Light Source Characteristics

NHTSA Workshop

Headlamp Safety Metrics

Balancing Visibility and Glare

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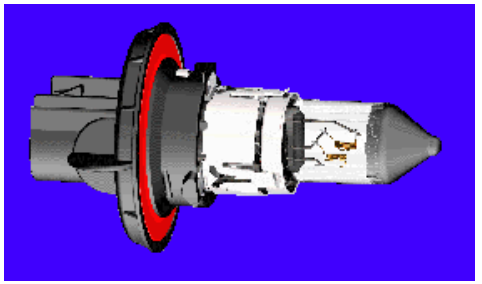
SYLVANIA

Light Source Technologies

- Halogen / Incandescent
- High Intensity Discharge (HID)
- Light Emitting Diode (LED)



Light Source Characteristics

Primary Characteristics

- Light Output (Lumens)
- Luminance (Lumens / Area)
- Dimensional Tolerance
- Stray Light
- Dual / Single Filament

Secondary Characteristics

- Spectrum
- Lumen Maintenance
- Energy Efficiency
- Reliability

These characteristics are important to headlamp design impacting many aspects of system performance including glare and visibility! These factors are changing with new and evolving technologies.

Increased Light Output (Bulb Lumens)

Visibility

- ↑ Distance Vision (Hot Spot)
- ↑ Peripheral Vision (Spread)
- ↑ Foreground Light

Glare

- ↑ Scattered Light

Other

- ↑ Beam Uniformity

- Halogen 1000 to1500 Lumens
- HID 3000 Lumens
- LED 30 to 200 Lumens (multiple required)

More light permits a better beam pattern

Increased Luminance (Lumens / Area)

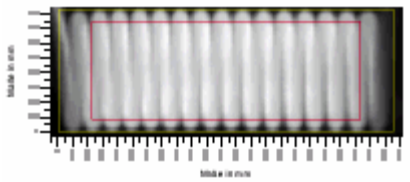
Visibility

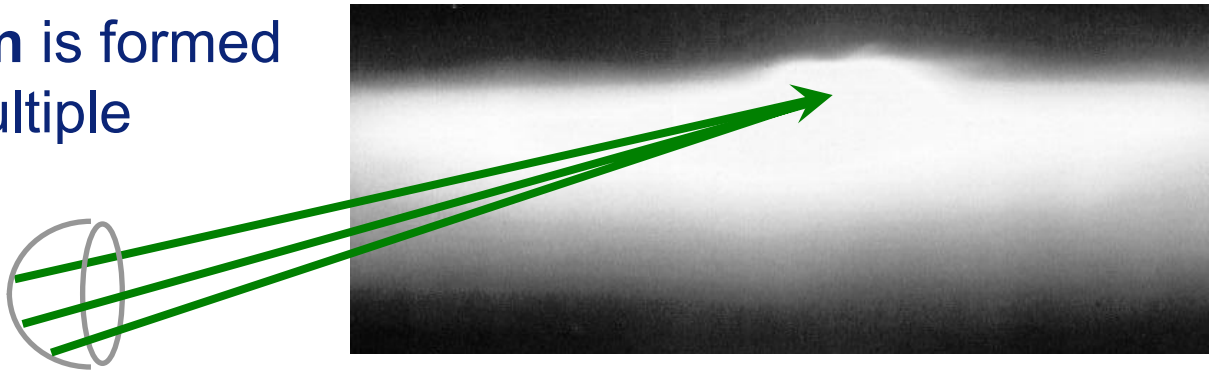
↑ Distance Vision (Hot Spot)

Glare

Negligible Impact

The **beam pattern** is formed by stacking up multiple source images





- Halogen 15-25 cd/mm²
- HID 70 cd/mm²
- LED 5 to 15 cd/mm² (Progressing Rapidly)

Higher luminance permits better distance vision

Tighter Dimensional Tolerance of the Source to the Reflector

Visibility

- ↑ Better Formed Beam Pattern
- ↑ Distance Vision (Hot Spot)

Glare

- ↓ Beam Control (focus)

Other

- ↑ Headlamp Design Freedom

- Halogen +/- 0.9 to 0.2 mm (improved w/ new bulb designs)
- HID +/- 0.5 mm
- LED Too Early to Tell (multiple source challenge)

Better tolerances and optical referencing result in better headlamp performance and design possibilities

Reduced Stray Light

Visibility

↑ Adverse Weather Driving

Glare

↓ Scattered Light

Other

↑ Lower Cost & Complexity of Headlamp System

- Halogen — Better Performance From New Designs
- HID — Good Performance
- LED — Too Early to Tell

Reduced stray light means better control and reduced glare

Dual Filament vs. Single Filament

Visibility

- ↓ Optical Tradeoffs Required
- ↓ Shadows

Glare

- ↑ Scattered Light (Reflections)

Other

- ↑ Smaller Headlamp Possible
- ↑ Lower Cost & Complexity

➢ Halogen	Dual & Single Filament Available
➢ HID	Dual Filament Functionality w/ added hardware
➢ LED	Individual Control of Multiple Sources

The two approaches offer different costs and benefits

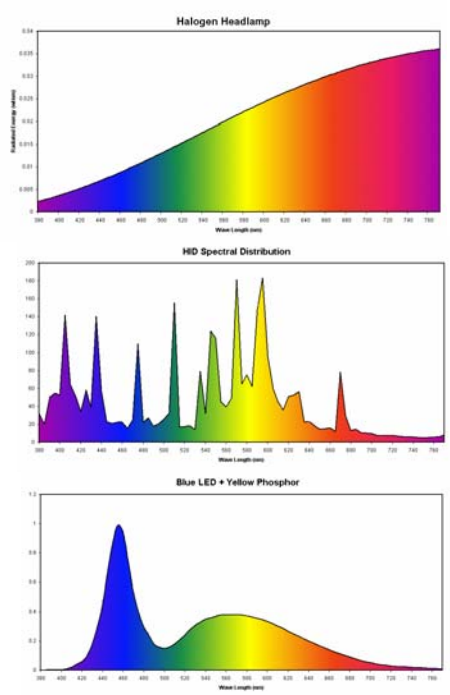
Spectrum Uniformity

Visibility

- Object Recognition (Color Rendering)
  - Halogen CRI = 100
  - HID CRI = 65
  - LED CRI = 70

Glare

Negligible Impact



Higher CRI is desirable, but it does not affect performance

Spectrum:
Short Wavelength Content

Visibility

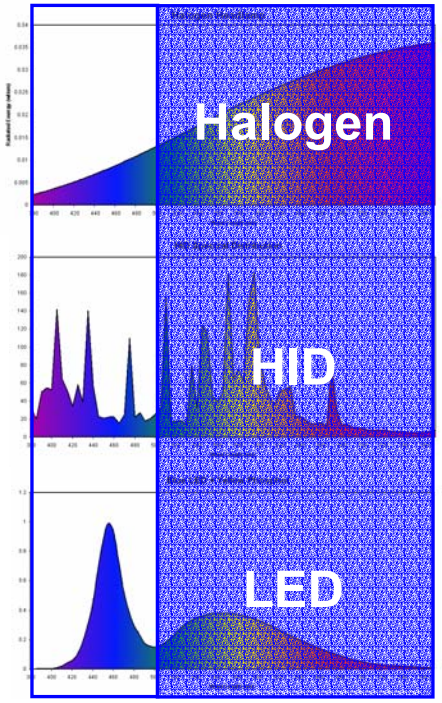
↑ Peripheral Vision (Rod Cell)

Glare

↑ Discomfort Glare

Other

↑ Styling



- Halogen — Little light at short wavelengths
- HID — Greater light at short wavelengths
- LED — Greater light at short wavelengths

Wavelength is a trade-off between peripheral vision & glare

Improved Lumen Maintenance

Visibility

↑ More Light for Old Cars

Glare

Negligible Impact

- Halogen 70% at 2000 hrs (Beyond the life of many halogen sources)
- HID 80% at 2000 hrs
- LED Too Early to Tell (~Life of Vehicle)

New Technology will provide better long term performance

Increased Energy Efficiency

Visibility

Better Performance From HID

Glare

Negligible Impact

Other

↑ Fuel Economy

- Halogen — Baseline
- HID — ~ 3 x Halogen
- LED — Similar to Halogen (Progressing Rapidly)

Higher efficiency can drive vehicle system savings

Increased Reliability

Visibility

Negligible Impact

Glare

Negligible Impact

Other

↑ Lower Warranty

- Halogen — Baseline
- HID — ~ 3 x Halogen (Life of Vehicle)
- LED — Too Early to Tell (~Life of Vehicle)

Better reliability reduces the number of cars with failed lights

System Interactions & Conclusions

Visibility

- Significant

Glare

- Significant

- Voltage Sensitivity
- Vibration Sensitivity
- Tolerance of Matching Parts
- Switching & Operating Cycle

New Technology	*Provides Improved Capability*
System Interactions	*Performance Requires Team Work*
Tradeoffs	*Light Source Design & Application is a Balance*

Any Questions?