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Hammer cage and hammer developments

By Denis Wilson, Al Guy, Imre Matrahazi

ABSTRACT

Safety is a constant concern for hammer throwers, coaches, officials and meeting organisers. Improvements in technique and training methods mean that modern elite hammer throwers are capable of launching the implement at a higher velocity than throwers in the past. The issues that this has created include the size of the landing sector and the danger zone around the sector, hammer cage design, the strength of the netting used in the hammer cage and the design of the hammer itself (and its effect on the distance thrown). Over the past twenty years there has been a gradual evolution of both the IAAF Rules related to the event and the recommendations provided in IAAF Track & Field Facilities Manual. This article traces the various changes that have been made and provides insight into the reasons behind them.

AUTHORS

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Introduction

Over the past twenty years there has been a gradual improvement in various rules and designs related to the hammer throw to cater for the increased release velocity and distances thrown by elite throwers. The evolution of hammer cage design is summarised in Table 1. In this article we will discuss this evolution and changes to the design of the hammer itself. The aim is to inform officials and event organisers about the changes and thereby improve the safety of the event.

Twenty years ago

The basic plan of the hammer cage illustrated in the IAAF Handbook 1985-1986 is shown in Figure 1.

The netting at the rear of the cage had a minimum height of 5m and the two gates at the front were 2m wide with a minimum height of 5.5m. The netting at the back of the cage was shown as chords within a circumscribing circle with a 3.5m radius. The throws were into a 40° landing area sector. However, the danger zone for all throws was stated as being 85°. The netting of the cage was required to withstand a hammer travelling at

Table 1: IAAF Rule Changes for Hammer Cages since 1985-1986

IAAF Handbook Year	Min. Height Rear Netting (m)	Min. Height of Gates (m)	Maximum Speed of Hammer (m/s)	Min. Radial Clearance to Rear Netting (m)	Angle of Landing Sector (degrees)	Min. Cord Breaking Strength kgf
85/86	5	5.5	29	Circumscribed 3.5	40	130
94/95	7	9	29	Circumscribed 3.5	40	130
96/97	7	9	32	Circumscribed 3.5	40	165
00/01	7	9	32	Circumscribed 3.5	40	300
02/03	7	9	32	Inscribed 3.5	34.92	300
04/05	7	10	32	Inscribed 3.5	34.92	300
06/07	7	10	32	Inscribed 3.5	34.92	300*

* The netting specifications were removed from the Competition Rules and will be included in the IAAF Track & Field Manual 2006 Edition

a speed of 29m per second with the minimum breaking strain (sic) of the cord or wire being 130kg.

The hammer handle illustrated in the IAAF Handbook 1985-1986 is shown in Figure 2 with the description: "The grip may be either of single or double loop construction, but must be rigid and without hinging joints of any kind. It must not stretch appreciably while being thrown. It must be attached to the wire in such a manner that it cannot be turned within the loop of wire to increase the overall length of the hammer,"

Gradual Improvements

Concern that throwers could throw over the existing cage was remedied in the 1994-1995 IAAF Handbook by increasing the minimum heights of the rear netting of the cage and

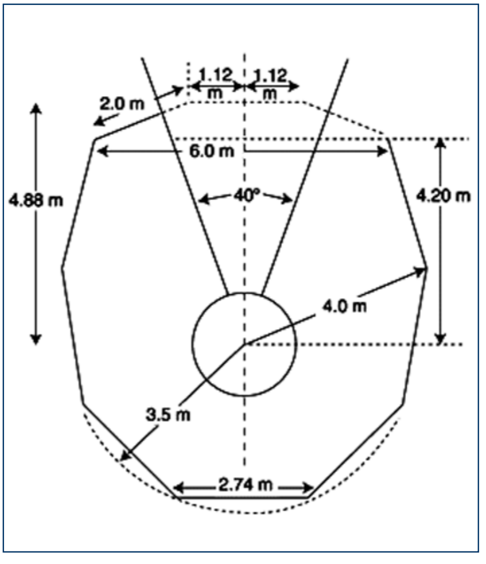

Figure 1: Official hammer cage design 1985-86 (IAAF Handbook 1985-1986)

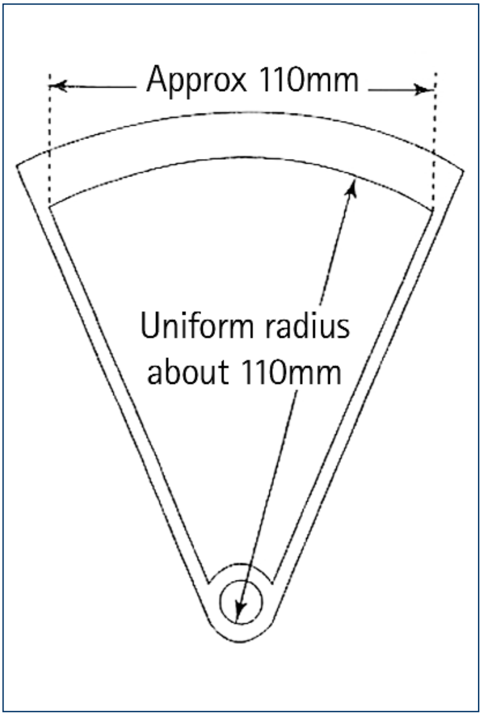

Figure 2: A suitable handle, IAAF Handbook 1985-1986

the gates to 7m and 9m respectively. The basic layout plan as shown in Figure 1 was retained.

When the IAAF Track & Field Facilities Manual was first published in 1995 the comparable figure in the Manual had the rear netting of the cage as chords to an inscribed circle with a 3.5m radius. This discrepancy between the two "bibles" was eliminated by changes to the IAAF Handbook 2000-2001.

After several deaths in throwing accidents and the decision by the 2001 IAAF Congress to reduce the landing sector angle to 34.92°, there was greater urgency to improve the hammer cages as well. ACT Athletics (Canberra, Australia) was commissioned by the IAAF in 2002 to prove the practicability of having effectively smaller discus and hammer cage openings by conducting field tests using athletes. These tests were undertaken at the Australian Institute of Sport (AIS) in Canberra, Australia, with the cooperation of AIS athletes and the collaboration of Cardno Young Con-

Photograph 1 - Hammer Cage at the Australian Institute of Sport in Canberra, Australia

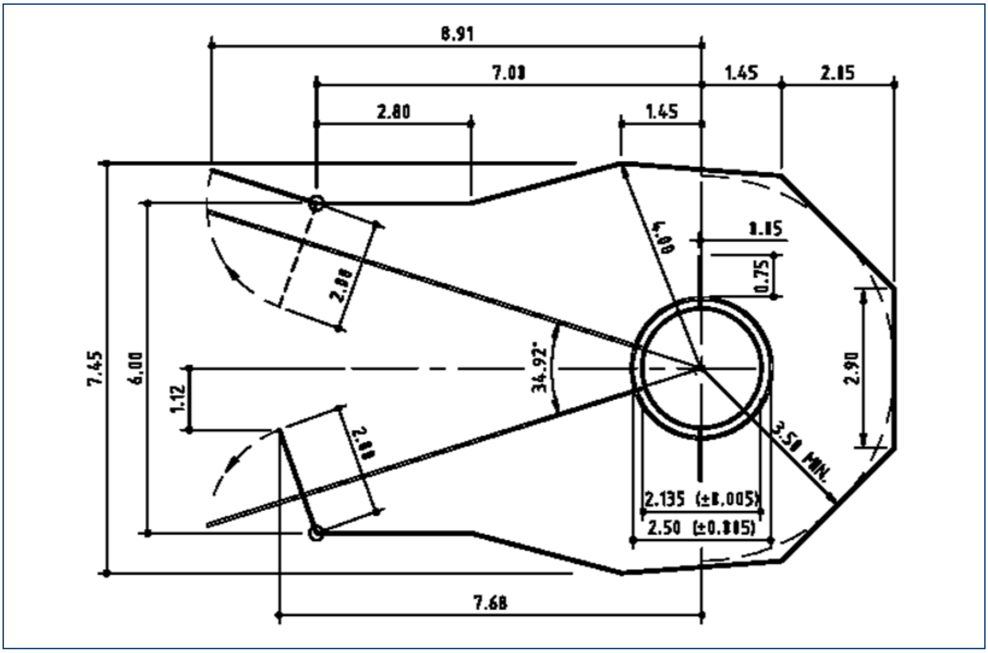

Figure 3 - Combined discus and hammer cage with concentric throwing circles (dimensions in m)

sulting Engineers, designers of the AIS combined discus/hammer cage. The cage has a plan similar to Figure 1 but with the heights and detail meeting the IAAF Handbook 2000-2001 requirements. The gates' netting is suspended from gallows type frames as shown in Photograph 1. The gates were temporarily increased in length from 2m to 2.84m and 3.5m. This also corresponded to discus cage side lengths from the centre line of the circle of 7.04m and 7.70m when the gates were both opened.

The effectiveness of increasing the width of the hammer cage gates in reducing the danger zone was proven.

Subsequently, the IAAF received a new cage design proposal submitted by a group of elite Hungarian hammer throwers. It was based on their experience with the cage at the IAAF Accredited Training Centre in Szombathely, Hungary, the venue for IAAF World Athletics Final in Hammer Throwing from 2003 to 2005. This design kept the 6m wide cage opening and 2m wide gates but inserted two additional 2.8m long side panels so as to better protect throwers from hammer rebound from the cage gates while keeping the same effective opening width. This proposal was adopted by the 2003 IAAF Congress in Paris and was included in the IAAF Competition Rules 2004-2005. It is illustrated in Figure 3. As in this design the gate pivot points are 7m from the centre of the circle, the trajectory of the hammer necessitated that the minimum height of the additional two side panels and the gates be increased to 10m.

The IAAF recognised that other cage designs can provide the same size danger zone as the more elaborate Szombathely design. Some possible alternative designs were canvassed in an article published in New Studies in Athletics[1]. The AIS cage in Canberra (Photograph 1) has had its gates lengthened from 2m to 3.2m in a relatively simple and cheap operation to meet current IAAF safety requirements.

One side effect of the new design regulations is that when separate hammer and discus circles are located within the same cage, the discus circle must be located in front of the hammer circle.

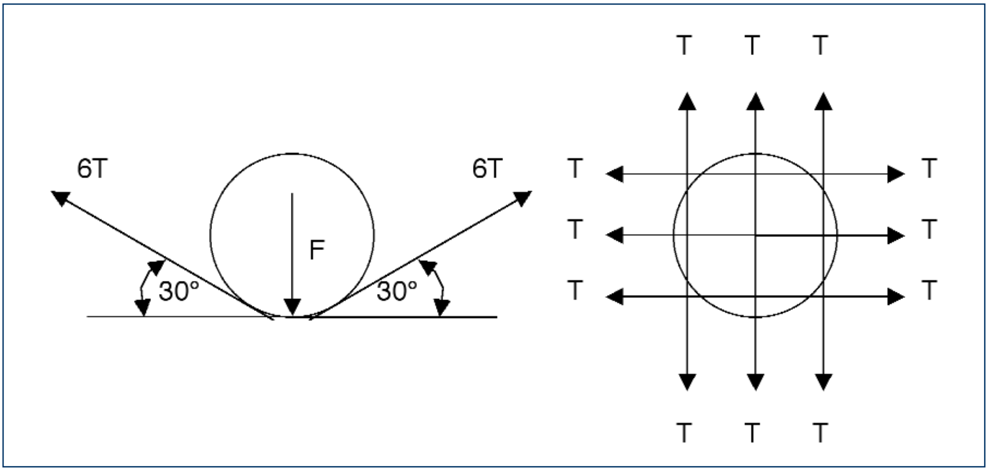

Figure 4 – Netting cord theoretical reaction to a hammer impact

Netting

Studies of elite throwers have shown that the maximum release speed of the hammer has increased over the years. In the 1996-1997 IAAF Handbook the netting was required to withstand a hammer travelling at 32m/s and the corresponding minimum breaking strain (sic) of the netting cord was increased to 165kg. A paper[2] presented to the 1998 meeting of the IAAF Technical Committee showed that the 165kg minimum breaking strength of the cord could be easily exceeded if the hammer hit the netting near a point of support. The very simplified calculation illustrated in Figure 4 assumes that at the point of contact six cords in two directions at right angles stop the hammer within 0.4m.

The kinetic energy of the hammer at 32m/s:
$0.5mv^2 = 0.5 \times 7.26 \times 32 \times 32 = 3717Nm = 3.717kJ$

The energy absorption of the netting:
$0.5 \times 0.4 \times F = 3717$

$F = 18\,585N$
$12T \times \sin 30° = 18\,585$
$T = 3098N = 316kg$ force

The Technical Committee agreed, as an interim measure, to increase the minimum breaking strength of netting cord to 300kg and this figure appeared in the IAAF Handbook 2000-2001. The netting in fact absorbs the kinetic energy of a striking hammer by more complex strain energy distribution in the netting meshes at the point of impact. If the point of impact is not close to a support more of the netting provides strain energy resistance. Close to a support the netting mesh struck is less able to distribute the load to surrounding mesh so that it is more likely that the mesh cords will be stretched to breaking point. The weight of the netting also can affect the reaction of the netting to a hammer strike particularly when the hammer hits the netting well away from the supports so that a large area of netting is moved.

Subsequent papers presented to the Technical Committee by the same author indicated that the only international testing standard that simulated the dynamic conditions close to those experienced by a hammer cage net was EN 1263-1: 1997 “Safety Nets: Safety Requirements, Test Methods” in which a 100kg sphere is dropped 7m into the netting being tested. The kinetic energy of the test sphere at impact is 700kgf.m (6860Nm) that takes into account deterioration of the netting due to ultraviolet light degradation of the netting and provides a factor of safety of at least 1.5 over the assumed maximum breaking energy of 4.4kJ. Similarly, the static strength of netting is tested by the application of tractive power to a smooth surfaced steel ball

(500mm diameter and 100kg mass) at constant speed until the netting is ruptured.

Type B nets complying with EN 1263-1:1997 have minimum breaking energies of 4.4kJ compared with the theoretical maximum energy 3.717kJ imparted by a hammer. Therefore, prima facie, it is assumed that Type B netting that meets EN 1263-1:1997 requirements will also be suitable for hammer cage netting. The new and additional requirements will be included in the 4th edition of the IAAF Track & Field Facilities Manual rather than in the Competition Rules. This in keeping with the decision taken by the Technical Committee, after the publication of the first edition of the Manual, to move detailed technical requirements for design and construction of facilities, and/or checking of facilities in advance of an event from the Competition Rules to the Manual.

Hammer Design

The Technical Committee was increasingly concerned that elite throwers were able to throw onto the track in cases where the cage is located on the infield. In 2000 the IAAF commissioned a study by Hungarian investigators[3] on possible changes to the weight and/or length of the hammer so as to limit the distance thrown. A summary of the results of the study is given in Table 2.

The Technical Committee considered that such radical changes to the hammer would change the nature of the event detrimentally. Instead, it opted at its 2001 meeting to recommend that the landing sector angle be reduced to 31.92°. In the event, the 2001 IAAF Congress only reduced the landing sector to 34.92°.

During the men's hammer throw final at the 2000 Olympic Games it was discovered that the hammer being used by all the throwers had stretched some 9mm during the competition as the side wires of the hammer handle were pulling out of the grip. The same defect was found in the same model of hammer handle used at the warm-up track.

In IAAF Handbook 2002-2003 and subsequent editions, changes were made to Rule 191.7 (the dimensions of the handle and its specification) in an endeavour to improve the reliability of the handles. The current wording as compared with that of 1985-1986 given above gives the following additional specification:

Table 2 - Comparable Theoretical World Record Distances for varying hammer weights and lengths

Comparable World Record (m)	Hammer Weight(kg)	Hammer Length (mm)
40-45	13.00	900
	12.00	700
45-50	10.00	700
	12.00	900
50-55	8.00	600
	11.00	800
55-60	9.00	800
	7.26	700
	10.00	1000
60-65	9.00	1000
	7.26	800
65-70	9.00	1100
	7.26	900

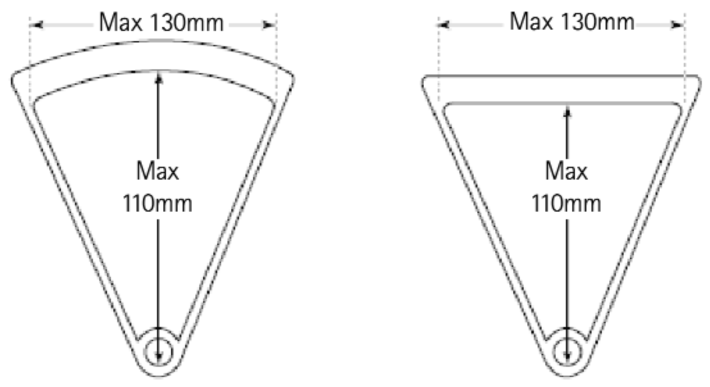

Figure 5 - Examples of hammer handles from the IAAF Handbook 2006-2007

"The handle may have a curved or straight grip with a maximum width inside of 130mm and a maximum length of 110mm. The minimum handle breaking strength shall be 8kN (800kgf). The sides of the handle may be straight or slightly curved where the sides meet the grip so as to provide greater room for the thrower's hands.

Note: The strength of a handle shall be determined in accordance with the procedures given in the proposed IAAF Calibration Handbook to be published later."

The School of Aerospace, Civil and Mechanical Engineering, University of New South Wales, Australian Defence Force Academy, Canberra was engaged by the IAAF to develop a test for determining handle breaking strength and to test manufacturers' hammer handles. The test procedure developed is currently being used to test more handles. It is anticipated that a paper will be submitted when the current work is completed.

Conclusion

The new hammer cage design has worked well in terms of reducing the risk of hammers landing on the track, as the maximum danger zone has been reduced from 85° to 53°. However, the cages are large and expensive and there is concern that they encroach on the infield to an extent that it affects its use of for other sports.

More information is now available for manufacturers, facility owners and technical judges who have to ensure that the cage netting remains strong enough to stop hammers effectively.

Investigation work on manufacturers' new hammer handles is ongoing.

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