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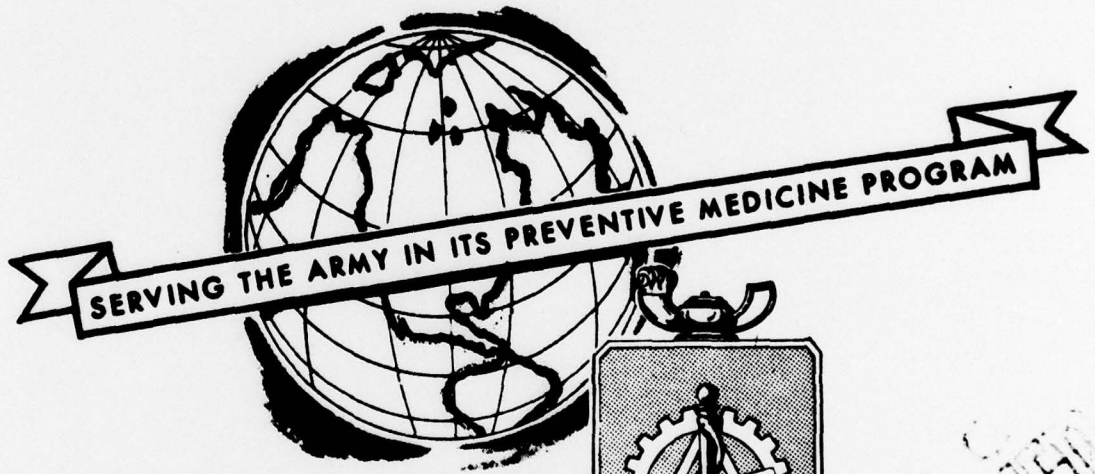
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NONIONIZING RADIATION PROTECTION SPECIAL STUDY NO. 42-0320-77
PRODUCTION MODELS, LASER MARKSMANSHIP SYSTEM
TRAINING AIDS SERVICE OFFICE
FORT GORDON, GEORGIA
DECEMBER 1976



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U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
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10 Pedro F. Del Valle
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9 NONIONIZING RADIATION PROTECTION SPECIAL STUDY ^{rept} 42-0320-77

6 PRODUCTION MODELS, LASER MARKSMANSHIP SYSTEM
TRAINING AIDS SERVICE OFFICE
FORT GORDON, GEORGIA
DECEMBER 1976

ABSTRACT

A laser radiation protection special study of the Training Aids Service Office (TASO), Rifle Laser Marksmanship System, was conducted at Ft Gordon by this Agency. Radiometric measurements made on 55 of 110 production model systems indicate that this laser system does not present an intrabeam viewing hazard under any operating conditions. It is recommended that these units or future systems be reevaluated if output parameters are changed to increased levels. It was also recommended that either the Food and Drug Administration exemption labels be affixed to the laser devices, or that TASO and the manufacturer certify the device according to applicable Federal regulations.

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NONIONIZING RADIATION PROTECTION SPECIAL STUDY NO. 42-0320-77
PRODUCTION MODELS, LASER MARKSMANSHIP SYSTEM
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FORT GORDON, GEORGIA
DECEMBER 1976

1. AUTHORITY.

- a. AR 40-5, Health and Environment, 25 September 1974.
- b. Letter ATMD, US Army Training and Doctrine Command, 3 October 1975, subject: Rifle Laser Marksmanship System, with indorsement thereto.

2. REFERENCES. See Appendix A for listing of references.

3. PURPOSE. To evaluate the potential eye hazards associated with the use of the production model Training Aids Service Office (TASO) Laser Rifle Simulator and to make recommendations designed to prevent exposure of personnel to potentially hazardous near-infrared laser radiation from this device.

4. GENERAL.

a. Background. The prototype Laser Marksmanship System, formerly referred to as the Laser Rifle Simulator, was developed by the US Army Electronics Command, Fort Monmouth, NJ. The production models of the Laser Marksmanship System were assembled by the TASO at Ft Gordon, GA, and were to be sent to Ft Jackson, SC, for actual use in training.

b. Inventory. At the time of this study 110 units had been assembled and were ready for shipment to Ft Jackson, SC (see the Figure). Several hundred more devices will be manufactured by TASO at Ft Gordon in the future.

c. Instrumentation.

- (1) EG&G Model 580 Radiometer System.
- (2) Calibrated Apertures.
- (3) FJW Industries Infrared Finderscope.
- (4) Tektronix Model 7633 Storage Oscilloscope.

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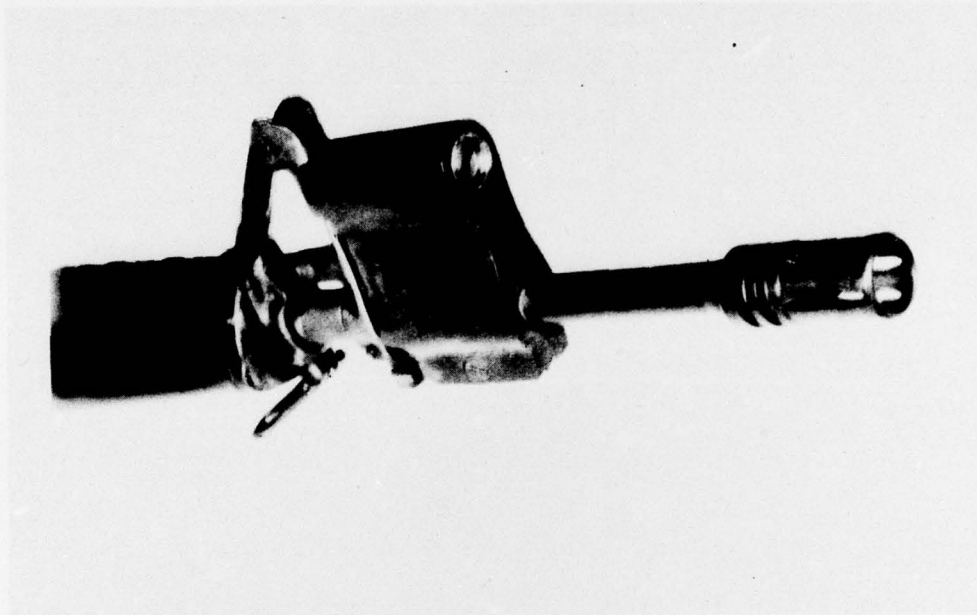


FIGURE. TASO LASER MARKSMANSHIP SYSTEM.

d. US Army Environmental Hygiene Agency (USAEHA) Measurements. Measurements on 55 of the assembled units were performed at TASO on 27 December 1976 by ILT Pedro F. Del Valle, MSC, Laser Microwave Division, USAEHA.

e. Abbreviations and Units. A Table of commonly used radiometric abbreviations and units is provided in Appendix B.

5. FINDINGS.

a. Measured Laser Parameters. The following Table lists characteristics of the Rifle Laser Marksmanship System determined from measurements made at TASO Ft Gordon.

b. Beam Characteristics as a Function of Range. Beam irradiance was measured at 0.1, 1.0 and 2.0 m. It was determined that the beam was focused at 1 m and that the effective beam diameter at that distance was smaller than a 7-mm aperture.

c. Variation in Pulse Repetition Frequency (PRF). Of the 55 lasers evaluated, 53 had a PRF of 75 Hz, system number 40 had a PRF of 140 Hz, and system number 54 had a PRF of 40 Hz. Each of these devices emitted energy levels which were below current protection standards (references 1 and 2).

6. DISCUSSION.

a. Direct Viewing. The present Army protection standard for intrabeam viewing of a single "point-source" gallium-arsenide, infrared emitting (904-nm) laser diode operating at 75 Hz is $1.5 \times 10^{-7} \text{ J/cm}^2$ or $5.8 \times 10^{-8} \text{ J}$ through a 7-mm aperture. These standards vary slightly with different PRF.

b. Laser Classification. It is desirable that training aid lasers not be considered hazardous under any condition. None of the systems measured exceeds the Army protection standard, therefore, these devices are considered Class I, Exempt, laser systems (Appendix C, TB MED 279). The lasers' outputs are also well below the Class I criteria of the Federal Regulation 21 CFR 1040 which has a limit of $4.98 \times 10^{-7} \text{ J/pulse}$.

c. Eye Examinations. Eye examinations as referred to in paragraph 5-32, AR 40-5, and paragraph 1-6, AR 40-46, are not necessary due to the absence of risk of exposure to hazardous levels of optical radiation from these devices.

7. CONCLUSION. Based upon present standards the TASO Rifle Laser Marksmanship System laser does not present an optical viewing hazard under any operating condition in field use.

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TABLE. MEASURED LASER CHARACTERISTICS

Serial No.	Energy/Pulse Q ($\times 10^{-8}J$)	Serial No.	Energy/Pulse Q ($\times 10^{-8}J$)
1	4.5	29	3.6
2	5.3	30	2.9
3	4.2	31	2.6
4	5.0	32	3.9
5	2.3	33	4.5
6	4.8	34	3.8
7	4.8	35	4.2
8	4.0	36	2.5
9	4.0	37	3.0
10	2.4	38	4.5
11	3.2	39	4.2
12	2.9	40	2.9
13	5.3	41	3.6
14	3.5	42	3.5
15	4.4	43	3.0
16	5.0	44	4.5
17	5.0	45	3.6
18	3.8	46	3.5
19	4.4	47	2.5
20	3.6	48	3.8
21	2.9	49	3.5
22	4.5	50	3.8
23	2.7	51	2.7
24	5.2	52	2.1
25	4.5	53	3.0
26	3.2	54	2.8
27	5.2	55	4.1
28	4.4		
		Mean \pm	3.77 \pm 0.87
		Standard Deviation	

8. RECOMMENDATIONS.

a. Ensure that a reevaluation of this device is performed by this Agency when significant changes are made in the laser output characteristics (paragraph 5-38, AR 40-5 and paragraph 1-5b, AR 40-46).

b. To comply with applicable Federal regulations (21 CFR 1040), TASO (the manufacturer) must choose either of the following courses of action.

(1) Demonstrate the product's compliance with the standard prior to certification by furnishing to the Bureau of Radiological Health (BRH) of the Food and Drug Administration (FDA) reports pertaining to the radiation safety of the product and the associated quality control program. Also, annual reports must be submitted, summarizing the records required to be maintained. The advantages of this course of action would be that no "Caution" labels would be required and there would be no restriction on surplus sales.

(2) As agreed upon by the exemption granted by the FDA to the Department of Defense (reference 5) for laser systems used for actual combat or combat training, place on each device an exemption label similar to the one shown below:

CAUTION

This electronic product has been exempted from FDA radiation safety performance standards prescribed in the Code of Federal Regulations, Title 21, Chapter I, Subchapter J, pursuant to Exemption No. 76EL-01DOD issued on 26 July 1976. This product should not be used without adequate protective devices or procedures.

(3) Apply to the BRH for a special Exemption for this TASO laser device to use a revised exemption label without the cautionary language and an exemption from the reporting procedures by explaining that the Department of the Army has alternative safety procedures and periodically monitors these laser products.

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(4) Manufacture the TASSO laser devices only at the installation that they will be used. The BRH has interpreted that their regulation (reference 7) applies only to laser products in commerce or moved from one installation of a large manufacturer (in this case the US Army) to another installation of that manufacturer. In this case no labels are required.

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APPENDIX A

REFERENCES

1. AR 40-46, Control of Health Hazards from Lasers and Other High Intensity Optical Sources, 6 February 1974.
2. TB MED 279, Control of Hazards to Health from Laser Radiation, 30 May 1975.
3. Report, HSE-RL/WP, this Agency, Radiation Protection Special Study No. 42-044-76, First Prototype Rifle Laser Marksmanship System, October 1975.
4. Report, HSE-RL/WP, this Agency, Nonionizing Radiation Protection Special Study No. 42-083-76, Second Prototype Rifle Laser Marksmanship System, January - February 1976.
5. Report, HSE-RL/WP, this Agency, Nonionizing Radiation Protection Special Study No. 42-303-76, Exemption from New Federal Laser Performance Standards for Tactical Army Laser Systems and Field Training Lasers, July 1976.
6. Title 21, Code of Federal Regulations (CFR), 1976 ed., Part 1040, Performance Standards for Light-Emitting Products.
7. FONECON, 21 January 1977, between Dr. Marshall Little, BRH, and Mr. David H. Sliney, USAEHA, subject: Possible Exemption of TASSO Laser Marksmanship System from Federal Laser Product Performance Standards.

APPENDIX B

TABLE 1
 USEFUL CIE RADIOMETRIC AND PHOTOMETRIC TERMS AND UNITS 1, 2

RADIOMETRIC			PHOTOMETRIC				
Term	Symbol	Defining Equation	SI Unit and Abbreviation	Term	Symbol	Defining Equation	SI Units and Abbreviation
Radiant Energy	Q_e		Joule (J)	Quantity of Light	Q_v	$Q_v = \int \phi_v dt$	lumen-second (lm·s) (talbot)
Radiant Energy Density	W_e	$W_e = \frac{dQ_e}{dV}$	Joule per cubic meter (J·m ⁻³)	Luminous Energy Density	W_v	$W_v = \frac{dQ_v}{dV}$	talbot per square meter (lm·s·m ⁻²)
Radiant Power (Radiant Flux)	ϕ_e, P	$\phi_e = \frac{dQ_e}{dt}$	Watt (W)	Luminous Flux	ϕ_v	$\phi_v = 680 \int V(\lambda) d\lambda$	lumen (lm)
Radiant Exitance	M_e	$M_e = \frac{d\phi_e}{dA} = \int L_e \cos \theta d\Omega$	Watt per square meter (W·m ⁻²)	Luminous Exitance	M_v	$M_v = \frac{d\phi_v}{dA} = \int L_v \cos \theta d\Omega$	lumen per square meter (lm·m ⁻²)
Irradiance or Radiant Flux Density (Dose Rate in Photobiology)	E_e	$E_e = \frac{d\phi_e}{dA}$	Watt per square meter (W·m ⁻²)	Illuminance (luminous flux density)	E_v	$E_v = \frac{d\phi_v}{dA}$	lumen per square meter (lm·m ⁻²) lux (lx)
Radiant Intensity	I_e	$I_e = \frac{d\phi_e}{d\Omega}$	Watt per steradian (W·sr ⁻¹)	Luminous Intensity (candlepower)	I_v	$I_v = \frac{d\phi_v}{d\Omega}$	lumen per steradian (lm·sr) or candela (cd)
Radiance	L_e	$L_e = \frac{d^2\phi_e}{d\Omega \cdot dA \cdot \cos \theta}$	Watt per steradian and per square meter (W·sr ⁻¹ ·m ⁻²)	Luminance	L_v	$L_v = \frac{d^2\phi_v}{d\Omega \cdot dA \cdot \cos \theta}$	candela per square meter (cd·m ⁻²)
Radiant Exposure (Dose, in Photobiology)	H_e	$H_e = \frac{dQ_e}{dA}$	Joule per square meter (J·m ⁻²)	Light Exposure	H_v	$H_v = \frac{dQ_v}{dA} = \int E_v dt$	lux-second (lx·s)
				Luminous Efficacy (of radiation)	K	$K = \frac{\phi_v}{\phi_e}$	lumen per watt (lm·W ⁻¹)
				Luminous Efficiency (of a broad band radiation)	$V(\theta)$	$V(\theta) = \frac{K}{K_m} = \frac{K}{680}$	unitless
Radiant Efficiency ³ (of a source)	η_e	$\eta_e = \frac{P}{P_i}$	unitless	Luminous Efficacy ³ (of a source)	η_v	$\eta_v = \frac{\phi_v}{P_i}$	lumen per watt (lm·W ⁻¹)
Optical Density ⁴	D_e	$D_e = -\log_{10} I_e$	unitless	Optical Density ⁴	D_v	$D_v = -\log_{10} I_v$	unitless
				Retinal Illuminance in Trolands	E_t	$E_t = \frac{L_v}{S_p}$	troland (td) = luminance in cd·m ⁻² times pupil area in mm ²

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 unit is then per wavelength interval and the symbol has a subscript λ . For example, spectral irradiance I_{λ} has units of W·m⁻²·m⁻¹ or more often, W·cm⁻²·nm⁻¹.
 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 nm or μ m are most commonly used to express wavelength.
 3. P_i is electrical input power in watts. 4. r is the transmission
 5. At the source $I = \frac{dI}{4\pi \cos^2 \theta}$ and at a receptor $I = \frac{dI}{d\Omega}$

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