Could you provide evidence to show the origin of the 6kN maximum arrest force for fall protection devices?

Analysis and evaluation of different types of test surrogate employed in the dynamic performance testing of fall-arrest equipment, Contract Research Report 411/2002 (HSE, 2002, Safety Squared) includes the following:

" … After discussing and emphasising the differences between falling and parachuting, it was concluded in Amphoux (1982) that it would be reasonable to half the upper tolerance limit of 12 kN to 6 kN as that acceptable for fall-arrest circumstances. This approach was also based on the crushing resistance of the spinal column, as most relevant in a feet-first trajectory fall. This was the limit accepted in the French technical standard for fall-arrest equipment, NF S 71-020 (1978), and has been accepted for modern-day European and International standards, e.g. EN 353-1 (1992) and ISO 10333-3 (2000), but it should be noted that these standards are based on a falling mass of 100 kg. In the American standard ANSI Z359.1 (1992) the French halving of the 12 kN figure to 6 kN was seen as arbitrary, and a limit of 8 kN was set, probably reflecting Canadian influence …".

Amphoux M.A. (1982) "Physiopathological Aspects of Personal Equipment for Protection Against Falls" in Sulowski A. C. (ed.) (1991) Fundamentals of Fall Protection pp 33-48, International Society for Fall Protection, Toronto.

Harness suspension: review and evaluation of existing information, Contract Research report 451/2002 (HSE, 2002, Paul Seddon) states:

"Amphoux raised the question of energy dissipation and described how the current figure of a maximum impact force of 6kN was decided:

"The second question concerns the dissipation of kinetic energy, consequence of the 'quantity of motion' acquired during the free fall. For a fall of four metres and a clothed worker of 80 kg, that makes more than 3,000 Joules to be absorbed. The human body's possibilities of absorption are limited, both for the complete human body and for some of the parts. Those limits are difficult to define. Data in the literature speaks more frequently of limits of tolerance to forces or pressures than to energy.

So, in practice, we measured the draw-back strength with a dynamometer between lanyard and the supporting equipment. Then we were able to compare this directly with the values measured in the same conditions at the moment of the opening of a parachute. In that moment, the strengths measured are frequently near 12 kN, without bad consequences. But parachutists are young, athletic, and have been given special training. They bale out voluntarily and have time to take the best position they learned before the opening. Rare accidents reported frequently occurred when the parachute opened with the body in an incorrect position.

The workers who fall are neither especially young nor specially trained. Moreover, they can't foresee their falling and will be stopped in any position, without essential protection of general muscular contraction learned by parachutists. So we thought it reasonable to propose an *upper limit for the acceptable maximum arrest force at **6 kN**. Some experts prefer 8kN, for technical more than physiological reasons. The probability of injuries is in direct ratio to the fixed limit, but it can't be calculated, for lack of possible tests."*

Amphoux pointed out that these values were only pertinent for a worker provided with a harness, by which he meant a full body harness …".

Survivable impact forces on human body constrained by full body harness, HSL/2003/09 (HSE, 2003, Harry Crawford) states:

"By the 1970s there was a beginning of access to the information learned from military and aerospace studies. In the UK, the source of such information was the RAF Institute of Aviation Medicine, Farnborough (Beeton, Ernsting, Glaister and Reader). The 1979 version of BS 1397 reflected this growing access in its test specification of 10G maximum for pole belts, 5G maximum for general purpose safety belts and chest harnesses, and 10G for general purpose safety harnesses. A special provision of 12.5G maximum, with full body harness, was made for coalmine riggers who had a preference for chain lanyards. All of these 1979 version tests were carried out with an "articulated anthropometric dummy" of 100kg. It is noteworthy that only full body harnesses are now considered suitable in fall-risk situations.

With the Treaty of Rome, 1975, and establishment of the European Community (later European Union) and the requirement for removal of barriers to trade, came the setting up of CEN. During the 1980's, working groups were formed with the aim of rationalising the various national standards. …

The working group (convened by Dr Maurice Amphoux) took account of the following factors:

- *Military parachute harnesses are designed with greater torso constraint than industrial harnesses, i.e. there is a greater risk of upper spine (cerebral vertebrae) injury in industrial harnesses, due to flexion.*

- *Industrial workers, in most cases, do not have the high level of physical fitness required of military personnel.*

- *Industrial workers include a probably wider age-band than military personnel exposed to fall arrest risks. The literature indicated deterioration of the spine for most at ages beyond 40 years (White & Panjabi [52], later Yoganandan [53]).*

- *The proposed increase in overall fall-height from 2m to 4m would cause increase in the duration of exposure to fall-arrest forces (it should be noted that France, through AFNOR standards, had adopted 6G maximum for FF 2 with 2m long lanyards during the 1980's).*

Such increase in the duration of exposure to impact would project fall arrest results beyond the force/duration data of Eiband and Stapp and their definition of impact (those researchers considered 'impact' to be an event that did not exceed 0.2s).

*These factors were accepted by the technical committee CEN/TC160, and **6kN** was adopted as the maximum arrest force for fall-protection devices used with industrial fullbody harnesses. The same norms have since been adopted for the relevant ISO standards. ...”.*

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