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American Standard Code for Information Interchange

Sponsor

Business Equipment Manufacturers Association

Approved June 17, 1963

AMERICAN STANDARDS ASSOCIATION
INCORPORATED

American Standard

Registered United States Patent Office

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Foreword

(This Foreword is not a part of American Standard Code for Information Interchange, X3.4-1963.)

This American Standard presents the standard coded character set to be used for information interchange among information processing systems, communication systems, and associated equipment.

Subsequent standards will prescribe the means of implementing this standard in the principal media, such as perforated tape, punched cards, and magnetic tape. Other standards will deal with collating and error control considerations. These standards will facilitate the interchange of digital information.

The 7-bit coded character set was developed by a group of highly qualified and experienced specialists in information processing and communication.* Past work in the field was reviewed, and a comprehensive program of original research and code design completed. Careful consideration has been given to the several conflicting code set requirements, and their resolution achieved in the standard code.

This standard was approved as American Standard by the American Standards Association on June 17, 1963.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American Standards Association, Incorporated, 10 East 40th Street, New York 16, N. Y.

The ASA Sectional Committee on Computers and Information Processing, X3, which developed this standard, had the following personnel at the time of approval:

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* Operating under ASA Project X3, Computers and Information Processing. The Business Equipment Manufacturers Association serves as sponsor of the X3 project.

At the time the proposal was developed and processed through ASA X3.2 subcommittee, the subcommittee membership was as follows:

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It should be recognized that although X3.2 members are variously affiliated, work on an ASA subcommittee is achieved primarily on an individual competence and experience basis. The membership above has with some exceptions been continuously active from the beginning of X3.2 work in 1960.

Contents

American Standard Code for
Information Interchange

1. Scope

This coded character set is to be used for the general interchange of information among information processing systems, communication systems, and associated equipment.

2. Standard Code

b_7				0	0	0	0	1	1	1	1
b_6				0	0	1	1	0	0	1	1
b_5				0	1	0	1	0	1	0	1
b_4	b_3	b_2	b_1								
0	0	0	0	NULL	DC_0	b	0	@	P		
0	0	0	1	SOM	DC_1	!	1	A	Q		
0	0	1	0	EOA	DC_2	"	2	B	R		U
0	0	1	1	EOM	DC_3	#	3	C	S		N
0	1	0	0	EOT	DC_4 (STOP)	$	4	D	T		A
0	1	0	1	WRU	ERR	%	5	E	U	UNASSIGNED	S
0	1	1	0	RU	SYNC	&	6	F	V		S
0	1	1	1	BELL	LEM	' (APOS)	7	G	W		I
1	0	0	0	FE_0	S_0	(	8	H	X		G
1	0	0	1	HT / SK	S_1	)	9	I	Y		N
1	0	1	0	LF	S_2	*	:	J	Z		E
1	0	1	1	V_{TAB}	S_3	+	;	K	[		D
1	1	0	0	FF	S_4	, (COMMA)	<	L	\		ACK
1	1	0	1	CR	S_5	−	=	M	]		(1)
1	1	1	0	SO	S_6	.	>	N	↑		ESC
1	1	1	1	SI	S_7	/	?	O	←	?	DEL

3. Positional Order and Notation

Standard 7-bit set code positional order and notation are shown below with b_7 the high-order, and b_1 the low-order, bit position.

	b_7	b_6	b_5	b_4	b_3	b_2	b_1
EXAMPLE: The code for "R" is:	1	0	1	0	0	1	0

4. Legend

NULL	Null/Idle	DC_1-DC_3	Device control
SOM	Start of message	DC_4(Stop)	Device control (stop)
EOA	End of address	ERR	Error

Legend continued on following page

Legend Continued

EOM	End of message		
EOT	End of transmission	SYNC	Synchronous idle
WRU	"Who are you?"	LEM	Logical end of media
RU	"Are you . . .?"	S_0-S_7	Separator (information)
BELL	Audible signal	b	Word separator (space, normally non-printing)
FE_0	Format effector		
HT	Horizontal tabulation	<	Less than
SK	Skip (punched card)	>	Greater than
LF	Line feed	↑	Up arrow (Exponentiation)
V_{TAB}	Vertical tabulation	←	Left arrow (Implies/ Replaced by)
FF	Form feed		
CR	Carriage return	\	Reverse slant
SO	Shift out	ACK	Acknowledge
SI	Shift in	①	Unassigned control
DC_0	Device control reserved for data link escape	ESC	Escape
		DEL	Delete/Idle

NOTE: Expanded definitions of some of the above terms may be found in the appendixes.

5. Qualifications

5.1 This standard does not define the means by which the coded set is to be recorded in any physical medium. The standard code does not include any redundancy or define techniques for error control. Further, it does not specify a standard collating sequence.

5.2 Deviations from the standard may create serious difficulties in information interchange and should be used only with full cognizance of the parties involved.

5.3 Unassigned codes are reserved for future standardization. Their use in information interchange prior to such standardization is a deviation from the standard.

5.4 The appendixes to this standard cover code design considerations and criteria, related subsets, extensions and deviations.

Appendixes

(These Appendixes are not a part of American Standard Code for Information Interchange, X3.4-1963, but are included to facilitate its use.)

Appendix A
Design Considerations for the Coded Character Set

A1. Introduction

A1.1 The standard coded character set is intended for the interchange of information among information processing systems, communication systems, and associated equipment.

A1.2 Work will continue in the following areas (not necessarily listed in order of priority):

(1) Representation of the coded character set in the principal media (perforated tape, magnetic tape, and punched cards)
(2) Error control considerations
(3) Collating conventions
(4) Relation of the standard set to other sets
(5) Assignment of meaning to presently unassigned codes as required
(6) Relationship to other standards

A2. Considerations Affecting the Standard

There were many considerations that determined the standard's set size, set structure, character selection, and character placement. Among these were (not listed in order of priority):

(1) Need for adequate number of graphics
(2) Need for adequate number of device controls and format effectors
(3) Desire for a non-ambiguous code, i.e., one in which every character has a unique meaning independent of other characters
(4) Physical limitations of media and facilities
(5) Error control
(6) Special interpretation of the all-zeroes and all-ones codes
(7) Ease in the identification of classes of characters
(8) Data manipulation requirements
(9) Collating conventions
    (a) Logical
    (b) Historical
(10) Keyboard conventions
    (a) Logical
    (b) Historical
(11) Other set sizes
(12) International considerations
(13) Programming languages
(14) Existing coded character sets

A3. Set Size

A 7-bit set is the minimum size that will meet the requirements for graphics and control in applications involving general information interchange. Both a 6-bit and an 8-bit set were considered and rejected—the 6-bit, providing only 64 graphics, could not accommodate essential format effectors, such as "carriage return," "line feed," "horizontal tab," etc; the 8-bit because it provides far more characters than are now needed in general applications.

A4. Set Structure

A4.1 In discussing the set structure it is convenient to divide the set into 8 columns of 16 characters each, as indicated in the standard.

A4.2 It was considered essential to have a dense 64-character subset which contained only graphics. For ease of identification this graphic subset was placed in 4 contiguous columns.

A4.3 Placement of the graphic subset was dictated by the requirement that the all-zeroes character be reserved for the "Null/Idle" function, and the all-ones character for the "Delete/Idle" function. Since the first and last columns contain these characters, the next logical choice for the graphic subset was the middle four columns of the code. Although this placement complicates the identification of the graphic subset since two bits must be examined (a one-bit test would have been sufficient had these graphics been placed in the first four or last four columns), this disadvantage is outweighed by the advantages of the dense graphic subset.

A4.4 The character set was structured to enable the easy identification of classes of graphics and controls.

A5. Choice of Graphics

Included in the set are the digits, a single case of the alphabetic letters A through Z, and those punctuation, mathematical, and business symbols considered most useful. The set includes the characters commonly encountered in programming languages. In particular, the COBOL graphics are included. It is not practicable to include all of the ALGOL graphics (which number 120).

A6. Graphic Subset Structure

A6.1 The basic structure of the dense graphic subset was influenced by logical collating considerations, the requirements of simply related 6-bit sets, and the needs of typewriter-like devices. For information processing, it is desirable that the characters be arranged in such a way as to minimize both the operating time and the hardware components required for ordering and sequencing operations. This requires that the relative order of characters, within classes, be such that a simple comparison of the binary codes will result in information being ordered in a desired sequence.

A6.2 Conventional usage requires that the word separator (space) be ahead of any other symbol in a collatable set. This permits a name such as "Johns" to collate ahead of a name such as "Johnson." The requirement that punctuation symbols also collate ahead of the alphabet ("Johns, A" should also collate before "Johnson") established the special symbol locations, including space, in the first column of the graphic subset.

A6.3 To simplify the design of typewriter-like devices, it is desirable that there be only a common 1-bit difference between characters normally paired on keytops. This, together with the requirement for a contiguous alphabet, the collating requirements outlined above, and international considerations, resulted in the placement of the alphabet in the last two columns of the graphic subset. This left the second column of the graphic subset for the numerals.

A6.4 Although the resultant structure of "specials" (S), "digits" (D), and "alphabetics" (A) does not conform to the most prevalent collating convention (SAD), it must be recognized that simple binary rules for collation do not necessarily apply between classes of characters.

A6.5 The need for a simple transformation from the set sequence to the prevalent collating convention was recognized, and dictated the placement of some of the "specials" within the set. Specifically, those special symbols, viz, ampersand (&), asterisk (*), comma (,), hyphen (-), period (.), and slant (/), which are most often used as identifiers for ordering information and which normally collate ahead of both the alphabet and the numerals, were not placed in the column containing the numbers, so that the entire numeric column could be rotated via relatively simple computer logic to a position higher than the alphabet. The sequence of the aforementioned "specials" was also established to the extent practical to conform to the prevalent collating convention.

A6.6 The need to adapt a useful 4-bit numeric set from the 6-bit graphic subset also played a role in the placement of characters. Such a 4-bit set, including the digits, asterisk, plus (+), comma, hyphen, period, and slant, can easily be derived from the standard.

A6.7 To further international standardization, and provide the 4-bit set mentioned in A6.6, the structure of the graphic subset precludes (logically) the historic keyboard association of colon (:) with semicolon (;). However, the dual character key assignment of the question mark (?) with the slant was maintained, as it was with a majority of the numerals and commonly associated symbols.

A6.8 Considerations of other domestic code sets, including the Department of Defense Standard 8-bit data transmission code (1961) as well as international requirements, played an important role in deliberations that resulted in the standard. The selection and grouping of the symbols dollar sign ($), percent sign (%), ampersand, and apostrophe (') and the symbols less than (<), equal (=), and greater than (>) permit contraction to either a business ($ % &) or scientific (< = > ') 6-bit subset. The sequence of these latter symbols and of the symbols comma, hyphen, period, and slant permitted an advantageous pairing on the keyboard. The historic pairing of question mark and slant is preserved and the less than and greater than symbols, which have comparatively low usage, are paired with period and comma so that in dual-case keyboard devices where it is desired to have period and comma in both cases the less than and greater than symbols are the ones displaced. Provision was made for the accommodation of alphabets containing more than 26 letters and for 6-bit contraction by the location of low-usage characters in the area following the alphabet. In addition, the requirement for the digits 10 and 11 used in sterling monetary areas was considered in the placement of the asterisk, plus, semicolon, and colon.

A7. Choice of Controls

A7.1 The control characters included in the set are those required for the control of terminal devices, input and output devices, format, or transmission and switching on a general enough basis to justify inclusion in a standard set.

A7.2 A group of eight codes has been reserved for information separators which when implemented in

a system shall bear a hierarchical relationship. They identify boundaries of various elements of information.

A7.3 Information separators are machine-oriented controls having two characteristics that differentiate them from human-oriented separators (word separator, punctuation, etc). First, machine-oriented separators are hierarchical in nature, whereas human-oriented separators have no fixed hierarchy. Second, machine-oriented separators must serve rigidly defined functions in a system, whereas proper interpretation of human-oriented separators requires knowledge of the context in which they are used.

A8. Control Subset Structure

A8.1 The first two columns were chosen for most of the assigned controls because there are more codes in the last two columns with a high probability of being inadvertently generated during an idle line condition than there are in the first two columns. "Acknowledge" was placed where its code could be generated by simple means. The "Escape" was placed so as to conform with the "special" function of the DOD standard 8-bit code and to facilitate the 6-bit contraction.

A8.2 The controls that were selected logically fall into four groups:

(1) Transmission controls
(2) Format effectors
(3) Device controls
(4) Information separators

Within each group the controls are ordered so that the binary and hierarchical order are directly related. This structure facilitates the contraction of the standard to related 6-bit sets and permits logical comparisons of related controls in the ordering of information. In particular, the placement of the format effectors and information separators facilitates their dual usage when contracting to a related 6-bit set.

Appendix B
Related Subsets and Adaptations

B1. Introduction

B1.1 The standard code was developed to provide for information interchange among information processing systems, communications systems, and associated equipment. Its structure facilitates conversion from the standard code to adaptations usable internally in a variety of equipments. In a system consisting of several equipments each with its local or native code, maximum flexibility will be achieved if each of the native codes is translated to the standard whenever information interchange is desired.

B1.2 Within any particular equipment or closed system it may be necessary to substitute characters. For example, some systems may require special graphic symbols and some devices may require special control codes. Design efforts on the standard code included consideration of these types of adaptations and the possibility that the parties employing them may develop a need to interchange information with others. If certain simple rules are followed in making such adaptations, minimum difficulty will be encountered in conversion to the standard code.

B1.3 The material below describes possible adaptations and logically related sets.

B2. Character Substitutions

B2.1 When a nonstandard character is introduced, only the code position where the substitution is made shall be affected.

B2.2 It is recommended that graphic substitutions be made only in the graphic area and control substitutions only in the control area. Any substitution involving a control should be made only with full cognizance of all possible operational effects.

B2.3 Any such substitution will result in a nonstandard coded character set.

B3. Unassigned Codes

A meaning was not assigned to a code unless that meaning was of sufficiently general use to warrant standardization. This resulted in some codes being unassigned. These codes are subject to future standardization. Where an unassigned code is given

meaning in a particular system, such meaning is nonstandard and use of this code in information interchange is hazardous.

B4. Illustrative Nonstandard Codes

Code sets obtained by modifying the standard as shown below, or by other replacements, are nonstandard.

B4.1 European Alphabets. The five graphics immediately following the letter Z can be replaced by the additional letters required for complete expression of certain European alphabets. Further, the single position preceding the letter A can be used for those alphabets requiring 32 characters. In most cases, only three additional letters will be required.

B4.2 Base 12 Numeric Digits. For those applications requiring use of the sterling monetary system or duodecimal arithmetic, the digits 10 and 11 can replace the two graphics immediately following the digit 9.

B5. Related Larger and Smaller Sets

Consideration has been given to the relationship between the standard set and sets of other sizes. A number of straightforward logical transforms are possible which result in a variety of sets related to the standard. None of the transformed sets should be considered standard.

Appendix C
Specific Criteria

C1. Introduction

C1.1 This Appendix contains the criteria on which the design of the code was based. Not all criteria have been entirely satisfied. Some are conflicting, and the characteristics of the set represent acceptable compromises of these divergent criteria.

C1.2 The standard has been designated a code for information interchange and not necessarily for internal use in information processing equipment. However, many of the criteria used in establishing the set are processor-oriented since simplicity in deriving logical and consistent processing sets was considered mandatory.

C2. Criteria

C2.1 All codes in the set shall consist of the same number of binary positions (bits).

C2.2 The standard set shall be so structured as to facilitate derivation of larger or smaller sets.

C2.3 Each character code shall consist of n binary bits. All possible 2^n combinations of ones and zeroes will be permitted and considered valid.

C2.4 The number of bits, n, shall be sufficient to provide for the alphabetic and numeric characters, commonly encountered punctuation marks, and other special symbols, along with those controls required for interchange of information.

C2.5 The numerals 0 through 9 shall be included in a 4-bit subset.

C2.6 The numerals 0 through 9 shall be so coded that the four low-order bits shall be the binary-coded-decimal form of the particular numeral that the code represents. In the selection of the two characters immediately succeeding the numeral 9, consideration shall be given to their replacement by the graphics 10 and 11 to facilitate the adoption of the code in the sterling monetary area.

C2.7 The interspersion of control codes among the graphic codes shall be avoided. The codes devoted to controls shall be easily separable from those devoted to graphics.

C2.8 Within the standard set, each character and its corresponding code shall stand by itself and not depend on surrounding characters for interpretation. The "mode shift" characters (SO, SI, or Escape) in an information stream shall signal a departure from the standard set.

C2.9 The alphabet A through Z shall be included in a 5-bit subset. Consideration shall be given to the need for as many as 32 characters in some alphabets.

C2.10 With the letters of the alphabet in their conventional order, A through Z, the codes shall be

assigned in continuous increasing binary order. This criterion prevents interspersion of non-alphabetic characters within the alphabet.

C2.11 Suitable control codes required for communication and information processing shall be included.

C2.12 Escape functions that provide for departures from the standard set shall be incorporated.

C2.13 A simple binary comparison shall be sufficient to determine the order within each class of characters. (For the purpose of this standard, the special graphics, the numerals, and the alphabet are each defined as distinct classes.) Simple binary rules do not necessarily apply between classes when ordering information.

C2.14 The "word separator" (i.e., the space between words) must collate ahead of all other graphics.

C2.15 Special symbols used in the ordering of information must collate ahead of both the alphabet and the numerals.

C2.16 Insofar as possible the special symbols shall be grouped according to their functions; for example, punctuation, mathematical symbols, and shorthand abbreviations. Further, the set shall be so organized that the simplest possible test shall be adequate to distinguish and identify the basic alphabet, numeric, and special symbol subsets.

C2.17 Special symbols shall be placed in the set so as to simplify their generation by typewriters and similar keyboard devices.

This criterion means, in effect, that the codes for pairs of characters that normally appear on the same keytops on a typewriter shall differ only in a common single-bit position.

C2.18 The set shall contain the graphic characters of the principal programming languages.

C2.19 The codes for all control characters shall contain a common, easily recognizable, bit pattern.

C2.20 The null, idle, and delete control functions shall be provided.

American Standards

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AMERICAN STANDARDS ASSOCIATION
INCORPORATED
10 EAST 40th STREET
NEW YORK 16, NEW YORK