AMERICAN NATIONAL STANDARDS INSTITUTE ACCREDITED STANDARDS COMMITTEE C18 ON PORTABLE CELLS AND BATTERIES

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A Brief History of the Standardization of Portable Cells and Batteries in the United States

Introduction

In the United States of America, common designations for cylindrical batteries are "AA," "AAA," "C," and "D." What happened to the "A" battery and where did the "B" battery go… or was it skipped?[1] These and other questions stimulated an interest on the part of ANSI Accredited Standards Committee C18 to write this brief history of portable cell and battery standards development in the United States.[2]

Pre-World War I

George LeClanche invented the wet battery in 1866. This was followed by the invention of the dry battery in 1888, by Dr. Carl Gassner. In the United States, the first dry battery applications were in telephones and early models of the automobile. The most common dry battery was known as the "6 inch" cell that was 6 inches tall with a diameter of two and a half inches. When, cell and battery designations were introduced and later standardized, it was simply known as the "No. 6."

In 1912, a committee of the American Electrochemical Society recommended standard test methods for dry cell batteries.

[1] The "A cell" is still manufactured and combined to form large portable batteries for lanterns, especially in Europe. The "A battery" and the "B cell" and "B battery" have disappeared altogether.

[2] A cell is defined as a basic functional unit providing a source of electrical energy by direct conversion of chemical energy. The cell consists of an assembly of electrodes, separators, electrolyte, container, and terminals. A battery is one or more cells, including case, terminals, and markings. Unless otherwise noted, the word "battery" is used to refer to either cell or battery or both in this document.

Between the Wars

Establishment of a Formal Standard Committee

As a result of World War I, work was initiated in 1917 to develop nationally recognized specifications that would include sizes of cells, arrangement of cells in batteries, tests, and minimum performance criteria. Representatives of battery manufacturers, the War Industries Board, and several government agencies developed these specifications that were then presented to the National Bureau of Standards (today's National Institute of Standards and Technology). The National Bureau of Standards approved these specifications and published them in 1919, in *Circular BS 79*, page 39.

Because of rapid advances in dry cells, the need became apparent to revise these early standards. Thus, representatives of manufacturers, interested branches of the federal government, and large users came together through the National Bureau of Standards at a conference in December 1921 and began the preparation of a specification, which eventually became known as *U.S. Government Standard Specification No. 58*, published in 1923.

In 1924, a committee of representatives from the battery industry, several large users of dry cells, and government agencies met somewhat informally and proposed a simple system to designate cell sizes, based on the letters of the alphabet, starting with the smallest cell in volume and going in ascending order, A, B, C, etc. The largest, and only cell with a numerical designation was the "No. 6," mentioned above. This designation system was first published in 1927 in the *U.S. Government Standard Specification No. 58A* and the subsequent ASA Standard C18-1928 (see below).

In 1926, the American Engineering Standards Committee, which became the American Standards Association, which later became the American National Standards Institute, authorized the formation of a sectional committee on dry cell batteries under the sponsorship of the National Bureau of Standards. This committee was designated as "C18." Successive standards appeared in 1928, 1930, 1937, 1941, 1947, 1954, and 1959. The Federal Specifications Board developed dry battery standards with similar requirements, but differing in form, until the Board was discontinued in 1952.

From the 1920s through the 1950s, the following companies supported the work of Committee C18 and sent representatives: Burgess Battery Co., Bright Star Industries, National Carbon Co. (Union Carbide), General Dry, Marathon Battery Co., and Ray-O-Vac Co. Various associations were occasionally represented and included the American

Institute of Electrical Engineers, the Association of American Railroads, Communications and Signaling Sections, the Electrochemical Society, and Electronics Industries Association. There were also representatives from the telephone and radio industries and from the Electrical Testing Laboratories. The U.S. Army and Navy usually supported the Committee work.

Improvements in Performance

Improvements in performance and new types and uses for batteries required that the standards be updated on a frequent and regular basis. Some examples from the era between the Great Wars include the following:

- The annual shelf deterioration of the No. 6 dry cell for general purposes decreased from 35% in 1901, to 25% in 1916, to 7% in 1934. By the early 1950s, annual shelf deterioration for the No. 6 battery and others had been reduced to 2%.
- No. 6 dry cells for telephones provided service for 155 days on the "light intermittent test" in 1910, 230 days in 1926, and when special types became available in 1930, they provided 450 days of service.
- Industrial flashlight cells, intended for heavier service than regular flashlight cells, appeared on the commercial market in 1930, and gave 250 minutes of service on the "heavy-industrial test." By 1925, they were giving 975 minutes of service on the same test.
- Radio B batteries containing D-size cells gave 377 hours of continuous service on the "5,000-ohm continuous test" in 1918, and 1,500 hours on the same test in 1934. After 1934, the radio test became intermittent, because an intermittent test seemed to better reflect typical use.

The major concerns during the first thirty to forty years of committee work were shelf life, electrolyte leakage, and discharge performance.

Cell and Battery Designations

In 1934, the earlier designation system, noted above, was expanded.[3] Letters were applied to the various cells sizes. A number in front of the letter indicated the number of cells in series in the battery (cells were 1.5 volts). If a number did not appear, it was understood that the battery voltage was 1.5 volts. A number behind the letter indicated the number of cells or groups of cells in parallel within the battery. When small letters "s" and "d" appeared, they indicated the structural arrangement, single or double rows of cells. An example would be 4F2d, which would indicate that the battery contained two four-cell groups in parallel, arranged in double rows. The voltage of this particular battery was usually 6 volts. Table 1 below gives the designation, dimensions, nominal volume, approximate weight, and principle use of cells in the early standards.

Table 1—Cylindrical Dry Cells

Cell Designation	Nominal Diameter (in)	Nominal Height (in)	Nominal Volume (in^3)	Approx. Weight (ounces)	Principal Use
No. 6	2-1/2	6	29.5	35	Telephone & general purpose
J	1-3/4	5-7/8	7.2	9.7	Group batteries
G	1-1/4	4	4.91	6.2	Large radio batteries
F	1-1/4	3-7/16	4.22	5.3	Railroad lantern, group, & radio
E	1-1/4	2-7/8	3.53	4.4	Portable telephone
D	1-1/4	2-1/4	2.76	3.4	Flashlight & radio
CD	1	3-3/16	2.50	3.2	Hearing aids
CL	15/16	2-5/8	1.81	2.2	Hearing aids
C	15/16	1-13/16	1.25	1.5	Flashlight
B	'3/4	2-1/8	0.94	1.2	Radio B and C batteries
BR	'3/4	1-1/2	0.66	0.71	Flashlight, radio, & export
BF	'3/4	1-5/16	0.58	0.78	Radio
A	5/8	1-7/8	0.58	0.73	Radio B batteries
R	17/32	1-5/16	0.291	0.39	Mostly radio
P	17/32	1	0.222	0.28	Mostly radio
N	7/16	1-1/16	0.160	0.21	Mostly radio
NS	7/16	'3/4	0.113	0.14	Mostly radio

Various groupings of cells were standardized, such as *flashlight* batteries. There were other groupings as well: *A-size batteries* were to supply current for the electron tube filament; *B-size batteries* were to provide current for the electron tube plate, and *C-size batteries* were to supply bias voltage to the electron tube. Later *transistor batteries* would supply current to transistors.

Prior to World War II, "flat-type" cells, or coin cells were introduced, but not yet standardized.

[3] Evidently, this expanded designation system first appeared in the Federal Specification Boards standard of 1935, *Federal Standard Stock Catalog, Specification Symbol W-B-101a* (May 7, 1935).

After World War II

Immediately after World War II in 1947, the AA-size battery was written into the battery standard because it came into both government and commercial usage during the War.[4]

In 1954, a new, sixth edition of *Specification for Dry Cells and Batteries* was approved as an American Standard by the American Standards Association and published and sponsored by the National Bureau of Standards. It was designated as ASA C18.1-1954. In this document, specifications appeared for the first time for "flat cells" and "air-depolarized cells," both made prior to World War II and used in hearing aids, and for the new alkaline primary cells, known as "mercury cells." Previous editions of the standard had been confined to cylindrical leclanche-type cells. The mercury cells were initially produced during World War II for military applications, but then found their first commercial applications in hearing aids.

The seventh edition of *Specification for Dry Cells and Batteries* was approved as an American Standard in 1959 (ASA C18.1-1959). This document contained, for the first time, specifications and tests for dry cells and batteries for use with transistor circuits. LeClanche cylindrical cells retained their alphabetical designations, except for the No. 6 cell. Mercury cylindrical cells were designated with a number preceded by an M, and flat cells were designated numerically preceded by an F. The AAA battery was added to the list of Leclanche cylindrical cells that were standardized.

The National Bureau of Standards sponsored the Committee through 1966. In 1967, the National Electrical Manufacturers Association (NEMA) became the committee secretariat. During the late 1960s, alkaline manganese batteries were introduced, a major product breakthrough.

Under the secretariat of NEMA, authors of the twelfth edition of *American National Standard for Dry Cells and Batteries—Specifications* (ANSI C18.1-1986) made a concerted effort to harmonize with the existing International Electrotechnical Committee battery standards. In 1984, the first standard for rechargeable batteries was published in *American National Standard for Batteries—Sealed Rechargeable Nickel-cadmium Cylindrical Bare Cells* (ANSI C18.2-1984). The newest version of this standard

[4] The "AA"and "AAA" designations were American Standard cell and battery size designations that have come into common usage, along with C and D and several other designations. Currently, American National Standards Institute (ANSI) designations are simply numerical. For example, the AA battery is the ANSI 15, the AAA battery is the ANSI 24, and the AAAA is the ANSI 25.

incorporates the nickel metal hydride and lithium ion rechargeable chemistries. This was followed in 1991, when Committee C18 issued the first standard for lithium primary batteries, *American National Standard for Primary Batteries—Lithium Primary Batteries—Specifications* (ANSI C18.3M-1991). Lithium primary batteries were developed in the 1960s and found their way into military applications in the 1970s and into commercial applications in the 1980s. Lithium battery applications have expanded into power sources for calculators, watches, cameras, and memory backup circuits for microprocessors.

During the sixties to the present, Union Carbide Co. (Eveready, Energizer), Mallory (Duracell), Rayovac Corp., Eastman Kodak Company, GE Co., Wilson Greatbatch, Ltd., and Matsushita Electric Corp. of America (Panasonic) have participated in the work of Committee C18. Other contributors have included independent testing laboratories, independent consultants, and the U.S. Navy.

In 1999, ANSI Committee C18 issued a new series of standards, covering both primary and secondary batteries and lithium and non-lithium electrochemical systems.[5] The standards were completely reformatted and safety requirements were added as separate, stand-alone documents. The series included the following:

- ANSI C18.1M, Part 1-1999, *American National Standard for Portable Primary Cells and Batteries with Aqueous Electrolyte—General and Specifications*.
- ANSI C18.1M, Part 2-1999, *American National Standard for Portable Primary Cells and Batteries with Aqueous Electrolyte—Safety Standard*.
- ANSI C18.2M, Part 1-1999, *American National Standard for Portable Rechargeable Cells and Batteries—General and Specifications*.
- ANSI C18.2M, Part 2-1999, *American National Standard for Portable Rechargeable Cells and Batteries—Safety Standard*.
- ANSI C18.3M, Part 1-1999, *American National Standard for Portable Lithium Primary Cells and Batteries—General and Specifications*.
- ANSI C18.3M, Part 2-1999, *American National Standard for Portable Lithium Primary Cells and Batteries—Safety Standard*.

[5] A “primary” battery is not designed to be charged electrically; a “secondary” battery is designed to be recharged.

This series of standards has recently been and will continue to be updated as new applications are developed and as new and more advanced battery products come to market.

From the 1960s to the present, there have been strong breakthroughs in battery performance, a vast improvement in shelf life, dramatic decreases in leakage, and increased environmental benefits with the elimination of added mercury in most primary cells. In this time, Committee C18 emphasized safety standards and test methods. Recent efforts of the Committee involve evaluation of resistive, current, and power based loads of both continuous and intermittent duty cycles for standardized testing.

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