INTERNATIONAL ASSOCIATION FOR SPORTS SURFACE SCIENCES

Calibration of Artificial Athlete Berlin/Stuttgart

Summary of Calibration Series Performed in 2000

1. Introduction and Rational

The Artificial Athletes Berlin and Stuttgart were developed by the FMPA Stuttgart (Otto-Graf-Institut) of the University of Stuttgart around 1970. The tests, which are specified in the German standards DIN 18035-6 "Sports Grounds; Synthetic Surfaced Areas" and DIN 18032-2 "Sports Halls; Sports Surfaces – Requirements, Testing, Maintenance",. and have been adopted by various national and international bodies (FIH, IAAF, ASTM, ITF, CEN, FIFA, UEFA). Over the years, especially the past 10 years, modifications to these DIN standards have taken place, which were at times inconsistent, resulting in major questions and concerns regarding the proper design of the test apparatus, the test procedure, the evaluation of measurements and the accuracy of the test results. The IAAF Accredited Labs of the ISSS felt that the resolution of these uncertainties was crucial and, based on the lack of response by the DIN (Deutsches Institut für Normung = German Institute of Standardization) to professional advice, took the initiative themselves to clarify the problems involved.

As a first step, the ISSS called for papers analysing the structure of the Artificial Athletes and providing solutions for the pending problems. The submitted papers were received from Mark Harrison (GB), Dr. Konrad Binder (A), Dr. John Dunlop (AU) and Hans J. Kolitzus (D). The papers were published on ISSS's website www.isss.de. In a meeting held in Le Mans (F) in September 1999, the papers and problems were discussed in depth and a unanimous resolution was passed covering all open problems. There were two essential elements in this resolution; the first was the agreement on the 120Hz Butterworth 9-pole filter roll-off characteristic for the treatment of all recorded data, the second was the agreement on a Calibration Series to be undertaken by all IAAF Accredited Labs to align the operation of the various instruments and to determine the accuracy of the tests.

2. Calibration Method

In the early years of the Artificial Athletes use, the proper operation of these test devices could only be controlled by calibrating the members of the measuring chain (i.e. load and deformation sensors, signal conditioner, A/D converter, spring number). This might have been satisfactory if there had not been a controversy over evaluation questions such as the filter cut-off frequency and the filter grade, which controls how sharply the filter eliminates frequency portions beyond the cut-off frequency. The DIN committees did not present acceptable solutions to these problems so other sources were sought for a resolution.

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A valuable contribution was made by the SKZ (Süddeutsches Kunststoffzentrum) - a physical replacement of a resilient surface system was designed from steel. Unfortunately, this general proposal was adopted by the DIN's without clarification of the essential issues: how this would be used to determine the physical characteristics in terms of Force Reduction and Vertical/Standard Deformation with a known accuracy; and how to proceed if a specific test device did not comply with the physical parameters as determined by SKZ. The procedure has not even been presented yet in writing in order to allow for public discussion and experimentation. The undiscosed calibration procedure of the steel „Reference Norms“ was left to the discretion of SKZ. „Blind-faith“ acceptance of an unproven method of calibration as a standardized procedure is atypical for technical bodies, and so was questioned.

The ISSS recognized the principle advantage of the Reference Norm concept if used in a systematic way. First, the Reference Norms had to be designed to deliver a consistant give within the elastic range when tested with the Artificial Athletes. Second, development of at least three levels of give was needed to control the typical range found in various sports surfaces (i.e. Force Reduction 30 – 60%). Since no master testing device exists, it was necessary to determine the 'true values' of the various characteristics of the Reference Norms through a calibration series to be performed by a minimum of 5 labs having regular test equipment as specified by IAAF-ISSS ("IAAF Performance Specifications of Synthetic Surfaced Track Facilities" and ISSS Resolution 9/99). This method of determination had the advantage of producing not only the 'true values' of the physical characteristics of Force Reduction and Standard/Vertical Deformation but also the accuracy of the test procedure

The calibration series was performed under the supervision/management of Bernd Härting. The results were first presented at the ISSS Symposium held in Schaffhausen, Switzerland, in September 2000. The Force Reduction values of the ISSS Reference Norms were found to be had Force Reduction values of about 30, 45 and 55%. These numbers were derived by calculating the average of the individual results of the participating labs (note: results which deviated more than twice the standard deviation of the common average were eliminated). In figure 1 the individual deviations of the various labs from the common average can be seen. From that it can be concluded that the accuracy between labs is about ±1.5% (absolute) for Force Reduction and ±0.05mm for Standard/Vertical Deformation.

3. Special Perceptions

While the calibration was performed by the various labs, the following observations were made which were or could be a source of inaccuracy. These aspects are not addressed directly in any of the named standards.

3.1 A **milled three-wire spring** is preferred over a bent one-wire spring because it can be manufactured to the precision specified.

3.2 The **tube encircling the spring** (spring guidance tube) of the Artificial Athlete Berlin must have a true minimum diameter of 71.0 mm. A tighter diameter causes the spring to be jammed against the inner sides of the tube when compressed during an impact. The result of this is to irregularly increase the effective spring number so that the reference peak force on concrete results in forces up to 8'000N (normally about 6'600N). Since jamming does not occur on most sports surfaces, the resulting Force Reduction on 'non-jammed' surfaces is much higher than the correct value (up to 6 % or more, absolute values).

3.3 The deformation of soft surfaces must be determined with **two pick-ups** positioned on both sides of the guidance tube/load cell. If the readings of the two pick-ups are displayed individually, the test foot can often be seen to rock or totter and sometimes produces erratic traces. When the traces are superimposed they look fine. Thus, only with two symmetrically positioned deformation pick-ups can the Standard Deformation be determined correctly under all circumstances.

3.4 In order to correctly determine the peak deformation of the test foot, **the individual readings of the pick-ups must** be superimposed before the maximum of the deformation trace is measured. If the maximum deformation of an impact is calculated from the average of the maxima of the two individual traces, the resulting Standard Deformation is too large (difference of 0.5 mm has been observed).

3.5 Although it is no longer a problem to filter recorded data with any type of filter, the mandatory use of a 120Hz **Butterworth filter** should be stated. Use of a 9-pole roll-off or an 8-pole one is not critical as long as the same filter is used consistantly for calibration (determination of peak force on concrete) and regular measuring.

3.6 It has been shown that the dynamic determination of the **zero line** with the Artificial Athlete Stuttgart at 400N cannot be performed correctly with certain deformation measuring devices (i.e. inductive systems). The dynamic zero line was introduced to eliminate the effect of soft top-textures such as those produced by large and soft granules in the top of a surface. There is an easy alternative to the dynamic method: release the 20kg drop weight 'statically' to the surface, take the occurring deformation and force situation as the basis (i.e. zero line) for the following impact of the missile. The missile should rest on the surface for the determination of the zero line for no longer than 5 seconds. It does not matter which method is used when testing Reference Norms since those are made of steel and have linear force-deformation characteristics.

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