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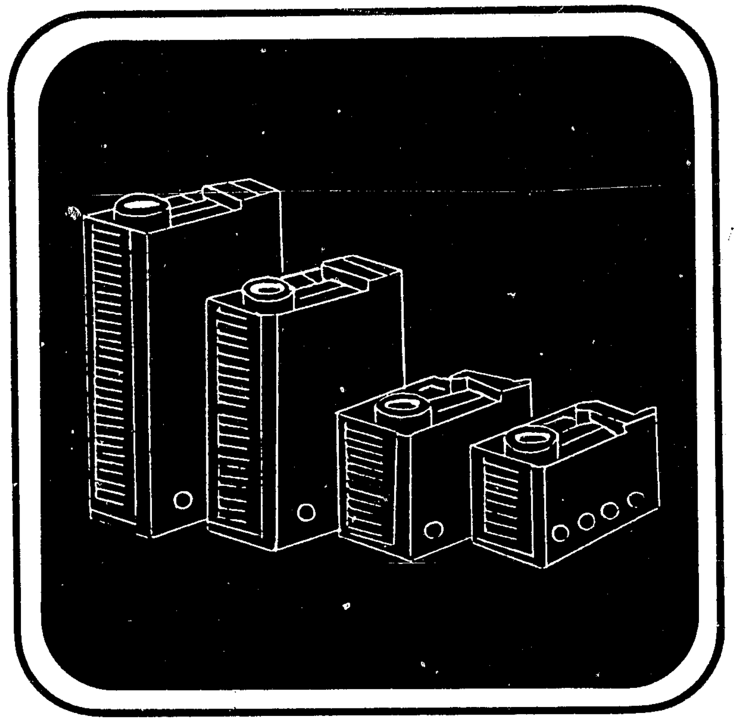
Technology Assessment Program
INFORMATION CENTER

BATTERIES FOR PERSONAL/PORTABLE TRANSCEIVERS



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BATTERIES FOR PERSONAL/PORTABLE TRANSCEIVERS

JULY 1984

PREPARED BY THE
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ABOUT THE TECHNOLOGY ASSESSMENT PROGRAM

The Technology Assessment Program is sponsored by the Office of Development, Testing, and Dissemination 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 Technology Assessment 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 nationwide and internationally.

The program operates through:

The Technology Assessment Program Advisory Council (TAPAC) 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 Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards, 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, LESL also produces user guides that explain in nontechnical terms the capabilities of available equipment.

The Technology Assessment Program Performance Test Center (PTC) operated by the International Association of Chiefs of Police (IACP), which supervises a national compliance testing program conducted by independent agencies. The standards developed by LESL serve as performance bench marks against which commercial equipment is measured. The facilities, personnel, and testing capabilities of the independent laboratories are evaluated by LESL prior to testing each item of equipment, and LESL helps the Center staff review and analyze data. Test results are published in Consumer Product Reports designed to help justice system procurement officials make informed purchasing decisions.

All publications issued by the National Institute of Justice, including those of the Technology Assessment Program, are available from the National Criminal Justice Reference Service (NCJRS), which serves as a central information and reference source for the Nation's criminal justice community. For further information, or to register with NCJRS, write to the National Institute of Justice, National Criminal Justice Reference Service, Washington, DC 20531.

James K. Stewart, Director
National Institute of Justice

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EXECUTIVE SUMMARY

The law enforcement community relies heavily on its mobile communications equipment, especially personal FM transceivers, to efficiently execute many of its necessary functions. The proper operation of these transceivers in field use depends, to a great extent, on the batteries that provide the power for this equipment.

The testing program to evaluate batteries for personal transceivers described in this report was conducted by the Performance Test Center (PTC)[1] of the International Association of Chiefs of Police (IACP) under a grant from the National Institute of Justice (NIJ). The PTC program is an applied research effort operated under the auspices of the NIJ Office of Development, Testing and Dissemination. It is part of the Technology Assessment Program involving NIJ, IACP, and the Law Enforcement Standards Laboratory (LESL) of the National Bureau of Standards (NBS), that is described on the back of the title sheet of this report. The program is a broadly-based mutual effort in which the PTC supervises independent testing of police equipment using standards that have been developed by LESL and issued by NIJ.

The battery testing accomplished during this effort was conducted in accordance with the test methods of NILECJ-STD-0211.00, Batteries for Personal/Portable Transceivers (June 1975), to determine compliance with the minimum performance requirements of that standard. While this standard covers all types of batteries suitable for use in transceivers, only secondary, or rechargeable, nickel-cadmium (NiCad) batteries were included in the test program.

The evaluation of the batteries was conducted by two independent testing laboratories selected in open competition after announcement of the program in the Commerce Business Daily. Final selection of the testing laboratories was based on an objective scoring of their competence to perform the required tests and on-site inspection of facilities, personnel, and test procedures by members of the Laboratory Accreditation Program of the NBS Office of Product Standards Policy, LESL, and IACP.

A total of 64 different NiCad battery models was tested during this program using a test lot of three batteries with one model being tested twice. The batteries were manufactured by 13 different companies including both transceiver manufacturers and independent companies that supply such batteries. The batteries selected for testing were specifically designed for use with transceivers that represent the basic models produced by six different manufacturers, all but one of which was tested by IACP for compliance with the NIJ standard for personal FM transceivers in 1981. A list of the batteries tested and the transceivers they are used with is given in Table 1 later in this report.

The NIJ standard for batteries requires that batteries must provide a minimum service life of 8 hours (h), or one shift, when discharged at ambient temperatures during continuous operation with a 10-10-80 (transmit-receive-standby) duty cycle. It should be noted that many manufacturers feel that this duty cycle is more demanding than the duty cycle that their products are designed to provide. Conversely, it should also be noted that some police departments feel that the 10-10-80 duty cycle is not stringent enough, particularly as to the amount of time (10%) allocated to receiving messages. Service life is also evaluated at low (-22 °F) and high temperatures (140 °F). In addition, the standard deviation of each set of service life measurements is used to calculate a performance factor that must be met. Each battery is also subjected to a test to evaluate the integrity of internal connections.

Overall, 12 of the 65 battery lots that were tested were in full compliance with the requirements of the standard for all minimum operating parameters. None of the battery lots was in full compliance with the labeling requirements; however, 10 models were found to satisfy the intent of the standard. Many manufacturers offer

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[1]Formerly the Technology Assessment Program Information Center (TAPIC), which replaced the Equipment Technology Center.

INTRODUCTION

This report is part of the IACP Performance Test Center's (PTC) ongoing effort to provide information on commonly-used law enforcement products based upon objective tests conducted in accordance with standards developed by the National Bureau of Standards (NBS) Law Enforcement Standards Laboratory (LESL), which are issued by the National Institute of Justice (NIJ) as voluntary national standards. Some of the products already tested include body armor, crash helmets, color test reagent kits, and personal transceivers. This report analyzes the results of a series of tests of batteries used with personal transceivers. Law enforcement and other public safety and emergency service groups will find these results revealing and of significant value when selecting batteries suitable for their specific requirements.

The testing program was undertaken in response to the recommendation of the Technology Assessment Program Advisory Council (TAPAC) that transceiver batteries be evaluated. The TAPAC Communications Committee, which advises IACP, LESL, and NIJ on police communication systems, found problems with transceiver batteries to be a major concern among almost all police departments. The larger police departments purchase thousands of batteries a year, and medium-size departments purchase hundreds every year. It is not uncommon for the police to receive defective batteries directly from suppliers, and many perform at levels less than expected in the field.

Although primary (nonrechargeable) batteries are available for use in personal transceivers, secondary (rechargeable) batteries are often preferred for such use because of their higher capacity, constant discharge characteristics and rechargeable feature. The latter attribute allows these batteries to provide more energy over a longer period of time than is ordinarily available from primary batteries. For more information on the various types of batteries, refer to LESP-RPT-0201.00, Batteries Used With Law Enforcement Communications Equipment: Comparison and Performance Characteristics (May 1972).[2] The TAPAC recommended that the scope of the battery testing program be limited to nickel-cadmium (NiCad) batteries.

In 1980, the Technology Assessment Program Information Center (now PTC), in conjunction with the TAPAC Communication Committee, conducted a survey of personal transceivers used by police departments throughout the United States in advance of initiating a program to test such equipment. Eight manufacturers were found to dominate the personal transceiver market. Twenty-six models of personal transceivers offered by the eight manufacturers were selected as representative of the spectrum of equipment used by various departments. The transceivers tested in the previous program were used as the basis for selecting the NiCad batteries to be tested in the present effort. Both transceiver manufacturers and independent battery manufacturers that compete in the replacement battery market produce batteries for use in these transceivers. A total of 64 different battery models were selected for test from the manufacturer product lines. These battery models are designed for use in 10 basic manufacturer series of transceivers, including 22 of the 26 transceiver models that were previously tested.[3] The manufacturers offer numerous transceiver models within a basic series, depending upon the frequency band of operation, the number of channels, and other options; consequently, the 64 battery models tested in this program are suitable for use in well over 100 different transceiver models. A sample of three of each of 63 battery models and six (two three-battery samples) of the 64th model, a total of 195 batteries, was purchased for use in the testing effort described in this report.

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[2]Available from the Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

[3]Police Personal FM Transceivers Report, September 1981, International Association of Chiefs of Police.

options to their basic transceiver models that require additional power. While not required by the standard, additional tests of service life under increased power drain conditions were conducted for information purposes. These transceiver/battery combinations may not be recommended by the manufacturer of the batteries. Detailed test results are provided in the body of this report.

A number of the manufacturers of the battery models that were tested have expressed concern that the test results presented in this report are not representative of current production units for a variety of reasons. The manufacturers have stated that since the time that the batteries were purchased they have redesigned the battery, made changes in production methods, changed component suppliers, or discontinued the production of certain battery models. The pertinent manufacturer comments are summarized in the final section of this report.

The reader is urged to review all test results presented in this report in detail prior to selecting batteries for use in his or her department's personal transceivers. It may be that certain environmental conditions under which a specific battery model demonstrated poor or marginal performance do not apply because of a department's geographical area of use. Similarly, size and weight constraints or a less demanding duty cycle may influence the selection of the rated capacity of the batteries. Further, it is recommended that, in all cases, the department solicit competitive bids from two or more suppliers before purchasing batteries, for it is a proven fact that competitive bidding results in reduced unit cost.

It should be noted that PTC plans to issue supplemental data sheets to update this report each time that manufacturers have new or improved battery models tested to the performance standard by the IACP certified testing laboratories. For this reason, the reader should request all current supplemental data sheets from PTC prior to issuing requests for bids for the procurement of batteries for transceivers.

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[2]Available from the Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

[3]Police Personal FM Transceivers Report, September 1981, International Association of Chiefs of Police.

Table 1 lists the 10 basic manufacturers' personal transceiver series discussed above, the nominal battery characteristics specified for these transceivers, and identifies which of the 64 battery models tested are intended for use with each series. The recharge rate for each battery model (rapid or slow) is also listed on the table. The battery models that individual battery manufacturers provide for a given transceiver do not necessarily provide a rated capacity identical to the nominal capacity stated by the manufacturer. For example, two of the four battery models presently offered for use with the first group of General Electric transceiver series (nominal rating of 500 mAh) have a manufacturer-rated capacity of 500 mAh, and two are rated at 540 mAh. The battery manufacturer specifications are presented later in this report. Attention is directed to the column labeled, "Test lot code." Each battery model was assigned an identifying code based on the particular personal transceiver series with which it was intended to be used. In order to minimize the space required for the tabulation of test results, all data presented in the body of this report will identify the batteries that were tested only by the test lot code. Thus, if your department uses General Electric "PE" or "MVP" portable transceivers (the first entry in Table 1) you will be most interested in data for batteries manufactured by General Electric, Alexander, Centurion, Energy Concepts and Multiplier; test lot codes G1 and G2; G1A and G2A; G1C and G2C; G2E; G1L and G2L, respectively, as appropriate for the output power of the specific model. Table 1 also identifies those battery models that the manufacturers have identified as discontinued or otherwise changed.

The batteries evaluated in the present effort were tested in accordance with the test methods presented in NILECJ-STD-0211.00, Batteries for Personal/Portable Transceivers (June 1975),[4] to determine compliance with the mimimum performance requirements of that standard. The testing was accomplished by two independent testing laboratories.

Attention is called to the fact that the service life requirements of the above standard do not necessarily agree with the manner in which the manufacturers of the battery models that were tested during this program rate their products. The battery industry sometimes uses a duty cycle (proportion of transmit, receive, and standby operation) that is less demanding than that required by the standard. Further, a number of manufacturers have indicated that their products have changed since the individual batteries were purchased and the publication of this report and have stated that they believe that the test results may not necessarily be representative of their current products. In most cases, however, changes to product lines occurred since January of 1983. The last section of this report summarizes the pertinent comments of the responding manufacturers concerning the data that are presented.

When selecting batteries for use in portable transceivers, law enforcement planners must weigh the value of each of a variety of factors. Some of these factors are cost, types of transceivers in use, provisions for extra batteries, operational need for rapid or slow charge capability, useful life (also referred to as service life), the performance of batteries in temperature extremes, and the quality of internal construction. Batteries that meet the performance criteria specified in the NILECJ standard can generally be considered to be of superior quality.

The sections of this report that follow discuss the selection of the independent testing laboratories that performed the evaluation, the technical aspects of the NILECJ standard for batteries, the detailed test results obtained during the program, and manufacturer comments on the test program and test results.

[4]Available from the Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

Table 1. Transceiver/battery combinations.

Personal transceiver				Battery		
	Nominal battery characteristics					
Manufacturer (model)	Voltage (V)	Capacity (mAh)	Test lot code	Manufacturer	Model number	Charge rate
General Electric (All PE and MVP models)	7.5	500	G1	General Electric	19D413522G-1	S
			G1A	Alexander	R2556*	S
			G1C	Centurion	PE5221*	S
			G1L	Multiplier	M522G1	S
	7.5	700	G2	General Electric	19D413522G-4	R
			G2A	Alexander	R2558*	R
			G2C	Centurion	PE5224*	R
			G2E	Energy Concepts	EC3522*	R
			G2L	Multiplier	M522G4	R
General Electric (MPX)	7.5	750	G3	General Electric	19D429763G-1	R
	7.5	1200	G4	General Electric	19D429777G-1	R
Harmon (formerly IEC LE-100)	10	540	H1	Harmon	BA-16	R
	10	540	H2	Harmon	BA-11	S
			H2A	Alexander	R608*	S
			H2C	Centurion	IC0100*	S
Motorola (HT-220)	15	450	M1	Motorola	NLN6761A	S
			M1C	Centurion	HT6761*	S
			M1D	Telecommuni-cation Devices	TD220*	S
			M1E	Energy Concepts	EC6761*	S
			M1J	Jabro	JB220	S
			M1L	Multiplier	M6761	S
			M1P	Power Group Intl.	P6761*	S
			M7	Motorola	NLN6761A	S
Motorola (MT-500)	15	450	M2	Motorola	NLN4463B*	R
			M2A	Alexander	H4463A	R
			M2C	Centurion	MT4463*	R
			M2D	Telecommuni-cation Devices	TD500FC*	R
			M2E	Energy Concepts	EC4463A*	R
			M2L	Multiplier	M4463	R
			M2P	Power Group Intl.	P4463*	R
Motorola (MX-300 Series)	7.5	800	M3	Motorola	NLN8840A*	R
	7.5	800	M4	Motorola	NLN8834B	D
			M4A	Alexander	H8834*	D
			M4C	Centurion	MX8834*	D
			M4E	Energy Concepts	EC8834*	D
	7.5	1250	M5	Motorola	NLN8841*	R
	7.5	1250	M6	Motorola	NLN8835B*	D
			M6A	Alexander	H5860	D
			M6C	Centurion	MX8835*	D
			M6E	Energy Concepts	EC8835*	D

Table 1. Transceiver/battery combinations. (Continued)

Personal transceiver				Battery		
Manufacturer (model)	Nominal battery characteristics: Voltage (V)	Nominal battery characteristics: Capacity (mAh)	Test lot code	Manufacturer	Model number	Charge rate
Repco (All RPX models)	12.5	450	R1	Repco	817-066-01	R
			R1A	Alexander	R817S	R
			R1C	Centurion	RP0661*	R
	12.5	450	R2	Repco	817-005-01	S
			R2A	Alexander	R817	S
			R2C	Centurion	RP0051*	S
	12.5	650	R3	Repco	817-024-01	R
	12.5	650	R4	Repco	817-125-01	S
			R4A	Alexander	R817L	S
			R4C	Centurion	RP1251*	S
Repco (TEK 10)	15	500	R5	Repco	810-266-01	R
	15	500	R6	Repco	810-156-01	S
			R6A	Alexander	H156*	S
			R6C	Centurion	RP1561*	S
			R6J	Jabro	JB156R	S
			R6L	Multiplier	M156-1	S
Standard (C731 L or C831 L)	12.5	450	S1	Standard	SC-UBP-4	R
			S1A	Alexander	BP4	R
	12.5	450	S2	Standard	SC-UBP-7	S
			S2A	Alexander	BP7	S
Wilson (MiniCom HH-250-C4 or HH-400-C)	11	500	W1	Wilson	8214	R
			W1A	Alexander	BP4W	R
			W1C	Centurion	BP0004*	R
			W1J	Jabro	J/BP4	R
			W1P	Power Group Intl.	BP4/1281*	R

R - Rapid charge rate (less than 8 h).
S - Slow charge rate (8 h or greater).
D - Dual charge rate (rapid and slow).
*Manufacturer states that this battery model has been discontinued or is not representative of current production (see details in last section of this report).

TESTING LABORATORIES

Extensive inquiries were made by the IACP to identify laboratories with the expertise needed to perform the battery tests called for in NILECJ-STD-0211.00. The testing program was announced to interested laboratories by publication of a notice in the Commerce Business Daily, and this was followed by mailing a Request for Proposal (RFP) to nearly 70 laboratories nationwide. The RFP contained:

- A description of the laboratory work required to perform the compliance tests.
- A questionnaire designed to determine the competence of the laboratories to conduct these tests.

In order to eliminate any possible conflicts of interest, laboratories affiliated with manufacturers of batteries were disqualified from consideration as testing laboratories for this program.

Evaluation and approval of the testing laboratories was performed by PTC and LESL with the assistance of another NBS organization, the Laboratory Accreditation Program of the Office of Product Standards Policy (OPSP). This NBS Office has the responsibility of assessing the competence of testing laboratories to conduct tests to specific standards.

Final selection of the laboratories was based on:

- An objective scoring of the information furnished by the laboratories in their replies to the questionnaire.
- On-site inspections of the top candidate laboratories by IACP, LESL, and members of the OPSP Laboratory Accreditation Program.

Both laboratories selected for this effort employed electrical engineers to conduct and monitor the testing. Also, each laboratory had previously designed a suitable configuration of test equipment which complied with the requirements of the standard. All test equipment used was calibrated using standards traceable to the National Bureau of Standards.

Contracts to conduct the tests were awarded to:

- United States Testing Company, Inc., Hoboken, New Jersey.
- Columbia Research Corporation, Arlington, Virginia.

These laboratories are approved IACP test laboratories for the evaluation of transceiver batteries to determine compliance with the requirements of NILECJ-STD-0211.00. In the future, the IACP will accept certified test results from these laboratories, conducted for battery manufacturers, for use in the preparation and issuance of supplemental data sheets to this report.

THE STANDARD

NILECJ-STD-0211.00, hereafter referred to as the Standard, established minimum performance requirements for transceiver batteries and methods to evaluate compliance with those requirements. The law enforcement community requires highly reliable equipment to perform its functions. The Standard is designed to assist law enforcement personnel in identifying batteries of high quality. While the Standard addresses more than one type of battery, only those portions of the Standard that concern NiCad batteries are discussed in this report.

Background

The ability of an officer to communicate with other officers in the field and the central dispatcher at all times is critical. Consequently, transceiver batteries are designed to facilitate ease of replacement, even in the field. Often, the transceiver battery is a self-contained unit that can be easily and quickly removed and replaced by another battery which is often snapped or twisted into position.

NiCad batteries used with personal transceivers consist of a number of individual cells that are interconnected in series to provide the proper voltage. During manufacture, the individual cells are connected, then two connections are made to the external power outlet terminals, and the assembly is then encased in a protective shell, often encapsulated in a molded plastic configuration. A typical NiCad battery also contains separate contacts that are utilized to charge it, so the transceiver can be inserted into a battery charger with the battery attached. The battery may also contain an integral electrical circuit to control the rate at which it will accept a charge.

Since NiCad transceiver batteries have numerous internal electrical connections, the quality of construction is very important. If any of these internal connections fail, the battery could cease to function, provide reduced voltage or reduced overall capacity.

All NiCad batteries for use with transceivers can be recharged using a slow charge rate that typically requires 14 to 16 h to recharge; rapid charge batteries that can be recharged in as little as 1 h are also available. In addition, many batteries are designed to permit charging with several different rates. The choice of NiCad battery charging characteristics determines, to a large extent, the need for an inventory of spare batteries and the operational procedures that are employed to ensure that individual batteries are fully charged at the beginning of each shift.

In order to test NiCad batteries according to the Standard it is essential to know: a) the number of individual cells and nominal operating voltage; b) the rated capacity in milliampere hours (mAh); and (c) the designed rate of recharge.

Service Life

Early in the effort to develop the standard for transceiver batteries, considerable attention was directed toward identifying the manner in which transceivers were used in the field. Obviously, a transceiver is not used to transmit messages continuously during an entire shift, during which time there is a maximum current drain, and it is not reasonable to expect the battery capacity to permit such use. Based upon a field usage investigation, a duty cycle of 10 percent, transmit-10 percent, receive-80 percent standby was selected as more representative of the way personal transceivers are used than any of the other duty cycles proposed and considered by manufacturers and users. For example, manufacturers often use a 5-5-90 transmit-receive-standby duty cycle to show that their batteries provide sufficient power to operate a personal transceiver for an 8-h shift. Many of the law enforcement agencies that were contacted in the field study objected to this, claiming that these batteries, with their lower-rated capacity, would cease to operate during a typical 8-h shift. Consequently, a 10-10-80 duty cycle was selected as the standard operational requirement for transceiver batteries. LESL has conducted several more recent studies involving communication systems, all of which support the 10-10-80 duty cycle as representative of personal/portable transceiver operational usage.

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The service life of a transceiver battery is measured as described in section 5.4 of the Standard. In order to conduct this measurement, a fully-charged battery is connected to a circuit that contains three different-valued load resistors, each of which will draw a current from the battery equivalent to that required by the transceiver for operation in one of the three modes; transmit, receive, or standby. The output of the battery is switched from one resistor to another continuously such that during each minute the battery is operated at the standby current drain for 48 s, the receive current drain for 6 s, and the transmit current drain for 6 s. The time required for the battery voltage to decrease to 1 V per cell is recorded as the service life of the battery.

The service life of the battery is measured at ambient temperature (68 to 86 °F) low temperature (-22 ± 3.6 °F), and at high temperature (140 ± 3.6 °F).

The Standard requires that more than one battery from each lot be tested for service life at each test temperature. For a lot size (single production run or purchase quantity from a production run) of 300 or less, a total of three test specimens selected at random is necessary. Such was the case for this test program. Larger lot sizes require more test specimens (as many as 15 for a production lot of up to 8000 batteries). The three transceiver batteries are required to provide a minimum mean service life of 8 h (1 shift) at ambient temperature; 2 h at -22 °F, and 7 h at 140 °F.

Service Life Performance Factor

The requirement that three or more batteries be subjected to the service life test permits a statistical determination of the extent to which all batteries from a single lot perform in a uniform or consistent manner. Large differences in the performance of individual batteries are often symptomatic of poor quality control during the manufacturing process, and field use of batteries manufactured under such conditions could be expected to result in unreliable operational communications.

Following the completion of the service life tests, the data obtained at each test temperature are analyzed according to standard statistical methods to determine a performance factor for each set of test batteries. The performance factor is calculated as the difference between the measured mean service life of the test batteries and the required service life (8 h at ambient, 2 h at low, or 7 h at high temperature), divided by the root mean square deviation of the measured service life. Those wishing to make such calculations will find a sample calculation in Appendix B of the Standard.

In order to comply with the requirements of the Standard, the mean service life of the three batteries must meet the minimum service life required at each test temperature and, in addition, the calculated performance factor at each test temperature must equal or exceed 0.958. The numerical value of the performance factor varies with the test sample size as specified in section 4.5 of the Standard.

Internal Connections

As noted earlier, transceiver batteries contain many internal electrical connections between the individual cells and external contacts. The integrity of these connections is critical to the ability of the battery to provide proper operating voltage and electrical power throughout its useful life. In order to determine whether the integrity of the internal construction is sufficient to preclude premature failure, each fully-charged battery is discharged at a very high rate for a period of 2 min. This rate is equivalent to five times the rate required to discharge a battery in 1 h. If the NiCad battery voltage does not fall below 1 V per cell during this test, its internal construction is considered to be of acceptable quality.

TEST RESULTS

In all cases, the batteries that were tested during this program were purchased directly from the manufacturer or its distributor. The source from which the batteries were purchased was not told that the batteries were being purchased for a test program. Each test laboratory was provided one or more battery chargers that were designed to recharge the particular type of batteries that were provided as test specimens. Prior to use, the battery chargers were tested to verify that they operated properly at the manufacturer's specified charging rate. The laboratories were instructed to charge the batteries in accordance with manufacturer's instructions, even if this procedure differed from that of the Standard. For example, the Standard specifies that slow-charge batteries be charged at a rate of 0.1 times the rated capacity per hour for 14 to 16 h, while one manufacturer specifies that one of its heavy-duty battery models be given an initial charge for a period of at least 24 h before use.

The tests were conducted by the test laboratories in the following sequence:

a) Service life and extra service life tests at ambient temperature.

b) Service life tests at high and low temperatures.

c) Internal connection tests.

Following tests at either high or low temperature, each battery was conditioned at ambient temperature for a minimum of 12 h prior to recharging the battery for the next test. All tests were initiated within 2 h of the time that the individual battery was fully charged.

Table 2 presents a summary of the test results for the 65 lots of batteries that were evaluated. Compliance with the requirements of the Standard is indicated by a blank space, while noncompliance is indicated by the letter N. Note that only 12 (19.5%) of the 65 battery lots were in full compliance with all of the requirements of the Standard.

When reviewing this data, keep in mind that compliance with the Standard requires that the battery have both a minimum service lifetime and a performance factor of 0.958 or greater to comply with the service life requirement. For example, test lot code G2 batteries had a mean service life of 8.37 h at 140 °F, considerably longer than the required 7.0 h; however, the standard deviation of the service life for the three test specimens was 6.65 h, which resulted in a performance factor of only 0.21, and therefore this lot did not comply with the requirement of the Standard. In contrast, test lot code G2L demonstrated a mean service life of 14.5 h at 140 °F, and the standard deviation was only 0.95 h, resulting in a performance factor of 7.89, significantly exceeding the requirement of the Standard.

Table 3 presents the measured service life test data and calculated performance factor for each test lot. As noted earlier, the mean service life requirement is 8 h at ambient temperature; 2 h at -22 °F, and 7 h at 140 °F, with a performance factor of 0.958 or greater at all test temperatures. As can be seen in the table, the service life performance of the batteries varied considerably at different operating temperatures. At ambient temperature, 24 test lots (37%) were found to comply with the requirements of the Standard, while at low temperature (-22 °F), 30 lots (46%) met the requirements and, at high temperature (140 °F), 29 lots (45%) complied with the requirements of the Standard.

Test lot codes M2A, M2C, M2D, and M2L would not discharge during the high temperature service life tests. This is thought to have been caused by internal protective circuitry within the batteries to prevent them from overheating during discharge. All of these lots performed normally when allowed to cool to ambient temperature. It would appear that these batteries could be a problem if used in extremely hot climates.

Because many of these batteries can also be used with transceivers that have higher power options, service life was also measured at two current drains higher than that specified by the Standard. For example, the G2 test lot code batteries were tested in accordance with the Standard using current drains of 14.5 mA for

Table 2. Battery compliance summary. (Requirement specified in NILECJ-STD-0211.00)

Test lot code	Requirement: Service life -22°F	Service life Ambient	Service life 140°F	Internal connection
G1		N	N	N
G1A		N	N	
G1C		N	N	
G1L		N	N	N
G2		N	N	N
G2A	N	N	N	N
G2C				N
G2E	N	N	N	N
G2L				
G3	N	N	N	N
G4		N	N	N
H1		N	N	
H2		N	N	
H2A	N	N	N	N
H2C		N	N	
M1				
M1C				N
M1D	N	N	N	N
M1E	N		N	N
M1J				
M1L				
M1P				
M7	N		N	N
M2		N	N	
M2A			N	
M2C			N	
M2D	N	N	N	
M2E		N		
M2L		N	N	
M2P		N		
M3	N	N		N
M4	N	N		
M4A		N	N	
M4C		N		
M4E			N	N
M5				N
M6				N
M6A				N
M6C				N
M6E				N
R1		N		
R1A		N		
R1C	N	N	N	
R2	N	N	N	N
R2A		N		N
R2C		N		N
R3				
R4				
R4A				
R4C				
R5		N	N	
R6				
R6A				
R6C				
R6J		N		N
R6L		N	N	N
S1		N	N	
S1A		N	N	
S2		N	N	
S2A	N	N	N	N
W1		N	N	
W1A		N	N	N
W1C		N	N	N
W1J		N	N	
W1P		N	N	

N - Noncompliance with standard.

standby, 140 mA for receive and 340 mA for transmit (the manufacturer specified current requirements on the basic General Electric PE and MVP models). The two higher power option tests for test lot code G2 batteries were conducted using transmit current drains of 630 mA (medium) and 1500 mA (heavy) required for options to the two series of transceivers. Standby and receive current drains remained the same for these additional tests. The mean service life of each battery with higher current drains for use with higher output power, in all cases at ambient temperature only, is also presented in Table 3. It should be noted that the manufacturer may not necessarily recommend that a given battery model be used with transceivers that incorporate higher power options. This additional data was taken for information purposes only, and no attempt was made to use this data to calculate a performance factor.

One battery from test lot code M1D (identification number 2674) was found defective on receipt, and would not accept a charge. Its zero lifetime for all conditions was used in the service life calculation and it was classified as a failure for the purpose of internal connection test. This is the principle reason that lot M1D was unable to obtain acceptable performance in any test.

A few test lots would have complied with the requirements of the Standard for mean service life if the one of the three-battery sample that was obviously bad [for example: those that (1) would not hold a charge or (2) could not pass the internal connection test] was not included in the service life and performance factor calculations. Lots that fell in this category were G2, G2A, G2C, and M7. Those test lots that were unable to pass the internal connection test because one battery in the three-battery sample was deficient included lots G1, G1L, G2, G2A, G2C, H2A, M1C, M1D, M1E, M4E, M7, R6J, and S2A. The above observations tend to confirm the concerns expressed by many police departments that they are receiving deficient NiCad batteries directly from the suppliers.

In addition to the performance criteria summarized in Table 2, the Standard also requires that each battery be clearly and legibly labeled with the following minimum information:

a) Manufacturer's name
b) Nominal voltage
c) Battery type and model
d) Rated capacity
e) Indication of polarity
f) Indication if the battery is rechargeable
g) Recharge rate
h) Month and year of manufacture

There was no consistency in the manner in which the manufacturers labeled the batteries that were tested during this program. For example, one manufacturer might specify a recharge time, another might list a recharge rate, while still others would simply indicate that the battery was either a slow or fast charge battery. In addition, in many cases the labels were so poorly affixed to the battery that one could expect the labels to be accidently removed soon after being put into operational use through normal wear from handling. The overall compliance of the battery models with the requirements of the standard is tabulated in Appendix A.

Based upon strict adherence to the labeling requirements of the standard, none of the battery models were in full compliance. Using a relaxed interpretation of the requirements, 10 of the battery model labels provided those items of information necessary to satisfy the intent of the standard. The relaxed interpretation permits the following variations in labeling: 1) a battery need not be labeled "rechargeable" if a recharge rate is clearly specified, 2) the battery polarity need not be labeled if the battery body is keyed or the contact arrangement makes it impossible to reverse the polarity of the battery when attached to or inserted into the transceiver, and 3) the year and month of manufacture can be in coded form or a production lot number can be substituted.

In three cases, the only label on the batteries was the manufacturer name. Thirteen battery models (20%) did not label the nominal voltage and 12 others (18.5%) were not labeled as to the model and type of the battery. The most serious labeling deficiency, however, was with respect to those items that affect battery charging: rated capacity, identifying whether the battery is rechargeable, and charging rate. A total of 16 battery models (24.5%) did not label either battery capacity or charge rate, making it difficult for anyone to properly recharge a battery without referring to other information. Granted, if a department uses a recharging system purchased from the battery manufacturer, this information may not be critical. Should a department wish to recharge batteries with existing systems not designed specifically for the batteries, however, this information is important. As discussed above, the requirement that the battery label identify whether the battery is rechargeable is considered to be satisfied if the label specifies a recharge rate; however, four battery models (6%) did not provide either item of labeling information.

If these NiCad batteries are to provide 1000 recharge cycles, as many manufacturers advertise, each battery should last almost three years if charged daily. If recharged less frequently, a service life of five or more years might be expected. Any department that has a large number of personal transceivers can be expected to have many different battery lots in operational use at the same time. The ability to determine when the battery was manufactured simply by looking at the label will assist the user in identifying those which can be expected to be near the end of the operational life. In 14 cases (21%) the batteries had no information as to date of manufacture. In addition, six of the battery lots (9%) were labeled with a code, which was assumed to be either a production lot number or date of manufacture; however, the code would be more difficult to use to gauge the length of time that a battery has been in service. The date of manufacture or lot number are also important to the user in the case of a defective production lot, if it becomes necessary to return such a lot to the manufacturer.

The internal connection test, as noted earlier, requires that each battery of the test lot provide a minimum voltage during a 2-min discharge at a high rate. Overall, when tested at the nominal rated capacity supplied by the transceiver manufacturer, 148 (74%) of the 195 batteries tested were in compliance with this requirement of the Standard. However, since all three of the batteries in each lot must pass this test, only 37 of the lots (approximately 58%) were in compliance with this requirement. The internal connection test results are not averaged, so the data do not conform to the tabular format of Table 3 and are not reported in the table. The data are presented, however, in the table in Appendix B to this report, which provides the manufacturer specifications for each battery model and all of the test results that were obtained for each battery tested.

Test lot codes M5, M6, M6A, M6C, and M6E failed to comply with the internal connection requirements. However, it should be noted that the current required to discharge these particular batteries at a rate five times the normal 1-h discharge rate was 6.25 A, considerably higher than that to which other lots were subjected during the internal connection test.

At the time that the battery models were submitted to the two independent testing laboratories, the PTC prepared data sheets for each lot of batteries based upon the characteristics of the transceiver with which the particular lot of batteries was intended to be used. This data sheet specified only the rated capacity of the battery normally supplied with the transceiver by the manufacturer of the transceiver. The testing laboratories inadvertently used the rated capacity from the PTC data sheets to determine the current drain to be used for the internal connection test for all batteries in the test lot.

In reviewing the test results, it became apparent that there were a number of instances in which the current drain that was used for the internal connection test was not consistent with the battery rated capacity as specified by each battery manufacturer. Having recognized this situation, the manufacturer rated capacity was checked with current catalog information, or verified through telephone discussions with the manufacturer of the battery model. The mAh capacity listed in Appendix B is the manufacturer's ratings as of May 1984. This situation serves to support the requirement that the batteries be properly labeled, for in the majority of those cases in which the current drain was not correct, the battery was not labeled with rated capacity and there was no way for the testing laboratories to recognize that the rated capacity was not as quoted by PTC.

Because of the use of incorrect capacities, there were five instances (test lot codes R4A, R4C, W1, W1J, and W1P) in which the batteries were tested originally at current drains in excess of those required by the Standard. All of these battery

Table 3. Service life test results for individual battery lots.

Test lot code	Ambient temperature		Low temperature -22 °F (-30 °C)		High temperature 140 °F (60 °C)		Medium load	Heavy load
	Mean life[a] (h)	Performance factor	Mean life[b] (h)	Performance factor[d]	Mean life[c] (h)	Performance factor[d]	Mean life (h)	Mean life (h)
G1	5.87	*	3.03	3.22	6.50	*	3.77	N/T
G1A	5.00	*	3.53	3.26	4.37	*	2.93	N/T
G1C	5.07	*	3.70	2.79	4.63	*	3.13	N/T
G1L	4.07	*	2.37	3.08	4.27	*	2.97	N/T
G2	9.07	.25	10.13	4.26	8.37	0.21	5.93	2.63
G2A	8.13	.02	5.73	0.74	8.97	0.25	6.23	2.70
G2C	12.03	1.52	9.20	1.08	12.30	1.65	7.83	3.20
G2E	7.20	*	*	*	*	*	3.23	1.50
G2L	14.13	11.15	11.90	27.50	14.50	7.89	9.67	4.63
G3	5.10	*	*	*	*	*	N/T	N/T
G4	5.80	*	3.67	11.13	5.87	*	2.87	N/T
H1	4.67	*	3.33	8.87	5.00	*	N/T	N/T
H2	5.10	*	2.20		5.13	*	N/T	N/T
H2A	6.00	*	2.03	0.02	5.90	*	N/T	N/T
H2C	5.37	*	3.37	9.13	5.47	*	N/T	N/T
M1	11.27	4.88	5.67	1.86	11.07	5.36	4.1	N/T
M1C	10.23	2.97	4.33	8.03	10.30	12.69	3.8	N/T
M1D	7.10	*	0.17	*	7.13	0.02	2.80	N/T
M1E	9.57	13.08	2.70	0.32	4.40	*	4.17	N/T
M1J	9.53	3.40	5.27	4.61	10.03	4.46	3.77	N/T
M1L	10.93	5.05	3.80	1.89	9.13	1.72	4.27	N/T
M1P	10.60	5.65	4.33	5.07	10.07	12.28	4.27	N/T
M7	10.37	1.21	3.30	0.52	8.4	0.32	2.23	N/T
M2	8.07	0.22	4.17	4.62	7.13	0.20	3.70	N/T
M2A	8.37	2.47	5.50	11.67	*	*	4.00	N/T
M2C	8.87	2.49	6.23	35.25	*	*	4.23	N/T
M2D	6.80	*	2.63	0.35	*	*	3.63	N/T
M2E	7.43	*	3.23	2.62	7.30	0.97	3.23	N/T
M2L	7.60	*	4.73	7.18	*	*	3.67	N/T
M2P	8.10	0.28	4.90	6.59	8.07	2.63	3.77	N/T
M3	7.67	*	0.77	*	8.20	12.00	4.7	N/T
M4	7.73	*	0.47	*	7.87	1.23	4.87	N/T
M4A	7.63	*	3.67	5.76	7.67	0.83	4.93	N/T
M4C	8.07	0.09	3.90	19.00	8.03	1.36	5.07	N/T
M4E	8.23	1.53	5.27	27.25	5.63	*	5.27	N/T
M5	12.93	8.08	6.43	3.63	11.97	9.94	7.43	2.03
M6	13.40	8.85	4.97	3.54	13.00	9.68	7.73	2.30
M6A	12.23	70.50	7.73	38.20	11.50	22.50	7.97	4.00
M6C	12.17	4.21	4.63	1.53	11.30	4.94	8.20	4.20
M6E	12.17	3.36	5.87	4.25	11.5	4.46	6.77	3.93
R1	8.17	0.40	5.23	8.50	8.4	3.89	4.17	N/T
R1A	7.60	*	3.00	1.79	7.87	3.48	3.77	N/T
R1C	7.20	*	2.47	0.31	6.33	*	2.67	N/T
R2	7.23	*	2.83	0.57	7.27	0.27	3.23	N/T
R2A	6.67	*	3.23	1.66	7.53	2.12	3.50	N/T
R2C	6.60	*	2.42	1.05	7.87	5.80	3.53	N/T
R3	9.97	3.34	5.20	5.25	9.89	50.23	5.53	4.40
R4	10.43	16.20	2.40	2.35	9.87	38.71	5.40	4.07
R4A	10.80	5.00	5.70	3.52	11.10	7.74	5.77	4.23
R4C	10.93	5.33	4.03	3.38	10.83	6.38	5.33	4.33
R5	6.10	*	5.50	5.74	6.93	*	N/T	N/T
R6	9.80	5.14	5.13	13.61	9.47	2.74	N/T	N/T
R6A	8.53	2.12	4.43	11.57	8.50	5.77	N/T	N/T
R6C	8.47	3.13	4.27	15.13	8.27	8.47	N/T	N/T
R6J	8.50	0.41	4.77	6.16	8.87	2.05	N/T	N/T
R6L	7.50	*	3.20	6.00	6.97	*	N/T	N/T
S1	4.00	*	3.00	10.00	4.37	*	N/T	N/T
S1A	4.00	*	2.83	6.92	4.37	*	N/T	N/T
S2	4.53	*	2.53	2.30	4.47	*	N/T	N/T
S2A	3.50	*	1.57	*	3.93	*	N/T	N/T
W1	6.73	*	3.23	4.92	4.87	*	N/T	N/T
W1A	7.23	*	3.13	18.83	4.97	*	N/T	N/T
W1C	6.60	*	3.07	3.34	5.00	*	N/T	N/T
W1J	6.97	*	3.47	12.25	4.70	*	N/T	N/T
W1P	6.87	*	3.00	3.85	4.50	*	N/T	N/T

*Performance factor negative or equal to zero.
N/T - Not tested because transceiver does not have higher power option.
[a]Eight-hour requirement, NILECJ-STD-0211.00.
[b]Two-hour requirement, NILECJ-STD-0211.00.
[c]Seven-hour requirement, NILECJ-STD-0211.00.
[d]Performance factor equal to or greater than 0.958, NILECJ-STD-0211.00.

lots met the requirement for the internal connection test, and would obviously continue to meet the requirement at a lower current drain. Test lot code S2A was tested at a current drain less than that required by the Standard. Since this battery lot had one battery that failed to meet the requirements of the Standard at the lower current drain, it was apparent that the lot also would not meet these requirements at a correct (higher) current drain.

There were, however, a number of instances in which the batteries were tested at current drains other than those required by the Standard and it was not possible to determine whether the batteries did, in fact, comply with the requirements. When originally tested at too high a current drain, test lot codes M3 and M4 did not comply with the requirements of the Standard. However, upon retest by PTC at the proper current drain, M4 was found to meet the internal connection requirement, whereas M3 failed to comply with the internal connection requirements of the Standard.

There were 10 instances in which battery lots were reported as complying with the requirements of the standard that were tested originally at too low a current drain. Eight of these (test lot codes G1C, G2L, M2, M2A, M2C, M2D, M2L, and S2) were retested by the PTC and found to fully comply with the internal connection requirements of the standard at the proper current drain. Originally, test lot codes G1A and S1A were also tested at too low a current drain. When retested by PTC at the correct current drain, two of the three batteries in each battery lot were found to comply with the internal connection requirements. Each battery lot, however, included a single battery that did not comply. Both batteries had performed satisfactorily during the original testing program. The condition of storage and handling of the batteries between the completion of the original testing and the retest effort are not known; therefore, test results are not reported, and the battery lots are considered to be in compliance with the internal connection test requirements of the standard for the purpose of this report.

As previously discussed, a number of the battery manufacturers continue to take exception to the 10-10-80 duty cycle that the standard requires for the determination of battery service life. The most often quoted duty cycle is 5-5-90, and many manufacturers tend to use this cycle as the means of determining the required battery capacity.

Those wishing to compare the performance of the batteries tested during this program on the basis of rated capacity, total delivered electrical power, and the capacities required to operate personal transceivers for 8 h using these two duty cycles may do so by reviewing the data in Appendix C.

The table in Appendix C lists the total electrical power capacity required to operate the personal transceiver that each battery lot is intended to be used with at both a 10-10-80 and 5-5-90 duty cycle (as calculated from the transmit, receive, and standby current specifications for the transceiver identified in Table 1 of this report). It also lists the manufacturer rated capacity for the battery model based upon manufacturers' specifications, which was obtained from published data sheets, or through direct contact with the manufacturer. The actual mAh capacity delivered during the ambient-temperature service life tests conducted during the testing are presented for each individual battery in the test lot. In all cases, the data for the mAh capacity are rounded to the nearest 10 mAh (i.e., a calculated capacity of 496 mAh is reported as 500 mAh, while a calculated capacity of 492 mAh is reported as 490 mAh).

These data are provided for information purposes, without comment.

MANUFACTURER COMMENTS

Following completion of the first draft of this report, copies of the results of tests of their own batteries were sent to each of the 13 manufacturers. Nine of the manufacturers submitted comments concerning the data, several of which objected to the publication of the test results, for a variety of reasons.

The PTC staff began to place orders for the batteries in late December 1981. Delays were experienced in obtaining both batteries and the required battery chargers, and it was the summer of 1982 before all batteries were on hand and the testing laboratories were able to begin the actual tests. United States Testing Laboratories prepared its test report in February 1983. Columbia Research Corporation, however, did not complete its testing until the summer of 1983.

Several manufacturers have stated that certain battery models are no longer in production and that they have made changes in production techniques, redesigned their products, or changed component suppliers. These manufacturers, therefore, expressed concern that the test results may not be representative of their current product line. Four of the manufacturers that commented on the test results suggested that new tests should be conducted of current production batteries and indicated a willingness to provide samples for such testing.

As noted in the individual manufacturer comments that are summarized below, most of the production changes occurred only 12 to 18 months prior to the publication of this report, and it is reasonable to assume that many battery models identical to those that were tested are still in use throughout the United States.

Alexander Manufacturing Co.

A total of 13 battery models manufactured by the Alexander Manufacturing Company was tested. This firm stated that they strongly objected to the publication of test results for several of their battery models: R2556, R2558, R608, H8834, and H156; test lot codes G1A, G2A, H2A, M4A, and R6A, respectively. The basis for objecting to the publication of test results for these battery models was that these batteries have been drastically changed since the tests were run, and in most cases, even the part numbers have changed.

This firm felt that the data are confusing and possibly false, citing Model R2558 (G2A) as an example, which in their opinion demonstrated that the batteries' performance was not tested, but rather the performance of the charger.

Centurion International

A total of 12 battery models manufactured by Centurion International was tested. This firm stated that it felt that the labeling requirement for recharge rate is superfluous for rapid charge packs are clearly marked as such and this differentiation is all their customers require, as the customers simply drop the pack into a charger over which they have no control.

This firm also stated that it changed cell suppliers early in 1983.

In the case of Centurion battery model MT4463 (test lot code M2C), the firm took exception to the test results at elevated temperature, for this battery model incorporates a bimetallic poly switch for temperature and short circuit protection that is calibrated to show an open circuit at 140 °F.

Motorola, Inc.

A total of six battery models manufactured by Motorola, Inc. was tested. Basically, Motorola Inc. took major exception to the testing program on the basis of the duty cycle that was used and their opinion was that this is one of the most misunderstood subjects concerning the application of portable transceivers.

The firm stated in their letter and subsequent telephone conversations that, of the six types of batteries tested, only the NLN6761A (M1) and NLN4463B (M2) remain in production. Battery model NLN8835 (M6) has been out of production for three to four years. During these telephone conversations, company representatives noted that batteries NLN8840B (M4) and NLN8841 (M5) were discontinued about January 1983 and that NLN8834A (M4) was no longer in production. It questioned the performance of the batteries initially tested and stated that it was not clear how old they were and what their actual condition was.

The firm also questioned the current drains, stating that it appeared that those used were from service sheet specifications intended for use in diagnosing radio problems, which are not typical of actual radio use.

The firm noted the use of what is considered to be nonrecommended combinations of radio power levels, batteries, and duty cycles. The firm stated that such tests, if conducted for information purposes, would be supported by Motorola, Inc. provided that the results were noted as an application not recommended by the manufacturer. It also took exception to the 10-10-80 duty cycle, which it does not consider representative of actual public-safety application. It expressed concern that the data might mislead a nontechnical user into selecting a battery that is excessive in size and cost for the application.

Motorola, Inc. recommended a meeting between its battery engineering staff and the PTC testing agency to discuss the issues.

Energy Concepts

A total of five battery models manufactured by Energy Concepts was tested. This firm stated that it did not want the results published because 1) the products, either in whole or part, have been substantially redesigned since the samples were first submitted in the fall of 1982, and 2) the company did not have a copy of the standard employed in testing the product.

Energy Concepts also called attention to the fact that it started operation in January 1982, and that its products have evolved and improved during the past two years.

General Electric

A total of four battery models manufactured by General Electric was tested. This firm questioned the service life data, stating that it appeared that the data were obtained from defective batteries, or batteries that needed refreshing due to extended out-of-service use.

The firm also took major exception to the 10-10-80 duty cycle and stated that it advertizes a 5-5-90 duty cycle as the specified cycle for its personal transceivers. It was noted that the selection of the battery for a transceiver is often a compromise, for most departments want maximum output power with minimum battery size and weight, which obviously results in shorter service life. The firm states that its opinion that a 5-5-90 duty cycle is acceptable is supported by the lack of customer complaints relative to service life.

The firm also took exception to the labeling requirements. It felt that the voltage level was irrelevant, for batteries are designed for use only with a specific transceiver and cannot be used with other transceivers.

With regard to labeling of the rated capacity, General Electric stated that new product batteries are now marked with rated capacity, and the information will be added to older battery models as the housings are retooled.

The firm also took exception to the requirement that the recharge rate be labeled, stating that the recharge rate is determined by the battery chargers, and that both trickle and fast chargers are available for all of the battery models that were tested.

General Electric questioned whether the publication of this report would be helpful to the user in view of their opinion that the test results are not descriptive of typical system use.

SAB Harmon Industries, Inc.

A total of two battery models manufactured by SAB Harmon Industries, Inc. was tested. This firm expressed concern over the publication of the results and asked what form the publication would take and what the distribution would be.

The firm did not want to see the test results published because it was not familiar with the NILECJ standard, and had not itself evaluated the test procedures of the standard. Further, it was questionable as to whether SAB Harmon Industries, Inc. was even trying to comply with the standard, and if in fact their batteries meet the requirements of their customers, the publication of what it considers to be totally negative test results might be very damaging.

Power Group International

A total of three battery models manufactured by Power Group International (formerly Power, Inc.) was tested. This group stated that it felt that the test results were out of date and not in keeping with current improved production and performance.

Telecommunication Devices, Inc.

A total of two batteries manufactured by Telecommunication Devices, Inc. was tested. This firm advised that the batteries were purchased by PTC in 1981 and are representative of an obsolete manufacturing procedure. The firm states that it changed the supplier of raw nickel cadmium cells in June 1983.

Wilson Product Group

One battery model manufactured by Wilson Product Group was tested. This firm questioned whether the transmit, reserve, and standby current drain were representative of those required by the transceiver for which the battery was designed. The firm noted that it manufacturers a variety of transceivers and batteries with a range of power capacity, including UHF transceivers with low power switches.

Wilson Product Group expressed concern that since only one battery model was tested the data might be interpreted as representing the best obtainable performance from any of its products. It was also noted that the firm was concerned that the tests represented worst case conditions using the highest current drain product that it manufacturers.

APPENDIX A--BATTERY LABELING

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APPENDIX A--BATTERY LABELING

Test lot code	Name	Nominal voltage	Type and model	Rated capacity	Polarity	Rechargeable	Recharge rate	Month and year manufactured
G1		N		N	K		N	
G1A		N		N	K		N	
G1C					K		N	
G1L		N	N	N	K	N	N	N
G2		N		N	K		N	
G2A		N	N		K		N	
G2C					K		N	
G2E				N	K	[a]		N
G2L		N	N	N	K	N	N	N
G3		N		N	K		N	
G4		N		N	K		N	
H1				N	K	[a]		N
H2	[b]			N	K	N	N	
H2A			N	N	K		N	
H2C					K		N	
M1							N	
M1C					A		N	N
M1D							N	C
M1E					A	[a]		N
M1J							N	
M1L								C
M1P		N		N	A		N	
M2				N		[a]		
M2A			N	N	A			
M2C				N	A			
M2D				N	A		N	
M2E			N	N	A	[a]		N
M2L				N				N
M2P		N		N	A		N	
M3				N				
M4				N				
M4A			N		K		N	
M4C					K		N	
M4E				N	K	[a]		N
M5				N		[a]		C
M6				N				
M6A				N	K		N	
M6C					K		N	C
M6E				N	K	[a]		N
M7							N	C
R1	[c]				K			
R1A			N		K		N	
R1C					K			
R2	[b] [c]				K			
R2A			N		K		N	
R2C					K		N	
R3	[c]				K			
R4	[c]				K			
R4A			N		K		N	
R4C					K		N	[d]
R5	[c] [e]							
R6	[c] [e]				K			
R6A			N		K		N	
R6C					K		N	
R6J	[c]	N		N	K		N	
R6L		N	N	N	K	N	N	N
S1						[a]		N
S1A					A	[a]		
S2							N	N
S2A					A		N	
W1	[f]					[a]		C
W1A					A	[a]		N
W1C					A		N	
W1J	[c]						N	
W1P		N		N	A		N	

APPENDIX A--BATTERY LABELING (Continued)

N - Noncompliance with requirements of the standard.
K - Keyed to ensure installation with proper polarity.
A - Fabricated with asymmetric contact points to ensure installation with proper polarity.
C - Coded information provided.
[a] Not labeled but recharge rate provided.
[b] All batteries not labeled the same.
[c] Label may be easily removed.
[d] Date not legible.
[e] Labeled TEK 10-8.
[f] Labeled as GE battery (41B025AK00201 8214, 450 mAh).

APPENDIX B--BATTERY DATA AND TEST RESULTS

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APPENDIX B--BATTERY DATA AND TEST RESULTS

IACP control data		Battery data						Test results					
								Service life test					
								Ambient temperature			Low temp. -22°F (h)	High temp. 140°F (h)	Internal connection test (V)
Test lot code	ID no.	Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Standard (h)	Medium (h)	Heavy (h)			
G1	2366	General Electric	19D413522G-1	6	7.5	500	16	5.9	4.0	-	2.9	6.6	6.30
	2367							5.6	3.3	-	2.8	6.3	5.82
	2368							6.1	4.0	-	3.4	6.6	6.14
G1A	1920	Alexander	R2556	6	7.5	540	16	5.3	3.0	-	3.9	4.5	6.40
	1921							4.9	2.9	-	3.0	4.4	6.28
	1922							4.8	2.9	-	3.7	4.2	*b*
G1C	2740	Centurion	PE5221	6	7.5	540	16	5.2	3.1	-	4.1	4.7	6.15
	2741							5.3	3.2	-	3.0	4.8	6.33
	2742							4.7	3.1	-	4.0	4.4	6.38
G1L	2661	Multiplier	M522G1	6	7.5	500	16	4.0	2.9	-	2.3	4.1	5.99
	2662							4.1	3.0	-	2.3	4.4	6.11
	2663							4.1	3.0	-	2.5	4.3	6.10
G2	2619	General Electric	19D413522G-4	6	7.5	700	3	12.0	8.2	4.3	11.7	12.6	6.75
	2620							11.0	7.8	3.4	8.0	11.8	6.76
	2362							4.2	1.8	0.2	10.7	0.7	4.66
G2A	1941	Alexander	R2558	6	7.5	700	3	2.7	0.8	0.1	0.2	0.6	3.34
	1942							8.2	7.5	3.4	7.0	10.2	6.20
	1943							13.5	10.4	4.6	10.0	16.1	6.35
G2C	2734	Centurion	PE5224	6	7.5	700	3	13.2	9.4	4.4	12.5	13.8	6.74
	2735							9.0	4.5	0.5	1.5	8.6	5.27
	2736							13.9	9.6	4.7	13.6	14.5	6.77
G2E	2719	Energy Concepts	EC3522	6	7.5	700	3	*a*	*a*	*a*	*a*	*a*	*a*
	2720							14.4	9.7	4.5	*a*	*a*	*a*
	2721							*a*	*a*	*a*	*a*	*a*	*a*
G2L	2670	Multiplier	M522G4	6	7.5	800	3	14.1	9.6	4.7	12.3	14.0	6.28
	2671							13.6	9.4	4.5	11.6	13.9	6.27
	2672							14.7	10.0	4.7	11.8	15.6	6.30
G3	2363	General Electric	19D429763G-1	6	7.5	750	1	4.4	*a*	-	*a*	*a*	*a*
	2364							4.5	*a*	-	*a*	*a*	*a*
	2365							6.4	*a*	-	*a*	*a*	*a*

APPENDIX B--BATTERY DATA AND TEST RESULTS
(Continued)

IACP control data		Battery data						Test results					
								Service life test					
								Ambient temperature			Low temp. -22°F (h)	High temp. 140°F (h)	Internal connection test (V)
Test lot code	ID no.	Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Standard (h)	Medium (h)	Heavy (h)			
G4	2369	General Electric	19D429777G-1	6	7.5	1200	1	4.9	2.4	-	3.5	4.5	5.78
	2370							6.6	2.9	-	3.8	6.3	5.70
	2371							5.9	3.3	-	3.7	6.8	5.67
H1	2359	Harmon	LA-16	8	10	540	3	4.6	-	-	3.3	5.0	8.71
	2360							4.6	-	-	3.2	4.9	8.77
	2361							4.8	-	-	3.5	5.1	8.72
H2	2629	Harmon	BA-11	8	10	540	16	5.0	-	-	2.2	5.0	8.85
	2630							5.1	-	-	2.2	5.3	8.88
	2355							5.2	-	-	2.2	5.1	8.94
H2A	1929	Alexander	R608	8	10	540	16	5.8	-	-	3.3	5.8	8.39
	1930							6.3	-	-	2.8	6.2	8.47
	1931							5.9	-	-	a	5.7	0.59
H2C	2743	Centurion	IC0100	8	10	540	16	5.4	-	-	3.5	5.4	8.21
	2744							5.3	-	-	3.4	5.6	8.51
	2745							5.4	-	-	3.2	5.4	8.20
M1	2372	Motorola	NLN6761A	12	15	450	16	11.7	4.6	-	7.0	11.6	13.62
	2373							10.5	3.6	-	3.4	10.2	13.32
	2374							11.6	4.1	-	6.6	11.4	13.72
M1C	2731	Centurion	HT6761	12	15	450	16	11.0	4.1	-	4.5	10.2	11.73
	2732							10.2	3.8	-	4.5	10.6	13.28
	2733							9.5	3.5	-	4.0	10.1	13.14
M1D	2673	Telecommunication	TD220	12	15	450	16	10.6	4.2	-	0.3	10.6	12.25
	2674	Devices						a	a	-	a	a	a
	2675							10.7	4.2	-	0.2	10.8	12.03
M1E	2716	Energy Concepts	EC6761	12	15	450	16	9.5	3.9	-	3.8	3.8	13.23
	2717							9.5	4.0	-	0.2	0.2	10.50
	2718							9.7	4.6	-	4.1	c	12.85
M1J	2634	Jabro	JB220	12	15	450	16	9.1	3.3	-	4.5	9.5	12.83
	2635							9.5	3.7	-	5.9	9.8	13.11
	2636							10.0	4.3	-	5.4	10.8	12.12

APPENDIX B--BATTERY DATA AND TEST RESULTS
(Continued)

IACP control data		Battery data						Test results					
								Service life test					
								Ambient temperature			Low temp. -22°F (h)	High temp. 140°F (h)	Internal connection test (V)
Test lot code	ID no.	Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Standard (h)	Medium (h)	Heavy (h)			
M1L	2664	Multiplier	M6761	12	15	450	16	11.6	4.8	-	3.7	9.8	12.17
	2665							10.6	4.3	-	4.8	9.9	13.63
	2666							10.6	3.7	-	2.9	7.7	13.41
M1P	2664	Power Group Intl.	P6761	12	15	450	16	10.5	4.2	-	3.8	10.1	13.67
	2665							10.2	4.3	-	4.6	9.8	13.68
	2666							11.1	4.3	-	4.6	10.3	13.77
M2	2643	Motorola	NLN4463B	12	15	500	1	7.7	3.4	-	3.8	6.4	13.03
	2644							8.3	3.9	-	4.7	7.6	13.27
	2645							8.2	3.8	-	4.0	7.4	13.29
M2A	2375	Alexander	H4463A	12	15	500	1	8.4	3.8	-	5.5	*c*	13.05
	2376							8.5	4.2	-	5.8	*c*	13.03
	2377							8.2	4.0	-	5.2	*c*	13.07
M2C	2348	Centurion	MT4463	12	15	500	1	9.2	4.5	-	6.3	*c*	12.86
	2349							8.5	4.2	-	6.1	*c*	12.85
	2350							8.9	4.0	-	6.3	*c*	12.79
M2D	1944	Telecommunication Devices	TD500FC	12	15	500	1	5.0	3.1	-	1.3	*c*	12.31
	1945							7.7	3.9	-	1.9	*c*	13.18
	1946							7.7	3.9	-	4.7	*c*	13.71
M2E	2728	Energy Concepts	EC4463A	12	15	450	1	7.7	3.4	-	2.7	7.6	13.41
	2729							7.7	3.4	-	3.6	7.4	13.51
	2370							6.9	2.9	-	3.4	7.0	13.31
M2L	2658	Multiplier	M4463	12	15	500	1	8.0	3.9	-	5.0	*c*	13.07
	2659							7.1	3.5	-	4.9	*c*	13.23
	2660							7.7	3.6	-	4.3	*c*	13.02
M2P	2697	Power Group Intl.	P4463	12	15	450	1	8.5	4.2	-	5.4	8.5	13.92
	2698							8.0	3.6	-	4.7	7.9	13.84
	2699							7.8	3.5	-	4.6	7.8	14.05
M3	2652	Motorola	NLN8840A	6	7.5	700	1	6.4	4.0	-	0.9	8.3	*d*
	2653							8.0	4.8	-	0.9	8.2	*d*
	2654							8.6	5.3	-	0.5	8.1	*d*

APPENDIX B--BATTERY DATA AND TEST RESULTS
(Continued)

IACP control data		Battery data						Test results					
								Service life test					
								Ambient temperature					
Test lot code	ID no.	Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Standard (h)	Medium (h)	Heavy (h)	Low temp. -22°F (h)	High temp. 140°F (h)	Internal connection test (V)
M4	2649	Motorola	NLN8834B	6	7.5	700	1, 16	7.4	4.8	-	0.5	3.0	6.08
	2650							8.9	5.6	-	0.5	8.5	6.15
	2651							6.9	4.2	-	0.4	7.1	6.03
M4A	2381	Alexander	H8834	6	7.5	800	1, 16	7.0	4.6	-	3.5	7.1	6.00
	2382							8.6	5.4	-	4.0	8.6	6.02
	2383							7.3	4.8	-	3.5	7.3	6.00
M4C	2339	Centurion	MX8834	6	7.5	800	1, 16	8.7	5.4	-	4.0	8.7	6.15
	2340							7.2	4.7	-	3.8	7.2	6.01
	2341							8.3	5.1	-	3.9	8.2	6.07
M4E	2725	Energy Concepts	EC8834	6	7.5	800	1, 16	8.4	5.4	-	5.4	8.5	5.88
	2726							8.2	5.2	-	5.2	0.0	6.19
	2727							3.1	5.2	-	5.2	8.4	6.21
M5	2655	Motorola	NLN8841	6	7.5	1250	1	12.4	7.1	0.6	5.1	11.5	4.52
	2657							12.8	7.5	3.1	6.7	11.9	4.59
	2658							13.6	7.7	2.4	7.5	12.5	4.58
M6	2646	Motorola	NLN8835B	6	7.5	1250	1, 16	12.7	6.7	1.9	4.0	12.3	4.58
	2647							13.7	8.5	2.4	5.4	13.5	4.81
	2648							13.8	8.0	2.6	5.5	13.2	4.75
M6A	2384	Alexander	H5860	6	7.5	1250	1, 16	12.3	8.1	4.0	7.9	11.5	5.77
	2385							12.3	7.9	3.9	7.6	11.3	5.76
	2386							12.2	7.9	4.1	7.7	11.7	5.93
M6C	2333	Centurion	MX8835	6	7.5	1250	1, 16	11.5	7.8	4.1	6.6	10.8	6.02
	2334							11.7	7.9	3.9	3.9	10.8	5.99
	2335							13.3	8.9	4.6	3.4	12.3	5.74
M6E	2722	Energy Concepts	EC8835	6	7.5	1250	1, 16	13.4	7.3	4.2	6.7	12.4	5.63
	2723							10.9	6.0	3.6	4.9	10.4	5.47
	2724							12.2	7.0	4.0	6.0	11.7	5.30
M7	2601	Motorola	NLN6761A	12	15	450	16	8.1	0.0	-	0.4	3.3	5.83
	2602							11.5	3.3	-	4.6	11.2	13.31
	2603							11.5	3.4	-	4.9	10.7	13.39

APPENDIX B--BATTERY DATA AND TEST RESULTS
(Continued)

IACP control data		Battery data						Test results					
								Service life test					
								Ambient temperature					
Test lot code	ID no.	Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Standard (h)	Medium (h)	Heavy (h)	Low temp. -22°F (h)	High temp. 140°F (h)	Internal connection test (V)
R1	2684	Repco	817-066-01	10	12.5	450	1	8.3	4.3	-	5.4	8.7	11.47
	2685							8.5	4.3	-	5.5	8.5	11.53
	2687							7.7	3.9	-	4.8	8.0	11.40
R1A	1908	Alexander	R817S	10	12.5	450	1	8.1	4.0	-	2.4	8.1	11.21
	1909							7.6	3.8	-	3.5	7.9	11.08
	1910							7.1	3.5	-	3.1	7.6	11.14
R1C	2336	Centurion	RP0661	10	12.5	450	1	7.6	2.3	-	2.9	6.1	11.31
	2337							6.7	2.6	-	0.8	5.9	11.26
	2338							7.3	3.1	-	3.7	7.0	11.27
R2	2621	Repco	817-005-01	10	12.5	450	14	7.7	3.6	-	4.2	7.9	11.29
	2623							6.2	2.8	-	1.3	6.1	7.73
	2686							7.8	3.3	-	3.0	7.8	11.36
R2A	1911	Alexander	R817	10	12.5	450	16	6.5	3.4	-	3.5	7.5	9.52
	1912							6.8	3.5	-	3.8	7.8	11.41
	1913							6.7	3.6	-	2.4	7.3	9.93
R2C	2342	Centurion	RP0051	10	12.5	450	16	6.7	3.7	-	1.9	8.0	8.18
	2343							6.9	3.9	-	2.6	7.9	11.35
	2344							6.2	3.5	-	2.7	7.7	11.24
R3	2691	Repco	817-124-01	10	12.5	650	1.5	10.4	5.5	4.6	4.9	10.0	10.75
	2692							10.2	5.5	4.3	5.9	9.9	10.80
	2693							9.3	5.6	4.3	4.3	9.8	10.76
R4	2683	Repco	817-125-01	10	12.5	650	20	10.4	5.4	4.0	2.2	9.9	10.56
	2689							10.6	5.5	4.1	2.5	10.0	10.50
	2690							10.3	5.3	4.1	2.5	9.8	10.47
R4A	1914	Alexander	R817L	10	12.5	540	16	11.3	6.1	4.5	6.7	11.5	11.13[e]
	1915							10.2	5.3	4.0	5.8	10.5	11.04[e]
	1916							10.9	5.9	4.2	4.6	11.3	10.96[e]
R4C	2345	Centurion	RP1251	10	12.5	540	16	10.4	4.6	4.1	3.4	10.2	10.89[e]
	2346							11.5	5.7	4.6	4.6	11.4	11.17[e]
	2347							10.9	5.7	4.3	4.1	10.9	10.95[e]

APPENDIX B--BATTERY DATA AND TEST RESULTS
(Continued)

IACP control data: Test lot code	IACP control data: ID no.	Battery data: Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Test results: Service life test: Ambient temperature: Standard (h)	Medium (h)	Heavy (h)	Low temp. -22°F (h)	High temp. 140°F (h)	Internal connection test (V)
R5	2680	Repco	810-266-01	12	15.0	500	1	6.0	-	-	5.2	6.8	13.52
	2681							6.7	-	-	6.2	7.1	13.61
	2682							5.6	-	-	5.1	6.9	13.34
R6	2622	Repco	810-156-01	12	15.0	500	14	9.6	-	-	5.0	8.9	13.60
	2624							9.6	-	-	5.0	9.0	13.60
	2683							10.2	-	-	5.4	10.5	13.70
R6A	1923	Alexander	H156	12	15.0	500	16	8.8	-	-	4.5	8.6	12.99
	1924							8.5	-	-	4.6	8.7	12.73
	1925							8.3	-	-	4.2	8.2	12.78
R6C	2330	Centurion	RP1561	12	15.0	500	16	8.6	-	-	4.1	8.3	12.52
	2331							8.3	-	-	4.3	8.1	12.68
	2332							8.5	-	-	4.4	8.4	12.62
R6J	2631	Jabro	JB156R	12	15.0	500	16	9.1	-	-	4.3	9	12.90
	2632							7.1	-	-	4.3	7.9	[a]
	2633							9.3	-	-	5.2	9.7	13.04
R6L	2667	Multiplier	M156-1	12	15.0	500	14	7.4	-	-	3.0	7.1	7.22
	2668							8.3	-	-	3.4	7.6	13.39
	2669							6.8	-	-	3.2	6.2	11.78
S1	2703	Standard Communications	SC-UBP-4	10	12.5	450	1	4.2	-	-	2.9	4.6	11.48
	2704							3.9	-	-	3.1	4.2	11.36
	2705							3.9	-	-	3.0	4.3	11.44
S1A	1932	Alexander	BP4	10	12.5	500	1	4.0	-	-	2.9	4.4	10.90
	1933							3.7	-	-	2.9	4.2	10.78
	1934							4.3	-	-	2.7	4.5	[b]
S2	2700	Standard Communications	SC-UBP-7	10	12.5	500	14	4.6	-	-	2.4	4.6	11.30
	2701							4.6	-	-	2.8	4.6	11.11
	2702							4.4	-	-	2.4	4.2	11.24
S2A	1926	Alexander	BP7	10	12.5	500	16	4.0	-	-	1.9	4.2	10.95[f]
	1927							3.0	-	-	1.3	3.7	10.72[f]
	1928							3.5	-	-	1.0	3.9	8.21[f]

APPENDIX B--BATTERY DATA AND TEST RESULTS
(Continued)

IACP control data		Battery data						Test results: Service life test					
								Ambient temperature			Low temp. −22 °F (h)	High temp. 140 °F (h)	Internal connection test (V)
Test lot code	ID no.	Company	Model number	No. cells	Nominal voltage (V)	Capacity (mAh)	Recommended charging time (h)	Standard (h)	Medium (h)	Heavy (h)			
W1	1947	Wilson	8214	9	11	450	4	6.8	-	-	3.5	4.8	9.98[g]
	1948							6.6	-	-	3.0	4.8	9.93[g]
	1949							6.8	-	-	3.2	5.0	9.95[g]
W1A	1935	Alexander	BP4W	9	11	500	4	7.5	-	-	3.2	5.0	9.35
	1936							7.2	-	-	3.1	5.0	7.82
	1937							7.0	-	-	3.1	4.9	9.22
W1C	2737	Centurion	BP0004	9	11	500	3	6.4	-	-	3.3	5.2	9.02
	2738							7.0	-	-	3.2	4.9	9.07
	2739							6.4	-	-	2.7	4.9	8.89
W1J	2637	Jabro	J/BP4	9	11	450	5	6.8	-	-	3.4	4.9	9.68[g]
	2638							6.8	-	-	3.6	5.0	9.67[g]
	2639							7.3	-	-	3.4	4.2	9.86[g]
W1P	2694	Power Group Intl.	BP4/1281	9	11	450	5	7.2	-	-	3.3	4.7	9.83[g]
	2695							6.6	-	-	2.9	4.3	9.72[g]
	2696							6.8	-	-	2.8	4.5	9.54[g]

[a]Battery was not able to accept an adequate charge.
[b]Test result not valid (see text).
[c]Battery was not able to hold charge.
[d]Below 6.0 V in less than 40 s.
[e]Values obtained when tested as a 650 mAh capacity battery (see text).
[f]Value obtained when tested as a 450 mAh capacity battery.
[g]Value obtained when tested as a 500 mAh capacity battery.

APPENDIX C--BATTERY CAPACITY DATA

APPENDIX C--BATTERY CAPACITY DATA
(Test Data at Ambient Temperature)

Test lot code	Nominal capacity 8 h operation (mAh) 10-10-80 duty cycle	5-5-90 duty cycle	Manufacturer rating (mAh)	Delivered capacity (mAh)	Test lot code	Nominal capacity 8 h operation (mAh) 10-10-80 duty cycle	5-5-90 duty cycle	Manufacturer rating (mAh)	Delivered capacity (mAh)
G1	477	296	500	350 330 360	M1J	359	216	450	410 430 450
G1A	477	296	540	320 290 290	M1L	359	216	450	520 480 480
G1C	477	296	540	310 320 280	M1P	359	216	450	470 460 500
G1L	477	296	500	240 240 240	M2	468	290	500	450 490 480
G2	477	296	700	720 660 250	M2A	468	290	500	490 500 480
G2A	477	296	700	160 490 800	M2C	468	290	500	540 500 520
G2C	477	296	700	790 540 830	M2D	468	290	500	290 450 450
G2E	477	296	700	a 860 a	M2E	468	290	450	450 450 400
G2L	477	296	800	840 810 880	M2L	468	290	500	470 420 450
G3	1188	714	750	650 670 950	M2P	468	290	450	500 470 460
G4	1188	714	1200	730 980 880	M3	888	552	700	710 890 960
H1	848	504	540	490 490 510	M4	888	552	700	820 990 770
H2	848	504	540	530 540 550	M4A	888	552	800	780 460 810
H2A	848	504	540	620 670 630	M4C	888	552	800	970 800 920
H2C	848	504	540	570 560 570	M4E	888	552	800	930 910 340
M1	359	216	450	530 470 520	M5	888	552	1250	1380 1420 1510
M1C	359	216	450	490 460 430	M6	888	552	1250	1410 1520 1530
M1D	359	216	450	480 a 480	M6A	888	552	1250	1370 1370 1350
M1E	359	216	450	430 430 440	M6C	888	552	1250	1280 1300 1480

APPENDIX C--BATTERY CAPACITY DATA (Continued)

Test lot code	Nominal capacity 8 h operation (mAh) 10-10-80 duty cycle	5-5-90 duty cycle	Manufacturer rating (mAh)	Delivered capacity (mAh)	Test lot code	Nominal capacity 8 h operation (mAh) 10-10-80 duty cycle	5-5-90 duty cycle	Manufacturer rating (mAh)	Delivered capacity (mAh)
M6E	888	552	1250	1490 1210 1350	R6A	422	231	500	460 450 440
M7	359	216	450	360 520 520	R6C	422	231	500	450 440 450
R1	509	302	450	530 540 490	R6J	422	231	500	480 380 490
R1A	509	302	450	520 480 450	R6L	422	231	500	390 440 360
R1C	509	302	450	480 430 460	S1	862	495	450	450 420 420
R2	509	302	450	490 390 500	S1A	862	495	500	430 400 460
R2A	509	302	450	410 430 430	S2	862	495	500	500 500 470
R2C	509	302	450	430 440 390	S2A	862	495	500	430 320 380
R3	509	302	650	660 650 590	W1	576	348	450	490 480 490
R4	509	302	650	660 670 660	W1A	576	348	500	540 520 500
R4A	509	302	540	720 650 690	W1C	576	348	500	460 500 460
R4C	509	302	540	660 730 690	W1J	576	348	450	490 490 530
R5	422	231	500	320 350 300	W1P	576	348	450	520 480 490
R6	422	231	500	510 510 540					

[a] Battery was not able to accept an adequate charge.

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