Selective Yellow Light

A car with selective-yellow headlamps

What is "selective yellow" light?

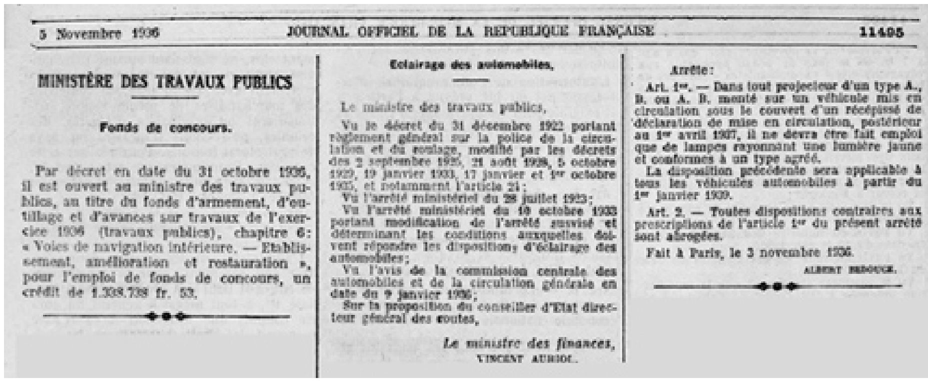
It is a particular kind of yellow light that was required from all road illumination lamps on vehicles in France for many years. Light appears (more or less) white when it contains a mix of all the colours—red, orange, yellow, green, blue, indigo, and violet. By removing (filtering) the blue, indigo, and violet out of white light, we get selective yellow light. It is not the same as the more orange colour called "yellow" or "amber" used for vehicle turn signals, side marker lights, and (in some countries) clearance and front position or "parking" lights.

Why and when did France require selective yellow light?

A number of folk explanations have long been in circulation for the French yellow-lights requirement that started in the mid-1930s. Some say it was a tactical decision at the urging of the military, to facilitate identification of the nationality of a vehicle at night, useful during the war. Some say it was because French road pavement had peculiar reflective properties. Some say it was nothing but market protectionism. And a particularly persistent myth holds that yellow light "penetrates fog better" because blue light scatters more, as evidenced by the sky being blue. The sky is indeed blue because of Rayleigh Scattering—short-wavelength light such as blue, indigo and violet does indeed scatter more—but only in droplets and particles equal or smaller than the wavelength of the light. That's much smaller than the particles and droplets that make up ground-level fog, rain, and snow; there is no Rayleigh Scattering happening to the light from a vehicle's front lamps, and whatever blue light those lamps might be producing does not get scattered by the fog, snow, or rain more than other colours of light.

The fact is, in late 1936 lawmakers in France put forth legislation requiring road-illumination lamps (headlamps, fog lamps, etc.) on all vehicles to emit selective yellow light. This legislation was based on advice from the French Central Commission for Automobiles and Traffic, which in turn was based on experiments done by the French Academy of Sciences, concluding that selective yellow light is less glaring than white. Here is the decree, published in the 5 November 1936 edition of the *Journal Officiel de la Republique Française* —Official Journal of the French Republic, like the U.S. Federal Register or the Canada Gazette.

Click this small image for a larger version in a new window:



5 Novembre 1936 JOURNAL OFFICIEL DE LA REPUBLIQUE FRANÇAISE 11495

MINISTÈRE DES TRAVAUX PUBLICS

Fonds de concours.

Par décret en date du 31 octobre 1936, il est ouvert au ministre des travaux publics, au titre du fonds d'armement, d'outillage et d'avances sur travaux de l'exercice 1936 (travaux publics), chapitre 6: « Voies de navigation intérieure. — Etablissement, amélioration et restauration », pour l'emploi de fonds de concours, un crédit de 1.338.738 fr. 53.

Eclairage des automobiles.

Le ministre des travaux publics,

Vu le décret du 31 décembre 1922 portant règlement général sur la police de la circulation et du roulage, modifié par les décrets des 2 septembre 1925, 21 août 1928, 5 octobre 1929, 19 janvier 1933, 17 janvier et 1er octobre 1935, et notamment l'article 24;

Vu l'arrêté ministériel du 28 juillet 1923;

Vu l'arrêté ministériel du 10 octobre 1933 portant modification de l'arrêté susvisé et déterminant les conditions auxquelles doivent répondre les dispositions d'éclairage des automobiles;

Vu l'avis de la commission centrale des automobiles et de la circulation générale en date du 9 janvier 1936;

Sur la proposition du conseiller d'Etat directeur général des routes,

Le ministre des finances,
VINCENT AURIOL.

Arrête:

Art. 1er. — Dans tout projecteur d'un type A., B. ou A. B. monté sur un véhicule mis en circulation sous le couvert d'un récépissé de déclaration de mise en circulation, postérieur au 1er avril 1937, il ne devra être fait emploi que de lampes rayonnant une lumière jaune et conformes à un type agréé.

La disposition précédente sera applicable à tous les véhicules automobiles à partir du 1er janvier 1939.

Art. 2. — Toutes dispositions contraires aux prescriptions de l'article 1er du présent arrêté sont abrogées.

Fait à Paris, le 3 novembre 1936.

ALBERT BEDOUCE.

This decree translates as follows:

> *The Minister of Public Works, in view of the decree of 31 December 1922 laying down general rules on traffic and traffic regulations, as amended by the decrees of 2 September 1925, 21 August 1928, 5 October 1929, 19 January 1933, and 17 January and 1 October 1935, and in particular Article 24; with regard to the Ministerial Decree of 28 July 1923 and that of 10 October 1933 amending the decree in question and determining the conditions to be met by the provisions of automotive lighting; and with regard to the opinion of the Central Commission of Automobiles and Traffic dated 9 January 1936; on the proposal of the State Councillor Director General of Highways,*
>
> *Be it enacted:*
>
> *Article 1: All road illumination lamps mounted on a vehicle registered after 1 April 1937 shall produce selective yellow light and shall comply with an approved photometric standard. This provision shall apply to all motor vehicles as from 1 January 1939.*
>
> *Article 2: All provisions contrary to the provisions of Article 1 of this Order are hereby repealed.*
>
> *Done at Paris, 3 November 1936.*

France maintained the requirement for selective yellow car lamps for almost 60 years. As late as 1988, French lawmakers were responding to citizen queries by saying the selective yellow lights were safer because of less glare and less light scatter with equal driver seeing ability. In the drive to remove trade and travel barriers by commonising vehicle technical regulations throughout Europe, the requirement was quashed in 1993 (along with unique vehicle lighting requirements in certain other countries) and white headlamps were allowed in France for the first time since 1937.

What does the science say?

Some technical papers out of France on the subject can be had **here** and **here**. These are both by Pierre Devaux, a scientist and member of the CIE (International Commission on Illumination). These, particularly the 1970 paper, go into great detail about why selective yellow light might be more suitable and less glaring than white light for night driving. A **1976 study** done in the Netherlands found no significant benefit to either colour over the other—an interesting result not only because it contradicted both the claims of yellow superiority, and also the counterclaims that white is better. But selective yellow lamps have consistently over the years been subjectively preferred as "better" in bad weather and lower in glare than white ones. Even now, when most of the world's fog lamps emit white light, the "good fog lamps are yellow" idea still has traction.

So is there a real benefit? Or is it just a subjective impression? Because yellow-light requirements are no longer on the lawbooks (except in Monaco, where it is probably not enforced) we probably will never know the vagaries of the answer to this question. There are problems with drawing a conclusion from the 1936-1993 European experience with selective-yellow headlamps. For one thing, car lighting technology of that timeframe generally did not give the driver enough light—of either colour—for safe night driving. And even if we disregard that, filtering out the blue-indigo-violet reduced the absolute intensity of the beam by about 12 percent. This may have had a part in reducing the glare (though maybe not; it's below the 15% change needed to cause an observer to see a just-noticeable difference—further discussion below).

What, then, explains the persistent subjective preference amongst experienced poor-weather drivers for selective yellow fog lamps (whether or not they happen to know that's the name of the colour), 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'. In fact it's because of the way the human eye processes different colours of light. Blue, indigo, and violet are difficult for the human optical system to process correctly. They are the shortest visible wavelengths and tend to focus in front of our retina rather than upon it. To demonstrate this to yourself, after dark find a deep blue storefront sign or blue lights on an airport runway or something else that's a deep blue light emitter 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. The blur effect is not present with nearby signs or lights of colours other than blue.

Blue also is a very difficult colour 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.

How can selective yellow light be obtained?

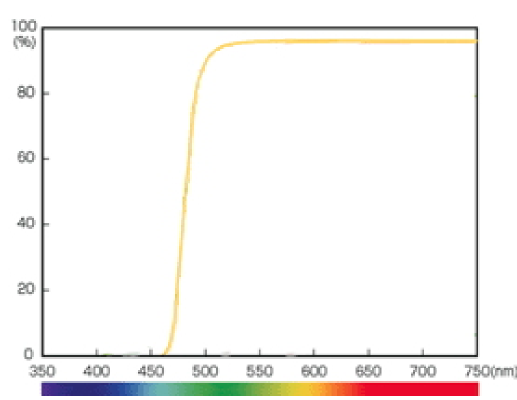
Traditional methods involved simple subtractive filtration: a lamp lens made of selective yellow glass, a selective yellow glass balloon over the colourless bulb, a bulb itself made with yellow glass, or a yellow reflector in conjunction with careful shielding so none of the white bulb's light would shine through the colourless lens without first hitting the yellow reflector. The yellow glass contained cadmium, a toxic metal that began in the 1990s to come under strict control for environmental reasons, so the industry shifted towards yellow coatings applied to the inside surface of the lamp lens or reflector.

Another technique is to have a dichroic filter on the bulb or the lens. Sold under a variety of names ("Gold", "Irridium", "Ion Crystal", "All Season", "All Weather", etc.), This is an irridescent multilayer interference coating which diffracts the blue-indigo-violet light so as to separate it out from the remainder of the light. That remainder (i.e., selective yellow light) passes straight through the filter. The blue-indigo-violet light, because it is not absorbed (blocked) but merely diffracted (bent to an angle) still leaves the lamp. It does so off axis, So lamps with a dichroic filter on the bulb or lens tend to glow blue when viewed from outside the main portion of the light beam, and there can be objectionable blue haze outside the brightest areas of the beam. The irridescence of these coatings also causes or amplifies second- and higher-order filament reflections, which can cause the lamp to emit more light into regions intended to be dark for control of glare or backscatter—such as above the cutoff of a fog lamp, or into the upward/leftward oncoming-eyes zone of a low beam. In other words, with the mirrorlike dichroic coating reflecting images of the glowing filament, light goes where it doesn't belong.

There are generally no longer any yellow bulbs available in quality worth buying. The market demand for them in Europe quickly dwindled once France stopped requiring yellow light; while yellow lights are still permitted in France and a variety of other countries, they're mostly regarded as a retro or styling item. This no longer justifies first-line manufacture, so most of the yellow bulbs now on the market are of unacceptable quality.

What about light loss due to filtration?

Here is a transmissivity curve showing the amount of light of different wavelengths passed by a selective yellow filter:



You can see most of the red-orange-yellow-green light is passed, but most of the blue-indigo-violet light is blocked, so less than 100% of the light going into the filter comes out of the filter. Filtration loss is sometimes pointed to as a reason to prefer white lights or reject selective yellow ones. It's a debatable point, because while intensity is the primary factor in how well a light lets us see, the filtration loss involved in going from white to selective yellow is less than the smallest intensity difference that causes an observer to see a just-noticeable difference, and quite a lot smaller than output differences caused by other factors such as bulb quality and feed voltage. Moreover, the human visual system's difficulty processing blue light means the "missing" light wasn't very useful to us. And the blue-indigo-violet being filtered out is only a very small part of the bulb's total output. The visible spectrum consists of all the colours of the rainbow: Red, orange, yellow, green, blue, and indigo + violet. Glowing filaments produce a great deal of light in the red-orange-yellow-green wavelengths, and only very little light in the blue-violet wavelengths. To put very rough numbers on the matter, an HB4 ("9006") bulb produces 1000 lumens, of which approximately 250 are red, 250 are orange, 250 are yellow, 175 are green, 50 are blue and 25 are violet.

To illustrate the relative effects of filtration losses depending on what colour we want to end up with, first let's look at doing the opposite of obtaining selective yellow light: suppose we want to add a filter to the glass that makes the light look bluer/colder. How does it do that? Well, there's no such thing as a filter that adds light into the beam passing through it; filters can only suppress light, not add it. So if we can't add green-blue-violet light, then the only way to get the light to look colder is to suppress green-blue-violet's opposites, which are red-orange-yellow. If we want the light to look, let's say, 20% colder, we suppress red-orange-yellow by 20%. Looking up above, we see that we've got a total of 750 lumens' worth of red, orange and yellow. So, cutting this by 20% leaves 600 lumens, plus essentially all of the bulb's original green-blue-violet output of 250 lumens, so we've now got a bulb that produces light that looks 20% colder and produces 850 lumens.

850 lumens happens to be the minimum legal output for a 9006. Unless we're craven marketeers who don't care about compliance or performance, we can't produce a bulb that produces only the bare minimum of light, because 50% of production will be 849 lumens or less. So, we have to put in a high-luminance filament to try to counteract some of the filtering losses. But we still have to come in under the max-allowable-wattage spec in DOT or ECE regulations.

So, let's say we build our 9006 with a super high luminance filament that produces 1200 lumens. That's too much for a 9006, but we're going to take away some of those lumens with our coloured filter (blue glass). This 1200-lumen filament produces, let's say, 300 lumens red, 300 lumens orange, 300 lumens yellow, 210 lumens green, 60 lumens blue and 30 lumens violet. Now we put that same blue glass over it, which suppresses red-orange-yellow by 20%. Now we've got 720 lumens' worth of red-orange-yellow after filtration, plus 300 lumens' worth of green-blue-violet. That gives us a 910-lumen bulb, which is enough above the 850-lumen legal "floor" that we can run the bulb and even if some filaments only produce 1150 lumens instead of 1200, we're still legally OK. Of course, we still only have 910 lumens instead of 1000, and our 1200-lumen filament is going to have a significantly shorter life than a 1000-lumen filament, but we've got our colder/bluer light appearance in a legal bulb.

This blue-bulb walk-through should bring clarity to why filtering for yellow does not significantly reduce light output: Take our 1000-lumen 9006 as broken down by colour output above. There's still No such thing as a filter that adds extra yellow light, so we have to get our yellow by suppressing blue-indigo-violet (selective yellow contains all the green found in white light. If we took out green, we'd have a turn signal type of amber light.) OK, then, let's cut blue-indigo-violet by 80%. That means we've got our 925 lumens' worth of red-orange-yellow-green, plus 15 lumens' worth of blue-violet (after filtration). Total: 940 lumens— a much smaller loss. Put in a very slightly better filament, say one that produces 1060 lumens, and now we've got 980 lumens' worth of red-orange-yellow-green, plus 16 lumens' worth of blue-violet (after filtration) for a total of 996 lumens, which is just 4 lumens off our original figure—for all intents and purposes identical to our original 1000-lumen uncoloured bulb. For context, the dimmest allowable parking lamp bulb produces 30 lumens.

If you want to try selective yellow fog lamps

If you want selective yellow lights, applying a coating to an optical element is an optically clean method that eliminates the need to find and get special bulbs in acceptable quality. 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**. This is a transparent yellow paint product of the correct hue, 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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