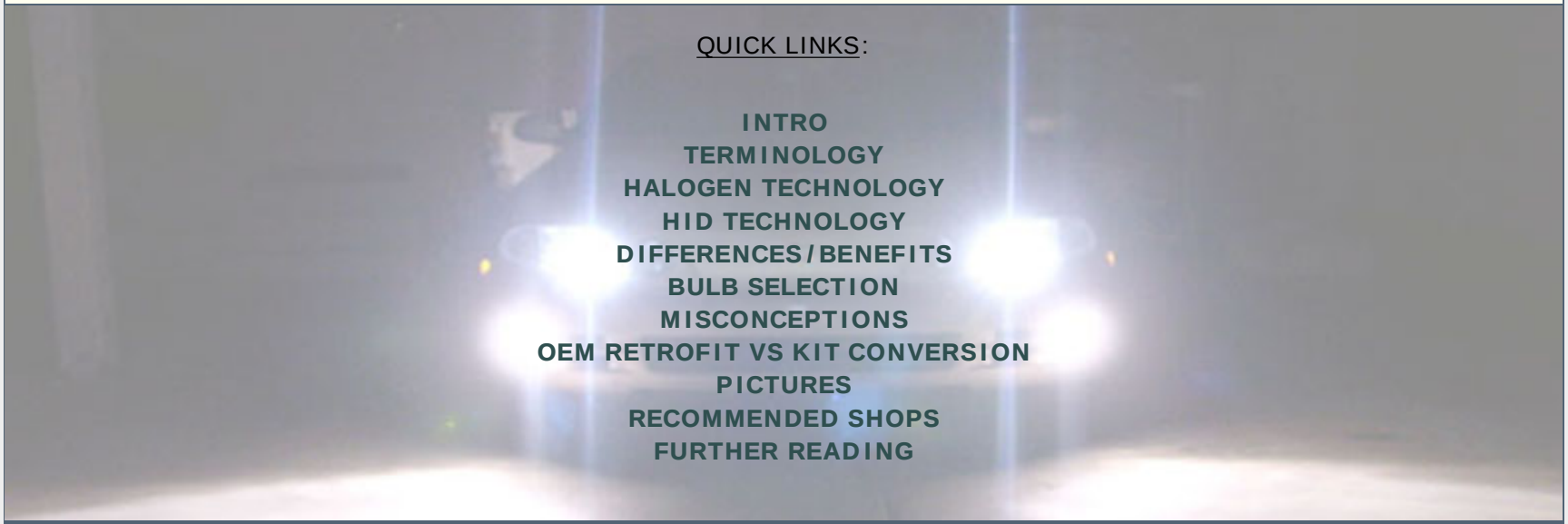
FEEDBACK

Intellexual.Net: HID Lighting Tutorial **Thursday July 28, 2005**

HIDo's & HIDon't's - The HID Lighting Tutorial



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Last updated on October 27, 2004

INTRODUCTION / FOREWORD

Due to the ever-growing popularity of HID headlamps and HID kit conversions, I have decided to write an HID tutorial to debunk the various myths and lies about HIDs as well as explaining some of the many benefits. This article may sometimes get technical, but most people should have no problem following the basic idea. Now if you're searching for an HID upgrade for your car, and just want the quick over, skip the science and start here...

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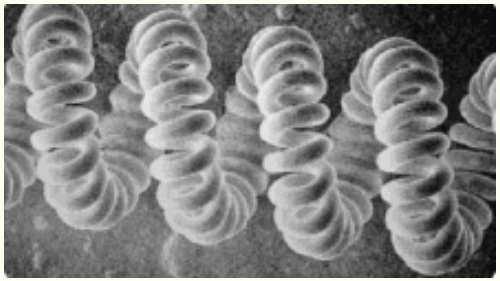
TERMINOLOGY

Significant Terminology	
Watt	Measure of electrical power (w)
Volt	Measure of electrical charge (v)
Kelvin	Measure of color temperature (K)
Lumen	Measure of light brightness (lu)
Candela	Measure of light intensity (cd)
Ampere	Measure of electrical current
Cut-off	A distinctive line of light produced by the shield in a headlight that blocks light above a certain height in order to prevent blinding of other motorists.
Beam Pattern	The pattern of light that is projected onto the ground which includes angle of lateral dispersion, width and depth of illumination.
Capsule	Another term for an HID bulb. Some refer to HID bulbs as gas discharge capsules.
Optics	The lighting control assembly structured around the bulb, which effects the dispersion of light and it's characteristics to a great degree.

HID (High Intensity Discharge) =	= Gas Discharge
Halogen =	= Incandescence

HALOGEN

First a background of automotive lighting technology. Before there was HID technology, there was halogen lighting. Halogen is what has been used in automotive lighting for the last 50 years or so and has peaked in its technological advancement. Halogen lighting involves a conventional direct-current direct-circuit setup. The bulb itself houses a filament commonly made of tungsten metal, which is basically a very delicate loose coil of exotic wire. The filament is held up by two chemically-treated, copper-coated steel (or molybdenum) lead wires. On some bulbs, like the 9006/HB4, the glass bulb that encases them is capped at the end with a nickel-plated brass film. The bulb itself is also filled with a noble gas of some sort, which we'll get into later. When electrical current is supplied to the positive lead wire in the halogen bulb, it crosses a path of tungsten wire, which has very high electrical resistance. It is this high resistance that produces heat and ultimately light as a byproduct. This is essentially the same principle of operation as fire: intense heat used to produce light. Halogen low beams will normally operate on 55 watts of power. Fog lights operate at around 35 watts to 55 watts, and high beams at 55 watts to 85 watts. It is a very simple technology fundamentally, but there are flaws in the halogen mostly relating to efficiency of power.



An enhanced picture of a tungsten filament in a halogen bulb

First of all, halogen bulbs produce more heat than they do actual light (incandescence), which translates to an inefficient usage of potential energy. Secondly, as the halogen bulb is used, tungsten atoms begin to evaporate from the filament due to the extreme heat. When the tungsten evaporates, it deposits itself on the relatively cool surface of the glass bulb (this is why dead light bulbs are often black), and the filament becomes thinner and more brittle. Sooner or later the filament will evaporate enough tungsten particles that it snaps in two pieces and breaks the electrical circuit. In simple terms you have a dead light bulb.

A 9006 halogen bulb

Now stepping back to the gas filling as mentioned earlier. Because tungsten evaporates away rather quickly,

researchers learned to fill the bulbs with inert gases like argon, krypton, and yes the infamous XENON! The sole purpose of these heavy gases is to create a level of pressure within the bulb that deters tungsten evaporation. Once a tungsten atom leaves the surface of the filament, it is immediately blocked by giant xenon particles that are crowding it and pushing it back towards the surface of the filament. Xenon is most commonly used because it is the heaviest of the inert gases and is also tied to HID lighting; therefore an opportunity for marketing deception arises. The reason why xenon-filled halogen bulbs don't work indefinitely is because tungsten is a smaller atom and still manages to escape the xenon, redepositing itself somewhere else on the filament, which still thins the filament where the atom originally evaporated from. Halogen bulbs can also be broken by a forceful jolt strong enough to fracture the filament, or by overpowering/mispowering bulbs to a degree that flash-boils the tungsten.

HIGH INTENSITY DISCHARGE

HID technology also known as gas discharge is quite different from halogens. HID uses a capsule (bulb) with two adjacent electrodes positioned in close proximity to each other. The capsule sends these two leads to an electronic HID ballast. The ballast is an electronic module that has a circuit board lined with several small high current capacitors, transistors, and resistors. This ballast acts as an ignition box to fire up the gas discharge process, and as a control unit to regulate a steady power flow. The HID capsule is filled with a rich mixture of noble gases as well as alkali earth metal salts. In this setup, the noble gases and metal salts are actually used as part of the lighting processes instead of as a buffer (as with halogens). For quick ignition, the ballast takes in a small amount of input power of 35 watts at 12 volts and inducts a solid-state charge of 25,000 volts to the positive electrode. This creates a very high-powered arc of electricity across the electrodes, which excites xenon gas into discharging photon particles (light). This process is known as the Gas Discharge Principle.

The light is relatively cool burning compared to halogen, consumes much less power, and produces much more light at a much higher color temperature. Halogen lighting in automobiles has become an archaic technology and is steadily being replaced by HID lighting systems in more and more automobiles. They are no longer limited in availability as high-end luxury amenities. Nissan, Toyota, and Ford are already offering factory HIDs in some of their cars.

A normal D2S gas-discharge bulb

DIFFERENCES/BENEFITS

Some of the benefits of HID over halogen are...

- Up to three times less wattage is used (HID = 35w, halogen = 55-100w)

- Up to four times more bright light produced (HID = 2400-3200lu, halogen = 800-1700lu)
- Up to ten times more intense light produced (HID = 202,500cd, halogen = 21,000cd)
- Up to six times longer lifespan (HID = 2500hr, halogen = 400hr)
- HID light contains less infrared and ultraviolet light, which fatigues the driver and surrounding motorists
- HID light illuminates the road with better contrast and more lifelike tones of color
- Halogen filaments naturally produce a color of 2300K to 4000K (2300K is yellowish, 4000K is whitish) Anything bluer requires the use of light-dimming color filters
- HID produces a natural color of 4100K to 6000K (4100K is daylight white, and 6000K is slightly bluish white) Anything bluer requires the use of light-dimming color filters
- HID lighting produces a wider and deeper beam pattern with razor sharp cut off lines and autolevelling motors*
- HID has low lumen maintenance, meaning bulbs do not dim down as much towards the end of their lives
- HID has high flux properties, meaning light is very evenly distributed when installed properly

*Only available in factory/OEM installed HID systems excluding Acura

BULB SELECTION

HID bulbs come in two common standards today known as: D2S and D2R. D2S uses the D2 base and a clear, naked bulb. D2R uses the same D2 base and a bulb with a metallic strip along one edge to combat unwanted glare in the reflector headlamp. So in OEM HID applications D2R is used in reflector-type HID assemblies whereas D2S is used in projector-type assemblies. When you're purchasing an HID kit, you want to go with a D2S bulb because it emits slightly more light than the D2R.

As far as color selection goes, there are two main color temperatures out there: ~4100 kelvin, which is OEM color, and ~6000 kelvin, which is aftermarket color. By the way, the term 'color temperature' does not have any correlation with the property of 'thermal temperature'. I personally do not see any reason for buying anything other than 4100K OEM, but that's me. Some people like blue light and are willing to pay extra money for extra blueness and less brightness---and thus the 6000K market. I'm sure the reason isn't because people like to see everything on the road in bluescale, but because they want their headlights to appear blue to onlookers. The proper way to achieve more blue/violet in your HIDs is to do an OEM projector HID retrofit and upgrade the projector lenses to ECE-spec. For more info on this, refer to the Retrofit Section of the tutorial.

Now in selecting the brand of HID bulbs, you really only have two right choices to make. The safest, most dependable bulb manufacturers to go with are quite simply Philips and Osram-Sylvania. Between the two, I tend to favor Philips as, mano a mano, the Philips are slightly brighter and bluer than Osram. Both are incredibly reliable brands though. All automakers make *seemingly* simple business decisions on which companies they subcontract their manufacturing to. They ask themselves questions like "Which bulb brand should we use in this car?". A basic question like that leaves millions of dollars hanging in the balance. One minor defect in a sub-par HID bulb could force up to 100,000 bulb recalls per year. So if you follow these successful corporations who pour many hundreds of man-hours worth of scientific research into this stuff, you'll notice that they unanimously select German Philips or Osram-Sylvania bulbs. Even the Japanese cars that use Japanese ballasts and Japanese projectors will still use German bulbs. Philips and Osram bulbs have a lifespan of between 2000-2500 hours (the longest in production). Studies have shown that the average "alternative" Taiwanese and Korean-made bulbs last about 176 hours. This is largely due to massive defects attributed to poor manufacturing technique, workmanship, quality control, and distribution channels. These other smaller companies simply lack the major

R&D money needed to develop the optimal chemical mixtures inside the capsules, which serves to preserve the electrode tips and prevent them from eroding prematurely. Automakers using exclusively Philips or Osram or both include: Acura, Audi, BMW, Cadillac, Chrysler, Ferrari, Ford, GM, Honda, Infiniti, Jaguar, Lexus, Lincoln, Mercedes, Nissan, Porsche, Saab, Toyota (2003), VW. No other automaker in the world uses any other name brand.

The following is probably one of the largest and most deceitful marketing ploys exploited on the internet today. So I will state, for the record: **Osram-Sylvania's highest color temperature bulb is 5400K and Philips' highest color temperature bulb is 5800K (marketed at 6000K Ultinon)**. Nowhere on either of their corporate or consumer websites do they claim, endorse, or offer any HID bulb or kit that produces light over 6000K. I subscribe to both companies' online newsletters so in the nearly impossible event that they do make a 7000K or higher bulb, I will be one of the first ones in public to know about it and this page will be editted on that same day. But here is why Osram and Philips will never sell you a 7000, 8000 or 12000K bulb. Osram and Philips control the entire market on OEM bulbs, and they make enough money off selling OEM 4100K bulbs to ride it out indefinitely. So there is no reason whatsoever for either of them to nurture the trendy idea of high Kelvin blue/ purple bulbs at the expense of their professional reputations.

MISCONCEPTIONS

There are many companies and private merchants out there that will advertise 7000K, 8000K, and even 12000K HID kits. Most of these vendors lurk around on ebay, online car forums, websites, and ricer accessory shops. 100% of the people that buy these kits do so because they are uninformed, uneducated, or misguided in the field of lighting, and will buy these junk kits thinking three things: that these bulbs are brighter, that these bulbs should cost more money, and/or that they will perform better. All three statements are completely false. Perhaps this misconception and frenzy for purple lights originates from BMW and Audi's infamous Hella projector HIDs.

So allow me to explain the real truth of the matter... Philips is the number one manufacturer of HID bulbs. The Philips OEM D2S bulb is rated at 4100K at 12.8 volts and produces 3200 lumens of light. The Philips Ultinon D2S is 5800K at 12.8 volts and produces 2400 lumens of light. As you can see, with all other factors remaining constant, the brightness of an HID bulb declines the higher up the color index you go. Vision, a Korean bulb manufacturer, makes an 8000K bulb, which they used to advertise on Acura-Forums as 2000 lumens bright. This is barely a marked improvement over halogens, and will produce more glare and eye fatigue than it is beneficial. 4100K has been proven through tireless independent research by the Germans, Japanese, and Americans to be the most functional, truest white and thus the brightest possible color temperature (ceteris paribus).

Every car manufacturer in the world (including BMW and Audi) uses none other than a standard 4100K gas-discharge bulb. No exceptions. The reason being is that 4100K is daylight white in color and produces the same color visible light as direct sunlight. This is least fatiguing functional color on the eyes and produces the most comfortable contrast on the road.

So the million dollar question is now: *Why do BMW & Audi lights appear blue when they use a white bulb?*

Well, this coloration is the result of the light projectors; the lenses: it's transparency, it's curvature, the tiny grooves etched into it; the projector assembly, the shield, and the reflector bowl. All these components work together to produce a signature of light unique to that particular optic's design. On the Audi and BMW projectors, the lens curvature at the edge bends the white light producing a "prism effect". White light is broken down to it's

fundemental colors. Since blue lights is high energy, it is absorbed last and thus travels farther. So with this prism effect, you'll notice that BMW HIDs are only purple and blue from the sides, the top, and the bottom edges, but are always daylight white on the road and in the beam pattern. This phenomenon can be demonstrated when you watch an oncoming BMW hit a pot hole or speed bump in the road and the car's nose pitches up and down. The headlights will flicker and "throw colors off", but returns to a solid white beam pattern directly on the road.

Trying to emulate this color-flickering effect with a solid-state blue or purple bulb is only detrimental to lighting performance, it doesn't fool anyone, but most importantly it endangers other motorists around you. Blue light has what we call a very high diffuse density, which causes it to radiate outwards as opposed to forwards. What results is a wide glow of light outside the beam pattern that is blinding to motorists you share the road with. A blue HID bulb will produce color bleed around the headlight, around the objects it lights up, outside of the beam pattern, and around the cut off line. This is effect is known as "glare", and these illegal and improperly installed HID kits are the reason why HIDs get a bad wrap. As common evidence of glare, observe a traffic light at night in a dimly lit area. There is red light and green light. Red is opposite blue and green is next to blue, thus we can substitute green for blue. If you observe the aura, or glow, of light around a red light and compare it to that of a green light, you'll notice that the green light produces much more glare than red. Blue is even worse. Purple, the worst.

Here are some examples...

Above you are looking at two 8000K HID low beam and fog light kits installed on a GS300 (gs300).
One of the foglights retains the orignal halogen bulb for comparison purposes.

What I'm trying to illustrate here is the glow of blue light (or glare) that radiates off 8000K bulbs. This glow breaks out of the beam pattern and blinds oncoming motorists. Also note how small the actual brightness gain is when you go from factory halogen to 8000K HID. Is it even worth your while?

Blue light also shifts the color hue of everything on the road to blue scale, which fatigues your eyes more than a standard halogen bulb, and it's brightness isn't that much of a marked improvement over a xenon-filled halogen bulb. As evidence of this blue eye fatigue, anyone in the Armed Forces, or anyone who is an astonomer/ stargazer, knows to read maps and charts at night using a red light. This is because red light (on the opposite end of the visible light spectrum from blue) doesn't burn into your eyes and affect your night vision like blue light does. As an experiment, momentarily shine a red LED in one of your eyes and a blue LED in the other. Close both eyes and notice how the blue LED burns into your cornea a lot more than the red does. This is because blue light is higher energy and thus causes more strain and wear on the light receptors in your eyes than red light. Kind of like blasting your car stereo at 100db for half an hour straight would fatigue your ears.

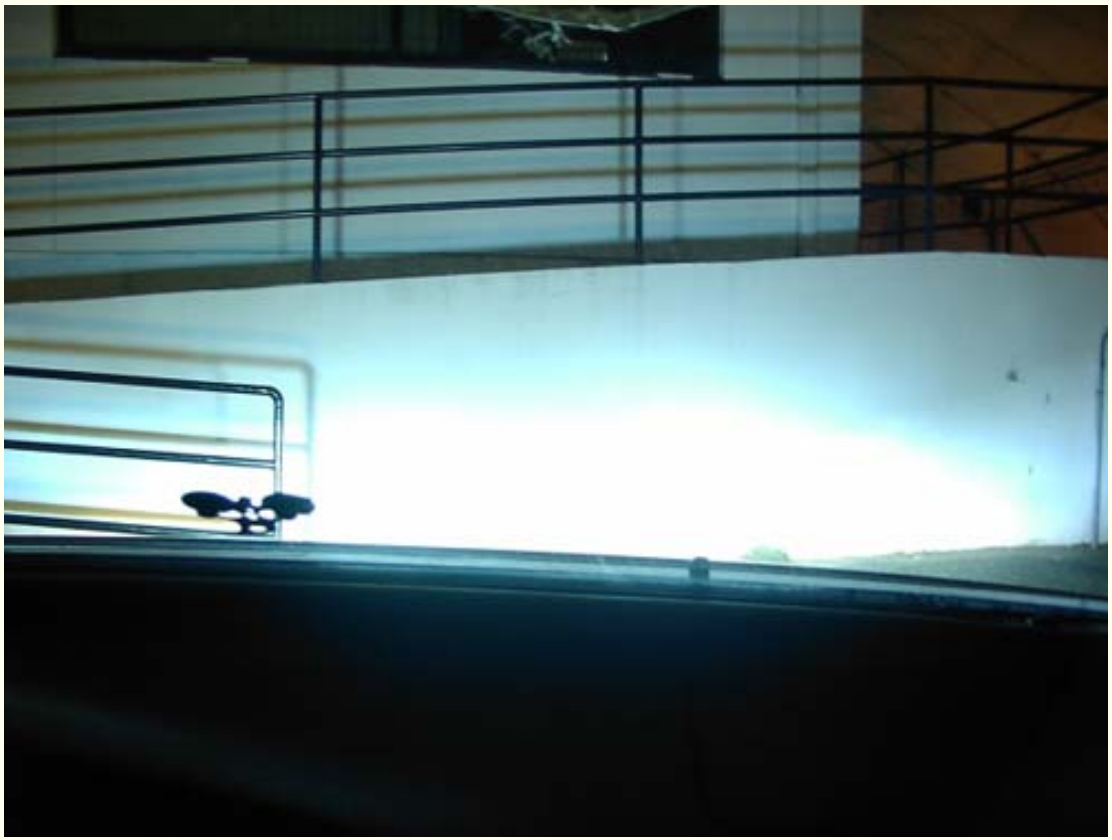
Color in light is caused by the absence of other primary colors; therefore a blue bulb is a bulb that lacks red and green hues. This also means that a white light is the presence of all primary colors of light. White light is more intense than any single color by itself. Why do you think those novelty black lights are so dim compared to regular incandescent bulbs? In fact a 5800K bulb is 800 lumens dimmer than a 4100K bulb made by the same manufacturer. It is also useful to know that 6000K is the highest marketed color temperature produced by the top lighting manufacturers in the world. Most bulbs marketed at 6000K are actually producing color slightly lower than 6000K. The reason 6000K is the plateau isn't because they physically can't make an 8000K bulb. It is because anything above 6000K is not effective as a lighting instrument. So don't believe those ebay auctions boasting "Revolutionary 12000K HID bulbs from Germany". That is just BS marketing gimmick at work.

One trick these HID con artists use is to market their HID kit as "German Philips 8000K HID kit". When I inspect

these advertisements closely, what they are in fact doing is selling you a real Philips ballast, but some cheesy, generic, unlabelled 8000K HID bulb. But what it sounds like is that you're getting genuine Philips 8000K bulbs. Not the case. Many of these 8000K bulbs aren't really even producing 8000K light internally. I've seen 5000K, 7000K, and 8000K HID bulbs with blue films coated over the bulb, which act to filter out all light produced except blue and purple. This in effect dims your light output substantially.

All of the bulb manufacturers that make bulbs over 6000K are smaller, relatively nameless start-ups. This explains why they are producing a poor selection of bulbs. Philips and Osram control the oligopoly on the HID bulb market, and the only way for these small guys to stay afloat is to appeal to the niche market of rice-boys who want their cars to look unique in any and all ways possible regardless of tact or taste. So they manage to successfully peddle these 8000K bulbs to a smaller group of uninformed buyers knowing that they'll have no chance trying to head-off Philips or Osram in the OEM market.

Here are some more examples...



Above is an 8000K HID kit conversion installed on a GS400 (a1exus) with typical poor cut-off and severe color bleeding above and around the cut-off line, and even in the shadows of the railings. This is just one example of blue light's high-energy wavelengths. All the light above the poorly defined cut-off can be translated into "glare" by other motorists.

Here is a 4100K OEM HID retrofit with sharp, clean cut-off as well as sharp defined beam pattern. The very well defined bounds are created by properly engineered optics used in their intended design. This is a perfect beam pattern. Notice that only the driver-side headlight is on and this is merely half of the light this car will end up producing.

OEM RETROFIT VERSUS KIT CONVERSIONS

HID kits commercially available online, at performance shops, and accessory shops include two of the three essential components in HID systems: (1) the HID bulb, and (2) the HID ballast. The missing factor here is (3) the HID optics. The HID optics are the main components that make up a projector/reflector assembly (reflector bowl, lens, shield, D2 base, etc). Without this third leg of the equation, you will still definitely achieve brighter lighting on the road, but you will not achieve the advertised 3200 lumen brightness, you will not achieve the signature color flicker seen in BMWs, and you will not achieve a proper beam pattern. Because of this, a subculture of retrofitters has emerged, salvaging OEM HID parts from wrecking yards, ebay, and other sources, in order to transplant identical systems into their own non-HID cars, and thus emulating the OEM HID lighting system. Most of these retrofitters congregate at the Philips Lighting Forum to exchange ideas, industry news, and retrofitting tips. Many of them will offer up their expertise and services to create a custom OEM retrofit into your own car. OEM conversions offer much more in the way of lighting performance, wow factor, and quality compared to plug and play kits. However, HID kits do offer the equally attractive benefits of ease of installation.

Within the realm of retrofitting, there is also a certain level of improvement and upgrading. This is mainly in regards to a projector system and its lenses. The U.S. DOT-spec HID lenses are not as translucent as the European ECE lenses (with the exception of Hella E39 lenses). ECE lenses produce a BRILLIANT blue-violet color flicker noticeable over a mile away, and increase the net light output substantially over its DOT counterpart. The key here is that the light remains true white on the road while the color flicker is intensified by the clear prismatic lens. The ECE cut-off line is also razor sharp comparatively and the farside flare is flattened out. Unfortunately, E-

code lenses are quite expensive and must be imported from Europe, but hey: you gotta pay to play. J-spec or JDM HIDs are similar to ECE/E-code except that the shield is flipped for RHD. Below is a picture of an ECE beam pattern. Notice the brilliant violet layer of light under the cut-off line, the amazing contrast of light to darkness, and the sharpness of the beam pattern. The violet light translated to onlookers will appear to be a rich, deep purple twinkle in the headlight...

Audi A6 ECE retrofit

MORE PHOTOS

Vick's Honda Prelude with 4100K Audi TT projector retrofit:

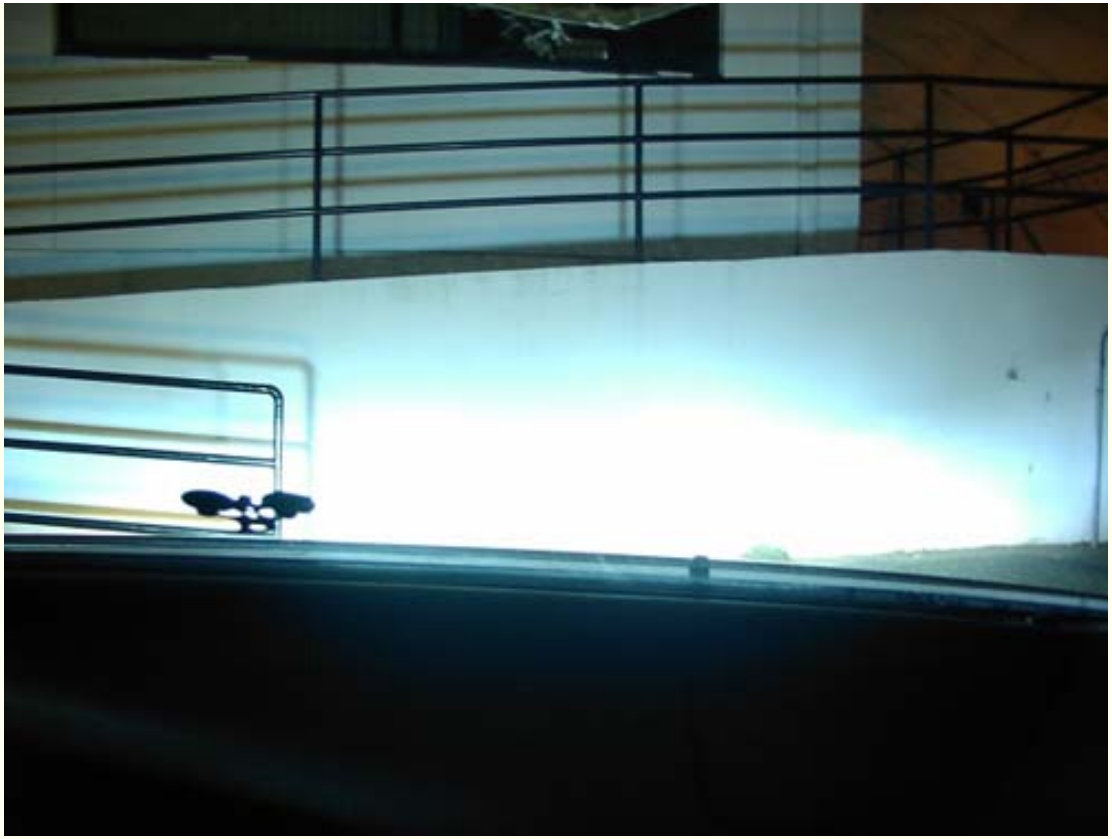
Johnny's 1998 Honda Accord with 6000K Audi TT projector retrofit:

Notice how the cut off is below all the surrounding cars' trim lines (side mirrors, windows, and trunk lid) so that the brightness of the HID light does not effect their ability to drive. Yet it still manages to illuminate a considerable amount of road.

Pliep's 1999 Honda Civic with 4100K Lexus IS/LS reflector retrofit:

Two Honda retrofits showing off their awesome lighting performance:

A1EXUS's Lexus GS400 with 8000K HID kit:



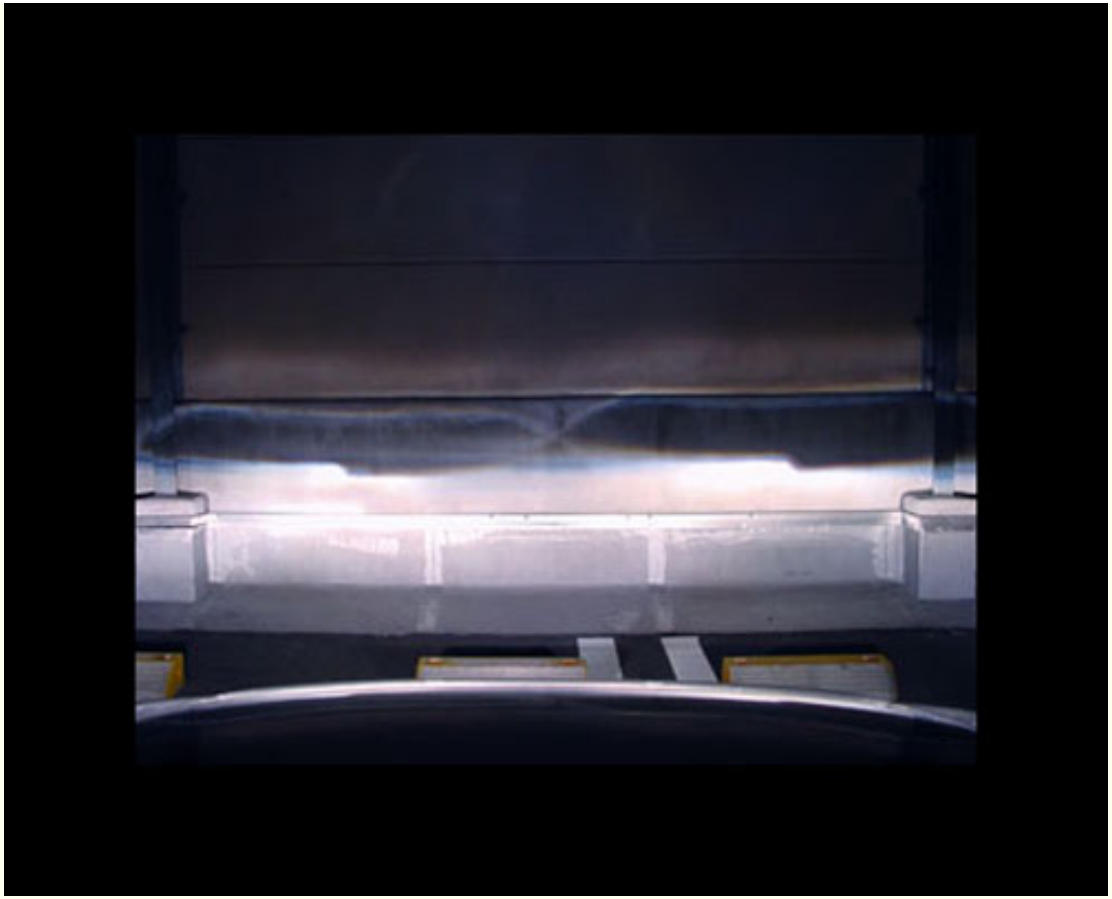
Everything on the road appears blue. After extended use of these 8000K lights (road trips), your eyes will fatigue.

Here's a picture of the blinding glare other motorists must endure from these plug-and-play 8000K HID kits. Both photos are taken at a standing position. Imagine how bad the view would be to a motorist sitting in a car eye-level with the light beam.

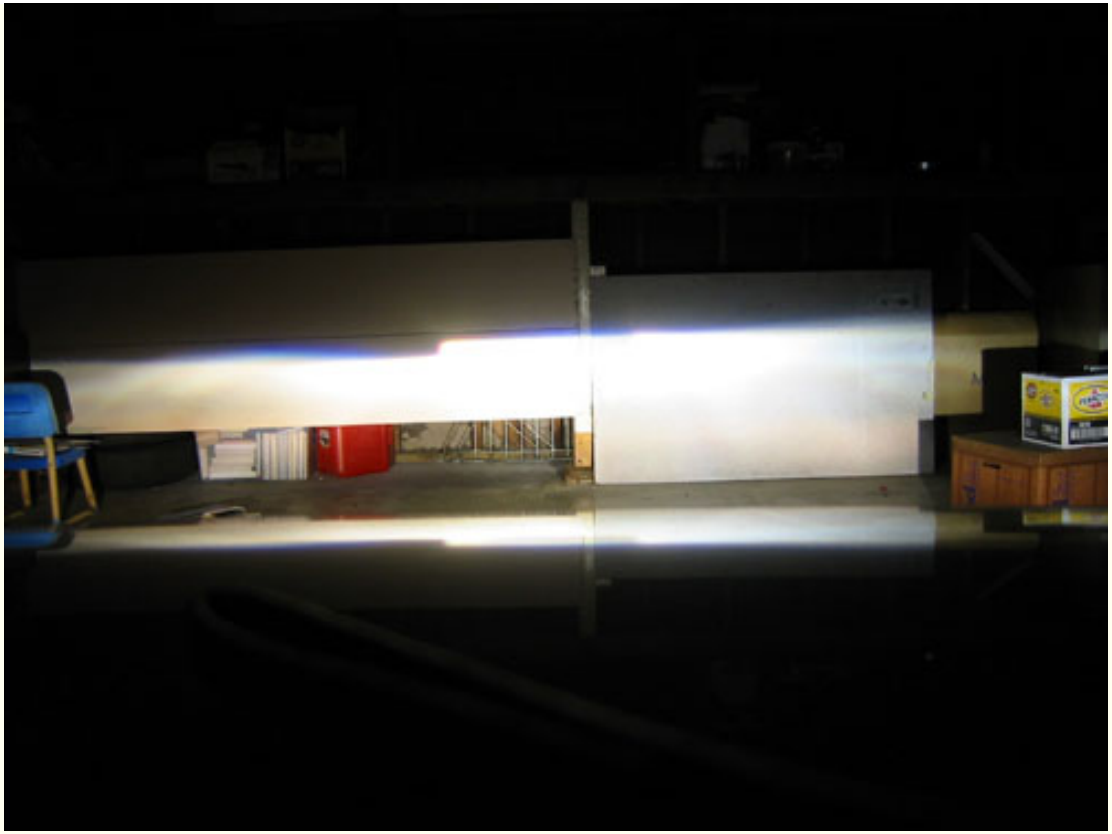
SOARISTO's Toyota Aristo V300 with 6000K Infiniti Q45 projector retrofit:


330
·3 00
LEXUS


TOM'S
330
·3 00



I QuiKSilvR I's Lexus GS300 with 4100K BMW E39 projector retrofit:



RECOMMENDED SHOPS

- Auto Lamps Online
- Illusion Lighting
- SUV Lights
- Daniel Stern Lighting

FURTHER READING

- Illumin Xenon
- Automotive Lighting FAQ
- Automotive Lighting Forum
- Philips' Lighting

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03/30/02

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