DEVELOPMENT STANDARD

QIC-170
Revision D
13 May 96

PREFORMATTED MAGNETIC MINICARTRIDGE
FOR INFORMATION INTERCHANGE

0.315 inch (8.0 mm) tape width
50,800 ftpi (2,000 ftpmm)
900 Oersteds (72,000 amperes/meter)

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(See important notices on the following page)

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REVISION HISTORY

Revision	Date	Comments
A	15 Jun 95	Initial revision. Based of QIC 95-14 revision C as marked up at the June 1995 QIC Technical Committee meeting.
B	31 Aug 95	Changes 95-74 per QIC revision B: 1. Corrected several errors in the figures. 2. Changed dimension A3 in Table 6.3 and B3 in Table 6.2. 3. Added 2 new fields to the contents of the Track ID block.
C	15 Dec 95	Changes 95-97 per QIC revision A: 1. Added corrupted burst/stripe statement below Tables 6.1 - 6.2. 2. Added a new section, **8.0 ADDITIONAL DATA RECORDED**... Changes 95-108 per QIC revision A: 1. Added QIC-148 to section 3.0.
D	13 May 96	Changes 95-98 per QIC revision C: 1. Added QIC-173 to section 3.0.

1. SCOPE AND INTRODUCTION

1.1 Scope

This document describes a format for a streaming magnetic tape minicartridge to be used for data interchange between information processing systems as well as archival and temporary data storage, and data retrieval which may be used in the event of a system malfunction.

This document describes a system that uses servo information for each data track, which provides the capability to compensate for cartridge alignment problems, drive-to-drive variations, and changes caused by wear and environmental extremes. This capability provides maximum data reliability and assures the interchangability of media between drives.

1.2 Introduction

1.2.1 This standard defines the requirements of 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 contained in this standard represent the minimum acceptable levels of performance for interchange purpose. 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 or substituted for purchase specifications.

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

1.2.4 U.S. engineering units are the original dimensions in this standard. Conversions of toleranced dimensions from customary U.S. engineering units (similar to British Imperial Units) to SI units have been done in this standard according to ANSI/IEEE STD 268-1982 and ISO 370-1975 Method A. Method A should be used for economy unless a requirement for absolute assurance of a fit justifies use of Method B. In the national standards of ISO member nations, additional rounding may be 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 above, interchange parties complying with the applicable standards should be able to achieve compatibility without need for additional exchange of technical information.

2. DEFINITIONS

For the purposes of this document, the following definitions apply:

A-Burst/B-Burst	A pair of single-frequency bursts of flux transitions, one written above the data track centerline, and the other below the data track centerline. The read signal amplitude of the two bursts are used to determine head position relative to the data track centerline, so that the head can be positioned precisely.
Bit	A single digit in the binary system.
Block	A group of 512 consecutive data bytes, plus additional control bytes, recorded as a unit.
BOT (Beginning Of Tape) Marker	A pair of closely spaced holes punched in the tape to indicate the approach of usable recording area when running in the forward direction. These holes also indicate that the usable recording area of the tape has been exceeded when running in the reverse direction, and that the physical beginning of tape is approaching. There are three BOT hole sets to assure reliable detection.
Byte	A group of 8 data bits operated upon as a unit.
Data Area	The area between LP (Load Point Marker) and EW (Early Warning Marker) that is used for recording data.
Data Density	Data Density. The nominal distribution of recorded data information per unit length of track, usually expressed in bits per inch (bpi) or bits per millimeter (bpmm). In this standard, the data density is higher than the transition density.
EOT (End Of Tape) Marker	A single hole punched in the tape to indicate that the usable recording area of the tape has been exceeded in the forward direction, and that the physical end of tape is approaching. There are three EOT holes to assure reliable detection.
EW (Early Warning) Marker	A single hole punched in the tape to indicate the approaching end of usable recording area in the forward direction, and the beginning of the usable recording area in the reverse direction.
Flux Transition.	A point on the magnetic tape which exhibits maximum free space flux density normal to the tape surface.
Flux Transition Spacing	A distance on the magnetic tape between flux transitions.
Frame	A group of 64 blocks forming a complete logical unit.

LP (Load Point) Marker	A single hole punched in the tape to indicate the approaching start of the usable recording area in the forward direction, and the end of the usable recording area in the reverse direction.
Magnetic Tape Cartridge	A cartridge containing magnetic tape wound on two coplanar hubs with an internal drive belt to transport the tape between the hubs.
Recorded Azimuth	The angular deviation, in minutes of arc, of the recorded mean flux transition line from the line normal to the cartridge reference plane.
Reference Tape Edge	The reference edge shall be the edge of the tape which is nearest to the baseplate of the cartridge.
Reference Tape Cartridge	A tape cartridge selected for a given property for calibrating purposes.
RLL (Run Length Limited) Encoding	A data encoding method where data bits are encoded so that certain constraints are met with regard to the maximum and minimum distances between flux transitions.
Secondary Reference Tape Cartridge	A tape cartridge intended for use in routine calibration purposes, the performance of which is known and stated in relation to that of the Reference Tape Cartridge.
Servo Track Centerline	The vertical location where the transducer reads equal amplitude for the A-Burst and B-Burst in the Servo Zone. This corresponds to the vertical location equidistant from the neighboring edges of the A-Burst and B-Burst. (See Figure 6.3.)
Servo Zone	The area between two stripes which contains one set of A-Bursts and one set of B-Bursts.
Signal Amplitude Reference Cartridge	A reference cartridge selected as a standard for signal amplitude and reference field.
Standard Reference Amplitude	The average peak-to-peak signal amplitude output of the Signal Amplitude Reference Cartridge when it is recorded on NIST measurement system at the maximum flux transition density specified in this standard.
Streaming	A method of recording on magnetic tape that maintains continuous tape motion without the requirement to start and stop within an interblock gap.
Stripe	A burst of flux transitions written across the full width of the tape. The stripes mark the boundaries of the individual servo zones.

Track A longitudinal area on the tape along which a series of magnetic signals are recorded.

Track-Id Frame Single frames of data written before the beginning of every data track between the last Stripe in the BOT Servo Area and the LP (Load Point Marker), or between the last Stripe in the EOT Servo Area and the EW (Early Warning Marker). The frames contain the track number for that track, along with miscellaneous tape parameters and cartridge identification information.

3. MEDIA

The media used shall be 900 Oersted Gamma Ferric Oxide tape per the following QIC standards:

QIC-164	Travan$_{tm}$ Cartridge
QIC-148	400ft, 0.315IN QIC-WIDE$_{tm}$ Cartridge
QIC-173	900ft, QIC-EX$_{tm}$ Cartridge

4. TAPE FORMAT LAYOUT

4.1 Full Tape Format Layout

The formatted tape has five distinct regions:

1. Physical BOT Area
2. BOT Servo Area
3. Data Area
4. EOT Servo Area
5. Physical EOT Area

Figure 4.1 illustrates the layout of these five regions.

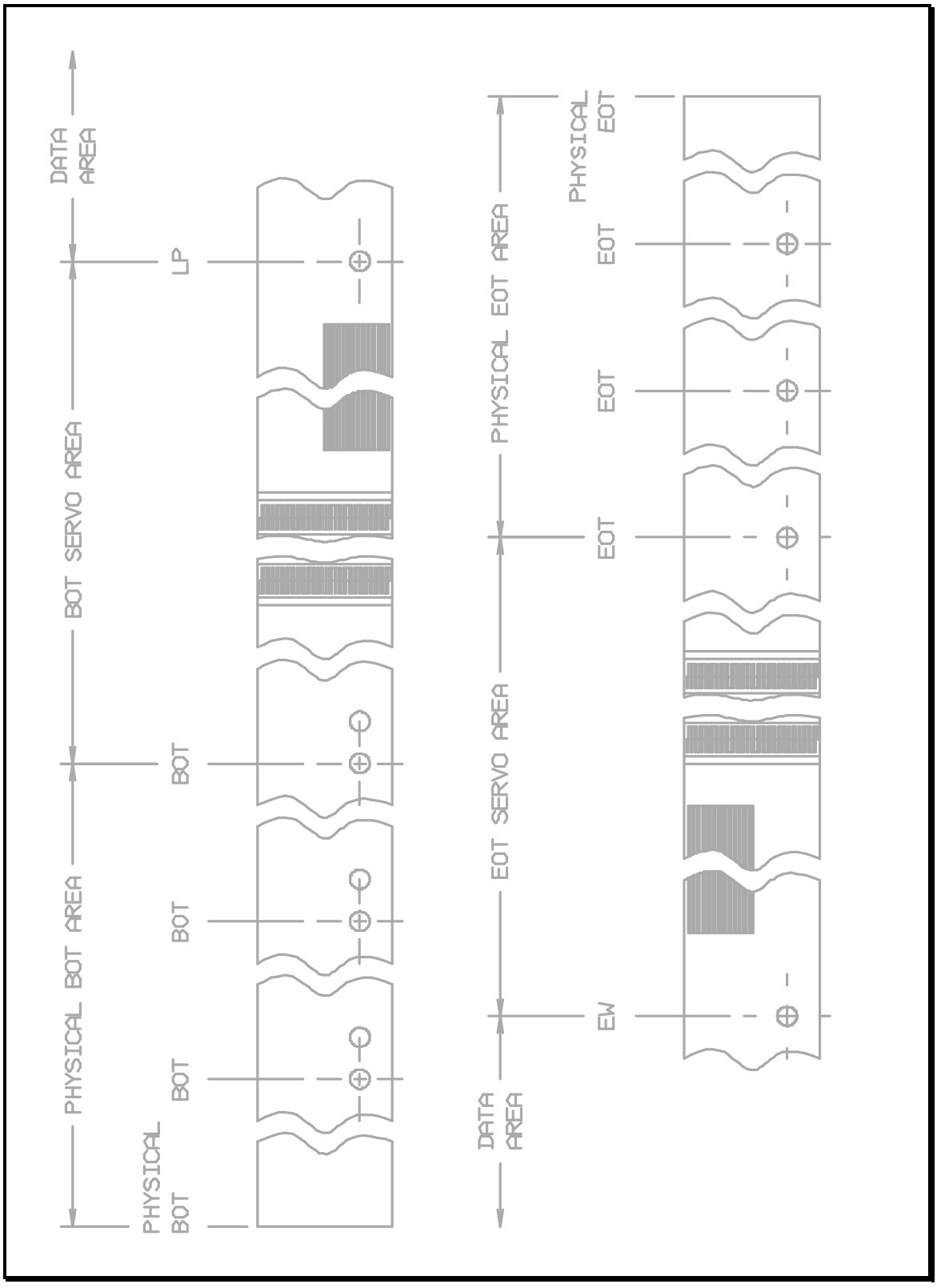

Figure 4.1 Full Tape Format Layout

4.2 Physical BOT Area

The region between the physical beginning of tape and the innermost BOT Hole is defined as the Physical BOT Area. This section of the tape contains 3 sets of BOT Hole pairs (including the last BOT Hole).

4.3 BOT Servo Pattern Area

The region between the innermost BOT hole and the LP marker is written with servo and physical track number information. The area is divided into a servo region and a Track-ID Frame region. The servo region contains A-Burst and B-Burst pairs, bounded by Stripes. The Track-ID Frame region contains one Track-ID Frame for every even numbered track, and for the directory track. The Track ID Frames are recorded in the forward direction.

4.4 Data Area

The region between LP and EW is the Data Zone, and is used for recording data. The data is recorded on 73 data tracks. The Directory Track, numbered 254, is in the center of the tape and is isolated from the even and the odd track groups by a larger guard band. Track 0 is the track immediately below the Directory Track. Track 2 is immediately below track 0, followed by track 4, and continuing down with the even numbered tracks until track 70, which is closest to the Reference Edge of the tape. Track 1 is the track immediately above the Directory Track. Track 3 is immediately above track 1, followed by track 3, and continuing up with the odd numbered tracks until track 71, which is closest to the top edge of the tape.

4.5 EOT Servo Area

The region between the EW marker and the innermost EOT hole is written with servo and physical track number information. The area is divided into a servo region and a Track-ID Frame region. The servo region contains A-Burst and B-Burst pairs, bounded by Stripes. The Track-ID Frame region contains one Track-ID Frame for every odd numbered data track, recorded in the reverse direction.

4.6 Physical EOT Area

The region between the innermost EOT Hole and the physical end of tape is defined as the Physical EOT Area. This section of the tape contains 3 EOT Holes (including the first EOT Hole).

5. TRACK GEOMETRY

5.1 Track Positions

The position of the centerline of Track 70 is dimensioned from the Reference Edge of the tape. The positions of all other tracks are defined by specifying the distance of their track centerlines from the centerline of Track 70. Figure 5.1 defines track locations and positions. The vertical track positions of all tracks on tape are found by seeking the centerline of adjacent edges of the A-Burst and B-Burst pairs. See the "SERVO" section for definition o the A-Bursts and B-Bursts.

5.2 Track Width

The width of the recorded track shall be: .0039 $\pm$.00008 inch (0.099 ± 0.002 mm).

5.3 Track Pitch

Track Pitch is defined in Table 5.1 and Figure 5.1. Cumulative track pitch error between multiple track centerlines shall be ± 0.0004 inches (± 0.01 mm) maximum for all even (forward) tracks, and ± 0.0004 inches (± 0.01 mm) maximum for all odd (reverse) tracks. See

Symbol	Description	Nominal	Tolerance
C1	Track Pitch, Directory Track to track 1	0.0061 inches (0.155 mm)	± 0.0002 inches (± 0.0051 mm)
C2	Track Pitch, Track 0 to Directory Track	0.0051 inches (0.130 mm)	± 0.0002 inches (± 0.0051 mm)
C3	Track Pitch, even tracks	0.0041 inches (0.104 mm)	+ 0.0002 / -0.0001 in. (+ 0.0051 / - 0.0025 mm)
C4	Track Pitch, odd tracks	0.0041 inches (0.104 mm)	+ 0.0002 / - 0.0001 in. (+ 0.0051 / - 0.0025 mm)

Table 5.1 Track Pitch Dimensions
(see Figure 5.1)

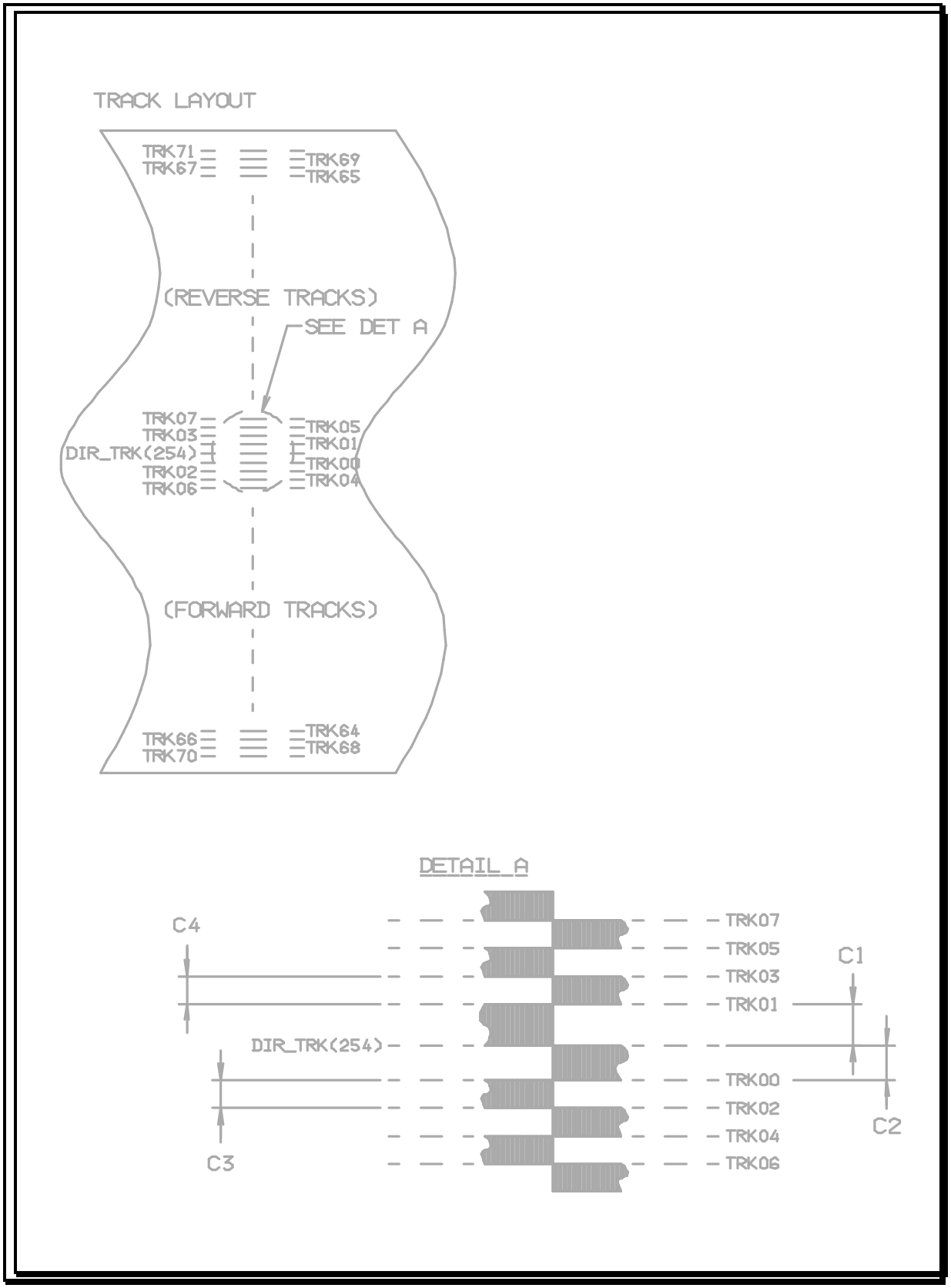

Figure 5.1 Vertical Track Layout

6. SERVO

6.1 Physical Requirements

6.1.1 Horizontal Dimensions

Figure 6.1 and Table 6.1 define the horizontal dimensions for the BOT Servo Area. Figure 6.2 and Table 6.2 define the horizontal dimensions for the EOT Servo Area.

This format requires a BOT1 to LP and EW to EOT1 dimension of 108 inches nominal (see unrecorded cartridge standard for details).

6.1.2 Vertical Dimensions

The vertical dimensions for the A-Bursts and B-Bursts are defined in Figure 6.3. The Stripes are written across the full width of the tape. The Track-ID Frames are written on the center of the actual data tracks, as defined by the A-Bursts and B-Bursts, within $\pm$ 0.0002 inch (± 0.005 mm).

6.2 Stripe/Burst Recording Parameters

6.2.1 Stripe Linear Density	15,000 ftpi (590.55 ftpmm)
6.2.2 Burst Linear Density	7,500 ftpi (295.28 ftpmm)
6.2.3 Writing Method	Square wave bi-level write current shall be used without write equalization for writing servo bursts/stripes
6.2.4 Write Current Used For Recording Stripes And Bursts	$1.15*I_{ref}$ for 15,000 ftpi (590.55 ftpmm) @ 23^{o} C $\pm 7^{o}$ C. (I_{ref} = write current that produces 95% of maximum output at 15,000 ftpi) (590.55 ftpmm)
6.2.5 A/B Burst Signal Mismatch	Average signal amplitude from adjacent bursts (A/B or B/A) to be equal within 2%.
6.2.6 Stripe/Burst Recorded Azimuth	$\pm$10 minutes of arc (2.9 mrad) relative to the cartridge -B- plane

SYMBOL	DESCRIPTION	NOMINAL	TOLERANCE
A0	Distance between BOT1 (Last Beginning-of-Tape Marker Hole) and First Stripe.	0.300 in (7.62 mm)	MIN
A1	First Stripe Length.	0.020 in (0.508 mm)	± 0.003 in (± 0.076 mm)
A2	Stripe/Burst Pattern Length.	0.100 in (2.54 mm)	± 0.005 in (± 0.13 mm)
A3	Distance between Last Stripe and Track ID Frame.	0.750 in (19.0 mm)	± 0.250 in (± 6.35 mm)
A4	Track ID Frame Length.	4.60 in (117.0 mm)	MAX
A5	Distance between Track ID Frame and LP (Load Point Marker Hole).	2.50 in (63.5 mm)	MIN
A6	Distance between Stripe and A-Burst.	0.010 in (0.254 mm)	± 0.003 in (± 0.076 mm)
A7	A-Burst Length.	0.030 in (0.762 mm)	± 0.003 in (± 0.076 mm)
A8	B-Burst Length	0.030 in (0.762 mm)	± 0.003 in (± 0.076 mm)
A9	Distance between B-Burst and Stripe.	0.010 in (0.254 mm)	± 0.003 in (± 0.076 mm)
A10	Stripe Length.	0.020 in (0.508 mm)	± 0.003 in (± 0.076 mm)
A11	Number of Burst/Stripe Sets.	1300	± 5

Table 6.1 BOT Servo Area Horizontal Dimensions

The last 2 servo burst/stripe sets of any track may be corrupted when formatting the tape. A minimum of 1295 good burst/stripe sets will be properly recorded on each track.

6.2.7 Erased Areas BOT

Tape areas A3 and A5, defined in Table 6.1 above, shall be erased such that the maximum amplitude seen by the reading head is < 5% of the nominal signal amplitude.

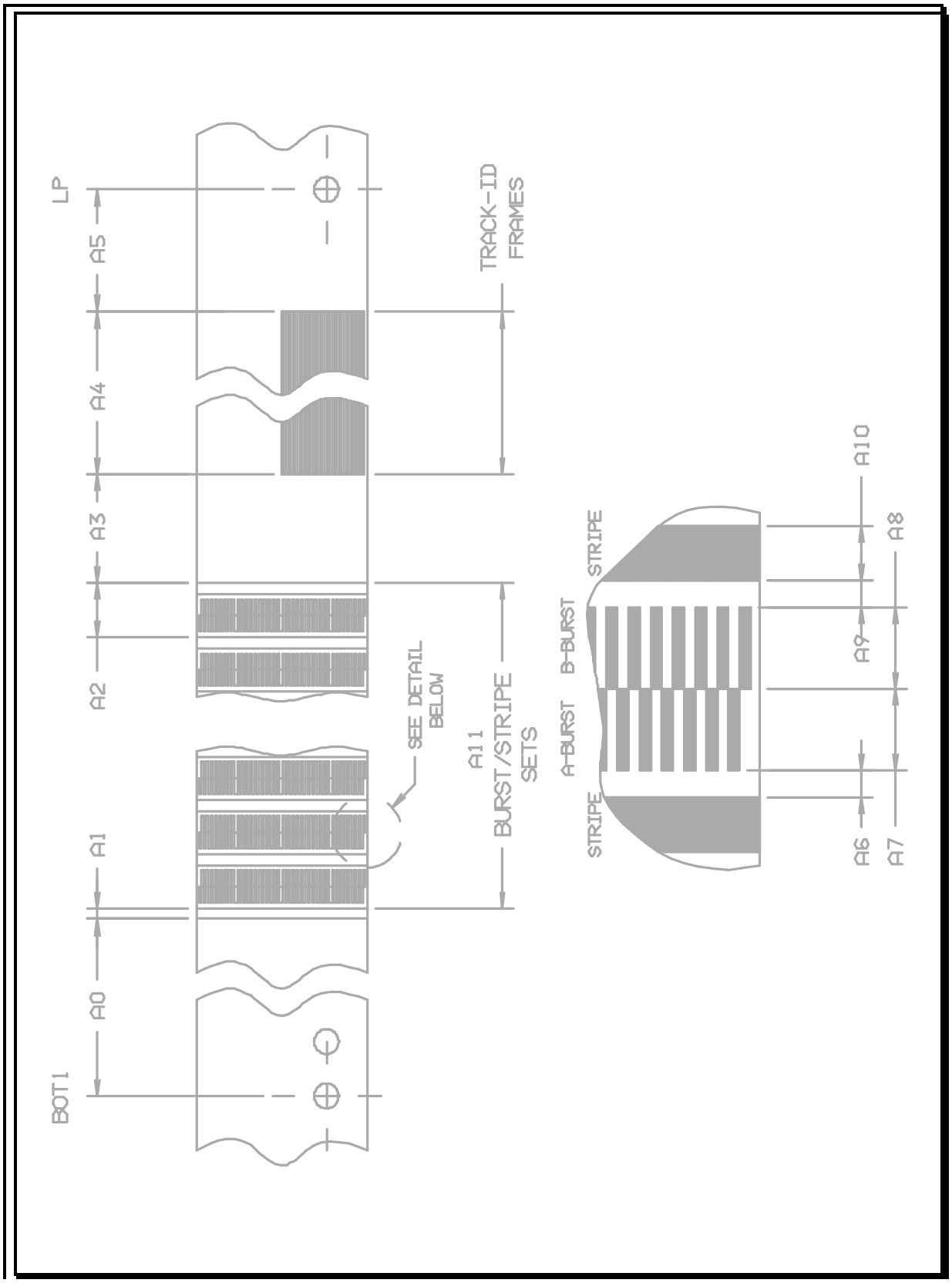

Figure 6.1 BOT Servo Area

SYMBOL	DESCRIPTION	NOMINAL	TOLERANCE
B0	Distance between EOT1 (First End-of-Tape Marker Hole) and First Stripe	2.50 in (63.50 mm)	MIN
B1	First Stripe Length	0.020 in (0.508 mm)	± 0.003 in (± 0.076 mm)
B2	Stripe/Burst Pattern Length	0.100 in (2.54 mm)	±. 0.005 in (± 0.127 mm)
B3	Distance between Last Stripe and Track-ID Frame	0.750 in (19.0 mm)	± 0.250 in (± 6.35 mm)
B4	Track-ID Frame Length	4.60 in (117.0 mm)	MAX
B5	Distance between Track-ID Frames and EW (Early Warning Marker Hole)	0.300 in (7.62 mm)	MIN
B6	Distance between Stripe and A-Burst	0.010 in (0.254 mm)	± 0.003 in (± 0.076 mm)
B7	A-Burst Length	0.030 in (0.762 mm)	± 0.003 in (± 0.076 mm)
B8	B-Burst Length	0.030 in (0.762 mm)	± 0.003 in (± 0.076 mm)
B9	Distance between B-Burst and Stripe	0.010 in (0.24 mm)	± 0.003 in (± 0.076 mm)
B10	Stripe Length	0.020 in 0.508 mm)	± 0.003 in (± 0.076 mm)
B11	Number of Burst/Stripe Sets.	1300	± 5

Table 6.2 EOT Servo Area Horizontal Dimensions

The last 2 servo burst/stripe sets of any track may be corrupted when formatting the tape. A minimum of 1295 good burst/stripe sets will be properly recorded on each track

6.2.8 Erased Areas EOT

Tape areas B3 and B5, defined in table 6.2 above, shall be erased such that the maximum amplitude seen by the reading head is < 5% of the nominal signal amplitude.

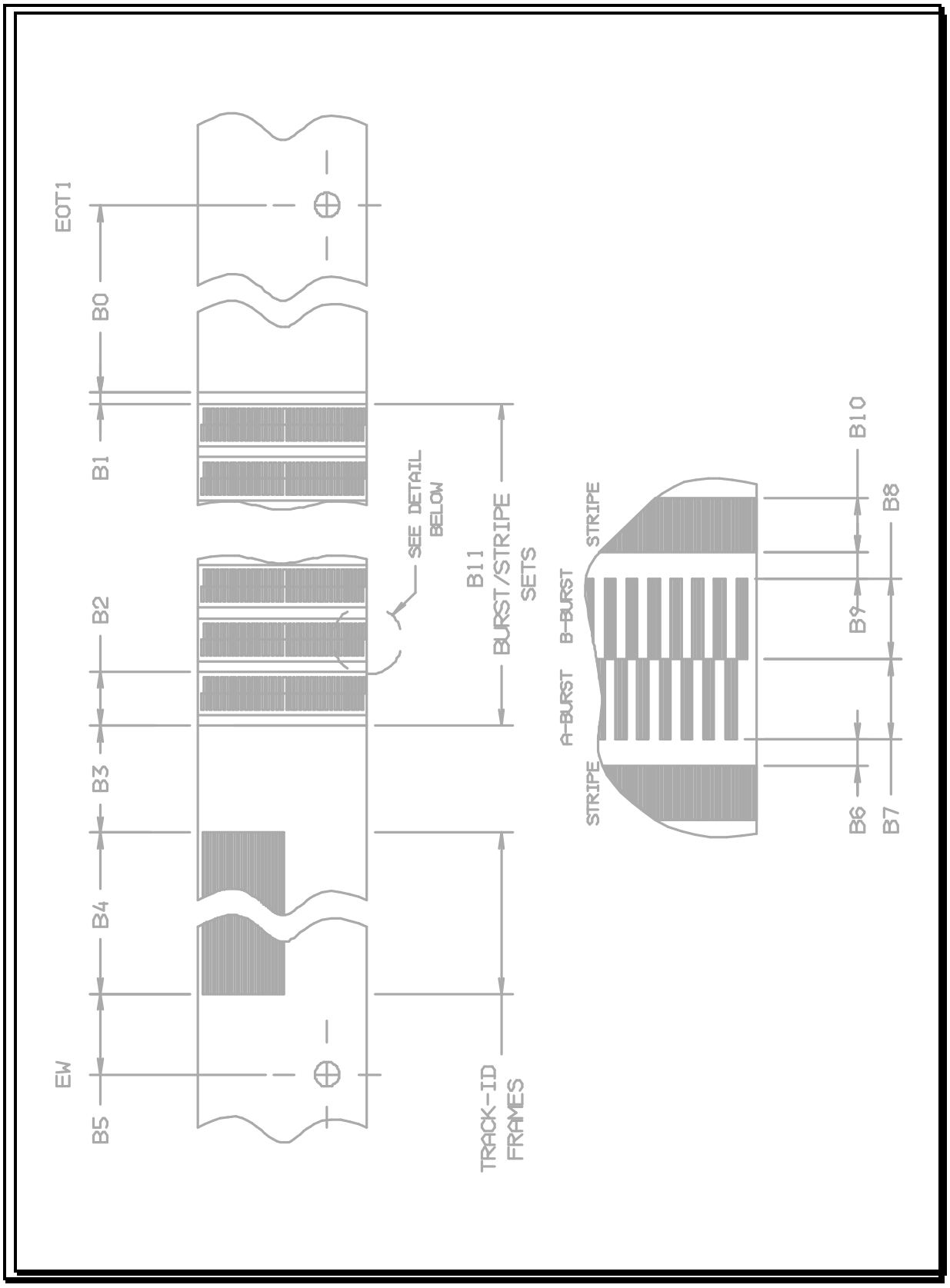

Figure 6.2 EOT Servo Area

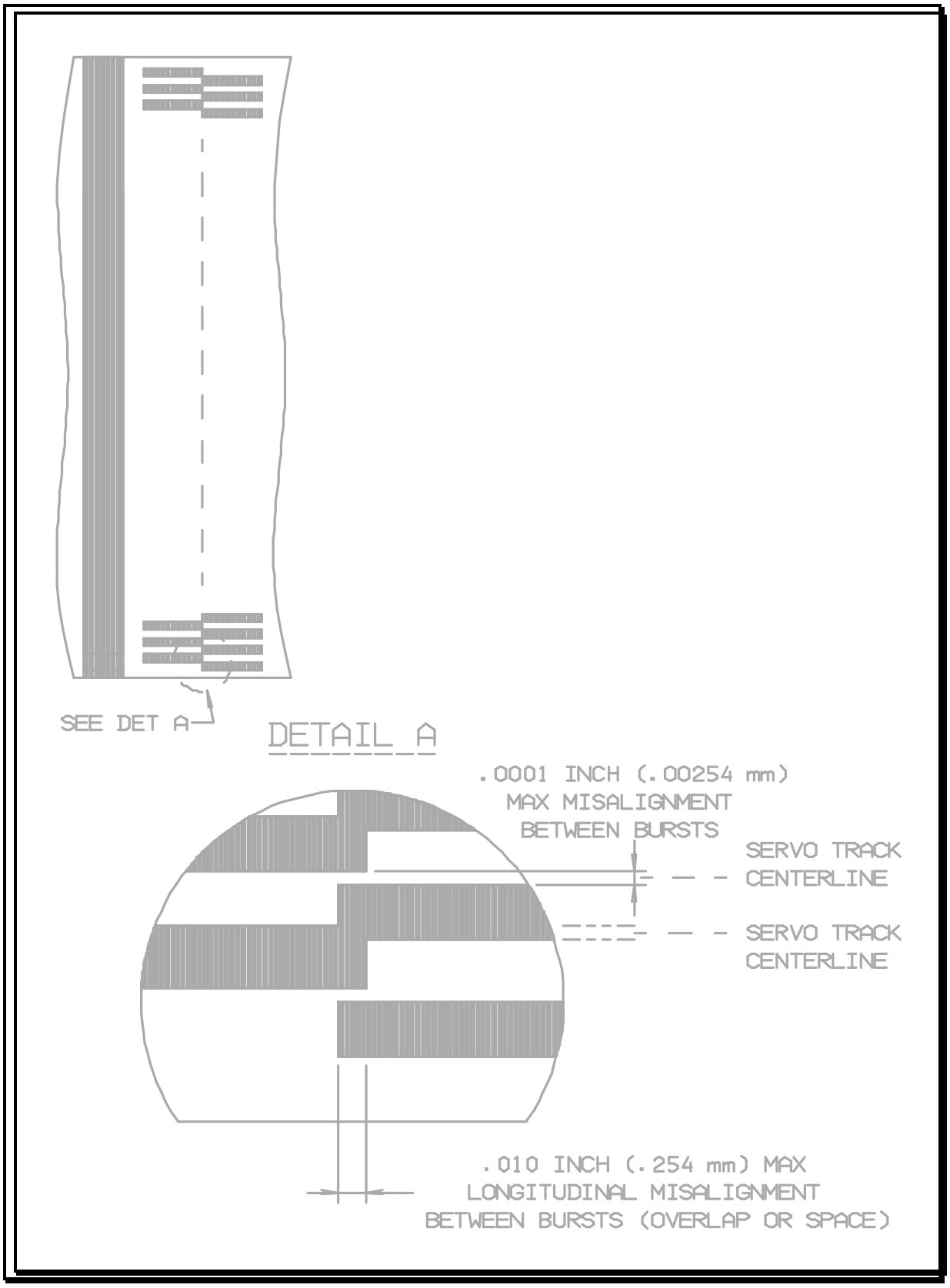

Figure 6.3 Servo Pattern Vertical Dimensions

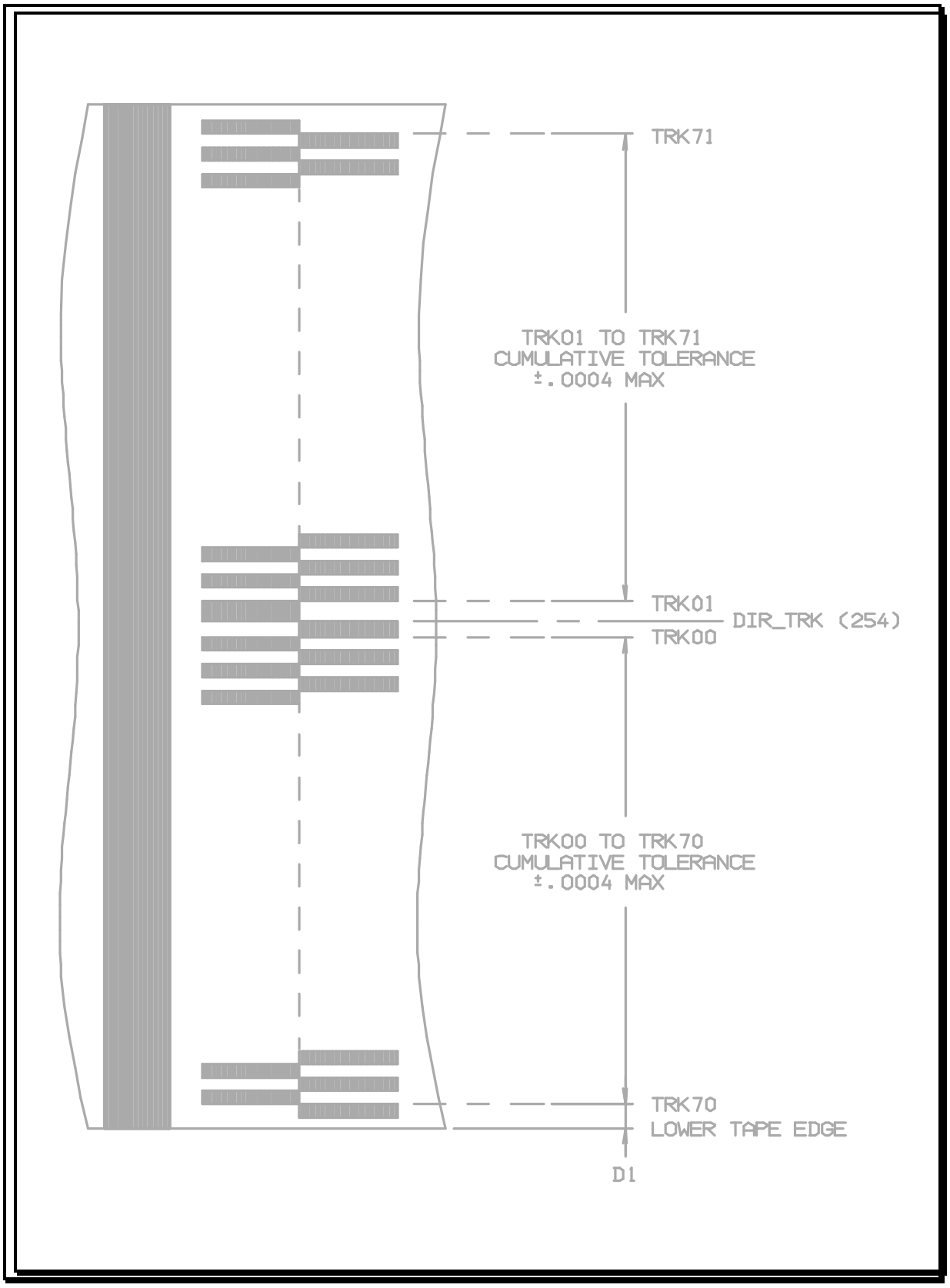

Figure 6.4 Reference Edge and Cumulative Pitch Tolerances

Symbol	Description	Nominal	Tolerance
D1	Lower (Reference) Tape Edge to Track 70 Centerline	0.0075 inches (0.19 mm)	± 0.0015 inches (± 0.038 mm)

Table 6.3 Reference Edge Tolerance

7. TRACK IDENTIFIER FRAME

7.1 Track ID Frame Makeup

Following the Servo Pattern Bursts, a Track ID Frame is pre-recorded on each even numbered track and the Directory Track on the BOT end of the tape, and on each odd numbered track on the EOT end of the tape, as part of the servo writing process. On the BOT end, the frames are recorded in the forward direction, and end at least 2.5 inches (64mm) before the LP hole. On the EOT end, the frames are recorded in the reverse direction and end at least 0.30 inches (7.6 mm) before the EW hole.

There is a Track ID Frame on the beginning end of every track. This allows the drive to verify which track it is on each time it completes the servo acquisition process. Care must be taken in normal recording operations to leave the Track ID Frames intact when ending each track. Following the Track ID Frames, low frequency postamble pattern is recorded at least 6 inches past the LP or EW hole during the tape format process. Part of this postamble pattern will be over-written the first time data is written on the track.

The first block in each Track ID Frame is given the Physical Block Address of 0. The Physical Block Address increments for each block of the frame. Control Byte 0 for each of the data blocks is set to 3E Hex, indicating an Identifier block. The Track Number is recorded in Control Byte 1. All 64 blocks of the Track ID Frame contain identical information in their data field. ECC encoding is not performed on the frame prior to recording it on the tape. See section 9 of QIC-3095-MC for more information on frame construction.

These frames identify the track number of each track as well as contain parametric and cartridge identification information. Each Track ID frame must be recorded in conformance to the requirements for a fixed data frame of QIC-3095-MC. Table 7.1 shows the contents of each data block of the Track ID frame.

BYTES	DATA	TYPE	EXAMPLE
0 - 7	QIC Format Document Number	ASCII CHAR	QIC-170D
8 - 15	Formatter Manufacturer	ASCII CHAR	SEAGATE
16 - 31	Formatter Location	ASCII CHAR	COSTA MESA, CA
32 - 43	Formatting Drive S/N	ASCII CHAR	953000001
44 - 51	Formatting Drive F/W Revision	ASCII CHAR	12.34
52 - 59	Cartridge Vendor	ASCII CHAR	3M
60 - 75	Cartridge Type	ASCII CHAR	TR4
76 - 107	Cartridge S/N	ASCII CHAR	123456789
108 - 113	Date (YYMMDD)	ASCII CHAR	950302
114 - 117	Time (HHMM)	ASCII CHAR	1435
118 - 127	Pad	ASCII CHAR	00 .. 00
128 - 129	Track Number	BINARY WORD	01
130 - 131	Cartridge Data Zone Length (Feet)	BINARY WORD	740
132 - 133	Last Data Track Number	BINARY WORD	71
134 - 135	Maximum Tape Speed (In per Sec)	BINARY WORD	120
136 255	Zero Fill (Reserved)	BINARY CHAR	00...00
256 - 511	Vendor Unique		

Table 7.1 Track ID Frame Data Field Contents

Binary word order is MSB, LSB.

The QIC Format Document Number shall be recorded exactly as shown in the example, including the revision letter. This field may be used to qualify the revision of the Track ID data block contents should they be changed in latter revision of this specification.

Each Track ID Frame is preceded by between 750 and 1250 recordings of the 2 byte low frequency preamble pattern followed by a normal preamble (refer to QIC-3095-MC for preamble definitions).

7.2 Writing Requirements

Environment:

Temperature	23^{o} C ± 7^{o} C
Relative Humidity	50% ±10%
Write current used for recording Track ID frame	1.15 * I_{sat} for 50,800 ftpi (2000 ftmm)
Recorded azimuth for Track ID frame	± 9.5 min of arc (2.76 mrad)

The Track ID field shall be recorded using write equalization recording in accordance with QIC-3095-MC.

8. ADDITIONAL DATA RECORDED ON FORMATTED TAPE

8.1 MEDIA HEADER FRAMES

Media header frames, followed by an EOD frame, are recorded on the directory track in accordance with QIC-3095 MC.

8.2 EOD FRAME

An EOD frame is recorded on Track 0 in accordance with QIC-3095 MC.