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CONTRAST FORMULAE FOR USE WITH CONTRAST MEASURING DEVICES

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Discussion

There are a number of formulae that may be used for calculating the contrast of two items or areas. Which formula is used depends on the 'norm' for the particular application in question. The choice is often subject as much to existing practice as to recognized standards.

The Contrast Measuring Systems manufactured by Spectrum Technologies PLC, namely CMS1 and CMS2, as well as systems manufactured by other manufacturers use the equation in formula 1 to calculate the contrast:

$$C= [(L_b – L_m)/L_b]x\ 100\% \quad ^{(1,2,3,4)} \qquad \textit{Formula 1}$$

Where C = Contrast
L_b = Luminance of Background
L_m= Luminance of Mark
and $L_b > L_m$

C can take any value between 0 and 100%

The formula is valid for white and coloured backgrounds and for white and coloured marks. However, the luminance of the background must be higher than the luminance of the mark for the contrast result to fall in the 0-100% range.

The validity of this formula has been questioned by some in relation to aerospace wire marking for marks on dark or coloured wires. Nevertheless, the contrast formula quoted above is both correct and accepted within scientific circles for mainstream contrast measurement. However, the visibility of the mark, which is a different matter, may be impaired in such instances; this remains a valid but separate issue. Mark contrast is certainly a key issue that controls visibility and therefore legibility. However, to be clear, a high contrast does not necessarily mean a high visibility nor a high legibility – the words and meanings are not strictly interchangeable. This paper does not attempt to address this issue. What is correct is that a low contrast certainly does mean reduced legibility.

Contrast levels have previously been quoted, as opposed to visibility or legibility scales, since this is a relatively easy quantity to measure. There are no devices to measure visibility reliably [(5)], and we have not come across any legibility measuring devices, either.

Since Spectrum's CMS1 and 2 systems are contrast measuring devices, it is proposed that the key output result will remain the contrast as determined by formula 1. However, other results could be quoted. For example, the CMS2 software could be modified to display the results of other formulae, including these listed below, which have been found in the literature. For information, a collection of referenced formulae follows;

$$K = (L_b - L_m)/(L_b + L_m) \quad ^{(6,7)} \qquad \textit{Formula 2}$$

This formula is used where there is not background as such, for example spatially periodic patterns, e.g. sine patterns.

$$K = L_b / L_m \quad ^{(8)} \quad \text{where } L_b > L_m \qquad \textit{Formula 3}$$

This formula is used for contrast of characters on active displays, e.g. VDUs.

$$MRD = R_s - R_b \quad ^{(9)} \qquad \textit{Formula 4}$$

where R_s = Bar code spare reflectance
R_b = Bar Cod bar reflectance
MRD = Minimum reflectance difference

This formula is not equivalent to the others in that it doesn't actually return a contrast figure but a result that is applicable to a bar code reading device rather than a human eye.

Clearly none of the above are more applicable to contrast measurement in the context of a human reading printed information than Formula 1.

Conclusions

From the literature, it is clear that contrast, visibility and legibility are intimately linked. However, visibility and legibility are relatively less quantifiable. As contrast is accepted as a quantifiable key determinant of visibility and legibility, it is proposed that this be the main measure used for this purpose and that formula 1 continues to be used to generate the contrast for markings on wires. This proposal additionally supports compatibility with past results generated for the Aerospace Wire Industry and compatibility with at least three Contrast Measuring Systems.

References

1	CIE 95	"Contrast and Visibility"	CIE
2	JS11013	"Legibility of characters in cable marking"	BAe Sowerby Research Centre
3	prEN3838	6.6.4 Requirements and tests on user-applied markings on aircraft electrical cables.	European Standard
4	Companion Guide to Specifications (Bar Codes) (Where PCS = Contrast)		AIM Europe
5	CIE 95	"Contrast and Visibility"	CIE
6	CIE 95	"Contrast and Visibility"	CIE
7	Hecht	"Optics"	Addison
8	CIE 95	"Contrast and Visibility"	CIE
9	USS39	"Code 39"	AIM

Note: CIE is an abbreviation for Commission Internationale de L'Eclairage or International Commission on Illumination. It is an international organisation devoted to international co-operation and exchange of information among is its member countries on all matters relating to the art and science of lighting. Its membership consists of the National Committees in 37 countries and one geographical area and of 15 individual embers. The CIE is recognised as the authority on all aspects of light and lighting.