

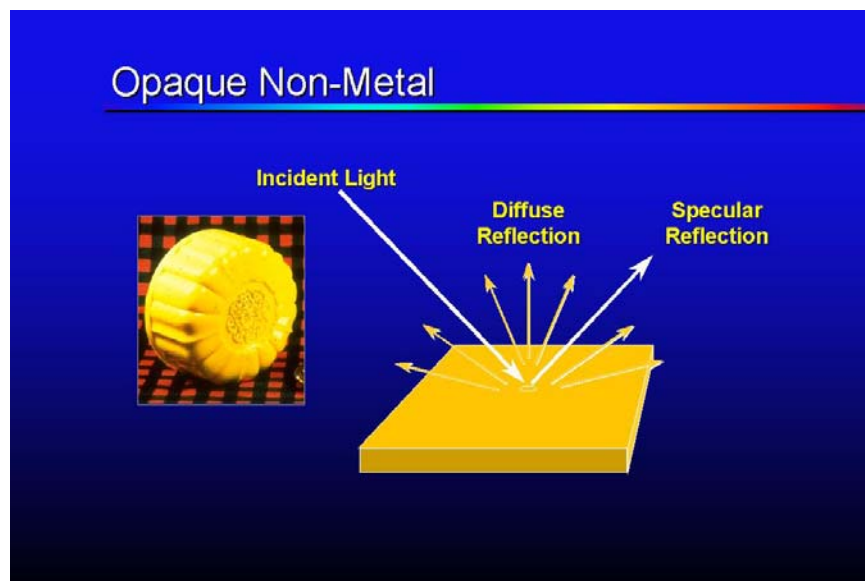


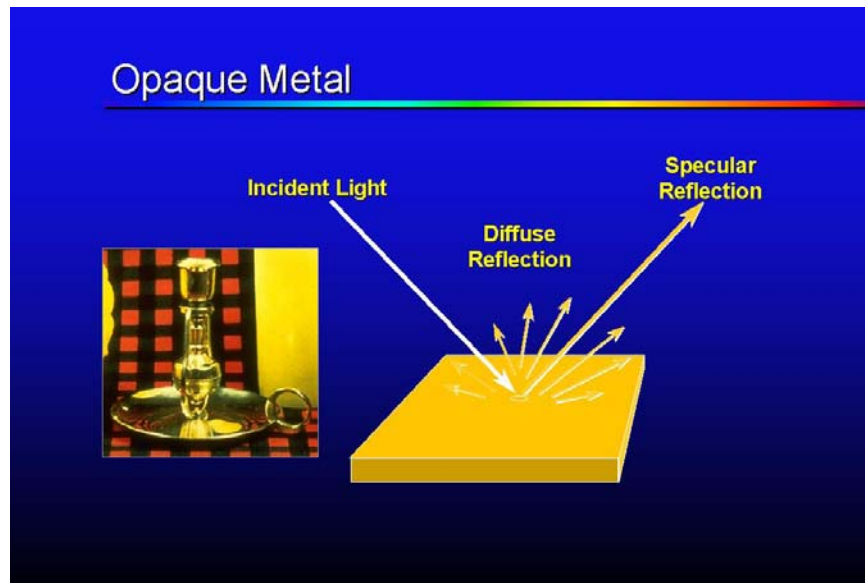
Reflectance Measurements: Specular Included versus Specular Excluded

HunterLab benchtop sphere (diffuse/8°) instruments, such as the ColorQuest XE, UltraScan XE, UltraScan VIS and UltraScan PRO, can measure reflectance in two different modes:

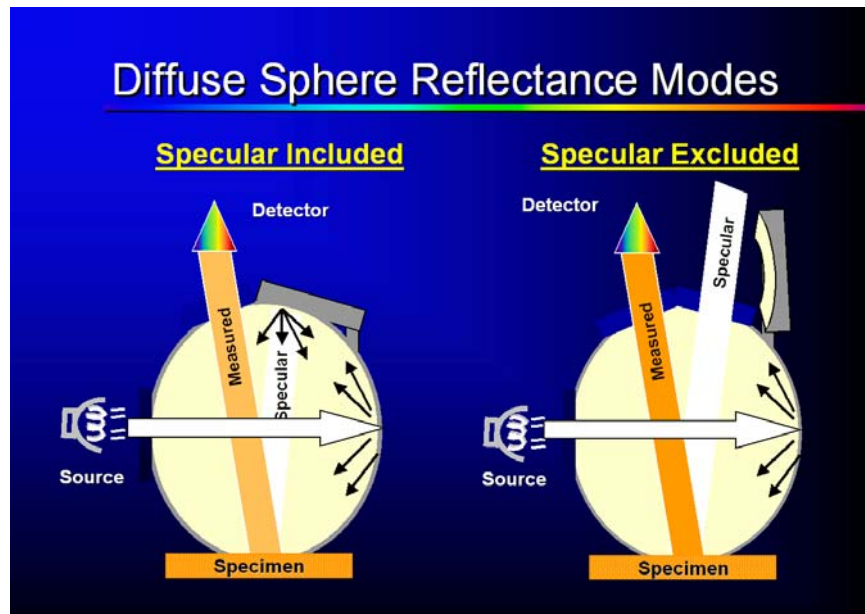
- **Reflectance-specular included (RSIN)**, which measures total reflectance, including diffuse reflectance (color) and specular reflection (direct reflection of the light beam in an equal but opposite direction, like a mirror)
- **Reflectance-specular excluded (RSEX)**, which measures diffuse reflectance only.

Diffuse and specular reflectances are illustrated in the images below for the two types of samples normally measured in reflectance.





When RSEX mode is being used, the specular component of the reflected light is excluded from the measurement by opening the section of the sphere where light would ordinarily reflect specularly from the sample to the detector. For the ColorQuest XE, UltraScan XE, UltraScan VIS and UltraScan PRO this is done using a motorized specular included/excluded port door that opens or closes the appropriate section of sphere as needed. The instrument configurations for a sphere instrument with the sphere port door closed and open are shown below.



These images show what the two modes look like inside the transmission compartment of a ColorQuest XE, UltraScan XE, UltraScan VIS or UltraScan PRO.



The specular exclusion port closed (RSIN mode)

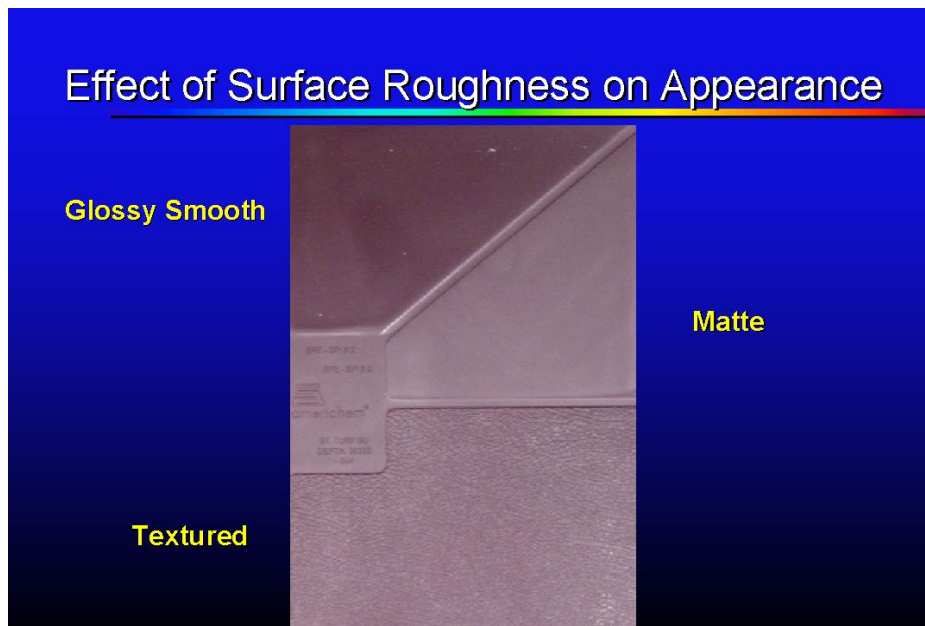


and open (RSEX mode)

Note: This specular exclusion is not complete for diffuse/8° instruments, so different models may yield different measurements in RSEX mode, particularly for dark, glossy samples.

So, when should RSIN mode be used and when should RSEX mode be used?

In general, brightened bare metals should be measured in RSIN mode, since their color is seen primarily in the specular reflection. (Note that the specular reflection arrow is yellow on the Opaque Metal picture on page 2.) If your sample is not a shiny metal, though, the answer to the RSIN versus RSEX question depends on the answer to another question: *Do you want your measurements to measure color as an actual physical property (as if to determine the exact amount of pigment used), or do you want to measure specimen appearance (that is, what it looks like to a human being)?* Consider a sample of a single color of plastic or paint with areas that differ only in surface texture, as in the picture below.



The color is constant throughout the three areas, as previously mentioned. However, the surface texture makes them *appear* differently to the eye. The glossy smooth area appears darker and more saturated than the matte and textured areas.

If the three areas were measured on a sphere instrument in RSEX mode, which approximates the way the glossy surface would ordinarily be viewed visually, the appearance difference would be shown by

the instrumental measurements. If, on the other hand, the areas were measured in RSIN mode, measuring all the light the sample reflects, the values would indicate that the color is indeed the same across the three areas.

As an illustration, a single paint chip with both a glossy surface and a matte surface was measured in RSIN and RSEX modes on an UltraScan XE. As you can see from the table below, in RSEX mode, the difference between the two surfaces was readily apparent (ΔE_{cmc} is 2.75), but not significant in RSIN mode (ΔE_{cmc} of 0.21).

RSIN					RSEX				
	L*	a*	b*			L*	a*	b*	
Glossy standard	32.97	19.24	5.17		Glossy standard	25.00	25.84	7.68	
	ΔL^*	Δa^*	Δb^*	ΔE_{cmc}		ΔL^*	Δa^*	Δb^*	ΔE_{cmc}
Matte sample	0.24	-0.01	-0.16	0.21	Matte sample	3.08	-2.76	-1.44	2.75

Therefore, if you want your instrument to measure **appearance** and **appearance difference** as seen by the eye, taking into account the effects of texture and finish, you would want to measure in **RSEX** mode. If you were concerned with the **actual color content** or doing **color formulation**, you would want to use **RSIN** mode.

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