperature in each segment;

d) can control and measure temperatures and power inputs and calculate, record and present the parameters;

e) can be immersed to the neck in water without causing failure in the electrical system if water leaks inside the outer clothing;

f) can be calibrated both in and out of the water;

g) shows reproducible results with less than ± 4 % variance for three tests on the same suit system.

3.8.1.3 Standard underclothing

The underclothing to be worn in connection with the suit system shall be specified by the manufacturer. If not specified by the manufacturer, the following standard underclothing shall be used for testing.

a) For class A suit systems:

   — underwear (short-sleeved, short-legged);

   — long-sleeved shirt;

   — trousers (not woollen);

   — woollen socks;

   — appropriate footwear (if the suit is used with footwear).

   The thermal insulation of the dry standard underclothing shall be no more than 1 clo measured with the thermal manikin in air.

b) For class B, C and D suit systems: as for class A, with the addition of two woollen long-sleeved pullovers.

The underclothing shall be in good condition and shall not be altered by use or otherwise damaged. The size of each piece of underclothing shall be suitable for the individual human test subject.

3.8.1.4 Procedure

The thermal protection provided by a suit system shall be assessed by measurement of the effective insulation of the whole suit system and associated underclothing placed on a thermal manikin and immersed in calm but

circulated water. The suit shall be filled with the amount of leakage determined according to 3.7.1 and 3.7.2. The immersed position shall be defined by using a male human test subject of approximately a 50th percentile size and having an in-water weight of (55 ± 10) N, to correlate the tests with the tests using human test subjects. Both tests shall show equivalent results.

The in-water weight of this male human test subject wearing a swim suit is taken with the tip of the chin and bottom of the ear lobes touching the water at the bottom of the normal breathing cycle. The in-water weight is the highest repeated value out of 10 readings or the third highest value if none is repeated.

3.8.2 Using human test subjects

3.8.2.1 Human test subjects

Human test subjects shall be volunteers meeting the requirements in 3.3.2 and shall have signed an informed consent form. Children (person aged 16 years or younger) are not allowed to undergo thermal tests.

Due to the nature of this test, different human test subjects to those used in the other tests may be used. Each human test subject shall be familiarized with the test procedure, medically screened, and their fat content shall be measured prior to the start of the test. Each human test subject shall not be more than 10 % overweight or underweight for his height and physical type as determined by a physician or physiologist or from published physiological data. Each human test subject shall have had a normal night's sleep before the test, a well-balanced meal 1 h to 5 h before the test, and no alcoholic beverages for 24 h prior to the test. In addition to the suit system, each human test subject shall wear the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3.

The testing laboratory has to take care of the safety of the human test subjects by medical check-up, monitoring and reporting the test by a physician or physiologist. The preparation, the test and the follow-up have to be supervised by a physician or physiologist experienced with the medical treatment of hypothermia. For the preparation of the tests, ISO 9886, ISO 10551 and ISO 12894 should be considered.

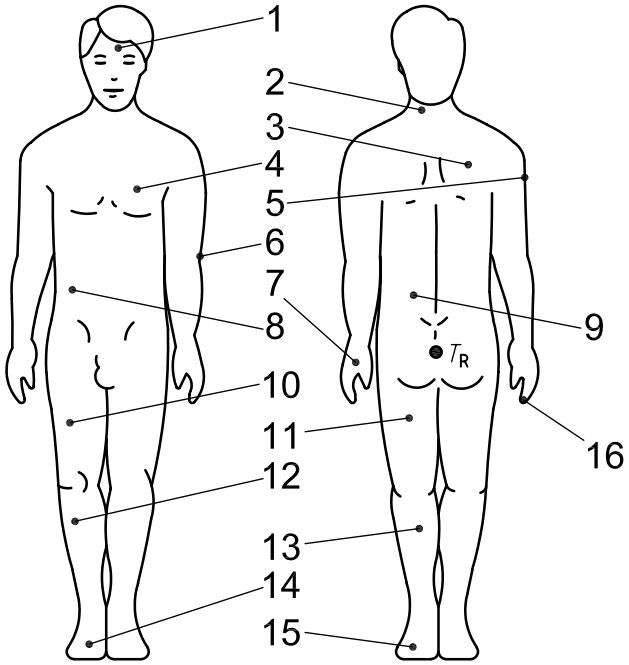
3.8.2.2 Principles

NOTE 1 The testing of immersion suits using human test subjects is based on sound and proven procedures used for tests under SOLAS rules. The procedures are comparable and the results can be used vice versa. This will reduce the amount of tests for the benefit of users, manufacturers and human test subjects. The test of ISO 15027-2:2012 class A suit system will correspond with an insulated SOLAS suit, whereas class D will be comparable to an uninsulated SOLAS suit. The ISO classes B and C will fit in-between.

Rectal temperature shall be measured. Skin temperature shall be measured using temperature transducers placed on 16 sites (S1…S16) on the skin, see Figure 3.

The transducers shall be capable of measuring the surface temperature (accuracy ± 0,2 °C).

NOTE 2 Rectal temperature represents core temperature.



Key

1 forehead (S1)
2 neck (S2)
3 right scapula (S3)
4 left upper chest (S4)
5 right arm — upper location (S5)
6 left arm — lower location (S6)
7 left hand (S7)
8 right abdomen (S8)
9 left paravertebral (S9)
10 right anterior thigh (S10)
11 left posterior thigh (S11)
12 right shin (S12)
13 left calf (S13)
14 right instep (S14)
15 left heel (S15)
16 small finger (S16)

T_R = rectal temperature

Figure 3 — Position of measuring sites

Mean skin temperature (MST) shall be calculated according to Figure 3:

$$MST = (0{,}07 \cdot S1 + 0{,}175 \cdot S3 + 0{,}175 \cdot S4 + 0{,}07 \cdot S5 + 0{,}07 \cdot S6 + 0{,}05 \cdot S7 + 0{,}19 \cdot S10 + 0{,}2 \cdot S13).$$

3.8.2.3 Procedure

3.8.2.3.1 General

The test shall be conducted in calm but circulating water with a temperature as specified by the different procedures. The air temperature shall be between 5 °C and 10 °C. Each human test subject shall be fitted with the specified number of temperature transducers placed at the sites shown in Figure 3.

Following the placement of the transducers on the body, the human test subjects shall don the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, and the suit system. The water shall be introduced between the suit system and the underclothing in the approximate locations as determined in 3.7.1 and 3.7.2. All primary and secondary closures shall be secured. The human test subjects shall enter the still water with care and assume a relaxed position. Human test subjects may undertake moderate activity movement to prevent discomfort during the exposure.

The test shall be stopped if any human test subject's core temperature has fallen more than 2 °C. The test shall be stopped if any human test subject's skin temperature has decreased to ≤ 10 °C at any of the 16 specified transducers for more than 15 min.

3.8.2.3.2 Class A suit system

Six human test subjects as specified shall be exposed for a time of 6 h to water with a temperature of (2^{+1}_{0}) °C.

3.8.2.3.3 Class B suit system

Six human test subjects as specified shall be exposed for a time of 4 h to water with a temperature of (2^{+1}_{0}) °C.

3.8.2.3.4 Class C suit system

Six human test subjects as specified shall be exposed for a time of 2 h to water with a temperature of (5^{+1}_{0}) °C.

3.8.2.3.5 Class D suit system

Six human test subjects as specified shall be exposed for a time of 2 h to water with a temperature of (10^{+1}_{0}) °C.

NOTE Class D suits will mainly cover a wide variety of designs such as wet suits, one-layer suits and thermal protection aids.

3.9 Temperature cycling test

3.9.1 General

The temperature cycling test shall be carried out as a preconditioning before all other tests.

3.9.2 Procedure

The suit, along with any attachments, shall be subjected to the following exposures with the suit packed in accordance with the manufacturer's instructions. The stowage pack shall not be closed or sealed for the exposures. The suit shall be subjected to 10 alternating cycles of 8 h continuous exposures to temperatures of (65 ± 2) °C and (– 30 ± 2) °C. These alternating temperatures need not follow immediately after each other. On completion of the temperature cycling test, the suit shall be visually inspected for signs of degradation to the materials or construction or to any attachments.

3.10 Ergonomic performance testing

3.10.1 General

3.10.1.1 Sampling

The tests shall be carried out on a representative sample set of a minimum of six suits.

3.10.1.2 Test in conjunction with other items

Where a safety harness or other item tested to an International Standard forms an integral part of a suit system, the performance shall be tested in conjunction with these items and according to the related standards.

3.10.1.3 Procedure

The suit system shall be tested by human test subjects selected according to 3.3, in front of an assessment panel of not less than three persons, experienced in the use and assessment of this type of equipment. Testing shall be conducted in a swimming pool containing fresh water, treated as necessary for hygienic purposes. Where the standard calls for testing to be conducted using a PFD tested according to the relevant part of ISO 12402, this PFD shall not be required if the suit itself has been tested according to the relevant part of ISO 12402. The testing shall be conducted in the order of appearance in 3.10, except for the helicopter transit suit tests. The tests in 3.10.7 for a helicopter transit suit may be conducted as a separate test sequence.

3.10.1.4 Hand protection

If the suit system is supplied with removable hand protection, the tests in 3.10 may be performed without the hand protection.

3.10.2 Donning

3.10.2.1 General

a) Abandonment suit

Following a demonstration, each human test subject, out of sight of the other human test subjects, shall be able to unpack, don and fully secure the suit over the underclothing within the required donning time of two minutes according to ISO 15027-2:2012, 4.11.3 at an air temperature of (20 ± 2) °C and without assistance. If necessary, the human test subject may sit or lie on the floor but shall not make use of a chair or any vertical support.

In the case of a suit which is to be worn in conjunction with a PFD, the two minutes shall include the time to don the recommended PFD without assistance. If a PFD is not required and there is an inflatable element on the suit, it shall also be inflated within the two minutes for this test.

Three suits in their bags (one for each human test subject size range) shall be placed in a cold chamber for 24 h at a temperature of (– 30 ± 2) °C. Human test subjects shall be able to unpack and don the suit in the cold chamber within five minutes. These tests shall be performed with the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3. In the case of a suit which is to be worn in conjunction with a PFD, the donning time shall include the time to don the PFD without assistance. If a PFD is not required and there is an inflatable element on the suit, it shall also be inflated within the five minutes for this test.

The suit system shall be checked visually for any damage after donning.

b) Constant wear suit

Following a demonstration, each human test subject out of sight of the other human test subjects, shall be able to unpack, don and fully secure the suit over the underclothing within the required donning time of five minutes according to ISO 15027-1:2012, 4.10.3 at a temperature of (20 ± 2) °C and without assistance. If necessary, the human test subject may sit or lie on the floor but shall not make use of a chair or any vertical support.

In the case of a suit which is to be worn in conjunction with a PFD, the five minutes shall include the time to don the recommended PFD without assistance. If a PFD is not required and there is an inflatable element on the suit, it shall also be inflated for this test.

The suit system shall be checked visually for any damage after donning.

3.10.2.2 Suits for helicopter transit flights

Where the suit is intended to be used for helicopter transit flights and is designed to be worn unsealed in flight, it shall be capable of being correctly sealed by the user within 10 s. This action shall be possible when seated at the user's normal position in a helicopter with harness fastened and wearing an un-inflated PFD, if required. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test.

3.10.3 Walking

3.10.3.1 Constant wear suits (including helicopter transit suits)

Each human test subject shall wear the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3. Each human test subject shall walk at a normal speed (2,5 km/h to 3 km/h) a distance of 120 m on a smooth wetted surface along a course with at least four turns of at least 90°. Each human test subject shall walk the course twice wearing only underclothing and appropriate footwear, and the average time shall be recorded. The routine shall be repeated with the human test subject wearing the suit system over the underclothing and a PFD, if required. If an inflatable PFD is used, it shall not be inflated for this test. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. The average time for each human test subject wearing the suit shall not be more than 10 % greater than his average time without the suit. The human test subject shall be allowed to rest between each walk

3.10.3.2 Abandonment suits

Each human test subject shall wear the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3. Each human test subject shall walk at a normal speed (2,5 km/h to 3 km/h) a distance of 30 m on a smooth wetted surface along a course with at least one turn of at least 90°. Each human test subject shall walk the course twice wearing only underclothing, and the average time shall be recorded. The routine shall be repeated with the human test subject wearing the suit system over the underclothing and a PFD, if required. If an inflatable PFD is used, it shall not be inflated for this test. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. The average time for each human test subject wearing the suit shall not be more than 25 % greater than his average time without the suit. The human test subject shall be allowed to rest between each walk.

3.10.4 Climbing

3.10.4.1 Constant wear suits (including helicopter transit suits)

Each human test subject shall climb a 5 m vertical ladder to a height where his feet are 3 m above the ground. Each human test subject shall climb the ladder twice wearing only the underclothing specified by the manufacturer or if no underclothing has been specified by the manufacturer the standard underclothing according to 3.8.1.3. The average time to reach the 3 m height and return to the ground level shall be recorded. The routine shall be repeated with the human test subject wearing the suit system including underclothing and a PFD, if required. If an inflatable PFD is used, it shall not be inflated for this test. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. The average time recorded for each human test subject wearing the suit system shall not be more than 10 % greater than his average time without the suit. The human test subject shall be allowed to rest between each climb.

3.10.4.2 Abandonment suits

Each human test subject shall climb a 5 m vertical ladder to a height where his feet are 3 m above the ground. Each human test subject shall climb the ladder twice wearing only the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3. The average time to reach the 3 m height and return to the ground level shall be recorded. The routine shall be repeated with the human test subject wearing the suit system including the underclothing and a PFD, if required. If an inflatable PFD is used, it shall not be inflated for this test. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. The average time recorded for each human

test subject wearing the suit system shall not be more than 25 % greater than his average time without the suit. The human test subject shall be allowed to rest between each climb.

3.10.5 Dexterity and mobility

3.10.5.1 Dexterity tests for constant wear suits (including helicopter transit suits) and abandonment suits

Each human test subject shall wear the suit system, the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, and a PFD, if required. Each human test subject shall be able to bend over (without squatting), pick up a length of 8 mm to 10 mm diameter rope, pass it round his waist and tie a double overhand knot in front of him. If an inflatable PFD is used, it shall not be inflated for this test. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. If the hand protection is removable, the test may be done without hand protection (see 3.10.1.4).

In addition for abandonment suits, the test subject shall pick up a pencil and write.

3.10.5.2 Mobility tests for constant wear suits (including helicopter transit suits) and abandonment suits

Each human test subject shall be able to complete the following series of movements wearing the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3,, the suit system and a PFD, if required. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. A pass shall be obtained if there is no visual damage to the seams of the suit and the tests are able to be completed by the human test subjects, without any discomfort. If any human test subjects fail any of the following tests then they shall repeat them without the suit to ensure that they can perform them.

a) Kneel on both knees, lean forward and place both hands on the floor 450 mm in front of the knees.

b) Position hands at chest level, palms out, reach directly overhead, interlock thumbs, extend arms fully.

c) Kneel on the right knee, place left foot onto the floor with the left knee bent 90°. Touch toe of left foot with the thumb of the right hand.

d) Extend arms fully in front of body, lock thumbs together, twist upper body 90° to the left and right.

e) Stand with feet a shoulder width apart, arms at side. Raise the arms until they are parallel to the floor in front of the body. Squat down as far as possible.

f) Kneel as in movement c) with left arm hanging loosely at side, raise right arm fully overhead.

3.10.6 In-water performance and field of vision tests

3.10.6.1 Jump test

Each human test subject shall wear the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, the suit system correctly fastened and a PFD, if required. The human test subject shall jump feet first into water of a temperature of ≥ 15 °C from a height of $4,5\ ^{+0,5}_{0}$ m . If an inflatable PFD is used, it shall not be inflated for this test. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. Each human test subject shall then leave the pool and the suit system shall be inspected for damage. If damage has occurred then the suit shall be deemed to have failed. Any injuries to the human test subject shall be reported.

3.10.6.2 In-water donning

3.10.6.2.1 When in the water, the human test subjects shall be able to fasten any secondary suit closures within 2 min.

3.10.6.2.2 Where the suit system has removable hand protection or is required to have hand protection, each human test subject wearing the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, the suit system and a PFD, if required, shall demonstrate the removal of the hand protection from storage and its donning in 3 min. If a PFD is not required and there is an inflatable element on the suit, it shall not be inflated for this test. The time to remove and don the hand protection shall be recorded.

3.10.6.3 Turning test

Each human test subject shall wear the suit system, the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, and a PFD, if required. The human test subject shall swim three breast strokes forward and then relax, arms by sides and legs closed, face down. A PFD or inflatable parts of the suit shall not be inflated. Then the test shall be repeated with all inflatable elements of the suit system inflated.

After establishing a stable floating position, each human test subject shall demonstrate that they can turn themselves from a face-down to a face-up position in not more than 5 s.

Then each human test subject shall adopt the face-up floating position with arms by their sides and legs together. After 5 min, they shall be assumed to have established a stable floating position and the freeboard shall be measured according to ISO 12402-9:2006, 5.6.2.

3.10.6.4 Conspicuity

3.10.6.4.1 While each human test subject is in the stable position of 3.10.6.3, measure the area of retro-reflective material clear of the water.

3.10.6.4.2 To approve the proper application of retro-reflective material, use the following procedure.

a) Take a new piece of the same reflective tape which is used for the suit. Place it adjacent to and on the same angle as a selected piece of tape applied on the suit. Size and shape of both pieces must be similar.

b) Pour water over both pieces and the respective area of the suit.

c) Perform the following visual assessment in a darkened room.

d) Use a torch, which is held at eye level, and compare the reflective performance of both pieces of tape from a distance of approximately 10 m.

3.10.6.5 Field of vision

3.10.6.5.1 A protractor plate for measurement with radial and vertical lines drawn every 10 degrees from the centre shall be set on the floor. Then each human test subject wearing the immersion suits shall be seated on a chair so as to be positioned with the eyes of the human test subject at the centre of the angles on the plate.

3.10.6.5.2 The human test subject shall be positioned to look forward with the head fixed and eyes allowed to move. The lateral and vertical field of vision shall be measured for each human test subject with a suitable moving visible target at the same height as the human test subject's eyes above the protractor plate.

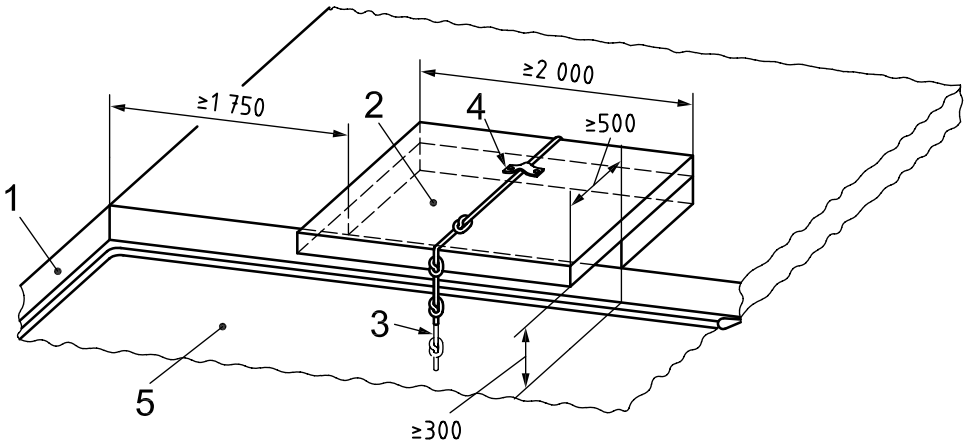
3.10.6.6 Swim and boarding test

Each human test subject shall re-enter the water wearing swimming costumes, shall swim for (50 ± 5) m and then attempt to board a static platform as shown in Figure 4 without any assistance. This attempt shall be carried out in a test pool filled to a depth that prevents a human test subject from pushing off from the bottom of the pool. Each human test subject shall repeat this test, wearing the suit system, the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, and a PFD, if required. If an inflatable PFD is used, it shall be inflated for this test. If a PFD is not required and there

is an inflatable element on the suit, it shall be inflated for this test. The test shall be repeated with all inflatable elements of the suit system deflated.

The human test subject may have as many attempts at this action as required within a time limit of 5 min.

Dimensions in millimetres



Key

1 platform
2 pool side
3 rope, about 12 mm diameter, knotted every 300 mm, hanging (150 ± 50) mm into the water
4 rope fixing point
5 water level

Figure 4 — Boarding platform

3.10.7 Helicopter transit suits

3.10.7.1 Helicopter escape (for helicopter transit suits as specified by ISO 15027-1 only)

One of the human test subjects with a 95th percentile (large) bi-deltoid width, shall wear the suit system, the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, and a PFD, if required. If an inflatable PFD is used, it shall not be inflated for this test. The human test subject shall be able to exit a helicopter cabin simulator through an emergency exit of 420 mm × 660 mm. This action shall be carried out in air and underwater with the top of the exit at least 300 mm below the water surface.

3.10.7.2 Buoyancy measurement (for helicopter transit suit only)

The buoyancy of the suit system shall be determined by measuring the in-water body weight of each human test subject, according to ISO 12402-9:2006, 5.6.1.4 when wearing a swimming costume. The measurement shall be repeated, with each human test subject being vertically immersed, when wearing the suit system, the underclothing specified by the manufacturer or, if not specified by the manufacturer, the standard underclothing according to 3.8.1.3, but no PFD. If there are inflatable elements on the suit system, they shall not be inflated for this test. Suit systems that are not equipped with automatic venting should be tested manually vented in accordance with the manufacturer's instructions and approved drills.

When determining the buoyancy, the human test subject's variable lung volume shall be taken into account by taking the values at the end of the breathing cycle.

Annex A
(normative)

Test results — Uncertainty of measurement

For each of the required measurements performed in accordance with this part of ISO 15027, a corresponding estimate of the uncertainty of measurements shall be undertaken. This estimate of uncertainty shall be applied and stated when reporting test results, in order to enable the user of the test report to assess the reliability of the data.

Bibliography

[1] EN 340, *Protective clothing — General requirements*

[2] ISO 9886, *Ergonomics — Evaluation of thermal strain by physiological measurements*

[3] ISO 10551, *Ergonomics of the thermal environment — Assessment of the influence of the thermal environment using subjective judgement scales*

[4] ISO 12894, *Ergonomics of the thermal environment — Medical supervision of individuals exposed to extreme hot or cold environments*

[5] *Declaration of Helsinki (World Medical Association, 1964) as amended at Edinburgh 2000*

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