

TEST REPORT

CLIENT: Applied Innovative Technologies
PO Box 754
Fort Lupton, CO 80621
Attn.: Steve Vettori

MATERIALS: Thirteen new Nightstar flashlights were delivered by the client and marked with numbers "1" through "13" by Hauser. All the flashlights were clear. Flashlights 1-12 were identical. Flashlight #13 was identified as an "improved version" and had a foam insert inside the unit as a sound damper, an improved seal around the lens, and an additional flat area on the side of the handle with the marking "Nature and technology can coexist."

TESTS: The flashlights were evaluated for durability, functionality, and performance by four different tests: exposure to temperature extremes, exposure to external water pressure, immersion in various chemicals, and light penetration through smoke. Functionality was verified before and after each test by shaking the flashlight to charge the capacitor, operating the switch and observing whether the LED produced light (a simple "on" or "off" determination). After each test, the flashlights were also visually inspected for any damage or changes.

Temperature Test: Five flashlights were exposed to operating temperature extremes and storage temperature extremes as defined by the client. For the operating temperature test, the flashlights were placed in a chamber at -40°C for a period of 3 hours and then immediately checked for functionality. This was then repeated at +55°C. These flashlights were then subjected to the storage temperature test, which consisted of 10 temperature cycles as follows: 5 hours at +60°C, a 2-hour transition to -50°C, 5 hours at -50°C, and a 2-hour transition to +60°C. After the storage test, the flashlights were returned to room temperature and again checked for functionality.

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Chemical Compatibility Test: Following the temperature test, each flashlight was exposed to one of the chemicals listed in the Results section of this report. Each flashlight was completely immersed in the chemical for a period of three days at room temperature. The chemicals were not refreshed during the exposure. Following the exposure, the flashlights were removed, rinsed or wiped off, inspected and checked for functionality.

Water Pressure Test: Following the chemical compatibility tests, four flashlights were subjected to hydrostatic water pressure to determine the depth to which they could be submerged without leakage or failure. Each flashlight was placed in a pressure vessel filled with water and gradually pressurized to 200 feet of water (86 psi). The flashlights were then inspected for damage or evidence of water leakage. This was then repeated at pressure levels of 500 feet of water (215 psi), 1000 feet (430 psi), and then to failure if the flashlight was still undamaged.

Light Penetration through Smoke: One Nighstar flashlight was used to demonstrate and measure the amount of light that penetrates through a smoke cloud. Testing was comparative, using a "medium" size Maglite® brand flashlight (model S2C016, which uses 2 C-size batteries). New Energizer® brand batteries were used for all the tests. Testing was conducted in a sealed 2 x 2 x 8 foot box, with the lights shining in the 8-foot direction. The lens of both flashlights was placed at one end of the box. A light meter was placed at a distance of either 4 feet or 8 feet from the lens of the flashlights. The Maglite was adjusted so that its light pattern was approximately the same size as the Nightstar's pattern. The flashlights and the light meter were oriented so that the center of the light pattern was on the center of the meter. The light sensor was approximately 0.9 inches in diameter. The box also included provision so that the light meter could be mounted in the same plane as the flashlight lenses, so that a measurement of the amount of light reflected off the smoke cloud could be taken. The smoke box included a Bunsen burner apparatus for igniting or smoldering materials to produce a smoke cloud. A small fan was used to evenly distribute the smoke throughout the box.

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The following procedure was used to run a test. Baseline light output measurements from each flashlight were taken with no smoke in the box. These measurements were taken at distances of 8 feet and 4 feet. The box was then filled with smoke. Light output measurements were then taken at 8 feet and 4 feet and 0 feet (reflected light), in that order. A second measurement at 8 feet was then taken as an indication of how quickly the smoke cloud was changing with time, due to leakage from the chamber or condensation of the smoke on the box surfaces. Both flashlights were turned on for 30 seconds before a reading was recorded. The readings from each flashlight were taken within a minute of each other. The Nightstar flashlight was always recharged before each measurement. It was found that consistent light output readings from the Nightstar flashlight could be obtained by allowing it to be on for 2 minutes before recharging. Recharging was done by 90 shakes as directed in the manufacturer's instructions. Smoke from three different sources was used: smoldering paper, burning rubber bands, and smoldering dry leaves.

For additional light information, the total light output from each flashlight was measured by placing each flashlight directly against the sensor of a light meter. The light meter used for this test had a sensor diameter of approximately 1.65 inches – similar to the lens area of both flashlights. The light pattern from each flashlight was also mapped in the X and Y axes by taking readings at 1 or 2 inch intervals. Measurements were taken at a distance of 4 feet. The Maglite's pattern size was the same as that used in the smoke testing. The light sensor size used for mapping was 0.9 inches in diameter.

Testing was performed on January 28 – April 30, 2003.

RESULTS: Temperature Test: All five flashlights were functional after the operational temperature exposure and after the storage temperature exposure. No damage or changes were observed by visual inspection.

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Chemical Compatibility Test: The chemicals used and observations of functionality, damage or change are shown in Table 1 below.

Table 1. Chemical Compatibility Test Results			
flashlight	chemical	functional?	observations
7	isopropyl alcohol	yes	Blue lens retainer ring fell out, but lens was intact and sealed.
10	methanol	no	Blue lens retainer ring loose, but lens was intact and sealed. The switch was swollen and inoperable.
11	motor oil	yes	
9	ammonia cleaner, undiluted	yes	
6	diesel fuel	yes	
12	gasoline	no	Switch was swollen and soft and was inoperable. The lens was slightly cloudy and the body turned white. The blue lens retainer was loose, but the lens was intact and sealed.
1	bleach, undiluted	yes	Significant crazing on body and lens.
3	5% saltwater	yes	
8	10% acetic acid	yes	
2	10% phosphoric acid	yes	
5	10% Ajax cleaner solution	yes	
4	10% Drano solution	yes	Brown residue around edge and underneath the switch.

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Water Pressure Test: The results from the water pressure test are shown in Table 2 below.

Table 2. Water pressure test results.	
flashlight	result
9	Cracked the body at 1200 feet of water (520 psi) and filled the flashlight with water. Light still functioned normally (had to drain out the water to charge it by shaking).
3	A small amount of water was found inside the light after exposure to 200 feet of water (86 psi); the light still functioned normally. Testing was continued until failure of the body at 1480 feet of water (640 psi). The body failed by flattening between the coil and the power cell. The inner tube was fractured by crushing, but the outer tube was only deformed. The body was still near-watertight, as there was no significant increase in the amount of water inside the light.
11	A small amount of water was found inside the light after exposure to 200 feet of water (86 psi); the light still functioned normally. Testing was continued until failure of the body at 1430 feet of water (620 psi). The body failed by flattening between the coil and the power cell. The inner tube was cracked on one side. The outer tube was deformed, but did not fracture. The light was approximately half full of water; the location of the leak was likely somewhere around the lens.
13 (improved version)	No leaks or failures were observed when inspected after exposure to 1000 feet of water (430 psi). During the next pressurization increment, a pressure fluctuation was observed at 1430 feet of water (620 psi), again at 1730 feet of water (750 psi), and again at 2210 feet of water (960 psi) accompanied by a sharp audible noise. The test was stopped and the light inspected at this point. The body of the light was deformed in three locations: flattening between the coil and the power cell, flattening to a lesser degree between the coil and the bottom end of the light, and deformed in a convoluted manner around the power cell. The pressure fluctuations likely occurred as each section deformed. There was no water inside the light.

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Light Penetration through Smoke: The amount of light transmitted through each type of smoke cloud is shown in Tables 3, 4 and 5.

Graphs 1 and 2 show the mapping of the light pattern from each type of light. Graph 3 shows the total light output of the Maglite over time (as the batteries wear out), measured with the meter against the lens of the flashlight.

Images 1 - 3 were taken with a digital camera in place of the light meter in the smoke box at a distance of 8 feet from the flashlights. These images were taken to give a visual indication of the appearance of the lights through smoke. In each image, both lights were on and had been on for approximately 30 seconds.

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Table 3. Smoke penetration test results at 8-foot distance				
smoke type	flashlight	baseline light (Lux)	light through smoke (Lux)	amount of baseline light transmitted (%)
paper	Nightstar	1.73	0.25	14.4
	Maglite	250	18.4	7.4
rubber band	Nightstar	1.89	0.23	12.2
			0.37	19.6
	Maglite	259	14.8	5.7
			25.7	9.9
leaves	Nightstar	1.68	0.51	30.4
			0.66	39.4
	Maglite	240	48.0	20.0
			59.9	25.0

Results shown in the shaded boxes are from measurements taken approximately 12 minutes after the first measurements.

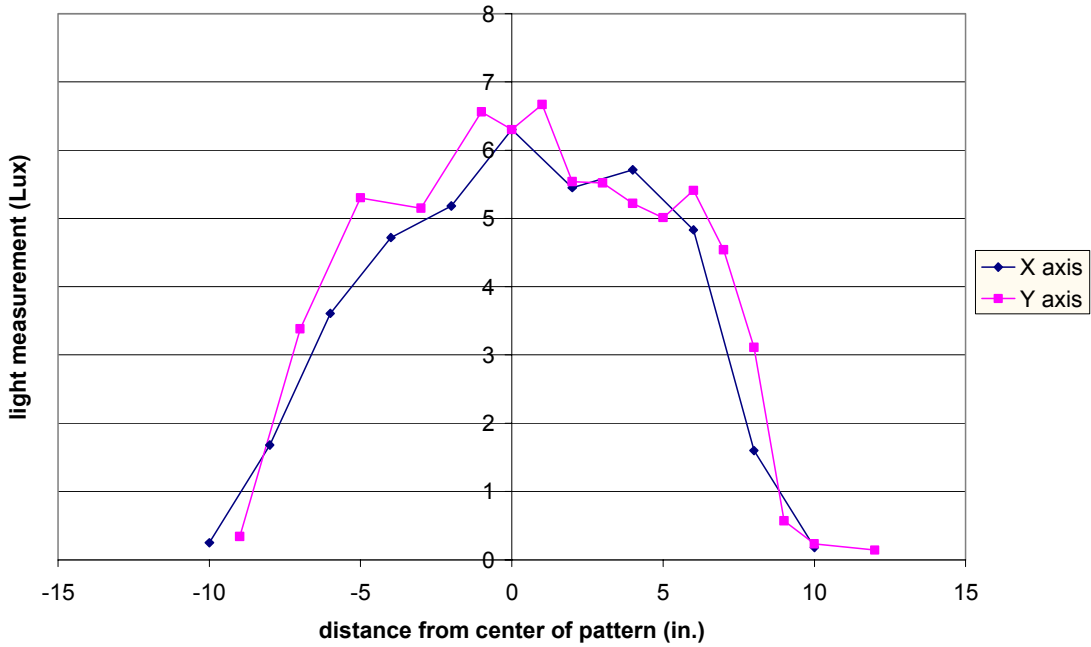
Table 4. Smoke penetration test results at 4-foot distance				
smoke type	flashlight	baseline light (Lux)	light through smoke (Lux)	amount of baseline light transmitted (%)
paper	Nightstar	7.06	2.59	36.7
	Maglite	690	191	27.7
rubber band	Nightstar	6.71	2.37	35.3
	Maglite	699	166	23.8
leaves	Nightstar	5.96	3.38	56.7
	Maglite	587	279	47.5

Table 5. Light reflectance test results			
smoke type	flashlight	light reflected off of smoke (Lux)	reflected light as percentage of total flashlight output, (%)
rubber band	Nightstar	0.11	0.0045
	Maglite	2.27	0.012
leaves	Nightstar	0.08	0.0033
	Maglite	1.88	0.010

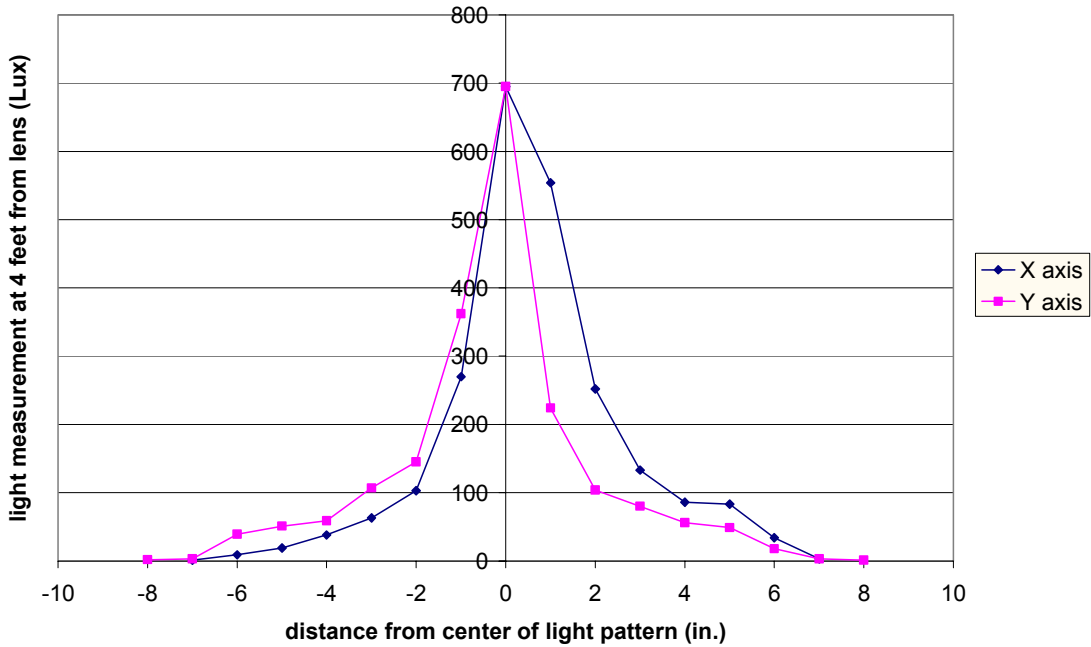
The total amount of light output from the flashlights, measured with the meter against the lens, was 2,430 Lux for the Nightstar and 18,300 Lux for the Maglite.

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Graph 1. Light pattern map of Nightstar

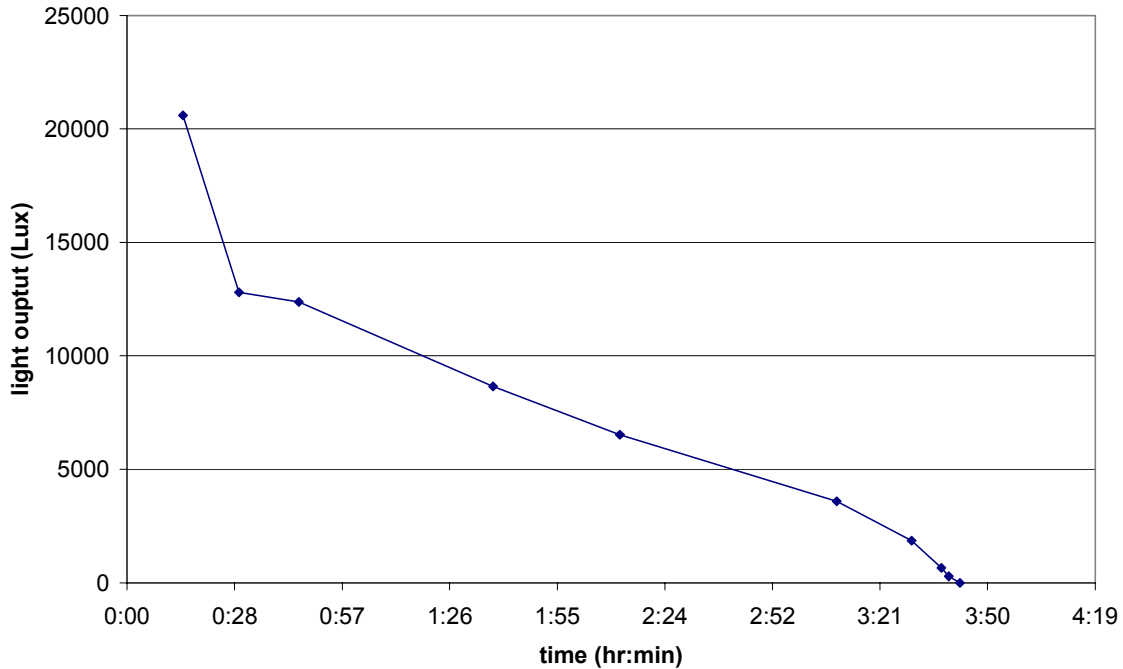


Graph 2. Light pattern map of Maglite



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Graph 3. Total light output of Maglite over time



Graph 3 above shows the total light output from the Maglite over time, as the batteries wear out. The light had been used for a time estimated to be about 15 minutes in previous testing before this data was taken. The total light output was measured with the lens placed directly against the meter. The total light output with a different, new set of batteries was measured at 29,500 Lux after 30 seconds of total use. The light output dropped to 20,300 Lux after 14 minutes of continuous use.

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Image 1. Light from both flashlights with no smoke in the box. The light output at 8 feet was measured at 172 Lux for the Maglite and 1.92 Lux for the Nightstar.

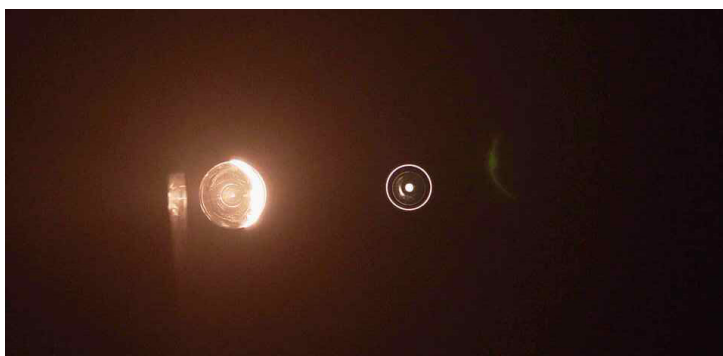


Image 2. Light from both flashlights with the box full of smoke from smoldering paper. The Nightstar is the light on the right. The light output at 8 feet was measured at 1.32 Lux for the Maglite and 0.07 Lux for the Nightstar.



Image 3. Light from both flashlights after some of the smoke was removed from the box. The light output from the Maglite was measured at 3.61 Lux and the output from the Nightstar was 0.16 Lux.

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REPORT BY:

John Hindman,
Engineer III

REPORT REVIEWED BY:

Lynette Lobmeyer,
Department Manager

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