

Review of Driver Clubhead Characteristics 1992-2018

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1. Introduction

Golf club technology has progressed rapidly over the last couple of decades. The most notable difference is in clubhead size, which can be directly attributed to the inception of metallic clubs. The use of metals in club design allowed clubs to be hollow and hence larger, while maintaining mass properties and low production costs. With this increase in size comes the potential to increase other characteristics such as moment of inertia (MOI) and coefficient of restitution.

From the early 20th century until the early 1980s, persimmon wood drivers were the typical driving club used by touring professionals and amateur golfers. Throughout these same decades, golf club designers were developing a metal-headed drivers. Initially, aluminium was used but this soon evolved to steel and eventually titanium. However, it was not until the 1980s that metal clubs became ever present on the PGA TOUR and the PGA European Tour. In 1982, Jim Simons became the first player to win a professional tour event (Bing Crosby National Pro-Am) with a metal wood in his bag. Two years later Lee Trevino became the first player to win a major championship (1984 PGA Championship) with a metal wood.

The early 1990s saw the introduction of the Callaway Big Bertha and with it an upsurge to the then-called oversized clubheads. In 1998, the USGA set a limit on the coefficient of restitution (COR) of woods at $0.822 + 0.008$; The R&A, however, did not impose this limit until 2003. Although few players hung onto the persimmon club, it is thought the last persimmon driver used on tour was in 2001. By 2004, the pendulum test (R&A and USGA, 2004) for drivers and fairway woods was imposed. The pendulum test set to limit characteristic time, to $239 \pm 18 \mu\text{s}$, which correlates to a COR of 0.822 ± 0.0008 . Throughout the early 2000s, clubhead size continued to increase and this led to volume and size limits being imposed in 2004 by The R&A and USGA. In 2006 a limit to the moment of inertia (MOI) of 5900 gcm^2 was also imposed. See Appendix A for a timeline of rules and innovation milestones.

This report aims to provide quantitative data to create a historical perspective of driver clubhead characteristics both before and after these rules were introduced. To achieve this, the characteristics of a selection of clubheads, ranging from 1992 to 2005, were chosen at random and characterised using a variety of measurements. Additionally, conformance data available from submissions to The R&A between 2010 and 2018 were analysed to confirm that a period of stability in these characteristics has been introduced.

2. Pre-Rules Data

2.1 CT, MOI and Volume

A selection of drivers with production years ranging from 1992-2005 were randomly chosen from The R&A archive at Allan Robertson House, Kingsbarns. Each club was de-shafted, if necessary, before several measurements were taken to characterise the clubs. These included MOI, volume, characteristic time (CT), centre of gravity location (CG), and the dimensions and mass of each clubhead. These measurements are standard procedure as per The R&A conformance tests; a full description of each procedure is described in The R&A's Test Protocols (R&A and USGA, 2003, 2005 and 2006 respectively). CG location and clubhead mass, on the other hand, are not directly conformance tested; Figure 1 gives a description of the three measurements required for the CG location measurement. Clubhead mass was measured during the procedure for CG location.

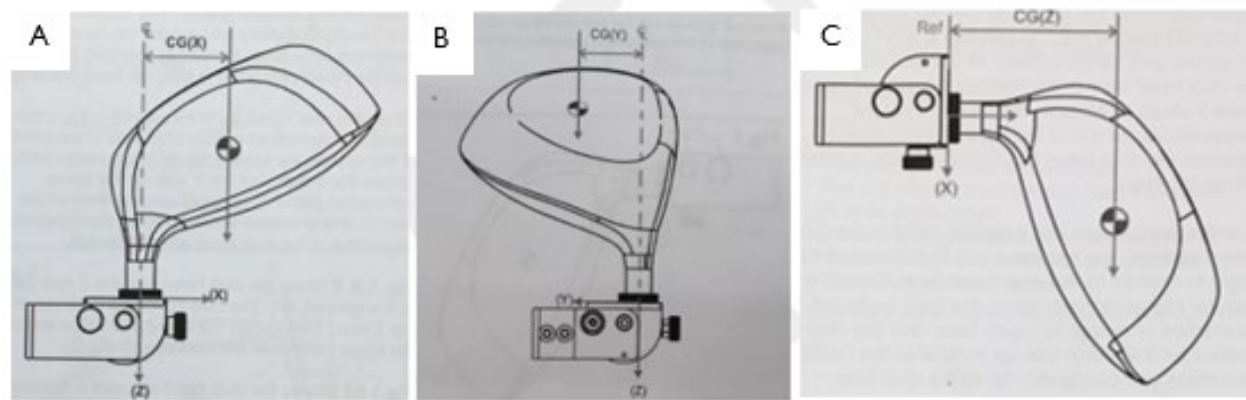


Figure 1 Description of CG location measurements, A) CGx, B) CGy, C) CGz

All measurements were repeated three times and an average of the measurements for each characteristic was calculated. The CT, volume and MOI were plotted against the year of manufacture and these are shown, respectively, in Figure 2, Figure 3 and Figure 4 respectively. In each figure, the limit and the corresponding year the limit was imposed are presented. The figures show that for each characteristic there has been an increase through time. For all figures throughout this report there is an orange band which represents a tolerance area and a red band which indicates non-conforming data points. Submissions within the orange band during conformance testing would be issued with a warning but conformance still achieved.

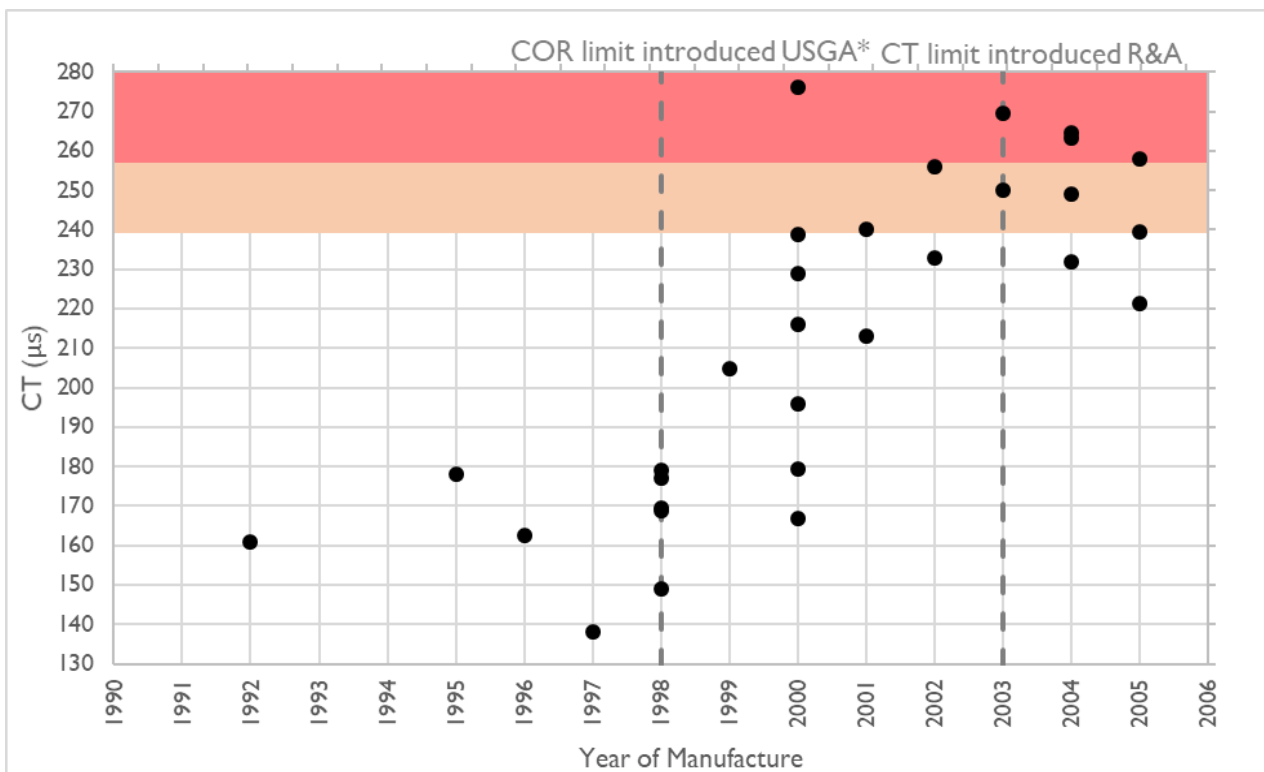


Figure 2 Graph to show the change in CT over time. The CT limit is $239 + 18 \mu s$. *The 1998 limit by the USGA was COR rather than CT (although 239 CT correlates to 0.822 COR). The CT limit was then introduced by The R&A in 2003.

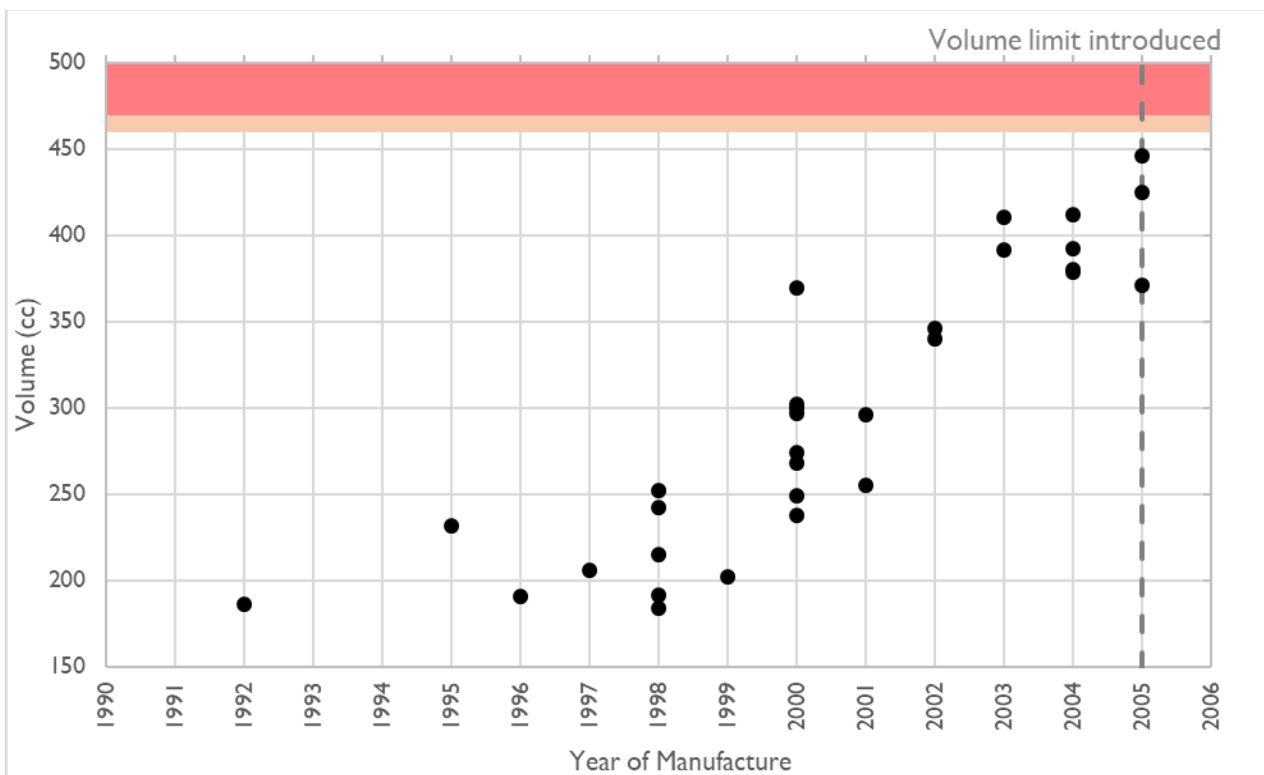


Figure 3 Graph to show the change in volume over time. The volume limit is $460 + 10 cc$ and was introduced in 2004.

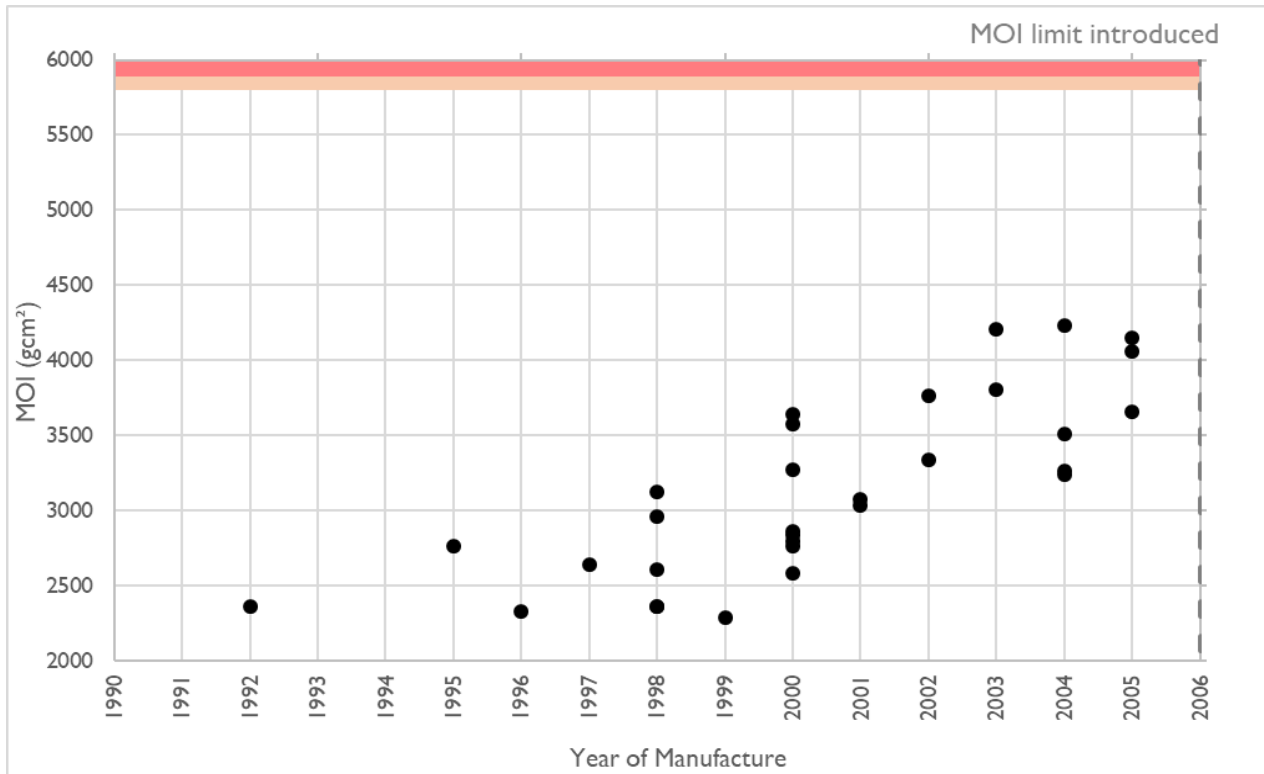


Figure 4 Graph to show the change in MOI over time. The MOI limit is $5800 + 100 \text{ gcm}^2$ and was introduced in 2006.

2.2 CG measurements

The CG location is given by three distances, which together describe the location of the CG. Each of these distances is measured from the same origin, i.e., the top of the hosel pin (Figure 1). The CG measurements were plotted against the manufactured year (Figure 5, Figure 6 and Figure 7). This showed that CG_x moved further away from the origin over time, whereas CG_y and CG_z varied and the increase over time was not as clearly defined.

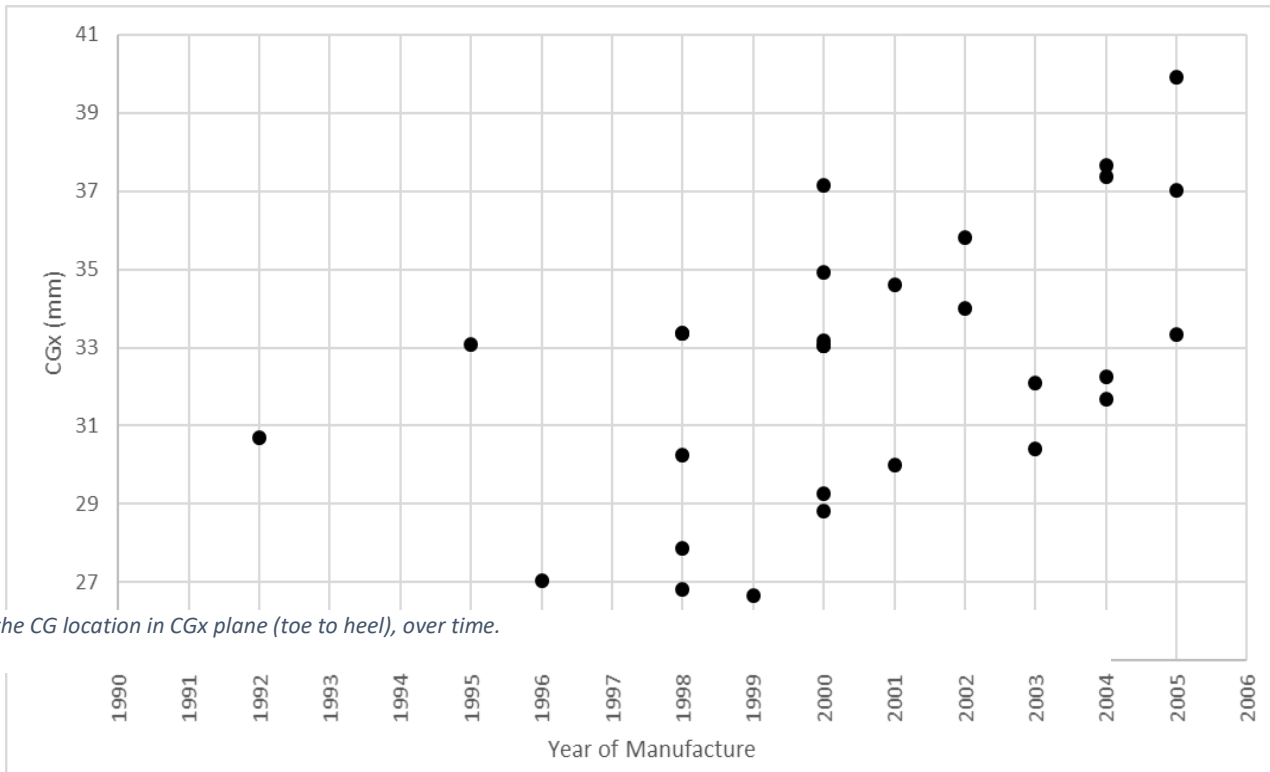


Figure 5 Shows the CG location in CGx plane (toe to heel), over time.

Figure 5 Shows the CG location in CGx plane (toe to heel) over time

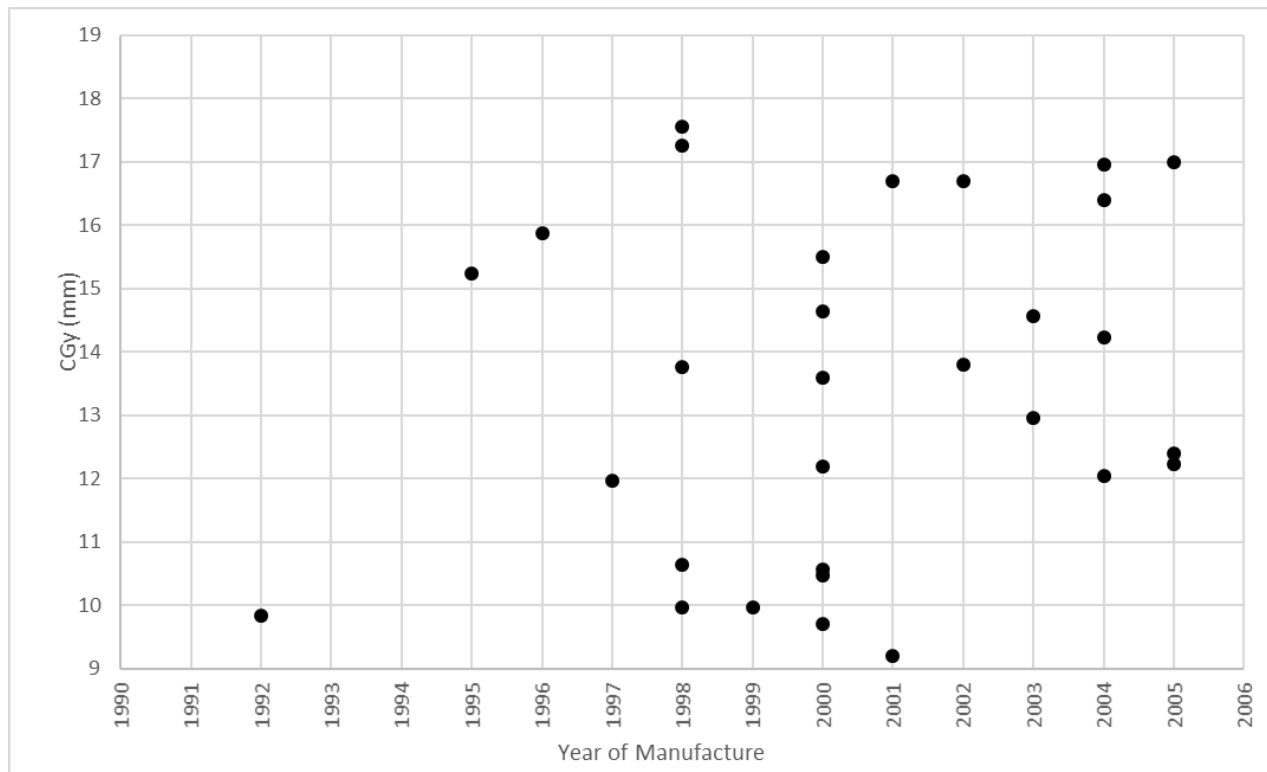


Figure 6 Shows the CG location in CGy plane (depth) over time

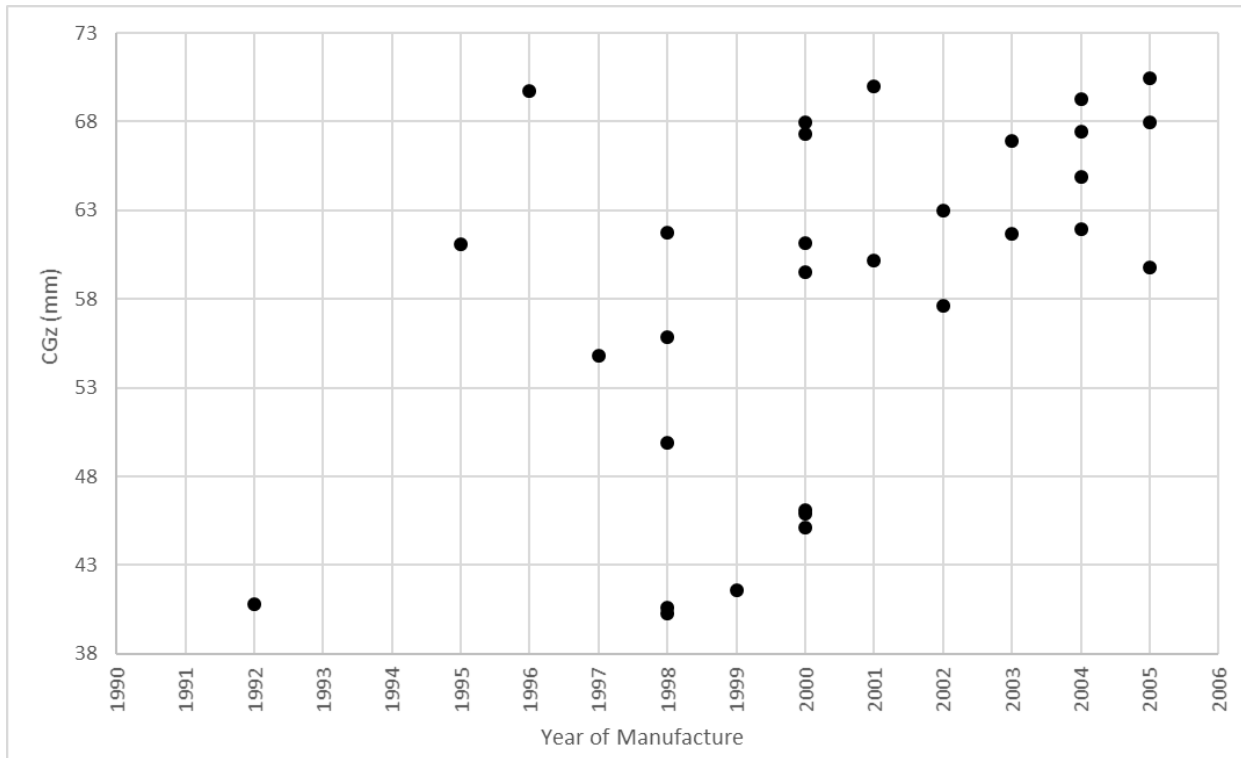


Figure 7 Shows the CG location in CGz plane (sole to crown) over time

2.3 Head Dimensions

Each of the three measured head dimensions were also plotted against manufactured year, Figure 8, 9 and 10. The size limit for clubheads was introduced in 2004 by both The R&A and USGA, which is represented on each plot along with the respective limit. The figures show that each measured dimension increases with time.

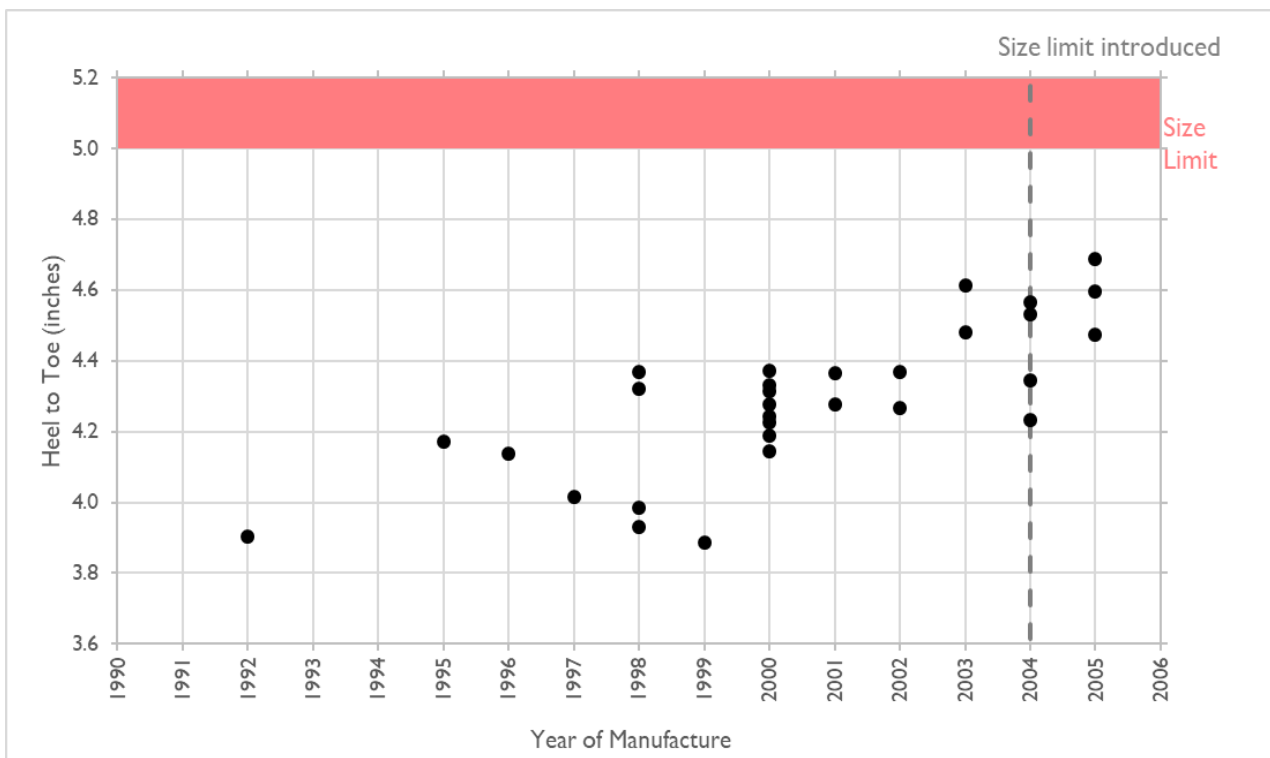


Figure 8 Shows the measured distance from heel to toe of clubheads over time

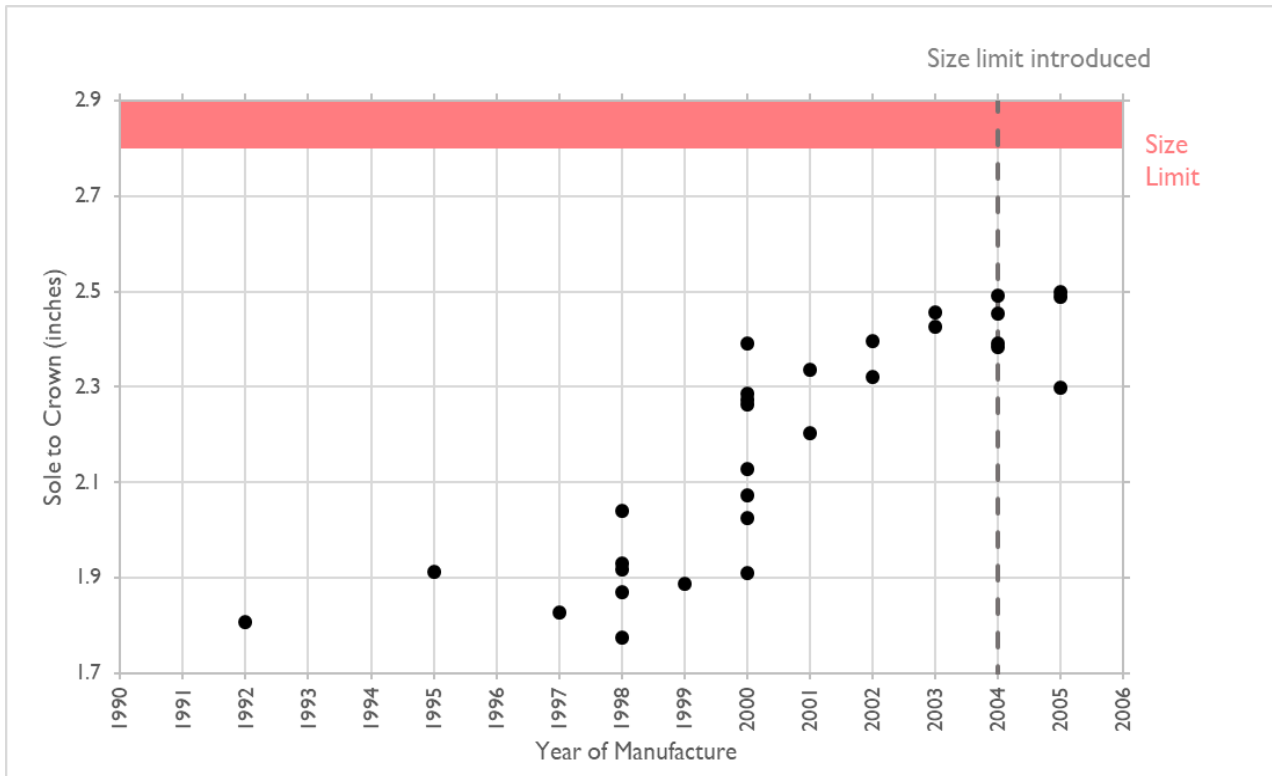
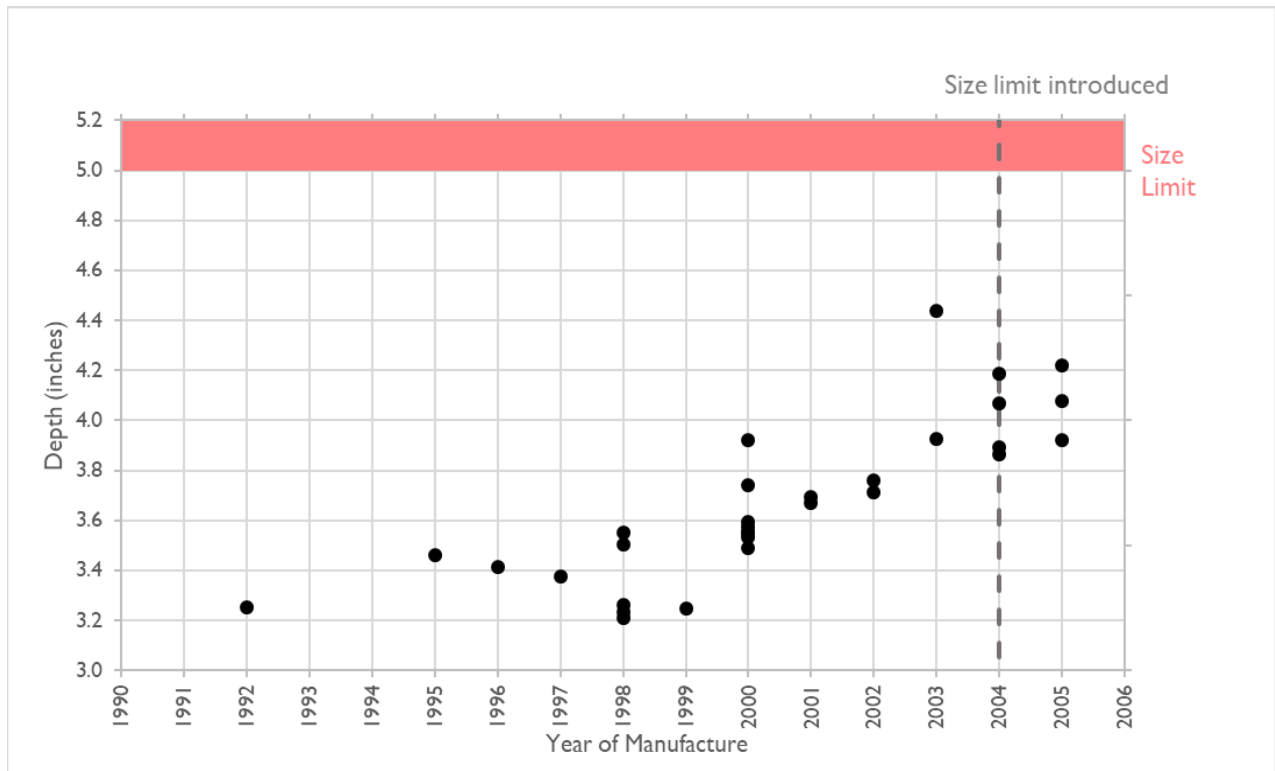


Figure 9 Shows the measured distance from sole to crown of clubheads over time



2.4 Clubhead Mass Over Time

The mass of each of the clubheads selected was also measured. Figure 11 shows the clubhead mass has not changed over time. Current views perceive an optimum for clubhead mass at 200g (Cochran and Stobbs, 1968). The data agrees with this as there is a collation of data around 200g and this is consistent over time. However, the plot shows a range of 14g in the year 2000. This is thought to be from outliers of clubs which have different mass properties rather than a trend for this particular year.

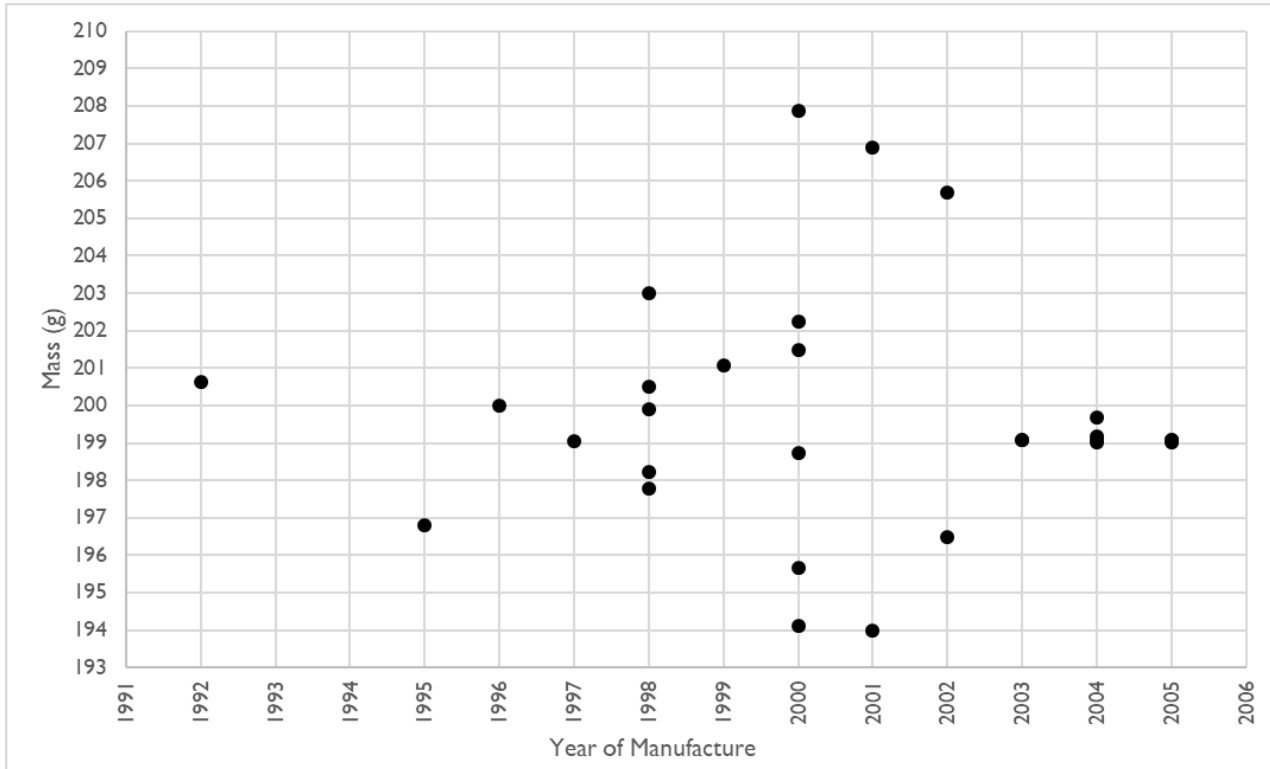


Figure 11 Shows the clubhead mass over time

3. Post Rules Conformance Data

The results from conformance testing since 2006 were used to present an historical perspective of post rules conformance data. As all limits of interest were applied by 2006, this was chosen as the starting point. The data was assessed to see whether the rules had created a period of stability. Figure 12, 13 and 14 show how the rules have restricted CT, volume and MOI respectively. While there are some data points which exist outside the conformance area, the data shows that the results from CT, volume and MOI have remained stable during the period. Figure 14 should be treated with some caution as the majority of the values for MOI were obtained during a screening test and therefore are only an estimate of the precise MOI. This only indicates whether the MOI of the clubhead will be below a certain value and does not directly calculate the MOI of the clubhead. Nevertheless, Figure 14 shows the conforming MOI screen values are generally consistent across this time period.

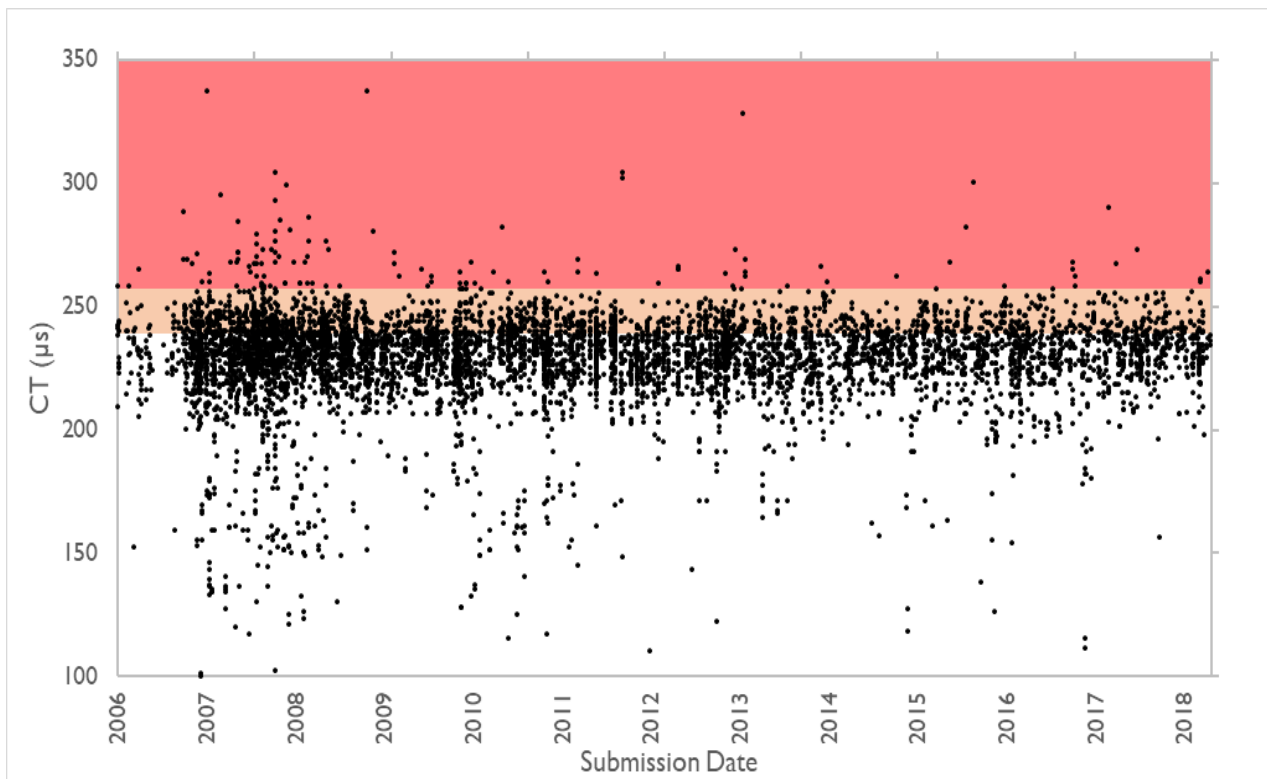


Figure 12 Shows the results from CT conformance measurements submitted to The R&A during the time period

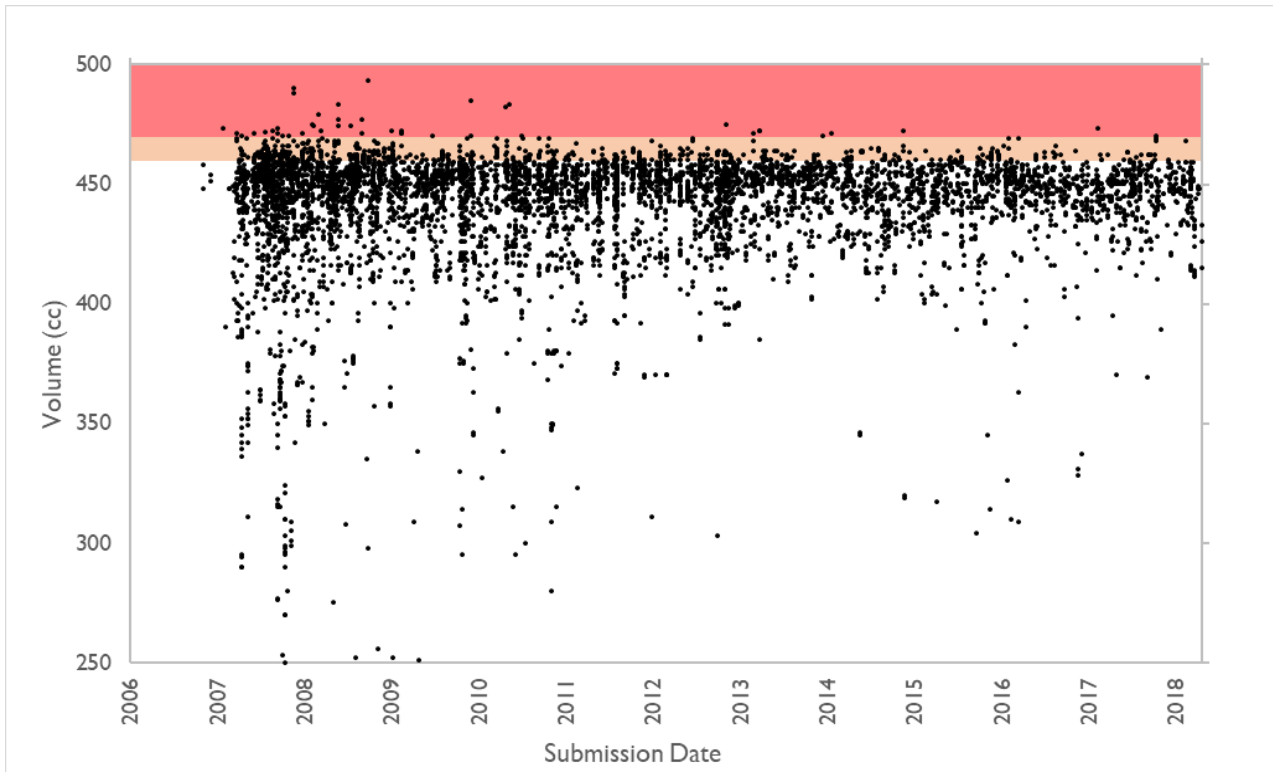


Figure 14 Shows the results from volume conformance measurements submitted to The R&A during the time period

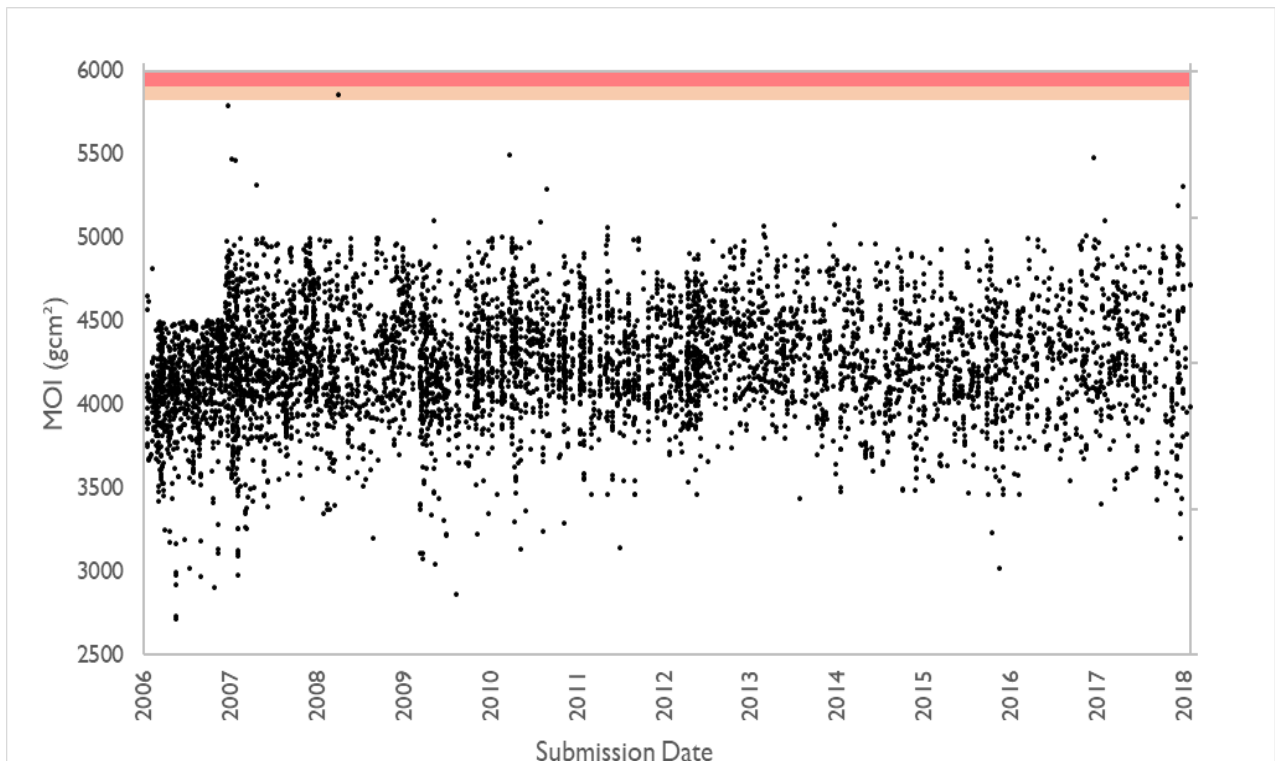


Figure 13 Shows the results from MOI conformance measurements submitted to The R&A during the time period

4. Discussion

The purpose of this report was to provide quantitative data to create a historical perspective of clubhead characteristics and to confirm that the rules introduced between 1998 and 2006 to limit the clubhead characteristics have provided a period of stability. The results show that before the rules were introduced, the clubhead characteristics, CT, volume and MOI were increasing with time (Figures 2, 3 and 4). The introduction of these rules provided a period of stability where no further increases to these characteristics could occur. This period of stability was shown in Figures 12, 13 and 14. The larger data set provides a clear and concise time scale for an historical perspective on conformance data.

Currently, there is no direct rule limiting the CG position. However, as this characteristic is easily measurable, this was measured on the clubheads randomly chosen from the years 1992 - 2005. Figure 5 shows the distance CGx clearly increased over time. The increase in all CG locations coincides with an increase to the head dimensions. All three measurements of the head dimensions showed an increase in size. Figures 8, 9 and 10 show each dimension increases at a similar rate. However, this can only be considered generally, since the results are from a random sample which may not directly relate to the population.

The results for clubhead mass agree with existing knowledge that an optimum for clubhead mass exists near 200g (Cochran and Stobbs,1968). This optimum for clubhead mass exists due to the conservation of momentum principle. Increasing clubhead mass would result in an increase to ball speed if the club could be swung at the same speed. However due to the increase in mass, the clubhead speed is reduced and any benefit from the increased mass is lost.

There are several limitations involved in this study. First, with any measurement, errors can be introduced. To minimise measurement error, each measurement was recorded three times and the same operator performed each measurement. All the equipment was calibrated before the measurements began to reduce the occurrence of any systematic errors. Further to this, the sample of clubheads chosen is very small when compared to the population of golf clubs on the market each year. The aim of the report was to provide quantitative data to provide an historical perspective of driver clubhead characteristics. The relatively small sample size can provide only an indication of the changes to clubhead characteristics over time. However, the low availability of clubheads dating from 1992-2000 was a further limitation of this study.

Nevertheless, this data set shows consistent trends for club characteristics having increased with time until the introduction of the rules set to limit the CT, volume and MOI. After this introduction, a period of stability was introduced which has limited the development of these characteristics. This report has given an overview of the clubhead characteristics over time, by providing quantitative data which shows both periods of progression and stability and thereby demonstrating how clubhead characteristics have both increased over time and have now been successfully controlled.

5. References

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Appendix A Extracts from Annual Driving Distance Report 2019

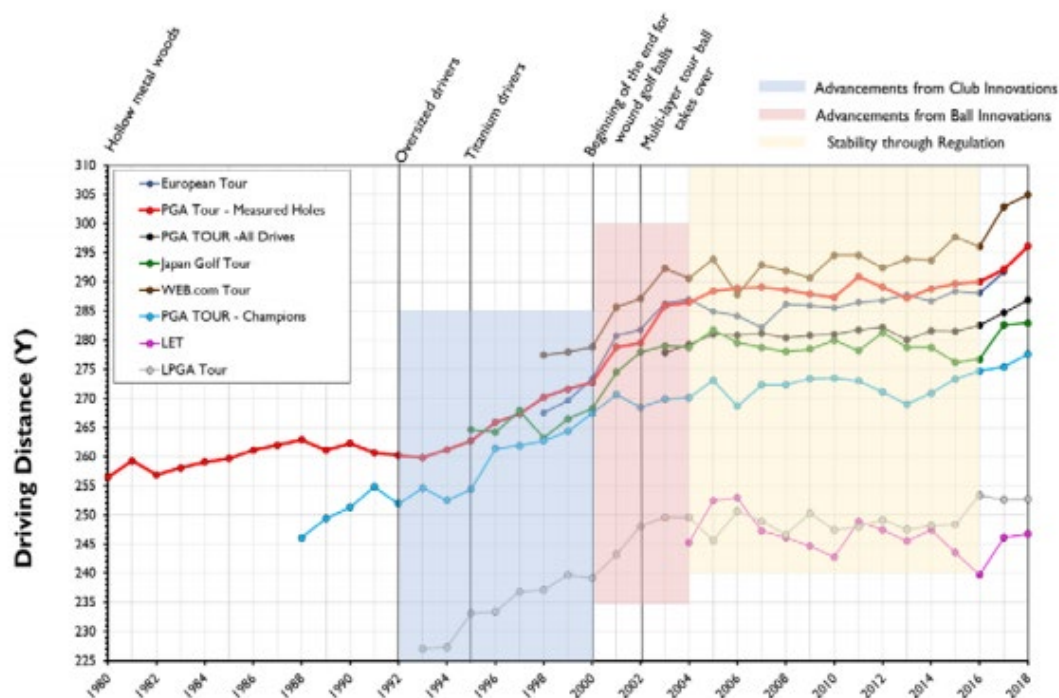


Figure 15 Average driving distance on the major tours with significant Rule change milestones overlaid

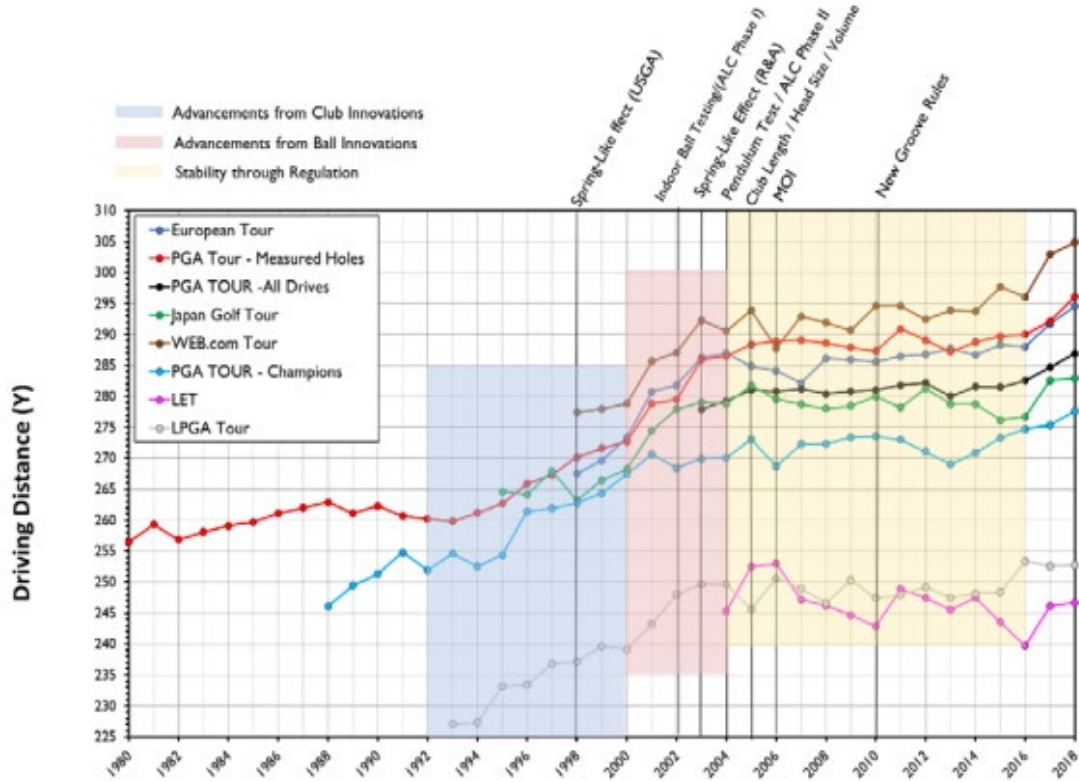


Figure 16 Average driving distance on tour with significant innovation milestones overlaid

Figure 15 shows the progression of driving distance over time with an overview of the new implemented rules. Figure 16 shows the average driving distance on tour with significant equipment innovation milestones overlaid.

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