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Bandwidth, Resolution, Reporting Interval, and the UltraScan PRO

Of the many specifications frequently given for spectrophotometers, three relate to the ability of the instrument to accurately measure samples having steep slopes (quick changes) in their spectral reflectance or transmittance curves. They are effective bandwidth, wavelength resolution, and reporting interval. These specifications are discussed with respect to the UltraScan PRO in the sections below.

The UltraScan PRO

Effective Bandwidth

Effective bandwidth indicates the ability of an instrument's polychromator optics to see small wavelength differences in spectral curves or to resolve spectral peaks that are close together. (The polychromator is the part of the instrument that divides the white source light reflected back from or transmitted through the sample into its various component wavelengths for detection. The UltraScan PRO uses two holographic grating polychromators.) For example, if a sample had two spectral peaks that were 8 nanometers (nm) apart, an instrument with a 10-nm effective bandwidth would see only one peak. An instrument with a 5-nm effective bandwidth would correctly see the two peaks.

The effective bandwidth of a polychromator depends on the groove density of the grating used and on the diameter of the polychromator's entrance optics. The benefit of a narrow effective bandwidth is seen when measuring samples having colorants with rapid changes in reflectance or transmittance with

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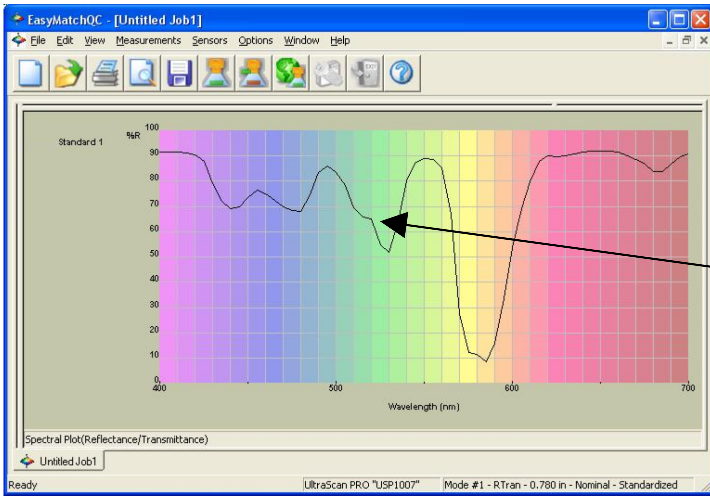
respect to wavelength (i.e., samples having steep spectral slopes). An instrument with a narrower effective bandwidth will give more accurate colorimetric and spectral readings for this type of sample.

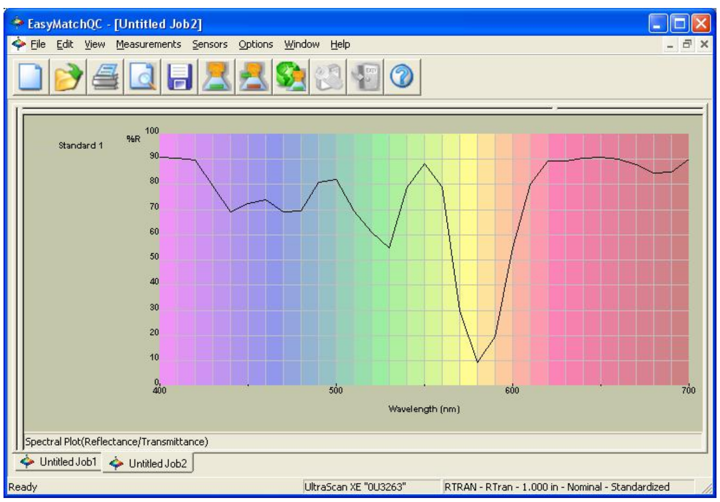
The effective bandwidth of the polychromators used in the UltraScan PRO is **5 nm**. The pictures below show the difference in spectral transmittance plots between the UltraScan PRO and an UltraScan XE with a 10-nm bandwidth when reading a single didymium filter. Note the smooth curves and higher definition on the UltraScan PRO plot.

Measurement on an UltraScan PRO



Note the distinction between curves here that is not shown below.

Measurement on an UltraScan XE



Wavelength Resolution

An instrument's wavelength resolution gives the sampling interval of its detection system in nm. This resolution is a function of the wavelength range scanned and the number of elements in the measurement array. For example, an instrument with a wavelength range of 400 to 720 nm (a 320-nm span) using a 16-element diode array for detection would have a wavelength resolution of 320 nm/16 elements = 20 nm/element. However, some elements in the detection system may not be used. It is common to not use the elements on each end of an array.

The UltraScan PRO measures the wavelength range of 350 to 1050 nm (a 700-nm span) and uses a detector with 512 elements. Though this calculates to a 700 nm/512 element = 1.37 nm/element resolution, the actual known wavelength resolution of the UltraScan PRO is about **2.35 nm/element** because some of the elements are not used. The 2.35 nm/element resolution means that the UltraScan PRO is taking a measurement every 2.35 nm along the spectrum. A small wavelength resolution allows

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you to more precisely calibrate the instrument's wavelength to achieve higher wavelength accuracy. This, in turn, results in more accurate spectral and colorimetric measurements.

Reporting Interval

An instrument's reporting interval is the interval (in nm) at which sample reflectance or transmittance data is actually output by the instrument. This is the interval of the spectral data that is displayed on your computer and that is used for the calculations that convert the spectral data to colorimetric data like L*a*b*. The reporting interval should always be equal to or larger than the wavelength resolution. If it is not, then the reported data is being interpolated and is not the true measurement.

The UltraScan PRO has a **5-nm** reporting interval and a 2.35-nm wavelength resolution. Thus, the data reported every 5 nm (i.e., at 350 nm, 355 nm, 360 nm, etc.) are true and accurate measurements. ASTM E308-01 Section 6.3 states, "For greater accuracy select the 5-nm measurement interval over the 10-nm interval where spectral data are available at 5-nm intervals." In addition, 5-nm spectral data gives more complete information about a sample's spectral characteristics when you are working with spectral data and spectral curves. This is especially important for samples having steep spectral slopes.

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