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# The Di Marzio-Davis Equations for Stereo Base

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**Mike Davis' enhancement of the Di Marzio Equation allows use of Depth of Field scales calculated with Circles of Confusion *other than* those equal to Camera FL / 2000 (a limitation of the Di Marzio Equation) and user-specification of the % MAOFD desired (instead of forcing On-Film Deviation to equal 100% of MAOFD).**

Note that the **Di Marzio-Davis Equations** still embody the ingenuity of Frank Di Marzio's original equation, cleverly exploiting the fact that our Depth of Field scales communicate the intrinsic depth of a scene, and thus, can be used to calculate Stereo Base. For additional information regarding the need to enhance Frank's equation, please see the tab captioned "The Di Marzio Equation" in the spreadsheet at this link: http://home.globalcrossing.net/~zilch0/tools/3dSep9.xls

## For Free Viewing:

(and for Infinity-focused stereo viewers with lenses matching focal length of the camera lenses)

**Base = M * Fc^2 / N / 6000 / Ca**

Where **M** is the % of MAOFD desired, **Fc** is the camera focal length, **N** is the f/number indicated on your Depth of Field scale or table, and Ca is the permissible Circle of Confusion diameter that was used to calculate Depth of Field.

## For Use With Stereo Viewers:

**Base = M * Fc * Di * Fv / (6000 * Ca * N * (Fv + Di))**

Where **M** is the % of MAOFD desired, **Fc** is the camera focal length, **Di** is the virtual image distance at which the viewer is focused (not the physical lens-to-film distance), **Fv** is the viewer focal length, **N** is the f/number indicated on your Depth of Field scale or table, and **Ca** is the permissible Circle of Confusion diameter that was used to calculate DoF.

(For a viewer focused at Infinity, specify a value of 1,000,000 mm for **Di**. When focused at 10-inches, specify 254 mm.)

Here is Frank's **Di Marzio Equation** for stereo base:

**Base = ( 100 * Fc ) / ( 3 * N )**

Where **Fc** is the camera focal length, **N** is "the smallest f/number (largest aperture) capable of providing a depth of field ranging from the near point Dn up to the far point Df."

**And therein lies the problem. What maximum permissible Circle of Confusion should be used to calculate this value N?**

**Frank wrote that we should use these CoC values:**

**For free viewing:**

**C = Fc / 2000**

Where **Fc** is the camera focal length.

**When using a stereo viewer:**

**C = Di * Fv / (2000 * (Fv + Di))**

Where **Fv** is the viewer focal length and **Di** is the "distance of the final image behind the stereo viewer lenses". (Di is the virtual image distance, not the physical lens-to-film distance. Di is Infinity for a viewer focused at Infinity.)

**Frank's uncorrected equation for stereo base only works when the CoC used to calculate N equals Fc / 2000 (for free viewing) or Di * Fv / (2000 * (Fv + Di)) (when using a stereo viewer).**

If you really want to use the DoF scales on your lens barrel, as Frank suggested, the equation **must be corrected** to compensate any difference between the CoC the Di Marzio Equation assumes and the CoC that was used to create the DoF scale on your lens. Frank hinted at this in two places within his technical paper.

Frank provided the means to reverse engineer the CoC that was used by the manufacturer to produce the DoF scale or tables for each of your lenses, but in my opinion, he did not sufficiently hearken the need to apply it (perhaps because doing so would spoil the apparent simplicity of his equation.) Unfortunately, in its published form, the very simple and elegant Di Marzio Equation only works when the CoC used to calculate N equals the camera focal length divided by 2000 (a rarity), **but we can enhance the equation and still make use of Frank's ingenious contribution.**

**We can find the following equation on page 7 of his technical paper:**

**Dh = Fc^2 / C * N**

Where **Dh** is the hyperfocal distance indicated on the lens barrel's DoF **scale, Fc** is the camera focal length, **C** is the actual Circle of Confusion diameter used to generate the DoF scale, and **N** is the f/number currently opposing the near and far point distances on the DoF scale.

http://nzphoto.tripod.com/stereo/3dtake/Di_Marzio_Equation_Technical_Web.pdf

**On page 5 of his technical paper, we see this example of how to read the hyperfocal distance for a given f/number:**

The following example illustrates how to find the hyperfocal distance for f/8. This depth of field scale is from an old Minolta lens.


With f/8 set to infinity, the nearest distance in good focus is 5m. Consequently since 5m corresponds to half the hyperfocal distance, then at f/8 the hyperfocal distance is 10m.

**On page 10, Frank gives us this application of the equation, from page 7 ( Dh = Fc^2 / C * N ) :**

In the earlier example of the Minolta lens depth of field scale, the hyperfocal distance at f/8 was 10m. Therefore the diameter of the circle of confusion C is

$$10000 = \frac{50 \times 50}{C} \quad \text{and so} \quad C = 0.03\text{mm}$$

$$10000 = \frac{50 \times 50}{C \times 8} \quad \text{and so} \quad C = 0.03\text{mm}$$

Since C = 0.03mm and $F_C$ = 50mm, then the general stereo base equation can be written as

$$B = \frac{50 \times 50}{60 \times 0.03 \times N} = \frac{1389}{N}$$

This simple equation will work for that Minolta lens and can be used to draw a graph of B versus N for that camera.

So, the Circle of Confusion used to produce the DoF scale of this 50mm Minolta lens does not fit the ratio Fc / 2000.
Fc / 2000 would be 0.025mm, but this DoF scale was calculated with a CoC of 0.03mm. Therefore, Frank points out that **B = 1389 / N** for this lens, instead of **B = 1667 / N (had when C = FL / 2000)**. **That's a significant difference in base!**

**Here is Frank's equation from page 7, rearranged to solve for Ca, the actual Circle of Confusion used to calculate DoF.**

**Ca = Fc^2 / Dh / N**

Where **Dh** is the hyperfocal distance indicated on the lens barrel's DoF scale, spinning disk DoF calculator, DoF tables, or any other type of DoF calculator; **Fc** is the camera focal length, **Ca** is the **actual** Circle of Confusion diameter used to generate the DoF scale, and **N** is the f/number currently opposing the near and far point distances on the DoF scale.

This equation allows you to determine what CoC value was used by the manufacturer to produce the DoF scale on your lens.
Revisit the example photo of the Minolta lens barrel, above, to see where the values come from.
In that example, Fc = 50mm, Dh = 10000mm, and N = 8mm, for a resulting Ca of 0.03mm.

It doesn't matter which f/number you select to perform this calculation as long as you make sure that a hyperfocal distance can be

read easily from the distance scale when the chosen f/number is opposite the Infinity symbol.

Equipped with the actual CoC value used to generate the DoF scale on your lens barrel, DoF tables, spinning disk calculator, etc…

**Here are the corrected Di Marzio Equations for Stereo Base, expressed with Frank's equation standing apart from the factors I've added to correct for his equation's assumption that C = FL/2000:**

**For Free Viewing:**

**Base = ( 100 * Fc / 3 N ) * ( ( Fc / 2000 ) / Ca )**

Where **Fc** is the camera focal length, **N** is the smallest f/number (largest aperture) capable of providing a depth of field ranging from the near point up to the far point, and **Ca** is the *actual* CoC used to calculate DoF.

**For Stereo Viewers:**

**Base = ( 100 * Fc / 3 N ) * ( ( Di * Fv / ( 2000 * ( Fv + Di ) ) ) / Ca )**

Where **Fc** is the camera focal length, **N** is the smallest f/number (largest aperture) capable of providing a depth of field ranging from the near point up to the far point, **Ca** is the *actual* CoC used to calculate DoF, **Fv** is the viewer focal length, and **Di** is the viewer Image Distance. (Di would be 1,000,000 for a viewer focused at Infinity, 254 mm for 10-inches, etc.)

Simplifying the equations and replacing the constant that forces OFD to 100% of MAOFD with a variable for the % MAOFD desired:

**Here are the Di Marzio-Davis Equations for Stereo Base** (Reduced from the equations above, but including a variable for specification of % of MAOFD desired.)

**For Free Viewing:**

**Base = M * Fc^2 / N / 6000 / Ca**

Where **M** is the % of MAOFD desired, **Fc** is the camera focal length, **N** is the smallest f/number (largest aperture) capable of providing a depth of field ranging from the near point up to the far point, and **Ca** is the *actual* Circle

of Confusion used to calculate DoF.

**For Stereo Viewers:**

**Base = M * Ca * Fc * Di * Fv / ( 6000 * N * ( Fv + Di ) )**

Where **M** is the % of MAOFD desired, **Fc** is the camera focal length, **N** is the smallest f/number (largest aperture) capable of providing a depth of field ranging from the near point up to the far point, **Ca** is the *actual* Circle of Confusion used to calculate DoF, **Fv** is the viewer focal length, and **Di** is the viewer Image Distance. (Di would be 1,000,000 for a viewer focused at Infinity, 254 mm for 10-inches, etc.)

**Note:** The **Di Marzio-Davis Equations** require that **Ca** (the CoC used to calculate DoF) **= Fc^2 / Dh / N.**

Where **Dh** is the hyperfocal distance indicated on the lens barrel's DoF scale, spinning disk DoF calculator, DoF tables, or any other type of DoF calculator.

The Di Marzio Equation assumes that **C** (the CoC used to calculate DoF) **= Fc / 2000**.

**For any Depth of Field scale, table, spreadsheet, or calculator for which Ca is known, the Di Marzio-Davis Equations will give results *identical* to the Bercovitz equation, when the stereo viewer is focused at Infinity and Viewer FL equals Camera FL (assumptions of the Bercovitz equation).**

These equations may not look as friendly, but just as with the Di Marzio Equation, the Di Marzio-Davis Equations only have to be used once for each lens - to produce the simple, two-column table of f/number vs. stereo base values appropriate for each combination of focal length and Circle of Confusion.

**The latest version of this spreadsheet can be found at this link:**

http://home.globalcrossing.net/~zilch0/tools/DiMarzio-Davis.xls