



National Institute of Justice

Law Enforcement and Corrections Standards and Testing Program

NEW TECHNOLOGY BATTERIES GUIDE

NIJ Guide 200-98

ABOUT THE LAW ENFORCEMENT AND CORRECTIONS STANDARDS AND TESTING PROGRAM

The Law Enforcement and Corrections Standards and Testing Program is sponsored by the Office of Science and Technology of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which created NIJ and directed it to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

The Law Enforcement and Corrections Standards and Testing Program is an applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationally and internationally.

The program operates through:

The *Law Enforcement and Corrections Technology Advisory Council* (LECTAC) consisting of nationally recognized criminal justice practitioners from Federal, State, and local agencies, which assesses technological needs and sets priorities for research programs and items to be evaluated and tested.

The *Office of Law Enforcement Standards* (OLES) at the National Institute of Standards and Technology, which develops voluntary national performance standards for compliance testing to ensure that individual items of equipment are suitable for use by criminal justice agencies. The standards are based upon laboratory testing and evaluation of representative samples of each item of equipment to determine the key attributes, develop test methods, and establish minimum performance requirements for each essential attribute. In addition to the highly technical standards, OLES also produces technical reports and user guidelines that explain in nontechnical terms the capabilities of available equipment.

The *National Law Enforcement and Corrections Technology Center* (NLECTC), operated by a grantee, which supervises a national compliance testing program conducted by independent laboratories. The standards developed by OLES serve as performance benchmarks against which commercial equipment is measured. The facilities, personnel, and testing capabilities of the independent laboratories are evaluated by OLES prior to testing each item of equipment, and OLES helps the Technology Center staff review and analyze data. Test results are published in Equipment Performance Reports designed to help justice system procurement officials make informed purchasing decisions.

Publications are available at no charge from the National Law Enforcement and Corrections Technology Center. Some documents are also available online through the Internet/World Wide Web. To request a document or additional information, call 800-248-2742 or 301-519-5060, or write:

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The National Institute of Justice is a component of the Office of Justice Programs, which also includes the Bureau of Justice Assistance, Bureau of Justice Statistics, Office of Juvenile Justice and Delinquency Prevention, and the Office for Victims of Crime.

New Technology Batteries Guide

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Director, Office of Science and Technology.

FOREWORD

The Office of Law Enforcement Standards (OLES) of the National Institute of Standards and Technology furnishes technical support to the National Institute of Justice program to strengthen law enforcement and criminal justice in the United States. OLES's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

OLES is: (1) subjecting existing equipment to laboratory testing and evaluation, and (2) conducting research leading to the development of several series of documents, including national standards, user guides, and technical reports.

This document covers research conducted by OLES under the sponsorship of the National Institute of Justice. Additional reports as well as other documents are being issued under the OLES program in the areas of protective clothing and equipment, communications systems, emergency equipment, investigative aids, security systems, vehicles, weapons, and analytical techniques and standard reference materials used by the forensic community.

Technical comments and suggestions concerning this report are invited from all interested parties. They may be addressed to the Director, Office of Law Enforcement Standards, National Institute of Standards and Technology, Gaithersburg, MD 20899.

David G. Boyd, Director
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BACKGROUND

The Office of Law Enforcement Standards (OLES) was established by the National Institute of Justice (NIJ) to provide focus on two major objectives: (1) to find existing equipment which can be purchased today, and (2) to develop new law-enforcement equipment which can be made available as soon as possible. A part of OLES's mission is to become thoroughly familiar with existing equipment, to evaluate its performance by means of objective laboratory tests, to develop and improve these methods of test, to develop performance standards for selected equipment items, and to prepare guidelines for the selection and use of this equipment. All of these activities are directed toward providing law enforcement agencies with assistance in making good equipment selections and acquisitions in accordance with their own requirements.

As the OLES program has matured, there has been a gradual shift in the objectives of the OLES projects. The initial emphasis on the development of standards has decreased, and the emphasis on the development of guidelines has increased. For the significance of this shift in emphasis to be appreciated, the precise definitions of the words "standard" and "guideline" as used in this context must be clearly understood.

A "standard" for a particular item of equipment is understood to be a formal document, in a

conventional format, that details the performance that the equipment is required to give, and describes test methods by which its actual performance can be measured. These requirements are technical, and are stated in terms directly related to the equipment's use. The basic purposes of a standard are (1) to be a reference in procurement documents created by purchasing officers who wish to specify equipment of the "standard" quality, and (2) to identify objectively equipment of acceptable performance.

*A standard is not intended to inform
and guide the reader; that is the
function of a guideline*

Note that a standard is not intended to inform and guide the reader; that is the

function of a "guideline." Guidelines are written in non-technical language and are addressed to the potential user of the equipment. They include a general discussion of the equipment, its important performance attributes, the various models currently on the market, objective test data where available, and any other information that might help the reader make a rational selection among the various options or alternatives available to him or her.

This battery guide is provided to inform the reader of the latest technology related to battery composition, battery usage, and battery charging techniques.

Kathleen Higgins

National Institute of Standards and Technology

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COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere	H	henry	nm	nanometer
ac	alternating current	h	hour	No.	number
AM	amplitude modulation	hf	high frequency	o.d.	outside diameter
cd	candela	Hz	hertz (c/s)	Ω	ohm
cm	centimeter	i.d.	inside diameter	p.	page
CP	chemically pure	in	inch	Pa	pascal
c/s	cycle per second	ir	infrared	pe	probable error
d	day	J	joule	pp.	pages
dB	decibel	L	lambert	ppm	part per million
dc	direct current	L	liter	qt	quart
$^{\circ}\text{C}$	degree Celsius	lb	pound	rad	radian
$^{\circ}\text{F}$	degree Fahrenheit	lbf	pound-force	rf	radio frequency
dia	diameter	lbf-in	pound-force inch	rh	relative humidity
emf	electromotive force	lm	lumen	s	second
eq	equation	ln	logarithm (natural)	SD	standard deviation
F	farad	log	logarithm (common)	sec.	section
fc	footcandle	M	molar	SWR	standing wave ratio
fig.	figure	m	meter	uhf	ultrahigh frequency
FM	frequency modulation	min	minute	uv	ultraviolet
ft	foot	mm	millimeter	V	volt
ft/s	foot per second	mph	mile per hour	vhf	very high frequency
g	acceleration/gravity	m/s	meter per second	W	watt
g	gram	N	newton	λ	wavelength
gr	grain	N-m	newton meter	wt	weight

area=unit² (e.g., ft², in², etc.); volume=unit³ (e.g., ft³, m³, etc.)

PREFIXES

d	deci (10 ⁻¹)	da	deka (10)
c	centi (10 ⁻²)	h	hecto (10 ²)
m	milli (10 ⁻³)	k	kilo (10 ³)
μ	micro (10 ⁻⁶)	M	mega (10 ⁶)
n	nano (10 ⁻⁹)	G	giga (10 ⁹)
p	pico (10 ⁻¹²)	T	tera (10 ¹²)

COMMON CONVERSIONS (See ASTM E380)

ft/s $\times$ 0.3048000 = m/s	lb $\times$ 0.4535924 = kg
ft $\times$ 0.3048 = m	lbf $\times$ 4.448222 = N
ft-lbf $\times$ 1.355818 = J	lbf/ft $\times$ 14.59390 = N/m
gr $\times$ 0.06479891 = g	lbf-in $\times$ 0.1129848 = N-m
in $\times$ 2.54 = cm	lbf/in ² $\times$ 6894.757 = Pa
kWh $\times$ 3600000 = J	mph $\times$ 1.609344 = km/h
	qt $\times$ 0.9463529 = L

Temperature: $(T_{\text{F}} - 32) \times 5/9 = T_{\text{C}}$

Temperature: $(T_{\text{C}} \times 9/5) + 32 = T_{\text{F}}$

batteries," "one-fifth the weight of Ni-Cd batteries," and can be recharged 500 times.⁹

In general, secondary (rechargeable) lithium-ion batteries have a good high-power performance, an excellent shelf life, and a better life span than Ni-Cd batteries. Unfortunately, they have a very high initial cost and the total energy available per usage cycle is somewhat less than Ni-Cd batteries.

2.4 SPECIALTY BATTERIES ("BUTTON" AND MINIATURE BATTERIES)

"Button" batteries are the nickname given to the category of batteries that are small and shaped like a coin or a button. They are typically used for small devices such as cameras, calculators, and electronic watches.

Miniature batteries are very small batteries that can be custom built for devices, such as hearing aids and electronic "bugs," where even button batteries can be too large. Industry standardization has resulted in five to ten standard types of miniature batteries that are used throughout the hearing-aid industry.

Together, button batteries and miniature batteries are referred to as specialty batteries.

Most button and miniature batteries need a very high energy density to compensate for their small size. The high energy density is achieved by the use of highly electro-positive—and expensive—metals such as silver or mercury. These metals are not cost effective enough to be used in larger batteries.

Several compositions of specialty batteries are described in the following sections.

2.4.1 Metal-Air Cells

A very practical way to obtain high energy density in a galvanic cell is to utilize the oxygen in air as a "liquid" cathode. A metal, such as zinc or aluminum, is used as the anode. The oxygen cathode is reduced in a portion of the cell that is physically isolated from the anode. By using a gaseous cathode, more room is available for the anode and electrolyte, so the cell size can be very small while providing good energy output. Small metal-air cells are available for applications such as hearing aids, watches, and clandestine listening devices.

Metal-air cells have some technical drawbacks, however. It is difficult to build and maintain a cell where the oxygen acting as the cathode is completely isolated from the anode. Also, since the electrolyte is in direct contact with air, approximately one to three months after it is activated, the electrolyte will become too dry to allow the chemical reaction to continue. To prevent premature drying of the cells, a seal is installed on each cell at the time of manufacture. This seal must be removed by the customer prior to first use of the cell. Alternately, the manufacturer can provide the battery in an air-tight package.

2.4.2 Silver Oxide

Silver oxide cells use silver oxide as the cathode, zinc as the anode, and potassium hydroxide as the electrolyte. Silver oxide cells have a moderately high energy density and a relatively flat voltage profile. As a result, they can be readily used to create specialty

⁹Battery Engineering Web Site, <http://www.batteryeng.com/>, August 1997.