

# Proposed Annex A of Draft ISO TS 10128

## Tone value

### A.1 General

Tone value, better known to some as apparent dot area, is a tool invented by the graphic arts community to monitor the relative changes in tone reproduction of an image as it moved through the various stages of film reproduction (positive and negative), to a printing plate, and eventually to the printed image. It was initially tied to halftone images that used centre weighted dot patterns. It is an estimate of the fractional area coverage that will have the same light absorption as the sample being measured. For reference, absorption is equal to 1 minus the reflectance. In computing the apparent fractional area coverage the sample is assumed to be composed of areas that have either the absorption of the substrate (clear film or bare paper) or that of uniform areas of a fixed absorption level equivalent to the maximum exposed density of the film or the solid area of the ink. This is an important assumption because halftone images on either film or paper are not uniform and in addition images on paper include an effect called optical gain. Optical gain is associated with the scattering of light within the paper substrate and results in more absorption of light than is accounted for by the actual area covered by ink.

Integrated reflectance measurements of course only see the combined result of optical gain, non-uniformities in the "solid" areas, and variations in absorption at the edges of dots etc. In addition this is further complicated by the fact that the absorption (reflectance) of paper, film, ink, etc varies as a function of the wavelength of the light being measured.

Traditionally, status density was the common tool available to measure both film and paper and this is what is often used to provide the estimates of tone value. From an ideal point of view, measurements over a very narrow wavelength band at the point of maximum absorption of the ink or dye is probably the most accurate measure to use to estimate tone value. Where colorimetric data is available it also can be used to estimate tone value. Any measure of light that is directly related to the absorption of light by the marking (light absorption) media being used is a valid candidate. In general, the closer the spectral band pass of the measurement system matches the wavelengths of maximum absorption of the marking medium, the more consistent the estimate of tone value will be.

### A.2 Computation of tone value

Because density is defined as the negative  $\log_{10}$  of the reciprocal of reflectance the equations for computing tone value from density appear to be different from those that compute directly from reflectance data. However, they are not.

The basic equation is:

$$\text{ApparentToneValue} = 100 \times \frac{(A_t - A_p)}{(A_s - A_p)} = 100 \times \frac{(R_p - R_t)}{(R_p - R_s)}$$

where  $A_t$  = absorption of the halftone tint area

$A_p$  = absorption of the paper

$A_s$  = absorption of the area of solid ink or dye coverage

and  $R$  = the reflectance of the comparable areas of the image.

In each case the absorption or reflectance is spectrally weighted by the appropriate densitometric, narrow band, or colorimetric function.

For density data the equation appears as follows:

$$ApparentTonevalue = 100 \times \left( \frac{1 - 10^{-(D_t - D_p)}}{1 - 10^{-(D_s - D_p)}} \right)$$

where D is the density of the comparable areas of the image.

Table A.1 shows the weighting functions typically used for printing inks for the three methods of computing tone value discussed.

**Table A.1 — Tone value computation weighting functions**

	Density <sup>a</sup>	Colorimetry	Narrow Band
Cyan	Red	X	640 nm
Magenta	Green	Y	530 nm
Yellow	Blue	Z	420 nm
Black	Visual	Y	460 nm

<sup>a</sup> Typically Status T density is used in some parts of the world and Status E with polarization in others.

### A.3 Matching between methods

One very critical issue is that the reference characterization data being matched and the measurements of the printing sample both need to be based on the same measurement parameter (density, colorimetry, narrow band). Where this is not practical it becomes important to provide correlation between the various measures of tone value.

A common situation that is encountered is reference characterization available as colorimetric data and printing process control based on densitometric data. For black ink, the apparent tone values are usually within a few tenths of a tone value unit of each other regardless of the parameter used (e.g., +/- 0,2 or 0,3 in tone value). For magenta and yellow the tolerance is typically up to +/- 1 tone value unit between any two of the methods described.

For cyan, the difference is larger, particularly between the values based on colorimetric data and either narrow band or densitometric data. One simple correction, that reduces this uncertainty to approximately the same magnitude as is found with the other two chromatic ink colours, is to substitute  $X - (0,55 \times Z)$  in place of the X value in the computation of cyan tone value.

NOTE Looking at the spectral shape of the X tristimulus function, one sees that in the region above 575 nm the absorption of the ink is determining the response. However below this value the response is primarily due to the paper. This correction equation is based on the assumption that the value of the Z tristimulus response for the same patch is a measure of the unwanted spectral response of the X tristimulus function when measuring a cyan ink. The value 0,55 is based on the average value for a sampling of printing inks.

More elaborate corrections between densitometric and colorimetric computations of tone value are possible but these usually require correlation of densitometric and colorimetric data measured from the specific ink and paper being used.