Technical disciplinary for electronically activated airbag protectors for workers at height– Revision number 0 of the July 07 2020

Introduction

Inflatable protectors for workers are devices either embedded within or worn on top of other clothing, which aim is to reduce the severity of injuries in the case of a fall to the ground when the user is not connected to any anchor points and in the case of collisions against other objects or elements when the user is connected to a secure anchor point via a full body harness (pendulum effect).

The protectors covered by this Technical Disciplinary gives protection only when inflated.

The performance requirements have been selected to provide the best practical compromise between protection, comfort, and ergonomic requirements. Protectors that are too stiff or heavy will not be worn. The test methods are designed to provide information on protection against mechanical impacts. The force levels in the tests do not relate directly to the forces users are exposed to during falls, but experiences have shown that products which meets the requirements of this Technical Disciplinary may reduce the severity of injuries caused by impacts/collisions.

1 Scope

This Technical Disciplinary covers requirements and test methods for electrically activated inflatable protectors for workers at height (in the following text called “protector”). It specifies the minimum level of protection, the intervention time/protection time of inflated bag, and the minimum coverage to be provided by workers’ protectors. The requirements of this standard are applicable to various design of inflatable protectors and refer to all body areas and their combinations which are claimed to be protected. Inflatable protectors covered by this standard may be incorporated in technical garments or combined with full body harnesses, or equipped with appropriate restraint systems and worn on their own.

This Technical Disciplinary contains the requirements for the performance of the system during a fall and details of the test methods, requirements for sizing, ergonomics, innocuousness, airbag, gas generator, algorithm, software, labelling and the provision of information.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited has been applied. For undated references, the latest edition of the referenced document (including any amendments) has been applied.

EN 13688:2013, Protective clothing — General requirements;

EN 1621-1:2012, Motorcyclists' protective clothing against mechanical impact — Part 1: Requirements and test methods for impact protectors;

EN 1621-2:2014, Motorcyclists' protective clothing against mechanical impact — Part 2: Motorcyclists' back protectors; Requirements and test methods;

EN 1621-3:2018, Motorcyclists' protective clothing against mechanical impact — Part 3: Motorcyclists' chest protectors – Requirements and test methods;

EN 1621-4:2013, Motorcyclists' protective clothing against mechanical impact — Part 4: Motorcyclists’ inflatable protectors - Requirements and test methods;

EN ISO 105-E01, Textiles — Tests for colour fastness — Part E01: Colour fastness to water (ISO 105-E01:2010);

EN ISO 11642, Leather — Tests for colour fastness — Colour fastness to water (ISO 11642);

IEC 61508, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems;

ISO 26262, Road vehicles – Functional safety.

EN 361-2002, Personal protective equipment against falls from a height — Full body harnesses

EN 363-2018, Personal fall protection equipment — Personal fall protection system

EN 364-1992, Personal protective equipment against falls from a height — Test methods

EN 388:2016+A1:2018, Protective gloves against mechanical risk

EN 13594: 2015, Protective gloves for motorcycle riders- Requirements and test methods

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the relevant part of EN 1621 (part 1, 2, 3) and the following apply.

3.1 **inflatable worker protector:** specific device worn by people who have to do manual labour at height and which inflates automatically in case of a fall;

3.2 **beginning of a fall:** instant of time when the balance/control of the body is irreversibly lost by the worker in the case of a fall. Instant t_0 represented in Figure 1;

3.3 **activation instant:** time instant in which the triggering system fires the gas generator. Instant t_1 represented in Figure 1;

3.4 **inflation instant:** time instant in which the inflation pressure inside the airbag raises consistently above the minimum operating pressure. It represents the instant after which the degree of protection of the device is guaranteed. Instant t_2 represented in Figure 1;

3.5 **impact instant:** time instant in which the subject impacts the ground or an obstacle. Instant t_3 represented in Figure 1;

3.6 **deflation instant:** time instant in which the inflation pressure inside the airbag decrease consistently under the minimum operating pressure. It represents the instant after which the degree of protection of the device is longer guaranteed. Instant t_4 represented in Figure 1;

3.7 **flight time:** time interval spent in flight by the subject and between t_0 and t_3 [in milliseconds]. T_1 interval represented in Figure 1;

3.8 **activation time:** time interval used by the triggering system to fire the gas generator, corresponding to the interval of time from the beginning of a fall t_0 to the firing of the triggering system t_1 [in milliseconds]. T_2 interval represented in Figure 1;

3.9 **inflation time:** time interval between the firing of the triggering system t_1 and the instant after which the inflation pressure raises consistently above the minimum operating pressure t_2 [in milliseconds]. T_3 interval represented in Figure 1;

3.10 **intervention time:** sum of the activation time T_2 plus the inflation time T_3 [in milliseconds]. T_4 interval represented in Figure 1;

3.11 **protection time:** time interval between the inflation instant t_2 and the impact instant t_3 [in milliseconds]. Interval T_5 represented in Figure 1;

3.12 **duration time:** time interval measured from the instant of activation of the trigger system t_1 and the instant beyond which the pressure contained inside the airbag decreases steadily under the minimum operating pressure t_4 [in seconds]. Interval T_6 represented in Figure 1;

3.13 **minimum operating pressure:** airbag pressure declared by the manufacturer above which the system is protective. Pressure p_0 represented in Figure 2;

3.14 **maximum inflation pressure:** maximum pressure value recorded in the airbag after the inflation instant and in the duration time. Pressure p1 represented in Figure 2;

3.15 **electrical triggering system:** system which is fired by a control unit and an algorithm based on electrical signals coming from sensors;

3.16 **fall:** event in which the worker loses balance/control of his body causing the worker's free flight;

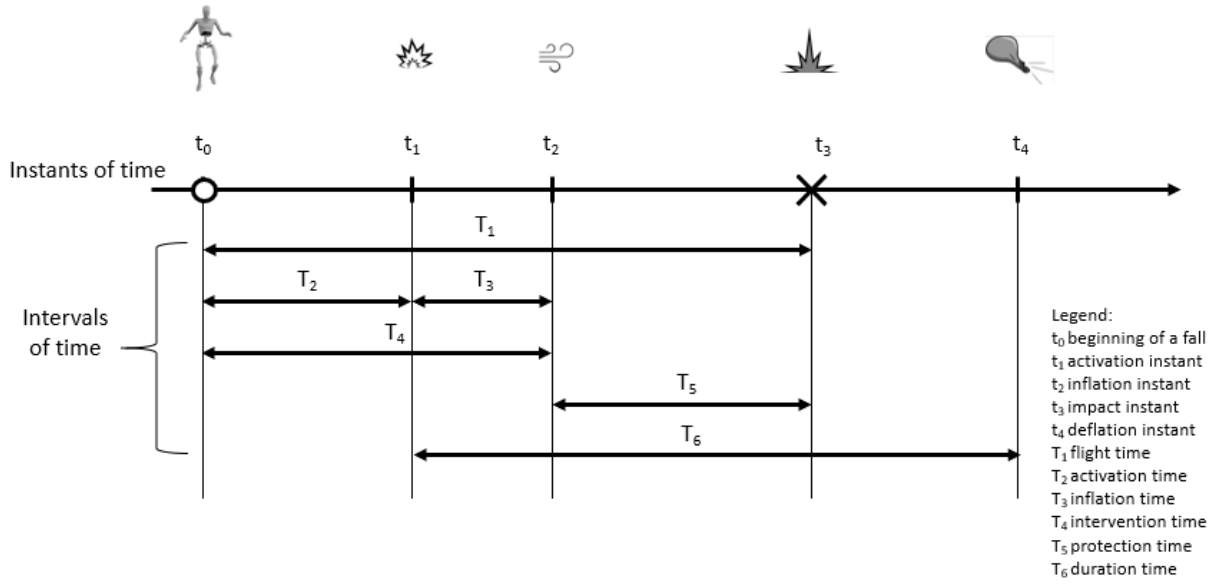


Figure 1 Representation of the notable instants and intervals

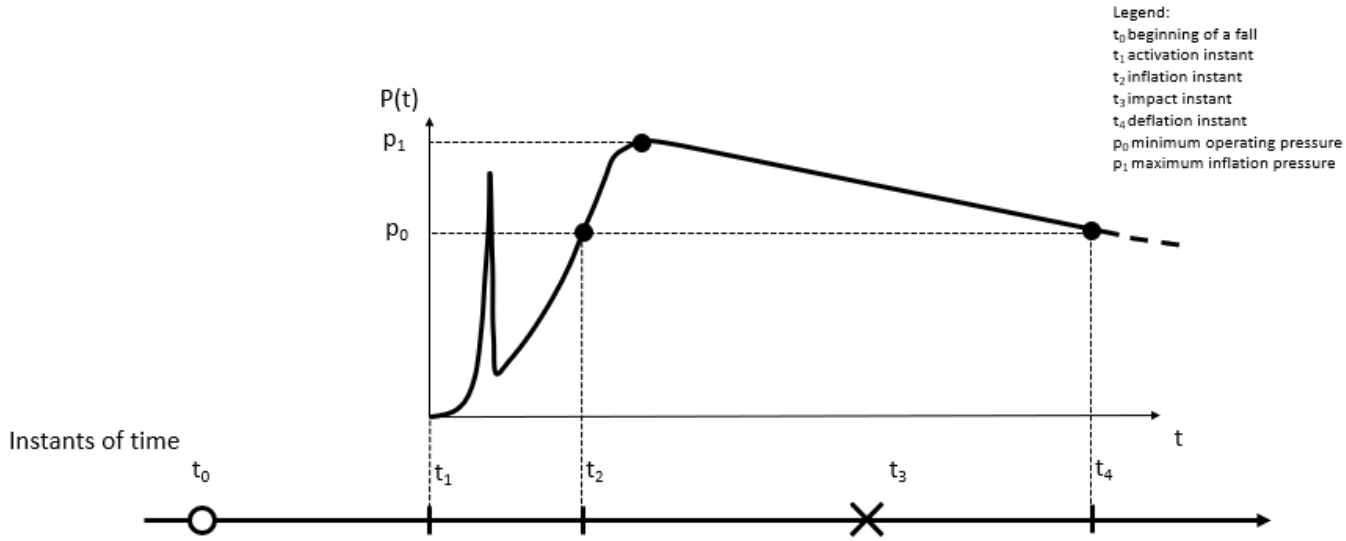


Figure 2 Representation of the notable pressure

3.17 **fall arrest:** prevention of the user of a personal fall protection system from colliding with the ground, structure, or any other obstacle during free fall;

3.18 **fall prevention:** prevention of the user of a personal fall protection system from going into a free fall;

3.19 **full body harness:** A body holding device which can be connected to a reliable anchorage point and which is intended to protect the user against falls from a height;

3.20 **fall arrest system:** personal fall protection system which limits the impact force on the body of the user during fall arrest;

Note 1: *it does not prevent a free fall*

Note 2: *it limits the impact force of a fall to a maximum of 6kN;*

3.21 **structural seam:** permanent joint between pieces of material held together by sewing or other method and capable of supporting specified loads;

3.22 **structural closure:** construction with a fastener system that closes and opens or joints two parts of the garment and capable of supporting specified loads;

3.23 **minimum intervention height "H":** minimum distance from the ground from which the manufacturer declares the airbag is able to protect from falls with ground impact. It has to be measured from the user's support surface

4 Requirements

4.1 General

Inflatable protectors for workers at height shall meet an overall requirement that they are safe to use, comfortable to wear and fit for their purpose.

Inflatable impact protectors shall have a triggering system which is electrical commanded: mechanically activated protectors are not contemplated.

4.2 Innocuousness

4.2.1 Colour

The materials of the protectors shall comply with the requirements of innocuousness of materials in EN 13688.

The colour fastness to water of the constituent materials which likely could come into contact with the skin of the user shall be determined in accordance with 7.2.1 and shall be at least grade 4 of the Grey scale for the staining of any component of the multi-fibre reference fabric.

4.2.2 Hard inclusions

No sharp edge shall be present in the protector.

A layer of impact attenuation material shall be present between any hard components present in the inflation or actuation systems and the body of the user. This requirement is applicable to mechanical parts of the inflation system; it is not applicable to zips, studs, fasteners and other elements not linked to the specific function of the inflating system. The protection shall be the same size of the component or its projected area plus a minimum border of 1 cm.

The transmitted force level shall not be more than 35kN. The impact attenuation protecting the user from hard components shall be tested in accordance with 7.2.2.

4.2.3 Temperature exposure evaluation (applicable only for hot gas generators)

Some gas generators, which contain pyrotechnic components, can generate hot gases when fired. These products shall be subjected to an evaluation heat exposure in accordance with 7.2.3.

The average temperature recorded over the duration of the test shall not exceed 48 °C. No single value shall exceed 55 °C.

NOTE Gas generators containing pyrotechnic composition are considered by Directive 2007/23/CE.

4.2.4 Thorax compression evaluation

When the airbag has to be used in combination with a full body harness, the pressure exerted by the inflated airbag on the chest during a fall shall not be dangerous in both fall arrests and in body suspended situations. For this reason, the inflatable protector must be tested in combination with different types of full body harness chosen by the manufacturer from those compliant with EN 361 and represented in Table 9 of Annex C with which its compatibility is declared. The chest compression criterion must not exceed 50mm (according to ECE-R 94) in accordance with 7.2.4.

4.3 Zones of protection

The body areas claimed to be protected shall be covered by the protector when inflated.

The protector can cover a protection zone described in the EN 1621 series of standards. In case the protector covers additional or larger parts of the body, the manufacturer must provide a suitable shape in order to correctly define the area of the body to be protected.

4.4 Intervention Time and protection time

The intervention time and the protection time for falls must be evaluated after performing a significant number of falls with impact on the ground / collision with an obstacle (for example 10 cases). The intervention time T_4 is evaluated only for falls without rotation, or when it is possible to determine with certainty the instant of start of the fall. For falls with rotation / collision against an obstacle, in which the instant of the start of the fall would be difficult to identify, the reactivity of the airbag system is evaluated by the protection time T_5.

4.4.1 Intervention time for falls without rotation

The intervention time shall satisfy the condition described by the following formula:

$$T_4 \leq \sqrt{\frac{2H}{g}}$$

where g is the universal gravitation constant and H represents the minimum intervention height declared by the manufacturer.

The inflation time is defined according to paragraph 3.9 and measured according to paragraph 7.3.4. The intervention time must be tested in accordance with paragraph 7.3.1.

4.4.2 Protection time

The protection time for falls with rotation T_5 must be greater than 0ms (the instant of impact t_3 shall always be after the instant of inflation t_2) and shall be tested in accordance with paragraph 7.3.2.

The protection time for collision with an obstacle T_5 must be greater than 0ms (the instant of impact t_3 must always be after the instant of inflation t_2) and must be tested in accordance with paragraph 7.3.3.

4.5 Duration time

The duration time shall not be less than 5 s when tested in accordance with 7.4.

4.6 Impact Attenuation

Inflatable protectors for workers at height shall be tested in the inflated status.

When a device is subjected to impact attenuation test in accordance to clause 7.6, with samples conditioned in accordance to clauses 7.1.1 (ambient conditioning) and 7.1.2 (wet conditioning), 7.1.3 (high temperature), and 7.1.4 (low temperature), the transmitted force shall comply with performance requirements listed in Table 1.

After each test, there shall be no fragmentation of the sample and no sharp edges shall be formed. However, formation of cracks and loss of soft debris is permissible.

Loss of pressure from the airbag due to bag puncture shall not be permitted.

Description	Requirement	Impact energy
Overall mean value (for type of conditioning and for zones of protection)	≤ 4,5 kN	(30± 1,5) Joule
Single strike	≤ 6 kN	

Table 1: Performance level and transmitted force for impact attenuation

The zone of protection shall be tested in accordance with the correspondent method described in the different parts of EN 1621. Additional zones of protection shall be tested with the method described in EN 1621-1 and/or EN 1621-2 and/or EN 1621-3. Zones of protection which are not covered by EN 1621-1 and/or EN 1621-2 and/or EN 1621-3 shall be agreed by the manufacturer and the Test laboratory.

4.7 Impact Distribution (Optional and only for chest protectors)

When a device is subjected to impact distribution test in accordance to clause 7.7, with samples conditioned in accordance to clause 7.1.1 (ambient conditioning), to clause 7.1.3 (high temperature), and to clause 7.1.4 (low temperature), the force transmitted must meet the requirement of Table 1. After each test, there must be no fragmentation of the sample and no sharp edges must be formed. However, the formation of cracks and soft debris is allowed.

4.8 Ergonomic requirements

The inflatable protector can be equipped with suitable and adjustable retention devices. The functions shall be assessed by ergonomic testing in accordance with 7.7. The protector is then put on by an assessor of suitable size, using, if applicable, the restrain elements supplied with the protector. If the inflatable protector is fitted in a garment, the retention devices can be incorporated into it. Otherwise, suitable fastening means, such as a suitable host garment provided by the manufacturer of the protector are to be used. In this case if the garment can be opened (zip, buttons, press stud, etc.), the user information shall contain a warning that the safety functions will work only with the garment being closed.

4.8.1 General requirements when worn by an assessor (Retention of the inflatable protector)

When examined and tested according to 7.7.1, protectors shall be found satisfactory for the intended use, as indicated in the information supplied by the manufacturer. All answers to the questions in 7.7.1 shall be “yes”.

4.8.2 Maximum acceleration of the head caused by airbag inflation

The resulting acceleration of the head (a3ms) caused by the inflation of the airbag shall not exceed 80g for more than 3ms (according to ECE-R 94) for both dummy and human tests. Test in accordance with 7.7.2.

4.8.3 Evaluation of the acoustic level

Pursuant to Legislative Decree 81/2008 and subsequent amendments (Legislative Decree 106/2009), art. 188, the accepted sound level limit shall be less than 140 dB (C). If this condition is not met, the manufacturer must clearly indicate in the manufacturer's instructions and information that a potential risk may arise in this sense for the user. Test in accordance with 7.7.3.

4.8.4 Controllability test

The inflatable protector shall not affect the movements of the worker during his usual activities. In case that an unexpected activation could strongly influence the movements of the worker, the subject could dangerously lose balance. Test in accordance with 7.7.4.

4.9 Triggering system and Functional Safety

A product whose functional safety has not been considered has a high probability of systematic failure. The functional safety of a complex electronic system is a key factor in determining its quality and resistance. The general functional safety of the device must take into account what is reported in the IEC 61508 standard or in the ISO 26262 standard.

The electrically activated inflatable protectors must meet the requirements for which they were created (enabling strategy) and must distinguish the possible voluntary movements from the impact / collision scenarios; the software and hardware must prevent possible failures during use.

Test in accordance with 7.8.

4.10 Gas generator

The gas generator shall be safe for transportation and operation. The manufacturer shall give appropriate documentation showing that the gas generator components can be transported by car, boat, train and plane, etc ... (e.g., certification of the components in according to the pyrotechnics articles directive, etc...).

5 Mechanical requirements

5.1 Mechanical requirements (Only if worn on top of other clothing)

If the device has to be worn over other clothing and is in direct contact with the outside, it must be able to withstand any situations of wear and damage that may occur during any normal work activity. If the device includes structural seams or closures, these must be checked by means of specific mechanical tests (paragraph 7.9.2). The requirement for mechanical testing is shown in Table 2.

Test	Requirement (N/mm)
Seam strength and structural closures	≥ 6

Table 2: Requirements of mechanical tests

6 Sampling

Test samples must consist of products complete with labels or copies of proposed labels and information supplied by the manufacturer. If considered appropriate, the garment in which it has to be contained shall also be provided. Alternatively, modified devices may be tested (for example, to allow the inflatable chamber to be refilled) provided the modifications do not preclude test results. The number of test samples provided for the test depends on the type of device to be evaluated: number of sizes produced, type of protection (temperature and protection zone), whether the protector can or cannot be recharged, etc ... Test Laboratory will require the number of samples to be tested according to the type of device.

7 Test methods

7.1 Conditioning and testing atmosphere

Each specimen can only be subject to a single type of conditioning.

7.1.1. Ambient conditioning:

Except for the controllability test (clause 7.7.4) and for test to evaluate the function of the activation mechanism (clause 7.8), all samples shall be conditioned for at least 48 hours into an atmosphere with a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %. If the tests are carried out into an atmosphere with different characteristics to these specified above, the tests have to be carried out within 5 min after being removed from the conditioning atmosphere. If necessary, recondition the sample immediately for further (45-60) min.

7.1.2. Wet conditioning:

- Store the sample for (72 ± 0,5) h directly above water in a sealed container that is then placed within a heated chamber at a constant temperature of (70 ± 2) °C.
- Remove and place the sample in a sealed water vapour proof bag that is at least 10% longer than the sample, hang sample at the top of the bag in ambient temperature of (23 ± 2) °C for a further (24 ± 0,5) h, ensuring the sample does not sit at the bottom of the bag in water.
- Remove the drained sample from the bag and start the wet impact tests within 5 min on the previously prepared impact test machine.

7.1.3. High temperature conditioning:

- The samples shall be conditioned for at (24 ± 0,5) h at the maximum temperature declared by the manufacturer in the information supplied. This temperature shall not be lower than (40 ± 2) ° C.
- Carry out the impact testing within 2 min after removing the sample from the conditioning environment. No hit shall be performed after that period.
- If necessary, recondition the sample immediately for further (45-60) min.

7.1.4. Low temperature conditioning:

- The samples shall be conditioned for at (24 ± 0,5) h at the minimum temperature declared by the manufacturer in the information supplied by the manufacturer. This temperature shall not be higher than (-10 ± 2) ° C.
- Carry out the impact testing within 2 min after removing the sample from the freezing chamber, no hit shall be performed after that period.
- If necessary, within two more minutes start to recondition the sample for a further period of 45 min to 60 min.

7.2 Innocuousness

7.2.1 Colour fastness

7.2.1.1 For colour fastness to water, materials of protective clothing shall be tested according to EN ISO 105-E01 for textiles and according to EN ISO 11642:2011 for leather.

7.2.2 Protection from hard inclusions

Each size produced shall be tested. The EN 1621-1 impact test apparatus and test method shall be used with the exception of the energy transmitted on impact which must be (30 ± 1.5) J.

The test shall be done on critical points of the device in not inflated status, including also the absorbing material.

This means that the assembly of hard components and shock absorbing material shall be positioned on the anvil in not inflated status in order to best simulate a mechanical impact occurring when the protector is worn by the user.

The use of cow leather (2,8 ± 0,2) mm - Clause 7.6.1 of this standard - is not applicable.

7.2.3 Temperature exposure evaluation (applicable only for hot gas generators)

The product should be examined to identify whether the surfaces above or adjacent to the generator which come into contact with the skin transmit an excessive amount of heat.

The temperature is taken with a quick response thermometer (e.g., non-contact IR thermometer or digital thermometer with low mass flat probe).

The protector is conditioned to the ambient temperature defined in 7.1.1. One sample per size must be examined.

The thermometer probe should be fixed on potential skin contact surfaces identified by visual examination. If the test is needed at more than one point, this can be done by applying multiple probes or repeated tests. If probes are used, they can be fixed using suitable supports (e.g., adhesive tape, elastic tape, etc.).

The protector is activated and the temperature is detected from 0 to 15 seconds after the start of inflation and is recorded continuously or at least every 3 seconds. Exposure to temperature is evaluated considering only the calculated average value.

7.2.4 Thorax compression evaluation (only if worn under a full body harness)

The product shall be tested in combination with each type of full body harness declared by the manufacturer between those complying with EN 361 and represented in Table 9 of annex C with which it is declared compatible.

The assessment is done through a static test which involves the use of a dummy equipped with a suitable sensor.

7.2.4.1 Static test: The dummy needs to be dressed up in a proper manner with the protector and the full body harness. The harness regulation shall not differ from the one indicated in the manufacturer's instructions for use. The dummy shall be suspended in the air by using a rope connected to a lifting structure and passing through the dorsal attachment point of the fall protection system indicated in standard EN 361. A load cell shall be prepared between the dummy and the lifting structure in order to measure the rope tension. The force value recorded shall not be less than 780N. After starting the recording, the dummy shall be lifted up and the airbag has to be activated. The dummy shall remain suspended for at least 1 minute and the thorax displacement values shall remain under 50mm during all the test. The thorax compression shall be evaluated keeping the dummy suspended in a vertical position and the devices shall be combined with all types of harness with which the manufacturer declares its compatibility. As a result, a test shall be performed with the dummy suspended in a horizontal position by using the harness that seems to be the most critical. For the vertical configuration, the test shall be performed at least on one sample for each harness to which the device is to be combined, while the horizontal test requires at least one sample to be tested with the harness that causes the highest value of thorax compression recorded during the vertical test. The protector size selected for the test shall be the one that best fits the dummy, considering the wearer size contained in the information provided by the manufacturer.

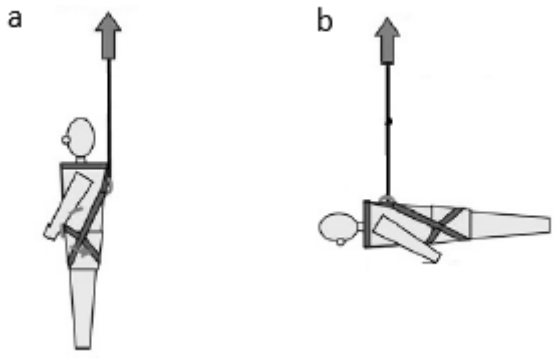


Figure 3 Static test of thorax compression configurations: (a) Vertical position; (b) Horizontal position

7.3 Intervention time and protection time

7.3.1 Intervention time of falls without rotation

The intervention time T_4 shall be determined as the sum of the activation time and the inflation time, expressed in milliseconds.

$$T_4 = T_2 + T_3$$

The height from which the dummy shall be dropped shall be equivalent to the minimum intervention height H declared by the manufacturer.

Determine the activation time T_2 by using appropriate instruments: an accelerometer to define the impact to the ground (alternatively or in addition to a high-speed camera), means connected to the airbag control unit in order to precisely define the moment of activation and the means to synchronize the signals. Pay particular attention to identify the instant of start of the fall, the instant of activation and the instant of the impact to the ground. The start of fall without rotation is considered from the point where the dummy begins to fly straight down as shown in Figure 4. To evaluate the activation time, at least 2 samples of the protector size that best suits the test dummy are required considering the measurement of the wearer contained in the information provided by the manufacturer.

Determine the inflation time T_3 as defined in point 7.3.4.

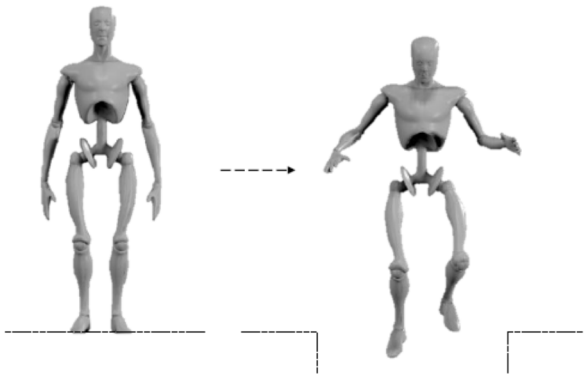


Figure 4 Falls without rotation

7.3.2 Protection time for falls with rotation

The protection time T_5 for falls with rotation shall be determined by subtracting the instant of activation t_1 and the inflation time T_3 at the instant of impact t_3, according to the following relationship:

$$T_5 = (t_3 - t_1) - T_3$$

The height form which the dummy shall be dropped shall be equivalent to the minimum intervention height H declared by the manufacturer.

Determine the period (t_3 - t_1) by using appropriate instruments: an accelerometer to define the impact to the ground (alternatively or in addition to a high-speed camera), means connected to the airbag control unit in order to precisely defining the instant of activation and means for synchronizing the signals. Pay particular attention to identify the instant of activation and the instant of impact on the ground. Figure 5 collects examples of falling with rotation. To perform each of the planned fall configurations, at least 1 sample of the protector size that best fits the test dummy is required considering the wearer measurements contained in the information provided by the manufacturer.

Determine the inflation time T_3 as defined in point 7.3.4.

Figure 5 Falls with rotation

7.3.3 Protection time for falls with collision against obstacles

The protection time T_5 for falls with collision against an obstacle shall be determined by subtracting the activation instant t_1 and the inflation time T_3 at the moment of impact t_3, according to the following relationship:

$$T_5 = (t_3 - t_1) - T_3 \qquad [1]$$

Determine the period (t_3 - t_1) by using each of the planned fall configurations: an accelerometer to define the impact (alternatively or in addition to a high-speed camera), means connected to the airbag control unit in order to precisely defining the instant of activation and means for synchronizing the signals. Pay particular attention to identify the

instant of activation and the instant of impact. Figure 6 represent an example of a fall with a collision against an obstacle.

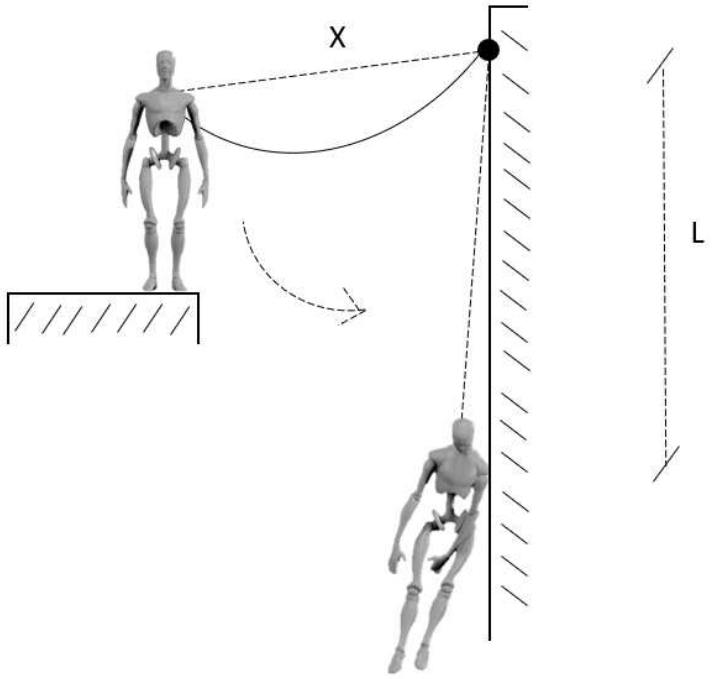


Figure 6 Falls with collision against obstacle

The distance L represent the length of the anchoring system (including any carabiners) and shall not be more than 2m for fall arrest systems. Distance X represents the distance from the harness attachment point to the anchor point; in any case the distance X shall be less or equal to L.
Three main scenarios can be identified:

1) Collision after a purely vertical fall (X=0);
2) Collision caused by free fall followed by a pendulum effect (X<L);
3) Collision caused only by a pendulum effect (X=L).

Case 1) is purely related to the case referred to in paragraph 7.3.1
In case 3) the evaluation procedure of the activation instant t_1 and the impact instant t_3 shall be applied by using the formula [1], then determine the period (t_3-t_1) of pure oscillation.
A pure oscillation test shall be performed at least under the most severe conditions amongst those provided by the manufacturer (the device shall be tested in its worst conditions related to its activation system, for example by performing impact tests both at the lowest and at the highest impact speed declared by the manufacturer).
Case 2) can be divided in two further scenarios depending on the distance travelled during the flight before the anchoring system is strained, as “h”, and on the minimum intervention height, as “H”:

- if h>H, the event is related to a fall without rotation (case specified in paragraph 7.3.1) so the system should activate during the flight phase before the anchoring system is strained;
- if h<H, the situation is similar to what has to be done for case 3, by performing impact tests at the worst conditions possible of activation / operation of the system.

In order to perform these evaluations at least 1 sample of the protector size that best fits the test dummy is required considering the wearer measurements contained in the information provided by the manufacturer. Each evaluation shall be done for all the expected fall configurations.
Determine the inflation time T_3 as defined in point 7.3.4.

7.3.4 Inflation time

Determine the inflation time with an appropriate instrument. At least one sample of each size produced shall be tested after ambient conditioning (see 7.1.1). At least one sample randomly selected between the size range declared for the device shall be tested after wet conditioning (see 7.1.2). At least one sample randomly selected between the size

range declared for the device shall be tested after hot conditioning (see 7.1.3) and finally, at least one sample randomly selected between the size range declared for the device shall be tested after cold conditioning (see 7.1.4). The T_3 inflation time value to be used for the evaluation of the intervention time (point 7.3.1) and of the protection time (clauses 7.3.2 and 7.3.3) is the highest obtained after performing the test on the samples above-mentioned.
NOTE: The inflation time can be determined by using a digital sensor suitable for detecting the inflation pressure. The inflation time is the time interval between the activation of the ignition system and the instant after which the inflation pressure constantly increases above the minimum operating pressure.

7.4 Determination of the duration time

7.4.1 Ambient conditioning: inflate three devices per size by activating the system. By using a suitable instrument (for example a digital pressure sensor), record the duration time as the interval of time detected before the instant in which the pressure contained inside the airbag decreases below the minimum operating pressure declared by the manufacturer (the time shall not be less than 5s, see section 4.5). For each sample size, the duration time is obtained as the average of all the time intervals measured.
NOTE: the digital pressure sensor must have a sufficiently high sample frequency to detect the transient of the pressure-time curve inside the bag.
7.4.2 Wet conditioning: inflate at least one sample chosen randomly from the declared sizes and repeat the test method proposed in paragraph 7.4.1. Determinate the duration time after wet conditioning as the time beyond which the recorded pressure falls under the minimum operating pressure specified by manufacturer. The duration time is obtained by averaging all the times measured.
7.4.3 Hot temperature conditioning: Inflate at least one sample chosen randomly form the declared sizes and repeat the test method proposed in paragraph 7.4.1. Determine the high temperature duration time as the time beyond which the recorded pressure falls under the minimum operating pressure specified by the manufacturer. The duration time is obtained by averaging all the times measured.
7.4.4 Cold temperature conditioning: Inflate at least one sample chosen randomly from the declared sizes and repeat the test method proposed in paragraph 7.4.1. Determine the low temperature duration time as the time beyond which the recorded pressure falls under the minimum operating pressure specified by the manufacturer. The duration time is obtained by averaging all the times measured.

7.5 Impact attenuation

7.5.1 Test method

For each protection zone, tests shall be carried out by using the test procedure in accordance with the relevant part of EN 1621 after setting the impact kinetic energy to (30± 1,5) J. Body areas covered by the airbag shall be tested by using a dropping equipment which has to be in line with the following requirements:

- Anvil: For standard protection areas in accordance with EN 1621, the anvil shall be the same used in the dropping tests described in the relative parts of EN 1621. Instead, body areas covered by the airbag and not included in EN 1621 shall be tested by using an anvil agreed by the manufacturer and by the Testing laboratory.
- Impactors: the impactors have to be made of polished steel and shall be of different shapes. For standard protection areas according to EN 1621, the impactor shall be the same used in the drop tests described in the relevant parts contained in EN 1621. Instead, the areas of the body covered by the airbag and not included in the EN 1621 standard shall be tested using an impactor agreed by the manufacturer and the Testing Laboratory;

To protect the anvil in case of breakage of the inflated protector, a single layer of chrome tanned cow leather (2,8 ± 0,2) mm has to be fitted on the anvil and shall be replaced in the event the protector collapses due to the impact.

Protectors on which the protection zone has been marked after they have been conditioned in accordance with point 7.1 shall be used. The marks applied on the devices shall be used for the determination of point of impact. The airbag shall be fully tested and shall not be cut.

The impact test shall be performed after inflating the device at the minimum operating pressure declared by the manufacturer. At least one impact test shall be performed on a sample regardless of its size at its maximum inflation pressure.

The test result is considered positive (PASS) if the result of each single impact is positive.

7.6.2 Selection of the test samples

7.6.2.1 Impact attenuation test after ambient conditioning: Protectors shall be conditioned as indicated at clause 7.1.1. Each size of inflatable protector shall be submitted at least to three impact tests for each protective zone (clause 4.3); this requires a minimum of three samples (one impact per sample). It is possible to perform more impacts on the same sample but only one impact shall be done for each protection zone. At least one additional sample shall

be required to perform the test at maximum inflation pressure. For each declared protection zone, the following case are possible:

For a single protection zone declared, the following scenarios are possible:

a) Samples provided for testing the protector which can be inflate by means of a gas generator only.

1) The inflatable protector cannot be recharged with a gas generator: three samples per size are examined and each sample is subjected to a single impact.
2) The inflatable protector can be recharged with a gas generator: one sample is tested after its first inflation and the other two samples are tested after the recharging operation (they are inflated by the burst of the airbag, then deflated and subsequently recharged and subjected to the impact test).

b) Samples provided to perform the inflatable test by other means than a gas generator, for example by a remote pipe: three samples per size are examined and one sample is submitted to impact once for each protection zone.

7.5.2.2 Impact attenuation test after wet conditioning: The protector shall be conditioned as indicated in clause 7.1.2. Only a randomly selected sample between the size declared by the manufacturer is tested with a single impact; if the device has more than one protection zone, at least one sample for each protection zone shall be subjected to the test.

7.5.2.3 Impact attenuation test after hot temperature conditioning: The protector shall be conditioned as indicated at clause 7.1.3. Only a randomly selected sample between the size declared by the manufacturer is tested with one single impact; if the device has more protection zones, at least one sample for each protection zone shall be tested.

7.6.2.4 Impact attenuation test after cold temperature conditioning: The protector shall be conditioned as indicated at clause 7.1.4. Only a randomly selected sample between the size declared by the manufacturer is tested with one single impact; if the device has more protection zones, at least one sample for each protection zone shall be tested.

7.6 Impact distribution

7.6.1 Test method

The test shall be performed using the drop equipment and the procedure in conformity with the relevant part of EN 1621-3. The kinetic energy on impact shall be (30± 1,5) J.

The protection zone shall be tested according to the corresponding method described in the different parts of EN 1621-3.

If the device is produced in different sizes, and these are not differentiated by type of protection zone, inflation pressure, type of gas generator and gas used, any size can be tested. If the device has variations between the sizes, each size shall be tested.

At least four impacts in total shall be carried out. The impact test shall be performed after inflating the device with the minimum operating pressure declared by the manufacturer. In case of divide chest protectors, an impact shall be performed on each half at point Y. For full chest protectors, an impact is done at point Y (left or right) and point X on each sample.

7.6.2 Selection of the test samples

7.6.2.1 Impact distribution test after ambient conditioning: Protectors shall be conditioned as indicated at clause 7.1.1. It is necessary to test at least one sample per size produced in the case of full chest protectors and at least one pair per size produced in the case of divide chest protectors. Samples shall be tested in the inflated status.

7.6.2.2 Impact distribution test after hot temperature conditioning: The protectors shall be conditioned as indicated at clause 7.1.3. Only randomly selected sample from the declared sizes for the device shall be tested. Samples shall be tested in the inflated status.

7.6.2.3 Impact distribution test after cold temperature conditioning: The protector shall be conditioned as indicated at clause 7.1.4. Only randomly selected sample from the declared sizes for the device shall be tested. Samples shall be tested in the inflated status.

7.7 Ergonomic tests

The ergonomics of the protector shall be verified by using the points listed below.

7.7.1 General requirements if worn by an assessor

One sample per size shall be visually examined to check its design features as well as any sharp edges or inclusion that may cause problems.

One protector is then put on by an assessor of suitable size and sex who then carries out the following tests. Manufacturer's instructions for donning and adjustment shall be respected.

The following tests shall be done with the protector in non-inflated status and then repeated with the protector in the inflated status. To get a positive result, all of the following questions need to be answered with "yes ":

- Do you confirm the protector fits you properly (not inflated status)?
- Is the anatomical area that device is intended to protect properly covered?
- Does the adjustment system cause intolerable discomfort, also considering breathing?
- Do you think the restraint system holds the protector firmly in place (if possible)?
- Does the harness tighten too much when the airbag is inflated?
- Can you pick up something from the floor by bending forward? (Three times, not for inflated status).
- Is the maximum separation between the two half parts of divide chest protectors less than 40mm?

7.7.2 Maximum acceleration of the head caused by airbag inflation

7.7.2.1 Most critical position evaluation: One sample per size of the inflatable protector shall be tested by at least an assessor – male and/or female - of suitable size. In case of a device produced in only one size, the minimum number of assessors shall be two.

The assessor has to fit a industrial safety helmet (size has to be recorded) equipped eventually with accessories (visor, headsets, etc…) and shall wear the device following the manufacturer's instructions for donning and adjustment. With the device inflated, the test subject shall tilt his head in the following positions: backward, forward, left and right. Evaluate the most critical position (which corresponds to the position where there is the greatest possibility of the head to be hit by the device when it instantly inflates during a fall) for the head based on the characteristics of the device. Deflate the device and record the maximum angle between the head and the neck angle that the assessor can reach by using a digital inclinometer.

7.7.2.2 Dummy test: A minimum of one sample shall be tested in the most critical position. The helmet used shall be set with a suitable instrument (e.g., Endevco high speed crash sensor, accelerometers, etc…) positioned inside the helmet (top of the head). Fit the helmet on the dummy's head and set the head inclination in the most critical position as defined at point 7.7.2.1; activate the device and record the resulting acceleration of the head a3ms caused by airbag inflation. If the dummy test seems to be safe for the assessor, head acceleration in the most critical position shall be detected on the human subject; otherwise, other tests shall be performed in order to exclude physical problems for the assessor or the device has to be declared not appropriate. If deemed suitable, the dummy test can be directly replaced by the assessor.

7.8.2.3 Human test: After having ensured that no risks for the assessor may occur, one sample per size of inflatable protector shall be tested by at least an assessor – male and/or female - of suitable size. In case of a device produced in only one size, the minimum number of assessors shall be two. Fit an inflated protector on the assessor in accordance with information supplied by the manufacturer; fit a suitable helmet on the assessor and position the head in the most critical position as defined at point 7.7.2.1. Activate the device and record the resultant head acceleration a3ms caused by airbag inflation.

7.7.3 Evaluation of the acoustic level

One sample for each size of the device shall be tested in order to exclude any critical situation or pain feeling during or after the inflation.

Determine the acoustic level with a suitable instrument capable of measuring the acoustic phenomenon for at least 10 s and with a frequency bandwidth of at least 500 Hz (central frequency of the audible field), for example using an active artificial acoustic head.

7.7.4 Controllability test for workers protector

Controllability tests shall be performed to determine how much an unexpected protector's inflation potentially influence the worker's movements. Workers at height are usually exposed to dangerous situations in which the probability of fall from a framework can be high. For this reason, it is extremely important that the inflation of the airbag does not affect them excessively. Controllability test shall be performed by simulating a working environment in which the most common working activities have to be reproduced. Table 3 lists some situations in which the protector shall be activated. Because of the intrinsic risk of the test, the test field shall include safety elements (for examples mattresses) in order to protect the subjects that perform test.

At least three test subjects of different size (small / medium / large) and sex who wear a full body harness shall confirm the device's innocuousness to pass the test.

Aim of the Test	Test Configurations
Walk along a path that includes flat, uphill and downhill sections	The subject shall walk along a path that includes walking on the flat, climbing and descending steps
Retrieve and rearrange work tools arranged in bulk	The subject shall reach a bench where some tools are arranged in bulk, reachable in an upright position or with the need to crouch, the subject has to collect some of these tools and put them inside a case.
Carrying a load along a narrow walkway	The subject shall maintain balance while carrying a briefcase along a path that includes the passage on a beam of reduced width raised from the ground first positioned inside the room, then adjacent to a wall.
Climb a structure and fasten bolts or screws using a power tool	The subject shall climb an elevated structure in order to fix bolts with a wrench or with a power tool and then descend.
Carrying out activities above a scaffolding	In the vicinity of a scaffolding, the subject shall hoist a briefcase on an elevated floor passing it to an operator who is in an elevated position, climb onto the scaffolding and carry out activities in different positions (standing, crouching). Once the activity is complete, the operator will have to arrange the tools in the case and pass it down to a second operator, then get off the scaffolding.
Retrieve an object above a ladder	The subject must go to a ladder where he must climb to retrieve an object, and then descend.
Assemble items under a low shelf	The subject must carry out activities in which he must move in a crouched position: for example, fasten screws to the ground or assemble some object.

Table 3

7.9 Function of the activation mechanism

Risk assessment of the airbag shall be carried out in order to exclude the airbag activation during normal working or even misuse events. On the other hand, the assessment shall ensure that the algorithm is able to trigger the airbag activation during risky situations occurring in case of accidents, such as falls.

The activation system shall take into consideration what is reported in IEC 61508 and/or in ISO 26262 guidelines.

The requirements regarding the activation algorithm are the followings:

a) the algorithm shall avoid the activation during normal working activities, during possible misuses by the worker and in case of situations that are not sufficiently dangerous to exceed the severity thresholds adopted by the manufacturer.

b) the algorithm shall clearly identify the fall condition. A set of mathematical functions which form the algorithm has to recognise that preset severity thresholds are exceeded, after the beginning of the fall.

To evaluate the efficacy of the inflatable protector activation algorithm with respect to **requirement a),** workers common activities shall be tested by considering different types of daily working situations and aspects that are integral part of professional workers activities.

A sufficient number of real time tests (e.g., 40 h of regular work activities) shall be carried out by a team of professional workers in several different scenarios such as in thermal/ hydroelectric generating plants, wind farms, electrical towers and ski lift (only competent persons trained in different working activities, that perform different works/actions during the day). The metrology (hardware and software) used for data acquisition and post-processing shall be state of the art and capable of providing data of sufficient quality. The device shall give a positive response also in the situations described in Table 5 of Annex B. Any of these circumstances must not lead to high risks of potential misfiring.

To evaluate the efficacy of the inflatable protector activation algorithm with respect to **requirement b),** a sufficient number of falls with ground impact and collision against obstacles tests (e.g., n° 10 different fall impacts/collisions) shall be performed to assess the algorithm triggering thresholds. Fall tests shall be planned in order to obtain a significant number of cases in which the algorithm is proved capable of correctly identifying the falling scenario.

The annex B provides an example-list of technical criteria which generally lead to a proper technical evaluation of the airbag activation.

On the basis of the results of the set of tests previously described performed by the manufacturers in agreement with the Testing Laboratory, a group of experts will be involved by the notified body to confirm that the test results give sufficient evidence to the fact that the algorithm is satisfying requirements a) and b).

In certain cases, virtual or physical simulation systems can be involved to support the evaluation process; in any case, the collection of the largest amount of real data taken from working experiences is recommended.

7.9 Mechanical tests (Only if worn on top of other clothing)

7.9.1 Tests

Mechanical tests shall be performed on complete garments. If not possible to perform any required test using an actual test sample garment, the test may be performed using a representative sample of same material(s) and construction as found in the complete garment.

7.9.2 Structural seams and Structural closures

The strength of the structural seams and of the structural closures of the garment shall be tested according to the test procedure in EN 13594, Annex B. Each type of combination of materials connected each other shall be evaluated and three test pieces of each seam or joint type, including all layers of materials of the garment that are present in the seam or joint shall be considered. The seam strength shall be calculated by dividing the breaking force by the length of the tested seam.

Test report shall contain:

- For structural seams: seam or joint type, central zone width (mm), breaking load (N) and breaking type;
- For structural closures: type of closure, central zone width (mm), breaking load (N) and breaking type;

The average of the test results coming from each group of three specimens shall be traced and shall meet the requirement given in Table 2.

8 Marking

Inflatable protectors for workers at height shall be permanently and conspicuously marked with at least the following information:

a) name and full address of the manufacturer;
b) trademark for the product;
c) identification of the type of product, commercial name or code;
d) production batch or serial number of the manufacturer or other means of traceability;
e) year and month of manufacture;
f) size of the protector;
g) indication of the zone in which protection is guaranteed, using the symbols indicated in the relevant standard EN 1621; if the protection zone is not conforming to a typical EN 1621 zone, a detailed description shall be reported;
h) the word "AIRBAG";
i) for chest protectors, the indication "D" if the optional impact distribution requirement is declared;

j) the pictogram "i" that suggest to read the package leaflet (see figure below).

9 Information supplied by the manufacturer

Protectors shall be supplied with information and instructions for fitting, use and maintenance. These are essential parts of the protective equipment. They shall include at least the following information in the official language(s) of the state or region in which they are placed on the market:

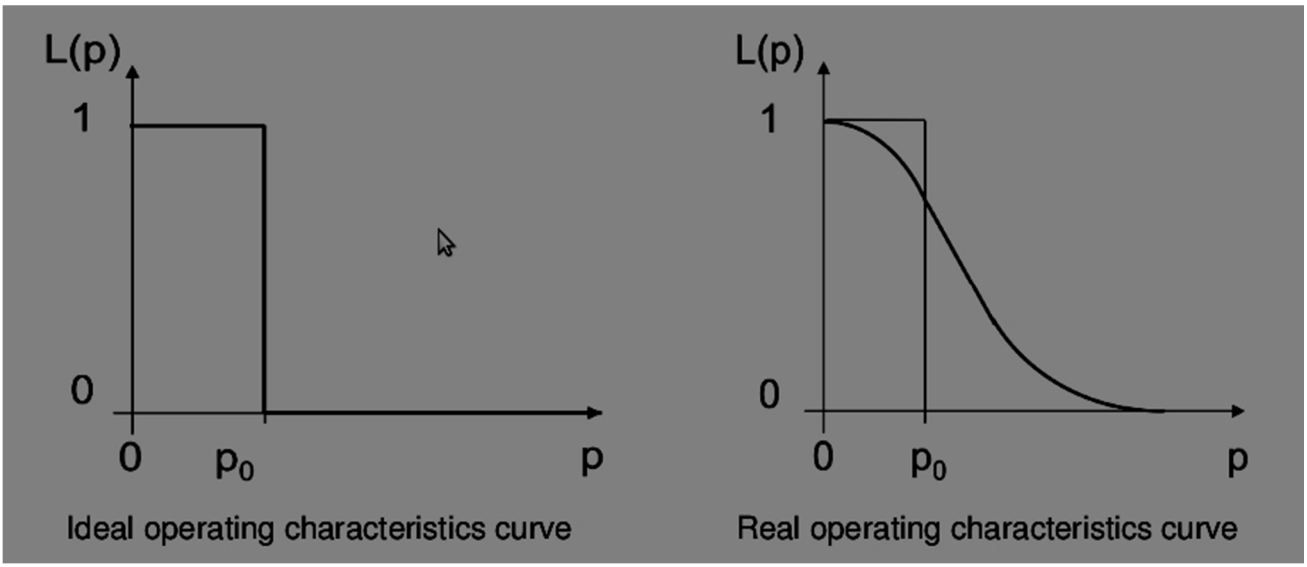
1) the name and full address of the manufacturer and/or his authorised representative in the EU;
2) the type of use the protectors are intended for including any relevant restrictions;
3) explanation of the protected area(s) as marked in the pictogram and (if applicable) of any exceeding protected area; all this informations with reference to the user's size for which the device is proposed;
4) the specific hazards against which the protection is given;
5) the specific hazards against which the protection is not given;
6) the relative limit parameters useful for the user in order to use the device correctly (for example the minimum and maximum height of use without a protection system against falls, the minimum fall height for which protection is guaranteed in the case of use together with a fall arrest system, etc ...);
7) all the information required in Clause 8 "Marking ";
8) explanation of the guidance on how to adjust the protector;
9) warnings and limitations of use, including the following statements:
   a) no protector can offer full protection against injury;
   b) the protector may not provide protection to the worker under all circumstances;
   c) the compatibility or not with other devices and garments;
   d) if applicable, a warning that the provided protection will be impaired if the garment is not closed;
   e) a warning about any contamination, alteration or misuse of the protector, that would dangerously reduce the performance of the protector.
10) instructions concerning periodical checks of the whole device and its specific components;
11) information on the selection of the correct size of the device;
12) instructions for care and cleaning. Use international care label symbols, including negative labels, if applicable;
13) instructions concerning inspection and recharging, if applicable,
14) instructions on how to decide on the necessary disposal and replacement;
15) instructions for the safe disposal of the protectors, in accordance with European regulations, and of any hazards that could happen during mechanically disrupting or incinerating the product;
16) warning that the equipment shall only be used by a person trained and competent in its safe use;
17) warning against making any alterations or additions to the equipment without the manufacturer's prior written consent, and that any repair shall only be carried out in accordance with manufacturer's procedures;
18) warning that the equipment shall not be used outside its limitations, or for any purpose other than that for which it is intended;
19) advice as to whether the equipment should be a personal issue item, where this is applicable;
20) information on the hazards that may affect the performance of the equipment and corresponding safety precautions that have to be observed e.g.: extremes of temperature, trailing or looping of lanyards or lifelines over sharp edges, chemical reagents, electrical conductivity, cutting, abrasion, climatic exposure, pendulum falls.
21) instructions for storage and transport;
22) Warning that the device contains potentially dangerous pyrotechnic charges, if any.

Annex A

Note 1. Functional Safety and FMEA activities. Functional Safety takes into consideration what is reported into IEC 61508 and into ISO 26262.

The general functional approach of the inflatable Airbag system is that sensors deliver information about the external conditions and an algorithm recognises whether an accident occurred or whether an activation of the airbag is necessary. Then, the airbag can be activated.

From a formal point of view the approach mentioned above is based on a mathematical function represented by a so-called operating characteristic curve shown in the figure below on the left-hand side.



We have a parameter p that indicates whether an accident occurred (in reality p is a set of parameters but that is not important for the following argumentation). The likelihood function L(p)for "no airbag activation" is exactly 100 % as long as p≤p0 with p0 as the minimum trigger level. Consequently, L(p) is exactly 0 for p>p0.

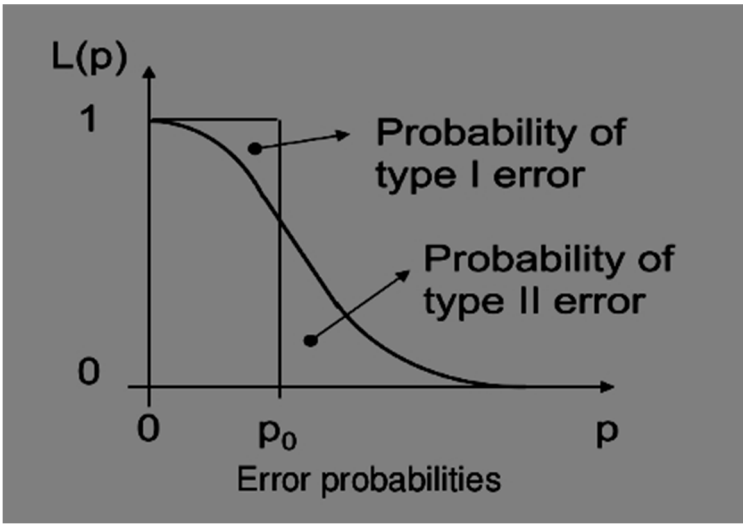
The figure on the right-hand side shows a real operating characteristic curve. In contrast to the ideal situation, L(p) decreases below 100 % for p≤p0 and is not exactly 0 for p>p0. With other words: There are certain likelihoods for airbag activation below the minimum triggering level and also for no activation beyond this level.

The statistical test theory speaks of two significant sorts of error. The context is that there is a "null hypothesis" H0 which corresponds to a presumed default "state of nature", e.g., that a worker has no accident (and there is no airbag activation necessary). Corresponding to the null hypothesis is an "alternative hypothesis" H1 which corresponds to the opposite situation, that is, that a worker has an accident (and the airbag activation is necessary).

The goal is to determine accurately if the null hypothesis has to be accepted or rejected. The result of the test may be negative (it does not indicate disease, guilt, accident). On the other hand, it may be positive (it may indicate accident). If the result of the test corresponds with the actual state of nature, then a correct decision has been made. But if the result of the test does not correspond with the actual state of nature, then an error has occurred.

The two kinds of error, classified as "type I error" and "type II error", are explained in the table below.

	H_0 true: No accident (airbag activation not necessary)	H_0 false: Accident (airbag activation necessary)
H_0 accepted (no airbag activation)	Right decision	Wrong decision Type II error, false negative
H_0 rejected (airbag activation)	Wrong decision Type I error, false positive	Right decision



Type I errors, occurring when H0 is rejected although it is in fact true (i.e., no accident but the tests results suggest airbag activation), are also known as "false positive". On the other hand, type II errors occur when H0 is accepted although it is false (i.e., there is an accident but the test's results suggest no airbag activation). In this case, it is a "false negative" error.

The areas between the ideal and real operating characteristic curves are representative of the probability of both types of errors shown in the figure below.

It is not possible to influence to the real operational characteristic curve but the minimum triggering level to change the error probabilities could be moved. Figure shows that both probabilities depend of each other.

***INCREASING** the minimum triggering level delivers a lower probability of type I errors (false positive –activation although there is no accident) and a higher PROBABILITY of type II errors (false negative – no activation although there is an accident).*

*On the other hand, **DECREASING** the minimum triggering level yields to higher probability of false positive errors and lower probability of false negative. **It is not possible** to minimise both probabilities, therefore. In other word: We have to decide what type of error is more dangerous for the worker.*

This decision is very easy because airbag activation is irreversible. We have to "save" the activation for real critical situations, therefore, and we are not allowed to "waste" it for not real critical situations. I.e., we have to avoid type I error (false positive – activation although there is no accident) as far as possible and we have to accept the resulting risk of type II errors (false negative – no activation although there is an accident).

This general safety approach is in correspondence with the result of the hazard and risk analyses. On one hand functions those avoid erroneous airbag activation got SIL2 classification there according to IEC 61508 which is corresponding to ASIL B/C according to ISO 26262. On the other hand, airbag activation functions are classified as SIL1 according to IEC 61508 or to ASIL A according to ISO 26262, respectively.

Annex B

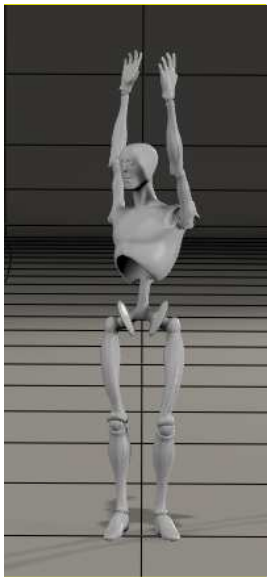
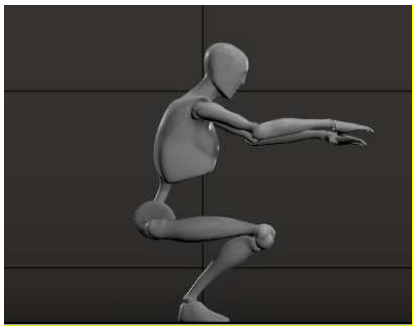
The annex B provides a series of technical notes and criteria which generally lead to a proper technical evaluation of the airbag activation.

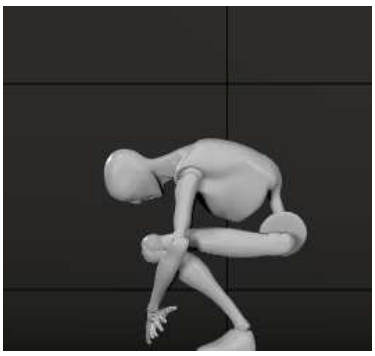
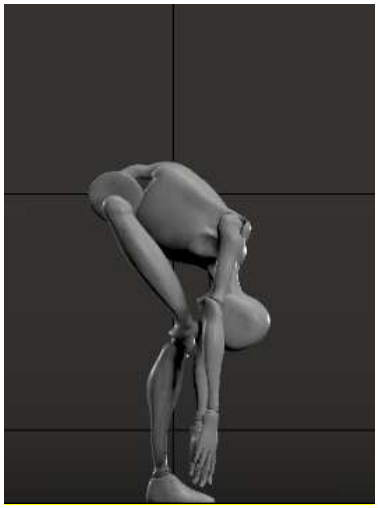
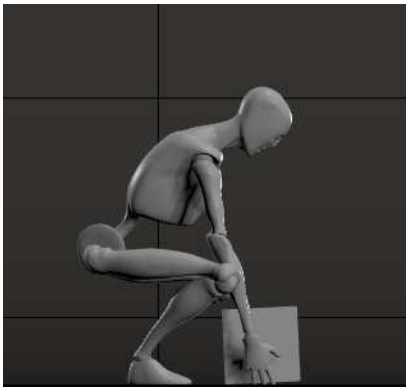
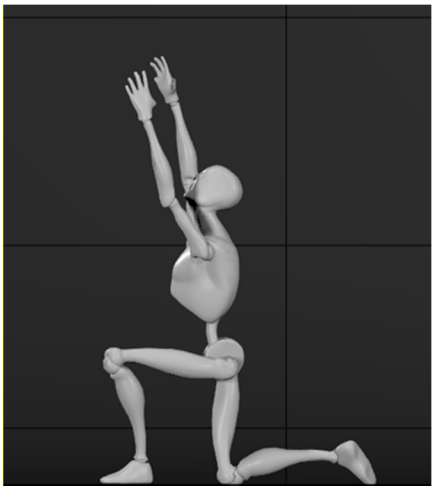
B.1 - Algorithm check against requirement a) (prevent misfiring)

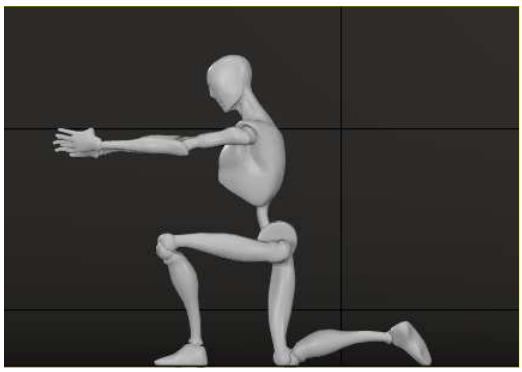
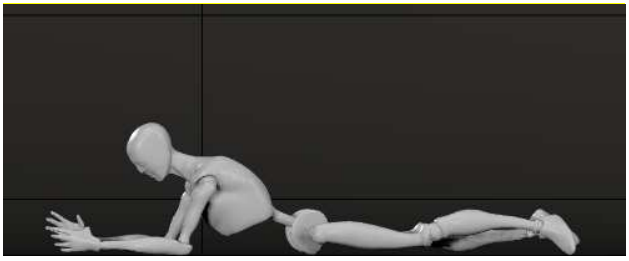
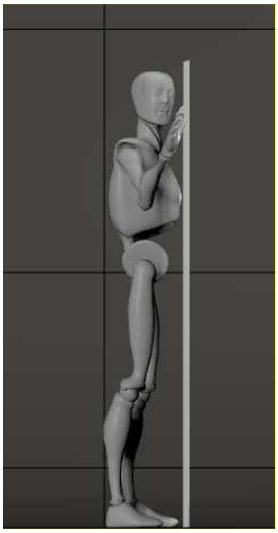
To fully understand the level of performance of the new product, the algorithm shall be tested using a large dataset based on real events. The results of all tests shall confirm that the algorithm is capable of distinguishing between misfiring events and accident scenarios where inflation is required. Care should be taken to the fact that workers at height are used to work on scaffolds next to the false ceiling without having the possibility to assume an upright position. Most of the time, workers have to bend down and lay on their knees in order to reach their work site and to start to operate. Moreover, workers are used to handle tools by stretching their arms upwards and then putting them on the belt or into the pouch they usually wear. In order to reach narrow places, workers have also to crawl facedown and face-up, thus to avoid unwanted activations, the sensors position in the airbag shall be carefully decided.

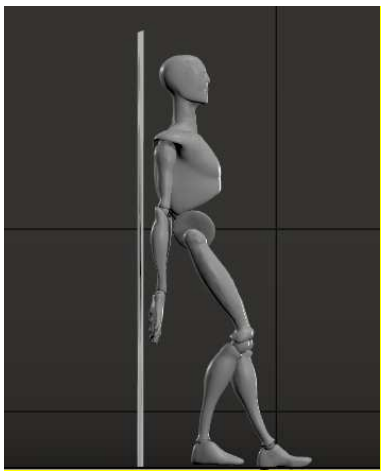
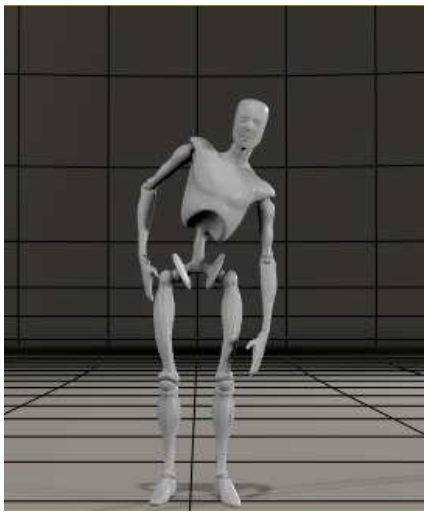
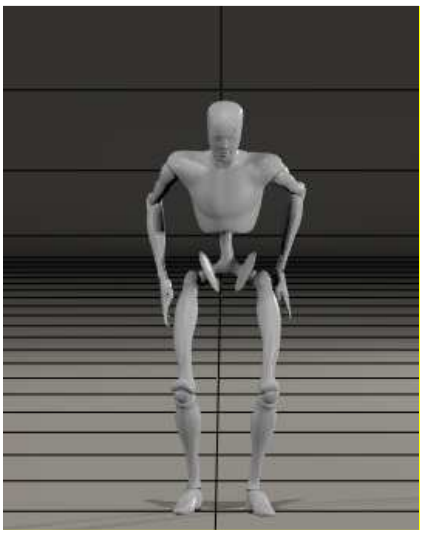
B.1.1 – Working situations Test

The algorithm shall be tested during some working situations in which the workers have to move by starting from an upright position, from a bent down position with a knee on the ground and from a lay down position. Tables 4,5 and 6 describe some conditions that shall be performed by at least three subjects of different size (small / medium / large) and sex.

Situation:	Description
	From an upright position, raise the arms and make them twirl, while the trunk rotates simultaneously.
	From an upright position, bend on the knees while keeping the trunk erected.

	From an upright position, bend on the knees while bringing them on the chest
	From an upright position, bend the trunk forward and touch the points of the feet with the hands
	From an upright position, simulate to lift something heavy from the ground
	From an upright position, bend on the knees with a knee on the ground, stretch the arms upwards by simulating to tighten something upon the head.

	From an upright position, bend on the knees with a knee on the ground, stretch the arms forwards by simulating to tighten something in front of themselves.
	From an upright position, get down facedown by supporting on the elbows
	From an upright position, get down face-up
	Move from an upright position by creeping the anterior part of the body on a wall by simulating to crawl in a narrow passage

	Move from an upright position by creeping the posterior part of the body on a wall by simulating to crawl in a narrow passage
	Extract an object from pocket of the coveralls and then replace it back
	Fix the pants on the waist

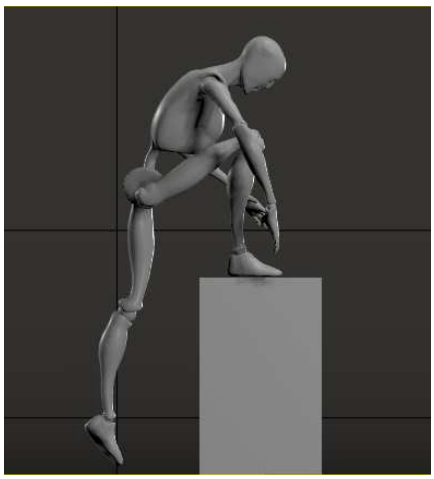
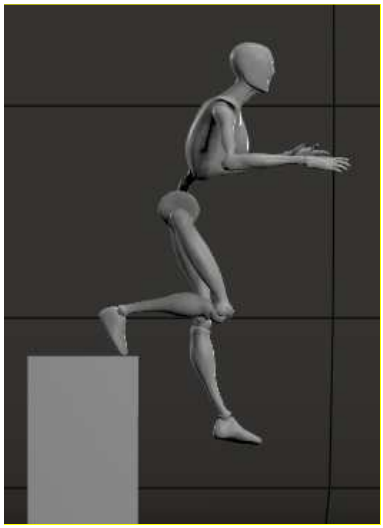
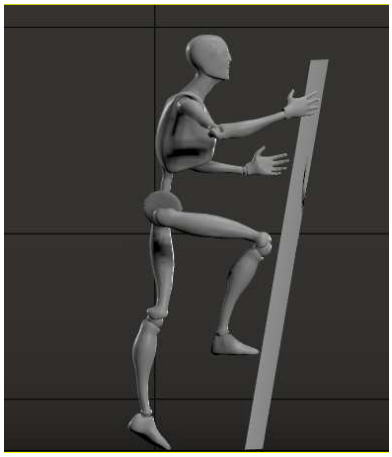
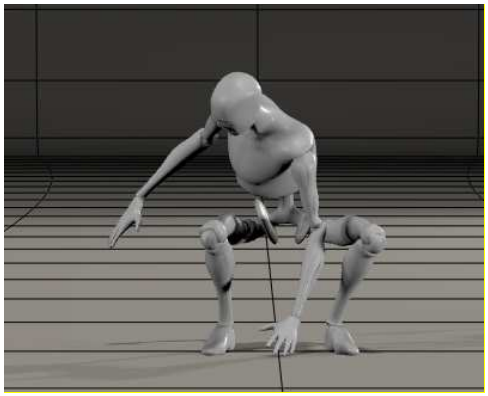
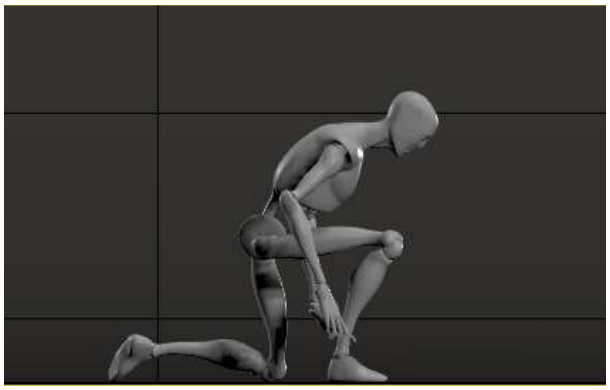
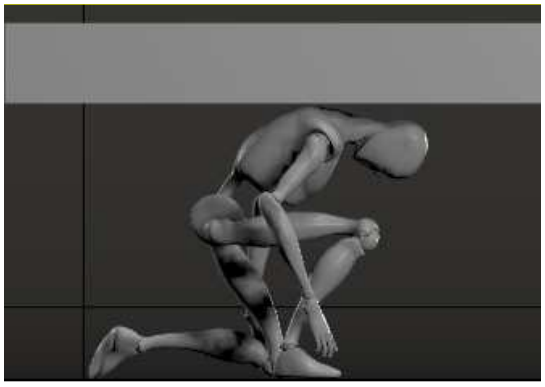
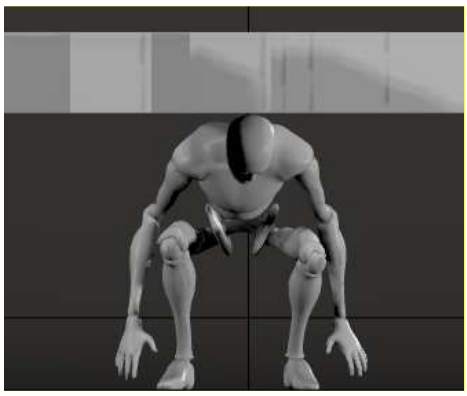
	From an upright position, get on a table of at least 0.7m height.
	From an upright position, jump off a table of at least 0.7m height
	From an upright position, climb quickly a ladder and then get down

Table 4 Movements starting from an upright position

Situation:	Description
	From a bent down position, move the hands on the floor and rotate the truck in order to simulate to collect something from the ground
	From a bent down position, with one knee on the ground, start to walk by making at least 20 steps ahead.
	From a bent down position under a table, start to walk ahead by crawling the posterior part of the body on the table above
	From a bent down position under a table, get up and hit the table above

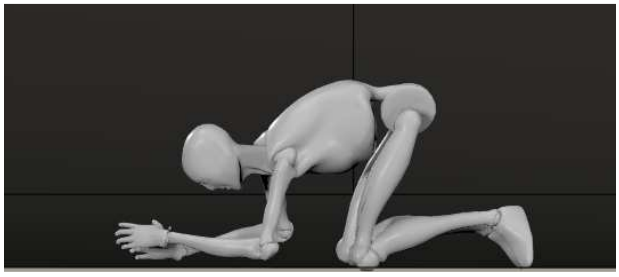
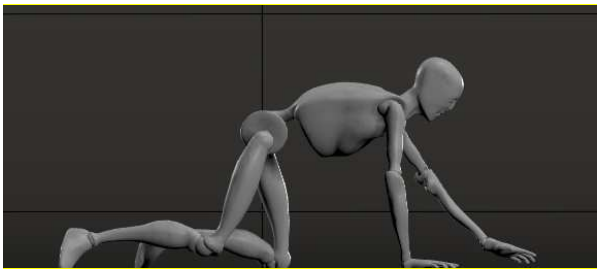
Situation:	Description
	Get on all fours a simulate to fix a joint positioned ahead
	Move ahead by standing on all fours and perform at least 20 steps

Table 5 Movements from a bent down position with a knee on the ground

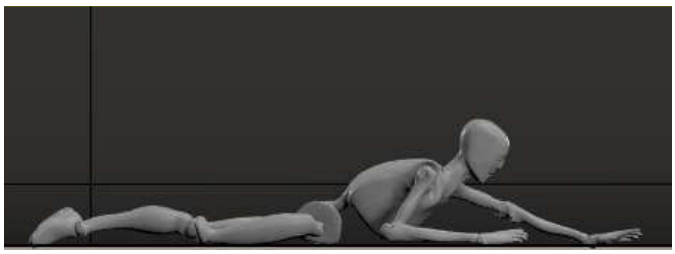
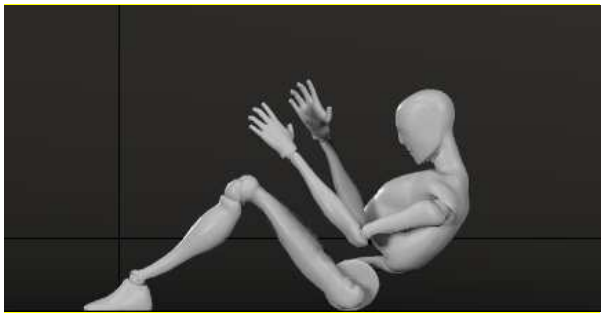
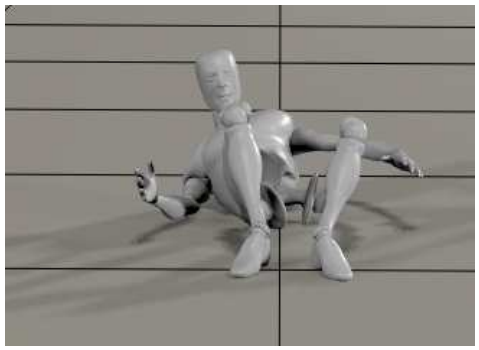
Situation:	Description
	Move from a lay down position and crawl face down in order to cover a distance of at least 3 m
	From a face down position, rotate in order to lay face up and perform at least 10 sit-ups
	From a face down position, rotate in order to lay face up and crawl both back and forth

Table 6 Movements from a lay down position

B.1.5 - Accumulation Test

Different workers shall be recruited in order to perform the test. Workers shall wear their traditional overalls and they has to be monitored during their typical work activities in the yards. Data shall be collected from sensors during their typical movements, which are briefly represented in Figure 7. Data could also be used to understand how close the triggering system goes to the activation conditions.

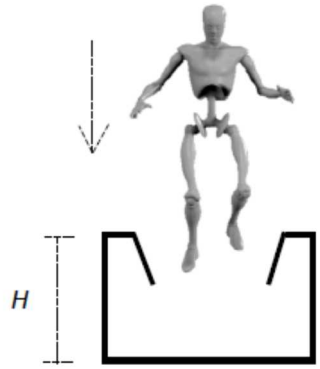
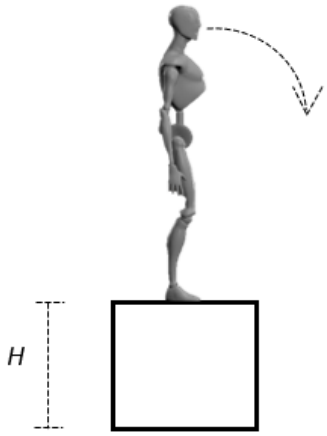
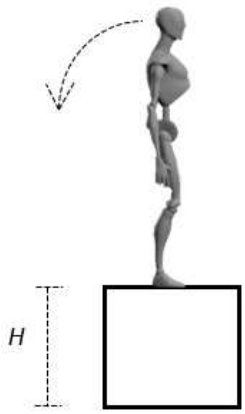
Figure 7

B.2 Algorithm check against requirement b) (ensure activation in falls)

B.2.1 – Falls Test

Fall test shall be distinguished in: FALL WITH GROUND IMPACT (Table 7) and FALL WITH OBSTACLE COLLISION (Table 8). In all these cases, the airbag shall be deployed in accordance with 4.4.

The algorithm shall be tested on all falling events described in Table 7. Data shall be taken from a significative number (e.g. 10 cases) of falls recorded. The following falling configurations shall ensure the correct activation of the system.

Type of event	Configuration	Description
Falls with ground impact	a. Vertical fall 	Fall that happens when a person falls vertically from a height (H)
	b. Fall forward 	Fall that happens when a person falls forward from a height (H)
	c. Fall backward 	Fall that happens when a person falls backward from a height (H)

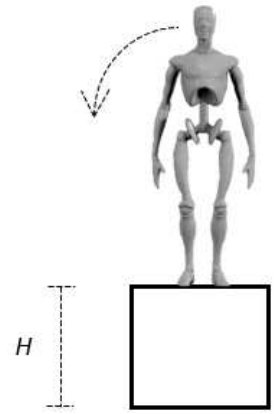
Type of event	Configuration	Description
	d. Lateral fall 	Fall that happens when a person falls laterally from a height (H)

Table 7

The height of the support (H) shall be equal to the intervention height.

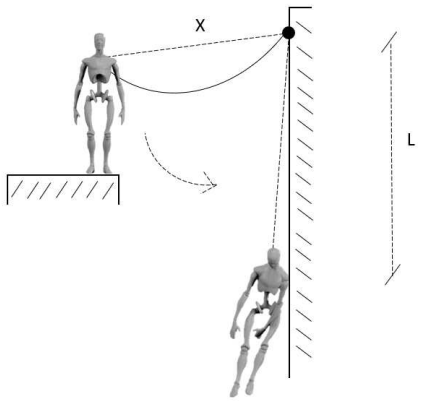
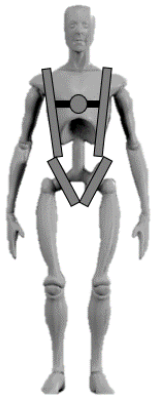
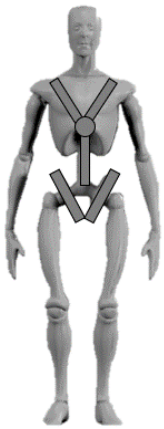
Type of event	Configuration	Description
Falls with obstacle collision	a. Collision 	Situation that happens when a person, who uses a harness, falls from a height and then collides against the surrounding structures after being arrested by the personal fall protective equipment

Table 8

The algorithm shall be tested simulating an adequate number of real fall and collision events. Collision test configurations shall be inspired to EN 364. Moreover, after being dressed up with a body harness, the dummy shall be dropped down from a height and it has to collide against the surroundings structurers. The test configuration shall be set so that the distance X from the dummy to the central point of rotation is in according to paragraph 7.3.3. The length L and the types of full body harness shall be agreed between the Testing Laboratory and the manufacturer.

Annex C

Table 9 provides a classification of the various types of full body harness on the market according to EN 361 and divided according to their structural and geometric conformation.

Type of full body harness	Configuration	Description
Type H		Seen from the front, the shoulder straps descend vertically and connect to each other with a secondary strap and/or with front attachment. These harnesses are divided into: - Type H/ A (Type H with front attachment) - Type H/ P (Type H with rear attachment) - Type H/AP (Type H with front and rear attachment)
Type X		Seen from the front, the shoulder straps descend crossing at chest height at the sternal attachment forming an “X”. these harnesses are divided into: - Type X/ A (Type X with front attachment) - Type X/ P (Type X with rear attachment) - Type X/ AP (Type X with front and rear attachment)
Type Y		Seen from the front, the shoulder straps cross at the sternal attachment point and go down to the belt by means of a single vertical and central strap: These harnesses are divided into: - Type Y/ A (Type Y with front attachment) - Type Y/ P (Type Y with rear attachment) - Type Y/ AP (Type Y with front and rear attachment)

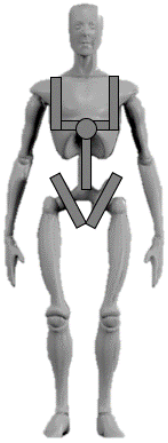
Type of full body harness	Configuration	Description
Type T		Seen from the front, the shoulder straps descend vertically to the strap where the sternal attachment point is present. Then they are joined by means of a single vertical and central tape. These harnesses are divided into: - Type T/ A (Type T with front attachment) - Type T/ P (Type T with rear attachment) - Type T/ AP (Type T with front and rear attachment)
Type I	Harness integrated into the workwear	These harnesses are supplied already integrated into a suit or work coat

Table 9

Annex ZA

Relationship between this Protocol and the Essential Requirements of EU Regulation 2016/425

Compliance with the clauses of this protocol given in Table ZA.1 confers, within the limits of the scope of this protocol, a presumption of conformity with the corresponding Essential Requirements of the Regulation (EU) 2016/425.

Table ZA.1: Correspondence between this Protocol and Directive 89/686/EEC

Clause(s) / subclause(s) of this Protocol	Essential Requirements (ERs) of Regulation (EU) 2016/425		Qualifying remarks / Notes
4.8	1.1.1.	Ergonomics	
4.2.2, 4.2.3, 4.2.4, 4.10	1.2.1.	Absence of inherent risks and other nuisance factors	
4.2.1	1.2.1.1.	Suitable constituent materials	
4.2.2, 4.8	1.2.1.2.	Satisfactory surface condition of all PPE parts in contact with the user	
4.8	1.2.1.3.	Maximum permissible user impediment	
4.3, 4.8	1.3.1.	Adaptation of PPE to user morphology	
4.5, 4.6, 4.7, 4.9	1.3.2.	Lightness and strength	
9	1.4.	Manufacturer's instructions and information	
4.8, 5.1	2.1.	PPE incorporating adjustment systems	
4.8	2.2.	PPE enclosing the parts of the body to be protected	
9	2.4.	PPE subject to ageing	
8	2.12.	PPE bearing one or more identification markings or indicators directly or indirectly relating to health and safety	
4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.9	3.1.1.	Impact caused by falling or ejected objects and collisions of parts of the body with an obstacle	

Table ZA.1