NONIONIZING RADIATION PROTECTION SPECIAL STUDY
EVALUATION OF THE LASER INSTRUMENTATION BEACON
DEVELOPED FOR OPERATIONAL TEST AND EVALUATION AGENCY
SEPTEMBER - OCTOBER 1976.

Approved for public release; distribution unlimited.

US ARMY
ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MD 21010
A laser radiation protection special study of the laser instrumentation beacons constructed for the Operational Test and Evaluation Agency by Harry Diamond Laboratories was conducted by this Agency on 16 September 1976.

Radiometric measurements indicated that these systems are Class II He-Ne laser products and, therefore, do not pose a momentary viewing hazard.
NONIONIZING RADIATION PROTECTION SPECIAL STUDY NO. 42-0306-77
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ABSTRACT

A laser radiation protection special study of the laser instrumentation beacons constructed for the Operational Test and Evaluation Agency by Harry Diamond Laboratories was conducted by this Agency on 16 September 1976.

Radiometric measurements indicated that these systems are Class II He-Ne laser products and, therefore, do not pose a momentary viewing hazard. It is recommended that unprotected personnel not be permitted to stare into the beam within 81 m of the laser or 1 km when viewing thru optical instruments, that the attenuating filters be used whenever possible to reduce the laser output and that the appropriate warning label be conspicuously attached to the device housing.

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1. AUTHORITY.


2. REFERENCES.

   a. AR 10-5, Department of the Army, 1 April 1975.

   b. AR 40-46, Control of Health Hazards from Lasers and Other High Intensity Optical Sources, 6 February 1974.

   c. TB MED 279, Control of Hazards to Health from Laser Radiation, 30 May 1975.


3. PURPOSE. To evaluate potential health hazards associated with the use of the laser instrumentation beacon developed for OTEA and to make recommendations designed to limit exposure of personnel to potentially hazardous radiation from this device.

4. GENERAL.

   a. Background. The Electro-Optics Systems Branch of the Harry Diamond Laboratories constructed several laser instrumentation beacons for the OTEA. The systems each consisted of a Metrologic Model 620 He-Ne laser. The laser beam was mechanically chopped to produce a unique "dot-dash" type of code. The beacons were developed to test various night vision devices. They will be mounted and boresighted with the night vision devices under test. Downrange observers (0.5 to 3.0 km) will determine when they are being tracked by a night vision device, and from the code they will be able to discern which device is doing the tracking.
b. **Inventory.** Eleven units plus two spare units were constructed by Harry Diamond Laboratories at the time of this study.

c. **Instrumentation.**

(1) EG&G Model 580 Radiometer System with Model 22A Detector Head.

(2) United Detector Technology Model 40X Optometer.

(3) Scientech Model 362 Disk Colorimeter.

(4) Tektronix Model 7633 Storage Oscilloscope.

d. **Radiometric Terms and Units.** The Appendix provides a table of the radiometric terms and units utilized in this report.

5. **FINDINGS.**

a. **Laser Parameters.** Two completed laser instrumentation beacons and six additional Metrologic Model 620 He-Ne lasers were measured on 16 September 1976 at the US Army Environmental Hygiene Agency. The two completed units (SN 633-167 and SN 632-44) were mechanically chopped at a slow rate and provided attenuation of the exit laser beam by two filters. The filter select knob was marked 100 percent, 10 percent, and 5 percent transmission. The output power of the six additional lasers (SN 634-128, SN 633-19, SN 634-135, SN 632-152, SN 633-208, and SN 631-43) was also measured. The following output parameters were obtained:

(1) **Wavelength:** 632.8 nm

(2) **Duty Cycle:** The exit beam was transmitted through the mechanical chopper 32 percent of the time. The maximum continuous on-time was 0.5 s ("dash"). The "dot" on-time was 0.09 s. The off-time between "dots" and "dashes" was 0.5 s except at the end of the cycle when it was 1 s.

(3) **Modes of Operation:** Two codes were evaluated: dash-dash-dot-dot and dash-dot-dash-dot. Other codes would change the duty cycle.

(4) **Radiant Power:** The continuous output power was between 0.51 mW and 0.97 mW for all of the eight lasers.

(5) **Laser Classifications:** Class II, low-power lasers.

(6) **Emergent Beam Diameter:** Approximately 0.12 cm.

(7) **Effective Beam Divergence:** 4.4 mrad at 1/e-peak-irradiance-points measured (12.5 mrad at 90 percent power specified).
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(8) Polarization: Random.

(9) Filter Attenuation: 14 percent measured in the 10-percent position and 3.2 percent measured in the 5-percent position.

b. System Safety. A mechanical beam shutter was present on the completed units. A Class II warning label was present on the lasers as supplied by Metrologic. This label could be partially or completely covered by the Harry Diamond Laboratories modification, and hence, an additional label would be required to be attached to the device housing.

6. DISCUSSION.

a. Protection Standards. The potential hazard from the laser instrumentation beacons is limited to the unprotected eyes of individuals staring into the beam for periods greater than 0.25-second at close range. The protection standard for momentary viewing of a continuous visible laser is 1 mW through a 7-mm pupillary aperture within the blink response of the eye. Since none of the lasers exceeded 1 mW, they do not pose a momentary viewing hazard. Long-term purposeful staring into the beam (4 to 8 hours) reduces the permissible level to 1 μW/cm² averaged over a 7-mm aperture. Beyond 81 m from the laser, the irradiance was below 1 μW/cm² for intrabeam viewing without an optical instrument. Viewing the beam through 13-power optics would extend this caution range to about 1 km.

b. Other Standards. Since these devices may be used in OTEA tests in the Federal Republic of Germany, the applicable safety standards outside of US Army installations are different. The German standards (VBG 93) limit direct-beam exposure of the human eye to 5 μW/cm² for exposure durations exceeding 0.1 second. This beam irradiance occurs at a distance of 36 m from the beacon. Presumably no tests would occur within 36 m of the edge of controlled military areas.

7. CONCLUSION. The laser instrumentation beacons emit optical radiation exceeding current protection standards. However, these devices may be operated safely provided that the operators are informed of the potential hazards and take appropriate precautions.

8. RECOMMENDATIONS.

a. Do not permit unprotected personnel to intentionally (continuously) stare into the beam within 81 m of the laser (or 1 km through optical instruments). Momentary viewing is not considered hazardous (paragraph 1-4a, AR 40-46).

b. Whenever possible, use the system attenuating filters to reduce the laser output (paragraph 1-4d, AR 40-46).
c. Install a warning label on the device housing such as [paragraph 1-5d(1), AR 40-46]:

![CAUTION Label](image)

Yellow

Black

Yellow

Black Symbol

Black Lettering

LASER RADIATION

DO NOT STARE INTO BEAM

0.97 mW He-Ne Laser

Class II laser product

TERRY L. LYON

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APPENDIX

USEFUL CIE RADIOMETRIC AND PHOTOMETRIC TERMS AND UNITS

<table>
<thead>
<tr>
<th>Term</th>
<th>Symbol</th>
<th>Defining Equation</th>
<th>SI Unit and Abbreviation</th>
<th>Term</th>
<th>Symbol</th>
<th>Defining Equation</th>
<th>SI Units and Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiant Energy</td>
<td>E</td>
<td>( \frac{dI}{dt} )</td>
<td>Joule (J)</td>
<td>Quantity of Light</td>
<td>( I_t )</td>
<td>( \frac{dI}{dt} )</td>
<td>lumen-second (lm-s)</td>
</tr>
<tr>
<td>Radiant Energy Density (Watt per cubic meter)</td>
<td>( \frac{dE}{dt} )</td>
<td>( \frac{dI}{dt} )</td>
<td>Joule per cubic meter (J-m⁻³)</td>
<td>Luminous Energy Density (Watt)</td>
<td>( \frac{dE}{dt} )</td>
<td>( \frac{dI}{dt} )</td>
<td>lumen-second (lm-s)</td>
</tr>
<tr>
<td>Radiant Power Flux Density (Watt)</td>
<td>( \frac{dE}{dt} )</td>
<td>( \frac{dI}{dt} )</td>
<td>Watt (W)</td>
<td>Luminous Flux (lumen)</td>
<td>( \frac{dE}{dt} )</td>
<td>( \frac{dI}{dt} )</td>
<td>lumen (lm)</td>
</tr>
<tr>
<td>Radiant Exittance</td>
<td>( N_e )</td>
<td>( N_e = \int L_e \cos \theta , dA )</td>
<td>Watt per square meter (W-m⁻²)</td>
<td>Luminous Exittance (lumen)</td>
<td>( N_e )</td>
<td>( \frac{dE}{dt} )</td>
<td>lumen per square meter (lm-s⁻²)</td>
</tr>
<tr>
<td>Irradiance of Radiant Flux Density (Watt per square meter)</td>
<td>( E_e )</td>
<td>( E_e = \frac{dE}{dA} )</td>
<td>Watt per square meter (W-m⁻²)</td>
<td>Luminous Intensity (candela)</td>
<td>( I_e )</td>
<td>( \frac{dE}{dA} )</td>
<td>lumen per steradian (lm-ster)</td>
</tr>
<tr>
<td>Radiance</td>
<td>( L_e )</td>
<td>( L_e = \frac{dE}{dt} )</td>
<td>Watt per second steradian (W-s⁻¹)</td>
<td>Luminance</td>
<td>( L_e )</td>
<td>( \frac{dE}{dt} )</td>
<td>candela per square meter (cd-m⁻²)</td>
</tr>
<tr>
<td>Radiant Exposure</td>
<td>( H_e )</td>
<td>( H_e = \frac{dE}{dt} )</td>
<td>Watt per square meter (W-m⁻²)</td>
<td>Light Exposure</td>
<td>( H_e )</td>
<td>( \frac{dE}{dt} )</td>
<td>lux-second (lux-s)</td>
</tr>
<tr>
<td>Radiant Efficiency (^1) (of a source)</td>
<td>( p_e )</td>
<td>( p_e = \frac{E}{I_0} )</td>
<td>unitless</td>
<td>Luminous Efficacy (^2) (of a source)</td>
<td>( \eta_e )</td>
<td>( \frac{E}{I_0} )</td>
<td>lumen per watt (lm-W⁻¹)</td>
</tr>
<tr>
<td>Optical Density (^3)</td>
<td>( D_e )</td>
<td>( D_e = \log_{10} p_e )</td>
<td>unitless</td>
<td>Retinal Illuminance in Troland</td>
<td>( E_t )</td>
<td>( \frac{L_e}{L_0} )</td>
<td>lux in Troland (lx)</td>
</tr>
</tbody>
</table>

1. The units may be altered to refer to narrow spectral bands in which case the term is preceded by the word spectral, and the symbol has a subscript \( \lambda \). For example, spectral irradiance \( H_\lambda \) has units of \( \text{W-m}^{-2}\text{-m} \) or \( \text{W-m}^{-2}\text{-mm} \).
2. While the meter is the preferred unit of length, the centimeter is still the most commonly used unit of length for many of the above terms and the mm or \( \mu m \) are most commonly used to express wavelength.
3. \( E_0 \) is electrical input power in watts.�. \( \gamma \) is the transmission at the source \( \lambda = \frac{dI}{dA} \) and at a receptor \( \lambda = \frac{dI}{dA} \).
4. At the source \( \gamma = \frac{dI}{dA} \) and at a receptor \( \lambda = \frac{dI}{dA} \).
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