Dynamic test method for full body harnesses exploited in cold climates

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Abstract. In this paper, a method of testing the dynamic strength of full body harnesses is proposed. The possibility of conducting the method in laboratory conditions is determined by testing the method while maintaining the specified conditions of low temperatures. The main attention is paid to the effect of the set temperature on the full body harnesses, when dynamic shock loads occur in user operation mode. The advantage of the developed method of dynamic testing of full body harnesses is the simplicity in bringing the test sample to the climatic parameters of operation by pre-conditioning. This makes it possible to implement dynamic testing under specified climatic conditions within mass laboratories in the chain of conformity confirmation. Pre-conditioning allows you to conduct research on the influence of climate factors on various characteristics of safety harnesses. The interaction of the binding elements with each other, previously reduced to the specified temperature parameters, is also studied. It is necessary to pay special attention to the resulting impact loads during dynamic tests, and their relationship when conditioning products at different temperatures.

1. Introduction

According to the statistics of industrial injuries, falling from a height takes the leading place among all dangerous industrial factors in the number of accidents and emergencies. They account for approximately 39.5%, if we add to these numbers accidents that occurred when objects fell from a height (an approximate figure of 10.5%), we will find that half of all accidents at work are related to factors that occur when the force of attraction, that results to the user falling, or the object on the user [1, 2].

An important aspect of ensuring the safety of employees at work is to provide them with personal protective equipment (PPE) and collective protective equipment (CPE) against falling from a height, as well as safety helmets. The widespread introduction and monitoring of mandatory use of protective equipment has significantly reduced the number of incidents related to the influence of hazardous production factors. The introduction of new rules on labor protection in the production of work at height has also saved many lives. Regulatory activities by the enforcement of the law allowed to structure and designate areas of responsibility to officials, and the necessary mandatory training in safe methods and techniques for performing work at height contributed to increasing the user competence [3, 4], despite the fact that there is a huge number of organizations that issue certificates without appropriate training. Another important reason for the increase in the level of safety and reduction in the number of accidents at work was the introduction of mandatory PPE certification, which includes an assessment of the state of production with on-site inspection control by an expert at the
manufacturer's enterprise, and certification tests [5] by an independent testing laboratory in accordance with the test methods included in the list of technical regulations. This type of activity is strictly controlled by the structures of the Federal accreditation service, which serves as filters for unscrupulous organizations, that periodically pass the barriers of regulatory authorities, violating the law for the sake of financial profit, reducing the overall level of safety and quality of products being turned up on the market.

The usage of CPE from falling from a height at the moment does not provide the necessary level of user safety, due to the lack of a clear regulatory framework and quality control of products [6]. Manufactured CPE are not subjected to mandatory certification, which in turn cannot have a positive impact on their quality.

The PPE used is in combination to create a security system in the form of system components. GOST R 58208-2018/EN 363:2008 "System of standards for labor safety (occupational safety). Personal protective equipment against falling from a height. General technical requirements" defines the following types of safety systems for work at height: holding system, workplace positioning system, rope access system, safety system, rescue system [7-10]. These designs include a device to support the body and a connecting system that connects to a secure anchor point. A body support device may be, for example, a full body harness for fall arrest, work positioning and suspension, harness for rescue operations, evacuation triangles. The most widely used are safety tethers, because they are mandatory for all situations in which the user may fall from a height. These tethers ensure that the user is correctly stopped when falling, and then held in the head-up position. The use of such tethers in the fall arrest system significantly reduces the risk of injury to the user during the overload they experience. To date, test methods represent the minimum safety requirements that can provide PPE in case of their correct operation. These methods do not confirm the quality parameters of products and the ability of products to resist harmful effects on them [11,12]. If there are no mandatory requirements for testing products in their operating conditions, the possibility of their safe use is questioned [13]. An important aspect of the use of PPE is the climatic conditions of operation, which differ sharply from the laboratory conditions (23±5°C) under which certification tests of PPE are carried out, which in turn puts the life and health of users at risk. PPE against falling from a height must protect the user from the risks associated with falling at all operating temperature ranges specified by the manufacturer and regulatory standards. The impact of temperatures on PPE against falling from a height is currently studied [14, 15] and it is necessary to develop such experience starting with research and control tests.

The purpose of this work is to ensure the safety of people who meet the factor of "height" and the dangers associated with it in their production activities. By developing new PPE testing methods that are close to real operational parameters, it will be possible to achieve a higher level of safety of the products themselves, as well as the preservation of human health and life. Information about the results and methods of testing will allow competent specialists in the field to build a more competent security system.

To achieve the above goals, the following tasks were completed:
- development of a method for testing products at low temperatures, based on current regulatory documents;
- testing of the method;
- analysis of results, comparative assessment of existing possible models for conducting such tests;
- the formation of findings and conclusions which will provide the necessary recommendations.

2. Methods and materials
Before performing dynamic tests, samples of full body harnesses were pre-conditioned in a climate chamber at a temperature of -60°C for 4 hours (figure 1). The time of conditioning in the climate chamber was chosen according to one four-hour work shift.
Tests of full body harnesses were carried out on a stand for dynamic tests of PPE against falling from a height [16]. Dynamic tests of full body harnesses were performed after conditioning for 90 seconds from the moment the sample was removed from the climate chamber. The safety leash was tightly put on a 100 kg dummy. As a sling, a dynamic rope with a diameter of 11 mm was used, meeting the requirements of EN 892-2016 “Mountaineering equipment - Dynamic mountaineering ropes - Safety requirements and test methods”. The total length of the sling from the place of attachment to the tether to the place of attachment to the anchor point of the test stand was 2 m. The dummy was lifted by the upper ring of the fastening bolt (feet down) (figure 2) to such a height that the free fall of the dummy was approximately 4 m before the sling begins to restrain the fall of the test dummy. By means of the release device, the dummy was allowed to go into free fall without initial velocity. After repeated conditioning of the same sample in the climate chamber, the dynamic test was repeated with the dummy, but suspended by the lower ring (head down).
3. Results and discussions

According to the requirements of GOST R EN 361-2008 "Occupational safety standards system. Personal protective equipment against falls from a height. Full body harnesses. General technical requirements. Test methods", for dynamic tests with a 100 kg dummy, the safety harness must withstand two consecutive drop tests with a free fall distance of 4 m without releasing the dummy (one drop test with the dummy's feet down and one drop test with the dummy's head down). After each fall, the dummy must stop in the head-up position and the angle between the longitudinal axis of the plane of the mannequin's back and the vertical is no more than 50°.

As part of the study, tests were conducted on 3 samples. During tests, samples of safety full body harnesses withstood falls, without releasing the dummy. After the fall, the dummy stopped in the head-up position and the angle between the longitudinal axis of the plane of the dummy's back and the vertical was within the allowed range (figure 3).

Fig. 3. Position of the dummy after the fall.

The advantage of the developed method of dynamic testing of full body harnesses is the simplicity in bringing the test sample to the climatic parameters of operation by pre-conditioning. This makes it possible to carry out dynamic tests under specified climatic conditions in the framework of mass laboratories in the chain of conformity confirmation, and the implementation of the method in the mass testing sector is an integral part of quality control and safety of the necessary technical parameters of the above-mentioned products.

The following disadvantages of this dynamic test method of the full body harnesses are distinguished:
- different changes in the temperature of samples from the set temperature during conditioning from the moment of sample extraction from the climate chamber, depending on the manufacturing materials and the preparation process;
- too short period of time from the moment the sample is removed from the climate chamber until the dummy is dropped;
the full body harness is put directly on the dummy, which does not take into account the presence of protective warm clothing on the user under real conditions of a cold climate.

4. Summary
Pre-conditioning is allowed to conduct research on the influence of climate factors on various characteristics of full body harnesses. When testing for dynamic strength, the interaction of the binding elements with each other, previously reduced to the specified temperature parameters, is also studied. It is necessary to pay special attention to the resulting impact loads during dynamic tests, and their relationship when conditioning products at different temperature parameters.

In the future, it is planned to conduct research on the influence of climate factors on other PPE against falling from a height, both with the help of pre-conditioning, and with the direct exposure of climate factors during static strength tests. Analysis of methods of direct conditioning and pre-conditioning of products with subsequent tests for impact and static loads, is potentially able to show the degree of simulation and reproducibility of such effects, as well as to correlate them with actual situations when the user falls into operating conditions at extremely low/high temperature parameters. It is also worth noting the importance of fixing the peak dynamic load on the product and anchor point when stopping the fall and its display in the test reports to obtain a more complete picture of the force load on the product and the user, since this is a very important and basic characteristic in systems for stopping the fall [17-19].

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