Indian Standard

TEXTILES – PROTECTIVE CLOTHING: EXTREME COLD WEATHER CLOTHING SYSTEM FOR - 50°C

1. SCOPE

This proper standard for protective wear, specifically for evaluation of wearability specifies different test methods and requirements. Development of testing methods for protective clothing in terms of ergonomic, comfort and wearability parameters for each layer of the garment expected of the end users, i.e. military personals could help manufacturers in improving the design, performance and functionality of the garments. A proper standard for wearability does not exist yet.

This standard of protective clothing is intended to protect as per climatic conditions at high altitude, provide resistance to extreme cold during extended periods in high altitude area of 18,000 ft. and above with extreme low temperatures i.e. up to -50°C., and provide necessary insulation for minimal heat dissipation. It consists of modular 3 layers, suitable for military and paramilitary operations in extreme cold weather conditions and rugged as well as snowbound terrains. This standard can be adapted for various sorts of protective ensembles and functionalities at high-altitude, low temperature environments.

2. REFERENCES

The following standards contain provisions that are referred to in this text as being provisions of this standard. The editions indicated were valid at the time if publication. All standards are subjected to amendment and parties to agreement based on this standard are encouraged to explore the possibility of applying the most recent editions of the standards as below:

IS 16890: 2018, Textiles — protective clothing for fire-fighters — specification

Other details of standard indicated in **ANNEX 1.**

3. TERMINOLOGY

For the purpose of this standard the following definitions, terms and symbols shall apply:

3.1 Protective clothing

Protective clothing is a specific garments or accessory that covers or restores personal clothing; which is specifically designed, and fabricated to protect personnel from physical, electrical, chemicals, biological, or airborne particulate matter hazards. In this Standard, the hazards are due to the extreme cold for extended periods of time at higher altitudes.

3.2 Garment

An item of clothing composed of single or multiple layers.

3.3 Wearability

Wearability is defined the durability of any wearable article to withstand prolonged wear. The word wearable implies the use of the human body as a backing environ for the product/item.

3.4 Cargo Pockets

Pocket is exteriorly located on the protective garment.

3.5 Composite

Layer which is provide necessary exterior protection from moisture, temperature and thermal barrier.

3.6 Component Assembly

Arrangement of the materials used to make multilayer clothing in the order of complete set of garments, including inner lining.

3.7 Hardware

Protective clothing composed of non-fabric components such as metal or plastic material.

NOTE — Examples include buttons, fasteners, rank markings, buttons, etc.

3.8 Closure System

Various combinations of more than one way for securing a closure are used in the method of fastening openings in the garments. For instance, a sliding fastener with an overlap is secured by a touch-and - close manner.

3.9 Innermost Lining

Lining placed on the component assembly's inner most interfaces.

3.10 Interface area

The area of body is not protected by protective garments like helmet, footwear, gloves. Hence, the area where helmet, gloves and footwear meet, it called protective coat/ helmet area, protective coat/glove area and protective trouser/footwear area.

3.11 Interface component

Interface areas have limited protection by specially designed items.

3.12 Interlining

The lining which is configure between innermost lining and outermost layer of a multilayer garment that is not exactly wearer next to the skin.

3.13 Manufacturer

Entity takes liability for compliant product and offers a warranty.

3.14 Material combination

Prior to the garment production stage, material made from a number of distinct layers that have been integrated intimately. For example: a quilt fabric.

3.15 Thermal Barrier

A special designed portion that resist heat dissipation, provide insulation.

3.16 Moisture Barrier

A special designed part of protective garment that resist transfer of liquid water to thermal barrier from environment.

3.17 Multilayer Clothing Assembly

Series of layers arranged as it worn separately in orderly manner.

NOTE: It may contain multiple material combinations, in single or multiple layers.

3.18 Outer material

The material is used to make outermost layer of protective garment.

3.19 Outer shell

The outermost outside interface of the garment; excluding of hardware, trim and reinforcing material.

3.20 Protective Hood

Interface of a component that protects limited body part. Provide protection to the protective coat/helmet interface area.

3.21 Protective Trouser

Interface of a component provide protection to leg, torso except feet.

3.22 Protective Jacket

Protective clothing designed and composed to provide protection to arm, upper torso and head excluding hand.

3.23 Protective Garment

Item(s) composed of single or multiple layers provide protection, including protective hood, protective trouser.

3.24 Protective Uniform Garment

A special designed garment that composed of both thermal barrier portion of protective garment or full thermal barrier and work uniform.

3.25 Protective Reversible component

Garment designed to use reversibly and provide thermal insulation as it worn both ways.

3.26 Seam

Sewing and other method used to permanently attach two edges of material junction with the garment.

3.27 Major A Seams

Seam assemblies of outer-shell where rupture could minimize the garment protection by uncovering thermal barrier, moisture barrier, work uniform and other clothing system or skin of wearer.

3.28 Major B Seams

Seam assemblies of moisture barrier and thermal barrier where rupture could minimize the garment protection by uncovering next layer of garment, work uniform and other clothing system or skin of wearer.

3.29 Minor Seams

Rest of seam assemblies that are not included in major A and major B seams.

3.30 Winter Liner

Composite layer designed to provide added thermal comfort against cold.

3.31 Wind skirt

The part of a clothing system that is hanging below around waist part for prevent wind flow in core of the garment.

3.33 Collar

A band of line designed around the neck of the garment.

4. DESIGN REQUIREMENT

4.1 General

This clause depicts minimum requirement and test procedures of protective clothing which worn in combination of garment (s) as per climatic conditions and requirements at high altitude. This portion covers overall clothing design, material used, requirement of minimum performance and testing methods for persuade these performance requirement.

4.2 Design Requirements

4.2.1 *Configuration*

The extreme cold weather protective clothing shall provide adequate protection/comfort to the personnel from extreme cold climate & rough weather conditions. It covers neck, arm, leg, upper and lower torso, head excluding hand and feet. It refers to a modular multi-layered cold weather protective ensemble comprising of the following three layers:

a. *Inner Layer:* Body hugging thermally insulating inner layer of textile material having good wicking capabilities for sweat absorption.

b. *Middle Layer:* The middle layer comprises of insulating jacket and lowers with garters. The middle layer has waterproof outer surface and reinforcement fabric patches.

c. *Outer Layer:* The outer layer insulating jacket and lowers which are waterproof and wind proof.

4.2.2 *Restriction of Movement*

Restriction of movement is a quantification of the distance and direction that a human joint can minimally flex. The protective clothing shall be designed in modular way that explores minimum joint restriction. It shall be compatible with other protective equipment like gloves, footwear, and helmet. Basic ergonomic features of multilayer extreme cold weather protective clothing shall be check in details as subjective parameter, referred to **ANNEX 2.**

4.2.3 *Multilayer Clothing Assemblies*

Multilayer clothing assemblies are used to meet a requirement; the layers must either be permanently affixed or clearly marked on each layer of garments to indicate that they must always be worn in combination. These following layers composed to multilayer assemblies:

a. ***Outer layer (outer + inner shell):*** *Reversible, breathable, thermal protection, waterproof and wind proof both outer and inner side. Water Vapour Resistance (Ret) permitted range ≤ 15 m2 Pa/W.*

b. ***Middle layer (outer shell):*** *Water penetration resistance for rain and snow, breathable. Water Vapour Resistance (Ret) permitted range ≤ 20 m2 Pa/W.*

c. ***Inner layer:*** *Provides insulation, wicking features and antimicrobial properties.*

Complete system thermal insulation value >6.5 CLO.

4.2.4 Seams

To maintain integrity and protection from minimum loss in strength of the garment, seams shall be made according. As per IS/ISO 13935-2 testing method, the seam breaking force shall have minimum 250N. It should maintain its sealing. According IS-13934-1, breaking and tearing warp and weft of outer layer (outer shell) not more than ≥ 1000 N and 50 N (min), for outer layer (inner shell) not more than ≥750, 75N (min) and for middle layer (outer shell) ≥500 N, 15N (min).

4.2.5 Hardware

The hardware of component assemblies shall be maintained its integrity during extreme cold environment. The hardware shall be tested according to standard testing method ISO 17493 as it shall not be separate, or drip.

4.2.6 Closure System

To fulfil the requirement of the garment closure system shall be composed for entire clothing system. Positive fastener type closure system shall be added to clothing assemblies. Long draw cord, water and wind proof overlapping storm flap shall be fixing with closure system as it provide protection against moisture and thermal. Elastic draw string with draw cord at the base circumference of garment shall be added for adjustability. The maximum interval distance of buttonhole shall be 150 mm and for complete closing with zipper, full length heavy duty slide fastener shall be designed to lock.

4.2.7 Sleeve Ends

The sleeves end shall be designed to provide protection against extreme cold environment to ensure thermal comfort. The ends of sleeves shall be compatible with the protective gloves wearing. Elastic and velcro based closing system shall be attached at the sleeves end for size adjustment.

4.2.8 Clothing Mass

To maintain the required performance, the clothing mass shall be light as possible.

4.2.9 Ease of Cleaning

The design of clothing system shall be promote ease of cleaning.

4.2.10 Labels

The performance of the clothing system shall not be adversely affected by any label and trim.

4.2.11 Protective Jacket

The protective jacket shall be designed with thermal, water, breathable and wind proof material to maintain required performance in extreme cold weather conditions. The jacket of the clothing system shall have reinforcement patches at elbow, pockets, waist adjustable draw cord, hoods, high collar, and double closure system, wind skirt.

4.2.12 Protective Trouser

The trouser shall be water and wind proof with external pockets, ankle slit, reinforcement patches and adjustable draw cord for better grip. To maintain required performance at extreme temperature trouser shall have thermal comfort.

4.2.13 Pocket

The garment shall have water proof cargo pockets in both parts, jacket and trouser. Pockets of jacket protected hand against cold and rain. Trouser pockets designed as per requirement.

4.2.14 Wind skirt

A detachable wind skirt shall be attached to the waist part of the reversible clothing system, to protect body from windy cold condition.

4.2.15 Hood

To maintain required performance garment shall have water proof hood system with adjustable draw cord for covering the forehead from snow blizzard.

4.2.16 Collar

Designed clothing system shall have high collar to cover mouth and nose in extreme cold condition.

4.3 Size Designations

Each protective clothing system shall be designed as per control size designation of height and chest girth; in cm. Different size designation of height and chest girth shall be given in Table 1.

Table 1 Height and Chest girth ranges for different size
(*Clause 4.3***)**

Sl No. (1)	Size Designation (2)	Height (cm) (3)	Half Chest Girth (cm) (4)
i.	S	152-155	48-52
ii.	M	156-159	53-57
iii.	L	160-163	58-62

5. SAMPLING

5.1 Samples

Sample shall be taken as material representative and employed garment construction. Conformity criteria and sampling shall be given in **ANNEX 3**

5.2 Size and Number of Specimens

The different tests shall be done for the size and number of specimens' accordance with respective standards. The test standard shall be carried out for the materials received.

5.3 Exposure surface

The following layers of protective clothing system shall be exposed for surface test; outer layer-outer shell, outer layer-inner shell, middle layer-outer shell, middle layer-inner shell and inner layer.

6. PERFORMANCE REQUIREMENTS

6.1 General Requirements

The control dimensions for protective clothing shall be height, weight and age of the test subject. These parameters are used to determine the standard baseline values for metabolic rate, respiratory rate, breathing capacity, core temperature, dehydration and heart rate in order to evaluate wearability and ergonomic suitability of different layers of protective clothing on type and duration of activity of test subject.

6.2 Test Procedure for wearability requirement

Test shall be happened two sets viz.,Minimal clothing, ECWCS clothing inner layer, ECWCS clothing inner and middle layer and ECWCS clothing inner, middle and outer layer. Test for each set shall be conducted on the same test subject after a resting period of 24 hours prior to each test set mentioned in clause 6.3. It shall be conducted according to standard protocols as mentioned in this document. Based on the intended use, the test set for minimal clothing shall be conducted at room temperature and that of complete ECWCS clothing (all three layers) shall be conducted at temperatures below -15^{o}C. Test set for combined Middle and Inner Layer of ECWCS shall be conducted at temperatures below 4^{o}C up to -15^{o}C. Humidity shall be set at 65±3% for minimal clothing and 80±3% for experiment set. Difference in values obtained for minimal clothing and ECWCS layers shall be calculated and considered as measured parameter for the ergonomic suitability of ECWCS. The maximum permissible values shall be defined by the user depending on targeted environmental temperatures and activity.
The procedure for a Simulation chamber test shall be given in **ANNEX 6**. The forced termination criteria for the test procedure shall be discomfort, high core temperature (>39^{o}C), abnormal Respiratory Rate (> 55 breaths/min) or HR (>185 beats/min), low SpO2 (<95%).

6.3 Wearability Requirements w.r.t Ergonomic aspect

Ensuring human comfort (HC) depends on the influences of a human's physiological and psychological states and the surrounding environmental conditions. Ergonomically suitable protective clothing for extreme cold weather shall meet the insulation requirement, physiological effects like perspiration, heart rate and metabolic demand, core body temperature and breathing capacity or range of motion at joints. Ergonomic requirements shall also be catered in design aspects of protective clothing so as to ensure proper

fit and avoid localized pressure, movement restriction and friction in different body segments during activities.

a. Objective Requirement

6.3.1 Metabolic Demand (VO_2/ml/kg): The amount of energy required by a body for a task over a period of time is called its metabolic demand (MD).Metabolic capacity (MC) is body's ability to take oxygen into the body and circulate it into the blood to the working muscles without causing fatigue.

Metabolic equivalent (MET) is defined as the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml O2 per kg body weight X min.

The Metabolic demand during rest and sub-maximal exercise can be calculated from HR and VO_2. Metabolic demands (MD) exceeding approximately 35% of metabolic capacity (MC) is proposed as a source of work related fatigue. Abnormal increase in metabolic demand on wearing the ECWCS in intended environmental conditions and intensity of activity is an ergonomically undesirable feature. The following calculation shall be used to measure metabolic demand:

%HRR = [(activity HR – resting HR) / (APMHR* – resting HR)] X 100

*APMHR = Age Predicted Maximum HR (220 – age)

%VO_2R = [(activity VO_2 – resting VO_2) / (VO_2 Max* – resting VO_2)] X 100

*VO_2 Max = maximum oxygen consumption (either estimated by questionnaire, submaximal test, or directly measured)

6.3.2 Heart rate (beats/min): Heart rate is the number of heart beats per minute. The normal heart rate in resting state is 60–100 bpm which increases with physical and physiological stress and exercise. Though the maximum heart rate can be roughly calculated using the formula 220- Age, the actual values could vary. The comparative rate of increase of heart rate between minimal clothing (at room temperature) and ECWCS (in sub-zero temperature) during a sub-maximal steady state exercise is an indicator of the physiological load. Abnormal rise or fall in heart rate on wearing the ECWCS in intended environmental conditions and intensity of activity is an ergonomically undesirable feature

6.3.3 Core body temperature (^{0}C): Core Body Temperature is the temperature of the internal organs of the body, which can be measured using a thermometer under the tongue or non-invasively using thermal heat transfer sensors. The body maintains its core temperature within a very narrow range of 36.5-38.5 ℃ [97.7-101.3 °F]. Abnormal rise or fall in core body temperature on wearing the ECWCS in intended environmental conditions and intensity of activity is an ergonomically undesirable feature.

6.3.4 Respiratory rate (breaths per minute): Respiratory rate is the number of breaths taken per minute. The normal respiratory rate for an adult is 12-20 breaths per minute which may increase to 40-60 breaths per minute during exercise. Abnormal rise or fall in respiratory rate on wearing the ECWCS in intended environmental conditions and intensity of activity is an ergonomically undesirable feature.

The Telemetric Data Logger system (Zyphyr) shall be used to monitor the physiological changes in the body during tasks and activities. Its telemetry range is 500m. It can monitor heart rate, core body temperature, and breathing rate. The entire procedure is added to **ANNEX 4**

6.3.5 SpO_2 (%): SpO_2 is the percentage of oxygen in blood. The normal SpO_2 range for an adult is 99% which may decrease due to tightness of the clothing system. It shall be measured by Oxymeter that placed on index finger and monitor the oxygen percentage in blood as per test procedure.

Abnormal range (<95%) of SpO_2 on wearing ECWCS in intended environmental conditions and intensity of activity is an ergonomically undesirable feature.

6.3.6 Range of Motion: Range of motion (ROM) is a quantification of the distance and direction that a joint can maximally flex. Human movement provides both a restraint and a source in design of dynamic ergonomic clothing due to the permitted range of motion in each body segment that needs to be unobstructive (**refer ANNEX 2**) and shall be measured by goniometer. Large reductions in range of motion on wearing the ECWCS in intended environmental conditions and activity is an ergonomically undesirable feature.

b. Subjective Requirement

The wearer feedback on the ECWCS provides information on psychological perception of comfort and wearability. The scoring is done on a 10 point scale for texture, insulation, ease of wearing, movement at joints, weight, comfort and overall satisfaction. Lower average scores indicate lower subjective acceptance. The entire questionnaire is added in **ANNEX 5**

6.3 Thermal insulation

The materials used in multilayer clothing system shall be tested for thermal insulation accordance with DIN EN ISO 15831: 2004, Atmospheric condition as per ISO 11092: 2014. Thermal insulation value of complete system measured at body and groin shall be 6.5 CLO (min). Each layer insulation value shall be 0.5 CLO (Inner layer), 2.5 CLO (Middle layer) and 3.5 CLO (Outer layer) as per standard test protocol.

6.4 Breathability

The Inner layer material of the clothing system shall be 100 % polypropylene or equivalent of OG and shall absorb and transport moisture released from body and dry fast as per AATCC-20/20A or equivalent international standard.

6.5 Absorbency

The inner layer of the composite system shall be 3 Sec (Max) absorbency powers in accordance to AATCC-79:2010.

6.6 Wicking power

The material of inner layer of the clothing assemblies shall be 3 Sec (Max) wicking power (time to reach 22mm) for both wales and coarse wise in accordance with AATCC 197: 2013.

6.7 Anti-microbial property

Inner material of multilayer clothing system shall have 99% anti-microbial finish in new condition and >90% after 20 washes as per AATCC-100-2019.

6.8 Breaking strength

The outer layer- outer shell, inner shell and middle layer- outer shell materials tested in accordance to ISO: 13934-1 2013 shall have breaking strength ≥1000 N, ≥ 750 N and ≥500 N (warp+ weft) respectively.

6.9 Tearing strength

The outer layer- outer shell, inner shell and middle layer- outer shell materials tested in accordance to ISO: 13937-2, 2000 shall have tearing strength minimum 50N, 75N and 15N (warp+ weft) respectively.

6.10 Surface wetting

The outer layer- outer shell, outer layer-inner shell and middle layer- outer shell materials tested in accordance with ISO 4920 : 2012, Wash as per ISO 6330: 2000, 2A, E shall have spray rating ≥5for initial and after 5 wash.

6.11 Shrinkage Resistance

The outer layer- outer shell, inner shell and middle layer- outer shell materials tested in accordance to BS EN 5077: 2007, Wash as per ISO 6330: 2012, 5A, E, Temp 40°C shall have maximum 2.0% dimensional change on both direction after washing at 40°C. For inner-shell shall have maximum ±3.0% dimensional change.

6.12 Hydrostatic Penetration Resistance

The multilayer clothing assembly outer layer- outer shell, inner shell and middle layer- outer shell materials tested for hydrostatic penetration resistance in accordance with ISO-811 (E) for new condition, ISO-811 (E)-Sample preparation as per EN: 343 for containment fuel of oil and ISO-811 (E) - Sample preparation as per EN: 1876-1 for sharp bend test under low temperature of -40°C. The clothing assemblies shall give minimum 1.0 bar in new condition, 0.5 bar for containment fuel of oil and 0.5 bar for sharp bend test under -40°C.

The multilayer clothing seam tested for water resistance in accordance to hydrostatic tester to test at 21kPA for two minutes wash as per ISO 6330:2000,2A,A., shall give no leakage result.

6.13 Water-vapour Resistance

Multilayer clothing system and its seams tested for water vapour resistance in accordance to ISO 11092: 2014 shall give result ≤ 15 m2 Pa/W for outer layer- outer shell, inner shell and ≤ 20 m2 Pa/W for middle layer- outer shell.

6.14 Abrasion Resistance

Specimen of clothing system tested for abrasion resistance in accordance to ISO 12947-2: 1998; 9KPa of load face, 60000 cycles/min shall show no breakage result.

6.15 Colour fastness

Colour fastness for different layers with different action shall be tested as per following standard protocol

- **a)** Colour fastness to light shall be 5 or better (ISO 105 B02: 2014)
- **b)** Colour fastness to washing shall be 4 or better (ISO 105 C06)
- **c)** Colour fastness to Perspiration shall be 4 or better (A2S: 2010, 30 Min)
- **d)** Colour fastness to Dry Rubbing shall be 4 or better (ISO 105 E04: 2013)
- **e)** Colour fastness to Wet Rubbing shall be 4 or better (BSEN ISO 105 X 12: 2016)

7. Marking

7.1 Label

Each layer of protective clothing assemblies shall have permanent and conspicuous label marking that attached to each layer according to figure no 1 at least 1.5 mm high. The label shall be located inside the garment configure usability of garment care and size.

7.2 Label Legibility

In clothing system, all attached label shall be legible to eye before and after subjected to use for pre-treatment. Specimen size shall not require in pre-treatment procedure.

7.3 Manufacturers' Information

7.3.1 Information of manufacturer shall contain following details:

a) Name, address and Contact details
b) Model and Article number of protective garment that has been certified for standard
c) Size information according to manufacturer; S-XXXL
d) Symbols of care labelling, specified in IS 14452
e) Indian Standard to which certified along with pictogram as given in **figure 2**

f) Declaration

1. The manufacturer shall include a note for compilation of information requirement of standard for different parts of upper and lower clothing system that shall protected and covered by protective clothing assemblies but other parts of the body which is not included that need essentials for fully protection.
2. The protective clothing have a specified design to protect from extreme cold weather with other associates like extreme cold weather boot, extreme cold weather gloves.

THIS EXTREME COLD WEATHER PROTECTIVE GARMENT MEETS THE REQUIREMENTS OF THIS INDIAN STANDARD
Manufacturer's Name and address
Country of Manufacture
Manufacturer's garment identification number
Model No.
Size
Date of manufacture
Batch/Lot No.
Care labelling symbols as specified in IS 1452
Garment material(s)
Pictogram as given in Fig. 2
"DO NOT REMOVE THIS LABEL"

Figure 1 LABEL

7.3.2 Instruction and Information

Manufacturer of protective garment shall put following instruction and information with each layer of the garment:

a) Cleaning instruction
b) Warranty information
c) Maintenance criteria & care
d) Repairing methods

7.3.3 Training Material

Manufacturers' of protective multilayer clothing assemblies shall provide training materials, but these are not limited to following criteria:

a) Safety issues
b) Storage
c) De-contamination procedures

7.4 BIS Certification Marking

The protective clothing system shall be marked with BIS standard marking. The standard marking, rules and regulation of garment usage shall be made under and governed by Bureau of Indian Standard Act, 1986. The licensed test standard details of a garment care may be granted to manufacturer from the Bureau of Indian Standard for use of standard mark or labelling.

ANNEX 1

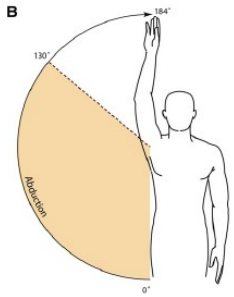
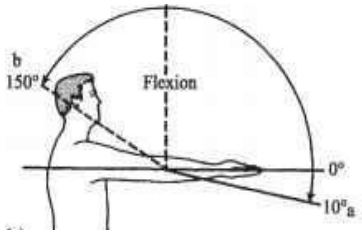
(Clause 2)

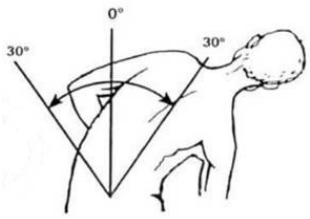
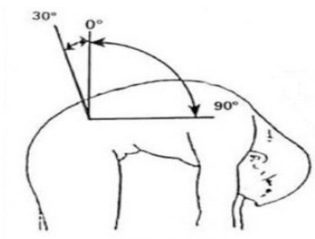
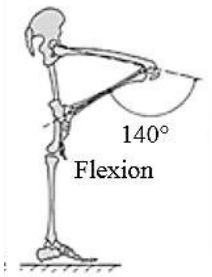
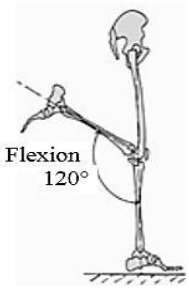
LIST OF REFERRED INDIAN STANDARD

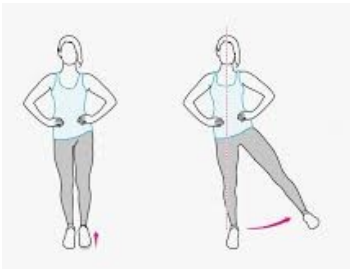
ISO: 13934-1 2013	Breaking Strength
ISO: 13937-2, 2000	Tearing Strength
ISO 4920 : 2012	Spray rating
ISO 6330: 2000, 2A,E	Spray rating test after 5 wash
ISO 11092: 2014	Water Vapour Resistance
BS EN 5077: 2007 (Wash as per ISO 6330: 2012, 5A,E, Temp 40^{O}c	Dimensional Property
ISO 105 B02: 2014	Colour fastness to light
ISO 105 C06	Colour fastness to washing
A2S: 2010, 30 Min	Colour fastness to Perspiration
ISO 105 E04: 2013	Colour fastness to Dry Rubbing
BSEN ISO 105 X 12: 2016	Colour fastness to Wet Rubbing
ISO-811 (E)	Hydrostatic Pressure Test in New Condition
ISO-811 (E), EN: 343	Hydrostatic Pressure Test in Containment Fuel of Oil
ISO-811 (E), EN:1876-1	Hydrostatic Pressure Test : Sharp bend test under low temperature of -40oC
ISO 6330:2000,2A,A	Seam sealing test
ISO 12947-2: 1998	Abrasion resistance
AATCC-20/20A	Material
ISO: 13938-1	Bursting Strength
AATCC-79:2010	Absorbency
AATCC 197: 2013	Wicking
AATCC-100-2019	Anti-microbial finish

ANNEX 2

RESTRICTION OF MOVEMENT

Exercise	Image	Ref. Value	Min Clo	L1	L1+2	L1+2 +3
Stretch up – Exercise to see clothing pile up at the shoulders and the neck, the angle deviation between each layer, and to assess resistance in movement due to material. It shall be measured the angle between the spine-to-head line and the arms.		150 ±20				
Elbow Bend – Exercise to see clothing pile up at the elbows, the maximum angle deviation between each layer, and to assess resistance in movement due to material. It shall be measured the angle between the arm and the forearm.		140 ±15				
Bear Hug – Exercise to see clothing pile up at the elbows, chest, and shoulders. To see the maximum angle deviation between each layer and to assess resistance in movement due to material. It shall be measured the angle between the arm and the shoulder-to-neckline.		80 ±10				

Side/Lateral Bend – Exercise to see clothing pile up at the hips, the maximum angle deviation between each layer and to assess resistance in movement due to material. It shall be measured the angle between the spine and the median line.		30 ±10				
Forward Bend – Exercise to see clothing pile up at the stomach, the maximum angle deviation between each layer and to assess resistance in movement due to material. It shall be measured the angle between the spine and the thigh bone.		80 ±10				
Knee Raise – Exercise to see clothing pile up at the knee, the maximum angle deviation between each layer and to assess resistance in movement due to material. It shall be measured the angle between the thigh bone and the calf bone.		120 ±20				
Knee Raise Back – Exercise to see clothing pile up at the knee, the maximum angle deviation between each layer and to assess resistance in movement due to material. It shall be measured the angle between the thigh bone and the calf bone.		100 ±20				

Lateral Leg Raise – Exercise to see clothing pile up at the waist, the maximum angle deviation between each layer and to assess resistance in movement due to material. It shall be measured the angle between the median line and the thigh bone.		55 ± 15				
Sitting Position – In this exercise, we see the shift in the way a person sits as more weight and more layers are added to his body. This shift is to make for the change in the CG of the body. It shall be measured 4 angles in this exercise: - Knee joint: between the thigh bone and the calf bone. - Hip joint: between the spine and the thigh bone - Elbow joint: between arm and forearm - Ankle joint: between calf bone and foot		90 ±15				
		90 ±20				
		100 ±20				
		90 ±20				

ANNEX 3

SAMPLE AND CONFORMITY CRITERIA

1: For the purpose of test and inspection of the sampling conformation, a lot is defined completed protective garment of same type, same assemblies, same size, one facility production, same material, production procedure and being offered to same type of buyer.

NOTE: The different size of protective clothing may be grouped as a one lot.

2: The conformity criteria of one lot as given in Table 2 shall be drawn from randomness of lot.

2.1: The defectiveness consider as the protective clothing lot not fulfilling criteria specified in this standard.

3: The lot of protective clothing shall be declared as conforming requirement of the sample, if this lot shall not have any defective protective clothing.

TABLE 2: Sample Size
(Clause 2 of ANNEX 3)

Sl No. **(1)**	**Number of Protective Clothing in the Lot** **(2)**	**Sample Size (No. of Protective Clothing)** **(3)**	**Permissible No. of Defectives** **(4)**
i.	Up to 90	3	0
ii.	91-149	3	0
iii.	150-500	5	0
iv.	501 and above	1/100 no.	0

ANNEX 4

PROCEDURE OF USING TELEMETRIC DATA LOGGER

1. For **Zephyr** telemetric data logger system components are:

   a) Bio-harness – the measuring device, placed along the 5th intercostal rib, on the chest of the subject (use little water for conductivity).

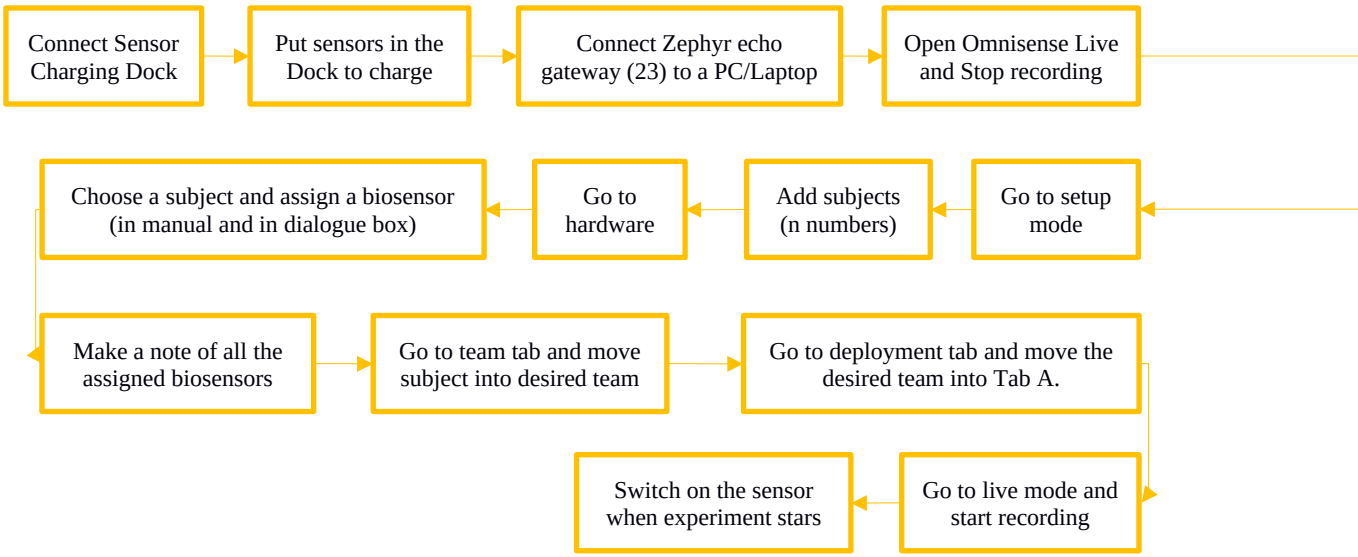
   b) Biosensor – the sensing device (On – short press, OFF – long press). To Mount, place onto the bio-harness' grooves, and to Dismount, press the back of the harness to pop it out.

   c) Zephyr Echo Gateway – the port to access the data from the sensors.

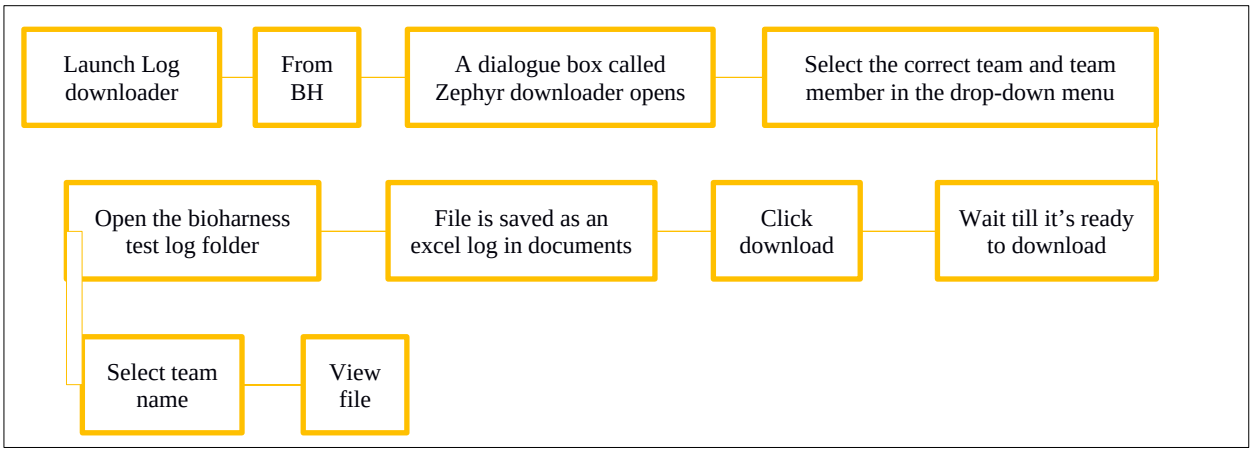
   d) Biosensor Charging Dock

   e) Software (Omnisense Live and Omnisense Analysis)

Omnisense Live

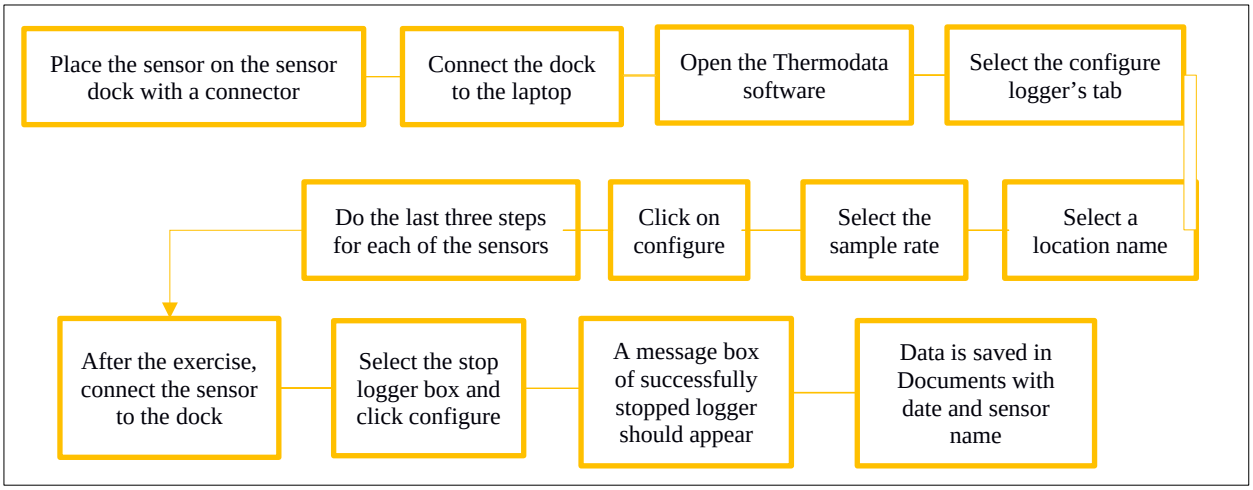


Omnisense Analysis



2. TEMPARATURE – HUMIDITY SENSORS:

For temparature & humidity measurements using 'Thermodata software' accompaning the Temperature-Humidity and the Temperature sensors used during the treadmill test.



The following steps shall be done as carefully and methodically as possible:

a. Time shall be kept methodically, and every second of the experiment was monitored. Each activity and the physical parameter fluctuation shall be evaluated w.r.t. that time.

b. The Zephyr bio-harness shall be placed along the 5th intercostal rib to monitor heartbeat, breathing rate, and core body temperature.

c. Two temperature-humidity sensors and two Temperature sensors shall be placed on the subject/user in the following manner:

i. On the skin/normal layer of clothing, place the first Temperature-Humidity sensor (TH1) above the Zephyr bio-harness.

ii. On the first layer, place the second Temperature-Humidity sensor (TH2) slightly away from where we placed TH1

iii. On the second layer, place the first Temperature sensor (T1)

iv. On the third layer, place the second Temperature sensor (T2)

ANNEX 5

SUBJECTIVE ASSESSMENT QUESTIONNAIRE (*Clause 6.3b*)

In the subjective assessment, the following list of questions was asked for each type of protective clothing, each layer, and each exercise (Refer **ANNEX 2**).

To make sure that the subject's comfort and the suit's wearability are not compromised. To make sure of that, the subject is asked a series of questions which range from difficulty in performing the tasks to difficulty in breathing, wicking facility, too much heat-trapping in the suit, and so on.

In the beginning, while acclimatizing:

a. Is there an issue with breathability?

b. Are you comfortable in this environment?

c. On a scale of 1 to 10, 10 being the most, how uncomfortable would you say you are?

With each new layer:

d. Is the material comfortable?

e. Is it wearable and is it possible to wear it with ease?

f. Is it too heavy?

g. Is there an issue with breathability?

h. Are you comfortable in this environment?

i. Is there any discomfort?

j. Is there anywhere the material or the product feels tight or painful?

k. Can the closure system, adjustable string be operated without difficulty?

l. Does the entire clothing system treat as Personal Protective Equipment (PPE)?

m. On a scale of 1 to 10, 10 being the most, how uncomfortable would you say you are?

With each new exercise:

n. Are you comfortable?

o. Is this the maximum you can stretch?

p. Is there any restriction to your movement?

q. Is there anywhere the material or the product feels tight or painful?

r. Does the ECWCS cover mentioned protective area during body movements?

s. On a scale of 1 to 10, 10 being the most, how uncomfortable would you say you are?

t. On a scale of 1 to 10, 10 being your best health, how would you describe your performance in these clothes?

Criteria for concluding that product is unacceptable

1. Clothing system may be fit to subject but not wear it with ease.
2. Breathing compromise.
3. Impossible to do task with wearing the clothing system.
4. Occurrence of pain while doing exercise.
5. Preventing of wearing of other PPE.

ANNEX 6

SIMULATION CHAMBER TEST PROCEDURE *(Clause 6.2)*

- Set simulation chamber temperature to 25±5ºC (room temperature) for minimal clothing test and (-15ºC) for ECWCS test. Relative humidity is set at 65±2% for minimal clothing and 80±2% for different test sets. Temperature for testing different layers of ECWCS can be selected based on test requirement.

- Anthropometric measurements like Age (years), Height (cm), Weight (kg), BMI [weight (kg)/ height (m) ^{2}], and sex shall be noted. SHAPE I category shall be considered for anthropometric measurement for military and paramilitary personnel.

  Age: 18-30 years
  Height: 165-175cm
  Weight: 65-75 kgs

- Baseline data for ergonomic parameters viz., Heart rate, Respiratory rate and Core body temperature of the subject shall be acquired at room temperature.

- Subject shall be made to sit comfortably in the simulation chamber and data for ergonomic parameters is acquired at rest for 10 min.

- Range of Motion data shall be acquired according to **ANNEX 2**

- The test subject shall be made to perform submaximal exercise on a treadmill (**Inclination 0^0, Speed 3.5kmph for acclimatization at least 5 min and 5.5 kmph for actual test for 3 min**) and ergonomic data for Heart rate, Respiratory rate, Core body temperature, Latency of perspiration and Metabolic Demand shall be acquired according to standard procedures (*clause 6.3*).

- The test shall be terminated either on completion of the sub-maximal exercise schedule or on noting any adverse effects mentioned in the forced termination criteria. The forced termination criteria for the test procedure is **Discomfort, high core temperature (>39ºC), abnormal Respiratory Rate (> 55 breaths/min) or HR (>185 beats/min), low SpO2 (<95%).**

- The test subject shall be made to rest for 5 minutes in sitting position.