

## Technical Committee – October 2007

Corvette headlights. In 1952 when the first Corvette prototype was designed and built, sealed-beam headlights were the technology of the day. At the center of this glass enclosure was a heat-resistant tungsten thread (filament). Early units were vacuum-sealed, allowing the filament to glow very bright yet not burn up. In the fifties, however, sealed-beam headlamps were filled with Argon gas to further slow filament deterioration. The tungsten-argon headlight has a big drawback however: Its low efficiency. In reality, a tungsten filament is nothing more than a toaster wire with a lot more current running through it. The design produces more heat than light, so the energy from the car's electrical system was mostly wasted.

Sealed-beam units were improved in the 1970s when the tungsten-halogen lamp was developed. Halogen lamps get their name from the gas within the bulb. Instead of an inert gas like argon, these bulbs have a gas from this highly reactive chemical element group. The halogen gas, usually iodine, has the very unusual property of combining with the tungsten vapor evaporated off the filament. If the temperature is high enough, the halogen keeps combining with the tungsten as it evaporates and then re-deposits the tungsten back onto the filament. Contrast this to argon filled lamps, where the tungsten vapor wound up coating the inside of the glass. This recycling property allowed engineers to increase the current through the tungsten filament, thus increasing the light output, all without decreasing the life of the lamp. Unfortunately, the headlights of those early halogen headlamp days were a complete, sealed assembly. A burnt out bulb meant replacing the entire headlight. Therefore, manufacturers used relatively standard shapes and sizes. If you remember, you could choose from basically round or rectangular headlights of various sizes.

The next advancement came around 1980 when engineers designed the replaceable halogen bulb. It was small enough to place in the focal point of a headlight assembly. Since the high temperature filament was so close to the encapsulating material, the bulbs were usually made of quartz in those days and had high-pressure halogen gas inside. Thus, the name "quartz-halogen." Later bulbs used high-temperature glass. Replaceable halogen bulbs opened new opportunities in headlight configurations, and advances in plastics and fiberglass in automotive design made model-specific headlights possible. In 1987 further headlight advancement came with "projector" headlights. The same halogen bulbs were used, but because the light could be focused in the center of an elliptical reflector, the efficiency of the resultant light output increased from 30% to 35%. Later, engineers continued to improve headlight design by using Free Form (FF) lenses to capture the light emitted from the bulb. Computer designed reflective surfaces, which look like a bunch of puzzle pieces within the headlight, could focus even more of the bulb's light output toward the road. The engineers could effectively position the tiny light reflectors in FF headlights to increase output efficiency up to 45%.

Even with all these advances in optical characteristics of the headlight lenses, the light generation was still provided by the 1970's technology tungsten-halogen bulbs. Finally, in 1991 (1995 in the US) High Intensity Discharge (HID) headlights were introduced. HID's get their name because of the method of producing light. Instead of passing a high current through a tungsten wire, these lamps pass an electric arc from one electrode to another in xenon gas, somewhat like a fluorescent tube. HID lamps have been used for years in fixed lights like street lamps and stadium lights. However, such large lamps are filled with argon gas, which means the full brilliance is not reached for 5 to 10 minutes after turn-on. Obviously, automobiles cannot accept this restriction. So, automotive HID headlights employ xenon gas and special metal halide technologies giving them the ability to come up to 75% intensity in just 4 seconds.

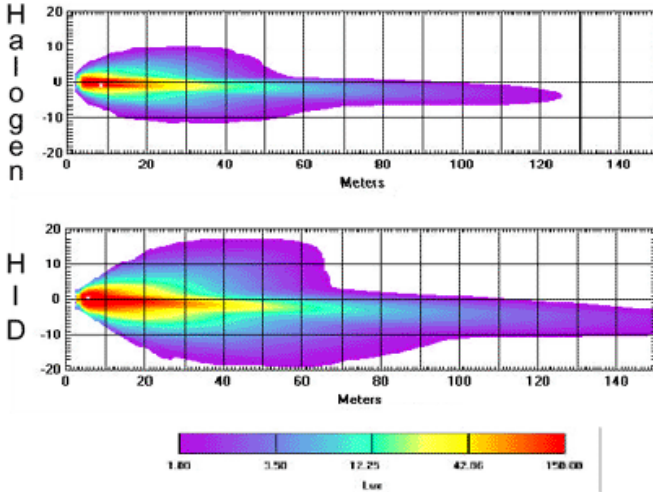
HID headlights have several advantages over their predecessors. They operate with a lot less current, which increases their useful life expectancy, 2000+ hours versus less than 500 for tungsten-halogen bulbs. They also produce a great deal more light with less power (wattage.) For example, HID headlamp bulbs produce between 2,800 and 3,500 lumens from 35 - 38 watts of electrical power, while halogen filament headlamp bulbs produce between 700 and 2,100 lumens using between 40 and 72 watts. Obviously, they have some disadvantages. The headlamp is expensive. The entire assembly for a C6 Corvette lists for \$1085 and the bulb alone is \$265. And, the ballast used to fire the lamp produces high voltage, 85 volts at the ballast and several thousand in the lamp. Safety becomes a real issue for mechanics handling these systems. Nevertheless, HID's are far superior in performance to the tungsten-halogen system. They have improved efficiency (up to 50%), draw less power from the car's electrical system, produce a great deal more light, and last a lot longer.

As a driver, you probably realize that HID lights shine a bit differently than previous headlights. They appear to have a bluish tinge instead of the yellow-white light from the tungsten-argon or tungsten-halogen lamps. This is because of the arc produce by the xenon gas. However, unlike Europe, where yellow headlights are intentionally manufactured and are legal, US law requires that headlights can only emit a white light. Tungsten-argon, tungsten-halogen filament lamps and HID's (4100 °K) are all legal under US law.

Nowadays, there are many efforts to emulate the HID headlamp. So, you ask, are any worth it and are the various approaches legal? Two methods are used to accomplish HID "blue light" emulation. First, tint the bulb blue. Unfortunately, such halogen bulbs are not legal under US law because they technically are not emitting white light. Also, these bulbs really do nothing to increase the output of the headlight. In fact, by cutting down the longer wavelength yellow light with blue tinting, these lamps actually cut down the available light to the road. Furthermore, the shorter wavelength of blue light means more scattering and less penetration under fog, rain and smoke. Ever wonder why some European lights are yellow? Yellow light is far more effective under poor weather conditions. Another attempt to shift the light output to the blue side of the spectrum is to coat the bulb housing with a yellow light "filtering substance." This method reduces light in the yellow portion of the spectrum thus, shifting the spectral output towards the blue. Technically, this approach is legal because no "tinting" is used. Yet, the adverse effects of such chicanery remain, a reduction in the light output of the halogen lamp to the road.

Now, there are bulbs that emulate another aspect of the HID: The increased light output. To accomplish this, such bulbs run above the 65-70 watts legal under US law. Some run 80 or even 100 watts. Although the light output is increased, you run the risk of

overheating and burning out the wiring harness to your headlights. Not a good idea for normal street use. Another recent advertising gimmick for the bulb manufacturers is the "Xenon" lamp. (Careful, here for some folks call HID's "Xenon Lamps") In this application, a standard tungsten-halogen lamp has some xenon gas added to the halogen gas inside the bulb. Adding Xenon gas does yield an improvement of sorts because the larger xenon atoms of the gas mixture have a tendency to improve the bulb's life span. However, there is no improvement in light output or spectral shifting. No matter how you cut it, HID headlamps give much more light for a given wattage. But, for those of you who believe in "one picture is worth a thousand words" check this out:



So, which lamps are HID's in the C6 Corvette? Actually, only the "low beam," uses HID technology. Those lamps contain a 35-watt D1S bulb producing 3200 lumens. The "high beam" lamps still employ conventional 65-watt, tungsten-halogen H9 bulbs with a 2100 lumen output. The fog lamps are also tungsten-halogen and are 45-watt 9145 (H10) bulbs with a 1000 lumen output.