Proportion Measurement

Tolerances for the GIA Diamond Cut Grading System

BY ILENE REINITZ, KELLY YANTZER, MARY JOHNSON, TROY BLODGETT, RONNIE GEURTS AND AL GILBERTSON

During its diamond cut research, the Gemological Institute of America (GIA) spent considerable effort analyzing which parameters were essential for its diamond cut grading system. Two essential parts of this process were determining how these parameters should be measured and to what precision these measurements should be reported and used in the system. The goal was to find the right "balance" of precision, providing the level of data required for an accurate system while preventing an unnecessary burden of excessive or over-precise measurements.

More than 70,000 observation tests for brightness, fire and overall appearance, along with testing of several non-contact measuring systems (NCMS) and extensive trade discussions, were used to determine the appropriate proportions and precisions for the GIA Diamond Cut Grading System. Once determined, the GIA was able to create a predictive cut grading system by calculating the cut grade results for 38.5 million different proportion sets.

MEASURING PROPORTIONS

Although various angles and linear distances are measured to obtain geometric information for a round brilliant diamond, the GIA Diamond Cut Grading System uses a combination of the angular measurements and proportions (in many cases, percentage values relating each proportion to the diamond's average girdle diameter). The replacement of linear distances with proportions allows this grading system to be used for a wide range of diamond sizes, as the proportions by nature are always scaled appropriately for any size. In most cases, when a diamond's proportions are indicated, they refer to both the angular measurements and proportions of the diamond.

Precision intervals for the proportions used in the GIA Diamond Cut Grading System

Quantity	Intervals
Table size	1.0%
Crown angle average	0.5°
Pavilion angle average	0.2°
Average star length	5.0%
Average lower-half length	5.0%
Average crown height	0.5%
Average pavilion depth	0.5%
Total depth	0.1%
Girdle size	verbal
Culet size	verbal

The angular measurements and linear distances of a diamond can be obtained by several methods, including a microscope equipped with a reticle, which is a measuring grid placed in the microscope eyepiece; NCMS, like Sarin's DiaVision™ or OGI Tech's Megascope or, in some cases, through visual estimation. The average diameter, calculated from the minimum and maximum diameter measurements (see figure 1), is used with other linear measurements to compute the following proportions: total depth percentage, table percentage, crown height percentage, and pavilion depth percentage. The lengths of the star facets and lower halves, also referred to as lower girdle facets, are measured in a projected view, looking perpendicular to the table facet. Unlike the other proportions, the linear distances of the star facets and lower halves are considered in relation to the distance between the table edge and the girdle edge for star facets and the girdle edge and the center of the culet for lower halves, rather than to the average diameter. The girdle thickness, at the "valley" positions, and culet size are visually evaluated.

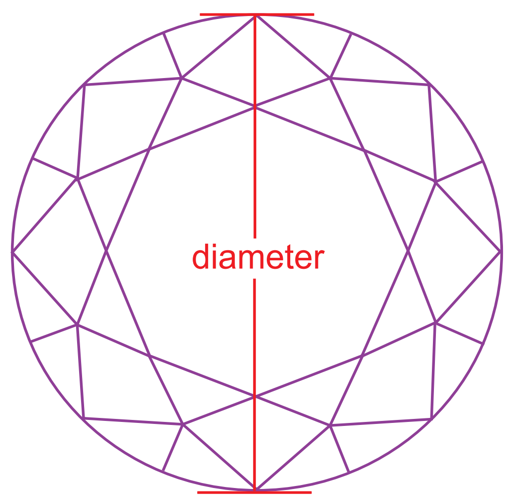

***Figure 1.** Diameter (mm) is the distance measured between two opposing points along the girdle's outline. The minimum and maximum girdle diameters are determined by taking several diameter measurements. Diameter is listed to the nearest hundredth of a millimeter (0.01 mm). Average diameter is equal to the sum of the minimum and maximum diameters divided by two: (min + max) ÷ 2. It is used in calculating certain percentages such as table percent, total depth percent, crown height percent and pavilion depth percent.*

PROPORTION PRECISION

The appropriate precisions for these measurements were chosen by evaluating three important considerations for designing a consistent, practical grading system: measurement, manufacturing and visual discernment. The first consideration was how well can a particular proportion be measured? If a precision less than or equal to the measuring uncertainty is chosen, the system will be difficult to apply in a repeatable way so that, for many cases, a second measurement of a proportion may give a different measurement value. In addition, the measurement uncertainty is not the same for all measuring tools used by members of the trade. But by choosing appropriate reporting increments for proportions, most diamonds should receive the same consistent measurements using different measuring devices or methodologies.

The second issue was how finely can a diamond manufacturer cut each proportion? It makes little sense to insist on precision that is beyond the manufacturer's control. It was important to determine a level of reporting that was practical and did not report values with unnecessary precision.

The final point was how much difference in a given proportion is needed to produce a change in face-up appearance noticeable by most observers? This last consideration may be the most important, since the purpose of the cut-grading system is to separate better-looking round brilliant diamonds from worse-looking ones. The GIA therefore analyzed its observation data — for brightness, fire, and overall appearance — at different levels of precision for each proportion to examine thresholds for distinct visual differences.

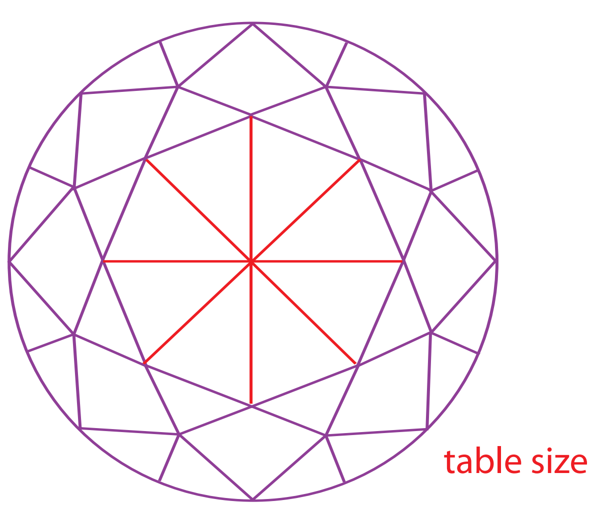

***Figure 2.** Table Size Percent is the average table size relative to the average diameter listed to the nearest whole percentage (1%). Table size is measured from bezel point to bezel point; the average of four measurements is used: (avg. table size ÷ avg. diameter) x 100.*

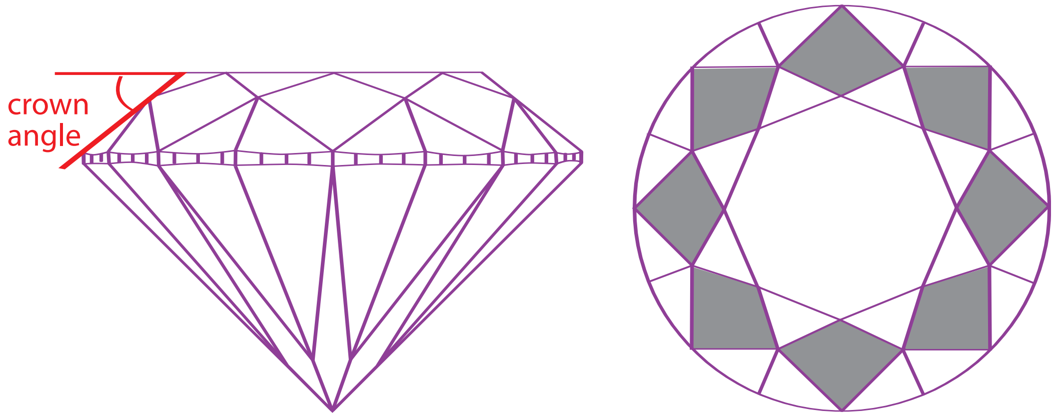

Figure 3. *Crown Angle Average is the average of all eight crown angles, listed to the nearest half of a degree (0.5%). A crown angle is the angle of the bezel facet plane relative to the table plane.*

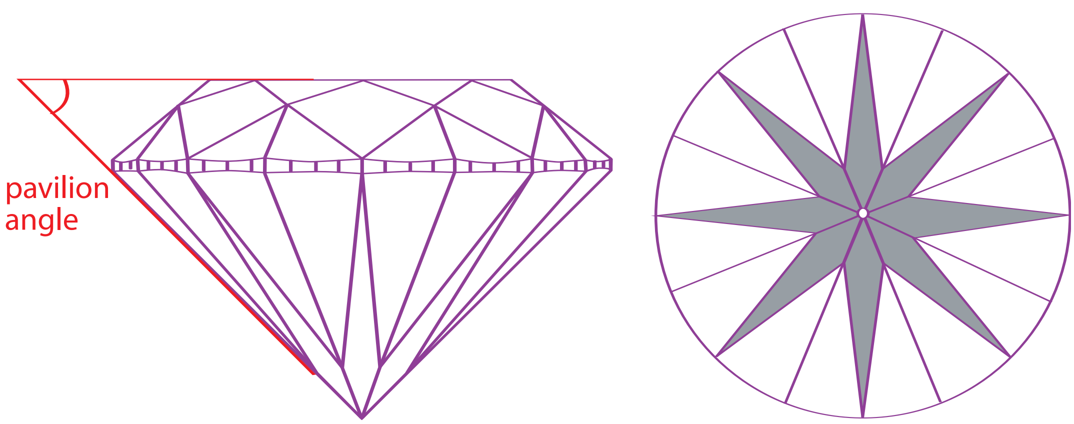

Figure 4. *Pavilion Angle Average is the average of all eight pavilion angles, listed to the nearest even tenth of a degree (e.g., 41.0°, 41.4°). A pavilion angle is the angle of the pavilion main facet plane relative to the table plane.*

For most proportions, the differences that yield changes in appearance are much larger than the measurement precision, and measuring diamonds more precisely than these visual-difference thresholds did not improve the prediction of their appearances.

By studying these three important factors, the GIA was able to arrive at a precision for each proportion in its system that is scientifically sound while also practical for the trade to use. Results for the GIA Diamond Cut Grading System have been calculated using the precision intervals listed in the table on page 34, each of which is discussed below in greater detail. The precision used in the cut-grading system is also the precision with which these proportions will be reported when the GIA introduces a cut grade on its GIA Diamond Grading Report and GIA Diamond Dossier®.

INDIVIDUAL PROPORTIONS

Table size precision results from both visual distinction and the ability to measure. Some NCMS report table size to 0.1 percent, but the actual reproducibility of this measurement can be several times larger; manual methods of measuring table size yield an uncertainty of about 1 percent. An experienced observer can estimate table size to 2 percent or less from the relative geometry of the facets. GIA researchers have found that table sizes with as much as a 3 percent difference

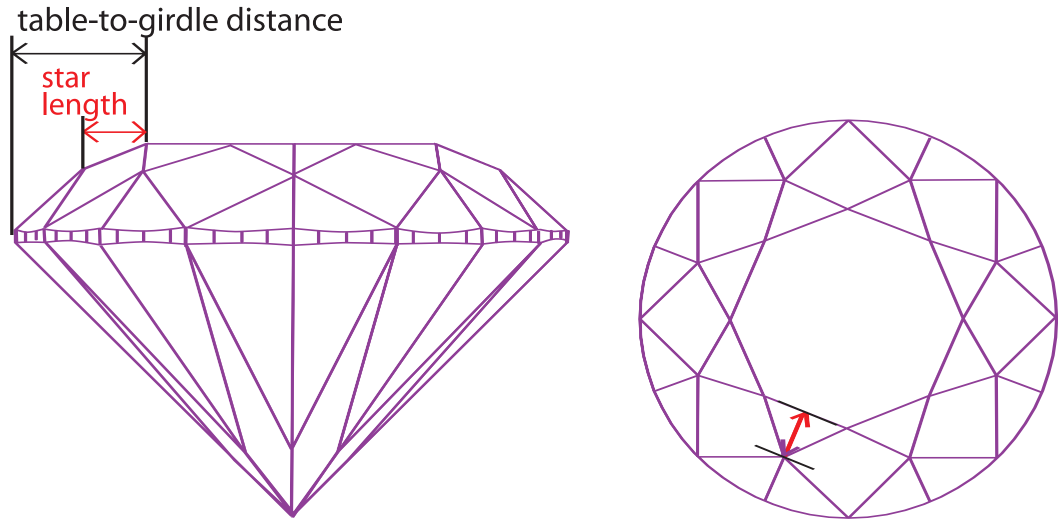

__Figure 5.__ Star Length Percent is the average star length relative to the distance between the table edge and girdle edge, listed to the nearest 5 percent (5%). Average star length is the projected distance, looking perpendicular to the table facet, from the star point to the edge of the table.

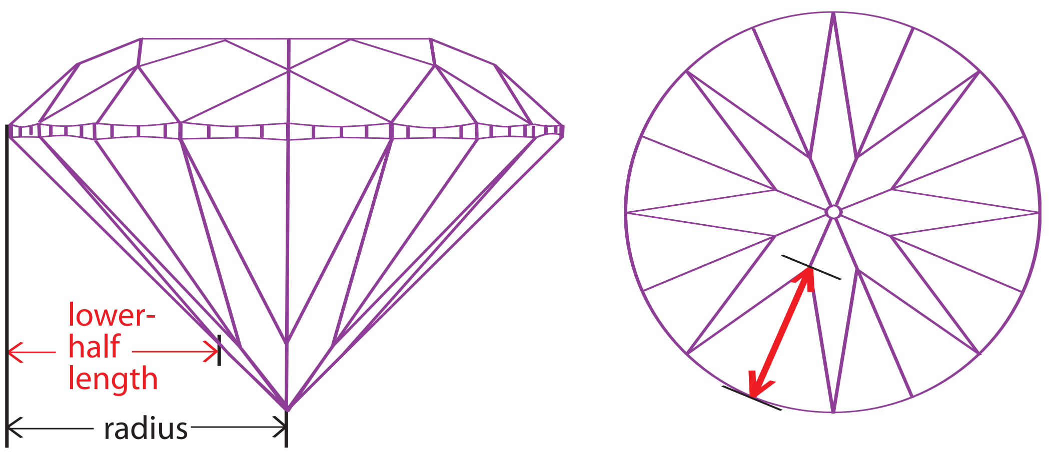

__Figure 6.__ Lower-Half Length Percent is the average lower-half length relative to the distance between the girdle edge and the center of the culet, listed to the nearest 5 percent (5%). Average lower-half length is the projected distance, looking perpendicular to the table facet, from the point where two pavilion mains meet to the closest edge of the girdle.

can produce very similar appearances. However, the GIA will continue to report table size to the nearest 1 percent for historical continuity and because it provides us good reproducibility for this measurement (see figure 2).

Crown angle can be tightly controlled during cutting and reproducibly measured to 0.5 degree, even by manual methods. The chosen precision of 0.5 degree was set by the smallest interval that consistently yielded distinct appearance differences (see figure 3).

Pavilion angle needs to be measured rather precisely, to 0.2 degree, to achieve visual consistency. This proportion strongly affects appearance. The GIA found reproducible visual distinctions at intervals only a little larger than the measurement precision, which is in turn close to the manufacturing precision for this proportion (see figure 4).

NCMS measure star and lower-half lengths to a precision of about 1 percent, but the best one can do with a reticle is about 2 percent. An experienced observer can estimate both of these proportions to the nearest 5 percent from the relative geometry of the facets; it takes about a 5 percent change to produce distinct changes in face-up cut appearance. Lower-half length is a difficult parameter for diamond cutters to control tightly, because a 1 percent change in length corresponds to a very small change in the angle

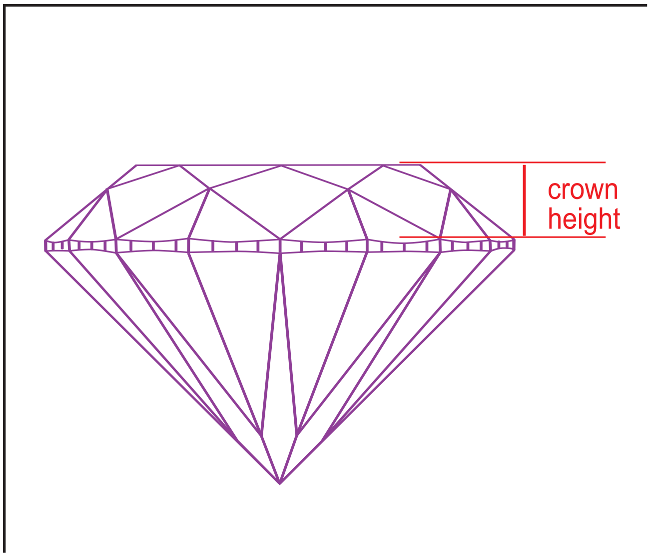

Figure 7. *Crown Height Percent is the average crown height relative to the average diameter, listed to the nearest half of a percentage (0.5%). Crown height is measured from the table plane to the intersection of the bezel facet with the girdle: (avg. crown height ÷ avg. diameter) x 100.*

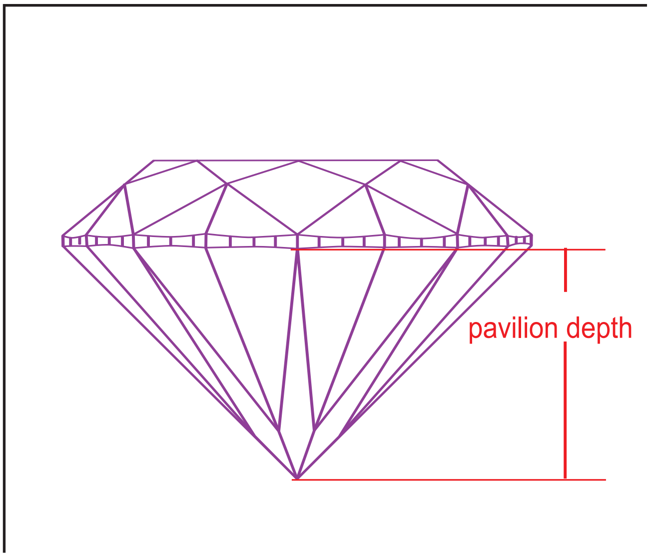

Figure 8. *Pavilion Depth Percent is the average pavilion depth relative to the average diameter, listed to the nearest half of a percentage (0.5%). Pavilion depth is measured from the intersection of the pavilion main facet with the girdle to the culet facet: (avg. pavilion depth ÷ avg. diameter) x 100.*

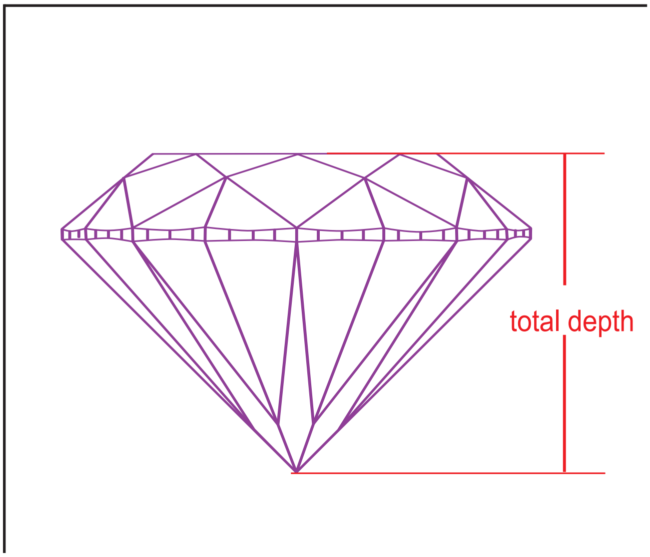

Figure 9. *Total Depth (mm) is the depth of the diamond measured from the table facet to the culet facet and listed to the nearest hundredth of a millimeter (0.01 mm). Total Depth Percent is the total depth relative to the average diameter, listed to the nearest tenth of a percentage (0.1%): (total depth ÷ avg. diameter) x 100.*

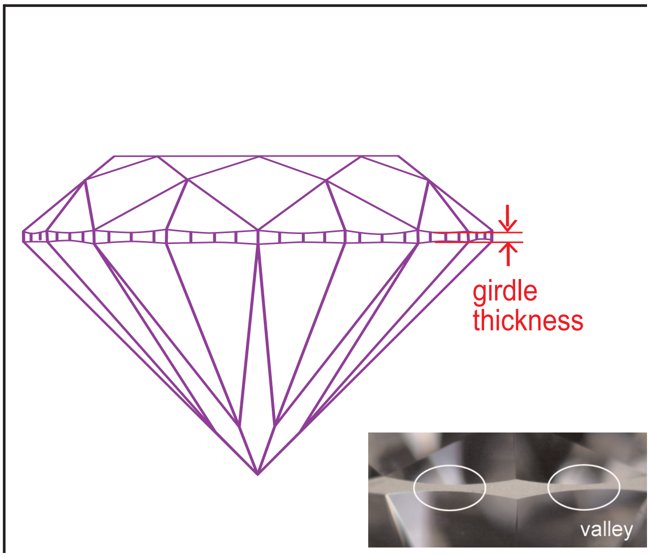

Figure 10. *Girdle Thickness (verbal description) is listed as a range from the thinnest to the thickest "valley" areas — i.e., "thin places" located between the bezel-main intersection and where the upper and lower halves meet. Descriptions include extremely thin, very thin, thin, medium, slightly thick, thick, very thick and extremely thick. Extremely thin appears as a knife-edge, an area where the crown meets the pavilion with no girdle in between.*

of these facets. For these reasons, a precision of 5 percent for star length (see figure 5) and lower-half length (see figure 6) was chosen.

The crown height and pavilion depth might be reported at a finer precision than 0.5 percent, since both are controlled during diamond cutting. However, in a symmetrical round brilliant diamond, the crown height percentage has a specific relationship to the average crown angle and table size; similarly, the pavilion depth percentage correlates with the pavilion angle and culet size. The GIA already specifies the two angle averages and the table size for the grading system and factors in culet size. Therefore, crown height percentage (see figure 7) and pavilion depth percentage (see figure 8) are only indirectly related to the cut grade. Increments of 0.5 percent were therefore chosen for these two proportions so that they would always be within tolerance of the values derived from other proportions.

Total depth is relevant to both the appearance and design components of the cut-grading system. The GIA will continue to report it to the nearest 0.1 percent, both for historical continuity, and as a convenient parameter for measuring the diamond (see figure 9).

Finally, visual evaluations of girdle thickness (see figure 10) and culet size (see figure 11) follow historical practice. Note that naturals, chips, abrasion and "painted facets" can interfere with NCMS measurements of culet and girdle sizes.

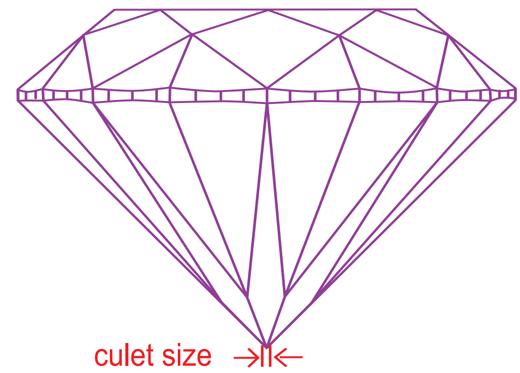

Figure 11. *Culet Size (verbal description) is the description of the average width of the culet relative to the average diameter. Descriptions include none, very small, small, medium, slightly large, large, very large and extremely large.*

CONCLUSION

In short, for a cut grading system to be practical, the measurements for various proportions need to be practical as well. There is little reason to measure or report values to a greater precision than is discernable in the face-up cut quality as seen by most observers. Providing a repeatable measurement standard to be used by cutters required careful examination of the tolerances of various measuring devices. The new GIA Diamond Cut Grading System incorporates all of these considerations, using measurement intervals that provide grades with noticeable visual differences in cut appearance, and yet are achievable by cutters and useful to those who use various measuring devices to predict cut grades. ✦

Obtaining Rounded Proportion Values From Measurements

Consider a round brilliant cut diamond with the following basic measurements:

Proportion	Measurements								Averages	% of Diameter	Final Rounded Values
Maximum diameter	5.61 mm								5.600 mm		
Minimum diameter	5.59 mm										
Total depth	3.41 mm									60.9%	60.9%
Table	3.08 mm	3.08 mm	3.07 mm	3.05 mm					3.07 mm	54.8%	55%
Crown angles	34.4°	35.1°	34.1°	35.2°	34.4°	34.6°	34.3°	34.6 °	34.58°		34.5°
Crown heights	0.88 mm	0.88 mm	0.85 mm	0.87 mm	0.86 mm	0.87 mm	0.86 mm	0.88 mm	0.87 mm	15.5%	15.5%
Pavilion angles	40.6°	40.7°	40.7°	40.8°	40.8°	40.8°	40.6°	40.7°	40.71°		40.8°
Pavilion depths	2.39 mm	2.40 mm	2.40 mm	2.40 mm	2.40 mm	2.40 mm	2.39 mm	2.39 mm	2.40 mm	42.8%	43.0%
Star lengths	48%	48%	48%	47%	49%	49%	46%	48%	47.9%		50%
Lower-half lengths	78%	77%	77%	76%	76%	77%	78%	76%	76.9%		75%

- Values are averaged by adding them together and dividing by the number of values. For example, the average star length is: (48 + 48 + 48 + 47 + 49 + 49 + 46 + 48) ÷ 8 = 47.9
- Calculate the average diameter to three decimal places. Note that if both diameters are even numbers (or both odd numbers) the third digit will be 0; if one is an odd number and the other is an even number, the third digit will be 5.
- Percentages (other than star length and lower-half length) are calculated by dividing by the average diameter. For example, the table percentage is: (3.07 ÷ 5.600) x 100% = 54.8
- Most noncontact measurement systems display the four table measurements as the percentage values to one decimal place and report their average. At this precision, either method of calculation yields the same final result.
- The averages and percentages are then rounded to the precision intervals given in Table 1, as shown. Please note that the GIA Gem Laboratory describes culet and girdle through visual assessment, and provides a verbal description for these proportions.