IAAF Calibration and Testing Manual

Edition 2010

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INTRODUCTION

The sport of athletics relies basically on the measurement of performance by time and distance. Over the past century there has been a marked improvement in the accuracy of these measurements. However, it is not possible or necessary to measure in our sport to the accuracy needed in science.

Over time, the IAAF has determined the required specifications for implements and equipment and all these require measurements of one or more of length, mass and time.

The purpose of this Manual is to indicate how measurement equipment is to be calibrated and the accuracy required for the resulting measurements. Also, suggestions are made as to how federations might more cheaply check the accuracy of their measurement instruments.

There are national and international standards for commonly used measurement equipment and also for specific measurements. However, different levels of measurement accuracy may be permitted to suit the nature of particular activities. Our sport also uses athletics specific equipment such as false start equipment which must also be calibrated. One problem relating to this equipment is that different manufacturers use different measurement techniques and the measurements resulting may not be consistent between manufacturers. This equipment is at present under serious research study and will be added progressively to the Manual once the Technical Committee is satisfied with the recommended calibration process.

Most countries have a national weights and measures authority, and/or a national accreditation organisation that determines the laboratories / organisations within the country that meet the accreditation requirements for particular measurement activities. These organisations may be a valuable source of information and assistance to National Federations.

The IAAF should welcome feedback from federations, organisations and individuals on the information presented in the Manual so that the subsequent editions can incorporate improvements deemed necessary as the result of using the methods proposed in the Manual.

The purpose of this Manual is to provide testing organisations, federations and manufacturers with clear advice on the testing and calibration methods to be adopted for measuring devices, some equipment and materials used in IAAF competitions.

Where possible, international standards or national standards are referred to and complemented as necessary.

It is intended that the Manual will be updated and refined as experience is gained in use of the methods listed.

Any comments on the Manual might be addressed to:

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GENERAL

Purchasing Measurement devices

Federations are advised to purchase all measurement devices with a calibration certificate provided by an accredited authority so that the measurements can be traced back to a national or international measurement standard as required by IAAF Competition Rule 148. This may increase the initial cost of the device but the additional cost will usually be considerably less than having it calibrated after purchase.

Appropriate Testing Organisations

Certification, inspection and testing work on measuring devices used in IAAF competitions should be undertaken by organisations that have demonstrated their competence by having ISO 17025 accreditation by a nationally recognised accreditation body.

Nationally recognised accreditation bodies are listed on the web pages of the International Laboratory Accreditation Cooperation (www.ilac.org) and the International Accreditation Forum (www.iaf.nu). The European Cooperation for Accreditation is also a source of information on European accreditation organisations.

Bureau International des Poids et Measures (BIPM) is the International Bureau of Weights and Measures. On its website www.bipm.org are listed the members. If a federation is from a country that is not listed by BIPM, it is still probable that your government has nominated an organisation responsible for national weights and measures.

Test and Calibration Reports

The test and/or calibration reports should provide all the necessary information for verifying that the measuring device is suitable for use in IAAF competitions.

The following information, as required by the international standard ISO/IEC 17025, should be included in each report:

- A title (e.g." Test Report" or "Calibration Certificate")
- Name and address of the laboratory, and the location where the testing / calibrations were carried out, if different from the address of the laboratory.
- Name of the national accreditation body that accredited the laboratory.
- Unique identification of the test / calibration document, including on each page an identification to ensure that the page is recognised as part of the document and a clear identification of the end of the document.

- Name and address of the client.
- Identification of the method used.
- Description, condition and identification of the item tested or calibrated.
- Date of receipt of the test / calibration item where applicable and the date the work was carried out.
- Reference to the sampling plan and procedures used by the laboratory or other bodies where applicable.
- Results with, where appropriate, the units of measurement.
- Name, function and signature or equivalent identification of the person authorising the test / calibration document.
- A statement on the estimated uncertainty of measurement where applicable
- A statement to the effect that the results relate only to the item tested or calibrated where appropriate.
- Where necessary for the interpretation of the test results, the following shall be included:

    1. Deviations, additions or exclusions from the test method, and specific test conditions, e.g. environmental conditions.
    2. A statement of compliance / non-compliance with requirements and/or specifications.
    3. Additional information required by specific methods or clients.
    4. Opinions and interpretations where appropriate and needed.
    5. Additional information required by specific methods or clients.

Calibration Certificates in addition to the information listed above shall include also where necessary for the interpretation of calibration results:

- Conditions, e.g. environmental conditions during calibration that may have an influence on the measurement results.
- Evidence that the measurements are traceable.
- If a statement of compliance with a specification is made, the clauses of the specification, which are met or not met, must be identified.
- Where a statement of compliance is made omitting the measurement results and associated uncertainties, the laboratory must record and retain those results.
- The uncertainty of measurement must be taken into account when statements of compliance are made.
- The calibration results before and after adjustment or repair, if available, must be reported.
- Calibration certificates or labels should not contain any recommendation on the calibration interval except when requested by the client.

When testing and calibration results are obtained from sub-contractors, the results of tests performed by sub-contractors must be clearly identified.

Where calibration work has been sub-contracted, the laboratory performing the work must issue the calibration certificate to the contracting laboratory.

Amendments to a test report or calibration certificate after issue must be in the form of another document and include reference to the original document. If a new test report or calibration certificate is required, it must be uniquely identified and include reference to the original it replaces.

MEASUREMENT OF DISTANCE

The devices covered by these regulations include steel measuring tapes, steel bars, video distance measuring (VDM) and electronic distance measuring (EDM) apparatus.

Steel Measuring Tapes

Applicable Standards:
ISO 8322-2 1999 Building construction - Measuring instruments - Procedures for determining accuracy in use - Part 2 Measuring tapes, or
BS 4035 Specification for linear measuring instruments for use on building and civil engineering construction works. Steel measuring tapes and retractable steel pocket rules, or
AS 1290.5-1999 Linear measuring instruments used in construction. Part 5: Coated and etched steel measuring tapes.

Tape Tension:
50m or shorter: 50N;
longer than 50m: 100N or the tape manufacturer's specified tensile force.

Test Temperature:
The calibration test shall be undertaken at a temperature selected by the laboratory within the range 20 to 23 degrees Celsius and stable to ±1.0 degree Celsius during the test.

Required 95% Confidence Limit Uncertainty of a Single Measurement with controlled temperature and tape tension:
±(0.5mm + 0.1mm/m)
For measurements made by truncating, the measurement to the nearest whole centimetre (as required by IAAF Rules), with the correct tension applied to the tape and with a tape temperature in the range 10 and 30 degrees Celsius without temperature correction then the uncertainty of a measurement at a 95% confidence limit is: +5mm ±(5.8mm + 0.154mm/m).

Reading
To the next lower graduation if it is not an even graduation.

Graduation Test Intervals:
Every 10m for initial and subsequent calibrations.

Recalibration Intervals:
Every four years or after damage / repair of the tape.

Limitation on Use:
The calibrated steel tape should not be used for other than measuring records or checking the accuracy of other working tapes.

Advice for National Federations

Steel measuring tapes might be certified by a practicing land surveyor using his standard measure which is traceable back to the national standard measurement. Such certification should be undertaken when the tape is purchased if it has not been purchased with a measurement calibration certificate, after repair of the tape and every year at a temperature close to 20 degree Celsius.

The tape should be check measured by the surveyor every 10 metres, and either side of a repair if the tape has been broken, against the surveyor's standard measure. The temperature of the tape and the tension applied to the tape (a tension of 5kg (50N) for 50m or shorter tapes and 10kg (10N) for 100m tapes would be appropriate) should be recorded on the certificate.

It should be recognised that temperature has a big effect on measurement with a steel tape. A temperature change of 9 degrees Celsius makes a 1cm difference per 100m. If your steel tape measures 100m against the standard measure at 20 degrees Celsius or lower then for all competitions where the temperature is higher the tape will measure "short" and you can be sure that the distance measured is not less than that shown on the tape.

Your calibrated steel tapes should not be used for everyday competition measurements but be kept for measuring records, check measuring when EDM or VDM is being used, and checking the accuracy of fibreglass tapes and subsidiary measuring devices like steel measuring bars. When measuring apply the appropriate tension to the tape using a spring balance attached to a tape puller. The steel tape should be kept in a cool place and only brought outside when a measurement is to be taken so as to minimise temperature errors.

Steel Measuring Bars

<u>Applicable Standards:</u>
BS 4372 1968 Specifications for engineer's steel measuring rules.

<u>Test Temperature:</u>
The calibration test shall be undertaken at a temperature selected by the laboratory within the range 20 to 23 degrees Celsius and stable to ±1.0 degrees Celsius during the test.

<u>Required 95% Confidence Limit Uncertainty of a Single Measurement with controlled temperature:</u>
±(0.5 mm + 0.1 mm/m).

<u>Reading:</u>
To the next lower graduation if it is not an even graduation.

Graduation Test Intervals:
Every 1m for initial and subsequent calibrations.

Recalibration Intervals:
Every four years or after damage / repair of the bar.

Limitation on Use:
The calibrated steel tape should be used for checking the accuracy of other working measuring bars.

Vernier Callipers and Micrometers

Applicable Standards:
ISO 6906:1984 Vernier calipers reading to 0.02 mm or
BS 887:2008 Precision Vernier calipers. Requirements and test methods or
AS 1984-1997: Vernier Callipers (metric series) or
JIS B 7507:1993 Vernier, dial and digital callipers or
DIN 862 (1988-12) Vernier calipers requirements and testing.
ISO 3611:1978 Micrometer callipers for external measurement or
AS 2102-1989 Micrometer callipers for external measurement or
BS EN ISO 3611 Micrometer callipers for external measurement or
BS 870:2008 Micrometer callipers for external measurement or
JIS B 7502:1994 Micrometer callipers for external measurement or
DIN 863-1 (1994-04) Micrometer callipers for external measurement.

Test Temperature:
The calibration test shall be undertaken at a temperature selected by the laboratory within the range 20 to 23 degrees Celsius and stable to ±1.0 degree Celsius during the test.

Required 95% Confidence Limit Uncertainty of a Single Measurement:
±0.05mm

Reading
To the nearest 0.1mm.

Recalibration Intervals:
Every four years or after damage / repair.

Electronic Distance Measuring

Applicable Standards:
Australia: Regulation 80 of the National Standard Measurement Act 1960

Required 95% Confidence Limit Uncertainty of a Single Measurement:
±(6mm + 4ppm.)

Recalibration Intervals:
Every year or after damage / repair of the instrument.

Calibration: The government authority responsible for surveying usually have one or more EDM calibration baselines available for use by surveyors or alternatively the calibration is undertaken by government surveyors. A typical EDM Calibration Handbook is produced by the ACT Government and is available at:
www.actpla.act.gov.au/__data/assets/pdf_file/.../edm-handbook.pdf
An EDM instrument is calibrated on a baseline with permanent monuments at known elevations and distances apart to determine instrument constants and errors. There is usually a computer program available to determine the instrument constants errors and their associated uncertainties.

Notes for federations: Off the shelf EDM are supplied to an industry maximum standard deviation of ±(3mm + 2ppm). A multiplying factor of 2.0 has been used above to convert the standard deviation to a 95% confidence limit. This is a simple interpretation of the ISO Guide to the Expression of Uncertainty of Measurement.

If you have a Total Station EDM that reads angles electronically it could have a "check and adjust" inbuilt program that should be used periodically.

Before each competition your EDM should be:

- Checked for any obvious damage
- Checked for horizontal angle measurement accuracy by:
    1. Bisecting a clear object about 100m away and record the horizontal angle.
    2. Change face and bisect the same object and record the horizontal angle.
    3. The difference between the readings should be 180^0 00' 00" ± the manufacturer's tolerance.

- Check for vertical angle measurement accuracy by:
    1. Bisecting a clear object about 100 m away and record the vertical angle.
    2. Change face and bisect the same object and record the vertical angle.
    3. The difference between the readings should be 360^0 00' 00" ± the manufacturer's tolerance.

If in doubt have your EDM checked by the manufacturer's local agent.

Road Running and Race Walking Course Measurement

Refer to the IAAF/AIMS "The Measurement of Road Race Courses" second edition 2004, updated 2008.

MEASUREMENT OF MASS

Mechanical or electronic scales that meet the specifications below may weigh the mass of implements, and other equipment such as relay batons and crossbars.

Weighing Machines

Applicable Standards:
As laid down by the national laboratory accreditation authority with measurements to be undertaken by a laboratory accredited by the national accreditation authority.

Test Temperature:
The calibration test shall be undertaken at a temperature selected by the laboratory within the range 20 to 23 degrees Celsius and stable to ±1.0 degree Celsius during the test.

Required 95% Confidence Limit Uncertainty of a Single Measurement:
±0.1g.

Reading:
To the next lower graduation if it is not an even graduation.

Test Intervals:
Every 0.5kg from 0.5kg to 10kg for initial and subsequent calibrations.

Recalibration Intervals:
Every year or after damage / repair of the machine.

Limitation on Use:
The weighing machine should be located on a firm flat surface and not be moved.

Comment:
When implements and other equipment are being check weighed at the stadium the mass shall be recorded to the next lower gram unless the mass measured is an even gram.
The current calibration certificate shall accompany record applications for the weighing apparatus used to check the mass of the implement before and after the competition.

WIND GAUGES

Applicable Standards:
ISO 17713-1:2007 Meteorology – Wind measurements – Part 1: Wind tunnel test methods for rotating anemometer performance.

ISO 16622:2002 Meteorology – Sonic anemometers/thermometers - Acceptance test methods for mean wind measurements.
AS 2923 – 1987 Ambient Air – Guide for measurement of horizontal wind for air quality applications.

Test Temperature:
The calibration test shall be undertaken at a temperature selected by the laboratory within the range 20 to 23 degrees Celsius and stable to ±1.0 degree Celsius during the test.

Required 95% Confidence Limit Uncertainty of a Single Measurement

Reading:
To the next higher graduation if it is not an even graduation.

Recalibration Intervals:
Every four years or after damage / repair of the anemometer.

Limitation on Use:

IAAF Product Certificate Test

1. The gauge and its working shall be examined critically to confirm that it complies with the intent of the IAAF Rules and construction regulations.
2. The manufacturer shall adjust the gauge so that it accurately measures a velocity of 2m/s parallel to the measuring direction over an interval of 10 seconds.
3. Velocity calibration: +0.5, 1.0, 1.5, 2.0, 3.0, 4.0m/s for a 10 second time interval parallel to the measuring direction.
4. Angle calibration: -60° to +60° at 30° intervals to the measuring direction with wind tunnel air velocity being such that the velocity in the measuring direction is +2m/s over a 10 s time interval.
   -60^0 and $+60^0$ angles with the wind tunnel velocity 4m/s
   -30^0 and $+30^0$ angles with the wind tunnel velocity 2.3m/s
5. Additional Time calibration: At timing intervals 5 and 13s at velocity +2m/s.
6. Anemometer Sensitivity test: Undertake the test in fluctuating light winds of between 1 and 4m/s in an open area free of obstructions by comparing the averaged readings from the instrument, orientated so that positive readings are obtained, with those obtained by say a Laser Doppler Anemometer with traceable calibration over a period of one hour.
7. Wind gauge calibration shall only be undertaken by a laboratory that is accredited by the national laboratory accreditation organisation recognised by the International Weights and Measures Organisation (BIPM).

Individual Wind Gauge Calibration

Each wind gauge on sale shall be supplied with a calibration certificate stating the uncertainty of calibration for a test over a 10 second interval at a velocity of + 2.0m/s. Such calibration certificates may be provided by the manufacturer if their test facility has been accredited by the national accreditation authority.

Recalibration

Each wind gauge shall be tested over a 10 second interval at a velocity of +2.0m/s every four years. Simple test procedures that federations may consider are given hereunder.

Comparison Testing

A wind gauge that has a current traceable calibration certificate may be used as a reference measure for other wind gauges. The wind gauges to be checked and the reference wind gauge should be set up in an open field when there are constant light winds with the measurement directions parallel to each other and the general wind direction.. At least five comparison measures of wind speed in the range of 1 to 3 metres per second but preferably as close to 2 metres per second as possible over a 10 second interval should be taken. Provided the average difference between the wind readings for the wind gauge being checked compared with the wind speeds of the reference wind gauge is not more than ±0.1metres per second then the wind gauge being tested may be certified as being in calibration. An appropriate sticker should be attached to the wind gauge indicating the date of test, the tester's name and the reference wind gauge's identification number. The test results should be filed by the Technical Manager for future reference.

Approximate Check 1 of Wind Gauge Accuracy

1. Locate a long corridor or hall in which all the doors can be closed, there is no ventilation air movement and is unoccupied for the period of the testing.
2. Mark the start and finish of a 20 metres straight line on the floor.
3. Check that you can walk the 20 metres in 10 seconds by using a stopwatch – it is a fast walking pace. It does not matter if you walk the distance slightly quicker than 10 seconds but it cannot be longer than 10 seconds. Therefore it is desirable that a second person time the 20m walk every time to ensure that time taken is less than 10 seconds.
4. Set the wind gauge at the 10 second measuring interval.
5. Hold the wind gauge on your shoulder or under your arm with the wind gauge parallel to the ground, vertically orientated as it is when in athletics use and parallel to the straight line you have marked with the arrow indicating wind direction towards you so that you are measuring positive wind which is the one of most interest for record purposes It would be helpful for another person to check the positioning of the wind gauge for you
6. Start walking several metres before the start line to get the gauge vanes moving switch on the gauge at the Start line and walk from the start to the finish of the 20 metres at a brisk walking pace and stop dead on the 20m mark. The wind gauge will automatically record the wind speed after 10 seconds. As you have walked 20 metres in 10 seconds the actual average wind speed is 2.0 metres per second.
7. Read and record the wind speed indicated by the wind gauge.
8. Repeat the process walking in the opposite direction and record the wind speed result.
9. The process may be repeated again and the average of all the wind speeds measured should be recorded against the identification number of the wind gauge.
10. If the average wind speed is between 1.9 and 2.1 metres per second then prima facie the wind gauge is in calibration. If it measures between 1.8 and 2.2 metres per second then the use of the wind gauge should be limited to less important meetings. Outside the latter range then the wind gauge should be repaired if the cost is not prohibitive.

Check 2 of Wind Gauge Accuracy

As for Check 1 above but instead of hand carrying the wind gauge, install the wind gauge on a flat bed trolley that can be pushed or pulled smoothly along a track.

The timing can be done by stopwatch as above or by photo-electric cell timing.

A more elaborate test set-up might have the trolley driven by a battery powered electric motor.

Approximate Check of the Wind Gauge Timing Device

Older vane wind gauges of the Cantabrian type use resistor-capacitor networks to time and these can drift with age. To test the gauge timing accuracy press the wind gauge start button and start a stopwatch simultaneously. Stop the watch when the LCD display on the wind gauge first appears. The stopwatch time should be between 9.9s and 10.2s to allow for the stopwatch operator's reaction time.

SYNTHETIC TRACK SURFACE

The required test procedures are given in Chapter 3.1.3 of the IAAF Track and Field Facilities Manual.

PHOTO FINISH

See Attachment C.

STOPWATCHES

See Attachment A.

TRANSPONDER TIMING

Still to be proposed.

FALSE START EQUIPMENT

Still under consideration.

HURDLES

Tilting Test

The hurdle tilting test shall be undertaken as per Rule 168.2 using either a spring balance graduated in kgf or by applying the horizontal force by hanging a 3.6kg weight over a pulley. The tilting force is the force just required to tilt the feet of the hurdle from the level ground. Note that as the hurdle tilts further the force required to continue the overturning becomes less. The hurdle should be tested at each hurdle height with the foot weights adjusted for the different heights.

The accuracy of the spring balance should be verified before commencing the test by hanging weights of 3.0kg and 4.0kg separately on the spring balance and noting the readings obtained by the spring balance.

Top Bar Deflection Test

Performance Requirement

With the hurdle feet held to the ground, measure the horizontal deflection at the centre of the top edge of the top bar at its mid-span, when applying 10kg load horizontally at this point, taking up any slack in the uprights before the zero measurement. For compliance the amount of this measured deflection shall be less than the 35mm permitted by Rule 168.2.

Testing method

Alternative methods of testing are possible. One acceptable method is detailed below:

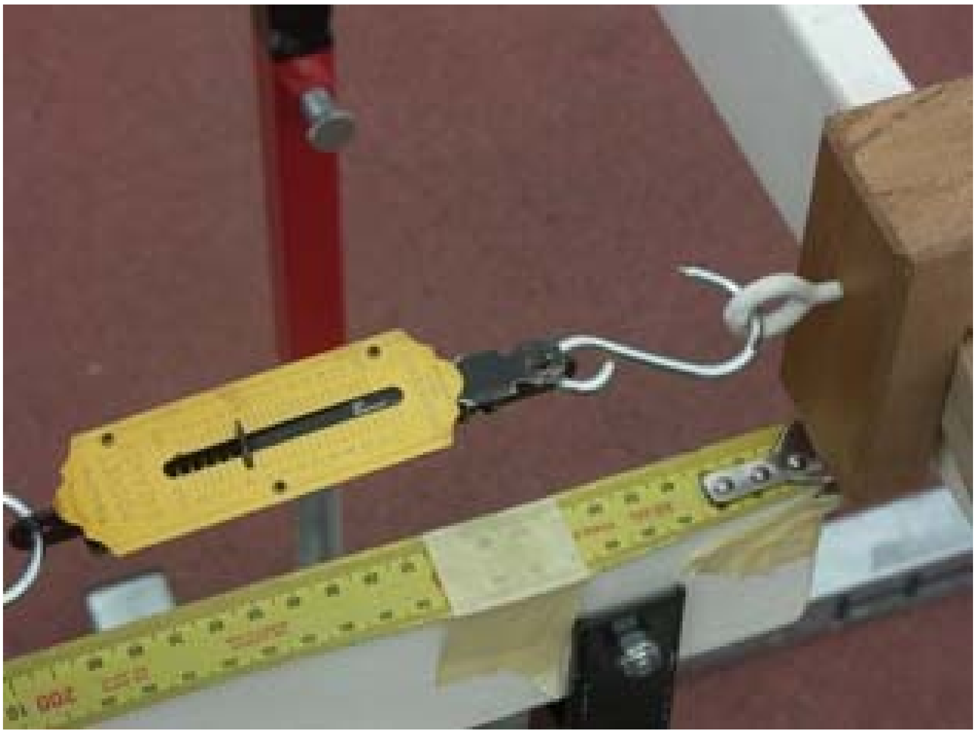
Acceptable Method

Purpose: This in-situ hurdle testing procedure provides a simple technique to ensure compliance with Rule 168.2. The intention of this in-situ procedure is to measure the horizontal deflection of the top bar (including any deflection of the vertical supports), in the assembled hurdle.

Equipment required

- Two hurdles (one to support measuring set up)
- Hand held spring balance to carry a minimum of 10kg load (as an alternative a 10kg weight can be suspended over a pulley).
- An appropriate connection for loading at the top edge of the top bar (a block of wood shaped to slide over both sides of the top bar, with an attached hook lining up with the top of the bar has been used in the example illustrated).
- Steel measuring tape.
- A resistance load to stop the loaded hurdle from tipping over (conveniently provided by one or two other people).
- A bag to support a 10kg load.
- A combination of certified shots and discus are suggested to provide a 10kg load.
- Sticky tape to attach the measuring tape.

Illustrations:



Procedure:

1. Calibrate the spring balance in the vertical direction using the bag with the 10kg load.
2. Set up two hurdles as illustrated. The testing shall be done in the normal direction of hurdling. The hurdle being tested should have the top bar at the Men's competition height. (There is no need to test hurdles at a lower height.)
3. For the simple reading of the horizontal deflection the steel measuring tape is fixed (sticky tape) to the top bar of the second hurdle in the position as illustrated, and the second hurdle is set at a height that allows the steel tape to directly line up with the connection block (or similar arrangement),
4. Apply load stability (one or two people) to the feet of the hurdle being tested.
5. Take up any slack in the uprights before the zero measurement.
6. Apply the 10kg load horizontally to the centre of the top edge of the top bar at its mid-span.
7. Measure and record the resulting horizontal deflection using the second hurdle as the fixed datum.

Results: Variations can be expected within a set of hurdles of similar manufacture:

- At higher temperatures deflections may increase (Testing should be done at temperature conditions typical for local competitions)
- Material stiffness varies.
- Assembly and bar fixing details have variations.

Procedure described by Don Mackenzie, Rod Syme and Alan Tucker (NZL).

SAFETY CAGES NETTING

Hammer

The netting mesh size shall be measured to check that the maximum mesh size is 0.05m for steel wire netting and 0.044m for cord netting. The mesh size, strand cross-sectional area and material composition shall be recorded.

A single strand of the netting tested in a tensile testing machine at a straining rate of 50 mm/minute for fibre and 5mm/minute for steel wire at a temperature of 21 degree Celsius shall have a minimum breaking strength of 300kgf (3000N).

Alternatively the energy absorption of the mesh shall meet the dynamic test principles laid down in EN1263-1:1996 "Safety nets Part 1: Safety requirements, test methods" such that the netting will withstand an object 100kg mass being dropped into the netting from a height of 7m. This equates with the energy absorbed when a 7.26kg hammer travelling at 32m/s is stopped by the netting allowing a safety factor and an ageing factor.

Discus

The netting mesh size shall be measured to check that the maximum mesh size is 0.05m for steel wire netting and 0.044m for cord netting. The mesh size, strand cross-sectional area and material composition shall be recorded.

A single strand of the netting tested in a tensile testing machine at a straining rate of 50mm/min for cord and 5mm/min for steel wire at a temperature of 21 degree Celsius shall have a minimum breaking strength of 40kgf (400N).

Alternatively the energy absorption of the mesh shall meet the dynamic test principles laid down in EN1263-1:1996 "Safety nets Part 1: Safety requirements, test methods" such that the netting will withstand an object 15kg mass being dropped into the netting from a height of 7m. This equates with the energy absorbed when a 2kg discus travelling at 25m/s is stopped by the netting allowing a safety factor and an ageing factor.

HAMMER HANDLE

Testing (see Attachment B)

ATTACHMENT A

STOPWATCH CALIBRATION

Introduction

The international standard for evaluating the accuracy of quartz watches is given in ISO 10553:2003 "Horology – Procedure for evaluating the accuracy of quartz watches". The procedure designed for quartz watches with an indicated accuracy of less than ±30 seconds per annum involves taking measurements over three days with a three day stabilisation period before and a twenty four rest period before the next stabilisation/test period. With three separate three day test periods the total measurement period for this test phase is 66 days and this is followed by a temperature simulation test program over thirteen days. As a typical stop watch may have an indicated accuracy of 6ppm i.e. about 0.5s per day such a test is not appropriate for competition stopwatches apart from being too expensive.

The calibration test method given below was suggested by the Centre for Sports Technology London and their permission to use their work is gratefully acknowledged.

Procedure

Determine an appropriate verifiable source of UTC time. This could be from a talking clock provided by the local telephone service, your computer or a GPS timer. The detailed procedure that follows is for a telephone service. Guidance for using other systems follows.

Reset the timer being checked to zero.

Whilst listening to the time on the telephone, start the timer at the third of a set of strokes or when the timing source reaches a full minute. Note the time. For long periods using the telephone time service, it is helpful to choose to start the clock when a full minute is reached at the third stroke.

When the required time has elapsed, stop the timer.

Where long intervals of time are involved, the telephone may be replaced and the call made again near to the time needed. The telephone will, in any case, disconnect automatically after a maximum of one minute in Australia but at different intervals elsewhere. Note that these days there is usually a charge for the telephone time service.

Repeat the test at least three times but preferably four or more times for each time interval so that the calculated standard deviation of the mean of the errors will be reasonably accurate.

Record the time recorded by the timer for each of the tests.

It would also be acceptable to compare a timer against another timer that has been calibrated professionally and is traceable back to a national or international standard. This could be a photo-finish timing system. Both timers would be started and stopped simultaneously, and the times compared. As stated above preferably five or more separate readings would be taken at the maximum time interval at which the timer being calibrated records the time in 1/100ths of a second.

Calculations

The error is the difference between the stopwatch reading and the reference time interval. Record the error of the time for each test interval including the sign of the error, "+" or "–". Calculate the mean and the standard deviation for each time interval. The mean time difference from the timing interval should not exceed the equivalent of 1 second per day. If the time difference exceeds this amount then return the watch to the supplier if it is under warranty. If the warranty has expired do not use the watch for competition timing. The standard uncertainty for the mean time is the calculated standard deviation for the mean time interval divided by $\sqrt{n}$ where n is the number of readings taken at the time interval. This is essentially the standard deviation of the difference between the start and stop reaction times. In the following uncertainty calculation a value of 0.050s has been used. The actual value obtained from the measurements should be used. The standard uncertainty value obtained should not exceed 0.010s. If it does exceed that figure then the whole test procedure and particularly the start / stop procedure should be reviewed or a different tester used.

Uncertainty (Precision and Accuracy)

The UK Speaking Clock is stated to be accurate to 5 ms and is corrected as necessary, twice a day, by reference to the NPL atomic clock.
These values for accuracy refer to the difference between the time given by the Speaking Clock and the 'true' time, as indicated by the NPL Clock. Over shorter intervals, provided the going rate of the clock is constant, errors should be pro-rata.

In other countries the speaking clock accuracy may be less as it will depend on the delay added by the telephone service as this can be variable as the information is possibly routed differently each time you call for a "time". As an estimate the delay might be taken as 15 milliseconds and a semi-range of 15 milliseconds might be achievable in Australia.

Using a programme from Dimension 4 it is possible to synchronise your PC's clock for Windows-based operating systems using a suitable source server preferably as close to your computer as practicable to minimise the number of routing nodes. The synchronising frequency can be set by you. Also note

that the network delay is determined by a one-way measurement that assumes that the send and return paths are the same. Due to the vagaries of the software clocks and the internet connection the errors are likely to be of the same order as for the talking clock but it is a cheaper option certainly in Australia.

A GPS timer might also be used as the source timer if it has been synchronised with an UTC source. However as cheap GPS receivers are generally primarily concerned with position the time display could be delayed by a variable amount.

The uncertainty of the time recorded will depend upon:

- variations in the speed of reaction of start and stop of the user (you will recall that the standard adjustment of stopwatch manual times for races 400m and less for comparing with automatic times is +0.24 s to allow for operator reactions);
- at least one digit with digital timers;
- the constancy of the speaking clock or other timing reference going rate.

An uncertainty budget for the calibration using the talking clock in Australia is given below.

UNCERTAINTY BUDGET FOR AN ELECTRONIC STOPWATCH CALIBRATED AGAINST A TALKING CLOCK IN AUSTRALIA

Component number	Uncertainty component	Nominal Value	Type	Uncertainty comment	Distribution	Standard uncertainty	Variance
1	Speaking clock accuracy	15 ms	B	Uncertainty is independent of timed interval = 8.66 ms	Rectangular	0.00866	0.0000750
2	Start/stop error	50 ms	B	sd of difference in reaction times	Normal	0.05	0.0025
3	Digitisation error stopwatch	10 ms	B	Resolution is 0.01 s	Rectangular	0.002887	8.333E-06
4	Timebase variations – i.e. crystal oscillator frequency.	Assume 10 ppm	B	For 100 s = 0.001 s	Rectangular	0.00057735	3.333E-07
						Combined standard uncertainty	0.051
						Uncertainty 95% CI	0.102

It can be seen that the largest effect by far on the uncertainty of measurement is operator start / stop error cf. its standard uncertainty (0.050ms) with the combined standard uncertainty of 0.051ms.

Start / stop errors will vary from person to person. For one person the errors will tend to be constant either always early or always late so there is a cancellation effect.

Mechanical watches and clocks going rate most probably will vary with temperature, the degree to which the watch is wound and physical movement of the watch particularly rotational. Mechanical timers must always be handled with great care, be full wound before use and be kept at constant temperature. These old technology timing devices should no longer be used for competition timing.

With electronic timers, the time-base is provided by a quartz crystal oscillator. These oscillators are selected for their stability and constant frequency, though they can be affected by temperature. Significant temperature variations cannot occur over short periods since the crystal is physically located within the clock or watch. If the frequency is constant over the calibration period a valid calibration can be carried out using periods much longer than the periods the watch is used to measure. Since as shown above the significant errors listed above are mostly constant and give rise to a constant-time uncertainty in the measured time, the longer the calibration period, the smaller the calibration uncertainty expressed as a percentage of the measured time. Therefore it is recommended that the calibration test interval be 24 hours or the maximum time at which the timer reads to 1/100ths of a second with the time being read and recorded to 1/100ths of a second. Federations are advised to purchase digital watches that continue to time in 1/100ths of a second even if the hour's digit returns to zero after 10 hours.

A summary of the results achieved in the testing should always be kept in the Federation Equipment Manual recording the "errors" indicated for future reference.

Check the results of the measurements against the acceptability criteria for the timer being calibrated.

ATTACHMENT B

HAMMER HANDLE TESTING

Test Requirements

The IAAF handle test requirements are:

- Hammer handles shall have load applied in a universal-testing machine at a uniform rate with the extension recorded until destruction.
- The gripping of the handle shall simulate in simple terms the grip by a thrower.
- A load extension curve shall be produced for each handle tested, the ultimate strength recorded, and the point and type of failure recorded.
- The physical details of the handle shall be recorded including handle make and model, length and width of the handle, the weight and the material composition of the handle if known.

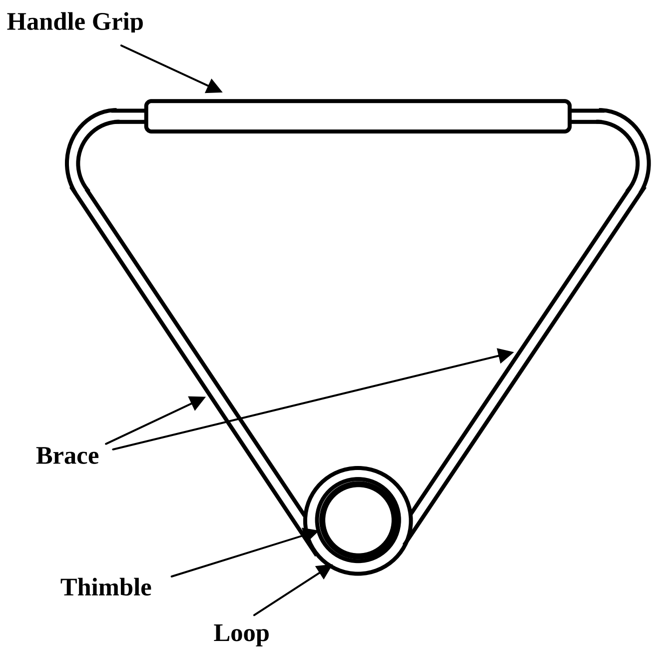


Figure 1 –Generic Hammer Handle Showing Nomenclature Used

Test Rig Design

The test rig used at the School of Aeronautical, Civil and Mechanical Engineering (SACME) ADFA Campus of the University of NSW to meet the above requirements was designed to load the hammer handles in uniaxial tension on a hydraulic universal testing machine (250kN capacity Instron in SACME). The test rig consisted of two parts: an upper component on which the handle grip is mounted and a lower mount to which the loop of the handle is attached. The component parts of the mounts are shown in Figure 2.

Figure 2. Components of Modified Test Fixture

A loading pin is inserted through the thimble or the loop in the brace at the apex of the hammer handle and mounted in a yoke that fits in the Instron lower grip.

The centrifugal pull from the handle wire is transmitted through the two side braces as lateral forces at the two ends (or the brace joints) of the handle grip. In the real situation these lateral forces on the handle grip are reacted by a distributed load provided by the fingers and the palm of the thrower. The actual distribution of the load on the handle grip may not be uniform but is likely to vary from person to person depending on individual variations in gripping. However, it appears reasonable that the two outer fingers are likely to provide greater support than the inner two fingers in a natural grip with the four fingers spread symmetrically along the handle grip. This situation is simulated in the loading rig by employing two rollers to provide simple support symmetrically at quarter points along the span of a 130mm wide handle grip. Note that the same test rig can be employed for testing hammers with straight handles as well as curved handles. The positioning of a hammer grip over the rollers is shown in Figure 3.

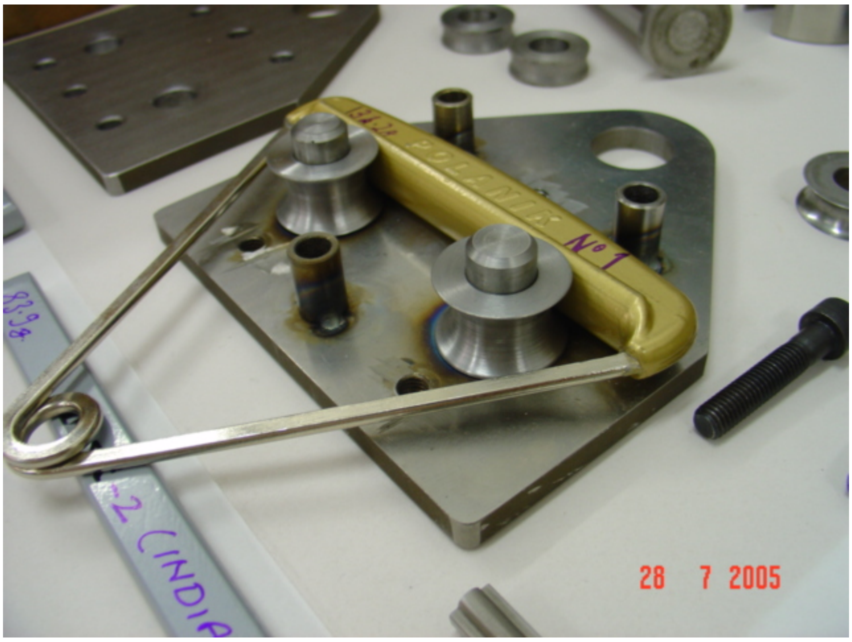


Figure 3. Handle in the Modified Test Fixture
(Note the thick ridge along the base of the grip)

The loading of the handle grip is shown schematically in Figure 4 along with the bending moment distribution along the span of the hammer grip. It may be noted that the bending moment due to the lateral load is then uniformly distributed across the central half of the span and has a value of PL/8, where L is the length of the handle grip (nominally 130mm). This situation is less severe but more realistic than the bending moment distribution provided by a point load at the centre, and at the same time easier to simulate than a uniformly distributed support along the mid-span of the beam.

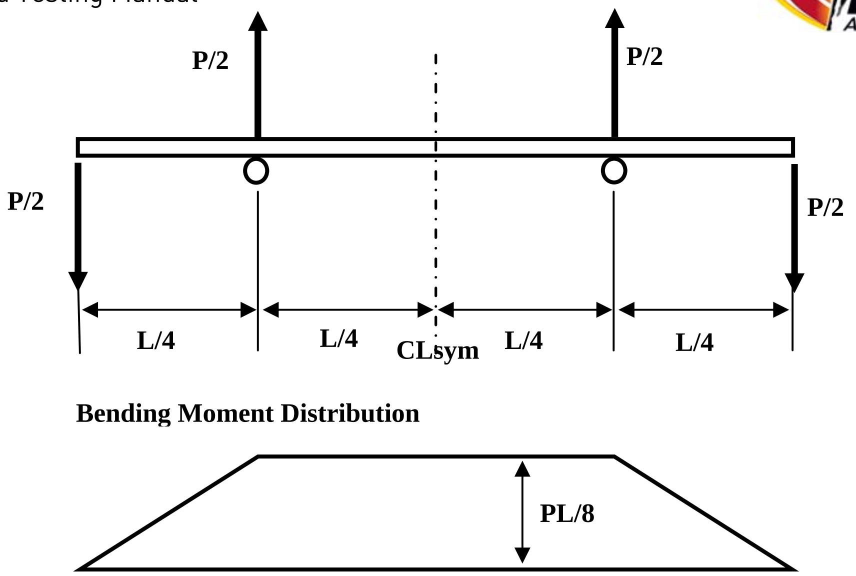


Figure 4. Schematic of Loading of Handle Grip and bending Moment Distribution

Test Procedure

The Hammer Handle is mounted on the upper and lower mounts as described above which were inserted into the jaws of the Instron Hydraulic Test machine. The test data consisting of the applied tensile load and the axial displacement (elongation of the hammer handle) are recorded digitally via a data acquisition board into a PC for processing. All specimens were initially loaded up to about 4kN (approximately the working load, i.e. the maximum load expected to be exerted on the hammer handle when used in competitions) at a slow loading rate of 1mm/min, and the load and displacement data collected at a sampling rate of about 4 samples/s. The specimens are then unloaded and inspected for any permanent deformations. An intermediate load step of up to 8kN is employed if the handle is capable of withstanding this load. Finally the specimen is loaded until failure occurs. For the final tests (loading up to failure) a typical displacement rate of 5 mm/min and sampling rate of 20Hz (20 samples/s) is employed. The failure mode of the hammer handle is observed and recorded photographically.

Performance Requirements

Using the above test procedure the total deformation of the handle in the direction of the load under a tension of 3.8kN shall not exceed 3mm and the minimum handle breaking strength shall be 8kN.

ATTACHMENT C

PHOTO FINISH CALIBRATION

Introduction

The following calibration procedure is proposed to show that the equipment design meets the IAAF Product Certificate requirements. A shorter test may be appropriate for the initial calibration of individual items that have a generic Product Certificate and for subsequent calibrations.

The calibration shall only be undertaken by a laboratory that is accredited by the national organisation recognised by the International Laboratory Accreditation Cooperation (ILAC).

The photo-finish equipment and its working shall be examined critically to confirm that it complies with the intent of the IAAF Rules and construction regulations.

Recommended Calibration Procedure

The calibration test shall be undertaken at a temperature selected by the laboratory within the range 20 to 23 degrees Celsius and stable to ±1.0 degree Celsius during the test.

An electrical pulse referenced to a traceably calibrated frequency standard shall simultaneously start the clock of the photo-finish equipment and operate an electronic flash or LED located 1.50 m in front of the camera. The flash or LED is to operate at the end of the selected test time interval.

The flank of the flashed light shall be evenly distributed over the line sensor or equivalent. The duration of the flash shall be such as to reproduce as a vertical line 10 pixels wide. For example, at an acquisition rate of 1000 lines per second this is 1/100 second.

The frequency standard shall produce timing pulses that shall have an error not exceeding 1 in 10^9 compared to International Atomic Time. This is to be verified with an uncertainty not exceeding 1 in 10^{10}. Tests shall be done every 15 minutes for 24 hours and shall have errors in the generated times of no more than 0.25ms. The times shall be recorded to a resolution of 0.5 ms or better. The calibration certificate shall give the generated time intervals and corresponding measured time intervals given by the equipment timer with uncertainties that are determined using the procedures given in the ISO Guide to the Expression of Uncertainty in Measurement and shall include a component for the stability of the equipment under test.

The time interval error shall not exceed 40ms for the 24 hour interval and proportionally less for shorter times. The uncertainty of the tests (95%

confidence interval) shall not exceed 0.051ppm of the time interval or 0.6 milliseconds in 15 minutes whichever is the greater.

This should ensure that the uncertainty does not exceed 5 ms for times up to the maximum 24 hour interval. The allowable error reaches 1.2 ms at a time interval of 1 hour.

Alternative methods of calibration may be proposed to suit the available laboratory equipment to meet the uncertainty expectations above including:

Generate a train of impulses, at TTL level into a 50 ohm load, of duration 900 s and multiples of this time, synchronised on the negative going edge by a 1 PPS signal referenced to UTC. Use these pulses to generate test time intervals and to operate a LED as well as initiating the sequence of time recording of the photo-finish camera.

The operation of the LED will be filmed by the photo-finish camera which records the time of each impulse with a resolution of 0.5ms. Each camera image has a time mark.

To extract the results, the time of the trigger for each flash of the LED may be manually placed on the image record using software provided by the photo-finish supplier.

Additional Calibration at Varied Temperature

Additional calibration shall be taken at approximately 10, 30 and 40 degrees Celsius stable within ±1 degree Celsius during the test to determine how well the camera oscillator is temperature compensated.

After the test temperature has stabilised the camera shall be tested at ten minute intervals for at least one hour using 0.001 second resolution.

PHOTO-FINISH COMPARISON TESTING

Introduction

The following procedure might be used by federations to verify that their photo-finish equipment is operating correctly and are of acceptable accuracy. This procedure can be used for comparing two or more cameras. It would be preferable if at least one of the cameras has a current calibration certificate.

Procedure

Starting Signal Synchronisation

The starting signal times for all cameras should be synchronised so that the times match. If over the period of say one hour from receiving the same start

signal the cameras being compared the times have drifted apart by more than the manufacturers' drift specification of say 1ppm i.e. 3.6ms in one hour then it indicates a faulty piece of equipment that must be identified and rectified.

It is worth noting that there can be a problem with the timing system even though it has satisfied a zero test.