American National Standard

Adopted for Use by
the Federal Government

FIPS PUB 93
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Front Cover

parallel recorded magnetic tape cartridge for information interchange, 4 track, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), phase encoded

american national standards institute, inc.
1430 broadway, new york, new york 10018

ANSI X3.72-1981

This standard has been adopted for Federal Government use.

Details concerning its use within the Federal Government are contained in FIPS PUB 93, Parallel Recorded Magnetic Tape Cartridge for Information Interchange, 4-Track, 6.30 mm (1/4 in), 63 bpmm (1600 bpi), Phase Encoded. For a complete list of the publications available in the Federal Information Processing Standards Series, write to the Standards Processing Coordinator (ADP), Institute for Computer Sciences and Technology, National Bureau of Standards, Washington, D.C. 20234.

ANSI ®
X3.72-1981

American National Standard
Parallel Recorded Magnetic Tape Cartridge for Information Interchange, 4 Track, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded

Secretariat

Computer and Business Equipment Manufacturers Association

Approved March 13, 1981

American National Standards Institute, Inc

American National Standard

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Published by

American National Standards Institute
1430 Broadway, New York, New York 10018

Printed in the United States of America

A4M1182/6

Foreword

(This Foreword is not part of American National Standard Parallel Recorded Magnetic Tape Cartridge for Information Interchange, 4 Track, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded, ANSI X3.72-1981.)

This American National Standard presents the standard technique for parallel recording of the American National Standard Code for Information Interchange, ANSI X3.4-1977 (ASCII), on a magnetic tape cartridge at 1600 bpi (63 bpmm), using phase recording techniques. It is one of a series of standards implementing the ASCII in media.

Related standards define more fully the physical and magnetic properties of the magnetic tape cartridge and specify a standard record format and labels.

The X3B5 Technical Committee on Magnetic Tape Cassettes, which developed this document, consists of a group of experienced and qualified specialists on the recording of digital information on magnetic tape.

In the development of this standard careful consideration was given to current practices, existing equipment and supplies, and the broadest possible acceptance, and to providing a basis for future improvement in the use of the medium.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Information Processing, X3. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the X3 Committee had the following members:

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Technical Committee X3B5 on Magnetic Tape Cassettes, which developed this standard, had the following members:

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Contents

American National Standard Parallel Recorded Magnetic Tape Cartridge for Information Interchange, 4 Track, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded

1. Scope and Introduction

1.1 Scope. This American National Standard is intended to provide a format and recording standard for a 0.250-inch (6.30-mm) -wide, 4-track magnetic tape in a cartridge to be used for information interchange between information processing systems, communication systems, and associated equipment utilizing the American National Standard Code for Information Interchange, ANSI X3.4-1977 (ASCII). This standard refers solely to recording on 0.250-inch (6.30-mm) magnetic tape cartridges; it complements American National Standard Unrecorded Magnetic Tape Cartridge for Information Interchange, 0.250-inch (6.30-mm), 1600 bpi (63 bpmm), Phase Encoded, ANSI X3.55-1977, where the following sections are dealt with in detail: general requirements, definitions, tape and cartridge, physical and magnetic requirements, speed requirements, and write enable feature. Compliance with ANSI X3.55-1977 is a requirement for information interchange.

CAUTION: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

No representation or warranty is made or implied that this is the only license that may be required to avoid infringement in the use of this standard.

1.2 Introduction

1.2.1 This standard defines the requirements and supporting test methods necessary to ensure interchange at acceptable performance levels. It is distinct from a specification in that it delineates a minimum of restrictions consistent with compatibility in interchange transactions.

1.2.2 The performance levels in this standard represent the minimum acceptable levels of performance for interchange purposes. They therefore represent the performance levels which the interchanged items should meet or surpass during their useful life and thus define end-of-life criteria for interchange purposes. The performance levels in this standard are not intended to be employed as substitutes for purchase specifications.

1.2.3 Wherever feasible, quantitative performance levels that must be met or exceeded in order to comply with this standard are given. In all cases, including those in which quantitative limits for requirements falling within the scope of this standard are not stated but are left up to agreement between interchange parties, the test methods and measurement procedures normally used in the industry shall be used to determine such limits.

1.2.4 U.S. engineering units are the original dimensions in this standard. Conversions of dimensions and tolerances from customary U.S. engineering units to SI units have been made according to Method A as described in American National Standard Metric Practice, ANSI Z210.1-1976, and Toleranced dimensions — Conversion from inches into millimetres and vice versa, ISO 370-1975, except as noted. Method A should be used for economy unless a requirement for absolute assurance of a fit justifies the use of Method B.

In the national standards of ISO member nations, additional rounding may have been done to produce "preferred" values. These values should lie within or close to the original tolerance ranges.

1.2.5 Except as indicated in 1.2.3, interchange parties complying with the applicable standards should be able to achieve compatibility without any need for additional exchange of technical information.

2. Definitions

2.1 Magnetic Tape Cartridge. A cartridge containing 0.250-inch (6.30-mm) -wide magnetic tape wound on two coplanar hubs with an internal drive belt to move the tape between the hubs. (See Fig. 1 in ANSI X3.55-1977.)

2.2 **Flux Reversal.** A reversal of flux polarity. The position of a flux reversal is the point that exhibits the maximum free-space flux density normal to the tape surface.

2.3 **Density.** The number of data bit flux reversals per unit length of recorded track, exclusive of phase flux reversals; usually expressed in bits per inch (bpi) or bits per millimeter (bpmm).

2.4 **Recorded Block.** A group of contiguously recorded bits which extend from one interblock gap to the next interblock gap. This includes the data bits, CRC, and synchronizing bits such as preamble and postamble. (See Fig. 2.)

2.5 **Data Block.** A group of contiguously recorded bits, excluding CRC and synchronizing bits such as preamble and postamble, considered and transported as a unit containing one or more logical records, or portions of logical records.

2.6 **Initial Gap.** The distance between the load point and the first bit of the first recorded block on the tape.

2.7 **Interblock Gap.** A dc-erased section of tape separating blocks of information.

2.8 **In Contact.** An operating condition in which the oxide side of a tape is in physical contact with a magnetic head.

2.9 **Control Block (Tape Mark).** A special block recorded on magnetic tape to serve as a separator between files and file labels, or to define the end of recorded data.

2.10 **Preamble.** A special sequence of bits recorded at the beginning of each recorded block.

2.11 **Postamble.** A special sequence of bits recorded at the end of each recorded block.

2.12 **Cyclic Redundancy Check (CRC) Character.** A 16-bit character that is written after the data and before the postamble of each block for the purpose of error detection.

2.13 **Beginning of Tape (BOT) Marker.** A set of two holes punched in the tape. Three sets of holes are provided, the innermost of which is for the purpose of identifying the storage position for the cartridge. In the storage position, all of the permissible recording area is wound on the supply hub and is protected by at least one layer of tape. Cartridges to be interchanged shall be rewound to the storage position prior to interchange. The two additional sets of holes are used to ensure reliability of detection. (See Fig. 2 in ANSI X3.55.)

2.14 **End of Tape (EOT) Marker.** A single hole punched in the tape. There are three such holes along a single line. The first to pass the photo sensor during forward operation indicates that the permissible recording area has been exceeded. The two additional holes are used to ensure reliability of detection. (See Fig. 2 in ANSI X3.55.)

2.15 **Load Point (LP) Marker.** A single hole punched in the tape to indicate the beginning of the permissible recording area in the forward direction. (See Fig. 2 in ANSI X3.55.)

2.16 **Early Warning (EW) Marker.** A single hole punched in the tape between recorded tracks for the purpose of indicating the approaching end of the permissible recording area in the forward direction. Recording must halt before the EOT marker is sensed. (See Fig. 2 in ANSI X3.55.)

2.17 **Amplitude Reference Tape.** A tape selected for a given property to establish the reference output signal level when recorded with continuous ONE data bits at 3200 flux reversals per inch (frpi) (126 flux reversals per millimeter (frpmm)).

2.18 **Standard Reference Current.** The minimum write current that, when applied to the amplitude reference tape, causes an output signal equal to 95% of the maximum output at 3200 frpi (126 frpmm).

2.19 **Standard Reference Amplitude.** The peak-to-peak output level that is read from the amplitude reference tape when written at 3200 frpi (126 frpmm) with a write current 1.5 times the value of the standard reference current.

2.20 **Track.** A longitudinal area on the tape along which a series of magnetic signals may be recorded.

2.21 **Frame.** An area the length of one recording position that extends across the width of a magnetic tape perpendicular to its movement. Several bits may be included in a single frame through the use of different recording tracks across the width of the tape.

3. Recording

3.1 **Method.** The method of recording shall be phase encoding. Each data bit requires a reversal of flux polarity (flux reversal) in a given direction for a logical ONE and in the opposite direction for a logical ZERO. Phase flux reversals will occur at the nominal midpoint between data bits in order to permit the proper polarity shift for the following data bit. "Self-clocking" is attained in this recording method through the consis-

tent occurrence of flux reversals for each data bit 1600 times per inch (63 times per mm). The erasing process described in 3.6 forms part of the recording procedure.

3.1.1 ONE Data Bit. A ONE data bit is a flux reversal to the same polarity as the interblock gap when reading in the forward direction.

3.1.2 ZERO Data Bit. A ZERO data bit is a flux reversal to the polarity that is opposite to that of the interblock gap when reading in the foward direction.

3.1.3 Phase Flux Reversal. A flux reversal that occurs at the nominal midpoint between successive ONE bits or between successive ZERO bits to establish proper polarity for the following data bit.

3.2 Equipment. The equipment and cartridge used for interchange must satisfy the requirements of 3.3 through 3.6. All signal measurements are made at a point in the read chain where the amplitude is proportional to the rate of change of flux in the read head. For the purpose of relating bit spacing along the tape to cartridge driving speed, the ratio of the tape speed to the surface speed of the belt capstan shall be assumed to be exactly 0.76:1.

3.3 Density. The nominal recording density shall be 1600 bpi (63 bpmm). Density statements in bits per inch (bits per mm) are always exclusive of phase flux reversals.

3.3.1 Nominal Bit Spacing. The nominal bit spacing exclusive of phase flux reversals is 625 μin (15.9 μm).

3.3.2 Long-Term Average Bit Spacing. The long-term average bit spacing shall be within ± 3% of the nominal spacing. This average shall be measured over a minimum tape length of 150 inches (3.81 m).

3.3.3 Short-Term Average Bit Spacing. The short-term average bit spacing with reference to a particular bit spacing is the average of the preceding four bit spacings.

The short-term average bit spacing, except as specified in 3.4, shall be within ± 7% of the long-term average bit spacing. In addition, the short-term average bit spacing shall not change at a rate greater than 2% per bit.

3.4 Flux-Reversal Spacing. To determine the instantaneous spacing between any two flux transitions, the following two tolerances must be taken together:

3.4.1 Data-Bit-to-Data-Bit Tolerance. The spacing between successive data bits without an intervening phase flux reversal shall be between 88% and 105% of the short-term average bit spacing.

The spacing between successive data bits with an intervening phase flux reversal shall be between 95% and 112% of the short-term average bit spacing.

3.4.2 Data-Bit-to-Phase-Flux-Reversal Tolerance. The spacing between a data bit and any adjacent phase flux reversal shall be between 44% and 56% of the short-term average bit spacing.

3.5 Signal Amplitude. The requirements in 3.5.1 through 3.5.5 apply to writing and reading in contact.

3.5.1 Average Signal Amplitude. The average peak-to-peak signal amplitude of the interchange tape at 3200 frpi (126 frpmm) shall deviate no more than +50%, -35% from the standard reference amplitude. Averaging shall be done over a minimum of 3200 flux reversals, which, for interchange cartridges, may be segmented into groups.

3.5.2 Maximum Signal Amplitude. The peak-to-peak signal amplitude at 1600 frpi (63 frpmm) shall be less than three times the standard reference amplitude.

3.5.3 Minimum Signal Amplitude. No tape when interchanged shall contain any adjacent flux reversals whose peak-to-peak signal amplitude is less than 20% of the standard reference amplitude.

3.5.4 Total Frame Skew. No data bit in a frame shall be displaced more than 800 μin (20 μm) from any other data bit in the same frame when measured in a direction parallel to the cartridge positioning plane. (See Fig. 1, Plane B.)

3.5.5 Rejected Regions. A rejected region is an area of tape extending across the track width and not more than 1.0 inch (25.4 mm) in length that exhibits permanent dropouts on two consecutive passes. The acceptable number of rejected regions in an interchange environment is a matter of agreement between the parties to the interchange.

3.6 Erase

3.6.1 Erase Direction. The tape shall be magnetized so that the BOT is a north-seeking pole.

3.6.2 Erase Function. Erasure, whether by the write head or by the erase head, shall ensure that the level of the readback signal amplitude is below 3% of the average signal amplitude at 3200 frpi (126 frpmm).

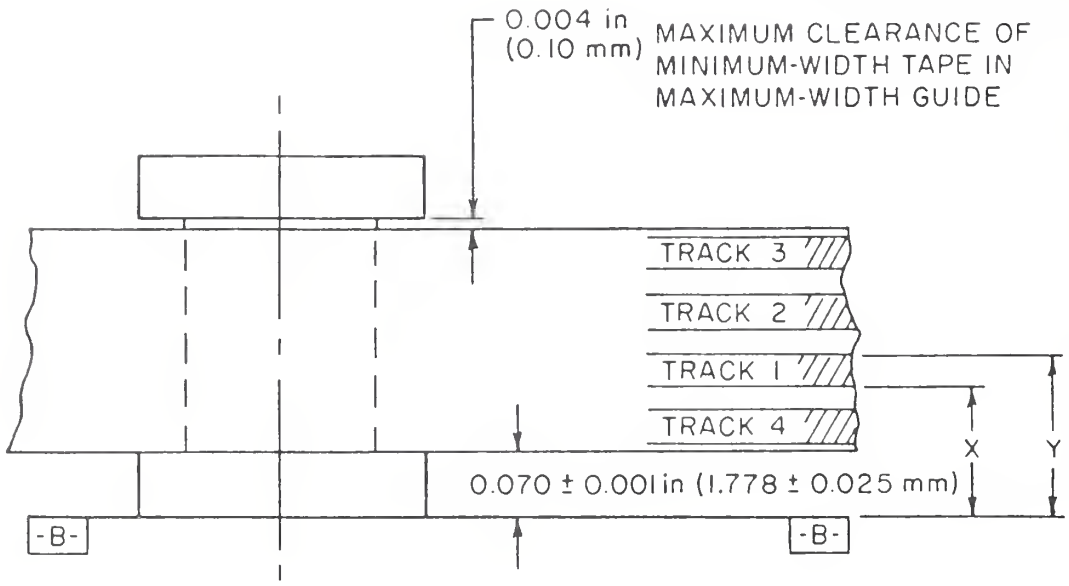
4. Format (See Fig. 2.)

4.1 Number of Tracks. The track format shall consist of four parallel tracks, numbered one through four.

4.2 Use of Tracks. Each track is a data track and shall be written simultaneously in parallel fashion starting near the BOT and continuing toward the EOT. Track locations and designations are shown in Fig. 1.

4.3 Byte and Code Requirements

4.3.1 Byte Size. The system shall be capable of reading and writing an eight-bit byte. The ASCII seven-



	Inches				Millimeters			
	Dimension X		Dimension Y		Dimension X		Dimension Y	
Track	Max	Min	Max	Min	Max	Min	Max	Min
1	0.146	0.130	0.194	0.178	3.71	3.30	4.93	4.52
2	0.210	0.194	0.258	0.242	5.33	4.93	6.55	6.15
3	0.274	0.258	0.322	0.306	6.96	6.55	8.18	7.77
4	0.082	0.066	0.130	0.114	2.08	1.68	3.30	2.90

Fig. 1
Tape Guide and Track Dimensions

bit coded character set (ANSI X3.4-1977) is recorded in the seven least significant bit positions of an eight-bit byte. The eighth position is always a ZERO bit when the other seven bits represent ASCII characters; the eighth position is a ONE bit when the other seven bits represent extended characters according to American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character Set for American National Standard Code for Information Interchange, ANSI X3.41-1974.

4.3.2 Location of Characters on the Tracks. Data bits are recorded on tape in parallel fashion, four bits per frame, or one eight-bit byte per two contiguous frames, as shown in Fig. 2. The lower-order ASCII data bits (b_1-b_4) are recorded in the first frame, and the remaining ASCII data bits (b_5-b_7) are then recorded in the following frame. The data bits of ASCII are numbered b_7, b_7, b_6, b_5, b_4, b_3, b_2, and b_1, from the high order to the low order.

4.4 Gaps

4.4.1 Initial Gap. The minimum length of the initial gap is 6.0 inches (152.4 mm).

4.4.2 Interblock Gap (IBG). For data interchange, the length of the interblock gap shall be a minimum of 1.2 inches (30.5 mm) and a maximum of 48 inches (1.22 m). Preambles and postambles are not considered as part of the IBG.

4.4.3 Gap Polarity. The polarity of all gaps shall be established by the erase function in the direction specified in 3.6.1.

4.5 Block Length

4.5.1 Minimum Data Block Length. The minimum data block is the smallest group of bits, exclusive of preamble, postamble, and CRC, that can be considered a valid block. This minimum block length, exclusive of the tape mark, is six eight-bit data bytes.

4.5.2 Maximum Data Block Length. The maximum data block length is 2048 bytes.

4.5.3 Preamble. Preceding the data in each block, a preamble consisting of 15 ZERO bits followed by a ONE bit shall be written in all tracks. (See Fig. 2.) The preamble may be used to establish a timing sequence so that data can be read in the forward direction.

4.5.4 Postamble. Following the data and the CRC

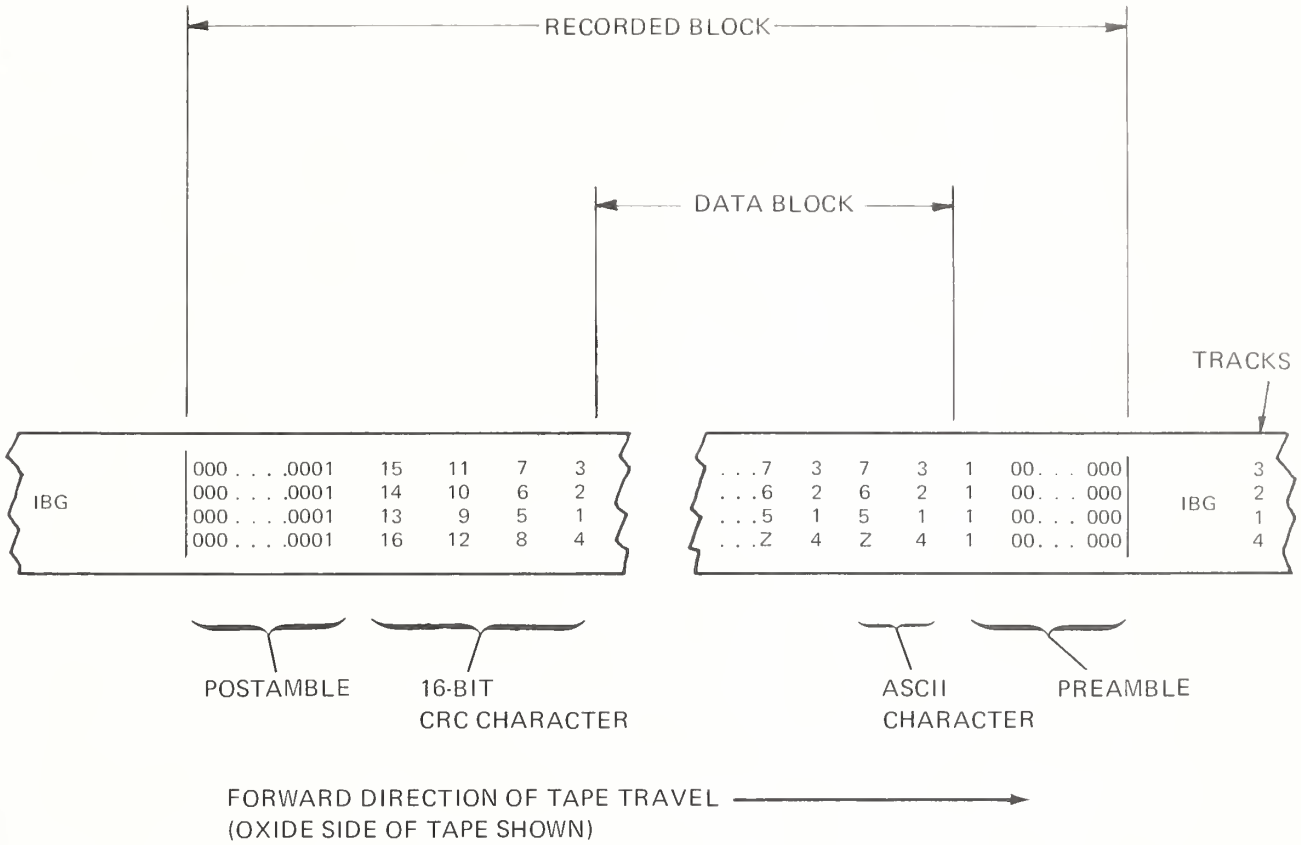


Fig. 2
Recorded Block Format

character in each block, a postamble consisting of a ONE bit followed by 15 ZERO bits shall be written in all tracks. (See Fig. 2.) The postamble may be used to establish a timing sequence so that data can be read in the reverse direction.

4.6 Control Block (Tape Mark). The control block (tape mark) shall consist of a preamble, two bytes of eight ZERO bits each, and a postamble written only in tracks one and two, with tracks three and four de erased.

4.7 CRC Character. A 16-bit CRC shall be written in each recorded block in the four frames following the data and immediately preceding the postamble. (See Fig. 2.) The CRC is generated by the polynomial $X^{16} + X^{15} + X^2 + 1$.

4.8 Usable Recording Area. All data to be interchanged shall be written within the usable recording area as defined in Fig. 2 in ANSI X3.55-1977.

5. Revision of American National Standards Referred to in This Document

When any of the American National Standards referred to in this document is superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.

American National Standards for Information Processing

X3.1-1976 Synchronous Signaling Rates for Data Transmission
X3.2-1970 (R1976) Print Specifications for Magnetic Ink Character Recognition
X3.3-1970 (R1976) Bank Check Specifications for Magnetic Ink Character Recognition
X3.4-1977 Code for Information Interchange
X3.5-1970 Flowchart Symbols and Their Usage in Information Processing
X3.6-1965 (R1973) Perforated Tape Code for Information Interchange
X3.9-1978 Programming Language FORTRAN
X3.11-1969 Specification for General Purpose Paper Cards for Information Processing
X3.14-1973 Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)
X3.15-1976 Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission
X3.16-1976 Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange
X3.17-1981 Character Set for Optical Character Recognition (OCR-A)
X3.18-1974 One-Inch Perforated Paper Tape for Information Interchange
X3.19-1974 Eleven-Sixteenths-Inch Perforated Paper Tape for Information Interchange
X3.20-1967 (R1974) Take-Up Reels for One-Inch Perforated Tape for Information Interchange
X3.21-1967 Rectangular Holes in Twelve-Row Punched Cards
X3.22-1973 Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)
X3.23-1974 Programming Language COBOL
X3.24-1968 Signal Quality at Interface between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission
X3.25-1976 Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication in the American National Standard Code for Information Interchange
X3.26-1980 Hollerith Punched Card Code
X3.27-1978 Magnetic Tape Labels and File Structure for Information Interchange
X3.28-1976 Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links
X3.29-1971 Specifications for Properties of Unpunched Oiled Paper Perforator Tape
X3.30-1971 Representation for Calendar Date and Ordinal Date for Information Interchange
X3.31-1973 Structure for the Identification of the Counties of the United States for Information Interchange
X3.32-1973 Graphic Representation of the Control Characters of American National Standard Code for Information Interchange
X3.34-1972 Interchange Rolls of Perforated Tape for Information Interchange
X3.36-1975 Synchronous High-Speed Data Signaling Rates between Data Terminal Equipment and Data Communication Equipment
X3.37-1980 Programming Language APT
X3.38-1972 (R1977) Identification of States of the United States (Including the District of Columbia) for Information Interchange
X3.39-1973 Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)
X3.40-1976 Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE)
X3.41-1974 Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange
X3.42-1975 Representation of Numeric Values in Character Strings for Information Interchange
X3.43-1977 Representations of Local Time of the Day for Information Interchange
X3.44-1974 Determination of the Performance of Data Communication Systems
X3.45-1974 Character Set for Handprinting
X3.46-1974 Unrecorded Magnetic Six-Disk Pack (General, Physical, and Magnetic Characteristics)
X3.47-1977 Structure for the Identification of Named Populated Places and Related Entities of the States of the United States for Information Interchange
X3.48-1977 Magnetic Tape Cassettes for Information Interchange (3.810-mm [0.150-Inch] Tape at 32 bpmm [800 bpi], PE)
X3.49-1975 Character Set for Optical Character Recognition (OCR-B)
X3.50-1976 Representations for U.S. Customary, SI, and Other Units to Be Used in Systems with Limited Character Sets
X3.51-1975 Representations of Universal Time, Local Time Differentials, and United States Time Zone References for Information Interchange
X3.52-1976 Unrecorded Single-Disk Cartridge (Front Loading, 2200 BPI) (General, Physical, and Magnetic Requirements)
X3.53-1976 Programming Language PL/I
X3.54-1976 Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording)
X3.55-1977 Unrecorded Magnetic Tape Cartridge for Information Interchange, 0.250 Inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded
X3.56-1977 Recorded Magnetic Tape Cartridge for Information Interchange, 4 Track, 0.250 Inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded
X3.57-1977 Structure for Formatting Message Headings for Information Interchange Using the American National Standard Code for Information Interchange for Data Communication Systems Control
X3.58-1977 Unrecorded Eleven-Disk Pack (General, Physical, and Magnetic Requirements)
X3.59-1981 Magnetic Tape Cassettes for Information Interchange, Dual Track Complementary Return-to-Bias (CRB) Four-States Recording on 3.81-mm (0.150-Inch) Tape
X3.60-1978 Programming Language Minimal BASIC
X3.61-1978 Representation of Geographic Point Locations for Information Interchange
X3.62-1979 Paper Used in Optical Character Recognition (OCR) Systems
X3.63-1981 Unrecorded Twelve-Disk Pack (100 Megabytes) (General, Physical, and Magnetic Requirements)
X3.64-1979 Additional Controls for Use with American National Standard Code for Information Interchange
X3.66-1979 Advanced Data Communication Control Procedures (ADCCP)
X3.72-1981 Parallel Recorded Magnetic Tape Cartridge for Information Interchange, 4 Track, 0.250 Inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded
X3.73-1980 Single-Sided Unformatted Flexible Disk Cartridge (for 6631-BPR Use)
X3.74-1981 Programming Language PL/I, General-Purpose Subset
X3.76-1981 Unformatted Single-Disk Cartridge (Top Loading, 200 tpi 4400 bpi) (General, Physical, and Magnetic Requirements)
X3.77-1980 Representation of Pocket Select Characters in Information Interchange
X3.79-1981 Determination of Performance of Data Communications Systems That Use Bit-Oriented Communication Procedures
X3.80-1981 Interfaces between Flexible Disk Cartridge Drives and Their Host Controllers
X3.82-1980 One-Sided Single-Density Unformatted 5.25-Inch Flexible Disk Cartridge (for 3979-BPR Use)
X3.83-1980 ANSI Sponsorship Procedures for ISO Registration According to ISO 2375
X3.84-1981 Unformatted Twelve-Disk Pack (200 Megabytes) (General, Physical, and Magnetic Requirements
X3.85-1981 1/2-Inch Magnetic Tape Interchange Using a Self Loading Cartridge
X3.86-1980 Optical Character Recognition (OCR) Inks
X3.88-1981 Computer Program Abstracts
X3.89-1981 Unrecorded Single-Disk, Double-Density Cartridge (Front Loading, 2200 bpi, 200 tpi) (General, Physical, and Magnetic Requirements)
X3.92-1981 Data Encryption Algorithm
X3.93M-1981 OCR Character Positioning

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