

# A place for CZ masters in diamond colour grading

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**Abstract:** Over the last 20 years and despite recommendations to the contrary, many gemmologists and appraisers have gravitated to the use of cubic zirconia (CZ) master stone sets to assist in the colour grading of diamonds. This investigation revisits with new insight, diamond grading technique and methodology. It addresses the judicious use of CZ master stone sets to augment diamond masters that are smaller in size and number. Study results support the use of accurately graded, carat-size CZs in reducing the subjectivity of colour grading when only incomplete (every other grade) diamond master sets of small (under 0.4ct ) sizes are available.

**Keywords:** colour grading, cubic zirconia, CZ, diamond



## Introduction

This investigation explores historical guidance in the use of diamond master stones, and offers a rationale for augmenting master stone sets of smaller and fewer diamonds with a full set of carat size CZ masters. The question addressed is: Can the acknowledged subjectivity of diamond colour grading be reduced by supplementing an incomplete set of smaller diamond master stones with a complete set of larger CZ masters? Along with two gemmologist-appraiser colleagues, the author also conducted and reports on a study of the accuracy of eight ten-stone sets of CZ master stones, four from each of two main manufacturers of these sets.

Findings are reported of studies in five areas related to diamond colour grading:

1. The historical development by the Gemological Institute of America (GIA) of a colour grading standard beginning with the GIA colour grading 'yardstick'.
2. Industry and GIA teaching of methods and recommendations for colour grading using GIA Diamond Masters, which reduce the subjectivity of colour grading.

3. The pros and cons in the use of CZ master stones in diamond colour grading.
4. A study of grading environments involving a multiplicity of lighting types resulting in additional recommendations for colour grading using CZ or diamond master stones.
5. An evaluation of CZ master stone sets from two main manufacturers.

## GIA's development of a colour grading system

Accurate colour grading of diamonds has been and remains one of the difficult challenges facing dealers, laboratories, gemmologists and appraisers. As diamond prices continue to rise, so does the necessity for accurate colour determination. Today, a single colour grade difference in, for example, a 2 ct, VS1, round brilliant can mean over a 20% change in its value. A mistake in grading can have this sort of large impact on appraised value. With amounts like this in the balance, it is incumbent upon the graders of diamond colour to be as accurate as possible despite the myriad of confounding factors that add an industry-

acknowledged degree of subjectivity to colour grading.

It is helpful to examine how the Gemological Institute of America (GIA) has addressed and answered the need for accurate and consistent colour grading. In 1941 the GIA introduced "a method of grading diamond colours against a standard in the form of a definitely set and constant scale, as incorporated in the new GIA Colorimeter. This is the first time a colour-grading 'yardstick' has been established." "Thus, the problem of the relative colour of the grades seems to have been largely solved for the jeweller who has a series of key stones (GIA Masters) graded on the 'yardstick'" (Shipley and Liddicoat, 1941). *Figure 1* is a representation of that numerical 'yardstick' and its relation to the GIA letter grades and to the master diamond grades. The letter grades, which correspond to the numerical grade ranges of the 'yardstick', were introduced by GIA in 1953. The D-Z letter grading system has become the 'lingua franca' of colour grading in the United States and largely worldwide, and GIA graded, master diamond sets have become the standard reference tool for

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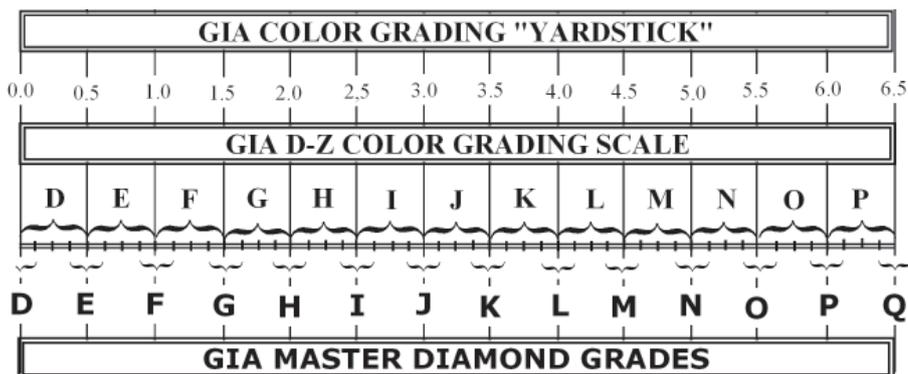


Figure 1: GIA 'yardstick', letter grades and GIA diamond master stone positions which define the letter grades.

diamond colour grading. The relationship between the letter grades, the numerical grades of the GIA 'yardstick', and the position and range of each master grade is shown in Figure 1. Notice the numerous brackets indicating the position and range of each grade relative to the GIA colour-grading 'yardstick'.

GIA master diamonds are graded with twice the accuracy of standard grading, so they in turn can be used for standard, whole-letter diamond grading. A master G, for example, is within a quarter grade range around the F/G border ( $1.5 \pm 0.125$ ), compared to the standard grade of G, which has a full grade range between the F/G border and the G/H border (1.5 to 1.999).

There is little to no argument with the view that a third carat or larger, complete set of GIA-graded master diamonds, like those shown in Figure 2, is the best tool for accurate colour grading. They are second-generation diamond master stones having been graded against the primary master stone set, which is often referred to as the 'master master' colour grading set at GIA (G. Roskin, pers. comm.)

In Figure 2 is a complete diamond master stone set of nine, heavy-third

carat, ideal cut, whole-grade master diamonds from E to L and N. Because of the expense of retaining diamonds of this size or larger for each colour grade, most small grading laboratories, gemmologist-appraisers and jewellers have purchased only a small number of quarter to third carat masters. Appraisers and laboratories certified by the American Gem Society (AGS) and the Accredited Gemmologist Association (AGA) are required to have at least five GIA-graded masters of a quarter carat or larger.

### Prescription for accurate colour grading

A review of the guidelines for the use of GIA-graded diamond masters is important. These instructions help reduce subjectivity caused by the many variables that can affect colour grading. These guidelines are from the organizations, literature and grading manuals of GIA and AGS and from the experience of professional diamond graders.

1. Grading should be done in a lighting environment of diffuse, daylight-equivalent illumination free of coloured reflections from adjacent

objects. This can be accomplished by using enclosures like those of the GIA DiamondLite and DiamondDock (Figure 3) or, as is often done, by using white-plastic diffusers over the light source and enclosing the diamond in a folded white card.

2. Clean the diamond to be graded and, if needed, also clean the master stones. Especially in the whiter colour grades, any dirt, particularly on the girdle, is liable to lower the apparent colour, possibly by as much as a grade or more.
3. To prevent distracting reflections and dispersion colours, use a dull, flat white background such as the several plastic trays from suppliers of gemmological equipment, the GIA DiamondLite or Diamond Dock trays or accordion folded white paper or cardboard. A non-fluorescing background is prescribed, but observation of industry practice and personal experience indicates that either non-fluorescent material or common white paper containing a blue fluorescent dye work equally well, as long as they are flat white with no bluish tint under the illumination used in grading.



Figure 3: GIA Diamond Dock, photograph by Jonathan Weingarten



Figure 2: Complete set of GIA-graded diamond master stones from E through L and N.

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Figure 4: Foreign buyers area, trading floor of the Israel Diamond Exchange, courtesy Israel Diamond Exchange

4. The GIA's prescription for the grading illumination is daylight equivalent light. In past years, GIA recommended and used in their grading the daylight fluorescent tubes of their DiamondLite. In addition to the DiamondLite, the GIA Diamond Course (GIA, 1994) stated: "Filtered, cool white, balanced fluorescent light is best." GIA laboratories and the American Gem Society Laboratory are now using the daylight illumination of the GIA DiamondDock. So the GIA is saying that the range of daylight colour temperatures best used in diamond colour grading is lighting from the 4200K of the cool white fluorescent to the 6500K of the standard daylight (D65) fluorescent tubes. Many gemmologists employ the small daylight fluorescent with white plastic diffuser attached to their GIA microscopes. Also in wide use by the trade is the eighteen-inch, daylight, 15-watt fluorescent tubes in a standard desk lamp. An example of their use can be seen in *Figure 4* which shows dealers on the trading floor of the Israel diamond exchange.

Notice that in spite of the available daylight from the large area of North

facing windows, and ceiling mounted fluorescents, those examining diamonds are employing the lighting from standard desk lamps.

True daylight varies widely, but the 4200K of a cool-white fluorescent to the 5500K colour temperature of noon daylight, and up to the 6500K of blue skylight are prescribed for diamond grading. Of this range of daylight colour temperatures, the 6500K daylight fluorescent tube is a little too bluish-white for some, the author included, who find better colour discrimination under noon-daylight from a fluorescent tube in the 5000K to 5500K range.

Examples are the 'full spectrum', tubes such as the Ott Light. Excellent colour discrimination can also be made in the 4200K colour temperature of a cool white fluorescent. The principle is that the illumination, like a diamond's immediate surroundings, should be flat white without a blue or yellow tint. Additionally, all these fluorescent tubes and the ones in the GIA DiamondLite and DiamondDock emit a component of UV, which needs to be considered when grading diamonds that fluoresce from UV excitation, but that is a subject for another article.

5. Place the master stones table down with increasing colour left to right, as in *Figure 5*, in order to look into their pavilions in directions perpendicular to the pavilion facets or parallel to the girdle.

On the basis of the tone/saturation of its colour, place the diamond being graded between the master stones closest to it. If it fits just above a G master stone, for example, (which the GIA graded to be within a quarter grade of the F/G boundary), the colour grade is F. If it fits just below the G master, the colour grade is G. This procedure assumes a master stone for every grade. Many sets are incomplete, and where there are missing colour masters, visual interpolation of the grade between the surrounding master diamonds is necessary, or the more difficult extrapolation of the grade is necessary if the diamond is outside the colour range of the masters.

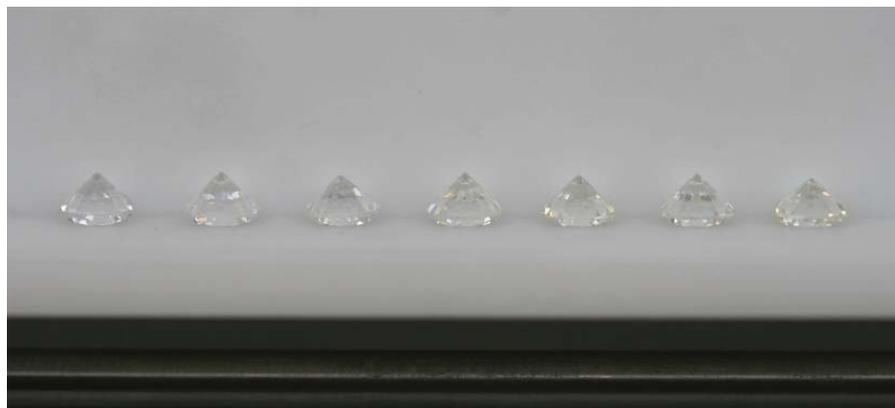


Figure 5: Six CZ masters and one diamond (colours E-K) in the tray of the Diamond Dock, photograph by Jonathan Weingarten.

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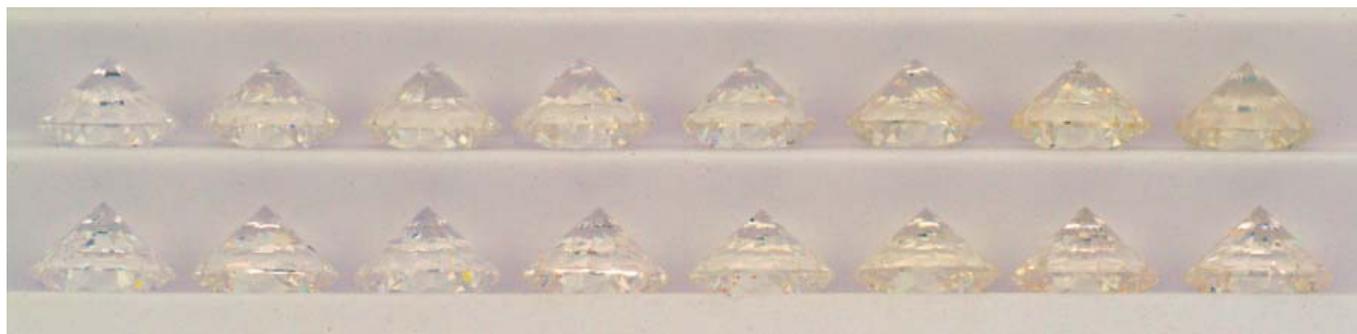


Figure 6: CZ master sets, colours E-L from manufacturer B (top row) and manufacturer A (bottom row).

6. To minimize confusion when comparing the unknown diamond's colour to the masters, these reference diamonds should be of similar well-made cut and proportions. They should be of Cape series, yellow hue, with no distracting inclusions, no more than faint fluorescence, and be similar in size with a minimum 0.25 ct weight. Master stones should not have thick and/or unpolished girdles, as these features can cause confusion. Unpolished girdles trap dirt and metal particles with handling, which can lower their perceived colour a grade or more.

This is the prescription for accurate colour grading using diamond masters. Attention to these instructions aids in reducing the subjectivity in diamond colour grading.

### For and against CZ master stones for colour grading

With all the vigilance needed in the use of diamond colour master stones, what are the pros and cons in the use of CZs as masters?

A sidebar from GIA's Diamond Grading Course (GIA, 1994), titled "No CZ for D-Z" makes it clear that GIA writers and educators have advised against the use of CZs as master stones for colour grading. The reasons given are the different yellow hue, confusing reflections from CZ's greater dispersion, the difference in lustre, and the concern over CZ's colour stability. Any case made for the use of CZ masters has to address these concerns.

Large laboratories such as those of the GIA and the AGS have multiple sets of GIA-graded diamond master stones

for colour grading. Small laboratories, such as the author's AGA Certified Gem Laboratory, and gemmologist-appraisers, who have obtained AGS's Independent Certified Gemmologist Appraiser (ICGA) designation, are required to grade with at least a five-diamond master set. However, many gemmologist-appraisers, the author included, feel it is necessary to use a complete set comprising each of the most important whole letter grades from E to L or lower.

A sample of 38 gemmologist-appraisers listing their colour grading equipment on the Internet revealed that 16 listed a combination of diamond and CZ master stones, seven listed only CZ, and 15 listed only diamond.

This small sample indicates that many gemmologist-appraisers have found a place for CZ in master stone sets. Many jewellers and others in the industry have employed CZ masters since they became available over 23 years ago. The appeal of CZ Masters is an economic one. Because of the poor economy of tying up large amounts of money in larger diamonds, most master stone sets consist of quarter to third carat sizes of four or more diamonds. Without a master diamond for each grade, visual interpolation or extrapolation is required, which increases the subjectivity of colour grading. In addition, disparity in size makes precise comparison of colour more difficult, and comparing the colour of a small quarter or third carat diamond master to a carat or greater size diamond requires considerable skill only obtained through practice and experience.

Both James Naughter GG FGA of A&A Gemological Laboratory (pers. comm.)

and Howard Rubin GG of Gem Dialogue Systems (pers. comm.) relate that they can much more effectively arrive at a colour grade of a carat or greater size diamond using carat size CZ masters than by using the smaller and fewer stones of their diamond master sets. They and others find that a more accurate grade can be obtained with a 10 stone master set of carat size CZs than can be obtained with a small, incomplete set of diamond masters.

Al Gilbertson (pers. comm.), one of the two original AGS, ICGA appraisers with over thirty years experience, states that when on appraisal assignment outside the laboratory, he would take on the road with him a set of CZs that he had checked periodically for accuracy against his diamond master stone set. His diamond masters remained in his laboratory, while he risked only the loss of the relatively inexpensive CZ masters. He would compare his CZ masters once or twice a week against diamonds graded by GIA to develop familiarity and skill in their use. Gilbertson's point was not to shun the use of CZs, but to be practised in their use when the need arose. Periodic practice and checking of CZs raises proficiency in their use and would reveal any possible colour change.

The laboratory of David Atlas GG, President of D. Atlas & Co. Inc. (pers. comm.), employed several sets of CZ master stones in their colour grading and GIA-graded diamond master stones were used to check frequently for any colour change in the CZs.

Several diamond wholesale dealers known to the author use CZ master sets in their buying. The often-narrow margins in their wholesale transactions mean that

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a one-grade mistake in colour grading can make the difference between profit and loss. Their success in the practical use of CZs in diamond buying and colour grading is testimony to the accuracy, and usefulness of their CZ masters.

For many, CZs have become a recognized and accepted tool in diamond colour grading. All these examples support the usefulness of CZ masters in the colour grading of diamonds.

### Considerations specific to the use of CZ in colour grading

For those who currently use or who are contemplating using CZs for colour grading diamonds, there are a few factors to consider in addition to the guidelines listed for GIA diamond master stones.

Of foremost importance is having a CZ master stone set that is accurately graded against a full, reference GIA diamond master set. The CZs should correspond in tone and saturation and be close in hue to their diamond master set equivalents. The biggest problem is the accuracy and evenness of colour spacing of these master sets. After all, the GIA master diamonds are a 'second generation' having been graded against the 'master master primary set'. The CZ master sets are third generation stones incorporating possible accumulated (or cancelled) errors of two graders.

A revealing test of initial accuracy and evenness of spacing of a ten stone master set of either diamond or CZ is to mix them up, and by eye try to put them back in order of increasing colour. Assuming normal colour vision, if your placing results in the set being out of order, it is the set that is the problem.

In considering the hue differences between CZs used as masters and the yellow tints in type 1a, Cape series diamonds, these are small and not nearly as difficult as comparing the tone/saturation of a pale grey or pale brown diamond with the pale yellow, Cape series, master diamonds. The author and those interviewed for this article found little difficulty comparing the colour of

yellow cape series diamonds to the yellow hue of CZ masters.

Addressing the concern for the colour stability of CZ, the experience of the author and of other owners and CZ-master manufacturers is that the type of CZ material used by the two main suppliers, one for over 22 years, has proved to be largely stable under normal care and use.

The differing absorption spectra of diamonds and CZ raises concern for possible colour shifts (called metameric failure) in different illumination environments. A way to avoid this possibility is by grading (and periodic checking and recalibrating against diamond masters) under lighting similar to illumination the manufacturer of the CZ set recommends and uses in his initial grading. Experiments by this investigator, grading in five different lighting environments, yielded the same colour grading determinations. This finding reduces the concern for possible colour shifts, as there was no apparent metameric failure. Relative to the diamond masters, no colour shifts of the CZs were observed.

### Evaluation of CZ master stone sets

To provide a preliminary assessment of currently available CZ master stone sets, a number were obtained from several different vendors of gemmological equipment. All these suppliers carry CZ sets from either or both of two sources, designated A and B in this study. Purchased were eight, 10 stone sets, four from each manufacturer. The purpose was to evaluate the accuracy of the sets.

This investigator graded each set against a background of accordion folded flat white paper with his complete diamond master set. To check for any possible colour shift in different lighting due to CZ's different absorption spectrum and varying small amounts of yellow fluorescence, the grading was done for each stone in five different lighting environments. These were a daylight fluorescent, a daylight fluorescent through a lexan plastic filter to remove UV, a cool white fluorescent, a 'full spectrum' fluorescent, and a white LED lamp.

Using all five lighting environments, the author found the same colour determination in each of these illuminations. This established that CZ's different absorption spectrum and varying amounts of fluorescence did not result in colour changes (metameric failure) large enough to cause additional error in colour grading.

Experimenting with these five different lighting environments resulted in the surprising finding that colour differences were more apparent and colour comparisons were more easily made in cool white and 'full spectrum' fluorescent lighting (colour temperatures from 4200K to 5500K). Colour differences of a grade or less were more difficult to see and evaluate in the slightly bluish-white daylight fluorescent and the LED lighting (colour temperatures 6500K and above). This finding is interesting, because, on one hand, it is at odds with the widespread prescription for north daylight equivalent (6500K) lighting (Bruton, 1978), while on the other hand, it supports GIA's Diamond Course (GIA, 1994) statement: "Filtered, cool white, balanced fluorescent light is best." The author suggests trying both to find a personal preference.

The B master sets contained the master stones D through L and N, while the A sets contained the stones E through N. The sets were evaluated as a 10 stone whole, and then re-scored for the more important eight grades E through L, shown in *Figure 6*, which both sets have in common.

The author graded all eight sets, and David Atlas and James Naughter graded four sets apiece, two from each manufacturer, and the results are given in *Table 1*. It is important to acknowledge that the errors measured are a combination of errors in the manufacturers' gradings, differences between our three master stone sets, and any errors in grading by the three of us. The author had the advantage of a full set of diamond master colour grades, while James Naughter used a GIA and AGS graded five diamond master set, and David Atlas used a full set of CZs graded against diamond masters and including

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Table I: Results of grading by D. Atlas (DA), M. Cowing (MC) and J. Naughter (JN) of four A (A1-4) and four B (B1, 3, 5, 7) CZ master stone sets.

Set	Grader	D	E	F	G	H	I	J	K	L	M	N
A1	MC	-	Hi E	E/F	E	F/G	Hi I	Hi J	H/I	I(<J)	K	N
	DA	-	D	E	F	G	H	I	J	K	M	O/P
A2	MC	-	Hi D	D	E	F/G	F	H/I	Hi K	K	L	L/M
	JN	-	Hi D	D	Hi H	I	Hi J	K	Hi L	L	Lo L	M
A3	MC	-	D	Hi D	E	Hi F	Hi G	Hi I	K	Lo K	K	O
	DA	-	E	E	F	G	H/I	J	L/M	M	N	O/P
A4	MC	-	Hi D	Hi D	Hi F	Hi G	Hi G	K	K	Lo K	M	L/M
	JN	-	Hi D	Lo D	Lo E	Lo G	Hi H	J	K	Hi L	M	N/O
B1	MC	D	E	Hi F	G	Hi H	Hi I	Hi J	K	Hi L	-	N
	DA	D	E	F	F/G	H	I	J	K	L/M	-	O
B3	MC	D	E	E	F/G	G/H	H/I	Hi J	Hi K	Hi L	-	N
	DA	D	E	E	G	H	I	J	K	L/M	-	N/O
B5	MC	D	E	Hi F	Hi G	H	Hi I	Hi J	Hi K	K	-	M
	JN	Hi D	Hi E	Hi F	Hi G	Hi H	Hi I	Hi J	Hi K	Hi M	-	N
B7	MC	D	E	E/F	F/G	Hi H	Hi I	I	K	L	-	O
	JN	Hi D	Hi E	Lo E	F/G	Hi H	Hi I	Lo I	Lo K	M	-	N

a GIA H master diamond. On any given stone, our errors may increase or decrease the true manufacturer error adding uncertainty to this measure. However, the results, including the total average error in comparing the group of four sets from each manufacturer, do indicate a sufficiently accurate evaluation that shows the relative accuracy and consistency of the sets from each.

Two measures of error were used to

evaluate the eight CZ master sets, the second being twice as demanding as the first. The first measure is normal colour grading, meaning the determination whether each CZ is within or at the top of its grade. This measure scores each CZ as either zero error if a stone is within or at the top of its stated grade or, if outside the grade, the number of grades it is off.

This first error measure, which determines how close the CZs were to

their labelled grades, finds that the A sets have an average per stone error, over the most important eight grades, of 1.36 grades (scoring of author, MC) and 0.88 grades (scoring of David Atlas, DA and James Naughter, JN). In comparison, the B sets have an average per stone error of 0.09 grades (MC) and 0.13 grades (DA and JN).

The second and more critical error measure, which determines how close the CZs were to the diamond master stones they represent, finds that the A sets have an average per stone error over the most important 8 grades of 1.16 grades (MC) and 0.80 grades (DA and JN). In comparison, the B sets have an average per stone error of 0.19 grades (MC) and 0.38 grades (DA and JN).

On the basis of this survey therefore, the B sets are the more accurate. In addition to having higher accuracy, the B sets also have the more even spacing between the grades. Due to this even spacing, no two grades were too close and it was possible to scramble the B sets and, by eye, put them back in correct order.

Having said this, it is important to state that this survey was carried out on only a small sample of sets purchased in 2008, whose dates of assembly are not known. It may be, for example, that the A and B

Table II: Closeness of CZs to their labelled grades; errors measured in units and decimal points of one grade.

Set A					
Set	Grader	10 error ave.	Worst error in 10	8 error ave.	Worst error in 8
A1	MC	1.25	2.5	1.31	2.5
	DA	0.95	1.5	1	1
A2	MC	1.45	3	1.5	3
	JN	1	1	1	1
A3	MC	1.5	3	1.5	3
	DA	0.85	2	0.75	2
A4	MC	1.05	2	1.13	2
	JN	0.8	1.5	0.75	1.5
A#	MC	1.31	3	1.36	3
	DA & JN	0.9	2	0.88	2

Set B					
Set	Grader	10 error average	Worst error in 10	8 error average	Worst error in 8
B1	MC	0	0	0	0
	DA	0.1	1	0	0
B3	MC	0.1	1	0.13	1
	DA	0.1	1	0.13	1
B5	MC	0.2	1	0.13	1
	JN	0.1	1	0.13	1
B7	MC	0.2	1	0.13	1
	JN	0.2	1.	0.25	1
B#	MC	0.13	1	0.09	1
	DA & JN	0.13	1	0.13	1

N.B.: A# = average for all stones, or worst in all stones

B# = average for all stones, or worst in all stones.

DA denotes D. Atlas, MC denotes M. Cowing and JN denotes J. Naughter

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Table III: Closeness of CZs to their equivalent diamond master stones; errors measured in units and decimal points of one grade.

A					
Set	Grader	10 error ave.	Worst error in 10	8 error ave.	Worst error in 8
A1	MC	1	2.5	1	2.5
	DA	0.65	2	0.5	0.5
A2	MC	1.05	2.5	1.13	2.5
	JN	1.2	1.5	1.25	1.5
A3	MC	1.28	2	1.23	2
	DA	0.95	2	0.75	2
A4	MC	1.18	2	1.29	2
	JN	0.71	1.5	0.7	1.2
A#	MC	1.13	2.5	1.16	2.5
	DA & JN	0.88	2	0.8	2

B					
Set	Grader	10 error average	Worst error in 10	8 error average	Worst error in 8
B1	MC	0.25	0.5	0.19	0.5
	DA	0.6	1.5	0.5	1
B3	MC	0.2	0.5	0.13	0.5
	DA	0.6	1	0.56	0.5
B5	MC	0.25	0.5	0.19	0.5
	JN	0.1	1	0.13	1
B7	MC	0.4	1.5	0.25	0.5
	JN	0.32	1.5	0.34	1.5
B#	MC	0.28	1.5	0.19	0.5
	DA & JN	0.41	1.5	0.38	1.5

N.B': Symbols as in Table II.

sets were assembled at different times. The implications of this survey for sets in the future are not quantifiable by the author.

## Conclusions

The main benefits of this study are in showing the practical use of accurately graded CZ master stone sets, and the factors and methodology in their proper use, and demonstrating the importance of verifying the initial accuracy of the set, as well as making periodic checks against full, diamond master colour grading sets to insure retention of that accuracy.

Interested gemmologist-appraisers are encouraged to explore for themselves why CZ masters have found a place in the colour grading of diamonds. This investigation finds that CZ masters have a contribution to make in reducing the subjectivity of diamond colour grading when, as is frequently the case, the available diamond masters are relatively

small in number and/or size. The study findings and results also support the argument that an accurate and complete set of CZ masters can, by themselves, be effectively employed in diamond colour grading, if periodically checked for retention of that accuracy.

## Acknowledgements

Thanks to the following individuals for their contributions, discussions, and suggestions: David Atlas, Al Gilbertson, Raymond Mason, James Naughter, Howard Rubin and Peter Yantzer, and special thanks to Richard Cartier for suggestions and assistance with organization and editing.

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