Chapter Five

A COMPARISON OF SHAFT TORQUE

Key words/phrases for understanding the information in Chapter 5:

Cut Shaft - Any shaft that has been trimmed according to manufacturer's directions for installation into a clubhead.

Deflection - The deviation of the tip from the butt centerline of a shaft after a known unit of force is applied to the tip to create a bend in the shaft.

Frequency - The rate of oscillation of a shaft after the tip is pulled down and released while mounted in a frequency-measuring device. Measured in cycles per minute (cpm).

Homogenous - A shaft made from like materials throughout (i.e. steel shafts are homogenous because the shafts are manufactured from the same material).

Raw Shaft - Any shaft in its manufactured form, before trimming and assembly into a golf club.

Sheet-Wrapping - A method of graphite shaft production in which successive sheets of graphite and epoxy resin "pre-preg" are wrapped around a steel forming mandrel. The mandrel is later removed and the shaft is trimmed, sanded, painted and a protective clear coat applied.

Torque - A shaft's resistance to twisting as measured in degrees of deviation from the shaft's resting point (zero).

In the era of wood shafts, torque was considered a necessary evil; an uncontrollable, unwanted side effect to which golfers had to adapt in order to master the various strokes of the game. Due to the natural grain of hickory and the many other hardwoods employed at the time, no wooden shaft had the ability to resist the natural forces of twisting that were placed upon the club during the swing. To reiterate the quote by British golfer and author Robert Browning, in identifying the problems 19th century golfers experienced with the lack of resistance to torque in wooden shafts, "... a bad player who got his timing wrong would sometimes bring the toe of the club forward so quickly that it caught the ground before it ever got to the ball."

Once the tubular steel shaft arrived on the scene, the shot making problems previously associated with the very poor resistance to torque of wooden shafts were immediately solved. Adequate torque resistance was an inherent quality of the steel itself, and proved to be one of the characteristics which quickly confirmed the position of steel as the golf industry's dominant shaft of choice. Average golfers raved at their new found ability to hit more controlled shots while experienced, more accomplished players decried the ruination of the skills of shotmaking due to the new metal shafts. Despite the differences in opinion, steel did completely replace hickory, and with this change, torque was eliminated, as a variable in the execution of a well struck shot.

Because a strong resistance to torque is automatically built into the design of a steel shaft, once hickory disappeared as a shaft material, little if anything was heard about torque for more than 40 years. However, in the mid 1960s and through the early 1970s, the spectre of torque began to raise its ugly head once more, first as an undesirable characteristic of fiberglass shafts and later as a similar problem with the industry's first graphite shafts. In an effort to prevent breakage and achieve the proper requirements of stiffness, creators of the early fiberglass and graphite shafts were not able to engineer their designs in such a way to counteract the twisting influences that occurred during the golf swing. As a result, the first composite shafts possessed far less resistance to torque than steel, in the process essentially linking the first generation of high-tech shafts back to hickory, at least from the standpoint of torque.

Not until the composite shaft manufacturers gained access to stronger fiber materials could engineers begin to effect a change in the graphite shaft's resistance to torque. With the introduction of much stronger graphite materials, shaft manufacturers no longer had to wrap all of the composite layers on the shaft with the fibers aligned longitudinally to achieve the necessary strength and stiffness. Since the new materials were so much stronger than before, fewer longitudinal layers were required to meet the strength and stiffness requirements of the shafts. Therefore, some of the layers previously devoted to strength and stiffness could now be aligned at different angles to the axis of the shaft to enhance the shaft's resistance to twisting. Once this multi-layer technique of fiber alignment was introduced, the shaft manufacturers gained the ability to independently control stiffness and torque in the production process. With this technical breakthrough, it became possible to create a tremendous number of new graphite shaft designs, each with its own unique combination of stiffness and torque.

A shaft's ability to resist the forces of twisting to which it is subjected during the golf swing can be recorded and expressed in a measurement of degrees of rotation. The lower the torque measurement in degrees, the greater will be the shaft's ability to resist the force of twisting placed upon it. The higher the torque reading, the less the shaft will be able to prevent twisting during the swing. If a shaft has very poor resistance to torque, the clubhead can arrive at impact "out of sync" to the path of the swing, in the process causing wild, off-line shots. In the early 1970s it was said the torque measurements of most of the first generation of graphite Driver shafts were between 6-10º, a range which represented a significant lack of resistance to twisting when compared to the 2.5-3.5º torque rating for the average steel Driver shaft. This disparity was the primary reason the first generation of graphite shafts failed to capture a considerable market share with players of the time.

With the second generation of graphite shafts, the picture began to change. Through the mid-to-late 1980's, as the shaft manufacturers became more adept in composite material selection and fiber alignment techniques within the shaft's different composite layers, the torque rating of some graphite shafts decreased to the point of actually being lower than the average steel shaft. The use of new and sophisticated wrapping techniques, coupled with the use of ever stronger fibers, made it possible by the late 1980s and early 1990s for a number of graphite shafts to be produced with less than 2º of torque!

With the ability to manipulate torque becoming standard fare in the composite shaft industry, the measurement of a graphite shaft's resistance to torque soon became a major point of marketing and advertising in the highly competitive golf equipment industry. Manufacturers capitalized on the promotional power of the quantitative measurement of torque - a single parameter that could distinguish one composite design from the hundreds of others on the market. Numerous advertisements soon were created that fostered the mistaken belief among golfers that regardless of any of the other shaft design features, the lower the torque measurement, the higher was the quality and performance of the shaft. Taken in by the hype, many golfers began to believe that a shaft with a low torque measurement would automatically hit the ball straight while any shaft with a higher torque reading would send the ball on a less desirable path.

Soon many average ability golfers discovered that a graphite shaft with a low torque dimension was not such a great help for their game. Compounding the problem was the fact that the torque measurements from one company to another, and even from one shaft to the other, were just not comparable. It is true that a pure quantitative measurement such as a shaft's resistance to torque can be valuable in helping golfers compare and make fitting decisions about the individual playability of particular shafts. But, as mentioned earlier in Chapter 2, once it became apparent that various shaft manufacturers employed slightly different methods to obtain their torque measurements, a measure of doubt was cast on the comparability of torque measurements from competing firms. Without the parameter of torque being measured in the same way by manufacturers throughout the industry, the viability of torque measurements needed viewed with a certain amount of pessimism.

Another discovery concerning torque that began to have an effect on the practice of shaft selection and fitting in the late 1980's was the suggestion that torque somehow contributed to the overall stiffness of a shaft. Trial and error experiments with many different low torque graphite shaft designs proved to golfers and designers alike that the lower the torque measurement of a shaft, the stiffer the shaft would feel to the golfer; and the higher the torque, the more flexible the shaft would tend to feel. No better evidence of this relationship was offered than when thousands of golfers of average or lesser ability bought and tried to use the Aldila HM-40 graphite shaft. Lured by its popularity on the PGA Tour, these average ability golfers soon found that the low 2º torque of the HM-40 contributed more to a loss, rather than an increase, in distance and accuracy. Simply stated, a shaft with a high frequency and just 2º of torque, such as the HM-40, is not playable for the majority of average ability golfers.

There was doubt in the comparability of torque measurements due to a lack of uniform standards for measuring torque. Because torque does have some as yet undefined effect on the stiffness feel of a shaft, it became apparent from the outset of the Dynacraft/Apollo shaft testing that the torque measurement phase was destined to carry great importance. Other than a few isolated, independent surveys, never before had such a wide range of different manufacturers' shafts all been measured for torque resistance under the same testing conditions.

To once more outline the parameters under which the torque measurements were initially obtained, each wood and iron shaft was tested both in its raw and cut shaft form using Apollo's computer-controlled shaft testing machine. After 1992, torque measurement techniques were duplicated in Dynacraft research facility. Two inches of the butt and 1" of the tip of the shaft were clamped into the testing device to secure the shaft in position for the measurements. After the computer completed the zero calibration of the shaft, a drive motor attached to the tip clamp began to rotate the shaft. Sensing the increasing force of rotation, a load cell connected to the drive motor constantly transmitted the rotation of the tip of the shaft back to the computer. At the moment the load cell sensed a force of exactly 1 ft./lb., the computer measured the shaft rotation (torque) to the hundredth of a degree. After re-calibrating the shaft, once more the computer conducted the torque test in the opposite direction of rotation. An average of the two readings was calculated and logged as the final measurement of torque for each shaft.

To provide a basis of accurate comparison, torque measurements were taken on both the raw and the cut version of each shaft. Again, the raw version of a shaft is that shaft as it is produced by the manufacturer in its uncut form, before assembly. Depending upon the manufacturer and the particular design, the raw length of each Driver shaft in the test ranged from 43" up to 50" and in iron shafts from 37" to 44". The cut version of each shaft represented the shaft after it was trimmed for installation. In the case of the shafts for woods, as trimmed for assembly into men's and ladies standard length, metal wood Drivers, and in the case of the iron shafts, for installation into men's and ladies standard length #5-irons

Overall Shaft Torque Averages for Each Flex

One of the most obvious points that can be seen from comparing a list of torque measurements from the Dynacraft/Apollo test to the manufacturers' own published ratings is that no company publishes torque measurements for their steel shafts. This is an interesting point which underscores the fact that torque in a steel shaft has to be considered an entirely different parameter than it is in a graphite shaft. The main reason shaft manufacturers do not publish torque measurements for steel shafts is that torque does not vary from high to low nearly as much as it does in a graphite shaft.

When a steel shaft is designed, once the weight, wall thickness, step pattern, length and the shaft's various diameters are set, the torque cannot be changed to any significant degree. Because the shaft is homogenous in its nature, i.e. made from the same material throughout, torque in a steel shaft is essentially a product of the geometric specifications of the shaft. To contrast, in a graphite shaft, once the manufacturer defines all of the geometric specifications of the shaft, the torque can still be altered significantly. By varying the strength of the composite material and changing both the number of layers and the orientation of the various layers are aligned to the axis of the shaft, a graphite shaft manufacturer has the ability to control the torque independently of the shaft's other specifications.

To first understand about torque, one must know that steel shaft do indeed have torque. Next, how does torque in steel shafts compare to that of graphite shaft? Chart 5-1 provides the torque average of current model shafts at the time of this second

Chart 5-1 - 2000 Shaft Torque Averages by Flex for Steel and Graphite Shafts

	Wood		Iron	
Flex	Steel	Graphite	Steel	Graphite
L[1]	3.32º	5.76º	2.12º	4.22º
A	3.30º	5.27º	2.12º	4.12º
R	2.96º	4.68º	1.93º	3.67º
S	2.73º	4.43º	1.75º	3.57º
X	2.61º	3.66º	1.69º	2.93º

[1] L-flex measured at ladies standard length for both the wood and iron models.

publication. This way, it enables a clubmaker to know exactly what is an "average" torque range for a given shaft and flex as means of comparison.

Comparing the average torque measurements in Chart 5-1, there is a trend that the stiffer the shaft, the lower the torque. Torque is primarily controlled by the stiffness of the shaft in steel shaft, thus the logical progression in torque measurements. However, the stiffness of graphite shafts can be designed independently of the torque. Yet, Chart 5-1 show that even the manufacturers design the torque according to the individual flex of the shaft. Over the years, manufacturers found that the average lady golfer did not need a low torque shaft or the very strongest of golfers do not necessarily need a high torque design, even though shafts can be designed in this manner.

It is interesting that the difference between the average Driver and #5-iron torque measurements is approximately 1º in both steel and graphite. However, if we compare the steel Driver to steel #5-iron shafts, the #5-iron is consistently 64% of the torque measurement of the Driver in each flex. Graphite #5-iron shafts are much higher percentage (nearly 80%) in regards to torque measurements to that of the average Driver shaft in each flex.

Chart 5-2 - 2000 Torque Deviations for Steel Shafts within Each Flex

		DRIVERS		
Flex	**Test Ave.**	**Low**	**High**	**Deviation**
L	3.32	UCV2000 L (3.47º)	Dynamic L (3.17º)	0.30º
A	3.30	UCV2000 A (3.67º)	Dynamic A (3.15º)	0.52º
R	2.96	UCV2000 R (3.52º)	Rocket R (2.70º)	0.82º
S	2.73	UCV2000 S (3.23º)	Extralite S (2.52º)	0.71º
X	2.61	Dynamic Gold w/ SensiCore X (2.79º)	Dynalite Gold X100 (2.41º)	0.38º
		#5 IRONS		
Flex	**Test Ave.**	**Low**	**High**	**Deviation**
L	2.12	Release L (2.41º)	TT Lite L (1.83º)	0.58º
A	2.12	UCV2000 A (2.65º)	TT Lite A (1.81º)	0.84º
R	1.93	UCV2000 R (2.34º)	Dynamic Gold taper R300 (1.75º)	0.59º
S	1.75	UCV2000 S (2.29º)	Dynamic Gold taper S300 (1.58º)	0.71º
X	1.69	Dynamic Gold Lite w/ SensiCore X (2.03º)	Dynamic X (1.53º)	0.50º

L-flex frequency measurements were tested at ladies standard length
A-X-flex frequency measurements were tested at men's standard length

An Analysis of the Range in Torque Measurements - Steel vs. Graphite

Once torque began to surface as an important shaft specification, speculation has centered on the range of torque within both steel and graphite shafts. Do steel shafts have any variance in torque at all? Do graphite shafts have a vast deviation in torque from high to low as has been thought? Answers to these questions can only come from comparing the range in torque from high to low between all of the steel and graphite/composite shafts that were tested in the Dynacraft/Apollo test project.

As one can analyze from Chart 5-2, the torque range among steel shaft within the same flex is nominal. Looking back at Chapter 4, Chart 4-7, many of the same shafts appear on Chart 5-2 as well. This is no surprise, because the stiffness of the shaft primarily controls the torque measurements. Each shaft that is listed on the low end of the torque range was also the most flexible, except the UCV2000 L-flex wood shaft which was the second most flexible shaft in its category.

It we analyze the high end of the torque range, only certain shafts show up as both the stiffest and the lowest torque shafts in each respective flex. The Dynamic pattern is well represented in the high end of the range because they are heavier weight shafts and subsequently have thicker walls in the tip area. The Rocket R-flex wood and the TT Lite A and L-flex irons were by far the stiffest shafts in their respective categories and not surprising each would have the lowest torque readings. The Extralite S-flex and Dynalite Gold X100 wood shafts are actually very lightweight shafts, yet they possessed the lowest torque measurements in their categories. This is partially due to a manufacturing design in which the tip is reinforced to reduce the likelihood of breakage. Examine the Dynacraft catalog and carefully look at the code for the True Temper wood shafts. In a few cases, an “H” will appear in the code, which standard for “heavy tip” or reinforced for metal wood assembly. When metal woods became popular, many of the True Temper models were manufactured for persimmon or laminated maple woods and a separate design was designated as a reinforced for metal woods model, all in an effort to reduce breakage or bending in the tip area of the shaft.

The maximum range in steel shaft torque within a given flex is much less than 1º on average. Thus lies the proof that among all steel shafts, torque does not exhibit a wide variance and is therefore not a factor of fitting with which clubmakers need to be concerned. As a result, shaft companies have never found it necessary to publish torque measurements for steel shafts.

With graphite and other types of composite shafts, the situation is quite different. Chart 5-3 will show the current range of torque among the most common graphite at this time of publication. Chart 5-4 will show the torque deviation for all shafts in each flex that had been tested in our on-going shaft testing project. To contrast, since Chart 5-4 showed that torque in graphite shafts can vary by more than 8º, torque becomes yet another shaft specification that can affect the performance of the shaft.

Chart 5-3 - Torque Deviations for Graphite Shafts within Each Flex - Current Models

Flex	Woods			Irons		
	Low	High	Deviation	Low	High	Deviation
L	4.19º	10.29º	6.10º	3.02º	6.22º	3.20º
A	3.94º	8.13º	4.19º	3.06º	5.70º	2.64º
R	2.88º	9.87º	6.99º	1.95º	6.85º	4.90º
S	2.86º	7.75º	4.89º	1.86º	5.17º	3.31º
X	3.03º	4.58º	1.55º	2.04º	3.06º	1.02º

Chart 5-4 - Torque Deviations for Graphite Shafts within Each Flex - All Models Tested

Flex	Woods			Irons		
	Low	High	Deviation	Low	High	Deviation
L	2.59º	10.29º	7.70º	1.68º	6.22º	4.54º
A	2.55º	8.13º	5.58º	2.06º	5.70º	3.64º
R	1.75º	9.87º	8.12º	1.75º	6.85º	5.10º
S	1.58º	7.75º	6.17º	1.46º	6.06º	4.60º
X	1.99º	6.10º	4.11º	1.07º	6.12º	5.05º

Therefore, the makers of graphite shafts make a practice of publishing the torque measurements of their shafts. As a result, torque does not play as much of an independent role in steel shaft fitting as it does in the fitting of graphite shafts.

Certain shafts tested do fall outside these ranges, most notably the Fiberspeed series. The Fiberspeed shafts, which were made of fiberglass, were not labeled with traditional flex designations, thus are not listed within Chart 5-4. The Fiberspeed shafts ranged from modest 4.32º (TP4000+ model) to the FS-100 which measured at a whooping 13.77º! On the other side of the spectrum, Titanium possesses very low torque readings, in some cases, less than steel. Titanium would be in a class of specialty metals, which would also include aluminum. Each of these shafts do need mentioned, although each material is rarely used in the golf industry anymore, but someday may return.

Charts 5-3 and 5-4, both demonstrate a wide torque deviation within a given flex. However, graphite shafts currently manufactured do not possess as wide a variation in torque that is possible, because the manufacturers may be more selective in the shaft they produce. They most likely found that typical lady golfers did not need 2.59º Driver shafts or the golfer who would normally select an X-flex shaft, didn’t need a 6.12º #5-iron shaft. At one time, there was a race to produce the lowest torque shafts

available. Two byproducts of lowering the torque ensued. First, the lower torque produced stiffer feeling shafts. Secondly, to produce the very low torque shafts required more expensive material and a much higher cost to the consumer.
The large torque deviation from shaft-to-shaft should not be considered a negative factor. Just the opposite, it demonstrates that graphite shaft manufacturers have the ability to customize the shafts they produce than in possibly with a homogenous material. The major concern should be, does each manufacturer measure torque the same way?

An Analysis of Torque Measurements for Raw and Cut Shafts vs. Each Manufacturers' Published Torque Measurements

One very important reason that torque measurements were taken on the raw shafts as well as the cut length shafts was to allow a comparison of a single, uniform method of torque measurement with the manufacturer's readings for each of their shafts. When manufacturers publish the torque measurements for their shaft patterns, it has never been clearly stated whether the dimension represents the torque for each shaft in its raw, uncut form or whether the torque measurement pertains to the shaft in its cut assembled form.

By listing the raw and cut shaft torque measurements from the Dynacraft/Apollo test with the manufacturers' own measurements, clubmakers can compare a list of uniform torque measurements with the torque rating each manufacturer publishes for its own shafts. From such an observation, it will be possible to determine if the published torque readings from each manufacturer can be accurately compared to those from another shaft maker. To begin the discussion on the torque measurement phase of the testing project, Chart 5-5 compares the torque dimensions for a small assortment of R-flex graphite wood shafts in both raw and cut shaft form. In each case, the manufacturers own stated torque measurement for each shaft is approximately 4º.

Chart 5-5 - Torque Measurements for Raw and Cut Length Test Results vs. Individual Manufacturers Measurements (Woods)

Manufacturer	Shaft	Flex	Dynacraft's Torque Cut	Raw	Manufacturer's Stated Torque
Aldila	LW	R	4.68º	4.98º	4.0º
Apache	PM30+	R	5.14º	5.64º	4.0º
Apollo*	Boron Tourline	R	3.81º	3.97º	4.0º
Carbon Fiber	Novus II	R	4.91º	——-	4.5º
Fenwick	ScoreLine	R	4.02º	4.10º	4.2º
Grafalloy	M29 Attack	R	4.35º	——-	4.0º
Harrison	Boron Gold	R	3.79º	3.93º	3.8º
Paragon	Low Torque	R	5.39º	——-	4.5º
Phoenixx	N1120	R	6.83º	7.33º	4.0º
Rapport Composites	Synsor	R	4.84º	5.34º	4.5º
Royal Precision	CW-6000	R	4.78º	5.03º	4.2º
SK Fiber	BM24	R	4.71º	4.83º	4.0º
System Flex	KF1 P.O.P.	R	4.26º	5.00º	4.2º
True Temper	SensiCore Tour Flight	R	3.94º	4.35º	3.9º
Unifiber*	T40	R	4.71º	4.83º	4.0º
U.S.T.	Speed Rated 8	R	4.09º	4.14º	4.0º

*** As of 2000, Unifiber, Carbon Fiber and Apollo are no longer in business.**

Take a moment to study the raw and cut shaft torque measurements in Chart 5-3 and compare the Dynacraft/Apollo test findings to those listed by the shaft makers. From observing Chart 5-5, it can be concluded that from manufacturer-to-manufacturer, torque is not measured consistently within the industry. In certain situations, a manufacturer's stated torque is similar to the measurement that was measured in the testing project. While many of the manufacturers' readings were closer to the cut shaft torque measurements from this project than they were from the raw shaft readings.

In the case of the Phoenixx N1120 shaft, the manufacturer does not list the actual measured torque, but rather a dynamic torque that compares to other 4º shafts in the industry. The thermoplastic material is said to play dynamically stiffer, both in flex as discussed in Chapter 4 and in torque than the measurements would indicate. In the case of the Apache PM30+, the manufacturer actually measures torque in two separate methods. Apache's own in-house method of measuring torque yields 5.3º, while the ASTM torque measuring method yields 4.0º. Apache's in-house method is closer to the method that was used in this shaft-testing project.

All that can be ascertained from an analysis of the manufacturers' own torque ratings against the results that have been obtained from this project is that apparently manufacturers have different methods of measuring torque. Virtually all shaft makers have slight differences in their testing procedures that would make it impossible to expect this test format to achieve torque ratings in line with all the manufacturers' specifications. The easiest comparison that can be made between the test measurements and those of the manufacturers are the torque ratings published in this study. Each shaft was cut to the same length and measured on the exact same equipment under the same testing procedures.

An Analysis of Torque Testing Parameters

But just what are some of the different methods of torque measurement currently being used in the shaft industry? And when one of the test parameters is changed, what effect does it have on the torque measurement? To determine some of the differences in the methods of torque testing, we called upon two different manufacturers of graphite shafts, Aldila and Apache. At Aldila, the world's largest producer of graphite golf shafts, torsional stiffness is measured under slightly different conditions in wood shafts than it is in iron shafts.

To test the torque of its wood shafts, Aldila applies 1 ft./lb. of twisting force 3" down the tip, but on the iron shafts, the same 1 ft./lb. is clamped only 1" down from the tip. The location for the butt clamp is always set 32.5" back from the tip clamp. Thus for a wood shaft of 44", the butt clamp would be secured some 8.5" from the butt end. For a 39" iron shaft, the butt clamp would be secured some 5.5" from the butt end. Unlike the Dynacraft/Apollo torque test, which employed a constant 2" butt-clamping dimension, in Aldila's testing the butt clamping position will vary, depending upon the length of the shaft.

At Apache, their in-house method utilizes a 1.5" collet tip clamp (for both wood and iron shafts are clamped 3" from the raw tip) and a 4.5" butt clamp from the raw butt end. The torque arm is positioned 4" forward of the butt end using a 2lb weight at 6", to produce 1 ft./lb. of force. In this case, the torque is measured from the butt end, while Aldila's method measures from the tip end. It should be noted that whether measuring from the tip or butt, as long as the force and beam length is identical, the final measurement would be the same.

To gain a better understanding of what effect changes in the tip and butt clamping dimensions, as well as the force of twisting, will have on the measurement; a test was performed on two different wood shafts during which various torque-testing parameters were varied. The information obtained from the tests can be found in Chart 5-6 that follows:

Chart 5-6 - Effects of a Variation of Torque Testing Parameters

Shaft	Torque Test Parameters	Torque	Deviation
ACT	2" butt clamp / 1" tip clamp; 1 ft./ lb force	3.20º	(Original)
ACTivator 3.5 R	4" butt clamp / 1" tip clamp; 1 ft./ lb force	3.09º	3% decrease
	2" butt clamp / 2" tip clamp; 1 ft./ lb force	2.95º	8% decrease
	2" butt clamp / 4" tip clamp; 1 ft./ lb force	2.54º	20% decrease
	2" butt clamp / 1" tip clamp; 0.66 ft./ lb force	2.08º	35% decrease
	2" butt clamp / 1" tip clamp; 0.33 ft./ lb force	1.06º	67% decrease
Apollo	2" butt clamp / 1" tip clamp; 1 ft./ lb force	2.37º	(Original)
MatchFlex 4	4" butt clamp / 1" tip clamp; 1 ft./ lb force	2.32º	2% decrease
	2" butt clamp / 2" tip clamp; 1 ft./ lb force	2.24º	5.5% decrease
	2" butt clamp / 4" tip clamp; 1 ft./ lb force	2.03º	14% decrease
	2" butt clamp / 1" tip clamp; 0.66 ft./ lb force	1.57º	34% decrease
	2" butt clamp / 1" tip clamp; 0.33 ft./ lb force	0.79º	67% decrease

In studying the results of varying the torque test conditions, it can be seen that changing the butt clamping position has less of a torque-altering effect than changing the tip clamping position. On both test shafts, the decrease in the torque measurement as a result of changing the tip clamping position from 1” to 2” was greater than the torque decrease that occurred from changing the butt clamping position from 2” to 4”.

However, neither one of the changes of the clamping positions had as much of an effect on the torque as did a change of the amount of twisting force. By decreasing the weight on the end of the 12” long moment arm that is attached to the shaft tip, first to 0.66 lbs. at 1 ft. and then to 0.33 lbs. at 1 ft., the torque decreased dramatically. Interestingly, the decrease in torque was directly proportional to the decrease in the twisting force; as the weight was reduced by a third and then two-thirds, so too was the torque measurement reduced by the same proportions.

Given the previous illustrations of the effect of changing the torque testing parameters, what does the torque data actually show? Referring back to the original list comparing the manufacturers’ own torque readings to the Dynacraft/Apollo torque measurement (Chart 5-5), and keeping in mind that a change in twisting force has a drastic effect on torque readings, the test measurements are fairly close to the manufacturers’ own readings. Therefore it stands to reason that most of the shaft producers must use the same 1 ft./lb. twisting force to perform their own torque tests. However, we know for a fact that Aldila and Apache use different clamping dimensions in their tests and because the torque data was different in test results than in the manufacturers’ own readings. It is also a safe conclusion that a whole host of different clamping standards do exist for the measuring of torque.

It is now known that the shaft manufacturers’ own torque measurements are possibly a little closer to the results obtained from one uniform type of testing than previously thought. Does this mean that we should stop the discussion of torque and say that just being close is enough to afford accurate shaft-to-shaft torque comparison? No. Close does not count in torque measurements for two major reasons. First, it is still not known whether the manufacturers quote torque dimensions for their shafts in the raw, uncut form or in the cut, assembled form. Second, despite the fact most manufacturers quote one single dimension of torque for each shaft design, torque does have the tendency to change from flex to flex within each shaft design.

The Relationship of Shaft Trimming to Torque

Consider an example of two different raw length shafts, A and B, both with the same torque measurement, but each with a different method for trimming and installation. After trimming for assembly into a metal wood Driver, both shafts will be of the same cut shaft length, however shaft A is slated to be all tip trimmed as its method of assembly while shaft B is designed to be all butt trimmed. Since both shafts had the same torque in their raw shaft form, will both shafts have the same torque after they are trimmed?

Chart 5-7 - Raw vs. Cut Shaft Torque Measurements

Shaft	Flex	Material	Raw Length	Raw Shaft Torque	Cut Shaft Torque	Tip Trim Amount	Butt Trim Amount
Dynalite Gold	R300	Steel	45”	3.09º	2.82º	1”	2.25”
Rocket	R	Steel	45”	3.14º	2.70º	3.25”	0”
Aldila SW	R	Graphite	45”	4.96º	4.86º	0”	3.25”
KF1 P.O.P.	R	Graphite	45”	5.00º	4.26º	2”	1.25”

Chart 5-7 is a comparison of the torque measurements between steel and graphite shafts in both raw and cut form. Each raw shaft torque measurement is based on identical raw uncut length and the cut length of each shaft in our shaft-testing project. Special attention must be paid to the shafts’ trimming instructions for each shaft. The column of cut shaft torque measurements represents the torque of each shaft after it has been trimmed for proper installation into men’s standard length metal Driver. The last two columns in the chart indicates how much each shaft was tip and butt trimmed to change it from raw to cut form.

Compare the raw torque measurements of each of theses selective shafts in Chart 5-7. In each case, the raw shaft readings are the very similar between each shaft pairing. The lower cut torque reading in the Rocket and System Flex KF1 P.O.P. is less than the Dynalite Gold and Aldila SW shafts, due to the greater amount of tip trimming. This leads us to an important aspect related to standardizing torque measurements.

If the manufacturers banded together and adopted the same method to measure torque, they would then need to decide whether to list the raw or cut torque measurements. Because the manufacturers produce shafts in their raw, uncut state, it would only make sense that how they should list the torque. But not all shafts of the same length and raw torque will yield the same cut torque

measurements due to the method of trimming. It would be nearly impossible for the manufacturers to publish a cut torque, because it would depends on several factors that the manufacturer cannot control after the shaft had been sold. For instance, which head would be used to publish a torque measurement? What about other factors, such as the assembled length of the club or even the bottom of bore to groundline measurement of the clubhead?

A main point of comparing each raw shaft torque measurements to their corresponding cut shaft readings is that if we recognize torque as being a very important part of the overall flex feel of a shaft. Accurate torque information is a must before any type of reliable shaft-to-shaft fitting comparisons can be made. A shaft manufacturer publishes raw shaft measurements for its shafts and the shafts are all to be tip trimmed as part of their assembly. There is no doubt the torque will be quite different when the shafts are installed and used in the golf club than what was conveyed in a measurement printed in the catalog of the shaft manufacturer.

As we have stressed many times so far in each of the chapter discussions of the test data, golfers do not play with raw shafts; they play with finished golf clubs with shafts that are installed in their cut shaft form. Therefore, in comparing torque as a fitting guide, it becomes even more important to use a complete list of accurate cut shaft torque measurements that have been obtained using only one common set of test standards. With such a list it is possible not only to be able to make “apples to apples” comparisons, but also to ensure more accuracy when trying to integrate torque with flex in an effort to express a shaft’s overall stiffness feel for fitting purposes.

A Final Word about Torque

As one of the newest terms in the vernacular of shaft descriptions, torque still remains somewhat of a mystery. While clubmakers and golf shaft manufacturers are becoming more aware of the role torque plays in the golf swing, the puzzle has yet to be solved. This examination of torque based on the results of our on-going testing project has shown significant findings, yet the overall picture of torque remains unclear. What we know with certainty, based on the test results is as follows:

Torque is not a shaft parameter that is comparable among various manufacturers because almost every shaft maker has its own methods of measurement. The Dynacraft/Apollo testing found torque measurements very near those stated by the manufacturers of some designs, while other models tested far from their maker’s stated specification. This is not to say that our method used for testing is the only one that is correct, but rather that torque is a measurement that varies widely from manufacturer to manufacturer.

When a torque measurement is listed for a shaft design, the clubmaker has no way of knowing if the manufacturer’s torque figure is for the raw, uncut shaft or for the cut shaft as it is prepared for installation into a golf club. The Dynacraft/Apollo testing found some torque readings among popular models that matched the raw torque measurements, but others coincided more closely with the cut shaft figures.

While torque definitely does exist in steel shafts, its effects are so negligible that torque cannot be considered as an independent variable in the fitting process, as it is with graphite shafts. This is, torque in steel shafts decreases as the stiffness increases. Graphite shafts can independently be altered separately from the stiffness the manufacturer designs in the shaft. However, torque is a major contributor to the overall feel of a graphite shaft, primarily because torque varies to a much greater extent than it does in steel shafts.

Trimming has a decided affect on torque. The method of trimming has a substantial effect on torque as well. The torque measurements on shafts that are trimmed from the butt (such as many graphite shafts) will not decrease as much from the raw shaft as will shafts that are trimmed more from the tip.