TECHNICAL GUIDELINES

THROWING CAGES - SAFETY CAGES

TRACK AND FIELD FACILITIES MANUAL, CHAPTER 6.3 - EQUIPMENT FOR THROWING EVENTS – UPDATE 2020

(In addition to the Technical Rule requirements, special requirements are detailed here.)

6.3.2 SAFETY CAGES

Hammer and discus shall only be thrown from an enclosure or cage to ensure the safety of spectators, officials and athletes. (Figures 2.4.1.2 and 2.4.2.2) The maximum danger sectors and the theoretical way of calculating these danger sectors for discus and hammer throws are shown on these figures. The same principles can be used to compare the effectiveness of different cage configurations and how the cages on the side closest to the implement release may restrict the implement, particularly the hammer, from landing within the landing sector.

Cages specified here are intended for use in major stadia in high class competition when the event takes place outside the arena with spectators present or when the event takes place in the arena and other events are taking place at the same time. Simpler and smaller cages may be adequate for competition of lower standard and for well-regulated training facilities.

Every competition and training venue should have danger zone diagrams prepared and displayed at the venue for each of its throwing facilities so that the facility manager, the technical officials and/or coaches are aware of the dangers and schedule events and training accordingly, as well as take normal safety precautions.

Advice is available from national federations or from the World Athletics Office.

Hammer cages may also be used for Discus Throw competition either by installing 2.135m/2.50m concentric circles (Figure 6.3.2) or by using an enlarged Hammer cage design but with a Discus circle installed in front of the Hammer circle. This latter construction is not recommended because of the cost involved, the space requirements and the effect on viewing.

The design of cages and in particular the gates in the case of a Hammer cage can be innovative provided that they give the same degree of protection as a conventional design and the relevant danger zone is not increased. The number of supporting posts may be reduced provided that the netting at the sides and to the rear of the circle is not closer than shown in Figure 6.3.2. This also means that if the gate netting pivot point is 4.2m from the centre of a combined discus hammer circle with 3.2m wide gates then in the discus throw configuration the gate netting should be parallel with a 6.0m wide opening not as shown in the Technical Rules. It is permissible for the near side gate to be drawn aside as shown for hammer throwing in Figure 6.3.2 for discus throwing.

The gates should be constructed so that they can be quickly moved during competition. The netting on gates of metal construction shall be hung at least 0.6m clear of the metalwork.

The nets, supporting structure and the footings shall be designed by a professional structural engineer to withstand a design wind speed commensurate with the proposed use with a minimum factor of safety

against overturning of 2 for cages with in-ground footings and 4 for free-standing cages. If a cage is to have the netting remain in place, then it should be designed for the 1 in 50 years maximum wind gust for the locality in the direction that creates the maximum load on the cage component. Where necessary geotechnical advice on the site conditions shall be obtained.

Manufacturers shall disclose the design wind speed to purchasers and in their documentation noting also the soil conditions for which the footings have been designed. When in doubt professional engineering advice should be sought. In addition, the design wind speed together with cage model number shall be indicated on an engraved plaque affixed in a prominent location on a post.

The whole construction, including handling equipment, shall be designed so as minimise the possibility of an implement striking a hard surface by suspending the netting well clear of supports and padding hard surfaces where necessary.

The centreline from the circle centre to the centre of the cage mouth must correspond with the centreline of the landing sector. Therefore, the orientation of the cage must be agreed with local technical officials before the cage footings are set out. Also, the orientation must ensure, as far as practicable, that the limits of the danger zone taking into account implement skidding do not reach the oval track or other field event sites.

Manufacturers should provide detailed setting out drawings and installation instructions, including footing designs, maintenance and operation instructions for the cage including the gates, net tensioning and anchoring.

The leading edge of the ends of the netting should remain vertical during windy conditions.

The desirable properties of any safety cage are the following:

- The cage structure and the netting meet the dimension requirements of the World Athletics Rules*.

- The netting cord must be strong enough so that it does not break under the impact of the implement, abrade where it is attached or deteriorate unduly under the effects of ultraviolet ray exposure*.

- The net can be quickly raised and lowered*.

- There is positive attachment of the netting at ground level which maintains the net in correct relationship to the throwing circle(s) particularly in windy conditions and there is sufficient netting at ground level so that an implement cannot penetrate under the netting (preferably a minimum of 30cm adequately anchored).*

- The netting when blown by wind does not impede the athlete making a throw (at no time should netting be tied to the cage superstructure).*

- The gate pivot posts and any gate metal frame should not be exposed so that it can be hit by an implement causing damage to both.

- The netting shall be hung clear of the support posts by at least 0.60m and arranged so when the gate is closed that the posts are not struck by a thrown implement*.

- The volume of netting needs to be sufficient to minimise rebound of implements but not slack enough to allow implements to push netting against the supporting structure.*

- The gates shall be easy to open and close manually quickly with a positive positioning arrangement in the fully open and closed positions.

- The leading edge of the gate netting must maintain a vertical line in order to maintain the integrity of the danger zone. This means that a tensioning of the leading edge will generally be required at each anchor point i.e. open and closed position.*

- The gates shall maintain their integrity under long term usage.

- The supporting frame shall be stiff enough so that it does not deflect out of position unduly under the weight of the net and the force of wind*.

- The cage should be easy to install and remove preferably without heavy lifting equipment*.

- The cage structure should not unduly block the spectator view of the track events when the netting is lowered*.

- Maintenance procedures required to maintain the safety of cage before, during and after competition must be provided. The users and maintenance staff should be regularly reminded of these procedures*.

* These properties also apply to a stand-alone discus cage.

6.3.2.1 Necessary Safety Precautions

National safety regulations may require tests in addition to those listed. However, the following are considered to be the minimum safety tests and requirements:

- Careful and regular check of all materials, joints, bolts, lifting mechanisms and supports before each competition season.

- Inspect netting and repair, if necessary, before each competition.

- Test netting materials at least once per year.

If fibre netting is used, several sample lengths, minimum 2 metres long, or several sample mesh pieces should be worked into the net by the manufacturer. One of these samples should be removed and tested at least annually to confirm the continued strength of the netting.

The netting cord must be strong enough so that it does not break under the impact of the hammer, abrade where it is attached or deteriorate unduly under the effects of ultraviolet ray exposure.

The cage must be properly operated during training and competition.

6.3.2.2 Hammer Cage (Figure 2.4.2.2)

The Hammer cage shall be designed, manufactured and maintained so as to be capable of stopping a 7.26kg hammer moving at up to speeds of 32m per second. This equates to a kinetic energy of 3.72kJ. It may be assumed that Type B1 netting with a minimum breaking energy at end of life of 4.4kJ as defined in EN 1263-1 will meet this requirement.

The netting which may be of suitable natural or synthetic fibre cord or of mild or high tensile steel wire should be arranged so that there is no danger of the hammer ricocheting, rebounding or forcing its way through joints in the netting or panelling, or under the netting.

The minimum height of the netting at its lowest point shall be 7.00m at the rear of the cage and at least 10m for the last 2.80m panels to the gate netting pivot points. There must be adequate attachments of the netting at ground level and at the top, which maintains the net in correct relationship to the throwing circle under windy conditions.

The maximum mesh size for wire netting shall be 0.05m and, for cord netting, 0.045m and the minimum breaking strength of cord or wire shall be 300kg. Alternatively, the energy absorption of the mesh shall meet the dynamic test principles laid down in EN 1263-1 such that the netting will withstand an object 100kg mass being dropped into the netting from a height of 7m.

The netting may be in sections or in continuous form hung from a well-supported and braced framework. It is desirable that the netting can be raised and lowered quickly. In any construction the minimum distance from the centre of the circle to any point on the cage netting shall be 3.50m. The netting shall be hung at least 0.60m clear of the support posts or frame so that a thrown implement cannot strike the posts or frame when the netting moves under the impact. The netting should be of sufficient length and arranged so that when a gate is closed the netting is not moved closer to a supporting post. The netting will need to have ropes threaded through it from each post cantilever arm to ground anchors so as to minimise movement of the netting under wind and implement impact and be arranged as for a tent guy so that the rope can be tensioned.

The supporting structure shall be rigid enough so that it does not deflect out of position unduly under the weight of the netting or the force of the wind.

The width of the cage at the mouth should be 6.00m when measured to the insides of the netting positioned 7.0m in front of the centre of the Hammer circle for the entire height of the opening. Two movable netting panels 2.00m wide and at least 10.00m high shall be provided at the front of the cage. These panels shall be constructed and erected so as to allow the panels to be opened and closed to suit "right-handed" and "left-handed" throwers. The structures supporting the front panels (gates) shall be easy to open and close manually and constructed so that they can be secured firmly in the fully open and closed positions.

The heights shall be measured to the lowest point of any netting catenary.

This cage is suitable for Discus Throw.

The Technical Rules indicates that for concentric circles in discus throwing configuration the Hammer cage gates should be fixed parallel to the closer landing sector line. This will reduce the danger zone to approximately 62˚ without impeding a throw. However, there is the opportunity for the danger zone to be further reduced by moving a gate closer to the sector line without impeding a throw. The national federation should advise where they want the gates to be positioned for discus throwing.

A cage that has a World Athletics Product certificate does not ensure that it meets the Technical Rules unless it is installed exactly as shown in installation drawings and instructions, is operated and maintained correctly.

6.3.2.3 Discus Cage (Figure 2.4.1.2)

The cage should be designed, manufactured and maintained so as to be capable of stopping a 2kg discus moving at speeds of up to 25.00m per second. This equates to a kinetic energy of 0.63kJ.

The netting which may be of suitable natural or synthetic fibre cord or of mild or high tensile steel wire should be arranged so that there is no danger of the discus ricocheting or rebounding or forcing its way through joints in the netting. It shall be at least 4.00m high at the rear of the cage but rising to at least 6m for the last 3m to the mouth. The heights shall be measured to the lowest point of any netting catenary. The end of the cage side particularly adjoining the track may be of greater height and/or length to the minimum dimensions specified so as to prevent a wayward discus landing on the track or beyond during a Discus Throw competition by going over the netting or past the end of the netting.

The maximum mesh size for wire netting shall be 0.050m, and, for cord netting, 0.045m. The minimum breaking strength of the cord or wire at any time shall be 40kg. Alternatively, the energy absorption of the mesh shall meet the dynamic test principles laid down in EN 1263-1 such that the netting will withstand an object 15kg mass being dropped into the netting from a height of 7.00m.

The netting may be in sections or in continuous form hung from a well-supported and braced framework. It is desirable that the netting can be raised and lowered quickly. In any construction the minimum distance from the centre of the circle to any point on the cage shall be 3.00m. The netting shall be hung at least 0.60m clear of the support posts or structure so that a thrown implement cannot strike these. The netting will need to have ropes threaded through it from each post cantilever arm to ground anchors so as to minimise movement of the netting under wind and implement impact and be arranged like a tent guy rope so that the rope can be tensioned.

The supporting structure shall be rigid enough so that it does not deflect out of position unduly under the weight of the netting or the force of the wind.

The width of the cage at the mouth, measured to the inner edges of the cage netting, should be 6.00m positioned 7.00m in front of the centre of the Discus circle.

This cage is not suitable for Hammer Throw.

A cage that has a World Athletics Product certificate does not ensure that it meets the Technical Rules unless it is installed exactly as shown in installation drawings and instructions and is operated and maintained correctly.

THROWING SAFETY CAGES STRUCTURAL DESIGN GUIDELINES

Introduction

These guidelines are provided for the information of the safety cage manufacturers and their professional structural engineers.

It is expected that the cages including their footings or counterweights, in the case of free-standing cages, will be designed in accordance with applicable national or international standards and these guidelines. The number of the standards and the clauses used shall be quoted against the parts of the calculation.

Free-standing cages and cages, the posts of which can be readily removed, may be regarded as temporary structures.

As the cages will be installed in a variety of locations the worst exposure and the poorest ground conditions situations shall be assumed.

The cage design wind to be stated in the manufacturer's documentation is assumed to be measured by a wind gauge with the anemometer positioned 1.2m above the ground level parallel to the direction of the wind being experienced at the time.

All documentation should indicate that the cage is to be installed on level ground. This must be particularly emphasised for free-standing cages.

Design Criteria

The designer will determine the loads likely to be experienced by the cage in accordance with appropriate national or international codes which shall be quoted. The most significant load for a cage is wind loading. The manufacturer may nominate a maximum wind velocity (measured as indicated above when the netting must be completely lowered) or the designer shall assume the maximum exposure situation.

The designer shall determine the worst wind direction situation for the cage which is likely to be one perpendicular to the face of the netting on one side of the cage where the weight of the netting marginally increases the overturning moment on a post caused by the wind.

Please note that throwing cages used at international competitions requiring Construction Category I, II or III as defined in the Track and Field Facilities Manual Chapter 1 must be designed for a wind 15 m/s or greater.

Wind Loading

Wind force $F = c \times q \times A$, where c = form factor, A = area(s) on which the wind is acting, q = wind pressure = $0.5\rho \times v^2$, where v = design wind velocity, ρ = air viscosity.

The form factor c may be determined from the appropriate code taking into account the positive and negative pressures on the element.

The area of netting exposed to the wind depends on its porosity factor i. For example, a 45 x 45 x 5mm cord diameter net will have a porosity factor i = $(45^2 - 40^2)/45^2 = 0.21$

The overturning moment at the base of the post for the wind load and dead load might be simply calculated as shown on the attachment.

Any computer programme used in the calculations should be identified and the input loads clearly indicated. In most designs, it is not necessary to use a computer programme to the loads carried by each post and its footing.

Footing Design

The footings shall be designed for the design wind load resulting bending moments plus dead load vertical and horizontal reactions such that the soil bearing pressures are not exceeded for the poorest assumed ground conditions at least sandy clay. Alternatively, a range of ground conditions may be assumed and different footing sizes provided for each ground condition.

The footings design shall be based on established soil mechanics practice.

The footings may be simple mass concrete blocks, reinforced spread footings or concrete piles. In many situations, bored piles may be the cheapest solution.

Throwing cage posts loads are similar to those carried by sign posts, lamp posts and flagpoles, as the greatest horizontal load and bending moment is that caused by wind on the netting and the post. The largest vertical load on the foundation is that from the weight of the footing.

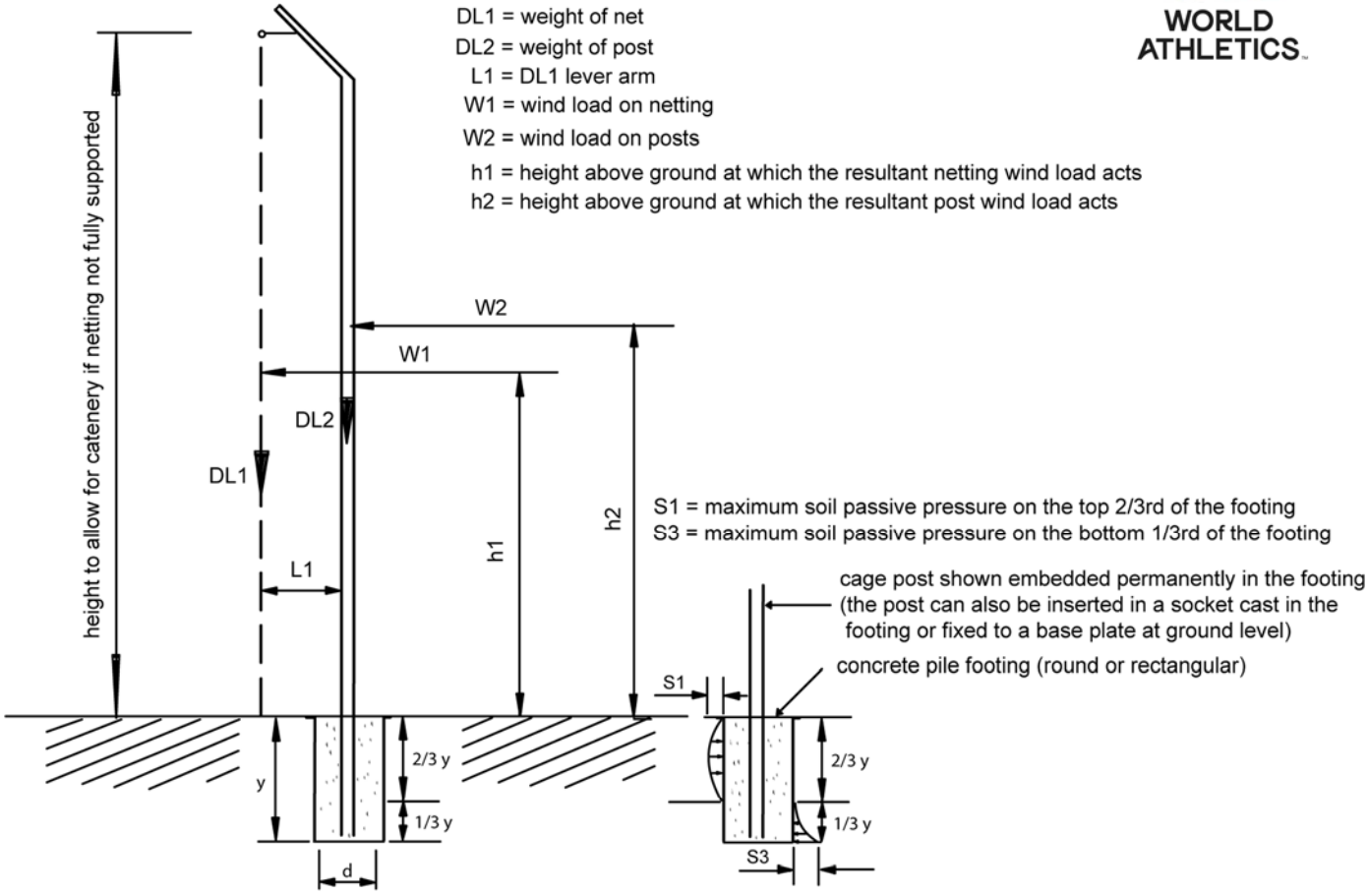
Under wind loading, the post and the footing can be allowed to move enough that a lateral passive soil reaction is applied to the side of the concrete footing (as the footing pivots slightly, passive soil pressure on opposing sides of the footing resists the movement).

The passive soil reaction at depth y = u × y × d × Kp, where y = depth of the footing, u = unit weight of soil, d = diameter (or breadth if it is rectangular) of the footing, Kp = coefficient of soil passive pressure. $Kp = (1 + \sin \phi) / (1 - \sin \phi)$, where ϕ = soil internal angle of friction.

The allowable soil pressure under the base of the footing is a higher value than the allowable lateral pressure.

There are a number of theories as to how the soil reacts to the horizontal force and moment applied to the footing. For simplicity, it is sometimes assumed in US practice for masts and posts that the post footing pivots at 1/3rd the depth of the footing above the base of the footing with the maximum soil passive pressure on the upper part of the footing S1 = 0.33 × S3, where S3 is the allowable maximum soil passive pressure at the bottom of footing. This is illustrated in the figure below.

If empirical data is relied upon in determining the size of the footings, the source documents shall be quoted.



SIMPLIFIED CAGE LOADING

FOOTING ASSUMED SOIL PASSIVE PRESSURE PROFILE (not to scale)
(under wind loading from right)

Post Overturning Moment at Base = W1 × h1 + W2 × h2 + DL1 × l1

The cage must meet all the new World Athletics requirements, each cage design application should provide:

- Fully dimensioned drawings of the cage and its footings which show inter alia the set-out; the overhang dimension of the netting from the posts, post material and dimension, the size of the footings, concrete quality and reinforcement;
- Wind load and structural calculations (by a professional structural engineer, in English) for the structure and its footings for various soil conditions to prove that the posts have adequate strength and there is a minimum factor of safety of 2 against overturning for footings in the ground and of 4 for free-standing cages relying on counterweights for stability at the design wind speed;
- Detailed instructions for setting out and installing the footings, gate fixing anchors (hammer cage), cage structure and the netting;
- Detailed instructions for gate operation and anchoring (hammer cage), and netting tensioning and anchoring;

- Details of the netting dimensions, strength and the specifications.
- The installation, operation and maintenance instructions and all documentation should be mandatory in English
- Detailed instructions for the periodic safety inspections of the cage and its fittings.

Once World Athletics is satisfied with this detail then a World Athletics inspector will examine an example of the cage at the manufacturer's expense using the proforma inspection report to check the adequacy of the cage and its ease of operation. The inspector may recommend improvements to the cage.

All existing cage designs should also be reassessed against the updated design criteria in the revised Manual particularly the minimum clearance of netting from posts. All the manufacturers should post on their websites the safe design wind speed for each of their certified cages.

ADVICE TO TECHNICAL OFFICIALS AND FACILITY OWNERS

Existing Cages

Many of the older cages were not designed for the netting to remain in place after the completion of a competition or a training session.

World Athletics, since requiring more information from manufacturers seeking a Product Certificate for their cage, has found that some cages in fact have quite low design wind speeds. World Athletics has now determined that cages that are to be used for major international competitions shall have a design wind speed of 15m/s or greater.

The minimum design gust wind speed for permanent structures designed by ultimate limit state analysis is according to the local regulations.

It is therefore suggested that there should be appropriate instructions promulgated at each venue when the cage netting must be lowered so as to protect the investment.

New Cages

Before purchasing a new cage, determine how you want to operate and maintain the cage.

The selection of cage type will also depend upon:

- Security of site
- Accessibility of public/unsupervised users
- How cage and netting is to be maintained
- Potential for damage e.g.; fire risk (nearness of vegetation), vandalism, misuse by users

Use of chain wire instead of cord netting could be a considered as an alternative particularly for training venues.

Hammer cages with metal framed gates are not recommended as the gates and their netting are very prone to damage from hammers, the gates are often very difficult to move particularly in a strong wind and if not locked firmly in the open or closed position can swing around and demolish a cage.

There are some designs with hung netting gates or sliding netting gates available.

Can the cage structure stay in place permanently? If not, how will the cage structure be installed or removed quickly without heavy lifting equipment?

The posts and anchor points can either be installed in sockets set into the post footings or attached to a fixed or hinged baseplate set into the footing. The latter may be the better solution.

If a cage structure can remain in place, then a cage with posts permanently set into the footings would be acceptable. However, note that the posts are longer and heavier, and accurately placing them plus keeping them vertical during footing concreting may be difficult.

Determine the make(s) of cage which meet your operational requirements with the design wind speed which meets your requirements and select the appropriate-sized footing for the soil conditions existing at your site.

If possible, have the cage supplier also install the required footings.

This document is for guidance and information purposes only and any drawing within is also for illustration purposes only. This guide is not a specification and must not be regarded as so. Any person who places reliance on it does so at their own risk who are responsible for satisfying themselves of its reliability. Manufacturers who use these guidelines to design and manufacturer their own [cages] are responsible for constructing, testing their products in compliance with all applicable laws and in accordance with any health & safety laws and regulations. To the fullest extent permitted by law, World Athletics does not accept any liability for any errors or omissions contained in this guidance, defects in the design or manufacture of cages by any third party as a result of using this guide or breach of any health & safety laws or regulations.