

**Product Design and Development
Individual Assignment**

How has changing the material used to make tennis rackets affected the design of rackets, as well as the overall game since 1967?



**10920
Mechanical Engineering with Advanced Design and Innovation
University of Bath**

Personal Tutor: Dr. Marcelle McManus

SUMMARY

The materials used to make tennis rackets have heavily changed since 1967. From wood to metals (steel and aluminum), to firstly graphite reinforced and then 100% graphite rackets, a large evolution has taken place in the materials used that has had wide implications on the game today. In the modern era, graphite is still the material of choice, but it is often mixed with other materials such as basalt or graphene.

Changing the racket material has directly affected tennis rackets designs, as manufacturers realized that they could have larger racket head sizes or thicker beams, whilst maintaining (or often reducing) the weight of the racket. These advances have led to the *ITF* introducing new regulations to keep the game competitive, as well as banning products that would give players an unfair advantage. Another side effect of changing materials has been advances in other areas, such as stringing technology and playing styles/techniques.

This essay aims to highlight the major changes in the materials used to make tennis rackets, and how material changes forced certain design modifications. It also discusses the variations that these advances in material and design forced in the overall game, including the widespread use of topspin and the two handed backhand, as well as why courts are slower today than in the past, as well as looking at the future of tennis rackets.

TABLE OF CONTENTS

Summary	2
Terminology	3
1. Introduction	4
2. 60s and 70s: The Battle of Wood vs. Metal.....	4
3. 80s: The Graphite Boom.....	6
4. 90s and 00s: Graphite Composites - Experimenting with Titanium.....	8
5. The Modern Era (03-): A Changed Game	9
6. Conclusion: What does the Future Hold in Store?.....	10
7. References.....	10
a. Image References.....	11

TERMINOLOGY

Term	Definition
<i>Babolat</i>	A French tennis racket and string manufacturer based in Lyon, France.
<i>Baseline</i>	The line marking the back of a tennis court.
<i>Beam</i>	The name given to the thickness of the tennis racket head.
<i>Dunlop</i>	A British sporting goods company that specialize in tennis and golf equipment.
<i>Feel</i>	The sensation players get for how they're striking the ball, as well as where it is going. An advantage for players, who can make adjustments in their technique.
<i>Grand Slam</i>	Consisting of the Australian Open, French Open, Wimbledon and US Open, these are the four most important annual tennis events.
<i>HEAD</i>	A sports equipment company, famous for their tennis rackets, based in the Netherlands and Austria.
<i>Head-heavy</i>	A racket that has the majority of its weight distributed in the head.
<i>Head-light</i>	A racket that has the majority of its weight distributed in the handle.
<i>Head-size</i>	The size of the hitting area within a tennis racket frame.
<i>Inside-in forehand</i>	A forehand that is hit down the line after running around a ball hit towards the backhand.
<i>Inside-out forehand</i>	A forehand that is hit crosscourt after running around a ball hit towards the backhand.
<i>ITF</i>	The <i>International Tennis Federation</i> , the governing body of world tennis.
<i>Midsized/midsized plus</i>	A racket that has an average sized head-size, and therefore an average sized sweet-spot. Defined as 80-94 square inches (midsized) and 94-105 (midsized plus).
<i>Newton's 2nd Law</i>	Given by $F = ma$, this law states that the acceleration of an object produced by a net force is directly proportional to the magnitude of the net force and inversely proportional to the mass of the object.
<i>Off centre</i>	A ball that is not hit in the sweet-spot of the racket.
<i>Open Era</i>	Beginning in 1968, this is when the Grand Slam tournaments agreed to let professional players to compete with amateurs. Before this, only amateurs were allowed to compete at Grand Slams.
<i>Oversize</i>	A racket that has a bigger head-size in order to increase the size of the sweet-spot. Defined as anything over 105 square inches.
<i>Prince</i>	A manufacturer and distributor of racket sports equipment, based in Atlanta.
<i>Reverse forehand</i>	A style of forehand that finishes over the head, compared to the traditional finish of over the shoulder.
<i>Serve and volley</i>	A playing style in which the server moves into the net after serving, ready to play an attacking volley off the service return.
<i>Stiffness</i>	The amount that a frame deflects during ball contact. This directly affects the potential power of the racket. However, stiffer rackets are harsh on the arm.
<i>Sweet-spot</i>	The hitting area of a tennis racket that gives the maximum power available.
<i>Stringing pattern</i>	The amount of strings that are contained horizontally and vertically in the racket head. A denser pattern is easier to generate spin with, as more strings interact with the ball in the hitting region.
<i>Throat</i>	The area of the racket that starts at the top of the handle and splits into two sections, which extends outwards to form the racket head.
<i>Topspin</i>	A ball that is rotating forwards as it is moving. This forward rotation creates a downwards force that makes the ball drop (due to the <i>Magnus Effect</i>).
<i>Wilson</i>	A sports equipment manufacturer, including tennis rackets, based in Chicago.
<i>Yonex</i>	A Japanese manufacturer of sporting equipment for badminton and tennis.

1. INTRODUCTION

With the exception of golf and F1, tennis is probably the sport most influenced by advances in design and technology. Since the Open Era began in 1968, these developments have changed the game beyond recognition; a power-based, baseline game has largely become the dominant style of play today due to differences in materials used to make the rackets, which in turn led to numerous design innovations. The change from wood to metals to composites meant that new and pioneering designs could be created, including lighter rackets with larger head-sizes and thicker beams.

These advances in tennis racket design and technology have often coincided with periods of dominance within the men's game, which is historically more power based; Connors and Borg during the 70s, Agassi and Sampras in the 90s and the trio of Federer, Nadal and Djokovic in the modern era. During the Open Era, the most successful players have often been the ones with the most up to date equipment (**Fig.1**), due to racket manufacturers creating bespoke rackets for players.

Rank ↕	Player ↕	Total ↕	Australian Open ↕	French Open ↕	Wimbledon ↕	US Open ↕
1	Roger Federer	17	4	1	7	5
2	Pete Sampras	14	2	0	7	5
	Rafael Nadal	14	1	9	2	2
4	Björn Borg	11	0	6	5	0
5	Novak Djokovic	10	5	0	3	2
	Jimmy Connors	8	1	0	2	5
6	Ivan Lendl	8	2	3	0	3
	Andre Agassi	8	4	1	1	2
9	John McEnroe	7	0	0	3	4
	Mats Wilander	7	3	3	0	1

Fig.1 – List of the most successful Grand Slam men's singles champions in the Open Era (as of December 2015). Three of the top five (in bold) are from the modern era (2003 -).

This essay aims to highlight the developments in the materials used in tennis rackets over the last fifty years, and to identify how these changes have changed the design of rackets, as well as how this has evolved the game into the form it is today. It also looks at how the rackets enabled certain players to dominate the sport, and speculates on design advances in the future.

2. 60S AND 70S: THE BATTLE OF WOOD VS. METAL

Prior to the late 60s, the only change that had occurred since the first racket (produced in the 19th century) was a change from solid to laminated wood. Wooden tennis rackets in this era were generally quite heavy and had small head-sizes (e.g. the *Jack Kramer Autograph* weighed 371g with a head-size of 69.6 square inches). However, tennis was to be changed forever in 1967 with the introduction of the *Wilson T2000*, the world's first metal racket (**Fig.2**). ^{[1][2]}

The *T2000* was revolutionary in a number of ways, but the most important was that it was made out of steel, a material stiffer than wood. It also had a rounder head, a slimmer beam and an elongated throat, meaning that it encountered less wind resistance; as a result, it could be swung quicker, leading to more powerful shots. For pros still playing with wooden rackets, this increase in power from their opponents was something that they could not handle; displayed when Billie-Jean King won the 1967 *US Open* without dropping a set, and when Jimmy Connors thrashed Ken Rosewall in the 1974 *Wimbledon Final* 6-1, 6-1, 6-4. The increase in power meant changes in playing style were introduced that are still used to this day; hitting with topspin (which allows players to hit harder, while still having their shots drop in) and the two-handed backhand (which allows players to hit powerful shots with greater control).

Rival manufacturers realized that they needed to create rackets that generated more powerful shots. They did – but in separate ways.



Fig.2 – Comparison of two Wilson rackets; the wooden Jack Kramer Autograph (1948) and the steel T2000 (1967). Both rackets are similar in head-size; however their shape is different.

In 1975, Björn Borg held only one Grand Slam title, mainly due to him using a wooden racket. Around this time however, *Donnay* developed a new racket with him that was wood based, yet reinforced with modern materials in order to provide extra stiffness (**Fig.3**). While it weighed a hefty 400g, this stiffness gave power to the wooden racket that other pros got from their metal rackets, whilst retaining the feel that wooden rackets provided (that tennis players of the era loved). This increase in power led to some players (including Billie-Jean King) to switch back to these rackets in the 70s, after incorporating topspin into their playing styles.

This suited Borg. Considered one of the pioneers of the topspin game, his style of play complemented the racket he used. He ended up in fourteen grand slam finals out of a possible sixteen entered from 1976-1981, winning nine titles in this timespan. He also developed a reputation for being a clay-court specialist, as historically topspin is most effective on it. [3][4]



Fig.3 – Borg with his Donnay Allwood, the racket he used for most of the 1970s. Advances in wooden racket design forced pros to change their style of play.

Meanwhile, *Prince* released the *Classic* in 1976 (**Fig.4**). One of the first aluminum rackets on the market; it was also the first oversized one, with a head-size of 110 square inches. Nearly 60% larger than what was used at the time, it meant that the racket had a larger sweet-spot which allowed players (especially recreational) to hit harder. Like the *T2000*, it also had a thin beam, but was a lot more flexible than both steel and wooden frames; meaning shots that didn't hit the sweet-spot would often ricochet in random directions (the reason why the head-size was so large). Momentary distortion of the frame often occurred during off-center shots. [5]

The introduction of these rackets during the 70s changed tennis, and the game at the end of the decade was very different to what it was at the beginning. The differences in material, as well as the lighter materials used often meant that the new rackets could be swung faster. Combining

this with the increases in stiffness for all materials meant that tennis became more about power, and as such, topspin began to become an important part of many players' games. Advances in racket design, including growing head-sizes, different stringing patterns and increased lengths (not achievable with wood, as its stress limits would have been exceeded) forced the ITF to introduce new rules in 1979 to ensure the game remained fair and competitive. [6]



Fig.4 – The Prince Classic (1976); one of the first aluminum frames. As this racket was flexible compared to steel and wood, an oversized head was incorporated into the design in order to increase the size of the sweet-spot.

3. 80S: THE GRAPHITE BOOM

Racket technology was moving quickly as the 80s arrived, with manufacturers competing with each other to create the stiffest, lightest racket possible. The advances of the 70s each had their flaws; aluminum was too unpredictable for off-centre shots, steel rackets generally were harsh on the arm and wood was too heavy. With the optimum design for these materials in use already, a new material was found to make rackets out of; graphite (a.k.a. carbon fiber), the stiffest and lightest material available.

Prince evolved their hugely successful *Classic* racket into the *Prince Original Graphite* (**Fig.5**) in 1978, but it wasn't widely used until the early 80s. Offered with two different head-sizes (110 square inches like the *Classic*, and 95 square inches for a lighter and more aerodynamic design), the *Graphite* had less twisting during off-center hits, solving the problems that many professionals had encountered with the aluminum version. Because it was made from graphite, this racket was stiffer, but it still had a thin beam, while also of the lightest yet (at 350g). This racket improved many players' games, including Gene Mayer, who rose from 148 to 4 in the rankings while using the *Graphite*. [7][8]



Fig.5 – The Prince Original Graphite.

The introduction of graphite continued the trend of lighter, stiffer rackets that had started in the 70s. As it solved the problems that steel, aluminum and wooden rackets had, this encouraged many racket manufacturers to release graphite reinforced, and then 100% graphite rackets throughout the 80s. Dunlop released the *Max 200G* in 1983; a 100% graphite racket that is associated to this day with John McEnroe, who used it for almost a decade. Wilson responded by

introducing the *Pro Staff Original* in 1984; the racket that Pete Sampras used for his entire career, which gave him a record fourteen grand slam titles (at the time). Another famous user was Jimmy Connors; who switched from his beloved *T2000* in 1987 to keep up with the evolving sport, as by this time it had become an outdated design. [9]

Having found what seemed to be an optimum material at the time, the focus in the second half of the 1980s went instead into trying composites with graphite in them, as well as different designs of the tennis racket. Having released a wood-graphite hybrid in the early 80s, *Prince* tried to innovate again with the *Spectrum Comp* in 1985. This ambitious racket combined some of the lightest, stiffest materials at the time (graphite, fiberglass, Kevlar and ceramic fibers), and became a best seller. After this, manufacturers continued to play around with the racket design. Some changes included wider beams (for extra stiffness without adding weight, **Fig.6**) and longer rackets (for greater reach).



Fig.6 – The Wilson Profile (1987). It was the first racket to increase racket stiffness without changing the material by increasing the thickness of the beam. A “widebody” tennis racket, it was 39mm at its thickest point (double the thickness of a wooden racket).

One side effect of these design changes was the reduction in head-size, as the oversize trend produced rackets with too much uncontrollable power. By reducing the head-size, the sweet-spot size was reduced, but this was compensated by the overall increased power in the frame. However, by the end of the 80s and early 90s, power (and therefore topspin) were two of the skills required to succeed in the game, with strings able to cope with the amounts of spin required developed especially. The third, which began in the 80s but took off in the 90s was a big serve, and as a result of this tennis in the 90s evolved into a serve and volley style sport, with very few rallies in points.

However, for wooden rackets it was the end. Last used at *Wimbledon* in 1987, by the end of the 80s these were seen as ancient in the game due to the rise of graphite and advances in design. This was highlighted when Borg, after retiring at 26 in February 1983, decided to make a comeback in the early 90s using a wooden racket. The most successful player ever at the time (with eleven Grand Slams), he was humiliated by a little known player called Jordi Arrese on clay using a graphite racket 6-2, 6-3 (**Fig.7**). His failed comeback, consisting of twelve straight first round defeats with just one set won, underlined the fact that graphite was now the material of choice. [10]

The 80's had some of the most diverse playing styles in tennis history, as players changed rackets and with it their styles. John McEnroe started the decade using a wooden racket, and was famed for ability to hit volleys into all areas of the court, before switching to a graphite frame. Lendl used topspin to devastating effect once he got his hands on a graphite frame, while Jimmy Connors hit the ball flat from all areas of the court with his *T2000*. However, as players started to use the same type of frame, their playing styles converged to one brand as well; something that still occurs to this day.



Fig.7 – Borg and Arrese before their match in 1991. The head-size of Borg’s wooden racket was much smaller than the graphite racket of Arrese. Borg’s coach later commented “playing with a wooden racquet in 1991, it was like going to Iraq with a rifle”.

4. 90S AND 00S: GRAPHITE COMPOSITES - EXPERIMENTING WITH TITANIUM

As the 90s arrived, manufacturers were sure that no material could better graphite. The experimentation of the 80s had delivered the most powerful rackets ever created, and also the lightest. The rackets designed in the 90s didn’t change from graphite; rather, the emphasis was to find a winning composite combination. One of the main materials used was titanium.

HEAD’s contribution was the *Ti.S6*, released in 1996 (**Fig.8**). While other manufacturers had graphite composites, this racket was a titanium composite with graphite woven in. Yet again, titanium allowed rackets to be lighter and more powerful; however they were only really successful in oversized designs. The last widely used oversized racket in tournament play (head-size of 115 square inches), this racket shifted the weight to the head of the racket, again for added power.

HEAD’s most successful racket ever, it did have one major flaw; because it was so light (just 252g) it vibrated too much. It also generated too much power; the combination of a thick beam, oversized head, head-heavy and light frame was just too much for pro players (but perfect for recreational). This design led manufacturers to consider shifting the weight of their rackets to the handle. ^[11] A successor, the *Ti.S7* was released; however, it was banned by the ITF due to its oval shaped head, as this shape meant certain strings were over the maximum 15.5” limit the ITF set.

The evolution of tennis in the 90s wasn’t of the racket as much as the 70s and 80s, but of the actual style of game played, due to the rackets the game was now being played with. As players could now hit the ball harder, the 90s are considered the era of serve and volley, where points rarely extended more than three shots in length. As a result of this, special emphasis was placed on two areas of the game; the first serve (a high percentage put an opponent under pressure) and the return of serve (a good return gave a hard volley for the server). It is telling that the two most successful players of the decade are considered among the best ever for their respective style of game; Sampras (12 Slams won) for his first serve, and Agassi (5 Slams won) for his return of serve. ^{[12][13]}

When rallies did get going, the power in the game was nearing its peak. Graphite rackets allowed players to hit shots they wouldn’t have thought of before, such as the reverse and inside-out/inside-in forehands. These shots would become staples of the modern era, with the reverse forehand becoming the signature style of Rafael Nadal.



Fig.8 – The HEAD Ti.S6. Rackets released after this generally got rid of extreme features (light and oversized with thick beams) and stuck to what we know today.

5. THE MODERN ERA (03-): A CHANGED GAME

The 70s and 80s had diverse styles, as every player at the time used a different racket material; but this died out in the 90s as everyone started using the same equipment, leading to the majority of players having the same playing style. The result was a sport that wasn't considered as entertaining as it was a decade earlier; this peaked at *Wimbledon* in 2001, when 126th seed Goran Ivanišević hit 213 aces during his winning campaign (the player with the most aces during *Wimbledon 2015* hit 165, a reduction of over 20%).^{[14][15]} This repetitive style of play led to several former *Wimbledon* champions, including McEnroe, Navratilova, Becker and Cash to pen an open letter to the *ITF*, asking them to reduce the size of rackets in an effort to slow down the game.^[16] When this was ignored, tournament organizers came up with another way of slowing down the game; by slowing the courts themselves. This led to longer rallies, something the viewing public loved.

This is where Newton's 2nd Law ($F=ma$) becomes important. In the 90s, the way to increase F was to reduce the mass, allowing the racket to be swung faster. In the modern era, the emphasis has been on how to distribute the mass while still swinging the racket as fast (if not faster). The solution was relatively simple; concentrate most of the weight in the handle (head-light), while introducing design changes and technology advances that allowed the racket to be swung faster at the same time. This is the trend every manufacturer follows to this day; the majority of them have technology allowing the racket to be swung faster (generating power) whilst retaining control (**Fig.9**).

Fig.9 – Comparison of the aerodynamic technologies each manufacturer offer today.

Manufacturer	Technology	Benefits
Babolat	AeroModular	A faster swing due to improved aerodynamics, as well as increased power while maintaining excellent ball control.
Dunlop	Aeroskin	A dimpled texture created localized turbulence and streamlines airflow over the racquet surface. This reduced drag by up to 25%, resulting in a faster racquet speed for more power.
HEAD	Graphene	By placing graphene in the shaft, weight could be redistributed to more functionally relevant areas of the handle and tip. This unique construction provides players with increased swing speeds for more power with less effort.
Prince	03 Speedport Technology	Up to 24% more aerodynamic giving players faster strokes for more power, spin and precision.
Yonex	AeroFin	Added aerodynamically designed "fins" inside the top of the frame. This decreased air resistance on the top of the frame by 14%, compared to their traditional frames.

Today, tennis is a game dominated by crushing baseline exchanges. The introduction of slower courts forced manufacturers, for the first time, to design a racket for a style of play and not vice versa. This is one of the reasons why no major changes in tennis racket design, material or style of play have occurred in the last ten years; previously, changes in material led to a change in design which led to a change in style. In the modern era however, there has been no change in style and new material hasn't been found, meaning no need for a major design change.

6. CONCLUSION: WHAT DOES THE FUTURE HOLD IN STORE?

Tennis has seen a lot of changes over the last fifty years, with advances in materials directly influencing changes in design, and indirectly influencing other factors such as the playing technique, the style of play and the speed of the courts. Other advances in areas such as stringing technologies and techniques had also been due to advances in rackets.

So what does the future hold?

Many say that the *ITF* hold the key. Based in Roehampton, they are responsible for all tennis regulations, and several of these rules have prevented tennis from continuing to follow the trend of the 90s (a sport dominated by serve). Given free rein, manufacturers are quite capable of designing rackets that offer power to an extent that the game would descend into a serving competition. ^[17] The role of the technical branch of the *ITF* is to ensure that tennis remains a competitive sport, and they do this by keeping tight control over technology that could advance the game too much. Over the years, they have banned technology such as “spaghetti strung” rackets (rackets strung without interweaving, banned for generating too much effortless spin), “The Silencer” from *Prince* (a vibration dampener that was inserted during stringing, banned because it was installed above the bottom crossed string) and the *Dynasport* moveable mass racket (a racket with fluid in the frame that redistributed itself during a swing, banned as the centre of mass changed during a swing). ^[18]

One technology that the *ITF* have allowed to go through is the use of sensors in a racket to give data to show a player is playing (however, this data cannot be accessed mid-match). The original idea, *Babolat Play*, has gyroscopes, accelerometers and a piezoelectric sensor in the handle. This works together to give the user data including where the ball hits the strings and the power/spin on a particular shot. In response, other companies such as *SONY* have started to develop their own trackers to do the same thing. However, these are designed to fit onto existing rackets, unlike *Babolat Play*.

While the material used in rackets hasn’t changed since the 90s, innovation in tennis continues to happen to this day. Instead of material, focus has stayed on finding the optimum composite; *Wilson* are now using basalt with graphite, while *HEAD* have patented the use of graphene, a material that is even lighter than graphite that still provides the same amount of stiffness. However, the big advances are now being made in aerodynamic design, with many new technologies offered by racket manufacturers being unique in the way that they make their designs sleeker.

7. REFERENCES

1. **Racket Museum, 2014.** Wilson Jack Kramer Autograph [online]. Available from: <http://racquetmuseum.com/2014/01/23/wilson-jack-kramer-autograph/> [accessed 31/12/2015].
2. **Complex, 2012.** The Evolution of the Tennis Racket [online]. Available from: <http://uk.complex.com/sneakers/2012/08/the-evolution-of-the-tennis-racket> [accessed 31/12/2015].
3. **Fabian Ceuterickx Tennis Blog, 2015.** Donnay [online]. Available from: http://www.fabianceuterickx.com/?page_id=349 [accessed 31/12/2015].
4. **Wikipedia, 2015.** Björn Borg career statistics [online]. Available from: https://en.wikipedia.org/wiki/Bj%C3%B6rn_Borg_career_statistics [accessed 31/12/2015].
5. **YouTube, 2011.** Evolution of the Racquet, Part 3 [online]. Available from: <https://www.youtube.com/watch?v=oZPBxD3HlcY> [accessed 31/12/2015].
6. **ITF Technical, 2015.** History [online]. Available from: <http://www.itftennis.com/technical/rackets-and-strings/other/history.aspx> [accessed 31/12/2015].

7. **Wikipedia, 2015.** Prince original graphite [online]. Available from: https://en.wikipedia.org/wiki/Prince_original_graphite [accessed 31/12/2015].
8. **80s Tennis, 2014.** Prince racquets [online]. Available from: <http://www.80s-tennis.com/pages/prince.html> [accessed 31/12/2015].
9. **80s Tennis, 2014.** John McEnroe racquets [online]. Available from: <http://www.80s-tennis.com/pages/john-mcenroe.html> [accessed 31/12/2015].
10. **ESPN, 2010.** Comebacks that are best forgotten [online]. Available from: <http://en.espn.co.uk/espn/sport/story/53051.html> [accessed 31/12/2015].
11. **Pro Tennis Tips, 2015.** Head Ti S6 Review [online]. Available from: <http://protennistips.net/head-ti-s6-review/> [accessed 31/12/2015].
12. **Perfect Tennis, 2011.** The Top 5 Servers of all Time [online]. Available from: <https://www.perfect-tennis.com/the-top-5-servers-of-all-time/> [accessed 31/12/2015].
13. **Tennis Earth, 2013.** The Best Returners in Men's Tennis in Recent Times [online]. Available from: <http://www.tennisearth.com/news/tennisNews/Best-Returners-in-Mens-Tennis-in-Recent-Times-337934.htm> [accessed 31/12/2015].
14. **Wikipedia, 2015.** Goran Ivanišević [online]. Available from: https://en.wikipedia.org/wiki/Goran_Ivani%C5%A1evi%C4%87 [accessed 31/12/2015].
15. **Wimbledon, 2015.** Gentlemen's Singles Ace Leaders [online]. Available from: http://www.wimbledon.com/en_GB/scores/extrastats/ [accessed 31/12/2015].
16. **BBC, 2003.** Players defend big rackets [online]. Available from: http://news.bbc.co.uk/sport1/hi/tennis/wimbledon_2003/3045404.stm [accessed 31/12/2015].
17. **BBC, 2015.** Tennis racquet technology comes with strings attached [online]. Available from: <http://www.bbc.co.uk/news/business-30746221> [accessed 31/12/2015].
18. **ITF Technical, 2015.** Product Conformity [online]. Available from: <http://www.itftennis.com/technical/rackets-and-strings/product-conformity.aspx> [accessed 31/12/2015].

A. IMAGE REFERENCES

Image	Available from:
Cover Page	http://www.smh.com.au/content/dam/images/g/h/s/7/f/u/image.related.articleLeadwide.620x349.ghsod1.png/1434935616621.jpg
Figure 1	https://en.wikipedia.org/wiki/Tennis_records_of_the_Open_Era_%E2%80%93_93_men%27s_singles
Figure 2	http://racquetmuseum.com/wp-content/uploads/2014/01/Wilson-Jack-Kramer-Autograph-301x550.jpg http://www.fabianceuterickx.com/wp-content/uploads/2013/12/wilsont2000.jpg
Figure 3	http://api.ning.com/files/3nUVCQ2gckCYAAfnteyN8GCpwepuGg9OfZj37Y-ipc8LqeLa1JfEHDcOmN1jEQ-/bjornborg.jpg?width=450&height=296
Figure 4	http://www.thevintager.de/WebRoot/Store13/Shops/63766379/50CB/6423/35FD/88CC/B3FA/C0A8/29BA/E3B3/IMG_1509.JPG
Figure 5	http://img.tennis-warehouse.com/reviews/GROMS-1.jpg
Figure 6	http://www.thevintager.de/WebRoot/Store13/Shops/63766379/5122/23C6/9E37/B08A/3E15/C0A8/29BA/CE40/IMG_4292.JPG
Figure 7	http://ep.imgci.com/PICTURES/CMS/15700/15778.jpg
Figure 8	http://theschoollocker.com.au/media/catalog/product/cache/1/image/1200x1200/9df78eab33525d08d6e5fb8d27136e95/h/e/head_tennis_racquet_ti_s6_original_l3_11139_1.jpg