Active-passive criteria as a measurement of the users' interaction with PPE

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Abstract: A good selection of personal protective equipment PPE is essential to protect workers. For its optimization, two concepts seem interesting: active and passive. These concepts are rarely used. The collective protective equipment is passive while the individual ones are active. The criteria are then dichotomous. The user's intervention level is varying for different PPEs in a same category; a level of activity seems measurable. Firstly, the definitions of the concepts are refined. Experimental tasks are executed in a controlled environment. The subjects are around ten students in steel erection. They will climb 6m on ladders and then do a typical task. They will wear standard PPE required by regulation. Several combinations of harness, lanyard with energy absorber, self-retracting lanyard will be tested to define the active/passive concepts and establish a level of activity scale. Perceptions, time, and the number of movements will be collected or observed.
Keywords: Personal protective equipment (PPE), active, passive, users' interaction, fall protection equipment.

1. Introduction

Personal protective equipment PPE is the last mean to protect workers when the hazardous phenomenon is not eliminated or controlled. Its selection shall be optimized to integrate the PPE to the task (Desjardins-David & Arteau 2011).

For this optimization, a concept seems interesting: active / passive. This concept is rarely used. An active equipment is one requiring actions for the user while a passive one does not required an action from the user to make his equipment effective. Generally individual protective equipments are active and the collective ones are passive. The criterion is dichotomous. The level of user's intervention varies for different PPEs form the same category. This level seems to be measurable.

After defining the active/passive criterion, the methodology is explained. A scale of the activity level is proposed starting at zero for totally passive. This scale will ease the selection of PPE.

2. Active-passive

2.1 Definitions

A literature review leads to the following definitions of active and passive. Active equipments are defined as any equipment made of an electronic or mechanic device requiring an external energy source to operate or requiring a human action to protect. Passive equipments are those without electronic or mechanic device. The passive

equipments are simple physical barriers which do not require a human action either a mechanical action or an external energy source to protect (CSA-Z259.16; INERIS 2008; Miller 2012). This first definition defines active and passive from the equipment.

Active equipment needs an action to be done by the worker for its first set-up or when the worker is performing his tasks. Passive equipment requires no action by the user neither for the set-up nor during the tasks.

2.2 Research questions

Is the active-passive criterion dichotomous or a scale of the activity level? Is the number of actions done on the equipment to maintain it effective, a measurement of the activity level? Is the activity level related to the interference with the worker's main tasks? What is the workers' preference: active or passive?

3. Methodology

3.1 General considerations

To answer the research questions, simulated tasks in a controlled environment will be monitored. Around ten subjects, students in steel erection, will perform these tasks at Centre de formation des métiers de l'acier CFMA (Training center for steel trades). This center reproduces real life situations without the weather constraint because work is done inside. The subjects will perform normal tasks with their PPE and tools. All PPE combinations are in agreement with the applicable regulations.

The main experimental tasks are:

- Climb on steel structure around 6m using a ladder;
- Execute a typical task on the steel structure;
- Do stretching movements on the ground to assess the comfort and the displacements of the harness webbings.

The individual fall arrest system IFAS is made of: a harness, a lanyard, an energy absorber or self-retracting lanyard, a sliding (mobile) fall arrester on a vertical rope, connectors and an anchorage.

Within the IFAS, the harness and the sliding fall arrester are the problematic components regarding the issue of active-passive. Some harness webbings have a tendency to loose their adjustment and some sliding fall arresters do not slide easily interfering with the task (Arteau 2012).

3.2 Mobile (sliding) fall arrester and self-retracting lanyard SRL

Three fall arresters and one self-retracting lanyard SRL will be used during the task: climbing a ladder on 6m. Their characteristics are described in Table 1-a. They have differences which presumably will generate different appreciations by the subjects. When compared to the fall arresters, the SRL could show the least interference (Arteau et al. 2007, 2008).

The dependant variables are the time to attach the system to the back D-ring of the harness, the time to climb 6m, the number of actions, the perception of safety, the perception of interference, a general appreciation and a rating the best to the worst to work with (Arteau et al. 2007, 2008).

Table 1: *Mobile fall arresters and self-retracting lanyard SRL. (a)Functional characteristics. (b) Expected rating*

	A **Fall arrester**	**B** **Fall arrester A modified ADP**	**C** **Fall arrester**	**D** **Self-retracting lanyard SRL**
a) Functional characteristics				
Set-up; connection to harness; **to vertical rope**	Same as B. Several different actions	Same as A. Several different actions	One action required to close the fall arrester on the vertical lifeline.	Only the connection of the snap-hook on the harness.
Easiness during climbing	Problematic fall arrester-rope compatibility	Less problematic fall arrester-rope compatibility	Slides easily on the vertical rope	No interference
b) Expected rating				
Global	4	3	2	1
Duration set-up.	4	4	1	1
Easiness climbing	4	3	2	1
Number of actions	4	3	2	1
1 = the best; 4 = the worst				

3.2 Harness

Some harnesses have their webbings loosing their adjustment during the work. Three harnesses will be used: one with rapid connectors, one with rapid connectors with blocking spring and one with tong and buckles. The dependant variables are: the time for adjustment the first time, the number of actions to adjust, the easiness to wear it for the second time and after, and the number of actions to maintain the adjustment during the simulated work; their perception of comfort and of easiness to do and finally the rating of the 3 harnesses. A similar procedure will take place after stretching exercises on the ground (Arteau et al. 2007).

4. Expected results

4.1 Mobile fall arresters and self-retracting lanyard

A and B should be the least appreciated among the four. The set-up of A and B on the vertical rope is long and is requiring several different actions by the workers; A and B should require frequent actions to make the device following the climber. They could be classified as the more active. C and D(SRL) could be classified as similarly active but less active then A and B. Only the subjects could confirm or negate these expected results even if they seem logical to the researchers.

The expected rating could be as per Table 1-b.

4.2 Harness

The expected results are summarized in Table 2. Quick connectors on the webbings require longer time for the first adjustment but the adjustment is more precise

and then presumably more comfortable. After, these harnesses are rapidly done. The tong-buckle type harnesses are rapidly done but their adjustment is precise to 25 mm, the distance between the holes. Quick connectors without spring have a tendency to loosen during work. Again these expected results have to be confirmed or negate by the subjects.

Table 2: *Harnesses. Expected rating*

	H1 Quick connect without spring	**H2 Quick connect with spring**	**H3 Tong and buckles**
Adjustment 1st time	2	3	1
Number of actions for adjusting	2-3	2-3	1
Easiness to wear 2nd time and after.	1	1	3
Number of actions to maintain the adjustment during the simulated work	3	1	1
Perception of comfort	2	1	3
Global rating	3	1	2
1 = the best; 3 = the worst			

5. Conclusion

All expected results require confirmation by the subjects. Whatever the results will be, a more precise definition of the active-passive concept will be proposed. The number of actions to activate (make the PPE effective) could be a good preselecting indicator. If confirmed, the selection of the least active PPE or the more passive one meaning less interference with the tasks will lead to a greater acceptability, a 100% of users during 100% of the time. This acceptability is in agreement with clauses 1.1.1 and 1.1.2.1 of Annex 2 of the European directive 89/686 on PPE.

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Gesellschaft für
Arbeitswissenschaft e.V.

Chancen durch Arbeits-, Produkt- und Systemgestaltung – Zukunftsfähigkeit für Produktions- und Dienstleistungsunternehmen

59. Kongress der
Gesellschaft für Arbeitswissenschaft

Fachhochschule Krefeld

27. Februar bis 01. März 2013

GfA Press

Bericht zum 59. Arbeitswissenschaftlichen Kongress vom 27.02. bis 01.03.2013

an der FH Niederrhein, herausgegeben von der

Gesellschaft für Arbeitswissenschaft e.V.

Dortmund: GfA-Press

ISBN 3- 978-3-936804-14-0

NE: Gesellschaft für Arbeitswissenschaft: Jahresdokumentation

Als Manuskript gedruckt. Diese Schrift ist nur bei der Gesellschaft für Arbeitswissenschaft e.V., Ardeystraße 67, 44139 Dortmund, erhältlich.
E-Mail: gfa@ifado.de, Internet: www.gfa-online.de

Schriftleitung: apl. Prof. Dr. M. Schütte

im Auftrag der Gesellschaft für Arbeitswissenschaft e.V.

Druck: City Druck, Heidelberg Technische Gestaltung: Stefan Cavadini
Printed in Germany

Gesellschaft für Arbeitswissenschaft e.V.
Jahresdokumentation 2013

Chancen durch Arbeits-, Produkt- und Systemgestaltung – Zukunftsfähigkeit für Produktions- und Dienstleistungsunternehmen

Bericht zum 59. Kongress der
Gesellschaft für Arbeitswissenschaft
vom 27. Februar bis 01. März 2013

herausgegeben von der
Gesellschaft für Arbeitswissenschaft e. V: