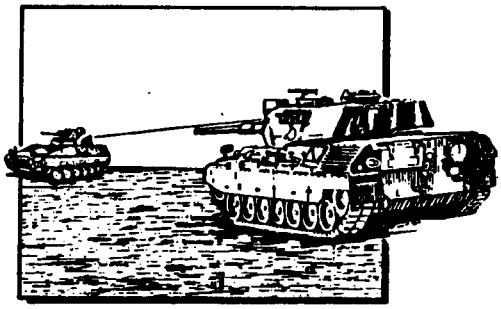
USAEHA

TG-083A

QUESTIONS AND ANSWERS

ON TANK

LASER RANGEFINDER HAZARDS



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Aberdeen Proving Ground, Maryland 21010-5422

DEPARTMENT OF THE ARMY
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ABERDEEN PROVING GROUND, MARYLAND 21010-5422

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USAEHA TECHNICAL GUIDE NO. 083A

QUESTIONS AND ANSWERS ON TANK LASER RANGEFINDER HAZARDS

1. **BACKGROUND.** This technical guide (TG) summarizes questions and answers on the hazards of vehicle-mounted laser rangefinders (LRF). It was prepared following briefings to armor units in the field by personnel from the U.S. Army Environmental Hygiene Agency (USAEHA).

2. **SCOPE.** The summary is directly applicable to:

   a. Two LRF:

      AN/VVG-1 mounted on the M551 Sheridan Vehicle

      AN/VVG-2 mounted on the M60A3 Tank

   b. One Neodymium:YAG LRF:

      AN/VVG-3 mounted on the M1A1 Abrams Tank

3. **PURPOSE.** To ensure the use of LRF to their full potential, this TG has been prepared to put to rest unwarranted worries about laser hazards. The LRF have been shown to be a significant addition to the fire control systems of combat vehicles. They greatly improve first-round hit capability with conventional ammunition.

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* This TG supersedes USAEHA TG No. 083A, March 1992.

IS THE LASER REALLY SO MUCH MORE HAZARDOUS THAN CONVENTIONAL LIGHT SOURCES?

Yes. Conventional light sources, such as an electric lamp, send their light out in all directions. The light bulb looks like an extended (large) source when viewed directly, and not a brilliant point source as does the laser. Figure 1 shows how laser light can be focused by the eye into a very small spot on the retina.

Compared with viewing a tank searchlight 100 meters (m) in front of tank, the laser would appear more than 100 million times brighter if it emitted visible light. The searchlight is only slightly less bright than the sun. The searchlight beam at 100 m is about 1/100 watt-per-square-centimeter, whereas the laser beam is about 80,000 watts per-square-centimeter.

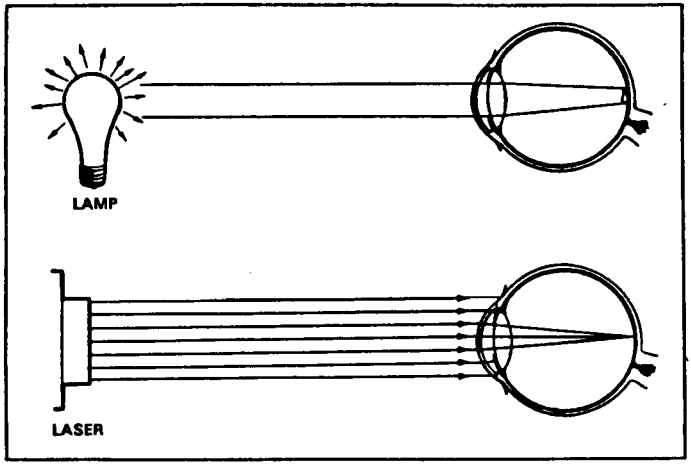

Figure 1. Comparison of Laser With Conventional Light Source.

SUPPOSE I REALLY GET IN THE LRF BEAM, WHAT CAN HAPPEN TO ME?

If you are unlucky enough to have your eye in the central part of the beam, and IF YOU ARE LOOKING BACK AT THE LRF AT A DISTANCE OF 100 M OR LESS, you will incur very serious eye injury in at least one eye. You will have a severe loss of vision for the rest of your life. As your distance from the laser increases, the severity of injury decreases.

- At 1,000 m, there is probably only a 50-50 chance of winding up with a very minimal injury - a tiny black speck in your field of view.
- At still greater distances, the chance of such injury is even less.
- Finally, at 9 kilometers (km), you may view the beam directly without protection.

HOW CLOSE TO THE CENTER OF THE BEAM MUST SOMEONE BE TO GET HURT?

- As the beam leaves the LRF, it is only 1 centimeter (cm) (3/8 inch) in diameter.
- At 100 m, it is about 10 cm (4 inches) in cross-section.
- At 1,000 m, it is 1 m (39 inches) across.

Unless a person's eye is within 1 radius of the beam center, there is little chance of injury. If it is raining, it is best to be one arm's length from the beam. Some people who have been near the beam of an M60A3 tank or an M551 have seen a bright red flash, but were not injured because they were really not close enough to the center of the beam.

IF I AM DOWNRANGE AND THE LRF BEAM IS COMING RIGHT AT ME, CAN I TAKE EVASIVE ACTION?

No. Each laser beam pulse lasts for only 20 billionths of a second. That time is so short that when it is compared with 1 second, 1 second would correspond to about a year and a half. Light traveling at 186,000 miles per second travels only 20 feet in this duration. If the laser beam was transmitted continuously for at least 1 second, your natural aversion response to bright light would limit your exposure to a quarter of a second. You simply do not have time to take evasive action from a pulsed laser beam.

HAVE THERE BEEN MANY ACCIDENTS WITH LASERS?

Yes. Although there have not been an extremely large number of laser accidents, there have been several recorded. These accidents occurred due to insufficient training and improper use of the laser equipment. Note that these accidents occurred with hand-held laser rangefinders or designators either before or after field training commenced or curtailed, not during field training.

IF A LASER WAS BEING DELIBERATELY AIMED AT ME AT CLOSE RANGE, COULD I TAKE EVASIVE ACTION?

Head movement prior to the laser firing would normally be effective. As pointed out previously, the beam is very small at close range, and it would be very difficult to deliberately aim this small laser beam, even into the eye of a cooperative subject trying to remain still. An uncooperative target would thus be difficult to injure.

ARE REFLECTIONS OF THE LASER BEAM HAZARDOUS?

Only certain surfaces are shiny enough to cause hazardous reflections. These include glass, standing water, and other flat mirror-like surfaces. Follow this rule of thumb: if you can see your reflection by looking at the surface, it is likely to cause a hazardous reflection.

HOW FAR WILL A REFLECTION BE HAZARDOUS?

A mirror-like ("specular") reflection is only a significant hazard only if the reflecting surface is flat. A glancing reflection from a flat glass surface can be as hazardous as the main beam. Curved surfaces (such as chrome bumpers and wraparound windshields) will spread the beam and a hazardous condition will only exist within a few meters of these surfaces (Figure 2).

WHAT "MIRROR-LIKE" REFLECTIVE SURFACES SHOULD I WORRY ABOUT OUT IN THE FIELD?

Generally the only surfaces of concern are flat glass surfaces such as view-blocks and windows in target vehicles. Broken glass lying on the ground and pools of standing water (Figure 3) can reflect a fraction of the beam, but always in the downrange direction.

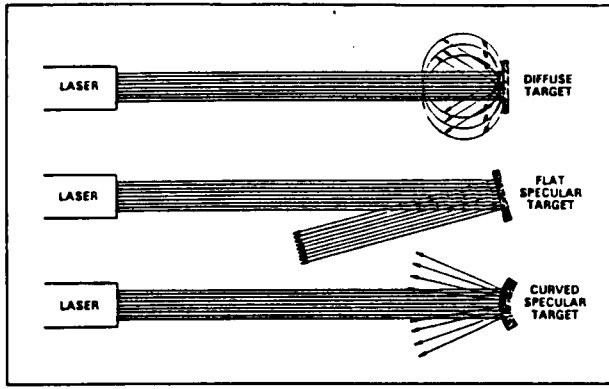

Figure 2. Only Flat, Mirror-Like Surfaces Produce Hazardous Reflections Over Significant Distances

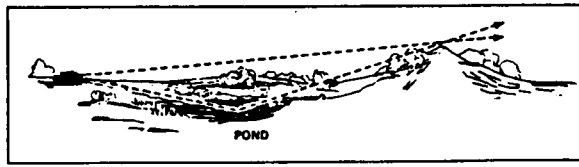

Figure 3. Specular Reflections From Standing Water

ARE REFLECTIONS FROM RAIN, SNOW, SLEET, OR WET LEAVES HAZARDOUS?

We have measured reflections from all of these and found that beyond an arm's length from the beam path these reflections are not hazardous to view.

ARE REFLECTIONS FROM DULL, DIFFUSE, OR LUSTERLESS SURFACES EVER HAZARDOUS?

Yes, but only for the ruby LRF. Only under an unusual circumstance can a reflection from a lusterless target of your ruby laser beam be hazardous. If the target is within 10 m (33 feet) of the laser port, if it is lightly colored, and if you are looking at it within 2.5 m (8 feet), then a hazardous condition exists.

If you wish to see the laser beam for a demonstration, place a lusterless target in the beam path beyond 10 m from the vehicle, or stand at least 2.5 m away from the target board. This will provide you with a better understanding of the beam size.

CAN THE LASER BEAM BE A HAZARD TO THE SKIN?

No. The LRF laser beam is not a significant hazard to the skin. The output level is too low for most people to even feel its impact on the skin, but you should not intentionally place your hand or other exposed parts of your body into the beam.

CAN THE LRF BEAM START A FIRE?

No.

WHO NEEDS LASER SAFETY GOGGLES?

Usually only personnel downrange who could be in the beam path need laser eye protection. If the range is cleared of exposed flat glass, no hazardous reflections could come back to the vehicle crew or to anyone at the firing line; hence, these personnel do <u>not</u> require eye protection.

WHERE CAN WE GET LASER SAFETY GOGGLES?

At the present time standardized anti-laser goggles are being developed for general use. Until the time these goggles become available, eye protection should be procured commercially. Assistance in this procedure can be obtained by contacting USAEHA.

In general, laser safety goggles are not considered necessary for routine training with fire-control lasers. Protection for personnel involved in special two-sided tactical exercises and for downrange personnel operating moving targets requires the use of standard laser eye protection which offers a high optical density.

DO OPTICAL SIGHTS INCREASE THE LASER HAZARD; AND WHY DO SOME SIGHTS HAVE LASER SAFETY FILTERS?

Yes, the hazard of looking into a direct beam (called "intrabeam viewing") is greatly increased when you are using a pair of binoculars, a battery commander's (BC) scope, or a telescopic sight in an armored vehicle. In effect, the viewer is placed closer to the laser by a factor of the magnifying power of the sight. As an example, if you are at 1,000 m from the laser, the hazard to your eye when looking through an 8X scope is equivalent to the unaided eye located only 1/8 that distance, 125 m, from the source.

Since hard-point targets, such as armored vehicles or fixed bunkers, are the targets of fire-control lasers, the personnel using the optical instruments at these targets have a high probability of hazardous exposure. They need protection and, fortunately, modern technology permits the use of lighter color filters in sights than in personnel safety goggles. Therefore, the filters that are built into the sights do not significantly reduce your visual ability to see targets like the snap-in filters do.

DO GREEN LASER SAFETY GOGGLES IMPAIR YOUR VISION?

Yes, to some extent. The primary difficulty in developing a standard laser-protective goggle has been the determination of how much reduced red color vision could be acceptable in a combat environment. We have learned, however, that after you have worn the green laser-protective goggles for several minutes, your eyes adjust to permit more normal vision. The red-sensitive visual cells in your retina become more sensitive, thus partially compensating for the reduction of red light by the filters.

CAN WE USE SUNGLASSES FOR LASER PROTECTION?

ABSOLUTELY NOT. Sunglasses reduce the laser light entering your eye only by 50-75 percent. Goggles suitable for protection from your ruby laser should have an optical density of 6 which is a 0.0001-percent transmission at the laser wavelength. On the other hand, the laser eye protection may transmit more total light of other colors than sunglasses. Polarizing glasses are also of little or no value as laser eye protection.

CAN WE USE LRF IN TWO-SIDED TACTICAL EXERCISES?

The headaches are many, but it is possible if all exposed personnel are equipped with laser eye protection and the maneuver site is not within line-of-sight of any uncontrolled area that can be occupied.

IS THERE REALLY ANY HAZARD TO PEOPLE IN A TOWN MORE THAN 10 KM (THE HAZARD RANGE) AWAY FROM THE LASER FIRING POSITION?

No. However, at one time consideration was given to the premise, if the laser is aimed in the general direction of the built-up area, one must always be concerned about the outside chance of someone in the town looking out toward the range with binoculars. Since binoculars extend the hazardous range, the thought was that there is no such thing as an absolutely safe distance from the laser. This is why laser range areas are selected for the presence of backstops. Recently this type of thinking has been replaced with the idea that the probability of someone viewing the range with magnifying optics is so remote that there is no reason for concern.

MUST WE HAVE A MOUNTAIN OR HILL AS A BACKSTOP?

Anything opaque to light can serve as a backstop. A line of dense trees is suitable if you cannot see through them.

IS SKYLINE LASER OPERATION PERMITTED?

The laser can be aimed at a target on the skyline (no vertical buffer zone) if the nautical airspace downrange is restricted over the range area to a distance of 10 km from the laser. No land mass that can be occupied should exist along the line-of-sight behind this skyline target.

IS IT POSSIBLE FOR TRAINING PURPOSES TO FILTER OR OTHERWISE REDUCE THE OUTPUT ENERGY OF THE LRF FOR THE PURPOSE OF SHORTENING THE HAZARDOUS DISTANCE?

Yes. To date there are eye safe simulated laser rangefinder (ESSLR) filters designed for training on the M1A1 and the M60A3 tanks.

For the M60A3 there exists two color coded filters, red and green, that attach to the exit optics of the laser rangefinder.

- The red training filter has an optical density of 2.9 and an associated hazard distance of 300 m for unaided viewing and 3.1 km for optically aided viewing.

- The green training filter has an optical density of 5.5 and attenuates the laser radiation to an eye-safe level under any viewing conditions.

The M1A1 has a ESSLR filter also. However, only one filter exists for this tank. The training filter for the M1A1 has an optical density of 4.5 and attenuates the output of the M1A1 LRF to an eye-safe level under any viewing conditions.

WHAT IS A CORNER-CUBE RETROREFLECTOR?

It is a glass prism which reflects a laser beam back precisely towards the laser, regardless of its orientation to the beam. Figure 4 shows how it works.

Reflective screens and bicycle reflectors work in a similar manner but are not nearly as efficient as a corner-cube.

Training agencies in the Army are now studying whether this approach for total LRF training safety is practical, feasible, and economically justified.

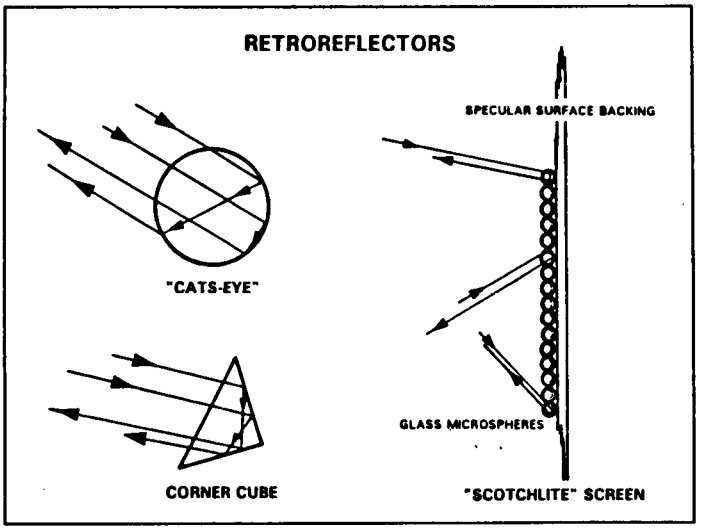

Figure 4. Retroreflection

WHO NEEDS A LASER EYE EXAMINATION?

An individual whose occupation or assignment may result in a significant risk of exposure to potentially hazardous levels of optical radiation shall have a preplacement medical examination, a termination of employment medical examination, and be included in an occupational vision program. These personnel would include individuals routinely using lasers in research, development, test and evaluation, and maintenance facilities.

However, personnel who are known or suspected to have been accidentally exposed to levels in excess of applicable laser protection standards shall be examined as soon as possible following such exposure.

Tank crewmen would not normally require examination.

WHAT ARE THE SOURCE DOCUMENTS ON LASER HAZARDS; AND WHERE CAN WE GET FURTHER INFORMATION?

The source documents are:

- TB MED 524, Control of Hazards to Health from Laser Radiation, 20 June 1985.
- AR 40-46, Control of Health Hazards from Lasers and Other High Intensity Optical Sources, 6 February 1974.
- AR 40-5, Preventive Medicine, 15 October 1990.
- DA Pam 385-63, Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat.

Additional information can be obtained by contacting Laser Microwave Division, USAEHA, Aberdeen Proving Ground, MD 21010

- DSN 584-3932/2331
- Commercial (410) 671-3932/2331

ARE LASER TRAINING DEVICES HAZARDOUS?

It depends upon which laser training devices you are referring to. For example:

- The MILES equipment is safe for field use.
- The M-55 training device is not hazardous in the pulsed mode and can only be considered marginally hazardous in the alignment mode where the laser transmits continuously. Do not look into the alignment beam.

ARE THERE ANY MAINTENANCE PROCEDURES THAT HAVE AN IMPACT ON LRF HAZARDS?

Yes. In particular, the installation of the AN/VVG-1 LRF on the M551 requires that the LRF be aligned with the tank's sighting optics. Improper alignment could result in the direction of the laser beam outside of a controlled target area. However, there are only about 100 of these vehicles left in the current inventory.

IS THE LRF IN THE M1A1 TANK JUST AS HAZARDOUS AS THE LRF IN THE M60 TANK?

No. Since the M1A1 LRF is a neodymium LRF, it operates at a safer wavelength in the infrared (1,064 nanometers). The ocular hazard distance is 7,000 m.