BALL APPROVAL TESTS

A key function of the Technical Centre is tennis ball approval – any ball used in tournament play must be approved by the ITF, based on the tests conducted in the ITF laboratory.

The regulations for testing of balls to obtain ITF Approval are specified in Appendix I of the Rules of Tennis. Testing is carried out in the following order:

- Acclimatisation
- Pre-compression (and conditioning)
- Mass
- Size
- Deformation
- Rebound
- Durability

Failures can occur in all tests, but the most common are the rebound and deformation tests. Least common are the size and mass tests. If a brand fails any of the tests, then approval cannot be granted. The manufacturer can re-apply by sending another sample, which is then tested in the same way.

Acclimatisation

Before testing, the balls are acclimatised for 24 hours in our climate-controlled laboratory. The laboratory operates at a temperature of 20 +/- 2°C and at 60 +/- 5% relative humidity. Studies have shown that temperature and humidity can affect tennis ball properties. High humidity can increase the mass of the ball, by increasing the moisture content of the felt, and high temperatures can affect the ball rubber, thus increasing bound height.

Pre-compression

Before any testing takes place, all balls are pre-compressed to remove any "set" in the ball. Set is a property that occurs in some materials when they are not subjected to varying forces. This is true for tennis balls between the time they are packaged and when they are opened for testing.

The pre-compression machine compresses each ball 2.54 cm (1 inch) three times from three directions using pneumatic actuators (fig 1).

Fig 1. Pre-compression machine

Mass

The weighing scales used in the laboratory are calibrated to +/- 0.01 grams (fig.2). The current acceptable mass range for standard tennis balls is 56.0-59.4 grams.

Fig 2. Weighing scales

Size

Diameter and mass are the oldest ball specifications, having been in the Rules of Tennis since 1880. Although it would appear to be an easy task, accurate and repeatable measurement of ball diameter is difficult.

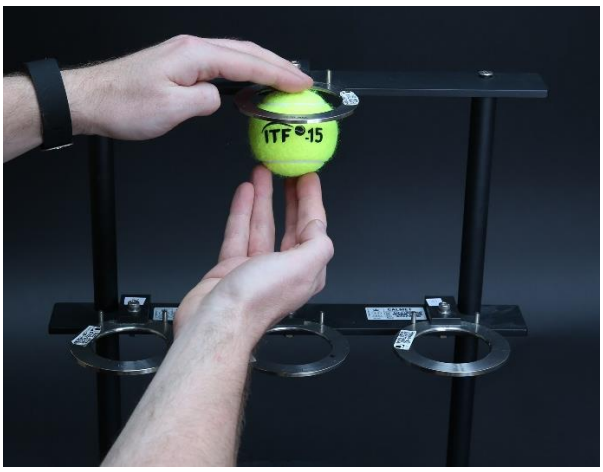

Fig 2. Upper limit ring gauge

Fig 4. Lower limit ring gauge

Whether a ball is of an appropriate size is determined using two ring gauges in a "go/no-go" manner (fig. 3 & 4). A ball must pass through the larger one under its own weight, but not through the smaller one. Each ball is rotated on the gauges to check its concentricity.

Deformation

The behaviour of tennis balls after impact with the racket and/or court surface is partly determined by the ball's deformation characteristics, which describe how the ball shape changes under a known load.

The original device for testing ball deformation is the Stevens Machine, named after its inventor (fig 5). This is a mechanical device which applies a known force to a ball placed between two plates. The operator compresses the ball by turning a handle and the amount of deformation under a known force is measured from a scale. While accurate, the Stevens Machine is a time-consuming process.

Fig 5. Stevens Machine

The automated deformation testing device can work about twice as quickly as a human operator using the Stevens Machine. This machine is controlled by computer, which specifies how many balls to test and what values to record (fig 6).

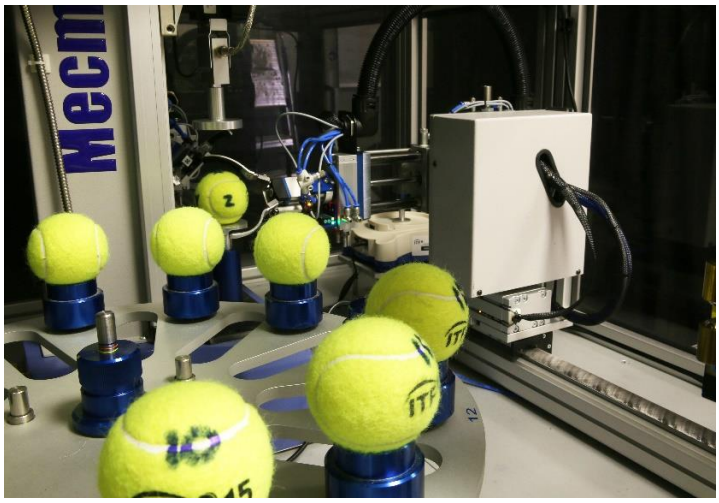

Fig. 6 Automated deformation testing device

A key advantage over the Stevens machine is elimination of operator error due to factors such as speed and timing of testing. In a year, this machine will compress over 5,000 tennis balls.

The deformation rule has been constant ever since it was introduced, although it was introduced in two parts; forward deformation in the 1930s; return deformation in 1967.

Rebound

The rule specifying how the ball should bounce was set in 1925 and is still in use today. The test involves dropping a ball vertically from a height of 254 cm (100 inches) and measuring the rebound.

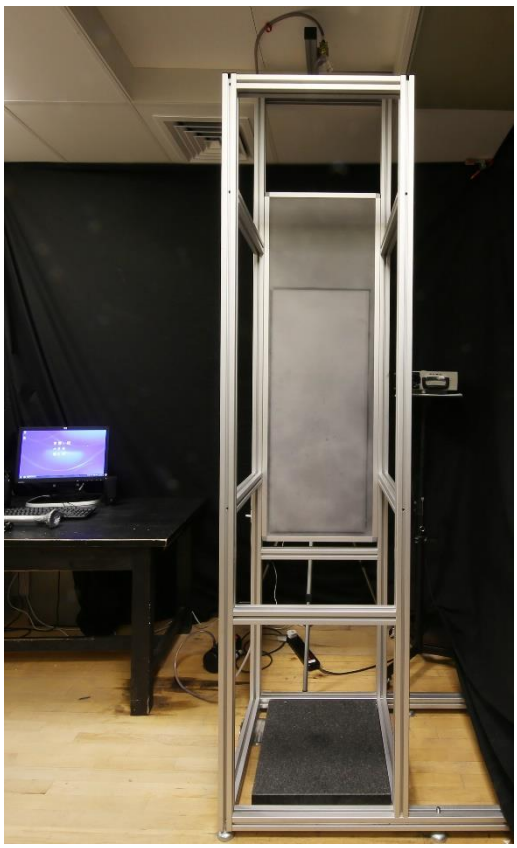

Fig 7. Bounce height test set-up

The equipment used in the ITF laboratory consists of a vacuum pipe (that holds the ball at the correct height before being released), a smooth granite block onto which the ball bounces, video camera and light source (fig 7). Each rebound is recorded and the rebound height is measured from the shadow of the ball that is cast against a scale. This is all done with software that analyses the video of the bounce in real time and calculates the height using the contrast between dark (the ball) and light (the background) over a series of frames either side of the peak.

Durability

The durability test is the most recent development in ball approval and was introduced in 2009. The changes in mass, size, deformation and rebound of six balls are measured following a standardised wearing regime. Laboratory equipment is used to simulate the effects of nine games play.

Wearing begins in the wear rig, consisting of an air cannon that fires balls onto a rigid surface at approximately 90° (fig 8). The impact speed of the ball is 40 m/s (144 km/h); each ball is subjected to 20 impacts. The outer surface (cloth) of the ball is then worn by putting two balls at a time in an abrasion box for two minutes. The abrasion box is lined with rough emery paper and has three rotating wooden paddles that knock the balls around inside the box (fig 9).

Fig 8. Wear rig

Fig 9. Abrasion box

The effects of nine games of play (i.e. a typical ball change) were established by measuring thousands of new and used balls from tournaments played on a variety of surfaces.

In general, balls soften (deformation increases) and weigh less after they have been used. However, the mass of a ball used on clay often does not change because particles of clay stick to the cloth.