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Ergonomija - Ergonomija kompletov osebne varovalne opreme (OVO)

Ergonomics - Ergonomics of PPE ensembles

Ergonomie - Ergonomie von PSA-Ensembles

Ergonomie - Ergonomie des ensembles d'EPI

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Ergonomics - Ergonomics of PPE ensembles

Ergonomie - Ergonomie des ensembles d'EPI

Ergonomie - Ergonomie von PSA-Ensembles

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European foreword

This document (EN 17558:2023) has been prepared by Technical Committee CEN/TC 122 “Ergonomics”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2023, and conflicting national standards shall be withdrawn at the latest by December 2023.

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

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EN 17558:2023 (E)

Introduction

It has long been recognized that personal protective equipment (PPE) can have unwanted side-effects on the wearer in terms of imposing additional physical workload, hindering movement, impairing sensory perception or in some cases causing considerable discomfort. Such side effects can reduce the efficiency of task performance and/or encourage the user not to wear the PPE or use the PPE incorrectly thereby impairing the level of protection afforded. This problem has been recognized in legislation. The Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment [18] places duties on PPE manufacturers to take account of ergonomic requirements and assists employers in demonstrating compliance with national legislation, whilst the associated EC Directive on the use by workers of personal protective equipment at the workplace (89/656/EEC) [19] places similar duties on employers providing PPE for use. These latter requirements have been transposed into national legislation in all Member States.

This document can be used to compare the performance of different ensembles as part of any PPE selection process, thereby again assisting employers in evaluating PPE Ensembles in standardized conditions.

To facilitate compliance with legislation, European technical product standards for individual items of PPE are gradually introducing tests for ergonomic characteristics. However, these standards are mainly for testing individual products and seldom include the assessment of interactions with other items of PPE except in isolated cases (e.g. helmet-mounted ear-muffs conforming to EN 352-3) where they are an essential element of their use. An exception as an example is ISO/TS 11999-2, which details a series of tests aimed at evaluating the compatibility of the different components of the PPE ensembles used by firefighters.

Some PPE items or ensembles incorporate Electronic Safety Equipment forming a smart system designed to enhance the protection provided. Such systems are included if they form a discrete wearable item or their integration is considered to possibly have an influence on the ergonomic impact of the ensemble on the wearer. For example, interconnections or integrated elements might have an adverse effect on the mobility of a wearer.

This document has therefore been prepared to enable PPE ensembles, such as those worn by police, firefighters and other emergency services, as well as some industrial users; to be evaluated and objectively assessed for ergonomic performance as complete ensembles, rather than in their component parts. As such it will provide a valuable tool to aid manufacturers and purchasers of PPE to make informed decisions in selecting and designing those ensembles and creating awareness of interaction issues between PPE items. Test and evaluation of PPE ensembles and systems (efficiency and ergonomics) should be carried out by those who create the ensemble. The wide range of methods described in the annexes may be used as specific test packages or handpicked and combined into dedicated test batteries to match the intended purpose of a particular PPE ensemble.

Some of the tests can also be suitable for adoption as part of product standards for individual items of PPE or they can refer to this document, although that is not their main purpose.

The principles relating to the ergonomics of PPE are presented in EN 13921. This document builds on those principles and provides appropriate tests to verify that an ensemble meets those principles.

1 Scope

This document contains test methods for comparing the performance of different ensembles as part of any PPE selection process.

This document does not replace the product standards for the certification of individual items of PPE. It specifies the testing of individual items of PPE as an ensemble, so that the interactions between the individual items of PPE can be evaluated and any adverse interactions between the individual items of PPE, the user and the environment can be identified.

It specifies requirements for testing by either assessing the performance of a PPE ensemble against a benchmark condition (i.e. benchmark testing) or assessing the performance of two or more PPE ensembles against each other (i.e. comparative testing).

This document incorporates examples of laboratory and field tests. It can also be used to assess the performance regarding the ergonomics of an ensemble that incorporates an item of PPE that has never before been incorporated into an ensemble, and the listed methods can be combined into dedicated test batteries for evaluating that ensemble.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 352 (all parts), *Hearing protectors*

EN 458, *Hearing protectors - Recommendations for selection, use, care and maintenance - Guidance document*

EN 13819-2, *Hearing protectors - Testing - Part 2: Acoustic test methods*

EN ISO 7731, *Ergonomics - Danger signals for public and work areas - Auditory danger signals (ISO 7731)*

EN ISO 9886, *Ergonomics - Evaluation of thermal strain by physiological measurements (ISO 9886)*

EN ISO 9921, *Ergonomics - Assessment of speech communication (ISO 9921)*

EN ISO 11904-1, *Acoustics - Determination of sound immission from sound sources placed close to the ear - Part 1: Technique using a microphone in a real ear (MIRE technique) (ISO 11904-1)*

EN ISO 12894, *Ergonomics of the thermal environment - Medical supervision of individuals exposed to extreme hot or cold environments (ISO 12894)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

EN 17558:2023 (E)**3.1****benchmark condition**

condition at which a test person is wearing non-restrictive, minimal, light clothing such as shorts and a cotton t-shirt and light, flexible footwear such as trainers or plimsolls

Note 1 to entry: Benchmark testing for thermal impact in accordance with Annex G might require the use of an alternative benchmark condition.

3.2**benchmark testing**

testing for assessing the performance of an ensemble against the benchmark condition

3.3**comparative testing**

testing for assessing the performance of two or more ensembles against each other

3.4**electronic safety equipment****ESE**

products that contain electronics embedded in or associated with the product for use by wearers that provides enhanced safety functions for wearers during operations in a use environment

3.5**functional performance test**

procedure testing specified functionalities with wearers of PPE ensembles under specified conditions

3.6**PPE ensemble**

collection of items of personal protective equipment worn by an individual

3.7**practical performance test**

test procedure with wearers of PPE ensembles under simulated or real work tasks and if relevant then also under expected use conditions

3.8**use conditions**

conditions under which different items of PPE normally are used by the wearer

3.9**smart PPE**

PPE that uses ESE (electronic safety equipment) or material solutions that interact actively, by responding or adapting to environmental changes or react according to external signal input

4 Ergonomics testing

Ergonomics of PPE can be tested by use of either test persons, use of manikins and/or use of (computer) models. This document is dealing only with testing of the ergonomics of PPE with test persons.

NOTE The General Data Protection Regulation, Directive 95/46/EC and ethical aspects of human testing and the Helsinki Declaration are applicable to any tests with test persons.

Information about alternative testing, e.g. with a manikin and/or (virtual) models, is available in Annex K.

A representative sample of target users shall be selected for relevant ergonomics evaluation (see Annex A for details). A balanced repeated measurement design shall be used for both the benchmark and comparative testing of ensembles to ensure that the order of experimentation does not influence the test results (Annex A).

Depending on the required level of complexity the tasks may consist of individual postures. Ergonomic analysis of tasks under use conditions is recommended before selecting specific tests in order to guarantee that all major potential constraints are covered. Testing may be done in either controlled laboratory conditions or field settings resembling expected use conditions, e.g. environmental parameters, such as heat, cold, poor lighting, noise, etc.

It is strongly recommended that a person who has been trained in ergonomics, e.g. health and safety expert, ergonomist, work hygienist, should interpret the test results. It is often a person who has been certified for that qualification, but may also be a person who has a long (documented) experience in the field of ergonomics, e.g. publications, documented earlier evaluations, etc.

5 Test ensemble

5.1 General

All the items of a test ensemble shall be worn by the test person during testing in accordance with the instructions of the manufacturer. A complete description of a test ensemble shall be recorded in a test report conforming to Clause 10.

Although items of clothing being worn with the ensemble might not be classified as PPE, they may influence ensemble performance. For example, clothing worn beneath protective clothing may influence heat exchange and consequently thermal comfort or safety. Similarly, tight fitting or bulky garments may influence mobility. Any description of a test ensemble shall therefore include all clothing layers, footwear, hand wear and headwear (including helmets, hearing protection, communications systems and respiratory protection) including the non-PPE items.

All testing shall either be conducted:

- a) to compare two or more PPE ensembles (with comparable protective functions), i.e. comparative testing in accordance with 5.2; or
- b) in an absolute comparison against an unrestricted benchmark condition, i.e. benchmark testing in accordance with 5.3.

5.2 Comparative testing

Where some items of an ensemble are being replaced, and undergoing assessment by comparative testing, other components of the existing ensemble need not be new. The status (new or used) of all items forming the ensemble shall be documented in the test report conforming to Clause 10.

Where all the items of an ensemble are undergoing assessment by comparative testing, each ensemble shall be subjected to the relevant tests specified in Clause 8.

Where only a selection of items of an ensemble is being tested, each ensemble shall be subjected to testing specified in Clause 8, however, if it may be reasonably assumed that the items of PPE undergoing testing have no influence on a particular test parameter specified in Clause 8, then it is not necessary to conduct the test for that parameter. Table 1 shows which tests from Clause 8 shall be conducted for a particular item undergoing assessment.

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Table 1 — Parameters from Clause 8 recommended to be assessed for a particular item of PPE undergoing assessment

Item of PPE being assessed (part of body protected)	Parameters from Clause 8 recommended to be assessed								
	Shoulder/ arm mobility 8.2	Trunk flexion 8.2	Hip/knee flexion 8.2	Clarity within field of vision 8.3	Normal field of vision 8.3	Total range of vision 8.3	Manual dexterity 8.4	Hearing 8.5	Thermal impact 8.6
Head protection	x	x		x	x	x		x	x
Eye protection				x	x	x		x	x
Respiratory protection	x	x		x	x	x		x	x
Hearing protection	x					x ^b			x
Clothing	x	x	x	x	x	x	x	x	x
Gloves	x	x					x		x
Footwear			x						x
Fall protection	x	x	x						x
Auxiliary heating or cooling device	x	x	x				x	x	x
Smart PPE ^a	x	x	x	x	x	x	x	x	x

NOTE x indicates which parameters from Clause 8 should be assessed for a particular item undergoing assessment.

^a Smart PPE, for example ESE, may be very different and cover various body areas including intra- and intersystem communication means, thus, the assessment parameters depend on the specific application and need to be chosen individually (see CEN ISO/TR 23383 for reference).

^b Hearing protection may interact with other items (e.g. bulky collar of lifejacket, or a hood) to restrict head movement and therefore total range of vision.

5.3 Benchmark testing

Where all the items of an ensemble are undergoing assessment by benchmark testing, all the items of the ensemble shall be new and each ensemble shall be subjected to the relevant tests specified in Clause 8.

NOTE For possible pre-treatment options see Annex B.

Where only a selection of the items of an ensemble are undergoing assessment by benchmark testing, those items being tested and all of those items which potentially impact upon the items being tested shall be new. Table 2 shows which items shall be new for a particular item undergoing assessment by benchmark testing. Where used ensembles shall be tested, e.g. for sustainability purposes, the requirements on items being new in this subclause and Table 2 do not apply.

Where only a selection of items of an ensemble is being tested, each ensemble shall be subjected to testing specified in Clause 8, however, if it may be reasonably assumed that the items of PPE undergoing benchmark testing have no influence on a particular test parameter specified in Clause 8, then it is not necessary to conduct the test for that parameter. Table 1 shows which tests from Clause 8 shall be conducted for a particular item undergoing assessment by benchmark testing.

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Table 2 — Items of PPE required to be new for a particular item undergoing assessment

Item of PPE being assessed	Items of PPE required to be new during assessment									
	Head protection	Eye protection	Respiratory protection	Hearing protection	Clothing	Gloves	Footwear	Fall protection	Auxiliary heating or cooling	Smart PPE ^a
Head protection	x	x	x	x	x				x	x
Eye protection	x	x	x	x		x			x	x
Respiratory protection	x	x	x	x	x	x			x	x
Hearing protection	x	x	x	x						x
Clothing	x		x		x	x	x	x	x	x
Gloves		x	x		x	x			x	x
Footwear					x		x		x	x
Fall protection			x		x			x	x	x
Auxiliary heating or cooling device	x	x	x		x	x	x	x	x	x
Smart PPE ^a	x	x	x	x	x	x	x	x	x	x

NOTE x indicates which items of an ensemble shall be new.

^a Smart PPE may be very different and cover various body areas including intra- and intersystem communication means, thus, the assessment parameters depend on the specific application and need to be chosen individually (see CEN ISO/TR 23383 for reference).

6 Test persons

6.1 Selection of test persons

The sample of test persons to be used should be established by statistical evaluation taking into account inter and intra-test person variability and the estimated magnitude of the effect of the combination of items of PPE on the user. It is recommended that a power analysis is used for this as described in Annex A. As a practical guideline in any case a minimum of six test persons shall be used to assess an ensemble against one or more others.

The test persons shall represent the total group of expected wearers reflecting the diversity among this group. Each test person shall be experienced or appropriately trained in the use of the PPE items' combinations and shall have passed medical examination (guidance on this is available in EN ISO 12894). The items of PPE to be evaluated shall be of the appropriate size and correctly fitted for the wearer (see EN ISO 15537 for support).

If it is not possible to use a representative sample from the user population then the sample used shall match as closely as possible to the user population (see also A.5 and A.6). For the individual test persons the most important characteristics are:

- age;
- height;
- body mass;
- gender;
- (self) reported physical fitness;
- skill at the task being simulated.

6.2 Test person withdrawal

Where test persons voluntarily withdraw or are withdrawn from the test battery, results from any completed activities undertaken shall be included in any assessment of ensemble performance. Where that withdrawal is for reasons unrelated to the ensembles tested and remaining test persons are still sufficient to complete the analysis of test results and ensure the required level of statistical significance, then testing may continue. If not, a new test person shall be recruited as replacement. See also B.5.

If the withdrawal is related to the design of the ensemble it is an important indicator for terminating the testing and not approving the ensemble. Pass/fail criteria, including the permitted number of ensemble related drop outs, shall be specified clearly before starting the test (see Clause 8 for ergonomic test requirements). If a certain number of test persons drop out due to ensemble design factors, then testing shall be terminated and the ensemble failed. Reasons for withdrawal shall be reported (for reporting details see Clause 10).

7 Statistical testing

In order to compare ensembles with each other or to a reference ensemble it is essential to look at the differences in the results (means) in relation to their standard deviation. Differences between the test ensembles and the benchmark condition or between two or more test ensembles undergoing comparative testing, shall be compared using statistical tests in order to determine the likelihood of observed differences being due to chance (see more in Annex A).

The statistical test used shall be stated in the test report conforming to Clause 10.

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8 Functional performance tests and requirements

8.1 General

The preparations for the testing specified in 8.2 to 8.7 should conform to Annex B.

Every outcome shall be reported and taken into account in the evaluation.

The criteria to be adopted will be related to the ensemble, the user (population), and the use conditions. For this, ergonomic relevant critical limits are needed to substantiate 'appreciable' effects and shall be specified. The factors included in this document may need to be combined with other factors depending on the specific application.

8.2 Mobility

Test mobility in accordance with Annex C.

No visible loss of primary protective function during any of the test movements shall be permitted. If any separation of protective elements is observed for an ensemble then that ensemble shall be deemed to have failed.

8.3 Normal and total field of vision

Test field of vision in accordance with Annex D.

For any class of ensemble requiring a reduction in field of vision to achieve satisfactory protective performance, appropriate evaluative criteria shall be devised and published in the report.

For benchmark testing, unless specific criteria have been identified for any of the individual items of PPE forming the ensemble, the normal and total field of vision shall be not less than 85 % of that in either axis in the benchmark condition.

8.4 Manual dexterity

Test manual dexterity in accordance with Annex E.

For benchmark testing, the test ensemble shall not reduce performance in any of the tests by more than 20 % compared to the unencumbered benchmark.

8.5 Hearing ability

Measurement of hearing ability of a PPE ensemble is not required where the ensemble includes a hearing protector. Where hearing protection is claimed, the sound attenuation methods of EN 13819-2, and requirements of the product standards (EN 352 series) shall be applicable to the assessment of the ensemble protective performance. Selection and use of hearing protectors are covered by EN 458.

Test hearing ability in accordance with Annex F.

For benchmark testing, the equivalent continuous sound pressure level (L_{eq}) at any octave frequency band shall differ from the benchmark readings by less than 6 dB.

As described in Annex F, differences in insertion loss at low and high frequencies might reduce speech intelligibility, particularly if consonants are lost. For applications where speech communication is regarded as essential, the difference between the sum of low frequency insertion losses (A_{LOW}) and the sum of high frequency insertion losses (A_{HIGH}) shall be minimized and A_{HIGH} shall be as low as possible (Annex F). Where speech intelligibility and/or perception of warning signals are considered critical, the assessment methods for speech communication (EN ISO 9921) and/or signal recognition (EN ISO 7731) shall also be applied.