

Conf-9411141--1  
SAND94-2625C

## Light Shaping Diffusers™ Improve Aircraft Inspection

by

Richard N. Shagam, Ph.D.  
Sandia National Laboratories  
Albuquerque, NM 87185-0615  
(505)-845-9079

and

Rick Shie, Jeremy Lerner  
Physical Optics Corporation  
20600 Gramercy Place, Building 100  
Torrance CA 90501  
(310)-320-3088

### SUMMARY

Physical Optical Corporation has introduced a Light Shaping Diffuser™ (LSD) for the specialized illumination requirements of aircraft inspection. Attached to a handheld, battery-powered flashlight, this light-weight, holographic diffuser element provides bright, even illumination as aircraft inspectors perform the important task of visually examining aircraft for possible structural defects. Field trials conducted by the Aging Aircraft Program at Sandia National Laboratories confirm that the LSD-equipped flashlights are preferred by visual inspectors over stock flashlights.

### AIRCRAFT INSPECTION IS A VISUAL PROCESS

Over 80 percent of aircraft inspection is performed visually. Aircraft inspectors must be able to illuminate the exterior surface of the plane, as well as interior areas, from a number of different angles. Many times an inspector must examine areas that have difficult accessibility. Thorough visual examination allows the trained eye to detect glints or shadows that could indicate cracks, scratches or corrosion in metallic components, or other underlying structural problems.

In close inspection work, the contrast between the background and the target area being illuminated is critical. Many times the structural defect is obvious; however, sometimes the effect that the inspector is looking for is subtle. For example, wavy surfaces--detected by grazing incidence illumination--may signal corrosion below the surface.

### UNEVEN ILLUMINATION DEGRADES AIRCRAFT INSPECTION

Aircraft inspectors traditionally have used handheld, portable, battery-powered flashlights to provide local lighting to otherwise dimly or un-illuminated areas of an aircraft structure. However, the greatest problem with flashlights is uneven illumination. A large number of flashlights on the market today have poor beam quality--an irregular shape and illuminance distribution because of the shapes of the reflector, the filament, and envelope of the bulb. Hot spots, dark spots and holes in the beam predominate.

Unfortunately, these factors tend to reduce the useful area of the flashlight beam to 70 percent or more *below* the peak beam illuminance. The visual result is loss of contrast in the scene being illuminated. The inspector may be examining a surface that appears as if it is in a shadow; inspection efficiency and accuracy suffer because of poor illumination. The inspector must sweep the site with his flashlight more carefully in order to screen out the shadows cast onto the surface. Moreover, during the course of an inspection (and often within only two hours of continuous use), battery performance of the flashlight will drop off significantly. Inspectors tend to use the flashlights for several hours and may be unaware that the intensity of the beam has diminished. With decreased scene illumination and loss of contrast an inspector could miss important defects. For these reasons, it is important that every lumen from a portable, handheld flashlight be efficiently used.

"Wall-plug" sources of light can offer brighter and more even lighting than do flashlights. However, they present a dangerous trip hazard to inspectors and other personnel. They also severely restrict the portability that a visual inspector requires for access to all areas of an aircraft. Visual inspectors often state that they would refuse to use illumination devices with a power cord.

### THE LIGHT SHAPING DIFFUSER ELIMINATES UNEVEN ILLUMINATION

A simple and low cost improvement easily adaptable to most commercial flashlights is the Light Shaping Diffuser from Physical Optics Corporation. It is an effective means for converting a non-uniform light beam into a smooth beam that improves the quality of an inspection. With a uniform, homogenized beam as an illumination source, the aircraft inspector is more likely to concentrate on the surface under observation, rather than on the properties of the beam. This fact is echoed by aircraft inspectors themselves, who have consistently reported that they prefer a flashlight with a more uniform beam for close inspection work.

The unique design and technical feature of the LSD, when combined with an existing commercial flashlight, provides ideal illumination for close inspection. It is a plastic disk that substitutes for the clear plastic or glass lens element in an adjustable or fixed-focus flashlight. A proprietary holographic replication process randomizes the phase of the transmitted light and scatters it so that over 90 percent of the flashlight beam is transmitted to the target in a narrow beam. The LSD can be compared to a refractive negative lens in that it bends light, but its surface is analogous to randomly distributed microlenses in varying sizes, that produce the desired diffusion angle. The benefit of using an LSD is that the projected spot from the flashlight is homogenized and made more uniform. The diffuser element smoothes out irregularities in the beam and eliminates glare and hot spots. Unlike other holographic optical elements, LSDs are not wavelength-sensitive; they diffuse light throughout the visible spectrum. They perform extremely well in white light from any source, including fluorescent, filament lamps, LEDs, tungsten halogen lamps and arc lamps.

#### FIELD TESTS DEMONSTRATE IMPROVEMENT

At Sandia National Laboratories in Albuquerque, researchers testing flashlights equipped with Physical Optics Corporation's Light Shaping Diffuser found them to be superior to currently commercially available flashlights. The FAA-sponsored Aging Aircraft Program at Sandia permits manufacturers to preview non-destructive evaluation methods on an actual high cycle Boeing 737 aircraft housed in a hangar on the premises. Field trials of LSDs among inspection and maintenance personnel at the hangar and at several commercial airlines yielded very positive results. Aircraft inspectors participating in the study readily adopted the new LSDs as part of their methodology; in fact, many were reluctant to give them up when the test was over. Most inspectors found that the LSD-equipped flashlights were less visually tiring to use than conventional flashlights. In practical applications in an actual work situation, inspectors preferred flashlights equipped with LSDs from Physical Optics Corporation over non-LSD-equipped flashlights. Simple and low cost, the diffuser elements added significant value during close inspection work.

*Richard N. Shagam, Ph.D. is a Senior Member of the Technical Staff of the Aging Aircraft Program at Sandia National Laboratories in Albuquerque, New Mexico. Dr. Shagam has performed numerous tests on LSDs™, in cooperation with commercial airlines. Rick Shie, sales manager of the Product & Engineering division of Physical Optics Corporation in Torrance, California, is responsible for worldwide marketing of Light Shaping Diffusers™. This work was performed, in part, for the Federal Aviation Technical Center under US Department of Transportation Contract #DTFA-03-91-A0018.*

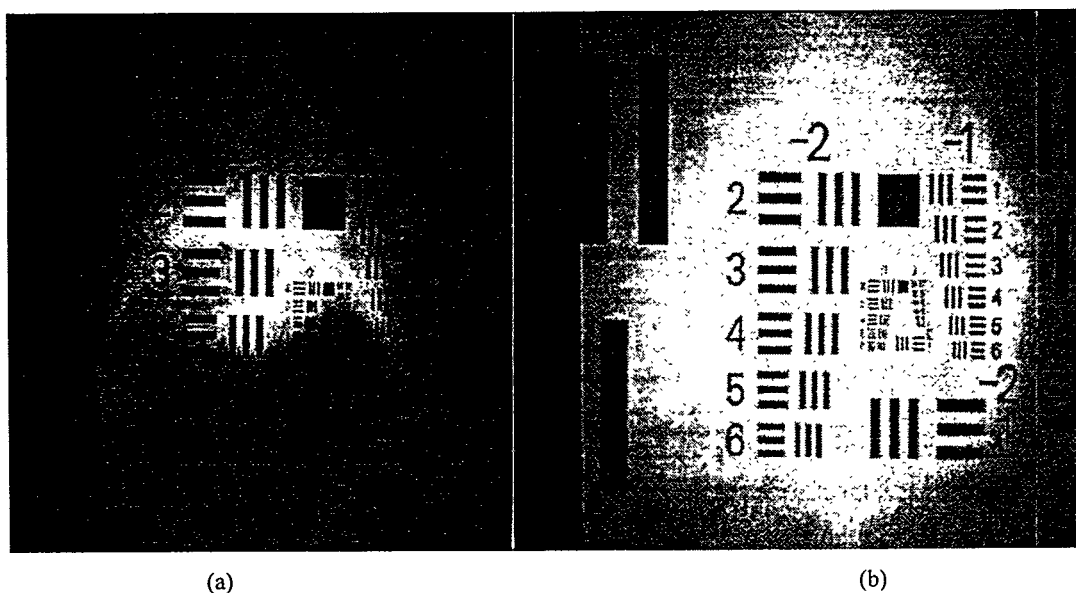


Figure 1: A resolution target illuminated by a flashlight (a) without and (b) with a Light Shaping Diffuser

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

## **DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**