Scan Resolution and Sharpening

Kodak Photo CD images provide an interesting way to test the role of scan resolution in image quality. Because each Photo CD file contains the same image at five different resolutions, it is easy to compare the exact same image at a variety of resolutions. Study the two sets of images on the following pages for quality differences, and then read the description below.

Photo CD resolution	Amount of data (lines by pixels)	File size	Resolution at an enlargement of 7.68 by 5.12 inches[1]	Scanning ratio (Resolution divided by screen ruling[2])
16 Base	2,048 by 3,072	18 MB	400 pixels per inch	2.67:1
4 Base	1,024 by 1,536	4.5 MB	200 pixels per inch	1.33:1
Base	512 by 768	1.13 MB	100 pixels per inch	0.67:1
Base/4	256 by 384	288 KB	50 pixels per inch	0.33:1
Base/16	128 by 192	72 KB	25 pixels per inch	0.17:1

[1] The resolution can be calculated in two ways: either by dividing the number of pixels by the width of the enlargement (i.e., 3072/7.68 = 400), or by dividing the number of lines by the length of the enlargement (i.e., 2048/5.12 = 400).
[2] The screen ruling used in these examples is 150 lines per inch.

Photo CD resolution

You cannot determine the effective spatial resolution of a Photo CD image in terms of “pixels per inch” until a size is assigned to it. Each of the examples on the following pages were enlarged to 7.68 by 5.12 inches (and later cropped to fit the space allowed). The chart above shows how the Photo CD file resolution can be described in a variety of ways.

16 Base has the highest resolution of a conventional Photo CD image.[3] The 4 Base, Base, Base/4, and Base/16 images have correspondingly less data. It will become clear in examining the images that pixelization becomes more visible as resolution decreases. On the higher resolution images it will help to examine sharp edge areas like the wings, as well as detailed areas like the lettering on the tail and fuselage.

[3] Please note that both Pro Photo CD and Print Photo CD allow higher resolution than Photo CD

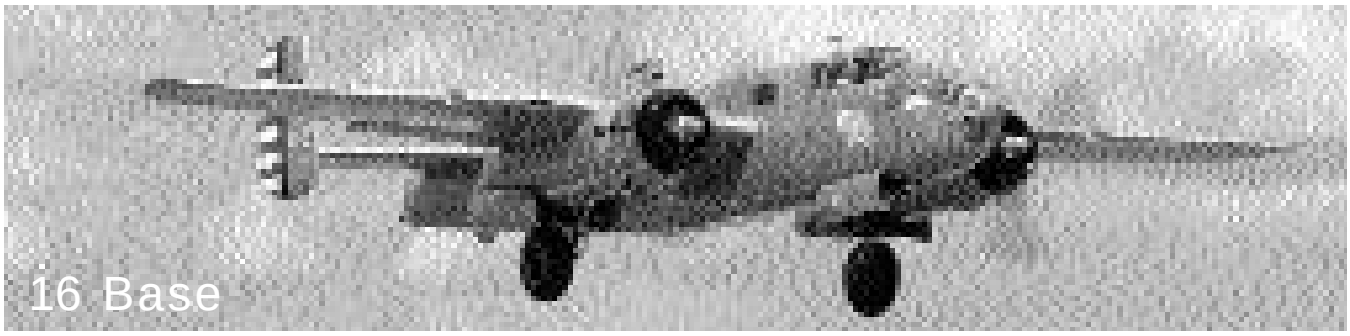
Scanning ratio

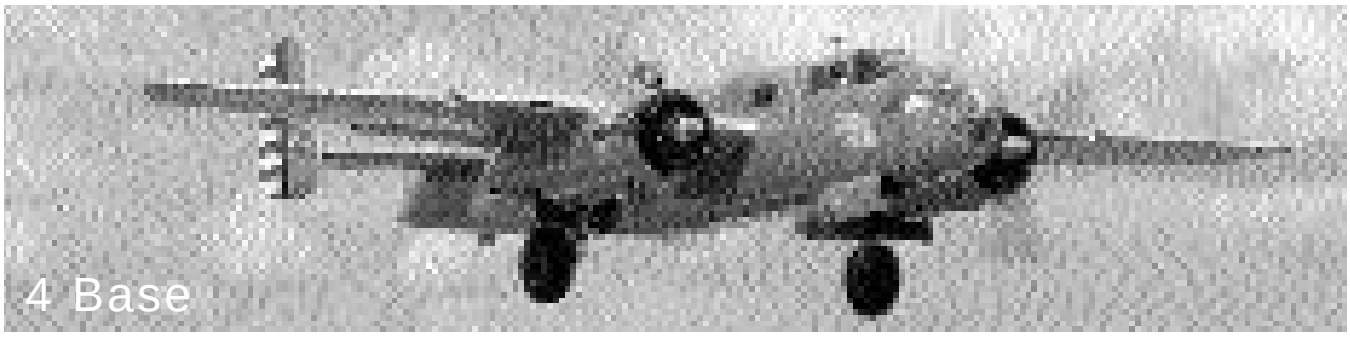
The scanning ratios (see chart) can be helpful in comparing the results of this test to future work that you might do. Generally, a scanning ratio of 1:1 is considered the absolute minimum required for reproducing an image. Therefore for an image that will be reproduced at a 150 line per inch screen ruling, the effective spatial resolution of the scan should be no less than 150 pixels per inch. It is also generally agreed that a scanning ratio of greater than 2:1 does not provide any added benefits.

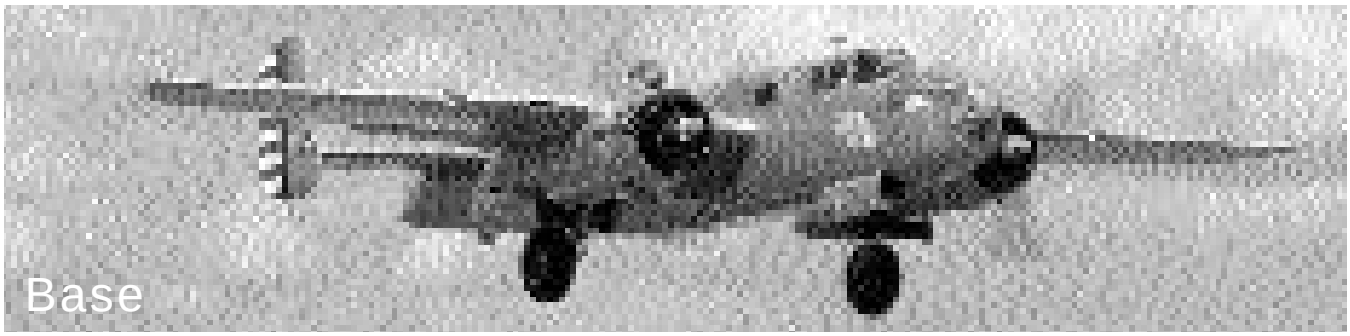
Scanning ratios as well as the related Nyquist theorem are discussed in greater detail in the following documents from the Linotype-Hell Technical Information series:

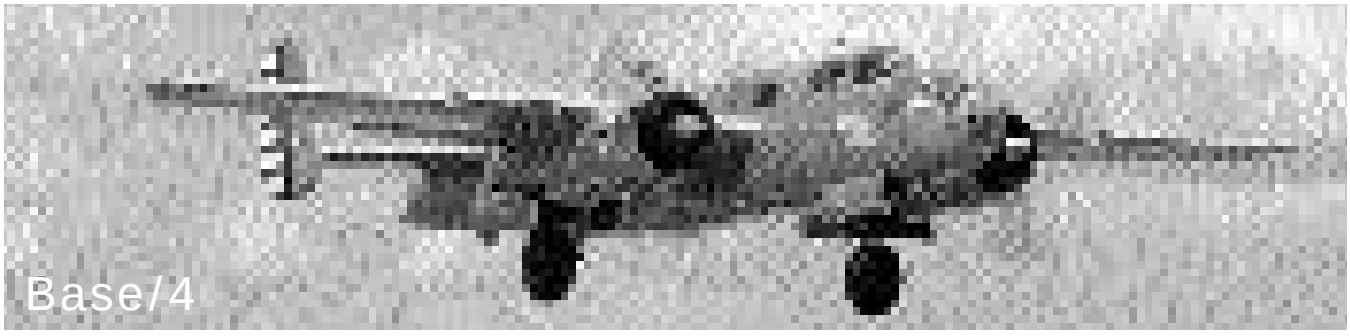
- *Scanned File Size* (this article appears in the 1992 notebook)
- *Line Art* (this article appears in the 1992 notebook)
- *Nyquist and Scanning* (this article appears in the 1994 notebook)

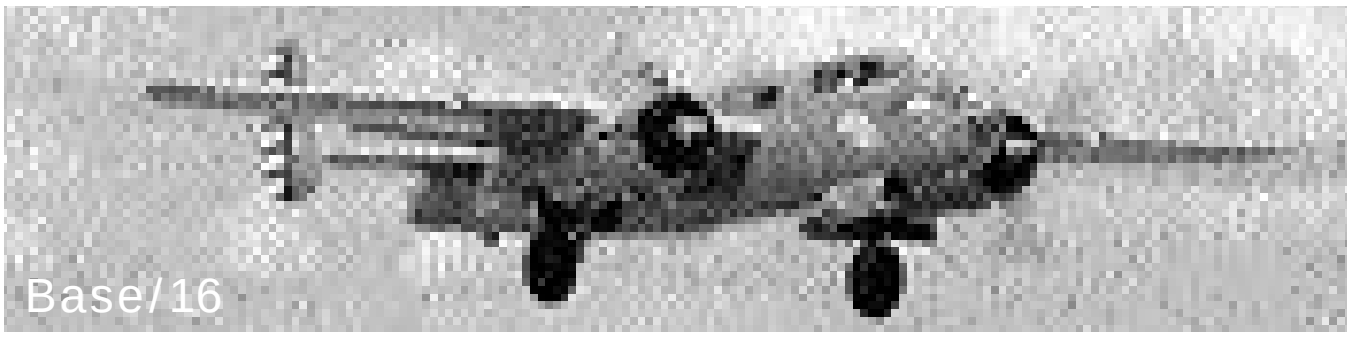
No Sharpening Filter Applied



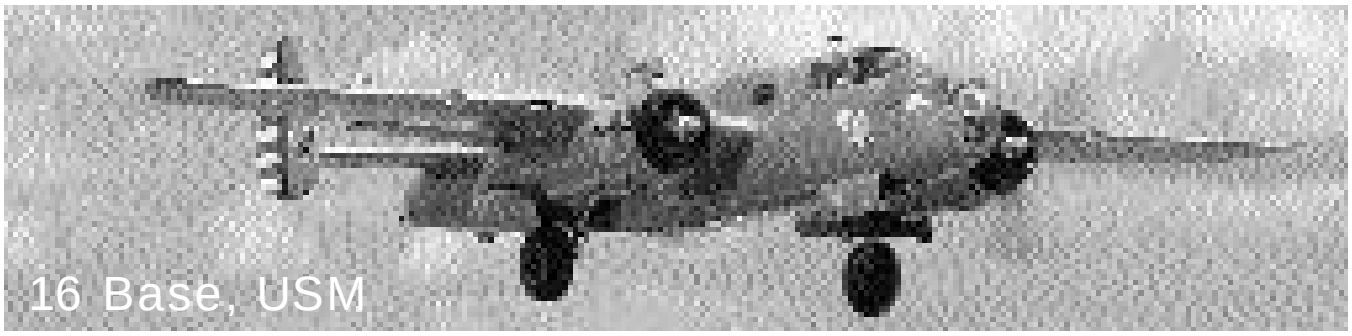


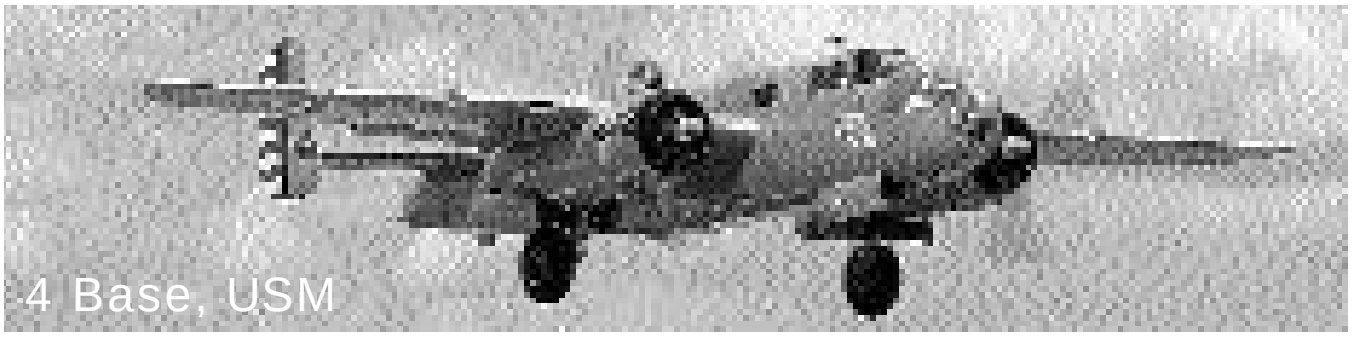


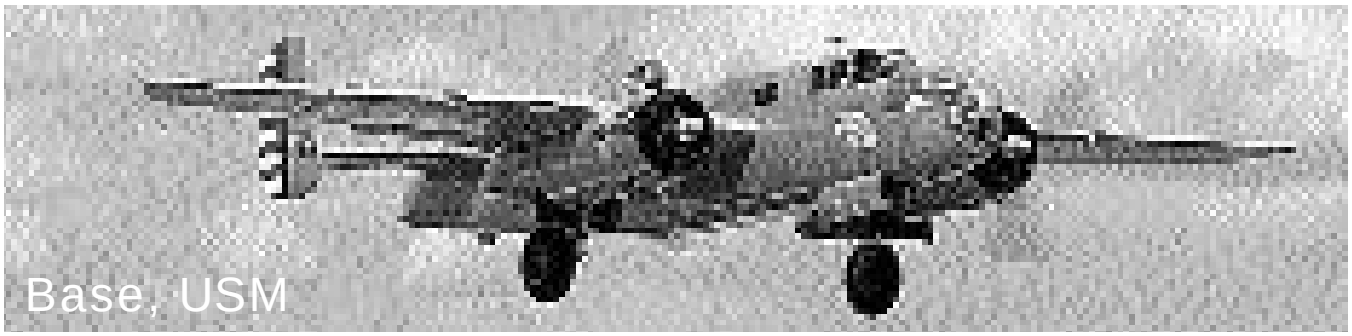


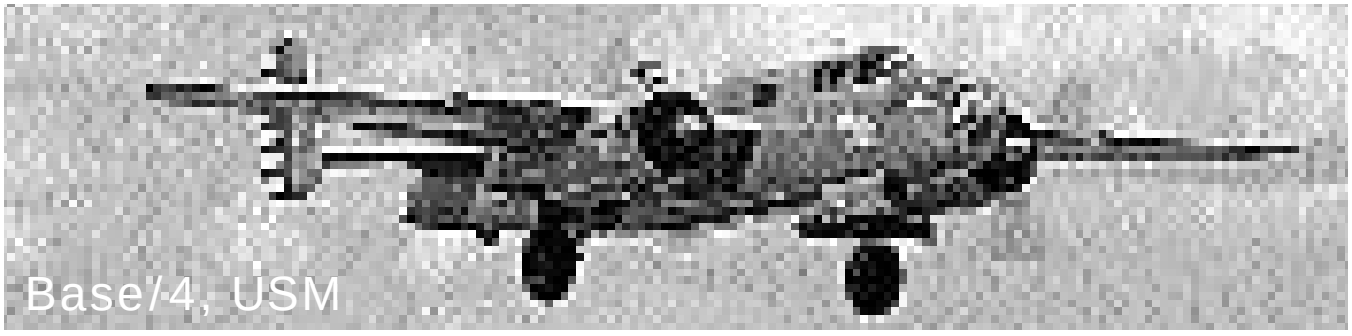


Sharpening Filter Applied









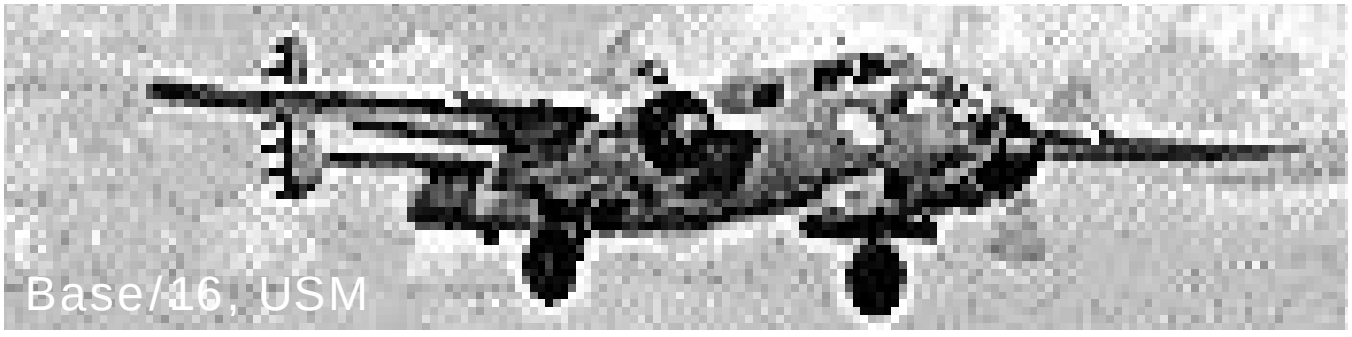


Image sharpening

Because image sharpening plays such an important role in image quality, this test shows the images both sharpened and unsharpened. The sharpened images are labeled 'USM'. USM stands for unsharp masking which is a term that is commonly used to describe sharpening filters.

Page 44 shows images with no sharpening filter applied. Page 45 shows the same images with sharpening filters applied. As before, look to edge and detailed areas for differences between the images.

Production notes

The Photo CD image on pages 44-45 comes from a Corel Professional Photos CD-ROM called *World War II Planes.* The 16 Base, 4 Base, Base, Base/4, and Base/16 images were brought into LinoColor™ 3.2 and resized to 7.68 by 5.12 inches. ColorAssistant was applied to each image to improve the color quality. The shadow detail value was increased by 2 units. The same default sharpening settings were used for all of the images on page 45. The files were then converted to TIFF CMYK. The separated TIFF CMYK files were placed in a QuarkXPress® 3.3 page and output on a RIP 60 and Linotronic® 630 using I.S. Technology™ at a screen ruling of 150 lines per inch. The imagesetter addressability setting was 2438 dots per inch.

Conclusion

A test of this type shows only a small number of the possible outcomes. By changing any single factor, the outcome could be very different. You may wish to conduct a similar test and change one or more of these factors:

- *Use a different image* – The image content, particularly the level of detail, can play an important role. Examine the proposed image for fine detail, edges between dark and light areas, and subtle gradations.
- *Change the screen ruling* – There is some reason to believe that the scanning ratio does not need to be as high for higher screen rulings. At some point, the human eye will not be able to resolve any more detail.
- *Try a different halftoning method* – There is some evidence that a frequency modulated screening method like Diamond Screening may not require as high a scanning ratio as an amplitude modulated (or conventional) halftone screening method.
- *Adjust the amount of sharpening* – The amount of sharpening applied to the image plays an important role in the level of detail that is visible. In addition, the same level of sharpening may not have the same effect on images if the scan resolution is significantly different. This is because sharpening filters search for and sharpen edges based on a matrix of a set pixel size, often three, five, or seven pixels. A low resolution scan has many fewer pixels than a high resolution scan, and as a result the sharpening filter matrix may see those edges differently.
- *Consider paper and press issues* – Paper type, dot gain, and ink density play a large role in image quality. Detail that is visible on the film may be lost by the time the image is printed.

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Please direct any questions or comments to: Jim Hamilton, Marketing Department, Linotype-Hell Company, 425 Oser Avenue, Hauppauge, NY 11788
(For subscription information on the Linotype-Hell technical information series, please call 1-800-842-9721.)

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