Chapter Three

A COMPARISON OF SHAFT DEFLECTION MEASUREMENTS

Key terms for understanding the information contained in Chapter 3:

Cut Shaft - The shaft after it has been trimmed according to manufacturer's directions and is ready for installation into the club.

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

Deflection Difference - The deviation in bending ability between two or more shafts. A shaft with more deflection is considered to be more flexible, and a shaft with less deflection is considered stiffer.

Flex - The ranking of a shaft's stiffness based on its ability to resist bending - noted on shafts as ladies (L), amateur or senior (A), regular (R), stiff (S) or extra stiff (X).

Frequency - The number of oscillations a shaft makes over a known period of time after the tip is pulled down and released while mounted in a special frequency-measuring device. Measured in cycles per minute (cpm)

Raw Shaft - The shaft in its manufactured form, before trimming and installation into a club.

Relative Stiffness - The stiffness of a shaft when compared to other shafts.

Pattern - The design of a particular shaft, indicating the distribution of flexibility about the shaft. Pertaining to this shaft testing project, pattern designates a particular model of shaft, e.g. Dynamic, Phoenix, Microtaper, Low Torque, etc. are all names that describe different shaft patterns.

The oldest of all the shaft specifications is flex. Once the production problems had been overcome which enabled steel shafts to become a reality, early steel shaft manufacturers began to experiment with producing shafts, which possessed different amounts of resistance to bending. Through the 70 years of shaft design that have followed the introduction of the steel shaft, companies have produced particular patterns of shafts with as many as 15 different flexes! What began with only regular and stiff, has now evolved into five basic flexes; **L**adies, **A**mateur (known as Senior or Flexible), **R**egular, **S**tiff and **EX**tra Stiff. The letter that is highlighted within the designation identifies each flex level.

As was mentioned in the discussion of the evolution of shaft fitting, shaft manufacturers originally intended the selection of flex to be based strictly on the golfer's strength. Much later, as more flexes were designed and the traditional shaft fitting principles were developed, golfer strength was related to distance and eventually, to clubhead speed, to enable clubmakers to perform the fitting of shaft flex more accurately. Following is an example of a 1970s type shaft fitting chart relating clubhead speed/shot distance to shaft flex:

Chart 3-1 - Typical Shaft Fitting Chart (1970's)

Clubhead Speed	Driver Distance	Recommended Shaft Flex
Up to 60 mph	Up to 160 yards	Ladies
60 - 75 mph	160 - 185 yards	Amateur
75 - 90 mph	185 - 220 yards	Regular
90 - 110 mph	220 - 250 yards	Stiff
110 mph and up	250 yards and up	Extra Stiff

General guidelines such as those above have served as the standard for fitting shaft flex for nearly 20 years. While there certainly is a need to use such information for fitting golfers with the proper flex, it must be understood that the use and accuracy of fitting charts which match clubhead speed/distance to flex assume that all of the five basic shaft flexes are equal among all shaft manufacturers. But are the different flexes the same from manufacturer to manufacturer?

For decades, the shaft manufacturers' primary method of establishing different flexes within each individual design has been to vary the diameter of the shaft. This method of establishing flex can be seen when studying the basic butt diameters of shafts within individual patterns. For example, in the design of the parallel tip version of the True Temper Dynamic steel shaft for woods, the combination A&L flex shaft (UDWAL) is made with a .560" butt diameter while the stiffer R&S flex version (UDWC) is produced with a larger .600" diameter butt. Since the tip diameters of the two combination flex shafts are the same (.335"), the 0.040" increase in butt diameter is the primary factor which makes the R&S version stiffer than the A&L design.

The difference in flex between parallel tip shafts is controlled by varying the butt diameter, while in the taper tip type construction shafts, flex can be varied by changing both the butt and/or the tip diameter in the same shaft. For example, in the design of the 44" raw length taper tip Dynamic steel shaft for Drivers, the R-flex has butt and tip diameters of .600" and .277" respectively, while the S-flex version is made with a .620" butt and a .294" tip. Both shafts weigh 4.37 oz. so the difference in flexibility between the two taper tipped shafts is a product of both the tip and the butt diameter changes. Please note this explanation of flex change within taper tip shafts has been offered for an example only. Because of the incredible number of shafts in the industry today, and the popularity of the parallel tip versions for use in component clubmaking, nearly all of the test data has been restricted to the parallel tip varieties of shafts.

As shaft-forming technology has improved over the years, alterations in the wall thickness of the shaft also have been employed as an additional way of creating different levels of flexibility within individual shaft designs. A bit more complicated than the process of changing the shaft's diameters, wall thickness changes are produced through very sophisticated production techniques involving a change in the internal mandrel against which the shaft is squeezed during its drawing stages.

Most manufacturers have used what is called deflection testing as a means to measure and compare the flexibility of their shafts. While the devices used to measure deflection may vary slightly from manufacturer to manufacturer, all deflection testing involves securing the butt end of the shaft, applying a known force to the tip to create a bend in the shaft, and measuring the deviation from the tip to the butt. Shafts with a high measurement of the deviation (deflection) from tip to butt are considered the most flexible and conversely, those shafts with the lowest deflection are read as the stiffest. Therefore, as an example, for two shafts of equal length, the shaft with a deflection reading of 5.37" is stiffer than a shaft with a 5.75" deflection measurement. This example brings up a very important point of the deflection portion of the Dynacraft/Apollo shaft-testing project. For two deflection readings to be accurately compared, the shafts must be of equal length. In the test project, while deflection measurements were taken for both raw and cut shaft lengths, the only meaningful raw shaft comparisons that could be made were between shafts of equal length. As a result, the most important deflection readings obtained in the test were those taken from the cut length shafts.

Over the years, three primary problems have stood in the way of allowing clubmakers to be able to use deflection measurements to make a true comparison or identification of shaft flex. First, and most important, there exists no standard in the shaft industry for how much force is to be applied to the tip to create the bend, or deflection. The oldest types of deflection measuring devices (deflection boards) involve actually hanging a weight from the shaft tip to record the measurement. While modern deflection boards are simply a more sophisticated refinement of these early devices, the amount of weight or force applied to the shaft tip in deflection testing that is currently performed in the golf industry varies from 4-7 pounds. Since the result of any deflection test is an actual quantitative measurement of the distance from the shaft tip to the butt centerline (usually recorded in inches or centimeters) it is not hard to see how a difference in tip force can create a huge variation in the deflection reading of a shaft. To explain, it is obvious if the same shaft is deflected twice, once with a 4-lb. weight and next with a 7-lb. weight, the tip will hang lower with the heavier weight. For clubmakers or golf club manufacturers who regularly build golf clubs using shafts made by several different manufacturers, such a lack of standardization in deflection testing can mean what one company defines as an R-flex might not be the same as the R-flex from another company.

The second problem with using deflection board readings for comparing the flex involves a point that has undergone some debate among the experts within the golf equipment industry. Many clubmakers believe that the deflection board itself, and the actual deflection readings, cannot take into account differences in bend point design between shafts. As a general rule, bend point has been defined as the area of the shaft where the point of maximum bending occurs. Therefore, some individuals believe between two shafts of equal stiffness but different bend point locations, the actual point of deflection between the two shafts will be slightly different, thus further confusing the issue of flex.

Finally, a number of golf equipment experts believe that the third reason deflection cannot be used as an accurate comparison of flex is because of the static nature of the test itself. Those who profess this belief base their argument on the fact shafts are used in fully-assembled golf clubs which are swung by people at speeds from 30 to 120 mph or more. Because there are many different lengths and headweights incorporated with the shafts as a part of finished golf clubs, they believe it is impossible to equate a static measurement such as deflection with such a dynamic action as what occurs when a shafted club is put into play.

In the Dynacraft/Apollo tests, deflection is measured and expressed to the hundredth of an inch (0.01”). A pure quantitative measurement, it is interesting to note that to date none of the shaft manufacturers have ever published deflection measurements for their shaft designs. As a result, clubmakers or golf club manufacturers who do not have their own “in-house” deflection device have no means of truly being able to compare the relative deflection stiffness of one shaft to another. In the end, most clubmakers, and all golfers, must trust the letter codes printed on the shaft labels as the only indicator for comparing flex.

In the Dynacraft/Apollo shaft-testing project, Apollo’s technical staff on its computer-driven testing apparatus recorded each shaft’s deflection. As mentioned in the preliminary outline of the tests in Chapter 2, each shaft was driven into a bent position in two opposite directions under a tip load of 6 lbs. The final deflection reading for each shaft was recorded as an average of the two measurements. For the purpose of achieving full data analysis, deflection readings were taken on both the raw and cut versions of each shaft. Following begins an overview of a number of the deflection readings for various shaft designs, as measured under one uniform standard.

Deflection Differences between Raw and Cut Shafts

The charts depicted over the next several pages (Charts 3-2 through 3-7) list the deflection measurements for a number of the golf industry’s most popular steel and graphite shafts for woods and irons (based upon the time of the original publication). It should be noted that many of the shafts in the ensuing charts (both this chapter and the following) are no longer available. However, this is the data that supports our conclusions about shaft fitting.To avoid confusion in the analysis of the data, please remember the raw shaft is the uncut form of the wood or iron shaft; the cut shaft is that shaft after it was trimmed and prepared for installation into the test Driver or #5-iron. In addition, it is important to keep in mind that shaft-to-shaft deflection comparisons can only be made when the lengths of the shafts are the same. Because

Chart 3-2 - Deflection Measurements: L - Flex Parallel Tip Shafts For Woods

Shaft	Deflection/Raw Length[1]	Deflection/Cut Length[2]
Aldila		
HM-40 L	5.94”/44”	5.15”/ 40.375”
HM-40 Low Flex L	5.41”/44”	4.36”/40.375”
Low Torque L3	5.94”/44”	5.03”/40.375”
Low Torque L3	6.22”/45”	4.84”/40.375”
Apollo		
G100 L	6.16”/45”	4.90”/40.375”
Spectre L	7.67”/46”	5.44”/40.375”
Brunswick		
Microtaper L	8.26”/46”	5.34”/40.375”
Phoenix L	8.42”/46”	5.08”/40.375”
ProPel II L	8.20”/46”	5.74”/40.375”
True Temper		
Dynamic L	8.15”/46”	5.54”/40.375”
TT Lite L	8.00”/46”	5.54”/40.375”

1 All 46” raw length shafts were combination A&L flex construction.
2 All L-flex cut shafts in this test were 40.375”, reflecting installation into a short bore metal Driver head with a 1.5” bottom of bore to heel dimension, assembled to 42” playing length, and allowing .125” for the thickness of the grip cap.
3 Two types of Aldila Low Torque shafts were tested. The 44” raw length version was Aldila’s discrete L-flex shaft, while the 45” raw length version was the company’s combination A&L flex design.
NOTE: Many more shafts were tested than what are included in the above L-flex deflection chart.

Chart 3-2 - Deflection Measurements: L - Flex Parallel Tip Shafts For Woods

Shaft	Deflection/Raw Length[1]	Deflection/Cut Length[2]
Aldila		
HM-40 L	5.94”/44”	5.15”/ 40.375”
HM-40 Low Flex L	5.41”/44”	4.36”/40.375”
Low Torque L[3]	5.94”/44”	5.03”/40.375”
Low Torque L[3]	6.22”/45”	4.84”/40.375”
Apollo		
G100 L	6.16”/45”	4.90”/40.375”
Spectre L	7.67”/46”	5.44”/40.375”
Brunswick		
Microtaper L	8.26”/46”	5.34”/40.375”
Phoenix L	8.42”/46”	5.08”/40.375”
ProPel II L	8.20”/46”	5.74”/40.375”
True Temper		
Dynamic L	8.15”/46”	5.54”/40.375”
TT Lite L	8.00”/46”	5.54”/40.375”

1 All 46” raw length shafts were combination A&L flex construction.
2 All L-flex cut shafts in this test were 40.375”, reflecting installation into a short bore metal Driver head with a 1.5” bottom of bore to heel dimension, assembled to 42” playing length, and allowing .125” for the thickness of the grip cap.
3 Two types of Aldila Low Torque shafts were tested. The 44” raw length version was Aldila’s discrete L-flex shaft, while the 45” raw length version was the company’s combination A&L flex design.
NOTE: Many more shafts were tested than what are included in the above L-flex deflection chart.

of the nature of the test, if two identical shafts are of different lengths, the same amount of force applied to the tip end will bend the shafts into two different deflections. In the tests, the cut shafts for the wood shafts were all 41.375” (except some L-flex tests performed at 40.375” to depict the ladies’ standard length test Driver). The cut shafts for the iron shafts were all 36” (except some L-flex tests performed at 35” to depict the ladies’ standard length test #5-iron). Therefore, all of the cut shaft deflections can be accurately compared to each other.

The only raw length shaft deflection measurements that can be accurately compared are those which are of equal length. Therefore, clubmakers are urged to keep this point in mind before making any flex judgments about shafts that are based strictly on deflection measurements.

Chart 3-3 - Deflection Measurements: L-Flex Parallel Tip Shafts For Woods

Shaft	Raw Shaft Deflection/Raw Length[1]	Cut Shaft Deflection/Cut Length[2]
Aldila		
HM-40 L	4.31”/39”	3.07”/35”
HM40 Low Flex L	4.82”/41”	3.32”/35”
Low Torque L[3]	3.92”/44”	3.00”/35”
Low Torque L[3]	4.68”/44”	3.30”/35”
Apollo		
G100 L	4.16”/39”	3.15”/35”
Spectre L	4.25”/40”	2.96”/35”
Shadow L	4.15”/38”	3.11”/35”
Brunswick		
Microtaper L	4.78”/40”	3.22”/35”
Phoenix L	4.41”/40”	2.97”/35”
ProPel 2 L	4.57”/40”	3.23”/35”
True Temper		
Dynamic L	4.67”/40”	3.28”/35”
TT Lite L	4.34”/40”	2.88”/35”

1 All 40” raw length shafts were combination A&L flex construction.
2 All L-flex cut shafts in this test were 35”, reflecting installation into a short bore metal Driver head with a 1.375” bottom of bore to heel dimension, assembled to 36.5” playing length, and allowing .125” for the thickness of the grip cap.
3 Two types of Aldila Low Torque shafts were tested. The 39” raw length version was Aldila’s discrete L-flex shaft, while the 41” raw length version was the company’s combination A&L flex design.
NOTE: Many more shafts were tested than what are included in the above L-flex deflection chart.

Chart 3-5 - Deflection Measurements: R-Flex Parallel Tip Shafts For Irons

Shaft	Raw Shaft Deflection/Raw Length[1]	Cut Shaft Deflection/Cut Length[2]
Aldila		
HM-30 R	3.54”/39”	3.29”/36”
HM-40 R	3.39”/39”	3.05”/36”
HM-40 Low Flex R	4.53”/41”	3.30”/36”
Low Torque R[3]	3.65”/39”	2.92”/36”
Low Torque R[3]	4.19”/41”	2.83”/36”
Apollo		
AP44 R	4.06”/41”	2.80”/36”
Boron Tourline R	3.59”/39”	2.74”/36”
G100 R	3.50”/39”	2.71”/36”
HMF Lo-Torque R	3.51”/39”	2.70”/36”
Shadow R	4.23”/41”	2.94”/36”
Spectre R	4.16”/41”	2.92”/36”
Brunswick		
Microtaper R	4.55”/41”	3.09”/36”
Phoenix R	4.40”/41”	3.01”/36”
ProPel II R	4.10”/41”	2.84”/36”
True Temper		
Dynamic R	4.06”/41”	2.89”/36”
Dynamic Gold R2	3.78”/39”	2.95”/36”
Dynamic Gold R3	3.77”/39”	2.97”/36”
Dynamic Gold R4	3.71”/39”	2.98”/36”
Jet Step R	4.08”/41”	2.84”/36”
TT Lite R	4.13”/41”	2.79”/36”

1 All 41” raw length shafts were combination R&S flex construction. Please note that the raw shaft deflection measurements will be the same for the R and S flexes since both cut shafts come from the same combination flex shaft.
2 All R-flex cut shafts in this test were 36”, reflecting installation into an ironhead with a 1.375” bottom of bore to heel dimension, assembled to 37.5” playing length, and allowing .125” for the thickness of the grip cap.
3 Two types of Aldila Low Torque shafts were tested. The 39” raw length version was Aldila’s discrete R-flex shaft, while the 41” raw length version was the company’s combination R&S flex design.
NOTE: Many more shafts were tested than what are included in the above R-flex deflection chart.

Chart 3-6 - Deflection Measurements: S-Flex Parallel Tip Shafts For Woods

Shaft	Raw Shaft Deflection/Raw Length[1]	Cut Shaft Deflection/Cut Length[2]
Aldila		
HM-30 S	5.03"/44"	4.49"/41.375"
HM-40 S	4.67"/44"	3.86"/41.375"
HM-40 Low Flex S	4.68"/44"	3.86"/41.375"
HM-55 S	4.89"/44"	4.39"/41.375"
Low Torque S[3]	4.98"/44"	4.14"/41.375"
Low Torque S[3]	5.12"/45"	3.66"/41.375"
Apollo		
AP44 S	7.00"/47"	4.64"/41.375"
Boron Tourline S	5.08"/45"	4.26"/41.375"
G100 S	5.19"/45"	4.22"/41.375"
HMF Lo-Torque S	5.13"/45"	4.32"/41.375"
Shadow S	7.32"/47"	4.76"/41.375"
Spectre S	7.08"/47"	4.66"/41.375"
Brunswick		
Microtaper S	7.50"/47"	4.82"/41.375"
Phoenix S	7.31"/47"	4.93"/41.375"
ProPel II S	6.97"/47"	4.76"/41.375"
Ti Shaft		
TI Titanium S	6.63"/45"	5.18"/41.375"
True Temper		
Dynamic S	7.19"/47"	4.75"/41.375"
Dynamic Gold S2	6.25"/45"	4.87"/41.375"
Dynamic Gold S3	6.26"/45"	4.80"/41.375"
Dynamic Gold S4	6.30"/45"	4.76"/41.375"
Jet Step S	6.77"/47"	4.62"/41.375"
TT Lite S	7.25"/47"	4.84"/41.375"

1 All 47" raw length shafts were combination R&S flex construction. Please note that the raw shaft deflection measurements will be the same for the R and S flexes since both cut shafts come from the same combination flex shaft.
2 All S-flex cut shafts in this test were 41.375", reflecting installation into a short bore metal Driver head with a 1.5" bottom of bore to heel dimension, assembled to 43" playing length, and allowing .125" for the thickness of the grip cap.
3 Two types of Aldila Low Torque shafts were tested. The 44" raw length version was Aldila's discrete S-flex shaft, while the 45" raw length version was the company's combination R&S flex design.
NOTE: Many more shafts were tested than what are included in the previous S-flex deflection chart.

Chart 3-7 - Deflection Measurements: S-Flex Parallel Tip Shafts For Irons

Shaft	Raw Shaft Deflection/Raw Length[1]	Cut Shaft Deflection/Cut Length[2]
Aldila		
HM-30 S	3.35"/39"	3.05"/36"
HM-40 S	3.43"/39"	3.03"/36"
HM-40 Low Flex S	4.12"/41"	2.83"/36"
Low Torque S[3]	3.13"/39"	2.68"/36"
Low Torque S[3]	4.19"/41"	2.68"/36"
Apollo		
AP44 S	4.06"/41"	2.62"/36"
Boron Tourline S	3.16"/39"	2.43"/36"
G100 S	3.06"/39"	2.43"/36"
HMF Lo-Torque S	3.11"/39"	2.36"/36"
Shadow S	4.23"/41"	2.77"/36"
Spectre S	4.16"/41"	2.75"/36"
Brunswick		
Microtaper S	4.55"/41"	2.91"/36"
Phoenix S	4.40"/41"	2.89"/36"
ProPel II S	4.10"/41"	2.65"/36"
True Temper		
Dynamic S	4.06"/41"	2.68"/36"
Dynamic Gold S[2]	3.50"/39"	2.73"/36"
Dynamic Gold S[3]	3.31"/39"	2.71"/36"
Dynamic Gold S[4]	3.42"/39"	2.65"/36"
Jet Step S	4.08"/41"	2.65"/36"
TT Lite S	4.13"/41"	2.67"/36"

1 All 41" raw length shafts were combination R&S flex construction. Please note that the raw shaft deflection measurements will be the same for the R and S flexes since both cut shafts come from the same combination flex shaft.
2 All R-flex cut shafts in this test were 36", reflecting installation into an ironhead with a 1.375" bottom of bore to heel dimension, assembled to 37.5" playing length, and allowing .125" for the thickness of the grip cap.
3 Two types of Aldila Low Torque shafts were tested. The 39" raw length version was Aldila's discrete S-flex shaft, while the 41" raw length version was the company's combination R&S flex design.
NOTE: Many more shafts were tested than what are included in the above S-flex deflection chart.

As a beginning observation of the actual deflection readings, in Charts 3-2 through 3-7 first note the difference in between the raw and the cut versions of each shaft. One of the points that became evident from a first study of this data is the tremendous change in deflection that occurs when a shaft is trimmed for installation. For example, the combination R&S flex Dynamic shaft for woods with a 47” raw length (UDWC) has a deflection measurement of 7.19”. Proper trimming calls for a total of 5.625” to be removed from the tip and butt ends of the shaft to achieve the cut shaft R and S flexes. As a result, after trimming, the deflection of the UDWC has been reduced by 1.95” (to achieve the R-flex) and 2.44” (for the S-flex).

To realize how much of a difference in deflection represents a change of one flex, think of the 0.49” difference in deflection that exists between the Dynamic R (5.24”) and the Dynamic S (4.75”) cut length steel shafts for Drivers. In the trimming of the UDWC raw shaft from which the R and the S flexes originate, the Dynamic S cut shaft has 2” more taken from the tip end and 2” less taken off the butt than the Dynamic R cut length Driver shaft. Most clubmakers are trained to expect a tremendous increase in stiffness whenever more of the tip end of a shaft is trimmed. However, using the Dynamic S-flex shaft in this example, shortening the tip of the shaft by 2” over the R-flex only increased the stiffness by 0.49” of deflection. To contrast, cutting a total of 5.625” from the raw R&S combination flex shaft changed the deflection by nearly five times that amount (2.44”)! Another interesting point from this observation may be the fact that this deflection difference of 0.49” between a Dynamic R and a Dynamic S-flex cut shaft represents the amount of stiffness increase the wood version of the shaft undergoes when an additional 2” are taken from the tip, or, when the first step on the shaft is moved 2” closer to the head. This information then points to the fact that tip and butt trimming together change deflection more than tip trimming alone.

Looking at the raw vs. cut shaft deflection measurements for Dynamic irons; the most obvious point to note is how much less stiff the iron shaft deflections are than wood shaft readings. This decrease in deflection among iron shafts is explained by three basic reasons: 1. The raw Dynamic iron shaft (UDIC) is 6” shorter than the raw Dynamic wood shaft (UDWC). Hence the shorter the shaft, the stiffer the deflection. 2. The tip of the UDIC is 0.035” larger in diameter than the tip of the UDWC. 3. Iron shafts are designed to be much stiffer than corresponding wood shafts, to be able to account for the increased bending effect of much greater head weights.

While the 47” raw length UDWC shaft has a 7.19” deflection measurement, its iron counterpart, the 41” raw length UDIC has a deflection reading of just 4.06”. As seen in Charts 3-5 and 3-7, when the UDIC is trimmed 5” to create the cut shaft versions of the Dynamic R and Dynamic S for a men’s length #5-iron, this raw UDIC deflection is only decreased by 1.17” (for the R-flex) and 1.38” (for the S-flex). Still this change from raw to cut shaft is far less than the deflection difference from the UDWC to the R and S-flexes in Dynamic wood shafts. As a result of this information, it can be said that the amount of deflection change required to achieve a change of one full flex is much greater for woods than it is for irons.

Chart 3-8 Overall Average Deflection Measurements For Each Flex

		WOODS		IRONS	
Flex	Shaft Material	At men’s Length	At Ladies Length	At Men’s Length	At Ladies Length
L-flex	Steel	5.79”	5.44”	3.36”	3.19”
	Graphite	5.07”	4.64”	3.32”	3.22”
A-flex	Steel	5.60”		3.22	
	Graphite	4.91”		3.02”	
R-flex	Steel	5.18”		2.98”	
	Graphite	4.67”		2.96”	
S-flex	Steel	4.73”		2.78”	
	Graphite	4.42”		2.70”	
X-flex	Steel	4.33”		2.54”	
	Graphite	3.68”		2.49”	

Note: All L-flex shafts were tested at cut shaft lengths that represented both the men’s and ladies standard playing lengths. This was done to allow comparing the L-flex shafts to the other flexes at similar length, as well as to observe the L-flex shafts in the length in which they are most commonly used.

Overall Deflection Measurement Averages for Each Flex and “Between” Flexes

It is not the goal of this shaft-testing project to establish industry standards for the various shaft specifications, only to provide uniform data for comparing shafts. Still, it is interesting to be able to identify industry averages for deflection measurements for each of the various flex levels of L, A, R, S and X for Drivers and #5-irons, in both steel and graphite shafts. For all of the shafts tested in the project, Charts 3-8 and 3-9 represent a reasonably accurate depiction of the average deflection measurements and the average difference in deflection between flexes in the shaft industry today. All averages are for the shafts in their cut form, as prepared for installation into a standard metal

Chart 3-9 Overall Average Deflection Differences Between Flexes

Difference	Material	WOODS At Men's Length	WOODS At Ladies Length	IRONS At Men's Length	IRONS At Ladies Length
L to A flex	Steel	0.19"	(-0.16")	0.14"	(-0.03")
A to R flex	Steel	0.42"	0.24"		
R to S-flex	Steel	0.45"	0.20"		
S to X flex	Steel	0.40"	0.24"		
L to A flex	Graphite	0.16"	(-0.27")	0.30"	(0.20")
A to R flex	Graphite	0.24"	0.06"		
R to S flex	Graphite	0.25"	0.26"		
S to X-flex	Graphite	0.74"	0.21"		

Note: All L-flex shafts were tested at cut shaft lengths that represented both the men's and ladies standard playing lengths. This was done to allow comparing the L-flex shafts to the other flexes at similar length, as well as to observe the L-flex shafts in the length in which they are most commonly used.

wood Driver and #5-iron.

Some very interesting observations can be made when the shaft test averages for deflection are compared from a flex-to-flex standpoint. Chart 3-9 represents the average deflection difference between adjacent flexes in steel and graphite cut length shafts for woods and irons. Deflection readings were taken for the L-flex shafts at two different length readings; one representing the standard ladies length and the other at standard men's length. The reason this was done was to allow deflection comparisons to be made with all the flexes at the same length, as well as to see just what the deflection of the L-flex shafts was at the length most ladies would play with the shafts. Since the A, R, S and X-flex shafts are predominantly men's shafts, all deflection testing for these flexes was performed at men's standard length. Therefore, all of these measurements are purely comparable.

From studying Chart 3-9 of average deflection differences between flexes, the first observation that can be made is how poorly matched the L-flex shafts are to the rest of the flexes. Looking at the steel shaft data, it is interesting to see that the overall averages for the change in deflection from one flex to another is very close, except between the L and the A-flex. In the steel shafts for woods, each of the changes from the A to R, the R to S and the S to X are within 0.50". And in the steel shafts for irons, the changes from A to R, R to S and S to X are each within 0.20". Yet the change between L and A flexes in both steel woods and irons is far from the norm, regardless whether the L-flex shafts were cut to men's or ladies length. When measured at ladies lengths (the actual length that almost all L-flex shafts are played), the L-flex deflections are even stiffer than the A-flex versions!

Looking at the average flex-to-flex differences in deflection for graphite shafts, the A through X-flex differences are not nearly as consistent as they are for steel shafts. Perhaps one of the main reasons for this is the fact that graphite shafts are far more susceptible to shaft-to-shaft inconsistencies than are steel shafts. This could be because sheet wrapping, the predominant form of graphite shaft manufacture does leave room for more errors in shaft deflection consistency than steel shafts.

The Significance of Deflection Inconsistency

Because deflection readings have never been published measurements, a word must be said about just how much deviation in the deflection should be considered significant. Upon scanning the overall list of deflection readings among identical length shafts in Charts 3-2 through 3-7, it becomes apparent from noting the various differences between adjacent flexes (L to A, A to R, etc.) that a deflection deviation of as little as 0.20" in the woods and 0.12" in the irons could be considered significant. Therefore, and as an example, when studying the deflection data, if the difference between two wood shafts is less than 0.15", or 0.08" between two iron shafts of the same flex design, for all intents and purposes the shafts would have to be considered to be so close as to be essentially the same in relative stiffness. On the other hand, should the difference in deflection between two identical flexes of shafts for woods be 0.20" or greater, or in the range of more than 0.12" or greater for iron shafts, the deviation would have to be considered significant enough so as to conclude the shafts - from a deflection standpoint only - could not be the same relative stiffness.

Key to this discussion of deflection and the understanding of the data is the fact that no matter how accurate the testing may be, deflection alone cannot be considered the only, or even the true depiction, of the real relative stiffness FEEL of shafts. Following this discussion on deflection will come a study of the vibrational frequency of the shafts, the other aspect of shaft flex measurement upon which a more meaningful testing analysis and shaft-to-shaft comparison will be judged.

Differences In Deflection between Adjacent Flexes

Referring back to the information found in deflection Charts 3-2 through 3-7, consider for a moment the difference in deflection between the cut versions of the R and the S-flex shafts that both originate from a single 47" combination flex design. Looking at the Dynamic, TT Lite, Jet Step, AP44, Spectre, Shadow, Pro Pel II, Phoenix and Microtaper patterns, all have a 2" tip trim/2" butt trim difference between their respective R and S-flex versions. That is to say, in the case of these shaft patterns, the S-flex version has 2" more trimmed from the tip and 2" less trimmed from the butt than the R-flex version. In such a case where the raw shaft "parent" of each R and S cut version has the same deflection, one would think that the difference in deflection between the R and the S of any of the patterns that come from a 47" raw shaft should be the same.

Studying a few of the cut shafts which came from a 47" combination flex raw shaft, the difference between the R and S cut shafts was as follows:

Combination Flex Wood Shaft	Deflection Difference Between The R and S-Flexes
AP44	0.43"
Dynamic	0.49"
Jet Step	0.29"
Microtaper	0.27"
Phoenix	0.38"
ProPel II	0.27"
Shadow	0.43"
Spectre	0.31"
TT Lite	0.35"
	Average = 0.358"

The difference in deflection between the R and S-flex shafts which all originate from a 47" raw length combination flex shaft ranged between a low of 0.27" (Microtaper) and a high of 0.49" (Dynamic). Since the playability difference between the R and the S-flex is perceived by golfers to be significant, regardless of pattern, such a range would seem to indicate that deflection alone cannot be regarded as a real indicator of flex differences. Otherwise golfers would all agree that the R and the S flexes of the Microtaper are much closer in "flex feel" than the R and the S of the Dynamic, a perception that is not prevalent among players today.

Chart 3-10 Comparison of Deflection Within The Same Pattern (Woods)

Shaft	Flex	Cut Shaft Deflection @ Ladies Length	Cut Shaft Deflection @ Men's Length
Dynamic	L	5.54" (40.375")	6.08" (41.375")
Dynamic	A	5.89" (41.375")	
Dynamic	R	5.24" (41.375")	
Dynamic	S	4.75" (41.375")	
Dynamic	X	4.37" (41.375")	
TT Lite	L	5.54" (40.375")	5.94" (41.375")
TT Lite	A	5.48" (41.375")	
TT Lite	R	5.19" (41.375")	
TT Lite	S	4.84" (41.375")	

To further drive home this point of what a small part deflection plays in overall flex feel, now add the other flexes within a single pattern to the discussion. Following is a list of the deflections of each individual flex for the game's two most popular steel shafts, the Dynamic and the TT Lite. For both patterns, the A, R, S and X flexes were tested at men's standard length. The L-flex shafts were tested at the ladies Driver standard of 42" playing length (40.375" cut shaft), as well as at the men's Driver standard of 43" playing length (41.375" cut shaft). The primary reason was to be able to compare the deflection of the L-flex shafts to the other flexes at both ladies and men's standard length, to determine which length would more closely match the rest of the flexes.

In looking at Chart 3-10 of deflection differences from flex-to-flex within the Dynamic and TT Lite patterns, it would be logical to think that the differences between each flex should be equal. After all, shaft companies have created the impression that the differences between each flex are as equal as steps up a ladder. Additionally, before inspection of the data it also would seem, regardless of the pattern, the difference between each flex should be the same. In other words, wouldn't it seem logical that the difference between a Dynamic R and S should be the same as the difference between a TT Lite R and S? Despite the fact that this discussion of the overall deflection averages for steel shafts has shown some consistency from the A through X-flexes, studying each individual shaft pattern design will show that not every shaft pattern has the same, consistent deflection difference from flex to flex.

Looking at the difference between the L and the A-flex for the Dynamic and TT Lite patterns, the same mismatch problem with the L-flexes first seen in the overall averages of deflection measurements can be seen again. As with all of the L-flex deflection measurements, the test was set up to determine the deflection of the L-flex shafts at both men's and ladies Driver lengths. At the ladies standard playing length of a 42" Driver (40.375" cut shaft) the deflection of the Dynamic L shows the shaft to actually be stiffer than the A-flex version! And for the TT Lite shaft, while the deflection reading for the L-flex is softer than for the A-flex version, the difference is so slight so as to lead the conclusion that the L-flex, when played at ladies length, is definitely stiffer than it should be. Only when the L-flex is made to the same men's standard length as the A-flex is the deflection in sequence with what one would expect its relative stiffness should be. Hence, should ladies play with L-flex shaft at men's length just to achieve the proper level of flexibility?

After thinking about the fact that the L and the A-flexes do originate from the same raw shaft (the 46" combination flex version), the results of the deflection analysis do become more logical. After all, if two different flexes come from the same shaft, when one is cut shorter in length (the L being 1" shorter than the A in cut form since ladies clubs are traditionally 1" shorter than men's), it should become relatively more stiff due to the decrease in length. Therefore, from deflection readings only, it can be said that there may be some fault in trying to achieve true L and A- flexes from the same combination flex "parent" shaft.

Comparing the A, R, S, and where possible, also the X-flex shafts within the same pattern, there appears to be no logical sequence to the flex-to-flex differences. Within the Dynamic and TT Lite patterns, the difference between these flexes is indicated in Chart 3-11.

Chart 3-11 Deflection Differences Between Flexes of Dynamic and TT Lite

Dynamic	Flex Change	TT Lite
(-0.35")	L[1] to A	0.06"
0.65"	A to R	0.29"
0.49"	R to S	0.35"
0.38"	S to X	N/A

Note: The negative sign in front of the L to A-flex difference in the Dynamic pattern indicates that the Dynamic L-flex shaft at ladies standard length has less deflection than the A-flex version at men's standard length. The N/A entry under the TT Lite column reflects that the X-flex is not available in the TT Lite pattern. L[1] - L-flex measured at ladies length.

Again, where it would seem logical for the deflection differences to is the same from one flex level up to the next, from a pure deflection standpoint the data shows this is not the case. What is interesting to note from this information are the larger changes from A to R and from S to X within the Dynamic pattern, as compared to the smaller difference between the R and the S. This is likely an illustration of the change from one raw shaft to another. The R and the S flexes of the Dynamic come from the same raw shaft, the A and the X come from different raw shafts. This points to the fact that two adjacent flexes that come from a single discrete flex shaft will likely be closer in relative stiffness than will two adjacent flexes that come from different raw shafts.

Deflection between Similar Patterns Made by Different Manufacturers

In 1990's clubmakers were aware of the fact that the world's three leading steel shaft manufacturers, True Temper, Apollo and

Brunswick, all produce steel patterns which are said to be identical in design. For example, the Dynamic, the AP44 and the Pro Pel II are all made with the same step pattern, the same tip and butt diameter specifications and the same pattern description of standard weight with a high bend point. Likewise, the TT Lite, Spectre and Phoenix steel shaft patterns also are considered to be identical in design, as are the Microtaper and Shadow patterns.

Experienced clubmakers are taught to use comparable shaft patterns whenever a particular pattern of choice is not available. For example, if a Dynamic is not available, it has been said the AP44 or Pro Pel II will play exactly the same. As such, how close in design, or from this part of the test, how close in deflection are the similar shaft patterns of different manufacturers? Charts 3-12, 3-13 and 3-14 compare deflection among similar patterns for the three most popular types of parallel tip, steel shaft pattern designs.

Take a moment to study the deflection readings between like flexes within each of the similar shaft patterns in Charts 3-12, 3-13 and 3-14. For this discussion, it must be understood that the discrepancies seen in comparing the L-flex shafts to the other flexes have already been revealed. Therefore, in determining how close the various similar steel shaft patterns are to each other, the conclusion is already made that the L-flex shafts are essentially all too stiff in a sequence of deflection when compared to the remaining flexes. With that point understood, this discussion will focus on the other flexes.

Chart 3-12 Standard Weight/High Bend Point Steel Shafts

Shaft /Company	Flex	Driver Deflection	#5-iron Deflection
Apollo AP44	R	5.07”	2.80”
	S	4.64”	2.62”
Brunswick Pro Pel II	L	5.74”	3.23”
	A	5.79”	3.33”
	R	5.03”	2.84”
	S	4.76”	2.65”
True Temper Dynamic	L	5.54”	3.28”
	A	5.89”	3.29”
	R	5.24”	2.89”
	S	4.75”	2.68”

Chart 3-13 Lightweight/Mid Bend Point Steel Shafts

Shaft /Company	Flex	Driver Deflection	#5-iron Deflection
Apollo Spectre	L	5.44”	2.96”
	A	5.50”	3.03”
	R	4.97”	2.92”
	S	4.66”	2.75”
Brunswick Phoenix	L	5.08”	2.97”
	A	5.46”	3.08”
	R	5.31”	3.01”
	S	4.93”	2.89”
True Temper TT Lite	L	5.54”	2.88”
	A	5.48”	3.06”
	R	5.19”	2.79”
	S	4.84”	2.67”

Chart 3-14 Lightweight/Low Bend Point Steel Shafts

Shaft /Company	Flex	Driver Deflection	#5-iron Deflection
Apollo Shadow	L	5.68”	3.11”
	A	5.83”	3.32”
	R	5.19”	2.94”
	S	4.76”	2.77”
Brunswick Microtaper	L	5.34”	3.22”
	A	5.67”	3.34”
	R	5.09”	3.09”
	S	4.82”	2.91”

Note: All L-flex shaft measurements taken at ladies standard length.

In analyzing the measurements for all the standard weight /high bend point steel shafts (Dynamic, AP44 and ProPel II) it is amazing how close the deflection readings are for each flex of each similar shaft. The only slight discrepancy among these three identically-designed patterns lies in the True Temper Dynamic R flex shaft for woods, with its 5.24" deflection indicating a slight increase in flexibility when compared to the 5.07" and 5.03" deflections for the R-flexes of the similar AP44 and Pro Pel II patterns.

In examining the deflection measurements of the lightweight /mid bend point steel shafts (TT Lite, Spectre and Phoenix) it becomes apparent that many discrepancies exist between the like flexes of the three patterns. In some cases, these three similarly designed patterns are not nearly as close to each other as are the standard weight/high bend point patterns. While the A-flex wood shafts of the three lightweight/mid bend point patterns are very similar, the R-flexes show a deviation of 0.34" (Phoenix R = 5.31" vs. Spectre R = 4.97"), and for the S-flex, a high-to-low range of 0.27" (Phoenix S = 4.93" vs. Spectre S = 4.66"). While the overall average difference between two adjacent flexes of the wood shafts of each of the three patterns is @0.030", from a deflection standpoint only, some of the similar flexes for the lightweight/mid bend point wood shafts are just not equal.

Similarly, the same situation of deflection inequality exists within a few of the iron designs of the lightweight/ mid bend point steel shafts. Keeping in mind that iron shafts have naturally lower deflection measurements than the woods, observation of the data shows the A-flex versions all matched each other within a very narrow high-to-low deflection range of 0.05". However, in the R and S-flex iron shafts, the deviations of 0.22" between the R-flexes and the 0.14" discrepancy among the S-flexes are particularly significant.

Continuing with the third analysis, the lightweight/low bend point designs, as of late 1991, only two such steel patterns were produced, the Shadow from Apollo and the Microtaper from Brunswick. While the Dynalite from True Temper was released in early 1992, due to the scope of this test project, including the Dynalite in this discussion was just not possible. In comparing the two other similar patterns, again some similarities as well as some discrepancies exist within the like flexes. Among the wood shafts, the only significant difference was found in the A-flex versions, with the Shadow A-flex exhibiting much more deflection flexibility than the A-flex of the Microtaper. Most important to note were the deviations between the R and S-flex versions of the irons, with both showing a departure of 0.15" in deflection. Referring back to the overall averages for steel iron shaft deflection differences between flexes, the 0.15" deviation within iron shafts does represent nearly one full flex level.

Deflection Differences within Frequency-Matched Shafts

From the late 1970's through the early 1980's, a number of shaft manufacturers began to offer shaft designs, which were said to be very accurate in their flex designations. Brunswick's Precision FM and True Temper's Dynamic Gold both were depicted as frequency-matched shafts and over the years have been accepted by clubmakers as being among the most accurate steel shafts ever made. While the two shafts are designed to achieve frequency matching in completely different ways, the concept behind the two was the same when promoted to clubmakers and golfers; club to club within a set, these frequency-matched shafts were more accurate than any other steel shaft.

While Brunswick matched the FM shafts strictly by vibrational frequency, True Temper chose to achieve shaft-to-shaft frequency sequencing through weight selection. By producing shafts to very tight weight tolerances, True Temper created sub-flexes within the most popular flexes of R, S and X. In the parallel tip form of the design, three sub-levels of the Regular, Stiff and Extra Stiff major flexes were produced, known as the R200, R300 and R400, the S200, S300 and S400, and the X100, X200 and X300. In each series, the higher the sub-flex number, the stiffer the shaft was said to be, made so by an increase in shaft weight from one sub-flex up to the next. Since weight is a minor component of shaft flex (within the same pattern, the heavier the shaft, the stiffer the flex) deflection tests were performed on the Dynamic Gold in parallel tip form to determine through deflection, whether the pattern exhibited such a closely defined separation in flex as claimed.

Chart 3-15 Comparison of Deflection Between Dynamic Gold Sub-Flexes (Woods)

Shaft	Flex	Raw Shaft Deflection	Cut Shaft Deflection
Dynamic Gold	R200	6.73”	5.16”
	R300	6.69”	5.37”
	R400	6.59”	5.18”
Dynamic Gold	S200	6.25”	4.87”
	S300	6.26”	4.80”
	S400	6.30”	4.76”

Chart 3-16 Comparison of Deflection Between Dynamic Gold Sub-Flexes (Irons)

Shaft	Flex	Raw Shaft Deflection	Cut Shaft Deflection
Dynamic Gold	R200	3.78”	2.95”
	R300	3.77”	2.97”
	R400	3.71”	2.98”
Dynamic Gold	S200	3.50”	2.73”
	S300	3.31”	2.69”
	S400	3.42”	2.65”

The concept of the sub-flexes within Dynamic Gold conveys that the higher numbered sub-flexes will increase slightly in stiffness, due to the progressive increase in shaft weight. In the case of the data obtained from testing each sub-level of the R and S flexes for the parallel tip version, results showed the relative stiffness (as indicated by deflection) did not always increase from the 200 up to the 400. In addition, it was also seen that the increment of deflection change between each sub-flex level was very slight. In fact, the change in stiffness between each Dynamic Golf sub-flex was so small that it is doubtful the stiffness increase would be felt by most golfers, if it can be assumed that deflection alone contributes to flex feel.

Within all the Gold shafts for woods as well as the S-flex iron shafts, stiffness did increase through the sub-levels of flex, with the exception of the S400 wood shaft, which, for the sample tested, decreased very slightly in deflection stiffness from the S300. Most interesting, however, was the relationship in deflection seen in the R-flex iron shafts. Instead of increasing through the sub-levels of the R-flex, the shafts decreased in deflection stiffness!

It must be noted that the deflection measurements of the R-flex irons were so close that, with some plus/minus tolerances built into the testing, no real conclusion can be made. To better understand the data, keep in mind the explanation of how difficult it was to obtain perfect weight and tip and butt diameter dimensions all together in one or two sample shafts. By looking in the accompanying addendum of data that features the full listing of test data, very, very slight deviations existed in each of the Dynamic Gold shafts from True Temper’s perfect design specifications. For example, the intended dimensions of the Dynamic Gold shafts as compared to our test samples were as noted in Chart 3-17.

Chart 3-17 Dynamic Gold Test Samples Vs. Stated Specifications

Wood	Flex	Weight / Spec.	Tip / Spec.	Butt / Spec.	Length / Spec.
R200	R	4.27 oz. / 4.25 oz.	.334" / .335"	.599" / .600"	45" / 45"
R300	R	4.31 oz. / 4.31 oz.	.334" / .335"	.601" / .600"	45" / 45"
R400	R	4.38 oz. / 4.37 oz.	.334" / .335"	.602" / .600"	45" / 45"
S200	S	4.34 oz. / 4.31 oz.	.334" / .335"	.600" / .600"	45" / 45"
S300	S	4.36 oz. / 4.37 oz.	.335" / .335"	.600" / .600"	45.06" / 45"
S400	S	4.42 oz. / 4.43 oz.	.333" / .335"	.601" / .600"	45.06" / 45"
Iron	**Flex**	**Weight / Spec.**	**Tip / Spec.**	**Butt / Spec.**	**Length / Spec.**
R200	R	4.19 oz. / 4.19 oz.	.369" / .370"	.601" / .600"	39" / 39"
R300	R	4.22 oz. / 4.25 oz.	.370" / .370"	.602" / .600"	39" / 39"
R400	R	4.28 oz. / 4.31 oz.	.370" / .370"	.601" / .600"	39" / 39"
S200	S	4.33 oz. / 4.31 oz.	.369" / .370"	.600" / .600"	39" / 39"
S300	S	4.37 oz. / 4.37 oz.	.368" / .370"	.602" / .600"	39" / 39"
S400	S	4.42 oz. / 4.43 oz.	.370" / .370"	.600" / .600"	39" / 39"

While each of the specifications of the test shafts were well within True Temper's production tolerances, no single shaft was perfect in all the specifications. Despite this fact, it is important to note that the sample shafts in all of the four groups of sub-flexes (R200, R300, R400 woods; S200, S300, S400 woods; R200, R300, R400 irons; S200, S300, S400 irons) did exhibit an increase in shaft weight through the sub-flex category. In other words, the key to each ascending sub-flex level of the Dynamic Gold is a slight increase in weight. While the test shafts did indeed get heavier, as intended, the deflection measurements did not always show that the shafts became more stiff as the weight increased, nor did they increase in deflection stiffness at a level that would easily convey the feeling of stiffness increase.

Two points must be understood from this deflection study of the Dynamic Gold shafts. First, and again to repeat a major point of this discussion, deflection cannot be used as the only expression of shaft flexibility. Second, it is not feasible to expect golfers to truly notice flex feel differences between such slight increases in stiffness, especially when it is realized that the test samples were hand selected to be as close to specifications as possible.

Comparison of Deflection between Frequency Levels of the Precision FM

While each Precision FM steel shaft is designed with a precise tip diameter, butt diameter and weight specification, the key element of the design is the fact it is sorted by frequency and not just by weight selection. Therefore, including the deflection measurements of the Precision FM steel shaft in this discussion affords the opportunity to compare frequency-matched shaft (Precision FM) with a weight-sorted, frequency-matched shaft (Dynamic Gold).

Unlike all other shafts available today, the Precision FM steel shafts are not assigned the normal letter designations of flex as other shafts. Instead, the FM is designed to frequency levels, as identified by a numerical sequence, such as 3.5, 5.5, 7.0, etc. Over the years, clubmakers have been able to make an association between the FM numerical levels and the golf industry's normal flex designations. For purposes of comparison, in the analysis of the test data, the FM3.5 may be equated to the L-flex, the 4.5 to the A-flex, the 5.5 to the R-flex, the 6.5 to the S-flex and the 7.5 to the X-flex. (In 2000, Royal Precision changed the numerical designation one full flex softer; i.e. 5.5 is now considered an S-flex)

As a form of additional check and control, the test results for frequency of each cut shaft for Drivers and #5-irons is included in Chart 3-18, along with Brunswick's intended wood shaft frequency specifications. Since weight specifications are used as the means of flex designation for the Dynamic Gold shafts, it is only fair to have a same type of control for the FM shafts as well. Since the FM shafts are selected and matched by frequency, this information also is included in the test results.

Chart 3-18 Precision FM Test Samples Vs. Stated Specifications

Flex	Wood Cut Shaft	Iron Cut Shaft	Iron Flex	Wood Cut Shaft	Iron Cut Shaft
FM 3.5	5.75”	3.45”	Dynamic L[1]	6.08”	3.59”
FM 4.0	5.57”	3.32”			
FM 4.5	5.48”	3.21”	Dynamic A	5.89”	3.29”
FM 5.0	5.28”	3.09”			
FM 5.5	4.92”	3.00”	Dynamic R	5.24”	2.89”
FM 6.0	4.75”	2.86”			
FM 6.5	4.53”	2.68”	Dynamic S	4.75”	2.68”
FM 7.0	4.45”	2.59”			
FM 7.5	4.21”	2.54”	Dynamic X	4.37”	2.48”

[1] Dynamic L and FM 3.5 were both measured at standard men's length for comparative purposes.

Analysis of the FM measurements in Chart 3-18 shows that there is a constant decrease in deflection from level to level, which represents an increase in deflection stiffness through the FM series. Note that despite the fact the FM shafts are frequency calibrated, the progression of deflection decrease (stiffness increase) was not completely consistent. Differences in deflection from one level to the next ranged from a low of 0.09” (FM4.0 to FM4.5 woods) to a high of 0.36” (FM5.0 to FM5.5 woods). Another interest of note is in most cases, the FM levels are stiffer, or have lower deflection readings, than the Dynamic pattern in what is considered comparable flexes.

Once again - and especially in the case of what is demonstrated as an accurate shaft (indicated by the accuracy of the frequency test vs. its specification) - it is just not reasonable to expect deflection differences between each flex to be completely consistent. In all fairness to the manufacturers, the Dynamic Gold is made to a weight tolerance of ±1/32 oz. and the Precision FM to a frequency tolerance of ±2 cycles per minute. For these companies to achieve such tight tolerances in shafts that cost as little as they do is, on its own, remarkable. Granted, the test machinery did show deflection stiffness increases up through some of the Gold sub-flexes of a few hundredths of an inch. If a deflection change of 0.25” or more is to be considered significant - which from the testing appears to be true - then a stiffness change of only 0.05” or less can hardly be considered an amount that could be felt by most golfers. Therefore, it could also be said that a shaft company's claim to be able to make shafts with such a perfect match or such a slight separation in flex, is a bit too much to believe. From this information, once more it must be stressed in no uncertain terms that deflection alone cannot be the major form of shaft flex comparison.

Graphite/Composite Shaft Deflection - A Contrast to Steel

When graphite shafts were introduced in the early 1970's, golfers immediately noticed the shafts felt more flexible than did the same flex in steel shafts. As a result, one of the early fitting guidelines for graphite shafts advised golfers to choose a flex that was one level stiffer than what they had been comfortable using in steel shafts.

The first generation of graphite shafts did feel and play more flexibly than steel shafts of the same flex because the shafts were not designed to accommodate the heavier headweight that was required by the lighter weight of the shafts. As clubmakers are now aware, between two Drivers of identical length and swingweight, one built with a standard weight steel shaft and one assembled with a lighter graphite shaft, the headweight of the Driver on the graphite shaft will be much greater than the headweight of the steel-shafted club.

For any golf club, as headweight is increased, the additional weight exerts more of a bending influence upon the shaft, thus making the shaft feel and play more flexible. Herein was the reason the early graphite shafts were perceived by golfers to be more flexible than steel; the shaft designers had not taken the presence of greater headweight into account when creating the stiffness levels of the shafts.

Learning from the experience, by the 1980s, when the second generation of graphite shafts began to appear, golfers discovered that Drivers built with the new composite shafts played to the same approximate levels of stiffness as their steel-shafted clubs. Keeping in mind the increased bending effect of higher headweight on shaft flex, it would stand to reason they would have to be designed in the raw form with a greater level of stiffness than steel shafts.

Clubmakers also should note that the Ti Shaft Titanium wood shafts are made within the normal range of steel shaft deflection measurements and not within the modern deflection ranges for graphite. This is partly due to the unique characteristics of the titanium material and because titanium is not considered to be as light in weight as graphite. Therefore titanium shafts do not require such a high headweight (as do the lighter graphite shafts) to achieve a normal range of swingweight, and as such, do not need to be produced to an increased level of stiffness.

Comparison of Graphite vs. Steel Deflection

Comparing the deflection measurements of the cut length shafts for graphite and steel note the graphite shafts for woods rate higher in relative stiffness than steel shafts of the same flex while the graphite iron shafts possess the same approximate deflection stiffness as the steel iron shafts.

Chart 3-19 - Average Cut Shaft Deflection Measurements with Different Shaft Materials

Flex	Woods Steel	Woods Graphite	Woods Titanium	Irons Steel	Iron Graphite
L[1]	5.44”	4.64”	N/A	3.19”	3.22”
A	5.60”	4.91”	N/A	3.22”	3.02”
R	5.18”	4.67”	5.50”	2.98”	2.96”
S	4.73”	4.42”	5.18”	2.78”	2.70”
X	4.33”	3.68”	4.84”	2.54”	2.49”

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

It was established earlier in this chapter that the average deflection change between flexes in steel shafts was @0.40” for woods and @0.22” for irons. Examine the average deflections for each steel and graphite flex in woods from Chart 3-19. It is fairly safe to say that from a deflection standpoint only, most graphite wood shafts are, in their cut form, are a little more than one full flex stiffer than their equivalent steel flexes. In addition, titanium wood shaft are one full flex more flexible than steel and two full flexes more flexible than graphite, with the same flex designation! Of course this is deflection only and does not take into account the flex-changing effect of torque on the overall stiffness of a graphite shaft. While the entire aspect of torque and its effect on flex will be discussed in Chapter 5, suffice to say for now that torque does figure into the overall picture of flex feel in graphite.

It has been established when two Drivers, one with a standard weight steel shaft and one with a lightweight graphite shaft, are made to identical length and swingweight, the Driver head on the graphite shaft will weigh approximately 10 grams more than the Driver head on the steel shaft. It also has been said in this discussion that most of today’s graphite shafts for woods are made one flex stronger in raw form to allow for the bending effect of greater headweight. Therefore, could it be said that a 10-gram addition of headweight would have the effect of decreasing the flex of a shaft by one full flex level? From deflection testing only, such a statement could be accepted. However, as was mentioned in the introduction to this section, deflection is a static measurement only and as such, is not accepted by experts as a true depiction of shaft flexibility performance. Further verification of such a relationship is best left for additional study, using shaft frequency comparison measurements to assist in making a final conclusion.

Deflection Conclusions - Meaningful Or Not?

After reading and making comparisons of the deflection measurements, it is very important to realize that while some inconsistencies do exist and in fact, might seem to be very significant, the deflection measurements cannot be used to make complete and final conclusions about flex. Flex is not a component of simple deflection readings alone. What the golfer feels when striking the ball with a club is a product of many factors not yet covered in our discussions. Does bend point affect the deflection measurement of a shaft? Can two shafts with the same deflection react differently with regard to flex when actually installed in a golf club and used to hit a ball? How do some of the other shaft specifications relate to the deflection to tell the whole story of flex? Keeping in mind that the primary goal of this shaft-testing project is to discover interrelationships of shaft specifications. It must be accepted that the search for discovery has only begun, and that many other factors uncovered in this test project will be integrated as the discussions in this book unfold.

Still, there are a number of points that have become apparent from the deflection testing that just cannot be ignored:

• The discovery that, in all cases, L-flex shafts at their standard playing lengths (Driver cut shaft length = 40.375"; #5-iron cut shaft length = 35") are not in a proper sequence of stiffness as compared to the other flexes is very significant. Without a doubt, as the discussion continues, other specifications of the L-flex shafts will be shown to have an effect on the final quotient of flex, some which even have the effect of softening the stiffness feel of a shaft. Yet despite this, there is still no doubt that the deflection measurements of the L-flex shafts are significant in proving the shafts may be too stiff for the average lady golfer, especially when used at standard ladies playing lengths. If it can be accepted that shaft flexibility is an important component for a slow swinging golfer's success, it can also be said that most ladies' attempts to improve their playing skills are possibly being hindered by the design of the shafts they most frequently use.

• The fact that the similar patterns of steel shafts made by the various shaft manufacturers are reasonably close to each other in their deflection measurements is another conclusion that can be made from this data. Again, while there were discrepancies between certain flexes within the similar patterns, until frequency data is added to the discussion, no wholesale judgment can yet be made.

• It is interesting to see from a deflection standpoint, that graphite shafts for woods are made to a greater level of stiffness than steel shafts of the same flex, while the graphite iron shafts are not. If the increase in shaft stiffness for the woods has been intentionally engineered to counteract the flex softening effect of greater headweight, why then has the same thing not been done in the matching iron shafts?

• Looking at overall averages for the deflection measurements, it was see that the separation between graphite flexes did not show a constant spacing from A through X-flex that was apparent between the same flexes of steel shafts. Not to misrepresent the information, the testing did show that the deflection separation between flexes of individual steel and graphite shaft patterns did not tend to follow the overall averages; very few individual shaft patterns exhibited the same flex-to-flex separation as depicted in the overall averages. Still, the data did show that graphite shafts displayed more flex-to-flex inconsistency in deflection than did steel shafts. This is a fact that may be understandable, due to the tremendous difference in how graphite shafts are made compared to steel. Successively wrapping layers of graphite around a mandrel can leave more room for deflection inconsistency, as opposed to drawing a steel tube through a diameter reduction die; especially when the testing equipment has the ability to measure deflection to the hundredth of an inch (0.01")!

As a final word about the deflection test analysis, clubmakers must understand that producing a shaft to any form of close deflection tolerance and consistency is a very difficult task. While the tests were all performed on shafts that were selected to be as close to the manufacturers' diameter and weight dimensions as possible, there still could be individual anomalies about the shafts that were tested which could cause some of the discrepancies that were seen. For example, in the case of the True Temper Dynamic Gold series, it would not be fair to judge the sequence of stiffness between the various levels of sub-flex within each major flex level just on the basis of deflection. Therefore, the deflection study and comparison is just the start; until other flex indicators such as vibrational frequency are studied along with the deflection readings, it is not yet possible to say if differences between flexes are consistent or not, only that some deflections are different.

Editor's Note: After the 1993 addendum was printed, deflection measurements were not included as part of the shaft comparison charts. Deflection testing was halted after 1992 as a means of comparing relative flex from shaft to shaft because it did not allow for the additional headweight that was used in the actual assembly of a golf club. Frequency measurements became the primary method of comparing the relative stiffness from shaft-to-shaft. In 1999, however, deflection measurements became a normal part of testing again at the Dynacraft research facility, but theses measurements are not detailed in this study. In time, a more comprehensive approach to analyzing deflection readings and how they influence feel and performance may be addressed.