DEVELOPMENT STANDARD

QIC-100-MC
Revision F
23 May 89

SERIAL RECORDED MAGNETIC TAPE MINICARTRIDGE FOR INFORMATION INTERCHANGE

0.250 in. (6.35 mm) Tape
24 Tracks
Transition Density: 12,500 FTPI
GCR 0,2 4,5 Encoding

Formatted Capacity: 86 Mbytes
(With DC2080 Minicartridge or Equivalent)

Quarter-Inch
Cartridge
Drive Standards, Inc.

311 East Carrillo Street
Santa Barbara, California 93101
Telephone (805) 963-3853
Fax (805) 962-1541

(See important notices on following page)

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TABLE OF CONTENTS

FIGURES

TABLES

1. Introduction

1.1 **Scope.** This standard provides the requirements for a tape cartridge to be used for information interchange among information processing systems, communication systems, and associated equipment utilizing a standard code as agreed upon by the interchange parties. This standard deals solely with the requirements for recording on magnetic tape. Compliance with the standard for unrecorded tape, Proposed American National Standard Unrecorded Magnetic Tape and Cartridge for Information Interchange 12/24-Track, Serial, 0.250 inch (6.35 mm), 12 500 ftpi (492 ftpmm) ANSI-X3.XX-198X is a requirement for information interchange. The unrecorded standard provides the general requirements, definitions, physical and magnetic tape characteristics, and the tape-cartridge requirements.

The use of a labeling standard, such as American National Standard Tape Label and File Structure for Information Interchange, ANSI X3.27 will support data interchange between data processing systems.

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1.2 **Purpose.** This standard defines the requirements and supporting test methods necessary to ensure information 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.

The performance levels contained in this standard represent the minimum acceptable levels of performance for data interchange purposes. They, therefore, represent the performance levels that the interchange 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.

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

The original dimensions and quantities for all numeric values in this standard are in U.S. Customary units (similar to British Imperial units) and centimeter-gram-second electromagnetic units (cgs-emu). Conversions of these units to the International System of Units (SI) have been incorporated in accordance with the procedures described in American National Standard Metric Practice, ANSI/IEEE 268-1982. Units of either of the two measurement systems may be referred to, but the two systems should not be intermixed or reconverted. Conversions of toleranced dimensions and quantities in this standard have been performed in accordance with Method A of ANSI/IEEE 268-1982 and International Standard Tolerance Dimensions-Conversions from Inches into Millimeters and Vice Versa, ISO 370-1975 to maintain the implied correspondence between the accuracy of the original data and the number of significant digits and rounding of the converted values. In the national standards of ISO member bodies, additional rounding may be done to produce "preferred" values. These values should lie within or close to the original tolerances.

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

1.3 **Conformance.** A magnetic tape cartridge conforms to this standard if it satisfies all mandatory requirements of this standard.

2.0 Reference Standards

2.1 **American National Standards.** This standard is intended for use in conjunction with the following American National Standards. When these standards are superseded with a revision approved by the American National Standards Institute, Inc., the revision shall apply. Copies are available from the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

The "Unrecorded Magnetic Tape Mini Cartridge," (Give ANSI number).

3.0 Definitions

The following definitions, listed in alphabetical order, and those given in the American National Standard Dictionary for Information Processing, ASC X3/TR-1-82, apply to this standard:

allocation unit. The minimum increment of storage which may be utilized or accessed.

alternate block. A block set aside at format time, highlighted as an alternate storage location for a flawed block detected during normal operation.

amplitude reference tape. The tape used to establish the standard reference amplitude when it is recorded with continuous ONEs at 12 500 ftpi (492 ftpmm).
Note: A master standard amplitude reference tape has been established at the National Bureau of Standards (NBS) for the physical recording density of 12,500 ftpi (492 ftpmm). Secondary amplitude reference tapes are available from NBS under the part number SRM XXXXXX.

For ordering information contact: Office of Standard Reference Material, Room B311, Chemistry Building, National Bureau of Standards, Gaithensburg, MD 20899.

beginning-of-tape (BOT) marker. The BOT marker is a set of two holes punched in the tape. There are three sets of holes provided, the innermost of which is used 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. The additional sets of holes are used to ensure reliability of detection.

bit. A single digit in the binary number system.

bit-cell. A distance along a recorded track between the flux transitions of adjacent bits.

block. A group of three frames utilized as a unit, and contained on a single track.

byte. A group of eight (8) data bits (10 encoded bits) that are operated on as a unit.

cyclical redundancy check code (CRCC). A five-byte code computed over the record excluding the preamble, postamble, and start-of-data mark used to provide error detection. [Note: The CRCC is recorded after the data and before the postamble in a data record].

early warning (EW) marker. The EW marker is one hole in the tape indicating the approaching end of the permissible recording area for even numbered tracks and indicating the approaching start of the permissible recording area for odd numbered tracks.

end-of-tape (EOT) marker. The EOT marker is a single hole punched in the tape. There are three holes along a single line. The first to pass the photosensor during forward operation indicates that the permissible recording area has been exceeded. The additional holes are used to ensure reliability of detection.

erase. To remove all magnetically recorded information from the tape.

error correcting codes (ECC). A special sequence of bytes used for error detection and correction.

flawed block. A block containing one or more highlighted flawed frames detected during a tape certification process or during normal tape operations.

flawed frames. Frames which have been determined to have media defects.

flux transition position. The point that exhibits the maximum free-space surface flux density normal to the tape surface.

flux transition spacing. The distance on the magnetic tape between successive flux transitions. Usually expressed as flux transitions per inch (ftpi) or flux transitions per millimeter (ftpmm).

forward direction. Tape motion from supply reel (BOT end) to take-up reel (EOT end).

frame. An element of a block consisting of a pair of records made up of an ID record followed by a non-ID record.

group-coded recording (GCR). A recording technique that collects 4-bit groups of data bits and encodes them into 5-bit groups prior to recording them on magnetic tape.

interleave. This is an organization obtained by inserting a number of non-logically connected frames between frames which are logically connected.

interleave factor. This is the ratio of the total number of frames to the number of frames which are logically connected.

inter-record gap. A section on a tape track separating records of information.

load point (LP) marker. A single hole punched in the tape indicating the approaching start of the permissible recording area for even numbered tracks and indicating the end of the permissible recording area for odd numbered tracks.

logical block. A physical block whose location is determined based upon defect mapping.

magnetic tape. A tape that accepts and retains magnetic signals intended for input, output, and storage of data for information processing.

manufacturer's block. The first three consecutive frames on each track set aside for the control and listing of media flaws determined during the format process.

nonoverlap. A relationship between the physical location of consecutive blocks of data. The first logical block frames are followed by the second logical block frames.

overlap. A relationship between the physical location of consecutive blocks of data. The first logical block frames are alternated with the second logical block frames.

overwrite. The process of recording new information over previously recorded information on a discrete section of tape.

parallel recording. A technique for simultaneously recording two or more records independently on two or more tracks.

physical block. A block whose location is determined by defined calculations based on the number of frames per track and interleave.

physical recording density. The number of recorded flux transitions per unit length of track, e.g. flux transitions per inch (ftpi) or flux transitions per millimeter (ftpmm).

postamble. A sequence of binary bits recorded at the end of each record on a magnetic tape to isolate data from the tape magnetization.

preamble. A sequence of binary characters recorded at the beginning of each record on a magnetic tape to provide electronic synchronization when reading in the forward direction of tape travel.

record. A group of consecutive bits comprising the preamble, start-of-date marker, record-type marker, optional data field, ID field, CRC, and postamble.

reference tape cartridge. A magnetic tape cartridge selected for a specific property to be used for calibrating purposes.

reverse direction. Tape motion from take-up reel (EOT end) to supply reel (BOT end).

secondary reference tape cartridge. A tape cartridge intended for routine calibrating purposes, the performance of which is known and stated in relation to that of the Reference Tape Cartridge.

signal amplitude reference tape cartridge. A reference tape cartridge selected as a standard for signal amplitude and reference field.

standard reference amplitude. The average peak-to-peak signal amplitude output from the master standard amplitude reference tape when it is recorded with the standard measurement current on the NBS measurement system at the test physical recording density. The signal amplitude shall be averaged over at least 12 500 flux transitions. Traceability to the standard reference amplitude reference level is provided by the secondary amplitude reference tapes.

thread. A series of logically associated frames, each of which is physically separated by one or more interleaved frames.

track. A longitudinal area on the tape along which a series of magnetic signals can be recorded.

uselog block. Three consecutive frames located on each track of the tape. These frames are located immediately after the manufacturer's block.

4.0 RECORDING

4.1 **Cartridge Conditioning.** Before use, the cartridge shall be conditioned by exposure to the operating environment for a time at least equal to the period during which it has been out of the operating environment (up to a maximum of 8 hours). The cartridge shall also be conditioned by running the tape one complete end-to-end pass in any of the following cases:

i) Each time that it is inserted in a drive.
ii) After prolonged operation over a limited area.
iii) When the temperature change to which the cartridge has been exposed is greater than 17 degrees C (30 degrees F).

4.2 **Method.** The method of recording shall be the "non-return to zero, change on one" (NRZ1) where a "one" is represented by a flux transition occurring in the bit-cell and a "zero" is represented by the absence of a flux transition in the bit-cell.

4.3 **Encoding.** Each 8-bit data is separated into two 4-bit groups. Each 4-bit group is encoded into a 5-bit GCR group for recording on the magnetic tape cartridge. The most significant group is recorded first. The encoded data has the property that no more than two consecutive "zeros" shall occur. The translation table for data groups (B3, B2, B1, B0) and GCR groups (G4, G3, G2, G1, G0) shall be in accordance with Table 1. GCR bit G4 is recorded first.

ENCODING

HEX	B3	B2	B1	B0	G4	G3	G2	G1	G0	HEX
0	0	0	0	0	1	1	0	0	1	19
1	0	0	0	1	1	1	0	1	1	1B
2	0	0	1	0	1	0	0	1	0	12
3	0	0	1	1	1	0	0	1	1	13
4	0	1	0	0	1	1	1	0	1	1D
5	0	1	0	1	1	0	1	0	1	15
6	0	1	1	0	1	0	1	1	0	16
7	0	1	1	1	1	0	1	1	1	17
8	1	0	0	0	1	1	0	1	0	1A
9	1	0	0	1	0	1	0	0	1	09
A	1	0	1	0	0	1	0	1	0	0A
B	1	0	1	1	0	1	0	1	1	0B
C	1	1	0	0	1	1	1	1	0	1E
D	1	1	0	1	0	1	1	0	1	0D
E	1	1	1	0	0	1	1	1	0	0E
F	1	1	1	1	0	1	1	1	1	0F

TABLE 1

4.4 **Nominal Density.** The maximum nominal density (flux transition in every bit-cell) shall be 12 500 flux transitions per inch (492 flux transitions per millimeter).

4.5 **Nominal Bit-Cell Length.** The nominal bit-cell length shall be 80.00 microinches (2.03 micrometers).

4.6 **Average Bit-Cell Length Variations.**

4.6.1 **Average Bit-Cell Length.** The average bit-cell length is the distance between N+1 flux transitions divided by n.

4.6.2 **Long-Term Average Bit-Cell Length.** The long-term average bit-cell length shall be the average bit-cell length measured over the data fields of 20 contiguous frames. The long-term average bit-cell length shall be within ± 5% of the nominal bit-cell length.

4.6.3 **Short-Term Average Bit-Cell Length.** The short-term average bit-cell length shall be the average bit-cell length measured over 16 bit-cells of the preamble prior to the start-of-data marker, as described in Section 6, Tape Format. The short-term average bit-cell length shall be within ± 7% of the nominal bit-cell length.

4.6.4 **Rate of Change.** The rate of change of the bit-cell length shall not exceed 0.25%. The rate of change is given by the relationship in Figure 1.

$$\text{Rate of Change} = \frac{(t1/4) - (t2/4)}{t3/5}$$

Where t1, t2, and t3 are the times between flux transitions as shown below. Periods 1 through 5 are contiguous and represent the repetitive data pattern 101010 within a data block:

RATE OF CHANGE

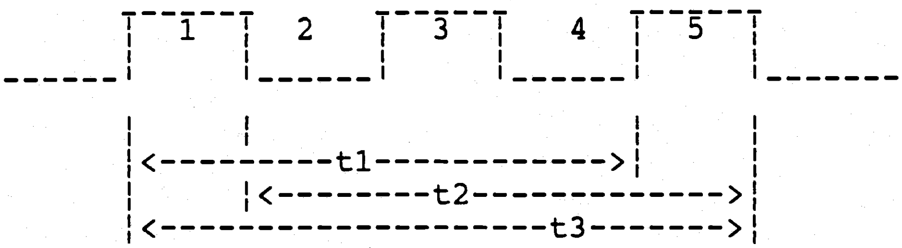

FIGURE 1

4.7 **Instantaneous Flux Transition Spacing.** The instantaneous spacing between flux transitions is influenced by the writing process, the pattern recorded (pulse crowding effect) and other factors. Instantaneous spacings between flux transitions shall satisfy the following conditions:

In a sequence of flux transitions defined by bit pattern 11100111, the center flux transitions (designated by "X's" in Figure 2) of each group of ONE's is called a Reference Flux Transition. This pattern is present in every record in the last 4-bits of the start-of-data marker and the first 4-bits of the record-type marker. The maximum displacement of flux transitions between the reference flux transitions shall not deviate by more than 35% of the nominal bit-cell length (d1), averaged over the five bit-cells between the reference flux transitions indicated in the bit pattern below. X denotes the Reference Flux Transitions.

INSTANTANEOUS FLUX TRANSITION SPACING

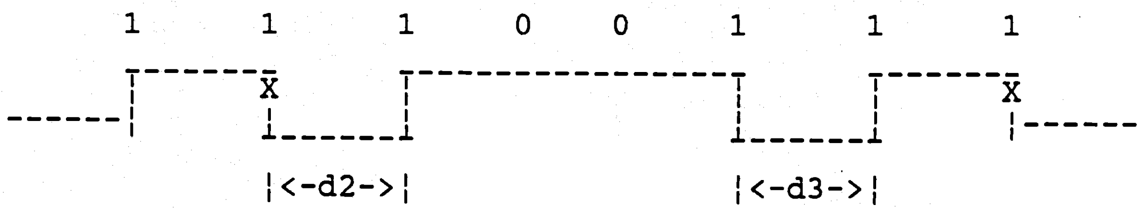

FIGURE 2

d1 is the nominal bit-cell length.
$(1.35 * d1) \geq d2 \geq (0.65 * d1)$ $(1.35 * d1) \geq d3 \geq (0.65 * d1)$

The tolerance of the long-term average spacing and of the short-term average spacing are included in this deviation.

4.8 **Signal Amplitude Reference Tape Cartridge.** A signal amplitude secondary reference tape cartridge (which will be supplied by the tape cartridge manufacturer pending availability of Standard Reference Material from the National Bureau of Standards) is a magnetic tape cartridge which has been calibrated against an interim Standard Reference Amplitude Tape, which has been selected as a standard for signal amplitude when recorded at 12 500 flux transitions per inch (492 flux transitions per millimeter). The interim Standard Reference Amplitude Tape is maintained by the manufacturer.

4.9 **Average Standard Reference Amplitude.** The average standard reference amplitude is the peak-to-peak signal amplitude averaged over a minimum of 12 500 consecutive flux transitions derived from the Signal Amplitude Reference Tape Cartridge when it is recorded at a density of 12 500 ftpi and at a recording current of between 155% and 165% of the current required to produce the Reference Field at 12 500 ftpi. The reference field is a minimum field which, when applied to the Signal Amplitude Reference Tape cartridge, causes a signal output equal to 95% of the maximum achievable output at the specified test density.

4.10 **Signal Amplitude.**

4.10.1 **Average Signal Amplitude.** The average peak-to-peak signal amplitude of an interchanged tape at 12 500 ftpi shall deviate no more than +50% or -35% from the Average Standard Reference Amplitude. This averaging shall be made over the central 100 flux transitions of the 125 contiguous flux transitions of the preambles of at least 120 non-ID records.

4.10.2 **Maximum Signal Amplitude.** The peak-to-peak signal amplitude of any interchanged tape recorded at 4167 ftpi (164 ftpmm) shall be less than 3 times the Average Standard Reference Amplitude.

4.10.3 **Minimum Signal Amplitude.** To be considered valid, a frame of an interchanged tape shall contain no adjacent flux transitions whose peak-to-peak signal amplitude is less than 25% of the Average Standard Reference Amplitude.

4.11 **Overwrite.** In an interchanged tape cartridge recorded with the longest wavelength and overwritten with the shortest wavelength, the amplitude of the residual long wavelength signal shall not exceed 6% of the amplitude of the shortest wavelength signal, when measured with a spectrum analyzer with a sampling bandwidth of 1% of the overall system bandwidth, which is determined by the shortest wavelength recorded.

4.12 **Azimuth.** The angular deviation of the mean flux transition lines from the line normal to the tape cartridge reference edge shall be less than 9 minutes of arc.

5.0 TRACKS

5.1 **Number and Use of Tracks.** There shall be multiple numbered tracks. Even numbered tracks shall be recorded in the forward direction of tape movement. Odd numbered tracks shall be recorded in the reverse direction of tape movement.

5.1.1 **Even and Odd Tracks.** Data for interchange shall be recorded between load-point marker and the early-warning marker a shown in Figure 3.

EVEN AND ODD TRACKS

```
 ------------------------------------------------------------
 |     |                                                |    |
BOT    LP  >>>>>>>>>>>>>> EVEN TRACKS >>>>>>>>>>>>>> EW   EOT
 |     |                                                |    |
 |-----------------------------------------------------------|
 |     |                                                |    |
BOT    EW <<<<<<<<<<<<<<<  ODD TRACKS <<<<<<<<<<<<<<< LP  EOT
 |     |                                                |    |
 ------------------------------------------------------------
```

FIGURE 3

5.1.1.1 **Even Tracks.** Even tracks shall be recorded in the forward direction only. All even tracks shall start a minimum of 3 inches (76mm) and a maximum of 4 inches (102mm) after (in the forward direction) the load-point marker.

5.1.1.2 **Odd Tracks.** Odd tracks shall be recorded in the reverse direction only. All odd tracks shall start a minimum of 1 inch (25mm) and a maximum of 2 inches (51mm) after (in the reverse direction) the early-warning marker.

5.2 **Reference Edge.** The edge of the tape nearest the tape cartridge base, as defined in the "Unrecorded Magnetic Tape Mini Cartridge" is the datum for track location.

5.3 **Track Format.** The Track Format shall consist of parallel tracks as shown in Tables 2 and 3.

12 TRACK FORMAT

< BOT CARTRIDGE UPPER EDGE EOT >

	<	d09 = 0.2325 in.	d09 = 5.906 mm ---	
	>	d08 = 0.2125 in.	d08 = 5.398 mm ---	
	<	d05 = 0.1925 in.	d05 = 4.890 mm ---	
T	>	d04 = 0.1725 in.	d04 = 4.381 mm ---	
R	<	d01 = 0.1525 in.	d01 = 3.873 mm ---	
A	>	d00 = 0.1325 in.	d00 = 3.366 mm ---	C
C	<	d03 = 0.1125 in.	d03 = 2.858 mm ---	
K	>	d02 = 0.0925 in.	d02 = 2.350 mm ---	
S	<	d07 = 0.0725 in.	d07 = 1.841 mm ---	B
	>	d06 = 0.0525 in.	d06 = 1.334 mm ---	
	<	d11 = 0.0325 in.	d11 = 0.826 mm ---	
	>	d10 = 0.0125 in.	d10 = 0.318 mm ---	A

CARTRIDGE REFERENCE EDGE

< BOT EOT >

A	Reference Edge to Track Centerline ± 0.0020 in.	Reference Edge to Track Centerline ± 0.051 mm
B	Tape Width and Tolerance = 0.2470 in. ± 0.0005 in.	Tape Width and Tolerance = 6.274 mm ± 0.013 mm
C	Track Centerline Spacing = 0.0200 in. ± 0.0020 in.	Track Centerline Spacing = 0.508 mm ± 0.051 mm
	dxx is the centerline of a track to the reference edge distance (where xx is the track number).	

TABLE 2

24 TRACK FORMAT

< BOT CARTRIDGE UPPER EDGE EOT >

	<	d21 = 0.2395 in.	d21 = 6.083 mm	
	>	d20 = 0.2295 in.	d20 = 5.829 mm	
	<	d17 = 0.2195 in.	d17 = 5.575 mm	
	>	d16 = 0.2095 in.	d16 = 5.321 mm	
	<	d13 = 0.1995 in.	d13 = 5.067 mm	
	>	d12 = 0.1895 in.	d12 = 4.813 mm	
	<	d09 = 0.1795 in.	d09 = 4.559 mm	
	>	d08 = 0.1695 in.	d08 = 4.305 mm	
	<	d05 = 0.1595 in.	d05 = 4.051 mm	
T	>	d04 = 0.1495 in.	d04 = 3.797 mm	
R	<	d01 = 0.1395 in.	d01 = 3.543 mm	
A	>	d00 = 0.1295 in.	d00 = 3.289 mm	C
C	<	d03 = 0.1195 in.	d03 = 3.035 mm	
K	>	d02 = 0.1095 in.	d02 = 2.781 mm	
S	<	d07 = 0.0995 in.	d07 = 2.527 mm	
	>	d06 = 0.0895 in.	d06 = 2.273 mm	
	<	d11 = 0.0795 in.	d11 = 2.019 mm	
	<	d10 = 0.0695 in.	d10 = 1.765 mm	B
	<	d15 = 0.0595 in.	d15 = 1.511 mm	
	>	d14 = 0.0495 in.	d14 = 1.257 mm	
	<	d19 = 0.0395 in.	d19 = 1.003 mm	
	>	d18 = 0.0295 in.	d18 = 0.749 mm	
	<	d23 = 0.0195 in.	d23 = 0.495 mm	
	>	d22 = 0.0095 in.	d22 = 0.241 mm	A

< BOT CARTRIDGE REFERENCE EDGE EOT >

TABLE 3

A	Reference Edge to Track Centerline ± 0.0015 in.	Reference Edge to Track Centerline ± 0.038 mm
B	Tape Width and Tolerance = 0.2470 in. ± 0.0005 in.	Tape Width and Tolerance = 6.274 mm ± 0.013 mm
C	Track Centerline Spacing = 0.0100 in. ± 0.0015 in.	Track Centerline Spacing = 0.254 mm ± 0.038 mm
	dxx is the centerline of a track to the reference edge distance (where xx is the track number).	

TABLE 3 cont.

5.4 Track Dimensions.

5.4.1 Track Width.

5.4.1.1 **12-Track Format, Trim/Straddle Erase R/W Heads.** The width of the active data area of the recorded track shall be 0.0100 ± 0.0005 inches (0.254 ± 0.013 mm) as shown in Figure 4.

5.4.1.2 **24-Track Format, Trim/Straddle Erase R/W Heads.** The width of the active data area of the recorded track shall be 0.0060 ± 0.0005 inches (0.152 ± 0.013 mm).

TRIM/STRADDLE ERASE R/W HEADS

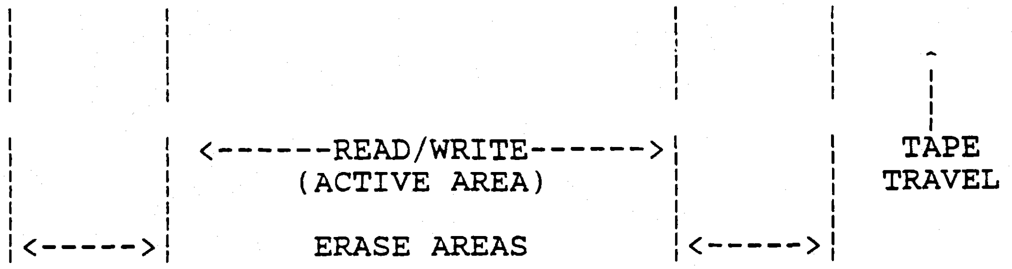

FIGURE 4

5.4.1.3 **12-Track Format, Wide-Write/Narrow-Read R/W Heads.** The total width of the written data area of the recorded track shall be 0.0190 ± 0.0005 inches (0.483 ± 0.013 mm) as shown in Figure 5.

5.4.1.4 **24-Track Format, Wide-Write/Narrow-Read R/W Heads.** The total width of the written data area of the recorded track shall be 0.0080 + 0.0010 inches or -0.0005 inches (0.203 + 0.025 mm or -0.013 mm)

WIDE-WRITE/NARROW-READ R/W HEADS

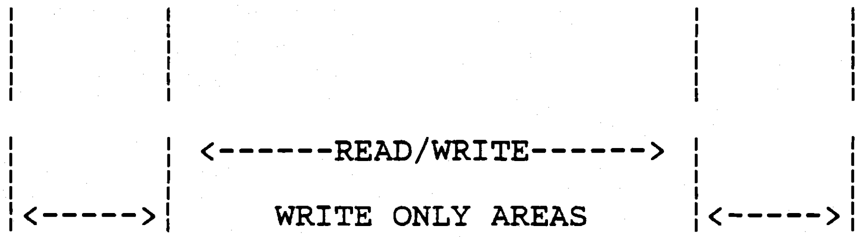

FIGURE 5

6.0 TAPE FORMAT

All records shall conform to the generalized record organization as shown in Figure 6. Certain fields within records are optional or may have a different definition depending on the record type. In any given formatted cartridge, only fixed-length records shall be employed.

The word format (16 bits) is two bytes long, the first byte being the least significant byte and the second byte being the most significant byte.

6.1 Generalized Record Organization.

GENERALIZED RECORD

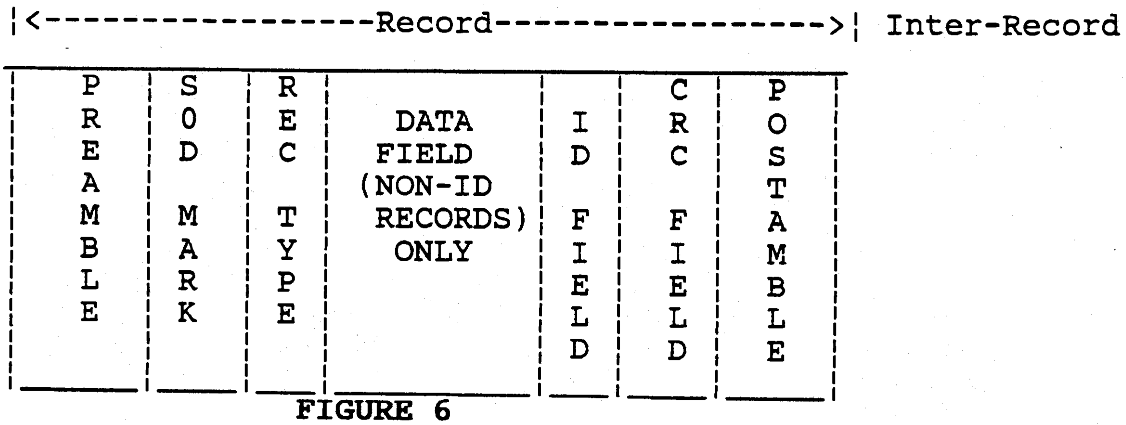

FIGURE 6

6.2 **Inter-Record Gap.** Each record shall be followed by an associated inter-record gap that separates records. There are two types of inter-record gaps, the post-data gap and the post-id gap. They may consist of erased media or may contain any flux reversal pattern other than a data pattern preamble.

6.3 **Preamble.** The preamble shall contain a minimum of 300 and a maximum of 320 flux transitions recorded at the maximum normal recording density of 12 500 flux transitions per inch (492 flux transitions per millimeter). The preamble shall be used to synchronize the data separator in the read electronics to the data frequency. The preamble shall consist of the GCR pattern G4=1, G3=1, G2=1, G1=1 and G0=1.

6.4 **Start-of-Data Marker.** The start-of-data marker shall identify the start of the active (non-preamble) area of the record and shall consist of the GCR pattern in Table 4. The First Group shall be recorded first.

START OF DATA MARKER

G4	G3	G2	G1	G0	G4	G3	G2	G1	G0
1	1	1	1	1	1	1	1	1	0

First Group   Last Group

TABLE 4

6.5 **Record-Type Marker.** The record-type marker shall identify the type of record, as indicated in Table 5.

|$_7$<---ss--->$_4$|$_3$<---rr--->$_0$|

Where:
ss is always 15 (all bits set on). See Section 4, Recording.
rr is the record type.

RECORD-TYPE MARKER

Marker	Record Type
0	Data record
1	ID record
2	Manufacturer's record
3	Parity record
4	File-system record
5	Uselog record
6 - 15	Unassigned (reserved)

TABLE 5

6.6 **Data Field.** The data field shall only be present in Non-ID records. In the ID records, the data field shall be omitted. All bytes of the data field are encoded into GCR in accordance with Section 4, Recording. The data field, as shown in Figure 7, shall contain 4160 bytes.

6.6.1 **System Data Sub-Field.** The system data sub-field shall be the first 64 bytes of the data field and be reserved for recording file-system dependent data.

6.6.2 **User Data Sub-Field.** The user data sub-field shall be the last 4096 bytes of the data field.

THE DATA FIELD

```
| <------------------DATA FIELD-------------------------> |
|                    (4160 bytes)                         |
-------------------------------------------------------------
|               |                                         |
-------------------------------------------------------------
|               |                                         |
| <--SYSTEM-->  | <--------USER DATA SUB-FIELD-----------> |
|     DATA      |           (4096 bytes)                  |
|   SUB-FIELD   |                                         |
|   (64 bytes)  |                                         |
```

FIGURE 7

6.7 **ID Field.** The ID field shall be identical in construction in all records but certain parameters within the ID field are defined differently depending upon the record type. Caution: The information in the ID field may be overridden by the contents of the uselog format descriptor if activated. (See Section 12.3.)

6.7.1 **ID Field of ID Record.** The ID field of each ID record shall consist of 26 bytes which identify and define the format and the recording equipment. The ID field shall be encoded into GCR bytes in accordance with the Section 4, Recording. Bytes identified in Figure 8 as "ZERO" shall have all bits equal to zero (0).

ID FIELD OF ID RECORD

TRACK NUM	ZERO	FRAME NUM	ZERO	ZERO	ZERO	ZERO	ZERO	FRAMES/TRK	TRKS/TAPE	POST DATA GP	POST ID GP	DRIVE SPEC	FORMAT DATE	FORMAT TIME	TRACK SPEC	LOT NUMBER	MANUFAC ID
1	1	2	1	1	1	1	1	2	1	2	2	1	2	2	1	2	2

(Number of Bytes in each Field)

FIGURE 8

6.7.2 **ID Field of Non-ID Record.** The ID field of each non-ID record, as shown in Figure 9, shall consist of 26 bytes which identify and define the format, the usage environment, and the recording equipment. The ID field shall be encoded into GCR bytes in accordance with the Section 4, Recording.

ID FIELD OF NON-ID RECORD

TRACK NUM	THREAD NUM	FRAME NUM	ERR CONTROL	CORR COUNT	ERR COUNT	DATA F LEN	FORM SPEC	FRAMES/TRK	TRKS/TAPE	POST DATA GP	POST ID GP	DRIVE SPEC	UPDATE DATE	UPDATE TIME	TRACK SPEC	LOT NUMBER	MANUFAC ID
1	1	2	1	1	1	1	1	2	1	2	2	1	2	2	1	2	2

(Number of Bytes in each Field)

FIGURE 9

6.7.3 ID Field Parameter Definitions.

6.7.3.1 **Track Number.** The track number shall carry the number of the current physical track. Track numbers shall range in value from zero (0) to 23.

¦$_7$<---uu--->$_5$¦$_4$<---tt--->$_0$¦

Where:
uu is unassigned, always equal to zero (0).
tt is the current track number.

During the format process, enter the proper values for each record type as indicated in Table 6.

TRACK NUMBER

rec. type	data	parity	file	man.	uselog	id
format	0-23	0-23	0-23	0-23	0-23	0-23

TABLE 6

6.7.3.2 Thread and Frame Number.

6.7.3.2.1 **Thread Number.** The thread number shall contain the current thread number.

¦$_7$<---uu--->$_5$¦$_4$<---tt--->$_0$¦

Where:
tt is the current thread number, one (1) to seven (7).
uu is unassigned, always equal to zero (0).

During the format or the operation process, enter the proper values for each record type as indicated in Table 7.

THREAD NUMBER

rec type	data	parity	file	man.	uselog	id
format	1-7	1-7	1-7	1	1	1
operation	1-7	1-7	1-7			

TABLE 7

6.7.3.2.2 **Frame Number.** The frame number shall contain the 16 bits of the physical frame number. The bits 8 through 15 contain the least significant byte of the frame number. The bits 0 through 7 contain the most significant byte of the frame number. Frame numbers shall range from 0 to 617+ per track on each track. Cartridges shall have the same maximum number of frames on each track.

¦$_{15}$<---ff--->$_{0}$¦

Where:
ff is the current frame number.

During the format process, enter the proper values for each record type as indicated in Table 8.

FRAME NUMBER

rec type	data	parity	file	man.	uselog	id
format	0-617+	0-617+	0-617+	0-617+	0-617+	0-617+

TABLE 8

6.7.3.3 **Error Control Method.** The error control method shall identify the type of error correction.

¦$_{7}$<---cc--->$_{0}$¦

Where:
cc is the error control method.

0 = ID record only with 40-bit CRC
1 = 40-bit CRC only
2 = 40-bit CRC plus redundant parity ECC
3 through 255 = reserved.

During the format or the operation process, enter the proper values for each record type as indicated in Table 9.

ERROR CONTROL METHOD

rec type	data	parity	file	man.	uselog	id
format	2	2	2	1	1	0
operation	2	2	2			

TABLE 9

6.7.3.4 **Error Correction Counter.** The error correction counter shall identify the ordinal position within a block of the current frame and the total number of frames (three) in a block.

$|_{7}<\text{---II---}>_{4}|_{3}<\text{---cc---}>_{0}|$

Where:
cc is the current frame (1,2,3) counter in a block of frames.

During the format or the operation process, enter the proper values for each record type as indicated in Table 10.

CURRENT FRAME COUNTER PER BLOCK

rec type	data	parity	file	man.	uselog	id
format	1-2	3	1-2	0	0	0
operation	1-2	3	1-2			

TABLE 10

11 is total number of frames (three) in a block as indicated in Table 11.

TOTAL FRAMES PER BLOCK

rec type	data	parity	file	man.	uselog	id
format	3	3	3	0	0	0
operation	3	3	3			

TABLE 11

6.7.3.5 **Error Correction Method.** The error correction method shall specify the error correction scheme used by the recording system in terms of the level of redundancy and dispersion factor.

$|_{7}<\text{---rr---}>_{4}|_{3}<\text{---dd---}>_{0}|$

Where:
rr is redundancy, it is computed as the ratio of data of frames to error-correction frames (parity frames).

0 = NO ECC.
2 = 50% ECC.

During the format or the operation process, enter the proper values for each record type as indicated in Table 12.

REDUNDANCY

rec type	data	parity	file	man.	uselog	id
format	2	2	2	0	0	0
operation	2	2	2			

TABLE 12

dd is the dispersion factor as indicated in Table 13. It shall be zero for interchange purposes.

DISPERSION FACTOR

rec type	data	parity	file	man.	uselog	id
format	0	0	0	0	0	0
operation	0	0	0			

TABLE 13

6.7.3.6 **Data Field Length.** The data field length shall specify the size of the data field according to the formula, SIZE = 32* (n+3) where "n" is the value of the data field length. It shall be 127, which corresponds to the data field length of 4160 bytes.

¦$_7$<---11--->$_0$¦

Where:
11 is the data field length.

During the format process, enter the proper values for each record type as indicated in Table 14.

DATA FIELD LENGTH

rec type	data	parity	file	man.	uselog	id
format	127	127	127	127	127	0

TABLE 14

6.7.3.7. **Format Specification.** The format specification shall specify the interleave factor (number of threads) used on the tracks, the use of parallel recoridng (number of simultaneously written tracks), and the use of overlapping frames.

```
¦<-oo->¦6<---pp--->¦3¦2<---ii-->0¦
  7
```

Where:
ii is the interleave factor.

During the format or the operation process, enter the proper values for each record type as indicated in Table 15.

INTERLEAVE FACTOR

rec type	data	parity	file	man.	uselog	id
format	2-7	2-7	2-7	1	1	0
operation	2-7	2-7	2-7			

TABLE 15

Where:
pp is the number of tracks recorded simultaneously as indicated in Table 16.

A value of one indicates single-channel, serial recording. A value of two indicates dual-channel, parallel recording.

PARALLEL RECORDING

rec type	data	parity	file	man.	uselog	id
format	1-2	1-2	1-2	1-2	1-2	0
operation	1-2	1-2	1-2	1-2	1-2	

TABLE 16

Where:
oo is the overlap bit as indicated in Table 17.
0 = the logical data is nonoverlapped.
1 = the logical data is overlapped.

OVERLAPPED

rec type	data	parity	file	man.	uselog	id
format	0-1	0-1	0-1	0	0	0
operation	0-1	0-1	0-1			

TABLE 17

Examples of this are illustrated in Figures 10 and 11.

OVERLAPPED DATA

```
        -----BLOCK 1-----       -----BLOCK 3-----
        |       |       |       |       |       |
. . . . A1  A2  B1  B2  p1  p2  A3  A4  B3  B4  p3  p4 . . .
            |       |       |       |       |       |
            -----BLOCK 2-----       -----BLOCK 4-----
```

FIGURE 10

Where:
p1 is computed from A1 and B1. p2 is computed from A2 and B2.
p3 is computed from A3 and B3. p4 is computed from A4 and B4.

NON-OVERLAPPED DATA

```
                                      (1+1)
        -----BLOCK 1-----       -----BLOCK 3-----
        |       |       |       |       |       |
. . . . A1  Am  B1  Bm  p1  pm  A2  An  B2  Bn  p2  pn . . .
            |       |       |       |       |       |
            -----BLOCK m-----       -----BLOCK n (m+1)
```

FIGURE 11

Where:
p1 is computed from A1 and B. p2 is computed from A2 and B2.
pm is computed from Am and Bm. pn is computed from An and Bn.

6.7.3.8 **Frames Per Track.** The frames per track shall specify the total number of frames recorded on each track at format time. This shall be the same for all tracks. The total number of frames includes flawed frames. The actual number of frames utilized may be less than the value of frames per track based on the interleave factor. (See Section 9, Interleave Organization).

¦$_{15}$<---ff--->$_{0}$¦

Where:
ff is the total number of frames per track.

During the format process, enter the proper values for each record type as indicated in Table 18. If the number of frames per track are unknown at the time of recording, this should be set to zero.

FRAMES PER TRACK

rec type	data	parity	file	man.	uselog	id
format	618+	618+	618+	618+	618+	618+

TABLE 18

6.7.3.9 **Tracks Per Tape.** The tracks per tape shall specify the total number of tracks on the tape to be either 12 for the 12-track format or 24 for the 24-track format.

¦$_{7}$<---tt--->$_{0}$¦

Where:
tt is the total tracks per tape.

During the format process, enter the proper values for each record type as indicated in Table 19.

TRACKS PER TAPE

rec type	data	parity	file	man.	uselog	id
format	12/24	12/24	12/24	12/24	12/24	12/24

TABLE 19

6.7.3.10 **Post-Data-Gap Size.** The post-data-gap size shall specify the length (from 400 to 462 bytes) of the post-data gap.

¦$_{15}$<---pp--->$_{0}$¦

Where:
pp is the post-data-gap size.

During the format process, enter the proper values for each record type as indicated in Table 20.

POST-DATA-GAP

rec type	data	parity	file	man.	uselog	id
format	400-462	400-462	400-462	400-462	400-462	400-462

TABLE 20

6.7.3.11 **Post-ID-Gap Size.** The post-id-gap size shall specify the length (100 bytes) of the post-id gap.

¦$_{15}$<---pp--->$_{0}$¦

Where:
pp is the post-id-gap size.

During the format process, enter the proper values for each record type as indicated in Table 21.

POST-ID-GAP

	data	parity	file	man.	uselog	id
format	100	100	100	100	100	100

TABLE 21

6.7.3.12 **Drive Specification.** The drive specification shall categorize the formatting hardware according to head types and head positioner types.

¦$_{7}$<---uu--->$_{4}$¦$_{3}$<-hh->$_{2}$¦$_{1}$<-pp->$_{0}$¦

Where:
uu is unassigned and set to zero (0).
hh is the head type (each channel).

00 = wide-write, narrow-read
01 = reserved
10 = reserved
11 - trim/straddle erase

During the format process, enter the proper values for each record type as indicated in Tables 22 and 23.

DRIVE SPECIFICATION

	data	parity	file	man.	uselog	id
format	0/3	0/3	0/3	0/3	0/3	0/3

TABLE 22

pp is the head positioner type.

00 = reserved
01 = edge-reference
10 = reserved
11 = reserved

POSITIONER TYPE

	data	parity	file	man.	uselog	id
format	1	1	1	1	1	1

TABLE 23

6.7.3.13 **Date.** The date (month, day, year) shall map into the 16 bits of date.

|$_{15}$<---yy--->$_{9}$|$_{8}$<---mm---$_{5}$>|$_{4}$<---dd--->$_{0}$|

Where:
yy is the current year since 1980 (0-119: 1980-2099).

During the format process, enter the proper values for each record type as indicated in Tables 24, 25, and 26.

CURRENT YEAR

	data	parity	file	man.	uselog	id
format	0-119	0-119	0-119	0-119	0-119	0-119

TABLE 24

mm is the current month.

CURRENT MONTH

	data	parity	file	man.	uselog	id
format	1-12	1-12	1-12	1-12	1-12	1-12

TABLE 25

dd is the current day.

CURRENT DAY

	data	parity	file	man.	uselog	id
format	1-31	1-31	1-31	1-31	1-31	1-31

TABLE 26

If the date was not available to the recording system, then this field is set to zero (0).

In ID records, the date carries the date when the tape was formatted.

In Non-ID records, the date carries the date the record was created or last updated.

6.7.3.14 **Time.** The time shall be in a 24-hour format.

¦$_{15}$<---hh--->$_{11}$¦$_{10}$<---mm--->$_{5}$¦$_{4}$<---xx--->$_{0}$¦

Where:
hh is the current hour.

During the format process, enter the proper values for each record type as indicated in Tables 27, 28, and 29.

CURRENT HOUR

rec type	data	parity	file	man.	uselog	id
format	0-23	0-23	0-23	0-23	0-23	0-23

TABLE 27

mm is the current minute.

CURRENT MINUTE

rec type	data	parity	file	man.	uselog	id
format	0-59	0-59	0-59	0-59	0-59	0-59

TABLE 28

xx is the number of two-second increments.

CURRENT SECOND

rec type	data	parity	file	man.	uselog	id
format	0-29	0-29	0-29	0-29	0-29	0-29

TABLE 29

If the time was not available to the recording system, then this field is set to 65,535.

In ID records, the time bytes carry the time when the tape was formatted.

In Non-ID records, the time bytes carry the time the record was created or last updated.

6.7.3.15 **Track Specification.** The track specification shall be reserved and is set to zero (0).

|$_7$<---tt--->$_0$|

Where:
tt is set to zero (0).

During the format process, enter the proper values for each record type as indicated in Table 30.

TRACK SPECIFICATION

rec type	data	parity	file	man.	uselog	id
format	0	0	0	0	0	0

TABLE 30

6.7.3.16 **Lot Number.** The lot number may be used as described below:

$|_{15}$<----ll---->$_{0}|$

Where:
ll is the lot number and is user unique.

During the format process, enter the proper values for each record type as indicated in Table 31.

LOT NUMBER

rec type	data	parity	file	man.	uselog	id
format	*	*	*	*	*	*

TABLE 31

* The lot number is not defined for interchange purposes.

In ID records, recorded at format time, the lot number provides manufacturer's of preformatted media a means of identifying the tape in terms of lot, batch, and date-code.

In Non-ID records, the lot number provides manufacturer's of duplicate software a means of identifying the source, content, etc. of the supplicated software.

6.7.3.17 **Manufacturer's ID.** The manufacturer's ID may identify the manufacturer of preformatted distribution media.

$|_{15}$<----m---->$_{0}|_{7}$<----m---->$_{8}|$

Where:
m is two bytes which indicate the special coded mnemonic of the formatter of the tape media, the first character of the manufacturing mnemonic being in bits 7---->0 and the second character of the mnemonic being in bits 15---->8.

During the format process, enter the proper values for each record type as indicated in Table 32.

MANUFACTURER'S ID

rec type	data	parity	file	man.	uselog	id
format	*	*	*	*	*	*

TABLE 32

* The manufacturer's ID is not defined for interchange purposes.

Using AM as an example:
A would be the low-order byte (bits 7 through 0) and
M would be the high-order byte (bits 15 through 8).

6.8 **CRCC Field.** A 40-bit (5-byte) CRCC field shall be recorded, most significant byte first, at the end of each record, immediately after the ID field and immediately before the postamble as in Figure 12. A valid CRCC shall occupy the CRCC field at the time of recording. The value of the CRCC field shall be computed by using the polynomial in Section 9, Error Control.

CRCC (5 bytes)

1	2	3	4	5
bits 39-32	bits 31-24	bits 23-16	bits 15-8	bits 7-0

FIGURE 12

6.9 **Postamble.** A postamble shall be used with a minimum of 10 and a maximum of 40 flux transitions recorded at the nominal density of 12,500 flux transitions per inch (492 flux transitions per millimeter).

6.10 **Record Types.** ID records shall range from 54 to 59 bytes long. Non-ID (all other types) records shall range from 4224 to 4229 bytes long.

6.10.1 **ID Records.** The ID record format shall be similar to the data record format, with the requirement that the data field shall be omitted. The record-type marker shall be one (1). The contents of the ID field shall differ in ID records as compared to non-ID records.

6.10.2 **Data Records.** The data records shall conform to the generalized record format. The record-type marker shall have a value of zero (0).

6.10.3 **Manufacturer's Records.** Manufacturer's records shall be distinguished by having a record-type marker value of two (2).

6.10.4 **Parity Records.** Parity records shall be distinguished by having a record-type marker value of three (3). The data field of parity records within a given block shall be constructed by combining the data fields of the data records in the same block using the "exclusive or" function on a byte-by-byte basis.

6.10.5 **File-System Records.** File-system records shall be distinguished by having a record-type marker of four (4). File-system records shall be identical in all other respects to date records.

6.10.6 **Uselog Records.** Uselog records shall be distinguished by having a record-type marker of five (5).

7.0 FRAMES

All frames shall conform to the generalized frame organization and shall consist of two records for each frame. The first record of each frame, the ID record, serves to identify the frame and its attributes and serves as a guide to precisely define the location of the non-ID record of the frame.

The ID records of all frames are recorded only at format time of the tape cartridge. ID records may not be updated at any time other than for the purpose of reformatting the tape cartridge.

The Non-ID records of all frames may also be recorded at format time (in order to overwrite all obsolete information which might be present on the tape) and may be re-recorded (updated) during ordinary use as a function of the host system in use.

7.1 **Generalized Frame Organization.** The generalized frame organization is shown in Figure 13.

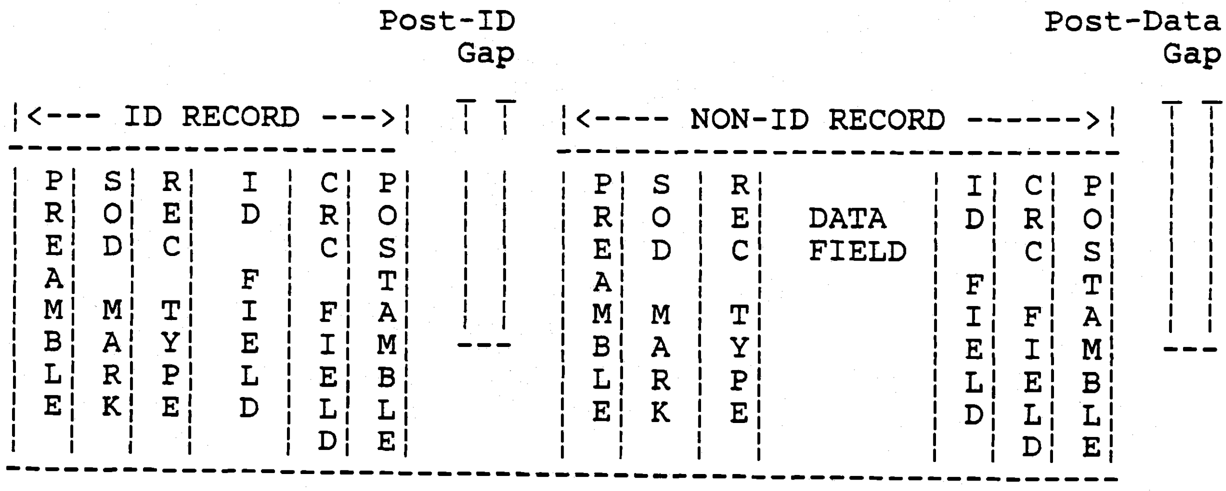

FIGURE 13

ONE FRAME

```
---------------------------
|  ID     |      NON      |
|         |      ID       |
---------------------------
```

STARTING FRAME NUMBER LAYOUT

```
------  ------ ------ ------ ------ ------ ------- -------
|MAN.|  |MAN.| |MAN.| |USE.| |USE.| |USE.| |DATA/| |DATA/|
|    |  |    | |    | |    | |    | |    | |FILE | |FILE |
----------------------------------------------------------

|<--Manufacturer's-->||<--Uselog Frames-->||<--Data or--->
    Frames                                   File System
                                                Frames
```

FIGURE 14

The beginning frame numbers of each track shall maintain the proper record type as indicated in Figure 14.

8.0 BLOCKS

Blocks shall be constructed of three (3) frames utilized as the minimum increment of storage space which may be modified. Blocks are the minimum unit of storage space of which error correction may be implemented. Each block shall be totally contained within a single track and is shown in Figure 15.

Except for the manufacturer's and uselog block, each block with an error control method of two (2), shall consist of two (2) frames containing data records, or file-system records and one (1) frame containing a parity record.

ONE BLOCK

```
------   ------      ------   ------      ------   ------
| ID |   |NON |      | ID |   |NON |      | ID |   |NON |
|    |   |ID  |      |    |   |ID  |      |    |   |ID  |
------   ------      ------   ------      ------   ------
```

BLOCKS ON ONE TRACK

Manufact Block	Use Log Block	Data 1 Block	Data 2 Block	...	Data i Block	Data i+1 Block	TRACK ZERO
Data i+j+1 Block	Data i+j Block	...	Data i+3 Block	Data i+2 Block	Use Log Block	Manufact Block	TRACK ONE
Manufact Block	Use Log Block	Data k+2 Block	Data k+3 Block	...	Data k+n Block	Data k+n+1 Block	TRACK TWO k=i+j

FIGURE 15

Blocks shall allocate frames starting on track zero, then frames are allocated on track one. After track one's frames are allocated, blocks shall then be allocated back on track zero (if non-overlapped mode is used) or on track two (if overlapped mode is used).

Blocks on each track shall be allocated in the above order, manufacturer's block, use log block and then the data blocks or file-system blocks.

9.0 ERROR CONTROL

Error control shall consist of detection and correction of flawed non-ID records. Error control differs between ID records and non-ID records. For ID records, only error detection is employed. For non-ID records, both error detection and error correction shall be employed.

9.1 **Error Detection.** Error detection capability shall be accomplished through the use of a 40-bit (5-byte) cyclical redundancy check code (CRCC) which occupies the last five byte locations preceding the postamble of each record as indicated in Section 5, Tape Format.

9.1.1 CRCC Polynomial.

$$X^{40} + X^{34} + X^{33} + X^{27} + X^{25} + X^{23} + X^{22} + X^{9} + X^{0}$$

Where + indicates an Exclusive OR operation.

The registers of the polynomial generator are preset to zero prior to calculation.

9.1.2 **Example CRCC Computation.** The numbers in the CRCC polynomial are the locations at which the carry bit at location X40 is to be exclusive OR'd in after the data bit has been shifted in. The data pattern 01 00 00 00 00 00 input is processed one bit at a time starting with the low order bit (1). The remaining bits in the byte are then processed, finally each successive zero byte. While processing the last byte, the low order bit (1) has passed through the CRC generator. Then the CRC generator sets the bits on at the polynomial bit locations X34, X33, X27, X25, X23, X22, X09 and X00. This can be seen as:

```
                                              Hexadecimal
  0     6     0     A     C     0     0     2     0     1

                                                    Binary
0000  0110  0000  1010  1100  0000  0000  0010  0000  0001

       XX         X X   XX                  X            X
       33         2 2   22                  0            0
       43         7 5   32                  9            0
```

9.1.2.1 **CRCC Computation Without Pre-Multiplication.** The data field is extended by appending five zeros corresponding to the CRCC field and is not pre-multiplied by X40. The CRCC shall be computed using the CRCC polynomial over the bytes of each record beginning with and inclusive of the record-type marker and extending through the last CRC byte of the record with the five CRC bytes equal to zero (0) as in Figure 16.

Short (6-byte) computation:

Address range: 0 - through - 5
Buffer contents: 01 00 00 00 00 00
Computed CRC: 06 0A C0 01 01

Long (10,623-byte) computation:

Address range: 0 - - - - - - through - - - - - 297E
Buffer contents: 01 00 00 . . . . .00 00 00
Computed CRC: C3 68 9D 7D 53

CRCC WITHOUT PRE-MULTIPLICATION

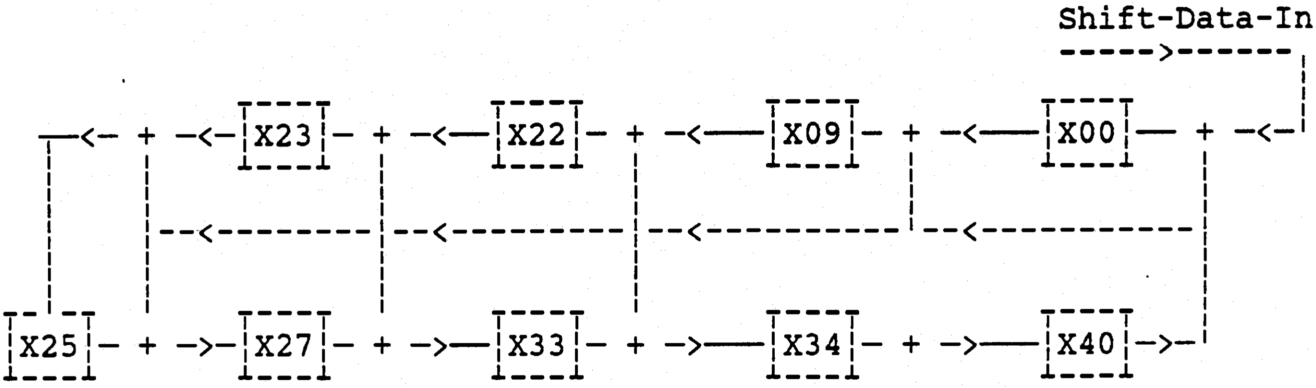

FIGURE 16

Where + indicates an Exclusive OR operation.
Where < and > indicate bit direction.

9.1.2.2 **CRCC Computation With Pre-Multiplication.** The data field excludes the five zeros described above and is pre-multiplied by X40 as in Figure 17.

Short (1-byte) computation:

Address range: 0 - through - 0
Buffer contents: 01
Computed CRC: 06 0A C0 02 01

Long (10618-byte) computation:

Address range: 0 - - - - - through - - - - -2979
Buffer contents: 01 00 00 . . . . 00 00 00
Computed CRC: C3 68 9D 7D 53

CRCC WITH PRE-MULTIPLICATION

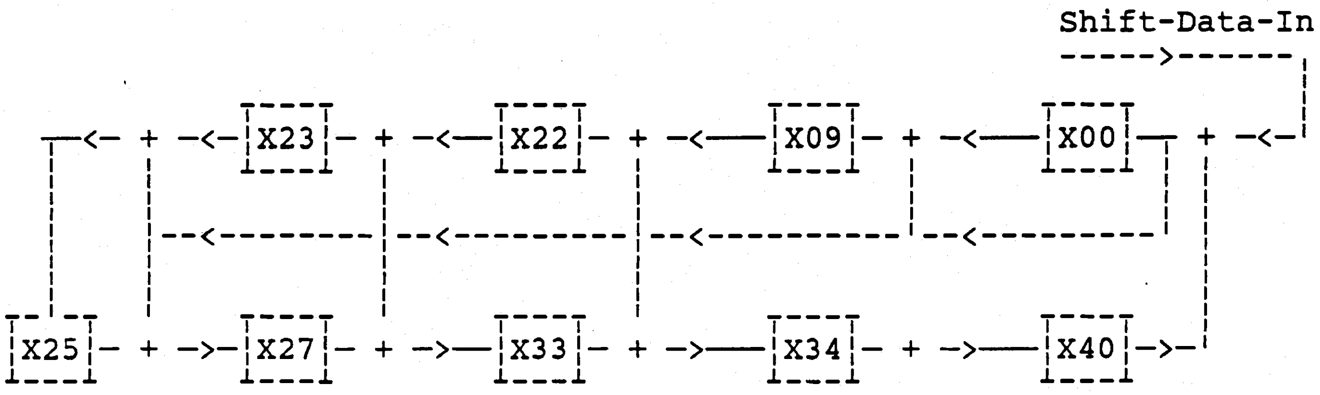

FIGURE 17

Where + indicates an Exclusive OR operation.
Where < and > indicate bit direction.

9.2 **Error Correction.** Error correction shall be implemented in the form of a parity record which accompanies every two (2) frames, except for manufacturer's block sand use blocks, which shall keep three (3) identical sequential frames. Block organization will be determined by the interleave factor as shown in Figures 18 and 19.

INTERLEAVE FACTOR 2

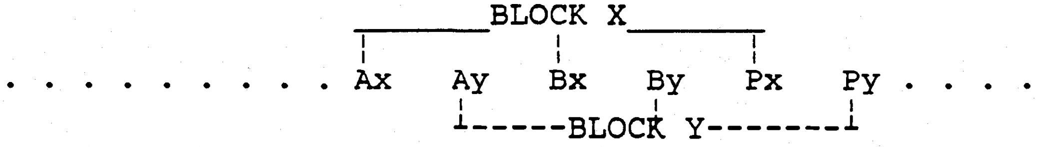

FIGURE 18

Where:
Px is computed over Ax and Bx.
Py is computed over Ay and By.

INTERLEAVE FACTOR 3

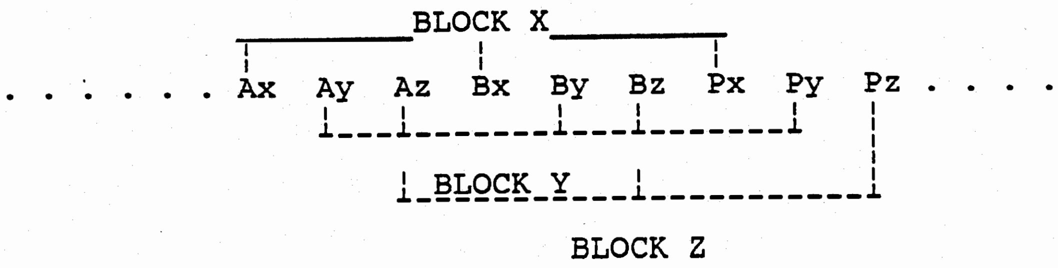

FIGURE 19

Where:
Px is computed over Ax and Bx.
Py is computed over Ay and By.
Px is computed over Az and Bz.

10.0 INTERLEAVE ORGANIZATION

Interleaving shall be implemented by threading from one (1) (interleave factor of two) to a maximum of six (6) (interleave factor of seven) interleaved frames between logically associated frames. The number of threads may be varied at the discretion of the user as a means of optimizing performance of a given system.

Interleaving shall not affect the utility or compatibility of a recorded tape. The number of frames actually utilized on a track with a given interleave factor is shown in Table 33.

INTERLEAVE ORGANIZATION

Interleave Factor	No. of Threads	Blocks/Thread (minimum)	No. of Usable Frames (minimum)
2	2	102	612
3	3	68	612
4	4	51	612
5	5	40	600
6	6	34	612
7	7	29	609

TABLE 33

10.1 **Track Pairing.** Tracks may be paired to facilitate enhanced access performance through the use of serpentine operation. A pair of tracks comprises a forward track n and a reverse track n+1 where n is 0, 2, 4, etc. Track shall contain a number of whole blocks. Even though tracks are paired to facilitate serpentine operation, blocks may not be split across a track pair boundary.

11.0 PARALLEL RECORDING

The reading and writing of multiple tracks simultaneously is permitted and where employed must be so indicated by setting the proper bits in the format specification. To accomplish parallel recording, associated adjacent blocks shall be independently recorded so as to reside on separate tracks. A given block shall not be split such that the various frames of the block reside on different tracks. Each block shall reside completely within its assigned track. 12 track tapes should not use parallel recording. Using a 24 track tape, the number of tracks parallel recorded shall be two (2).

PARALLEL RECORDING

Number of Tracks Simultaneously Recorded	Track Number Sets (Forward)	Track Number Sets (Reversed)
2	20,2	21,3
	16,6	17,3
	12,10	13,11
	8,14	9,15
	4,18	5,19
	0,22	1,23

TABLE 34

If the parallel recording bits are set to a value of two (2), for example, tracks 4 and 18 are recorded at the same time and tracks 21 and 3 are recorded at the same time as shown in Table 34.

12.0 FORMAT-TIME RESPONSIBILITIES

Tape cartridges must be formatted prior to ordinary use. One of the most important responsibilities of the formatting process is to install on tape the ID records which act as landmarks for locating the other (non-ID) records used in the format. As such, the timing of the formatting process is critical in controlling the size of gaps, relative position of records and frames, etc. Once the formatting process is complete, this timing is essentially "frozen" into the format and the heat system may largely ignore timing decisions by allowing the ID records to dictate all other record locations.

The information specified in the ID fields at format time specifically excludes the factors of interleave, error correction methods, error correction counter, and error control method since these are application specific and must not be entered during production of pre-formatted cartridges.

Frames 0, 1, and 2 of each track are called the manufacturer's block which are reserved for the flawed-frame list. Pre-formatted cartridges must include defect mapping information which is recorded redundantly in these three (3) frames.

12.1 **Manufacturer's Block.** The Manufacturer's Block shall occupy the first three (3) frames as shown in Section 8, Blocks. It is allocated on each tape track. It is recorded on each even numbered track of the tape at format time following the certification process. The information contained in the Manufacturer's Frame shall consist of a header describing the Manufacturer's Block followed by a list of flawed frames as determined by a tape certification process. The header shall start beginning in the first byte of the data field as described in Section 6, Tape Format.

The header and the list are recorded in each of the first three frames for additional redundancy; therefore, the list from any of the three (3) frames can be used to skip flawed frames. A maximum of 1036 flaws per tape shall be maintained. This is the maximum that can be contained in one (1) manufacturer's frame. The first 16 bytes of each of the three (3) frames in the Manufacturer's Block is a header called the Manufacturer Control block (MCB) as shown in Figure 20.

A MANUFACTURER'S FRAME

HEADER (MCB)	FLAWED FRAMES

Manufacturer's Control Block (Header)

# MAN FRAMES	CURR. FRAME	# FLAW FRAMES	RESV.	VERS.	RESV.

FIGURE 20

12.1.1 **Number of Manufacturer Frames.** The total number of frames in the manufacturer block shall be three (3).

¦$_{15}$<---tt--->$_{8}$¦$_{7}$---uu--->$_{0}$¦

Where:
uu is unassigned and is always zero (0)
tt is the total number of manufacturer frames.

12.1.2 **Current Manufacturer's Frame.** The current frame number of the manufacturer block.

¦$_{15}$<---cc--->$_{8}$¦$_{7}$---uu--->$_{0}$¦

Where:
uu is unassigned and is always zero (0).
cc is the current manufacturer's frame sequence number either 0, 1, or 2.

12.1.3 **Number of Unusable (Flawed) Frames.**

```
¦15<-----ff----->0¦
```

Where:
ff is the number of unusable (flawed) frames in the list.

12.1.4 **Reserved.** Two consecutive 16 bits fields.

```
¦31<-----rr----->0¦
```

Where:
rr is reserved for future use and is always zero (0).

12.1.5 **Version Number.**

```
¦15<---vv--->8¦7---uu--->0¦
```

Where:
uu is undefined and is always zero (0).
vv is an integer giving the version number of the formatting software.

12.1.6 **Reserved.** Two consecutive 16 bits fields.

```
¦31<-----rr----->0¦
```

Where:
rr is reserved for future use and is always zero (0).

12.2 **Flawed-Frames List.** The remainder of each frame of the manufacturer's block is defined as the flawed-frame list. Each entry in the flawed-frame list corresponds to a flawed frame on the tape. As show in Figure 21, an entry consists of a track number, a frame number and user defined attributes. Flaws detected in all frames shall be included in the flawed-frame list.

FLAWED-FRAME LIST ENTRY

<table>
<tr><td>track number</td><td colspan="2">frame number</td><td>attribute</td></tr>
<tr><td>¦7<---tt---->0¦</td><td>7<----ff---->0¦</td><td>15<----ff---->8¦</td><td>7<----aa---->0¦</td></tr>
</table>

FIGURE 21

12.2.1 **Track Number.**

¦$_{7}$<-----tt----->$_{0}$¦

Where:
tt is the track number.

12.2.2 **Frame number.**

¦$_{15}$<-----ff----->$_{0}$¦

Where:
ff is the frame number (See Figure 21).

12.2.3 **Attribute.**

¦$_{7}$<-----aa----->$_{0}$¦

Where:
aa is the bits of the attribute byte which are user unique.

12.3 **Uselog Block.** The uselog block should be used for tape interchange. The uselog is always allocated on each track and it's record type is five (5). The uselog is a block consisting of three (3) consecutive and identical uselog frames. These frames shall be frames 3, 4, and 5, which are located immediately after the manufacturer's frames. When the uselog is used, it is recorded on the even numbered tracks at format time. Normally, only the uselog on track zero is kept current. If the uselog on a track becomes unusable, then the information is maintained on the next even track number.

The information contained in a uselog frame shall consist of a header describing the uselog block followed by the alternate frames list, the format descriptor list and vendor unique data as in Figure 22. The header shall start beginning in the first byte of the data field as described in Section 5, Tape Format. The information is recorded in each of its three frames for additional redundancy, therefore, any one (1) of the three (3) frames can be used.

USELOG

HEADER (UCB)	ALTER. FRAMES	FORMAT DESC.	USER UNIQUE

FIGURE 22

12.3.1 **Uselog Control Block.** The first twenty-three bytes of the uselog are called the UCB (Uselog Control Block) as shown in Figure 23.

USELOG CONTROL BLOCK

# USE FRAMES	CURR. FRAME	RESV.	# OF PASSES	NO. LOADS	STATUS
INIT. DATE	CYCLE DATE	# OF ALTER.	RESV.		

FIGURE 23

Information in lists should be recognized even though the system may be incapable of updating that type of list. Lists that are present shall not be removed from a uselog frame.

12.3.1.1 **Number of Uselog Frames.** This is the number of usable uselog frames per track.

```
|15<-----nn----->0|
```

Where:
nn is three (3), the number of uselog frames.

12.3.1.2 **Current Uselog Frame.** The current uselog frames should be numbered 0, 1, or 2. The physical frame numbers are frames 3, 4, and 5.

```
|15<-----nn----->0|
```

Where:
nn is the current uselog frame.

12.3.1.3 **Reserved.**

```
|15<-----rr----->0|
```

Where:
rr is reserved for future use and is set to zero (0).

12.3.1.4 **Number of Passes.** This is the number of times the tape changes direction during normal operation of the tape drive. That is, it reads or writes from an even track, then an off track, or visa versa. It should be set to zero initially.

¦$_{15}$<-----nn----->$_{0}$¦

Where:
nn is the number of passes.

12.3.1.5 **Number of Cartridge Loads.** This is the number of times the tape has been loaded or initialized. Each time the tape is reloaded, the number of loads should be increased by one. It should be set to zero initially.

¦$_{15}$<-----nn----->$_{0}$¦

Where:
nn is the number of loads.

12.3.1.6 **Uselog Status.** This indicates different statuses of data on the cartridge.

¦$_{7}$<----ss---->$_{0}$¦

Where:
ss is the status of the uselog.
Bit zero (0) when set to one (1) indicates the uselog is active and maintained.
Bit one (1) when set to one (1) indicates the format descriptor list has been written to this tape.
This format descriptor list in this case will then override the definition of the format in the normal ID fields.
The other bits of the uselog are undefined and are user unique.

12.3.1.7 **Initial Use Date.** The initial use date (month, day, year) is the date in which user data is first written to the tape.

¦$_{15}$<-----yy----->$_{9}$¦$_{8}$<---mm--->$_{5}$¦$_{4}$<---dd--->$_{0}$¦

Where:
yy is binary years since 1980 (0-119: 1980-2099).
mm is binary month (1-12).
dd is binary day (1-31).

12.3.1.8 **Cartridge Recycle Date.** The cartridge recycle date (month, day, year), if not zero (0), is the date in which the tape is to be retired from active use.

¦$_{15}$<-----yy----->$_{9}$¦$_{8}$<---mm--->$_{5}$¦$_{4}$<---dd--->$_{0}$¦

Where:
yy is binary years since 1980 (0-119: 1980-2099).
mm is binary month (1-12).
dd is binary day (1-31).

12.3.1.9 **Number of Alternate Frames.** There shall be 48 alternate frames for 24 tracks. The 12 track format shall have 24 alternate frames.

¦$_{15}$<-----nn----->$_{0}$¦

Where:
nn is the total number of alternate frames.

12.3.1.10 **Reserved Fields.**

¦$_{47}$<-------rr------->$_{0}$¦

Where:
rr is reserved for future use and is set to zero (0).

12.3.2 **Alternate Frame List.** Directly after the uselog control block (UCB) is the alternate-frame list. The list of alternate frames should be determined at format time. The flawed frames found during normal operation should be replaced from the alternate-frame list. Reassignment of frames shall be made to a complete block.

In the case of frames becoming flawed during normal operation, even though the system is incapable of using the alternate-frame list for the reassignment of frames, it must still recognize the alternate-frame list and not overwrite the list. The uselog reassignment information should not be saved during a tape reformat operation because formatted data can be located at slightly different positions on a tape during a format process.

The alternate frame list in the format described in Figure 24.

¦$_{7}$<--tt-->$_{0}$¦$_{15}$<-----ff----->$_{0}$¦$_{7}$<---uu--->$_{0}$¦$_{15}$<---gg--->$_{0}$¦

Where:
tt is the original track number and shall be zero until an alternate is required.

ff is the original frame number and shall be zero until an alternate is required. If the original frame number is equal to zero (0), then the alternate is the available alternate. If the frame number is not equal to zero (0), then the alternate is an assigned alternate.

uu is the alternate track number

gg is the alternate frame number. If the frame number has bit 15, the high order bit, set off, then it is a validated alternate frame. If the frame number has bit 15 set on, then it is a re-assigned alternate frame. The frame number and'd with the low order 15 bits (bit 14 through bit 00) indicate it is a reserved alternate frame. A reserved alternate is used when an alternate frame has become flawed.

This table shall start at byte 23 and continuous through byte 310 in an ascending track/frame order as in Figure 24.

ALTERNATE FRAMES LIST

Original		Alternate		Original		Alternate			Original		Alternate	
Trk	Frm	Trk	Frm	Trk	Frm	Trk	Frm		Trk	Frm	Trk	Frm
0	0	0	159	0	0	8	159	12 TRACK	0	0	16	159
0	0	0	464	0	0	8	464		0	0	16	464
0	0	1	159	0	0	9	159		0	0	17	159
0	0	1	464	0	0	9	464		0	0	17	464
0	0	2	159	0	0	10	159		0	0	18	159
0	0	2	464	0	0	10	464		0	0	18	464
0	0	3	159	0	0	11	159		0	0	19	159
0	0	3	464	0	0	11	464		0	0	19	464
0	0	4	159	0	0	12	159		0	0	20	159
0	0	4	464	0	0	12	464		0	0	20	464
0	0	5	159	0	0	13	159		0	0	21	159
0	0	5	464	0	0	13	464		0	0	21	464
0	0	6	159	0	0	14	159		0	0	22	159
0	0	6	464	0	0	14	464		0	0	22	464
0	0	7	159	0	0	15	159		0	0	23	159
0	0	7	464	0	0	15	464		0	0	23	464

FIGURE 24

12.3.3 **Format Descriptor List.** This list may be used to initialize the Non-ID records after format time. It shall start at byte 311 and continues through byte 322 for 24 Track and it shall start at byte 167 and continues through byte 178 for 12 Track as in Figure 25.

FORMAT DESCRIPTOR LIST

FRAMES /BLOCK	ERROR CORR.	DATA LENGTH	FORMAT SPEC.	FRAMES /TRACK	TRACKS /TAPE
P.DATA GAP	P. ID GAP	DRIVE SPEC.			

FIGURE 25

12.3.3.1 **Frames per Block.** This is the number of frames per block, see Section 6, Tape Format.

¦$_7$<--nn-->$_0$¦

Where:
nn is three (3), the number of frames per block.

12.3.3.2 Error Correction Method.

¦$_{7}$<--nn-->$_{0}$¦

Where:
nn is the error correction method, see Section 6, Tape Format.

12.3.3.3 Data Field Length.

¦$_{7}$<--nn-->$_{0}$¦

Where:
nn is the data field length, see Section 6, Tape Format.

12.3.3.4 Format Specification.

¦$_{7}$<--nn-->$_{0}$¦

Where:
nn is the format specification, see Section 6, Tape Format.

12.3.3.5 Frames per Track.

¦$_{15}$<----nn---->$_{0}$¦

Where:
nn is the number of frames per track, see Section 6, Tape Format.

12.3.3.6 Tracks per Tape.

¦$_{7}$<--nn-->$_{0}$¦

Where:
nn is the number of tracks per tape, see Section 6, Tape Format.

12.3.3.7 Post Data Gap Size.

¦$_{15}$<----nn---->$_{0}$¦

Where:
nn is the post data gap size, see Section 6, Tape Format.

12.3.3.8 Post ID Gap Size.

¦$_{15}$<----nn---->$_{0}$¦

Where:
nn is the post ID gap size, see Section 6, Tape Format.

12.3.3.9 **Drive Specification.**

$|_7$<--nn-->$_0|$

Where:
nn is the drive specification, see Section 6, Tape Format.

12.3.4 **User Unique Data.** All data starting at byte 323 through the end of the data field are user unique.

13.0 **RUN-TIME RESPONSIBILITIES.** Run-time responsibilities are functions that are performed on a formatted tape during normal operation. These responsibilities include defect management, physical block calculations and physical block number to logical block number translation.

13.1 **Defect Management.** Defect management is the process of identifying flawed block and alternate block locations, and what data blocks are re-mapped into alternate block locations.

13.1.1 **Flawed Block.** If any frame of a block is found in the flawed-frames list, the block shall be considered a flawed block. Even though all frames of a flawed block may not be flawed, they shall not be used as part of another block.

13.1.2 **Alternate Block.** If any frame of a block is found as an alternate frame in the alternate frame list, the block shall be considered an alternate block.

13.1.3 **Block Reassignment.** Blocks should be reassigned with the first frame of the block being reassigned as the original frame in the alternate frame list. When a block is reassigned, the entire block is reassigned, not just the flawed frame of a block. The reason for reassigning an entire block and not just the flawed frame is to reduce additional seek time that could be involved if frames of a block were reassigned separately and to insure the proper interleave is maintained between frames (i.e., no two frames of a block may be adjacent).

Data for frame A of the original block shall be placed in frame A of the alternate block, data for frame B of the original block shall be placed in frame B of the alternate block and data for the parity frame of the original block shall be placed in the parity frame of the alternate block.

13.2 **Physical Block Calculations.** Physical blocks for a tape are calculated on all frames of a track following the manufacturer's block and the uselog block. When physical blocks are calculated for a tape, all tracks shall have the same number of blocks per track and all tracks shall have the same number of blocks per thread. Since the number of frames used by the physical blocks of a track may be less than the actual number of frames per track, (no blocks shall be calculated on non-existing frames of a track), all frames after the last frame of the last block on a track shall be considered non-existent remainder frames. If remainder frames are found in the flawed frame list of the manufacturer's block, they shall be ignored in flawed block calculations.

13.3 **Physical to Logical Block Translation.** For information interchange, the physical to logical block translation applies to non-overlapped data. There is no standard for physical to logical block translation in the overlapped data mode (see Section 6.7.3.7, Format Specification, for an explanation of overlapped data).

Note: Physical and logical block locations in the example figures are for explanation purposes only and do not necessarily represent the actual locations of alternate and flawed blocks.

If no flawed or alternate blocks are present on a tape, then the logical block numbers are identical to the physical block numbers.

Physical block numbers	=	0	1	2	3	4	5	6	7	8	9
Logical block numbers	=	0	1	2	3	4	5	6	7	8	9

When a flawed block (F) is introduced at physical block location -3-, the logical block numbers are slipped on all blocks following the flawed block.

Physical block numbers	=	0	1	2	3	4	5	6	7	8	9
Logical block numbers	=	0	1	2	F	3	4	5	6	7	8

Block re-numbering is handled for an alternate block (A), (physical block location -5-), the same as flawed block re-numbering.

Physical block numbers	=	0	1	2	3	4	5	6	7	8	9
Logical block numbers	=	0	1	2	F	3	A	4	5	6	7

The only time alternate block re-numbering is performed differently is when the alternate block location -5-, is a flawed block. In this case, the alternate block is slipped to the next non-flawed block location -6-.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   F   A   4   5   6
     Original alternate location -------------|   |
     New alternate location ----------------------|
```

The reason this can occur is, since the alternate frame is used as a key frame for determining the alternate block's position, an alternate frame list may be generated in the uselog block without any concern to the locations of flawed frames found at format time and the interleave factor used on the tape, allowing for the creation of a tape with uselog reservation but without the interleave and blocking factor being forced on the tape.

Block re-numbering is performed with alternate blocks and flawed blocks that are identified at format time (see Section 12.1, Manufacturer's Block). Re-numbering shall not be performed on flawed blocks found during normal operations.

When a block has a flawed frame (cannot be read/written) found during normal operations, the block may be reassigned to allow for the usage of the block.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   A   4   5   6   7
     Alternate block location -----------------|           |
     Flawed block found during operation ------------------|
```

Block numbering after reassignment of flawed block (B) to the alternate block position.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   6   4   5   B   7
```

13.4 **Physical Block Re-numbering.** Physical block numbers on a tape will remain fixed unless the number of frames per track is changed. This condition does not pose a problem if the tape is re-formatted, but can introduce compatibility problems if it is performed on a tape that has been in normal use. If the number of frames per track is changed from the original format value, or the interleave value is changed, the physical locations of blocks shall change. Interleave and frames per track may be changed by changing their values in the format descriptor list of the uselog block (see Section 12.3, Uselog Block). Physical block calculations (Section 13.2) shall be used to calculate the new physical block positions.

Since physical block locations have changed on the tape, the original frame location in the alternate frame list may not represent a flawed block. Therefore, to prevent invalid reassignment of blocks after physical block re-numbering has taken place, the uselog alternate frame list shall be re-initialized. This may be done by either erasing all entries in the original frame list or by constructing a new alternate frame list. By re-initializing, the uselog flawed blocks may be reassigned based upon their new physical block location.

When the number of frames per track is changed, the manufacturer's frame shall be modified, deleting frames from the flawed frame list that are greater than the frames per track. Flawed frame numbers shall not be deleted from the flawed frame list when they are valid frame numbers, (frame number is less than the frames per track), unless the flawed frame list is being modified due to a re-certification of the tape.

APPENDIX A.

Physical Block to Logical Block Re-mapping in the Overlapped Data Mode.

This Appendix is not a part of pdp ANS X3B5/88-XXX, but is included for information only.

A.1 **Overlapped Data Block Physical Numbering.** Overlapped data block numbering is described in Section 8.0, but an example is included here for clarification of overlapped data.

```
Block       0           0           0           0           0
Number      0           2           4           6           8
         +---+---+   +---+---+   +---+---+   +---+---+   +---+---+
         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
Frame   0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2
Number  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
           |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
           +---+---+   +---+---+   +---+---+   +---+---+   +---+---+
Block         0           0           0           0           0
Number        1           3           5           7           9
```

For the overlapped data methods of re-mapping, flawed blocks and alternate blocks are determined as defined in Section 13.0 Run-Time Responsibilities. It is how the flawed and alternate blocks affect logical re-mapping in the overlapped data mode that varies.

A.2 **Paired Block Re-mapping.** In this method of re-mapping, blocks are considered a paired entity with all defect mapping and block reassignments performed on block pairs. The block pair for any block can be determined by taking the block number, and'ing off the LS bit for the even block number of a block pair, then adding one to the even block number for the odd block number of the block pair.

Note: Physical and logical block locations in the example figures are for explanation purposes only and do not necessarily represent the actual locations of alternate and flawed blocks.

If no flawed or alternate blocks are present on a tape, then the logical block numbers are identical to the physical block numbers.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   3   4   5   6   7   8   9
```

When a flawed block (F) is introduced at physical block location -3-, not only is the block at block location -3- considered a flawed block, but the paired block at block location -2- is also considered a flawed block (f). The logical block numbers are slipped on all blocks following the flawed block pair.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   f   F   2   3   4   5   6   7
```

Block re-numbering is handled for an alternate block pair (a)(A), (physical block locations -6- and -7-), the same as flawed block re-numbering.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   f   F   2   3   a   A   4   5
```

The only time alternate block re-numbering is performed differently is when an alternate block pair (locations -6- and -7-), is a flawed block pair. In this case the alternate block pair is slipped to the next non-flawed block pair location (physical block locations -8- and -9-).

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   f   F   2   3   f   F   a   A
     Original alternate locations -----------------|---|   |   |
     New alternate locations ------------------------------|---|
```

When a block has a flawed frame (cannot be read/written) found during normal operations, the block pair may be reassigned to allow for the usage of the flawed block. When blocks are reassigned, the block pair is reassigned even though only the flawed block is recorded as the original frame in the alternate frame list (see Section 13.1.2, Block Reassignment).

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   f   F   a   A   2   3   4   5
     Alternate block location -------------|---|           |   |
     Flawed block found during operation ------------------|   |
     Pair block of flawed block -------------------------------|
```

Block numbering after reassignment of flawed block pair (b)(B) to the alternate block pair position.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   f   F   4   5   2   3   b   B
```

A.3 **Single Block Re-mapping.** In this method of re-mapping, blocks are considered a single entity with all defect mapping and block reassignments performed on single blocks.

If no flawed or alternate blocks are present on a tape, then the logical block numbers are identical to the physical block numbers.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   3   4   5   6   7   8   9
```

When a flawed block (F) is introduced at physical block location -3-, the logical block numbers are slipped on all blocks following the flawed block.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   4   5   6   7   8
```

Block re-numbering is handled for an alternate block (A), (physical block location -5-), the same as flawed block re-numbering.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   A   4   5   6   7
```

The only time alternate block re-numbering is performed differently is when the alternate block location -5- is a flawed block. In this case, the alternate block is slipped to the next non-flawed block location -6-.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   F   A   4   5   6
     Original alternate location --------------|   |
     New alternate location -----------------------|
```

When a block has a flawed frame (cannot be read/written) found during normal operations, the block may be reassigned to allow for the usage of the block (see Section 13.1.2, Block Reassignment).

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   A   4   5   6   7
     Alternate block location -----------------|           |
     Flawed block found during operation ------------------|
```

Block numbering after reassignment of flawed block (B) to the alternate block position.

```
Physical block numbers  =  0   1   2   3   4   5   6   7   8   9
Logical block numbers   =  0   1   2   F   3   6   4   5   B   7
```

The header and the list are recorded in each of the first three frames for additional redundancy; therefore, the list from any of the three (3) frames can be used to skip flawed frames.