What is Selective-Yellow Light?

It's what happens when you subtract blue from the output of a lamp producing white light. But first, what means "white light"? Under US Federal Motor Vehicle Safety Standard number 108 and Canadian Motor Vehicle Standards 108 and 108.1, headlamps as originally installed on motor vehicles (and as installed by anyone other than the vehicle owner) must produce white light. The relevant SAE (and identical ECE) color standards define "white" light as a rather large range within the CIE 1931 colorspace. That's why both brownish sealed beams and bluish HID headlamps are considered "white". It's also why "blue ion" or "crystal blue" bulbs with blue-pass dichroic filters sold to poseurs who want to try to pretend they have HIDs are *not* considered "white". The light can tend towards a yellow tint to a certain degree and still qualify as acceptable "white" light.

In 1936, the French for tactical reasons wanted a way to identify the registration nationality of vehicles at night. However, they did not want to reduce roadway safety, and wanted in fact to improve it if possible. So, they figured to remove the blue from the output spectrum of their vehicles' front lamps. Some technical papers out of France on the subject can be had here and here. White light with the blue component subtracted is known as "selective yellow" light. It is a pure yellow color with little or no orange component—hence the French yellow headlamps. Yellow lamps have consistently over the years been subjectively ranked as better in poor weather and lower in glare than white ones, but is the effect real? Or is it just a subjective impression?

One problem with this conclusion as drawn from the French experience with selective-yellow headlamps in France is that when the question was being considered, the lamps that were being compared with white lamps reduced the absolute intensity of the beam by about 12 percent. This fact may have had a part in reducing the glare. Because the requirement for yellow light no longer exists (though it remains allowed in many countries) we probably will never know the vagaries of the answer to this question.

What explains the persistent subjective preference amongst experienced poor-weather drivers for yellow fog lamps, despite decades of white fog lamp prevalence?

Selective yellow light can improve a driver's ability to see in fog or rain

or snow, but *not* because it 'penetrates fog better' or 'reflects less off droplets' as is commonly thought. That effect is known as Rayleigh Scattering, and is why the sky appears blue. However, it occurs only when the droplet size is equal or smaller than the wavelength of the light, which is certainly **not** the case with ordinary fog, rain or snow. Roadway Fog droplets are several orders of magnitude larger than visible light wavelengths, so there's no Rayleigh Scattering.

So, why do yellow fog lamps seem to work better? It's because of the way the human eye interacts with different colors of light. Blue and violet are very difficult for the human optical system to process correctly. They are the shortest visible wavelengths and tend to focus in front of our eyes' retinae, rather than upon it. To demonstrate this to yourself, find a dark blue store front sign or something else that's a dark, pure blue against a dark background in the absence of white light—from any appreciable distance, it's almost impossible for your eyes to see the blue lighted object as a sharply defined form;the edges blur significantly. Deep blue runway lights exhibit the same effect; check it out the next time you land at night.

Blue also is a very difficult color of light to look at; it stimulates the reaction we call glare. Within the range of allowable white light, bluer headlamps have been shown to be 46% more glaring than yellower ones for a given intensity of light — see studies here and here. So, it seems culling the blue out of the spectrum lightens the optical workload and reduces glare. For a more detailed examination of this effect with respect to driving in foul weather, see Bullough & Rea's study on the topic.

So, what's the best method of getting selective-yellow light? Until the mid 1990s, headlamps in France were required to produce yellow light. This was accomplished in one of several ways: With a headlamp lens made out of yellow glass, with a yellow glass balloon in front of the bulb either as part of the bulb or as part of the lamp unit, or, more recently, with a yellow-pass dichroic filter coating on a lamp's lens, reflector, condensor or on halogen bulbs themselves.

Cadmium glass was used to make the old French-market Selective Yellow bulbs; now that Cadmium's been more or less banned from auto parts for environmental reasons, the best remaining options are dichroic coatings applied to the bulb or absorption (non-dichroic) filters applied to one of the optical elements—the lens or reflector.

The blue-appearing lenses in many Asian-made fog lamps ("ion crystal", "gold irridium", and other such whimsical marketing names) are coated with a multilayer dichroic interference coating which passes selective-yellow light on axis, i.e., straight ahead. However, these dichroic filters don't absorb/block the blue light, they simply diffract it so it leaves the lamp *off* axis. So these lamps tend to glow blue when viewed off-axis, and in extreme cases there can be objectionable blue haze outside the brightest areas of the beam. The irridescence of these

coatings causes or aggravates secondary-reflection problems where none would exist absent the coating. With the mirrorlike dichroic coating reflecting images of the glowing filament, light goes where it doesn't belong.

Dichroic selective-yellow bulbs are, for the time being, available in some of the common fog lamp bulb formats (H1, H3), though these are going away because no country requires selective-yellow lamps any more. Selective-yellow HID headlight bulbs (D2R, D2S) have been marked by Philips in Japan and other parts of Asia for quite a few years—Philips part numbers are 85122YX and 85126YX—these are now showing up in Europe as well.

For those intent on having selective yellow lights for whatever which reason, applying a coating to an optical element is a more permanent, optically cleaner option that eliminates the need to find and get special bulbs. Good results have been obtained by removing the lamps, cleaning the lenses thoroughly and making sure they're warm, then spraying them with several wet-but-not-drippy coats of Dupli-Color Metalcast yellow, a transparent yellow paint product with good adhesion and durability. Let each coat "flash off" (dry most of the way) before applying the next, and use thin coats so you don't get drips and sags in the wet paint. With each successive coat, the yellow tint will grow deeper. Make it about 2 shades deeper than you think looks right, and it'll turn out well in the end. Of course, the coating needs to be permitted to dry and harden completely before you take the fog lamps out on the road, otherwise dust and grit will become embedded in the still-tacky surface. In the case of lamps with removable lenses, by coating the interior surface of the lens obviously answers questions of coating durability against pitting and scratching. Results of conversion can be seen here.

Daniel Stern Lighting (Daniel J. Stern, Proprietor)

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