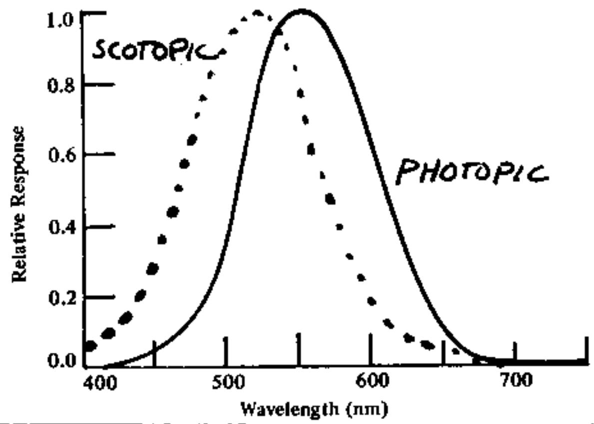
# OPTICAL ENGINEERING NOTE #65
## READING SPECTRAL CURVES

Generally the numbers 400 to 700 nanometers appear under the abscissa* of a spectral curve, while the ordinate** quantifies the degree of reflectivity, transmissivity, sensitivity, emissivity, etc. Often the shorter and longer wavelengths of ultraviolet and infrared spectra are included.

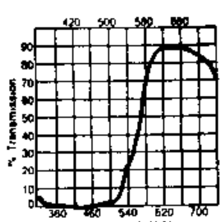
The most important spectral curve is that of the typical human eye, showing the relative response of the rods and cones to the visible spectrum, to the right. Note that our eyes do not see all colors equally well; photopic, or cone vision (which lets us see color), is most sensitive to the 550 nm green; the scotopic, or rod-dominated vision (lower light level but color-deficient) peaks at a slightly shorter wavelength.



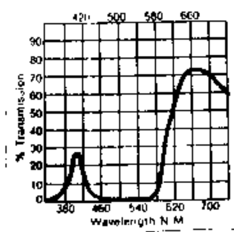

Notice that there is a small region at the border between violet and ultraviolet that the rods can pick up but the cones cannot. Since our color vision cannot assign a hue to this input, although we can sense it, it appears neutral. This is the origin of the term, black light.

Why an object appears a certain hue is due to its spectral reflectivity or transmissivity. Below are some curves showing the spectral distribution of colored filters, of various hues and saturations.

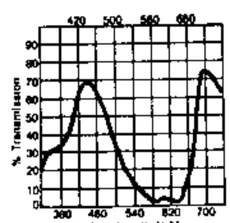
**#21** Golden Amber



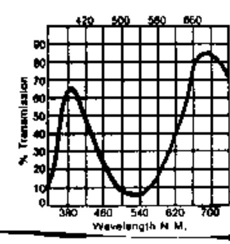
**#42** Deep Salmon



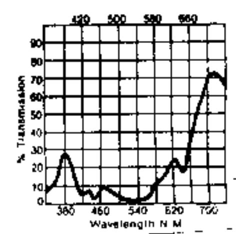
**#68** Sky Blue



**#48** Rose Purple

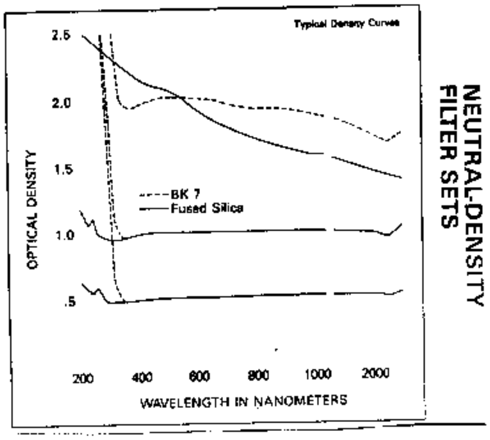


**#50A** Mauve



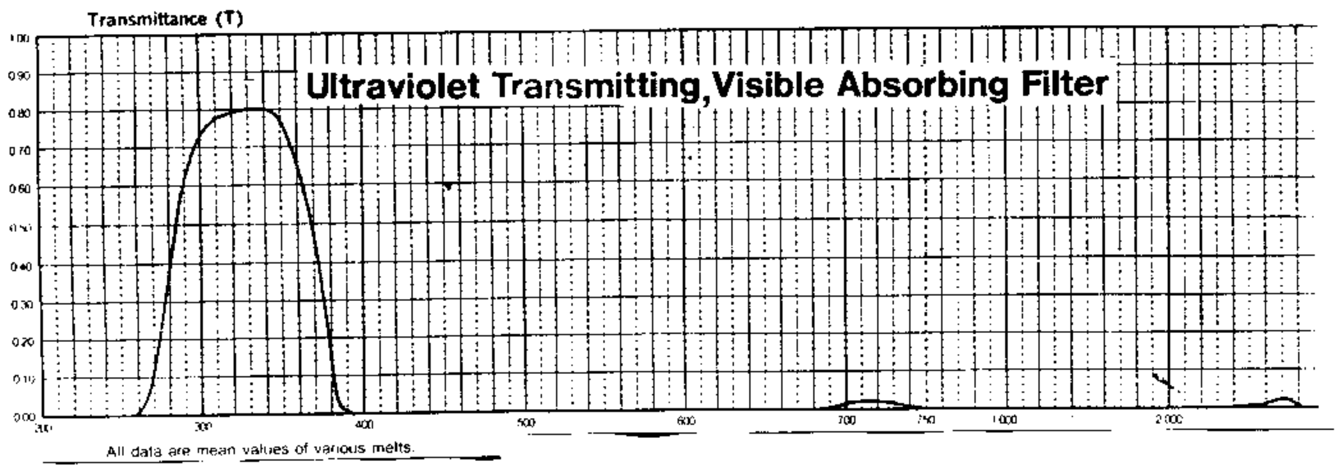
*The horizontal, or x-axis. How about this one for a crossword puzzle word!

**Matching word to the above footnote, meaning the vertical or y-axis.

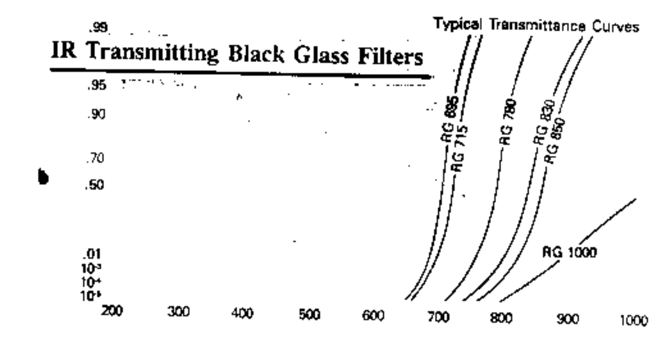


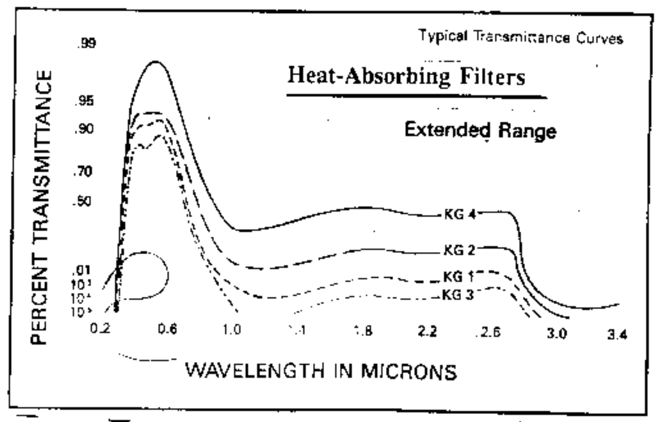

The graph of a filter of no hue, a <u>neutral</u>, is a horizontal line, as shown in the graph to the left. **BK-7 and fused silica** are the substrates **that** the filter material is **deposited** on, and they influence the density outside the visible. (Don't forget that a **Neutral Density** of 1.0 means 1/10 of the light is transmitted, 2.0 **means** 1/100 transmission, 3.0 1/1000, etc.

**The filter below appears black to the eye, notice how its transmissivity drops to 0 from 400 to 700 nm, but is 80% transmissive to the UV.**

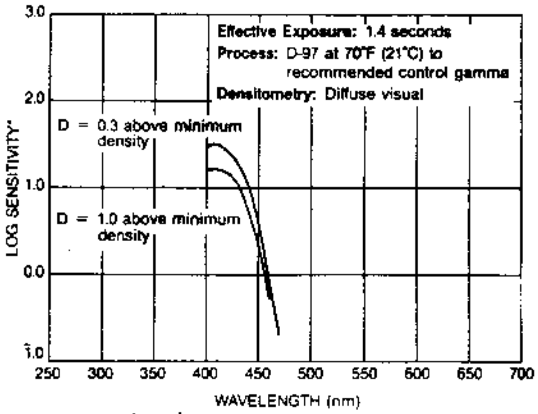



**The RG family** of glass filters on the left below also appear black, but they pass the wavelengths longer than the visible, and are useful for hiding sources for infrared surveillance. But the **Heat-Absorbing Filters** transmit the visible and try to block out the longer wavelengths.

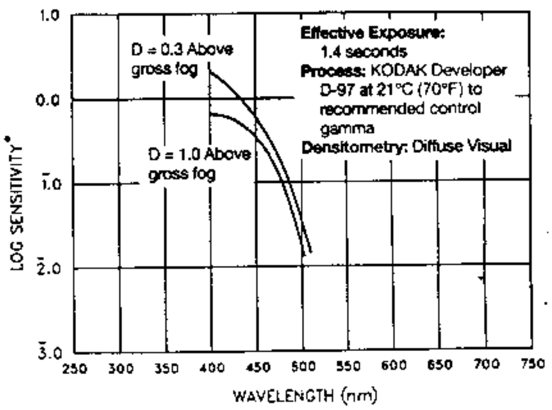


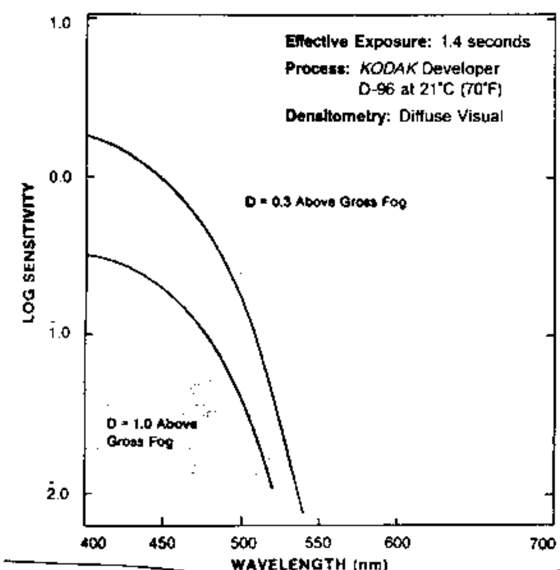
At the beginning of photography, the light-sensitive materials were primarily ultraviolet and blue sensitive. They were blind to green and red, and that is why trees and red lipstick lips would photograph black. The introduction of dyes into the emulsions extended the sensitivity range through the green, orthochromatic*, and finally all the way to the end of the visible, panchromatic**. Later infrared-sensitive emulsions appeared.

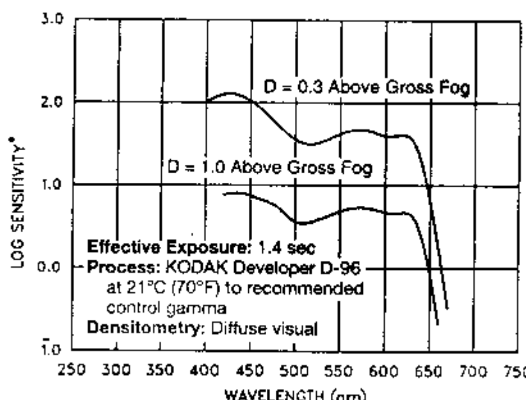


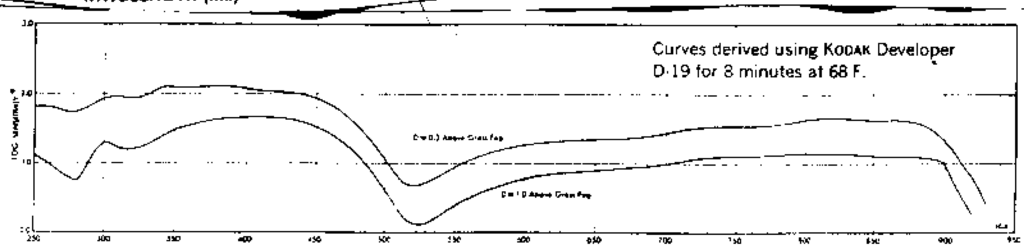

53/7362 HIGH CONTRAST POSITIVE




5302/7302 FINE GRAIN POSITIVE



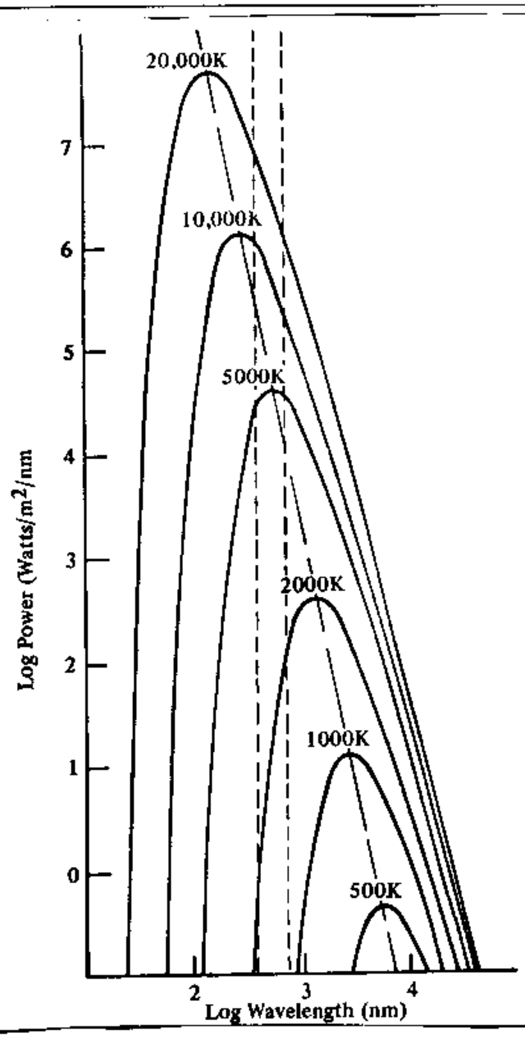

*Sensitivity is the reciprocal of exposure (ergs cm) required to produce specified density above density of base plus fog.

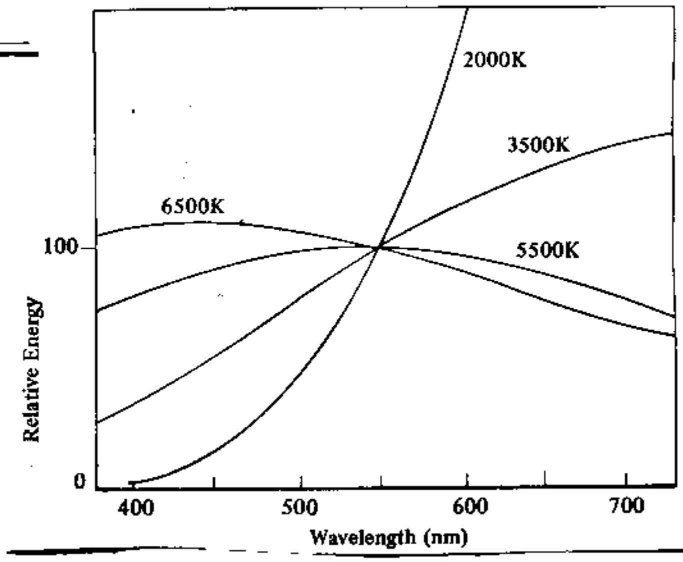
FIGURE 15—The curves above illustrate the typical sensitivity for KODAK High Speed Infrared Film 4143 (ESTAR Thick Base), KODAK High Speed Infrared Film 2481 (ESTAR Base), and KODAK High Speed Infrared Film. Since these films are quite sensitive to blue light in the approximate range of 400 to 500 nanometers, a blue-light-absorbing filter must be used.

*Ortho- correct, + chroma, color. Although improved from the ordinary, or blue-sensitive coatings, it really wasn't perfectly color-corrected, as reds still photographed darker than they should have.

**Pan-, throughout, + chroma, color. It sees through the whole spectrum.

Spectral Emittance of a Blackbody at Various Temperatures




Relative Spectral Energy Blackbody Curves

**The <u>black-body radiation curves</u> are graphs predicted by Lord Kelvin's equations governing theoretically perfect emitters*. The curve on the left uses an exponential abscissa, as the range of wavelengths extends from the UV to the IR. The dashed lines are the boundaries of the visible from 400 to 700 nm. The peak of the 500K curve is at about 10 microns, or 10,000 nm.**

**The curve on the right illustrates <u>red-hot</u>, <u>white-hot</u> and <u>blue-hot</u> distributions. The black-body curves on the right above have been <u>normalized</u> to 550 nm, the eyes' apparently brightest color, so that all their relative intensities can be compared.**

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***If they are perfect emitters, then they must also be perfect absorbers. To absorb everything equally well, these bodies must be perfectly neutral, or black, hence the term.**