Note about fall energy

Changes in figure fall energy in revision 4 of the manual "Prevention of falling objects"

Based on feedback from several operators, SfS has made changes in the figure showing fall energy to be used for preliminary severity classification of falling objects. These changes are included in Revision 4 of the Handbook "Prevention of dropped objects".

The two lowest categories; 0-20 Joule and 20-40 Joule are unchanged even though the color between 20-40 Joule is changed from yellow to dark green. A fall energy between 0 and 40 Joule may result in the need for medical treatment (20-40 Joule) or first aid / no injury (0-20 Joule).

A fall energy of over 40 Joule was previously marked with red and described as being able to cause serious injury or death. A limit of 40 Joule for possible fatalities is viewed as very low and we are not aware of fatalities resulting from such a low fall energy (it is expected that a helmet is used). However, there are several cases where people have survived being hit by falling objects with much higher energy. As an example, SfS safety film No. 8 reflects a real event where a person got a 12kg scaffolding plank in the head from a height of 3.5m. Total fall energy is here over 400 Joule, although the real energy may be a little lower since the scaffold was partially slowed down by a pipe when it fell.

Furthermore, DROPS has provided a note (see attachment 1) which gives the technical background for DROPS own calculator / graphs. The main focus in this material is on fatalities and from the graphs one can read that deaths are thought to occur (but then with low probability) in the range of 100 to 140 Joule. For low weights (less than 1 kg), the DROPS limit is approximately 100 Joule but for a weight of 10 kg the limit is about 140 Joule. SfS has chosen to go with the average (120 Joule) as one then can relate to a single graph (i.e. a single Joule limit) where deaths are thought to occur. A final assessment of severity must nevertheless be done in each case.

In the area between 40 and 120 Joule, we have chosen to divide the area into 2 parts to reflect the categories that the Petroleum Safety Authority uses; serious personal injury and absence from work (LTI). Given that there is little literature and studies on this, we have chosen to divide the area between 40 and 120 Joule in two equal parts:
Fallen energy between 80 and 120 Joule (orange area) may result in serious injury
Fallen energy between 40 and 80 joules (yellow area) may result in a absence from work (LTI)

By comparison, Drops has a slightly different section and uses a limit of between 60 and 80 Joule (depending on weight) for absence injuries (DAFWC).

Attachment 1 : DROPS notes on their dropped objects calculator.

1 Introduction: The DROPS dropped object calculator has been developed over recent years in the DROPS forum. The technical background to the calculator spreadsheet is presented in this note.

2 Background:

From reference 1 page 20, the probability of human fatality due to impact from glazing is assessed on the basis of hits on the head causing skull fracture and hits on the body causing penetration injuries. The curve used for skull fracture is from Fletcher et al (reference 2). The criteria for injury are based on the critical velocity that a fragment of a given mass needs in order to cause injury.

From Figure 8 reference 3, on page 57 the probability of fatality or injury due to impact from cladding is presented based on the criterion for non-penetrating fragments; reference 4. The criterion is shown in Figure 1.

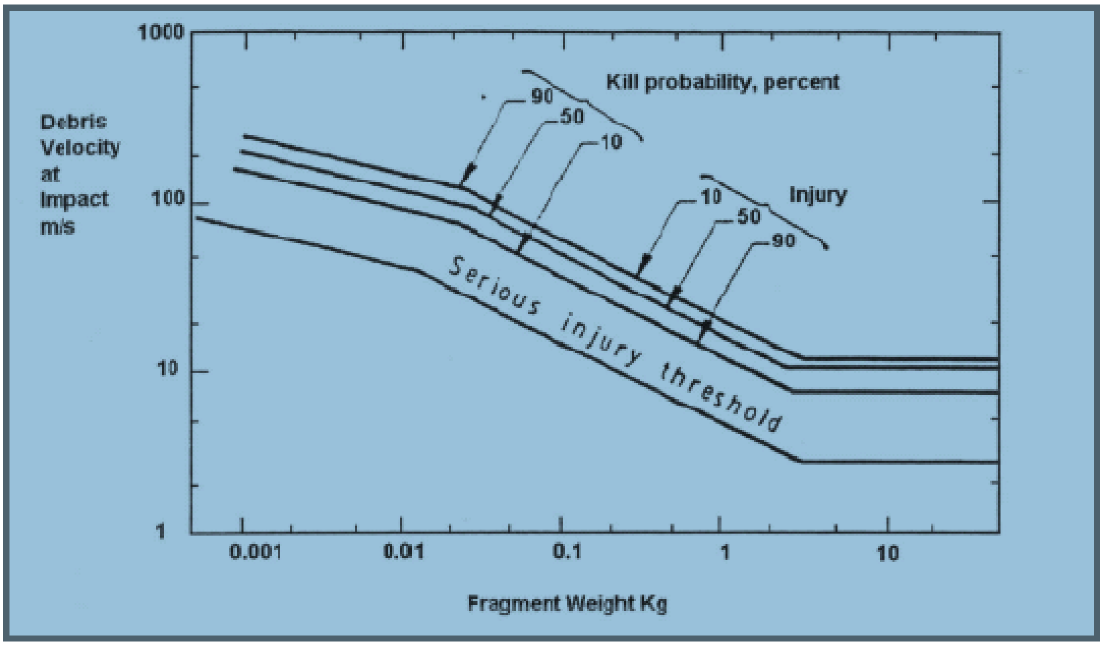


Figure 1 Personnel response to fragments impact (abdomen & limbs) from ref.4

Plotting "debris velocity at impact" versus "fragment weight", three distinct mass classes are presented. Thus the focus of the calculations is on the effect of an object of mass m (kg or lb) travelling at a velocity v (m/s or ft/sec) and the effect it has on the human body.

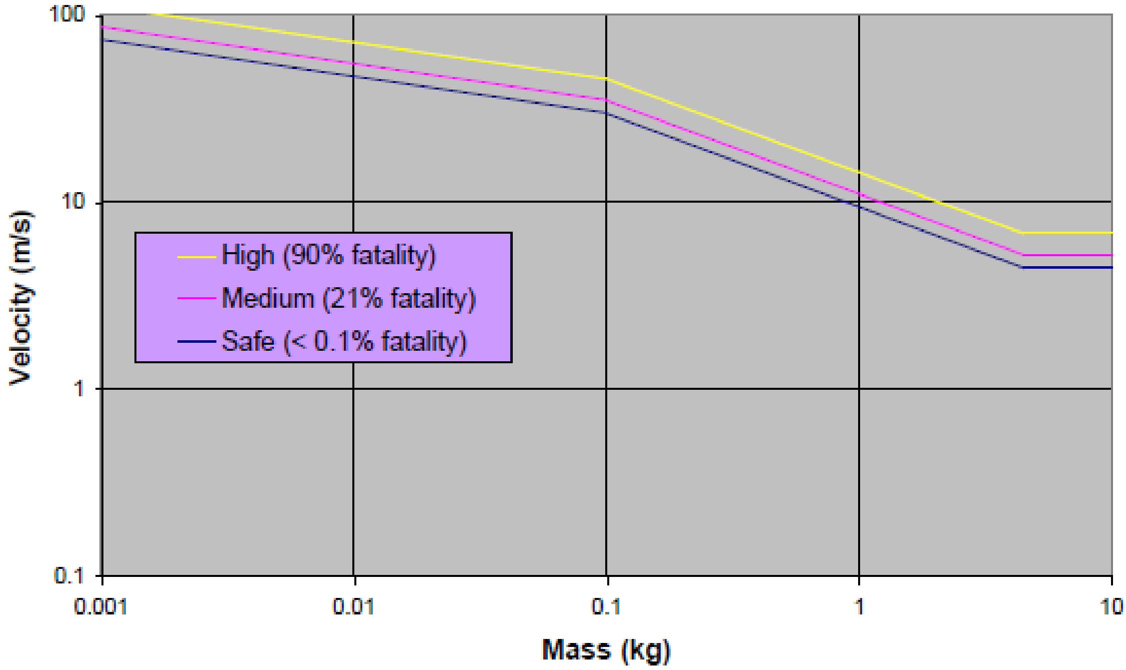
For the DROPS calculator, three classes of object size are also evaluated: less than 0.1 kg, 0.1kg to 4.5 kg and greater than 4.5 kg. The 0.1 kg threshold focuses on light objects such as shards of glass or metal. The 4.5 kg (10 lb) object has been the subject of research (page 44, references 3 & 5). The data presented in table 15 on page 44 is for a 10 lb missile and is taken from reference 6.

The DROPS calculator is based on page 27 of "The Green Book", reference 7, where similar to Figure 1, the probability of fatality has been assessed using set probability thresholds, which in this case are high 90%, medium 21% and safe, less than 0.1%.

Figure 2. DROPS fatality criterion (from reference 7)

For comparison with other dropped object assessment methods it is useful to record that for the 0.1 to 4.5 kg range, the corresponding threshold energy values are 103 Joules, 61 Joules and 44 Joules. The data presented in Figure 2 has modified prior to presentation as the DROPS calculator.

Modification 1



By assuming that no energy is lost and potential energy matches kinetic energy, the velocity of the dropped object can be re-expressed as a function of drop height so that:

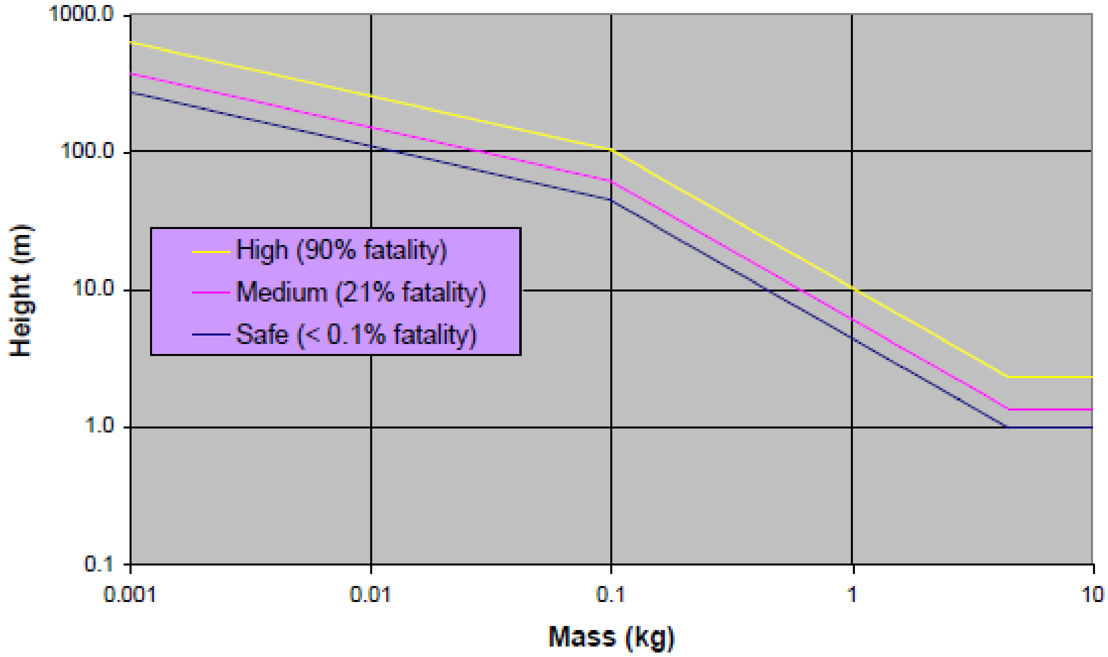
$$v^2 = 2*g*h$$

where
v = velocity (m/s)
g = gravitational constant = 9.81 m/s^2
h = drop height (m)

Using drop height h instead of impact velocity v, Figure 2 has been re-drawn as Figure 3

Figure 3. DROPS fatality criterion

Modification 2



With the focus on the heavier objects (greater than 0.1 kg) causing skull fracture, best-fit curves have been fitted to provide a smooth transition between 0.1 kg and 10 kg. With a change in name to the thresholds so that (Fatality = High, Medium = DAWFC, Recordable = Safe & First Aid for impacts less than Recordable) the curves are presented as the DROPS calculator, Figure 4.

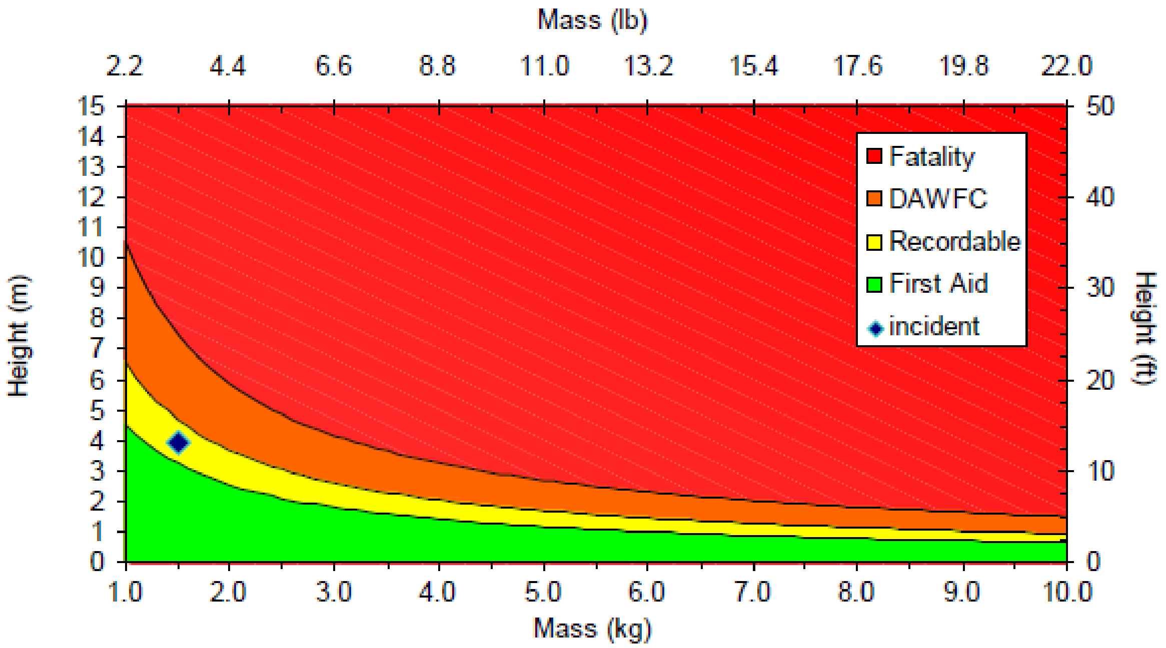


Figure 4. DROPS calculator

3 References:

1. ‘Derivation of fatality probability functions for occupants of buildings subject to blast loads. Phase 4’ WS Atkins Contract Research Report CRR 151/1997

2. ‘Glass fragment hazard from windows broken by Airblast’, Fletcher, Richmond & Yelverton, Lovelace Biomedical & Environmental Research Institute 1980

3. ‘Review of blast injury data and models’, Defence Evaluation & Research Agency (DERA) for the Health & Safety Executive (HSE) Contract Research Report CRR 192/1998

4. ‘Fragment Hazard Study’, Ahlers EB Minutes of the 11th US Department of Defence Explosives Safety Board (DDESB) Explosives Safety Seminar, Memphis Tennessee, 1969 pp81-107

5. ‘Explosion hazards and evaluation’, Baker WE, Cox PA, Westine PS, Kulesz JJ and Strehlow RA Elsevier Scientific publishing Company, Oxford 1983

6. ‘The Effects of Nuclear Weapons’, Glasstone S & Dolan PJ Castle House Publishing 1980

7. ‘The Green Book’. Committee for the prevention of Disasters TNO report CPR 16E Voorburg 1989