Designation: F3031 – 17 (Reapproved 2022)

Standard Practice for Range of Motion Evaluation of First Responder's Protective Ensembles[1]

This standard is issued under the fixed designation F3031; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Protective ensembles such as firefighter turnout gear, HAZMAT suits, etc., may impose a negative ergonomic impact on the wearer. This impact may involve restriction of movement and overall discomfort to the wearer. The possible increased restrictions of mobility during the use of protective ensembles may result in injuries to the musculoskeletal system, decreased performance, and decreased comfort. It is up to the end user to decide the meaningfulness of the information provided with the use of this standard for the performance of his/her job. This ergonomic standard practice is to determine and report the range of motion (ROM) of the protective ensemble or base ensemble, or both, and has been designed to allow for comparisons of the ROM between ensembles of the same class (firefighter turnout gear) and from different classes (firefighter ensemble versus HAZMAT suit).

1. Scope

1.1 This practice specifies the test equipment and procedures for assessing ROM on subjects wearing a protective clothing ensemble.

1.2 This practice covers the ergonomic measurements of range of motion and subjective perceptions.

1.3 To increase safety during testing, this practice requires the use of human participants who meet specific health and physical fitness requirements.

1.4 This practice does not attempt to determine other clothing characteristics, such as thermal insulation and evaporative resistance of the protective clothing ensemble. Test Methods F1291 and F2370 can be used for these measurements.

1.5 The values stated in this standard shall be SI units.

1.6 It is the responsibility of the test laboratory to obtain the necessary and appropriate approval(s) required by their institution for conducting tests using human participants.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1291 Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin

F1494 Terminology Relating to Protective Clothing

F2370 Test Method for Measuring the Evaporative Resistance of Clothing Using a Sweating Manikin

2.2 *BSI Standards:*[3]

BS EN 469 Protective Clothing for Firefighters – Performance Requirements for Protective Clothing for Firefighting

BS 8469 Personal Protective Equipment for Firefighters – Assessment of Ergonomic Performance and Compatibility – Requirements and Test Methods

[1] This practice is under the jurisdiction of ASTM Committee F23 on Personal Protective Clothing and Equipment and is the direct responsibility of Subcommittee F23.60 on Human Factors.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

2.3 *ISO Standard:*[4]

ISO 10551 Ergonomics of the Thermal Environment – Assessment of the Influence of the Thermal Environment Using Subjective Judgement Scales

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology F1494 for definitions of terms used in this practice.

3.1.2 *clothing ensemble, n*—for first responders, a protective ensemble.

4. Significance and Use

4.1 This practice can be used for the evaluation of the ROM of protective clothing ensembles worn under controlled conditions and can provide guidelines for the motion evaluation of PPE.

4.1.1 This practice utilizes a space large enough to allow users to move freely during the tasks and a chair and a stretcher to measure certain body joint mobility.

NOTE 1—Since required range of motion values will be related to the work task to be done while wearing the protective ensemble, the end user should decide meaningfulness of the information provided by this standard for the performance of their job.

4.2 This practice establishes general procedures for the evaluation based on the measurement of range of motion and subjective perceptions.

4.2.1 The data obtained can be used to evaluate the ROM of the test participant while wearing a protective clothing ensemble.

4.2.2 The data are also potentially useful in the research and development of advanced ensembles that are designed for optimal mobility and comfort or reduce strain on the wearer thereby reducing the potential injury associated with wearing the protective clothing ensemble.

4.2.3 The data are also potentially useful for first responder organizations to compare the ROM while wearing different ensembles.

4.2.4 This practice could also be used by consensus standards organizations in the development of ergonomic test criteria for protective ensembles.

4.3 Departures from the instructions in this practice have the potential to lead to significantly different test results. Technical knowledge concerning mobility of body joints, subjective evaluations, and testing practices is needed to evaluate which departures from the instructions given in this practice are significant. All departures must be reported with the results.

5. Apparatus

5.1 *Laboratory Space with Environmental Measures*—A room that is large enough to accommodate the tasks that the test participant will perform. Also, the room conditions shall be stable and recorded during testing. Use standard lab equipment to measure the ambient environmental conditions under which the testing occurs.

5.1.1 *Relative Humidity Measurement*—Use a humidity-sensing device and have an accuracy of ±5 % relative humidity and a repeatability of ±3 % to be acceptable (for example, wet bulb/dry bulb, dew point hygrometer).

5.1.2 *Air Temperature Sensors*—Use shielded air temperature sensors. The sensor shall have an overall accuracy of ±0.15 °C (for example, resistance temperature detectors (RTDs), thermocouple, sensor). The sensor shall have a time constant not exceeding 1 min.

5.2 *Measuring Mobility*—Standard instruments include a flexible tape measure, circumference tape, washable marker, and platform scale to perform anthropometric measurements. Use specific ergonomic assessment equipment during ergonomic assessments: large- and small-joint goniometer or electro-goniometer, flex tester sit-and-reach flexibility test box, and skinfold caliper.

5.3 *Measuring Subjective Perceptions*—Assess subjective perceptions, as it relates to ROM. Refer to ISO 10551 for the instructions on creating and using judgement scales.

5.4 *Participant Clothing Ensembles*—Choose and wear base ensemble clothing (of identical design and construction) that is appropriate for all of the different ensembles that are being evaluated. If the base ensemble is not specified, then a T-shirt, athletic shorts, socks, and underwear shall be used as the default base ensemble and shall be constructed of 100 % cotton where possible. Sock selection shall be based on the type of footwear used (for example, boot socks with boots). The participant must wear identical base ensemble clothing and shoes for all the tests for which they are involved, even if the test sessions occur on different days. The base ensemble worn must be recorded each session.

5.4.1 If intended to be reused or laundered, launder ensemble in accordance with the manufacturer's instructions. Set the number of laundering cycles to be consistent with the objectives of the testing.

5.4.2 *Athletic Shoes*—Wear athletic shoes with a soft rubber sole during testing, unless the protective ensemble includes footwear as part of the ensemble or if its instructions for use list a required type of footwear.

5.4.3 As needed between wear test sessions, protective clothing ensembles shall be cleaned in accordance with the manufacturer's instructions. The number of cleanings/launderings shall be recorded and reported.

6. Sampling, Participants, and Familiarization Period

6.1 *Sampling*—Test a minimum of eight different participants to evaluate the performance of each protective clothing ensemble.

6.2 *Test Participants*—Individuals who participate in this test shall do so strictly on a volunteer basis. Test laboratories shall adhere to all internal regulations regarding human testing and obtain the required human testing approval from their respective institutions. Participants shall be informed of all the details of this standard practice and the associated risks and benefits prior to providing their informed written consent. Complete anonymity and confidentiality shall be given to each participant.

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.