

Users oriented selection labelling for energy absorbers in fall protection

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Abstract: When working at heights, fall protection is required. The individual fall arrest system IFAS is made of a full body harness, an energy absorber, a lanyard, a connecting subsystem and an anchor. The energy absorber is the key component that maintains the arrest force at an acceptable level for the user. The safe maximum arrest force is relative the body mass; the safe deceleration is a constant around 10g. The energy to be dissipated during the arrest of the fall is the potential energy: the weight of the falling person (mg) multiplied by the free fall distance (h). Because the body mass varies considerably, two classes of energy absorbers are covered by the CSA Z259.11-05(R2010) Energy absorbers and lanyards. The actual classes are governed by the body mass but they do not take into account the free fall distance. The users have some difficulties in making a correct selection. A graphical label incorporating the mass and the free fall distance is proposed to simplify the selection.

Keywords: Personal protective equipment, fall protection, energy absorber, users oriented labelling.

1. Introduction

When working at heights, fall protection is required; protection is either provided by a fall prevention system or a fall arrest system. The individual fall arrest system IFAS is used when elimination of the fall hazard by design or when prevention by the use of guardrail are not feasible. The IFAS is made of a full body harness, an energy absorber, a lanyard, a connecting subsystem and an anchor (cf. figure 1). The energy absorber is the key component that maintains the arrest force at an acceptable level for the user.

The 2005 standard introduces energy absorber classes limited by body mass only. New problems arise because the safe use is governed by a combination of mass and free fall distance.

2. Technical background

2.1 Individual fall arrest system IFAS

The main performance requirements of the individual fall arrest system IFAS are arresting the fall, keeping the arrest force lower than the acceptable physiological level and maintaining the worker suspended after the fall arrest.

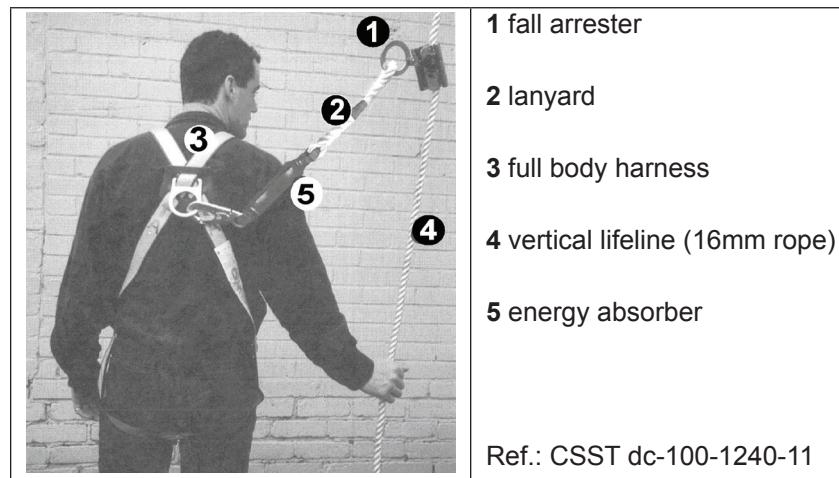


Figure 1: Individual fall arrest system

2.2 Energy absorber

The energy absorber is the key component that maintains the arrest force at an acceptable level for the user. The safe maximum arrest force is relative the body mass; a large person with stronger bones could safely sustain a larger arrest force than a small person. The arrest force divided by the body mass is the relative deceleration in g ($1g=9,81m/s^2$); the safe deceleration is a constant around $10g$ ($\approx 100m/s^2$) (Amphoux 1991). For an average person, the maximum arrest force is $6kN$ (Amphoux 1991); these values are used in all fall protection equipment standards (cf. Table 1). The energy absorber is generally made of a folded strap held by stitching and enclosed in a protective pouch; the energy is dissipated by tearing these stitches at constant force.

The mechanical behaviour of the energy absorber is represented in figure 2. The deployment starts with a peak force followed by a plateau at a nearly constant force.

The following equations describe the balance of energy.

Table 1: Parameters relevant for energy absorbers

Energy dissipating capacity	$F_{avg} g \ X_{max}$	
Free fall energy	$mg (h + x)$	F_{avg} : average deployment force g : $9,81 m/s^2$ h : free fall distance
Balance of energy for a fall	$mg (h + x) = F_{avg} x$	m : total mass (body + tools) x : elongation of the energy absorber
Elongation for a fall	$x = \frac{mgh}{F_{avg} - mg}$	X_{max} : maximum elongation
Limit for the free fall energy	$mg (h + x) \leq F_{avg} X_{max}$	
Maximum free fall distance	$h_{max} = \frac{X_{max}(F_{avg} - mg)}{mg}$	

In 1992, the standard CAN/CSA-Z259.1-1M92 (R1998) Shock Absorbers for Personal Fall Arrest Systems describes one class of energy absorber with a maximum arrest force MAF set at $4kN$ (dry) and at $6kN$ (wet and frozen). The body mass varies considerably and so the masses of tools and clothing to be added to the body mass (HSE 2005 RR342); therefore a large total mass and a large free fall distance will generate energy greater than the capacity of an energy absorber (Arteau 2003).

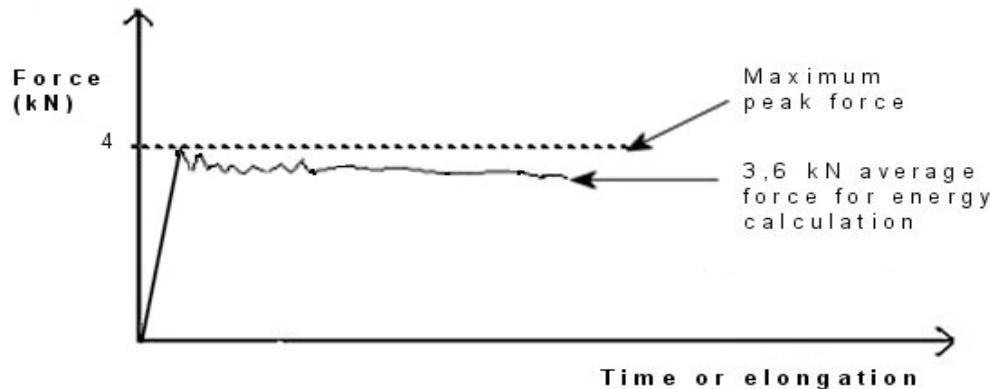


Figure 2: Mechanical behaviour of an E4 energy absorber – Force vs time (or elongation)

Two classes of energy absorbers were introduced in CSA Z259.11-05(R2010) Energy absorbers and lanyards standard: the E4 ($MAF=4\text{ kN}$) for a total mass between 45 kg and 115 kg and the E6 ($MAF=6 \text{ kN}$), for 90 kg to 175 kg. The actual classes are governed by the total mass but they do not take into account the free fall distance and the absorbing capacity. Further more E4 can be used by large persons with a limited free fall while E6 could not be used by small persons due to the maximum deceleration (10g). The users have some difficulties in making a correct selection. A graphical label incorporating the mass and the free fall distance is proposed to simplify the selection and to understand the limits of use.

3. Results

The maximum free fall distance vs the total mass is plotted to produced the figure 3. Any combination of mass and free fall distance that is under one curve is a safe condition of use for a given energy absorber. As example for a E6 energy absorber with $F_{avg} = 5,2 \text{ kN}$ (the open lozenge curve), a 130 kg mass and a 3 m free fall distance is safe.

4. Discussion and conclusion

Two aspects of the graphical label based on figure 3 require consideration: (1) the total mass and the free fall distance estimations and (2) the literacy of workers.

To use the figure 3 graphic, the total mass and the free fall distance must be estimated accurately. On worksites, workers do not currently use scales to measure their body and tools masses. The tool mass could be easily underestimated leading to overestimate the maximum allowable free fall distance. An E4 3,6 kN average deployment force energy absorber is used as example. The body mass is 80 kg, the tool and clothing mass is estimated at 10 kg but is really 20 kg leading to 100 kg as total mass; the maximum free fall distance varies from 4,3 m to 3,2 m, a 1,1 m overestimate, a possible error with dramatic consequences. The graphic shall be used with caution by trained personnel. A generous margin of safety must be given.

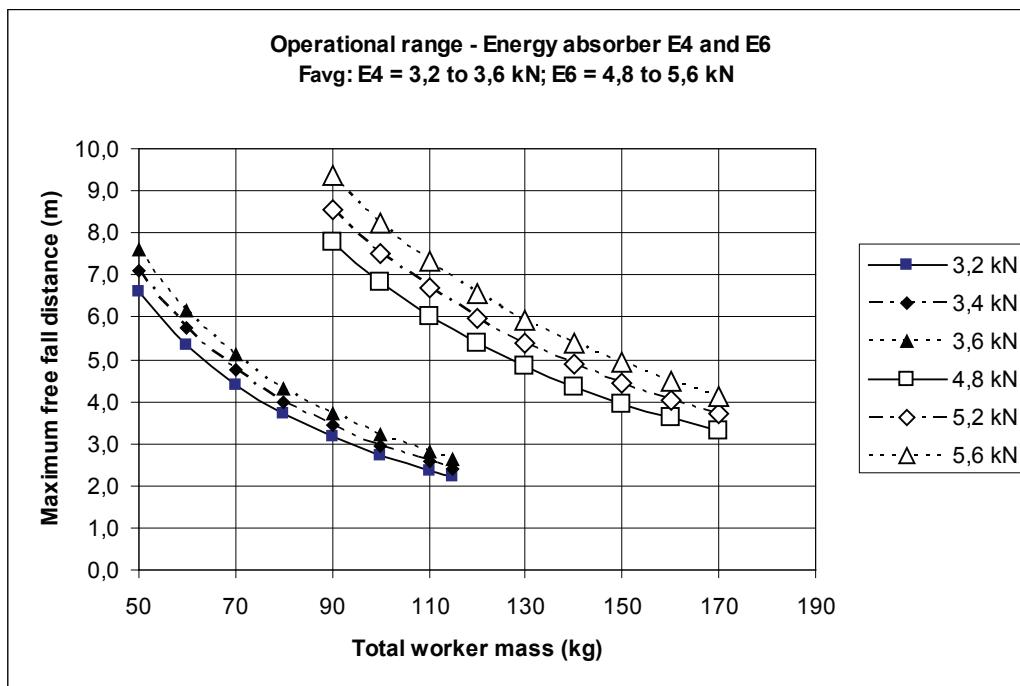


Figure 3: Operational range for E4 and E6 energy absorbers with different average deployment forces Favg. Any combination of mass and free fall distance under a Favg curve is safe. Favg is a constant for a specific model

In Canada, 20 % to 25 % of adults are illiterate to some extent (Le Devoir); therefore any written or graphical instructions are not understood even partially. The proportion of illiterates is larger within manual labourers, those more frequently exposed to fall hazard. The graphical label incorporating the mass and the free fall distance seems to be a good concept for technicians, OSH specialists and trained workers. For others, a strictly controlled limited free fall distance is necessary; a systematic selection methodology shall be used (Desjardins-David & Arreau 2011).

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59. Kongress der
Gesellschaft für Arbeitswissenschaft

Fachhochschule Krefeld
27. Februar bis 01. März 2013

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: Jahressdokumentation

Als Manuskript gedruckt. Diese Schrift ist nur bei der Gesellschaft für Arbeitswissenschaft e.V., Ardeystraße 67, 44139 Dortmund, erhältlich.
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Druck: City Druck, Heidelberg Technische Gestaltung: Stefan Cavadini
Printed in Germany



Gesellschaft für Arbeitswissenschaft e.V.

Jahresdokumentation 2013

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

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

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