

# SMPTE STANDARD

## for Digital Television Tape Recording — 12.65-mm Type D-11 Format



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### 1 Scope

This standard specifies the format for the recording of type D-11 compressed pictures, four channels of AES3 data, and associated data which form helical records on 12.65-mm (0.5 in) tape in cassettes. This standard also defines the helical track record parameters, the content and format of the longitudinal records, and the cassette physical specifications.

Type D-11 picture compression is defined by SMPTE 367M.

The recording format supports frame frequencies of 30/1.001 Hz, 25 Hz, 24 Hz, and 24/1.001 Hz.

### 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

AES3-1992, Serial Transmission Format for Two-Channel Linearly Represented Digital Audio Data

ANSI/SMPTE 276M-1995, Television — Transmission of AES-EBU Digital Audio Signals Over Coaxial Cable

SMPTE 12M-1999, Television, Audio and Film — Time and Control Code

SMPTE 292M-1998, Television — Bit-Serial Digital Interface for High-Definition Television Systems

SMPTE 367M-2002, Television — Type D-11 Picture Compression and Data Stream Format

SMPTE 369M-2002, Television — Type D-11 Data Stream and AES3 Data Mapping over SDTI

IEC 61213 (1993-11), Analogue Audio Recording on Video Tape — Polarity of Magnetization

IEC 61237-1 (1994-06), Broadcast Video Tape Recorders — Methods of Measurement — Part 1: Mechanical Measurements

### **3 Abbreviations and acronyms**

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

AUX: Auxiliary  
DCT: Discrete cosine transform  
ECC: Error correcting code  
EOB: End of block  
I-NRZI: Interleaved nonreturn to zero inverted  
MUX: Multiplex  
VLC: Variable length coding

### **4 Environment and test conditions**

Tests and measurements made on the system to check the requirements of this standard shall be carried out under the following conditions:

- Temperature:  $20^{\circ}\text{C} \pm 1^{\circ}\text{C}$
- Relative humidity:  $50\% \pm 2\%$
- Barometric pressure: from 86 kPa to 106 kPa
- Tape tension:  $0.3\text{ N} \pm 0.05\text{ N}$
- Tape conditioning: not less than 24 h

#### **4.1 Calibration tapes**

Calibration tapes meeting the tolerances specified below should be made available by manufacturers of digital television tape recorders and players in accordance with this standard.

#### **4.2 Record location and dimensions**

Geometrical location and dimensions of the recordings on the tape and their relative positions in regard to timing relations of the recorded signals shall be as specified in figure 27 and table 1 in 6.2. Tolerances shown in table 1 should, however, be reduced by 50% for calibration tapes.

## 5 Tape and cassette physical specifications

### 5.1 Magnetic tape specifications

#### 5.1.1 Base

The base material shall be polyester or its equivalent.

#### 5.1.2 Tape width and width fluctuation

The tape width shall be  $12.650 \text{ mm} \pm 0.005 \text{ mm}$ . Tape width fluctuation shall not exceed  $6 \text{ }\mu\text{m}$  peak to peak. The value of tape width fluctuation shall be evaluated by measuring 10 points, each 20 mm apart, over a tape length of 200 mm.

#### 5.1.3 Tape thickness

The tape thickness shall be from  $12.5 \text{ }\mu\text{m}$  to  $13.8 \text{ }\mu\text{m}$ .

#### 5.1.4 Offset yield strength

The offset yield strength shall be greater than 15 N.

#### 5.1.5 Magnetic coating

The magnetic tape used shall have a coating of metal particles or equivalent, longitudinally oriented. The coating coercivity shall be in the range of 120,000 A/m to 140,000 A/m, with an applied field of 800000 A/m (10000 oersted) as measured by a 50- or 60-Hz BH meter or vibrating sample magnetometer (VSM).

### 5.2 Cassette specifications

#### 5.2.1 Cassette dimensions

Two sizes of cassettes shall be identified as follows:

S cassette: 96 x 156 x 25 mm (as shown in figures 1 to 13)

L cassette: 145 x 254 x 25 mm (as shown in figures 14 to 26)

#### 5.2.2 Tape length and recording time

The maximum tape length and recording time are recommended as follows:

S cassette:	241 m + 2/- 0 m	40 minutes for 29.97PsF/59.94I	48 minutes for 25PsF/50I	50 minutes for 24PsF	50 minutes for 23.98PsF
L cassette:	732 m + 2/- 0 m	124 minutes for 29.97PsF/59.94I	148 minutes for 25PsF/50I	155 minutes for 24PsF	155 minutes for 23.98PsF

#### 5.2.3 Datum planes

Datum plane Z shall be determined by three datum areas, A, B, and C, as shown in figures 3a and 16a. Datum plane X shall be orthogonal to datum plane Z and shall include the centers of datum holes (a) and (b). Datum plane Y shall be orthogonal to both datum plane X and datum plane Z and shall include the center of datum hole (a) as shown in figures 2 and 15.

#### **5.2.4 Tape winding**

The magnetic coating side of the magnetic tape shall face outside on both the supply reel and the take-up reel as shown in figures 4 and 17.

#### **5.2.5 Label area and window area**

The hatched areas shown in figures 1 and 14 are for the label and window. Labels attached to the cassette shall not protrude above the outside cassette surface plane.

#### **5.2.6 Guiding groove**

For correct insertion into the VTR, four guiding grooves for S cassettes, as shown in figures 1 and 2 and three guiding grooves for L cassettes as shown in figure 15, shall be provided.

#### **5.2.7 Safety tab and safety plug for recording inhibition**

For S cassettes, a safety plug at the supply reel side and a hole of minimum depth 10 mm from datum plane Z at the take-up reel side shall be provided as shown in figure 2.

For L cassettes, a safety plug shall be provided at the take-up reel side as shown in figure 15.

The safety plug shall not be deformed by 0.3 mm or more when a force of 2.0 N (204 gf) is applied to the center of it, using a 2.5 mm diameter rod. (See figures 12 and 25.)

#### **5.2.8 Identification holes**

Six identification holes (holes 1 to 6) shall be located as specified in figures 2 and 15. For this format, holes 1, 2, 3, 4, and 6 shall be closed. Hole 5 shall be open.

#### **5.2.9 Reels**

The reels shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The locations of the reels, when in the unlocked position, are shown in figures 4 and 17. Dimensions of the reels are shown in figures 6 and 19. The height of the reels is shown in figures 7 and 20.

The reel shall be completely released when the cassette lid is opened 23.5 mm minimum from datum plane Z.

##### **5.2.9.1 Reel spring force**

The reels assembled in the cassette shall be pressed by the reel spring with a specified force under the conditions specified in figures 11 and 24. The spring force shall be  $1.5 \text{ N} \pm 0.5 \text{ N}$  (153 gf  $\pm$  51 gf) for S cassettes and  $3.5 \text{ N} \pm 0.5 \text{ N}$  (357 gf  $\pm$  51 gf) for L cassettes when pressing on a reel 2.4 mm above datum plane Z as shown in figures 11 and 24.

##### **5.2.9.2 Extraction force**

The force (F1, F2) required to pull the tape out from the reel shall not exceed 0.17 N (17 gf), as specified in figures 13a and 26a.

### 5.2.9.3 Friction torque

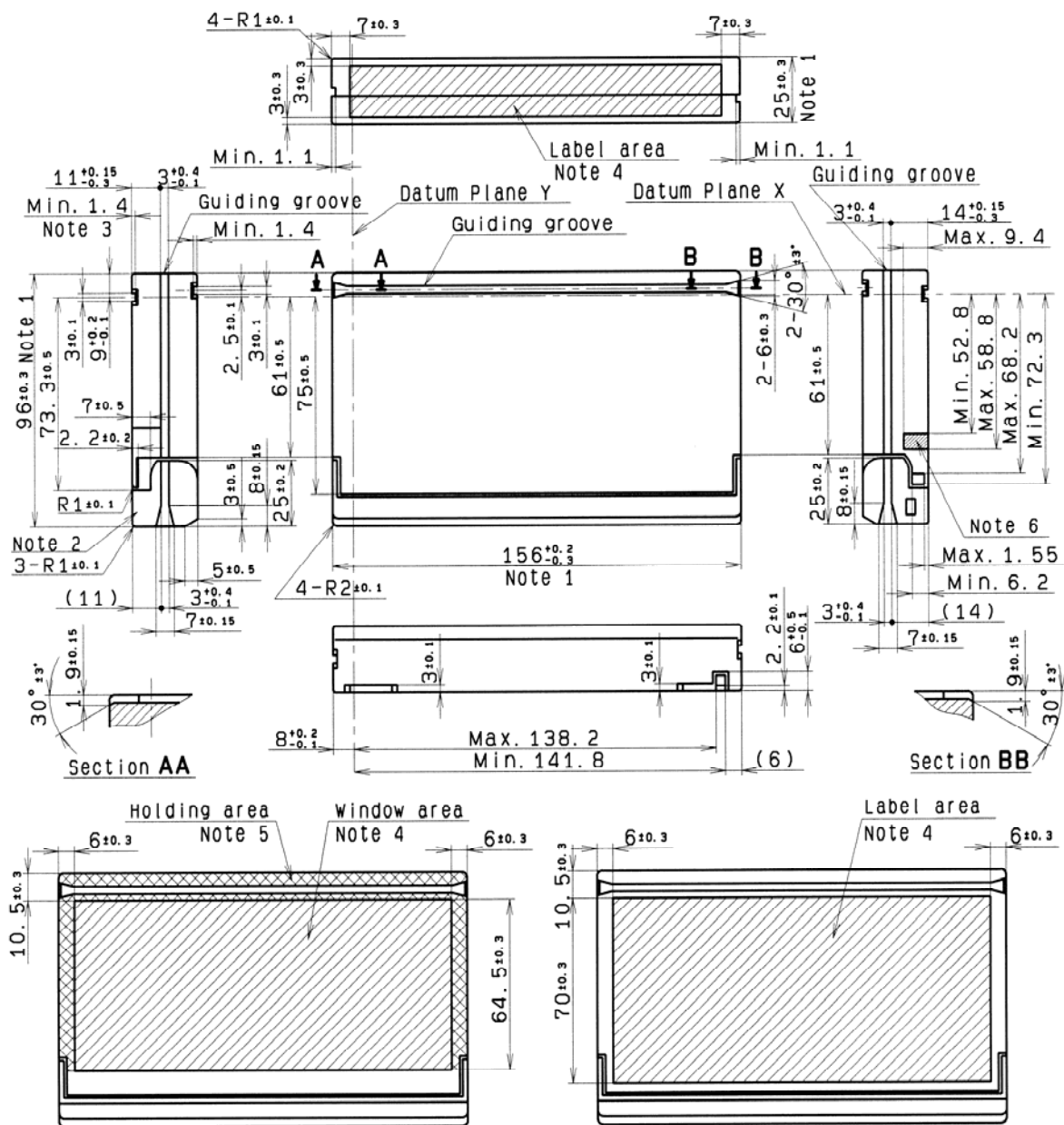
The torque required to wind the tape shall be less than 15 mN m (152 gf cm) for S cassettes and less than 30 mN m (305 gf cm) for L cassettes, as specified in figures 13b and 26b.

### 5.2.10 Protecting lid

The cassette lid shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The unlocking lever insertion area is specified in figures 8 and 21. The lid shall be unlocked when the lid lock lever is shifted in either direction A or B, as illustrated in figures 9 and 22. The force required to unlock the lid shall be less than 1 N (101 gf) in the A direction or less than 1.5 N (152 gf) in the B direction.

The lid shall open 29.0 mm with a force of 1.5 N (152 gf) or less as specified in figures 10 and 23.

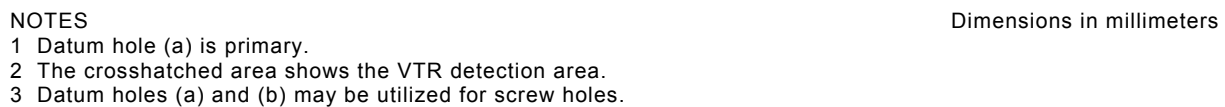


Dimensions in millimeters

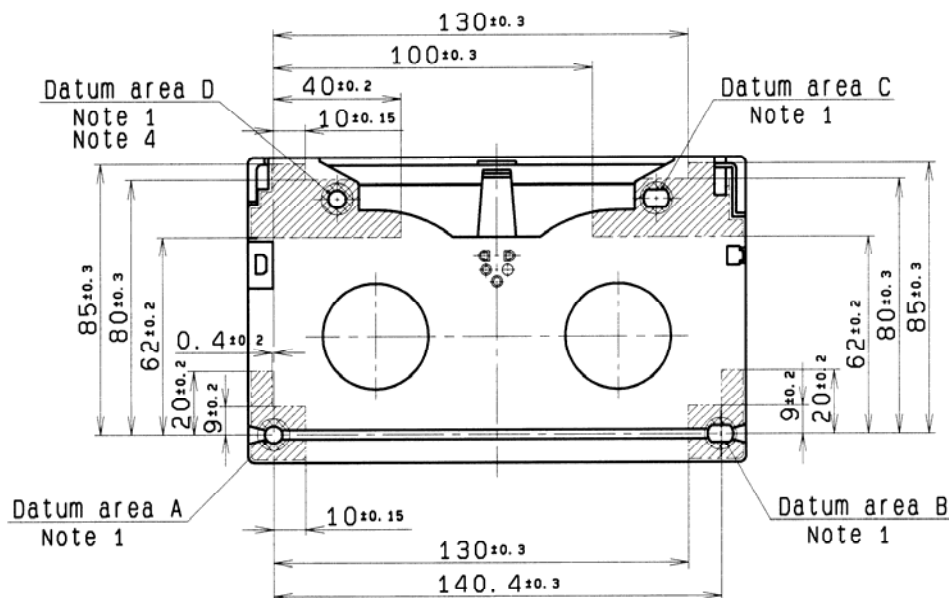
## NOTES

- 1 These dimensions are inspected by using limit gauges.
- 2 No part of the lid shall protrude beyond the bottom plane of the cassette when the lid opens or when it closes.
- 3 These dimensions shall be specified based on datum plane Z.
- 4 Label and/or window areas, shown by the hatched area, are available for the label and/or window.
- 5 The cassette may be held in position by the recorder and/or player unit on the holding area shown by the cross-hatched area.
- 6 The fine hatched area shows the acceptable range of the plug notch position and depth at the side.

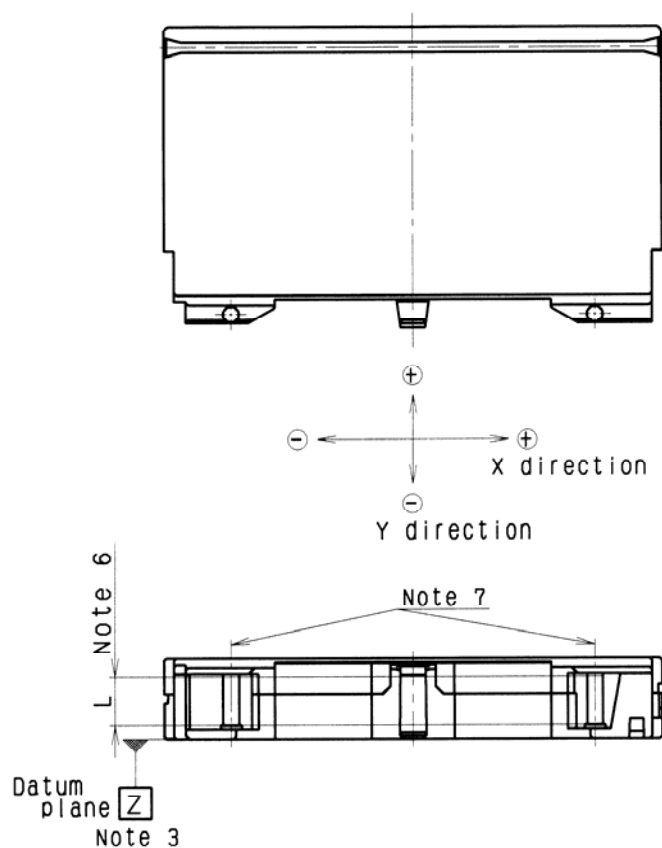
Figure 1 – Top and side view dimensions (S-cassette)



**Figure 2 – Bottom view dimensions (S-cassette)**



**Figure 3a – Datum areas and supporting areas**



### Figure 3b – Tape guides

Dimensions in millimeters



## NOTES

- 1 The crosshatched areas 10 mm in diameter are datum areas.
- 2 The four supporting areas shown by the hatched areas shall be coplanar with their corresponding datum areas within 0.05 mm of each of them.
- 3 Datum plane Z shall be defined by the three datum areas, A, B, C.
- 4 Datum area D shall be coplanar, within 0.3 mm, with datum plane Z.
- 5 The areas within 1 mm of the edges of a cassette shall not be included in the supporting areas.
- 6 Measurement L: 15 mm
- 7 Perpendicularity of tape guides is specified as follows (even if they themselves are tapered) :

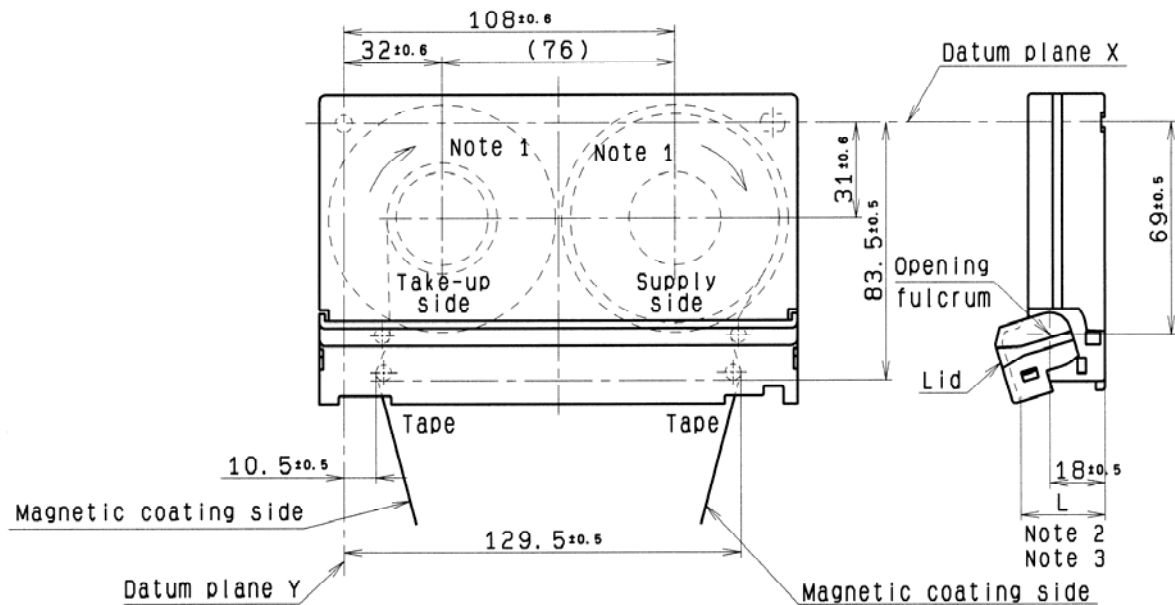
Direction	X	Y
Tape guide		
Supply side	$0 \pm 0.15$	$0 \pm 0.15$
Take-up side	$0 \pm 0.15$	$0 \pm 0.15$

*Dimensions in millimeters*

Direction X: Parallel to the tape running direction.

Direction Y: Horizontally orthogonal to direction X.

**Figure 3 – Datum areas, supporting areas, tape guides and associated dimensions (S-cassette)**

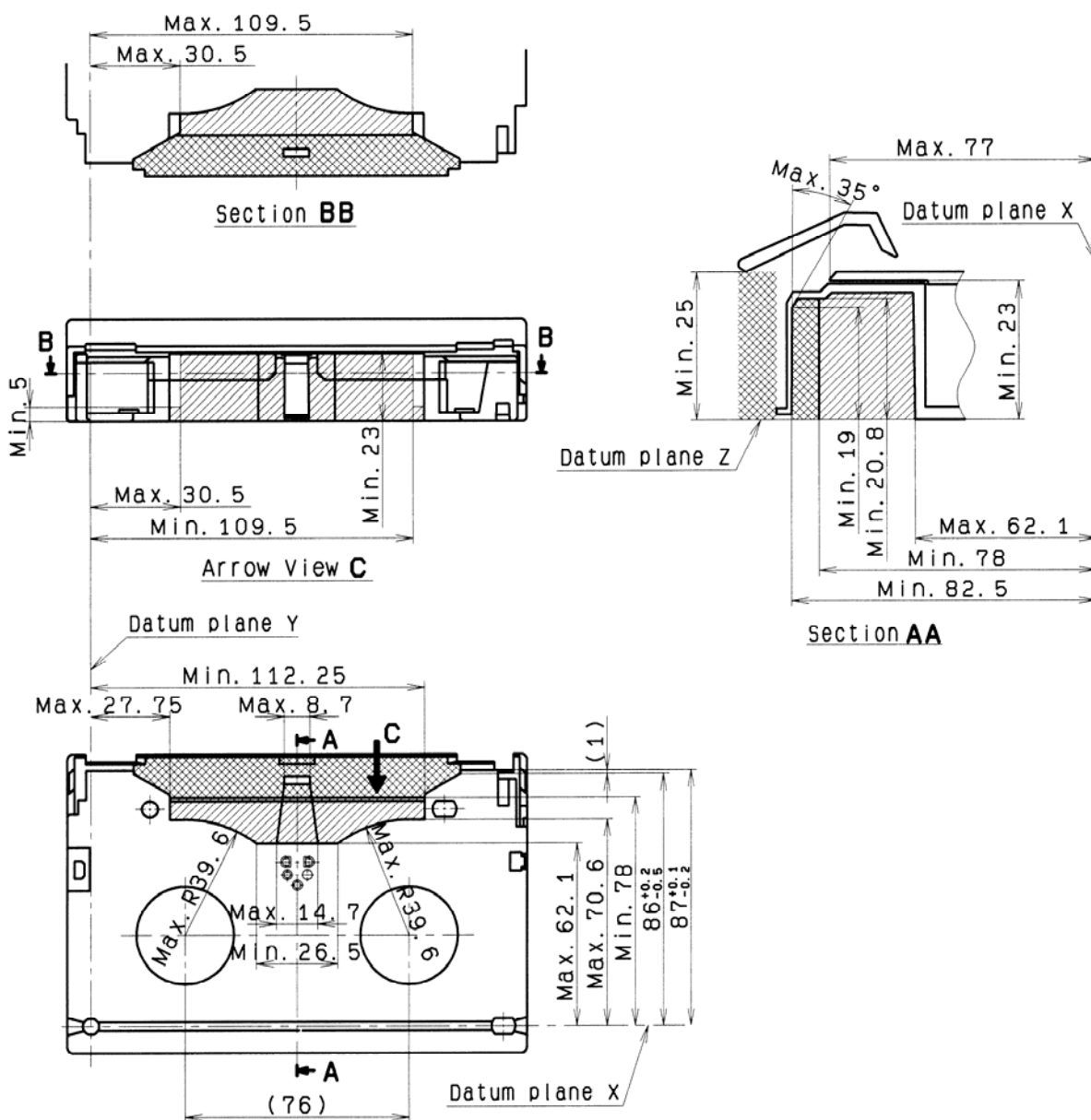


Dimensions in millimeters

## NOTES

- 1 The rotating direction of reels during forward operation.
- 2 The lid opening height L shall be 29 mm or more.
- 3 The reel shall be reset completely when the lid opening height L is 23.5 mm.

**Figure 4 - Reel location in the unlocked position (S-cassette)**



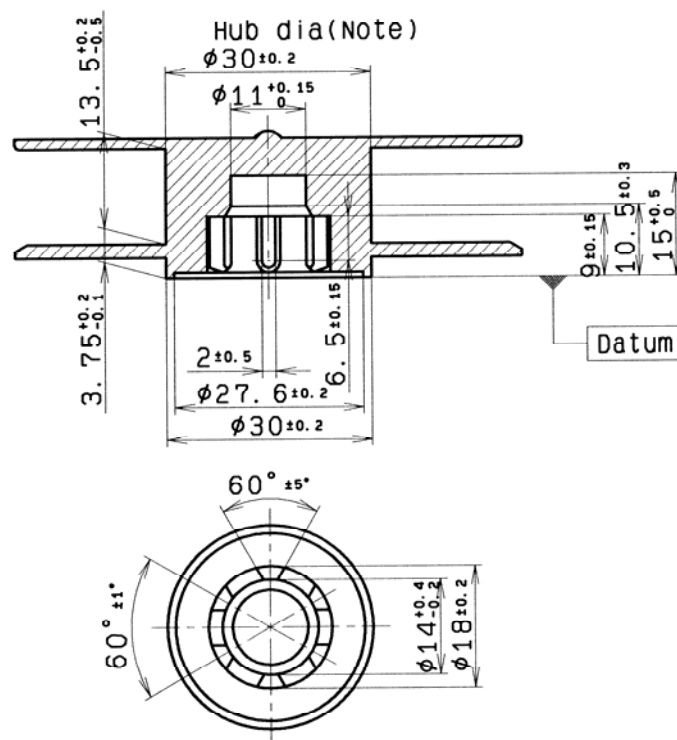
Dimensions in millimeters

## NOTES

- 1 The hatched area is where the loading mechanism of the video tape recorder and/or player unit positions the video cassette when it is inserted.
- 2 The hatched and crosshatched areas are so designed that the loading mechanism of the video tape recorder and/or player unit unwinds and extends the magnetic tape towards the head drum after the lid opens.

**Figure 5 – Protecting lid dimensions (S-cassette)**

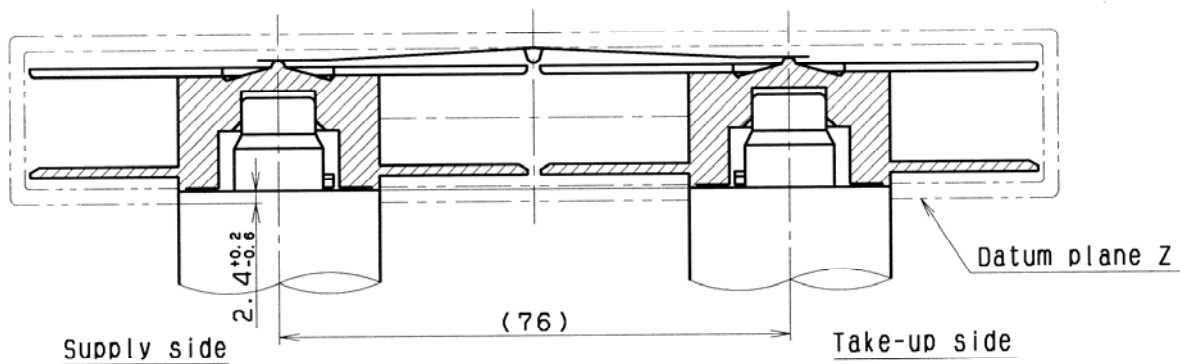
(Sometimes referred to as minimum space for loading mechanism)



Dimensions in millimeters

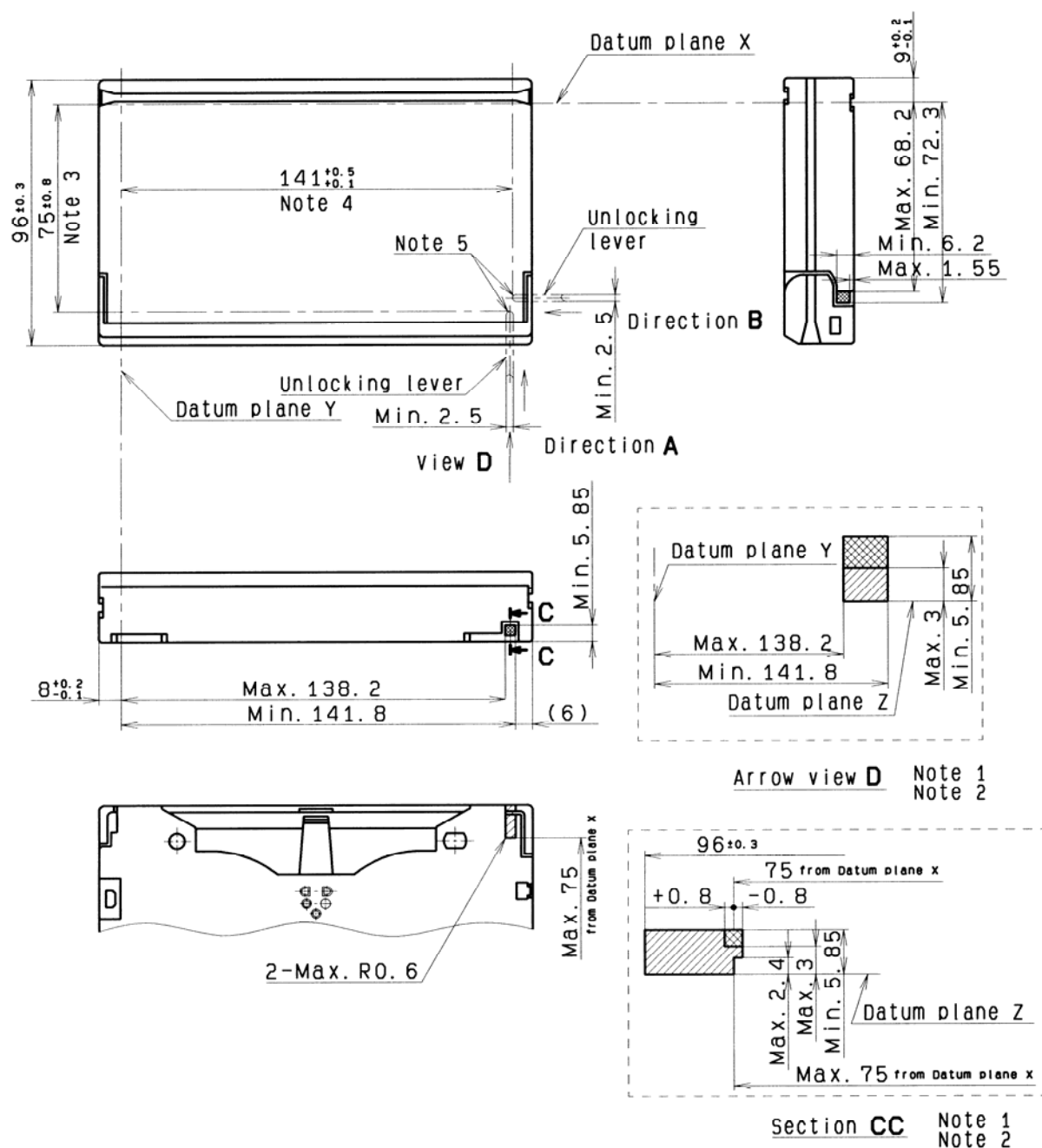
NOTE – The reels with large hubs (hub diameter  $53.3 \text{ mm} \pm 0.2 \text{ mm}$ ) can be used for cassettes whose recording time is less than 12 minutes.

**Figure 6 – Reel dimensions (S-cassette)**



*Dimensions in millimeters*

**Figure 7 – Reel height in the unlocked position (S-cassette)**



Dimensions in millimeters

## NOTES

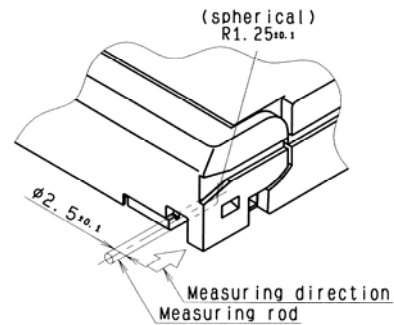
- 1 The crosshatched and hatched areas show the allowable total area where the unlocking lever extending from the video tape recorder and/or player unit can be inserted into a cassette.
- 2 The crosshatched area shows the range of the unlocking lever insertion which permits the lid to be unlocked.
- 3 Allowable range within which the unlocking lever can be inserted in the A direction.
- 4 Allowable range within which the unlocking lever can be inserted in the B direction.
- 5 The tip of the unlocking lever shall be shaped into a semicircle or hemisphere whose radius is half of the unlocking lever width.

**Figure 8 – Unlocking lever insertion area (S-cassette)**

Direction A

The force to unlock the lid shall be not greater than 1.0 N in the A direction.

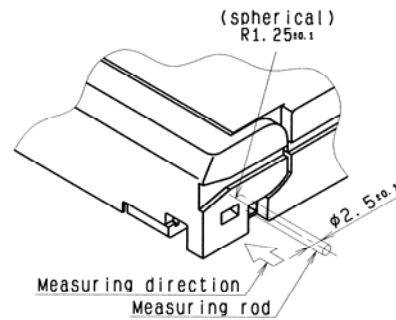
Refer to figure 8 regarding the measuring ranges.



Direction B

The force to unlock the lid shall be less than 1.5 N in the B direction.

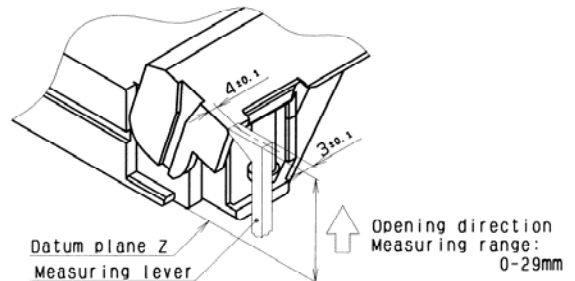
Refer to figure 8 regarding the measuring ranges.



Dimensions in millimeters

**Figure 9 – Lid unlocking force (S-cassette)**

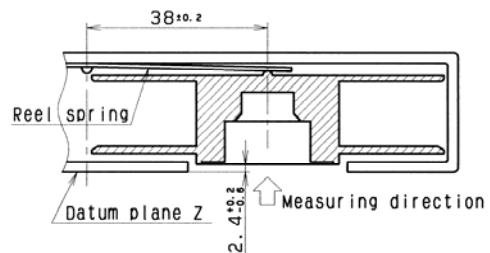
The maximum force to open the lid shall be 1.5 N.



Dimensions in millimeters

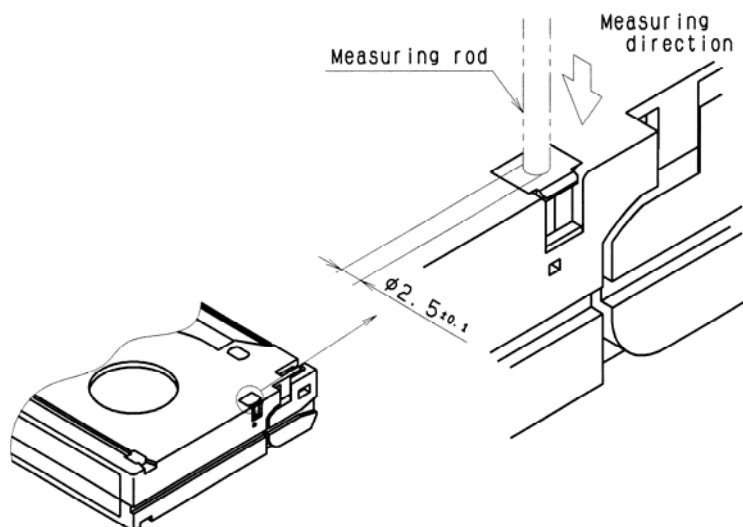
**Figure 10 – Lid opening force (S-cassette)**

The force of the spring for pushing down the reel shall be  $(1.5 \pm 0.5)$  N.



Dimensions in millimeters

**Figure 11 – Reel spring force (S-cassette)**



Dimensions in millimeters

Figure 12 – Safety plug strength (S-cassette)

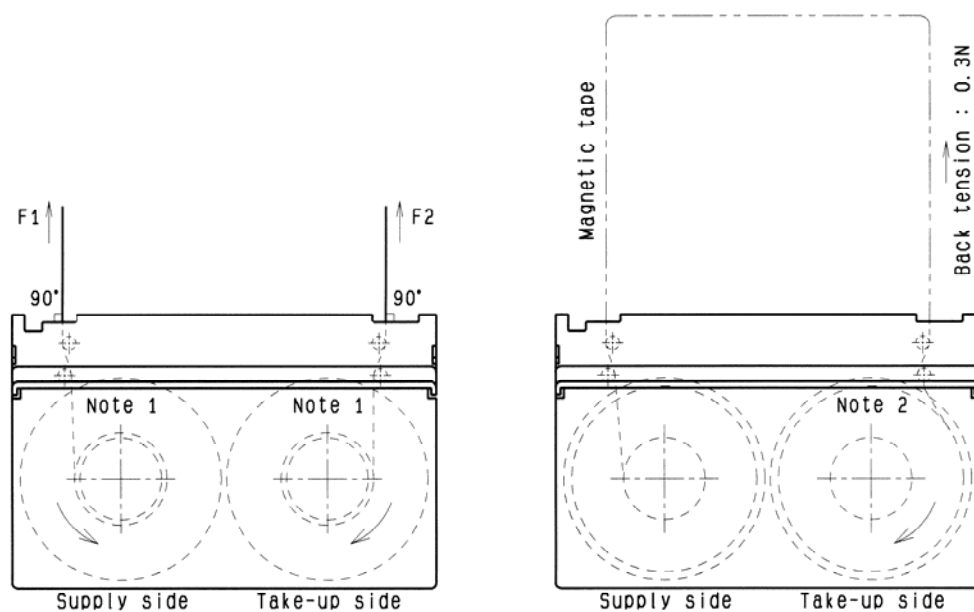


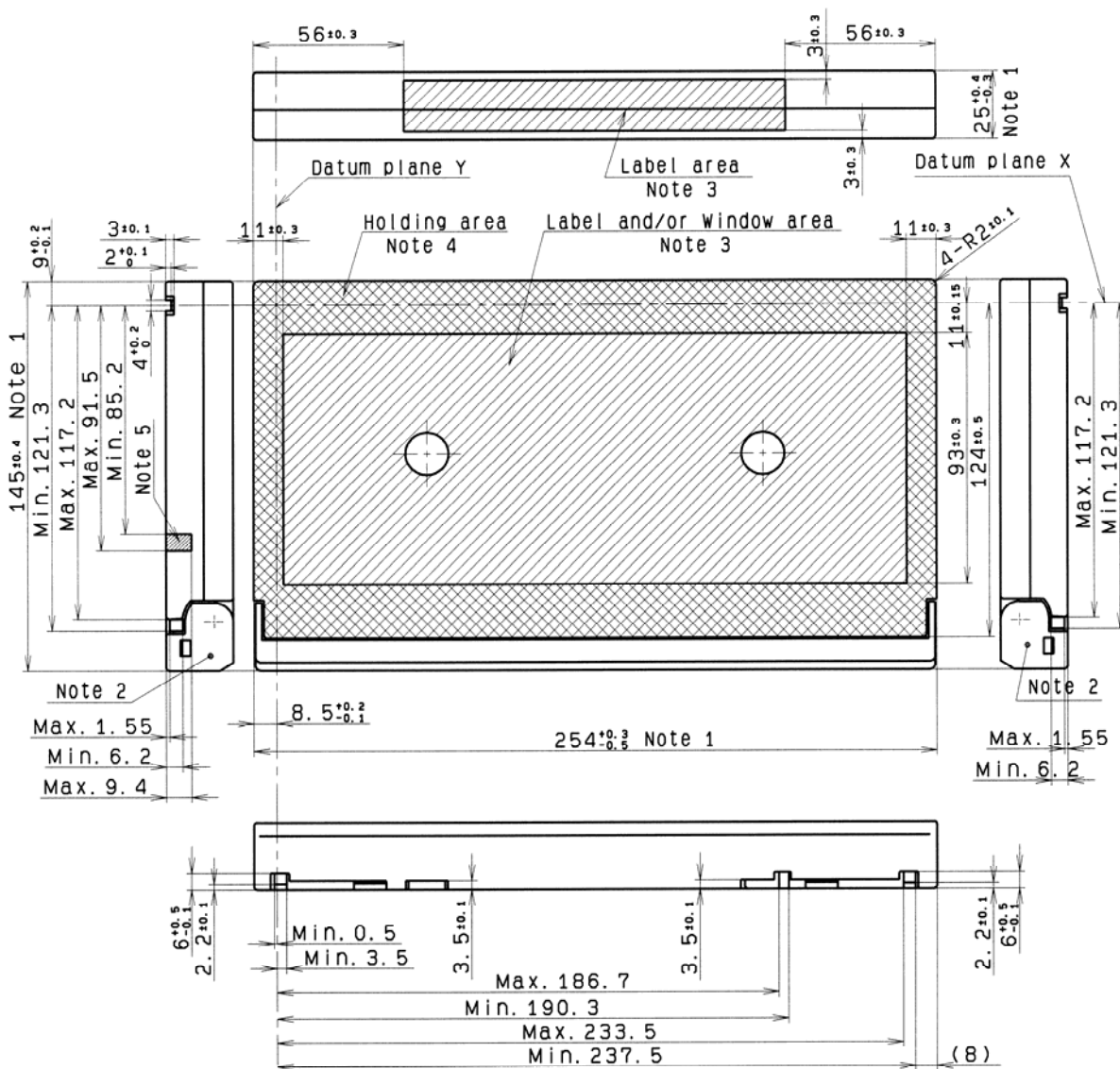
Figure 13a – Extraction force (F1, F2)

Figure 13b – Friction torque

## NOTES

- 1 Holdback torque of 1 mN m.
- 2 Friction torque to wind the tape.

Figure 13 – Extraction force (F1, F2) and friction torque (S-cassette)



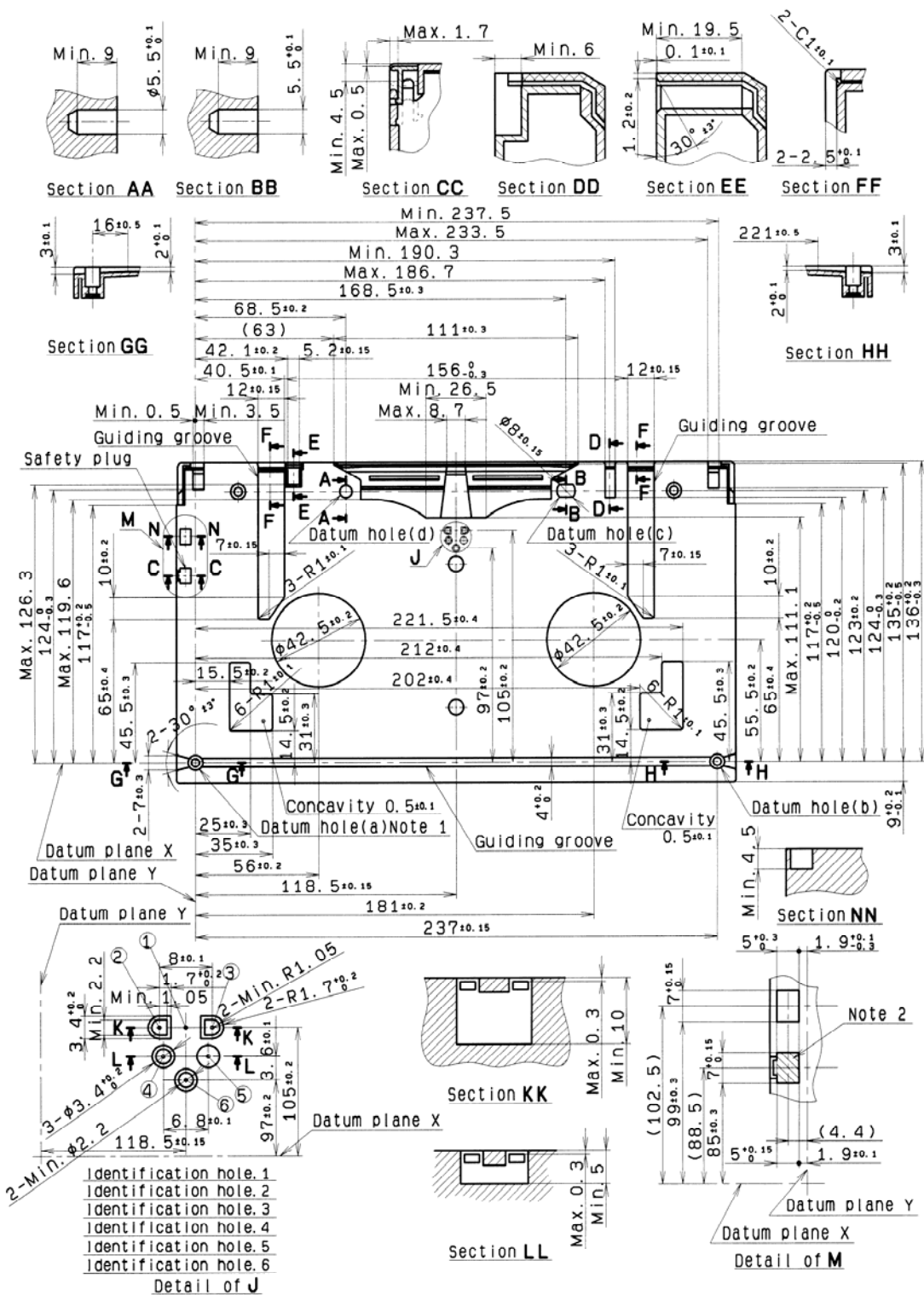
Dimensions in millimeters

## NOTES

- 1 These dimensions are inspected by using limit gauges.
- 2 No part of the lid shall protrude beyond the bottom plane of the cassette when the lid opens or when it closes.
- 3 Label and/or window area shown by the hatched area are available for the label and/or window.
- 4 The cassette may be held in position by the recorder and/or player unit on the holding area shown by the cross-hatched area.
- 5 The fine hatched area shows the acceptable range of the plug notch position and depth at the side.

**Figure 14 – Top and side view dimensions (L-cassette)**





**Figure 15 – Bottom view (L-cassette)**

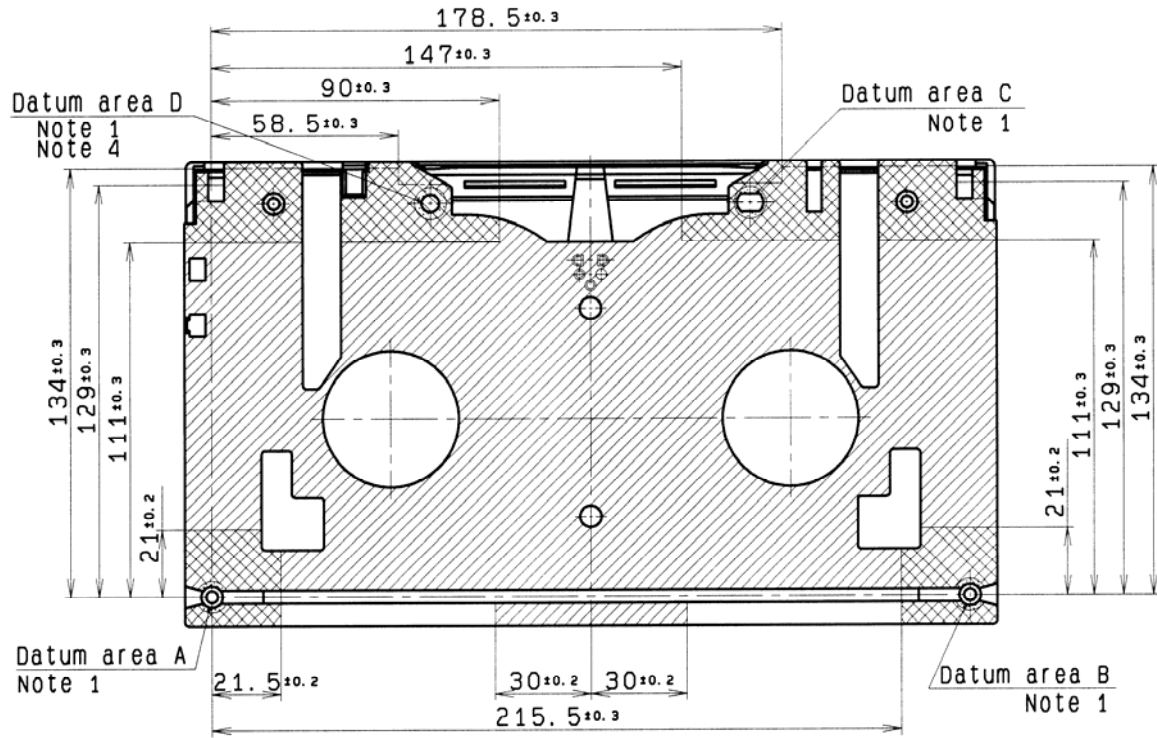


Figure 16a – Datum areas and supporting areas

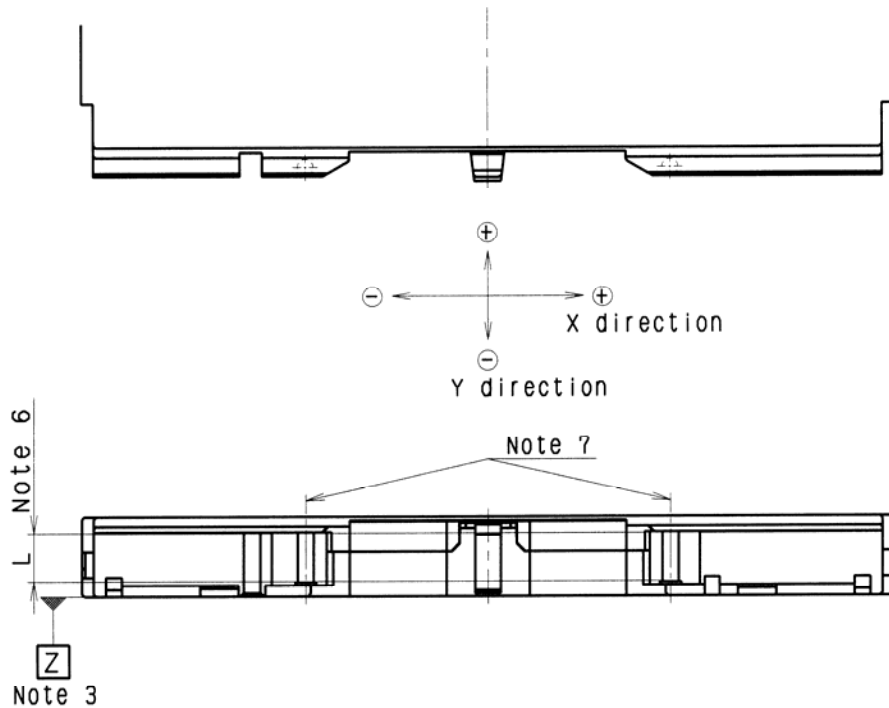
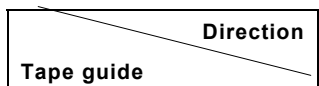


Figure 16b – Tape guides

Dimensions in millimeters

## NOTES

- 1 The four round areas 10 mm in diameter are datum areas.
- 2 The four supporting areas shown by the crosshatched areas shall be coplanar with their corresponding datum areas within 0.05 mm of each of them and shall be coplanar with the hatched areas.
- 3 Datum plane Z shall be defined by the three datum areas, A, B, C.
- 4 Datum area D shall be coplanar, within 0.3 mm with datum plane Z.
- 5 The areas within 1 mm of the edges of the cassette shall not be included in the supporting areas.
- 6 Measurement L: 15 mm
- 7 Perpendicularity of tape guides is specified as follows (even if they themselves are tapered):

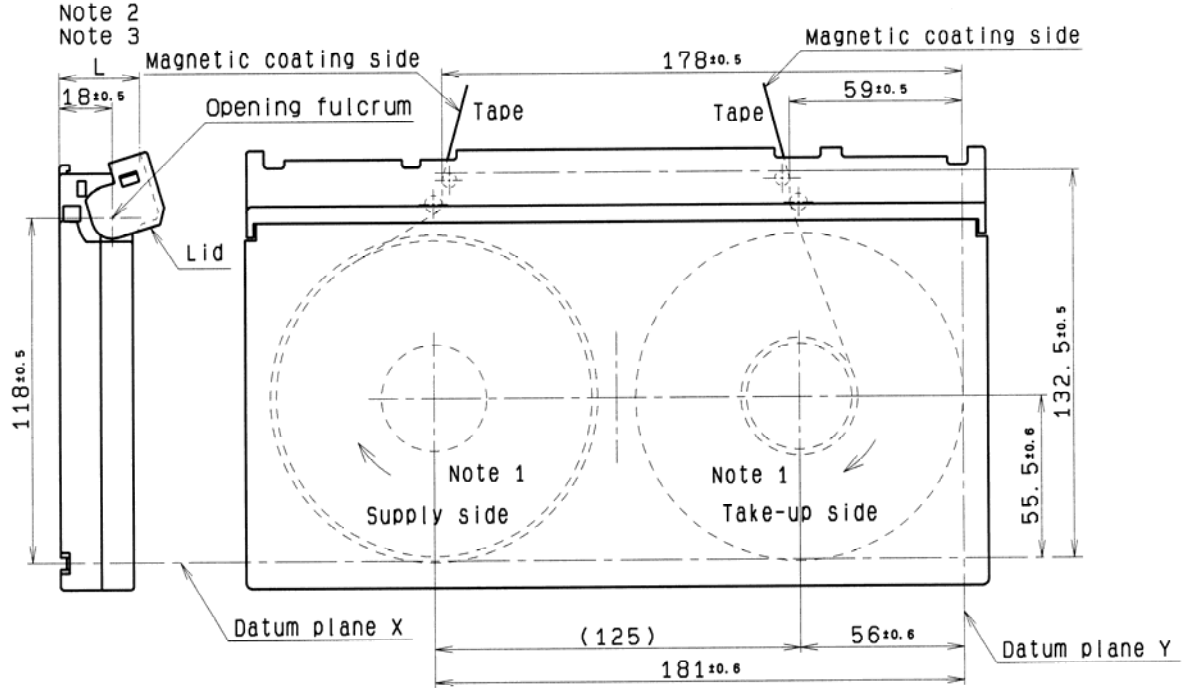
 <b>Direction</b>	<b>X</b>	<b>Y</b>
<b>Tape guide</b>		
Supply side	$0 \pm 0.15$	$0 \pm 0.15$
Take-up side	$0 \pm 0.15$	$0 \pm 0.15$

Dimensions in millimeters

Direction X: Parallel to the tape running direction

Direction Y: Horizontally orthogonal to direction X

**Figure 16 – Datum areas, supporting areas and tape guides (L-cassette)**

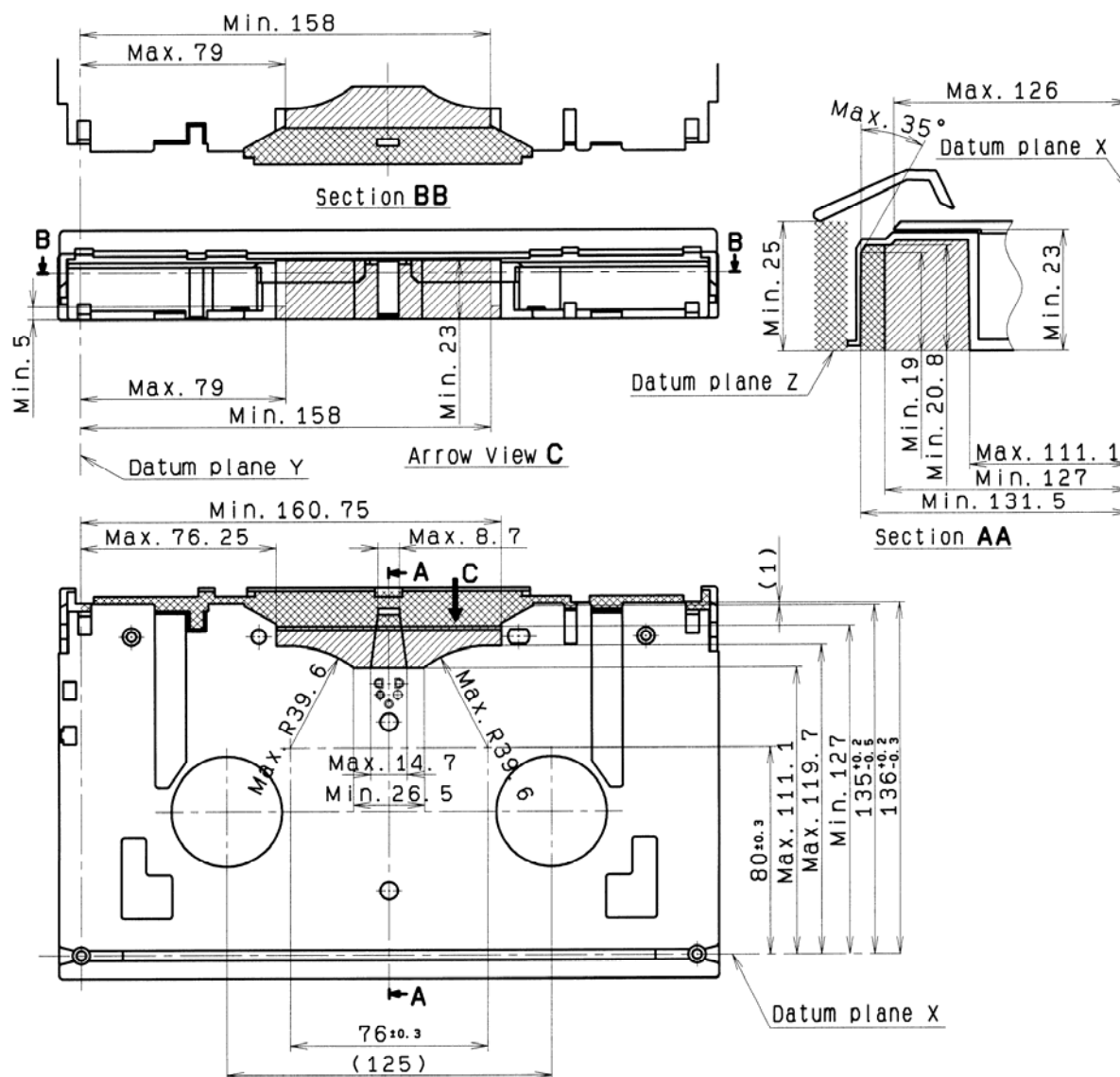


Dimensions in millimeters

NOTES

- 1 The rotating direction of reels during forward operation.
- 2 The lid opening height L shall be 29 mm or more.
- 3 The reel shall be reset completely when the lid opening height (L) is 23.5 mm.

Figure 17 – Reel location in unlocked position (L-cassette)



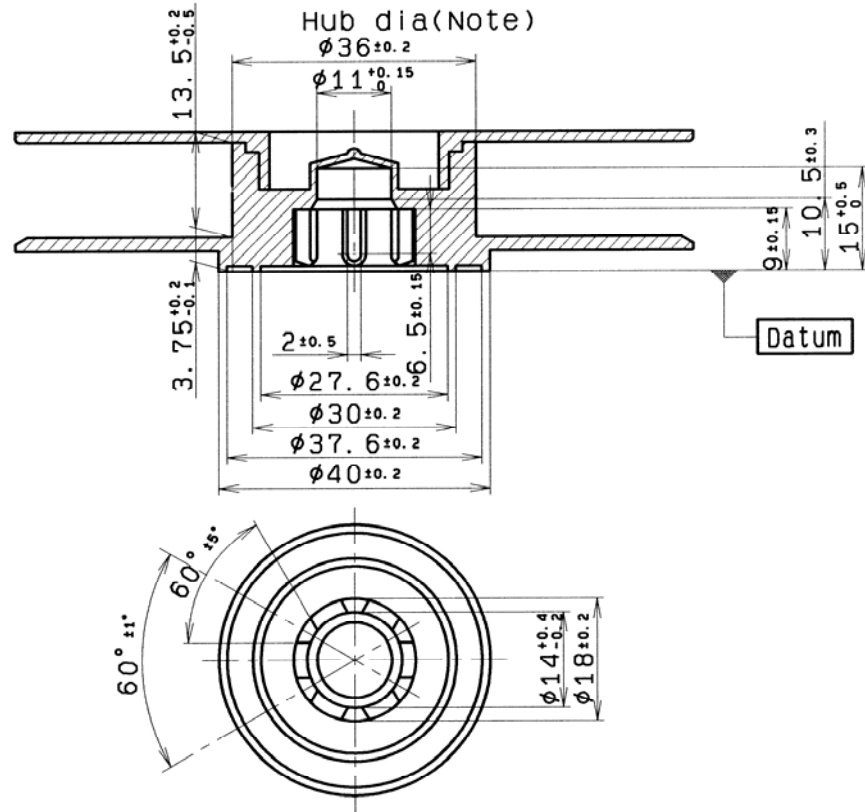
Dimensions in millimeters

#### NOTES

- 1 The hatched area is where the loading mechanism of the video tape recorder and/or player unit positions the video cassette when it is inserted.
- 2 The hatched and crosshatched areas are so designed that the loading mechanism of the video tape recorder and/or player unit unwinds and extends the magnetic tape towards the head drum after the lid opens.

**Figure 18 – Protecting lid (L-cassette)**

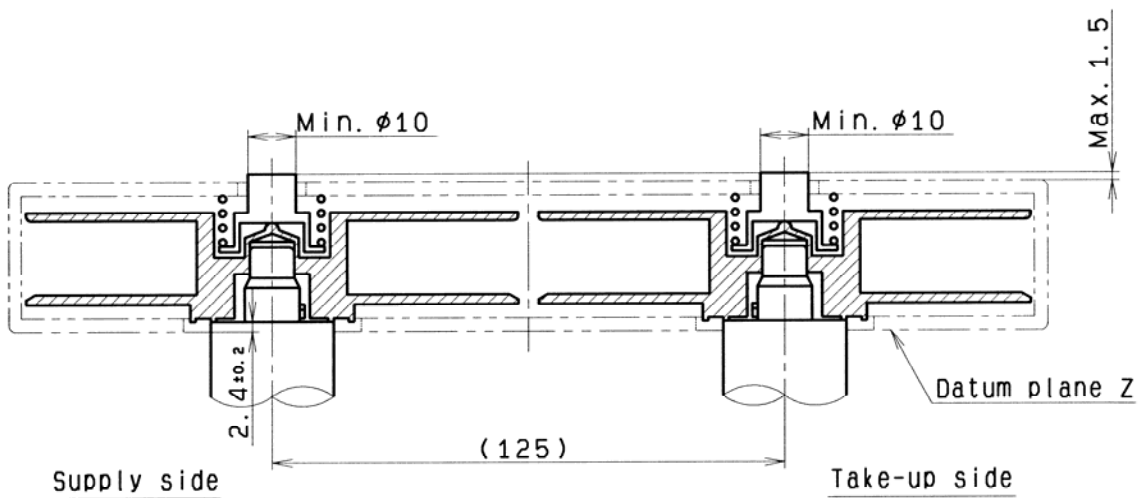
(Sometimes referred to as minimum space for loading mechanism)



Dimensions in millimeters

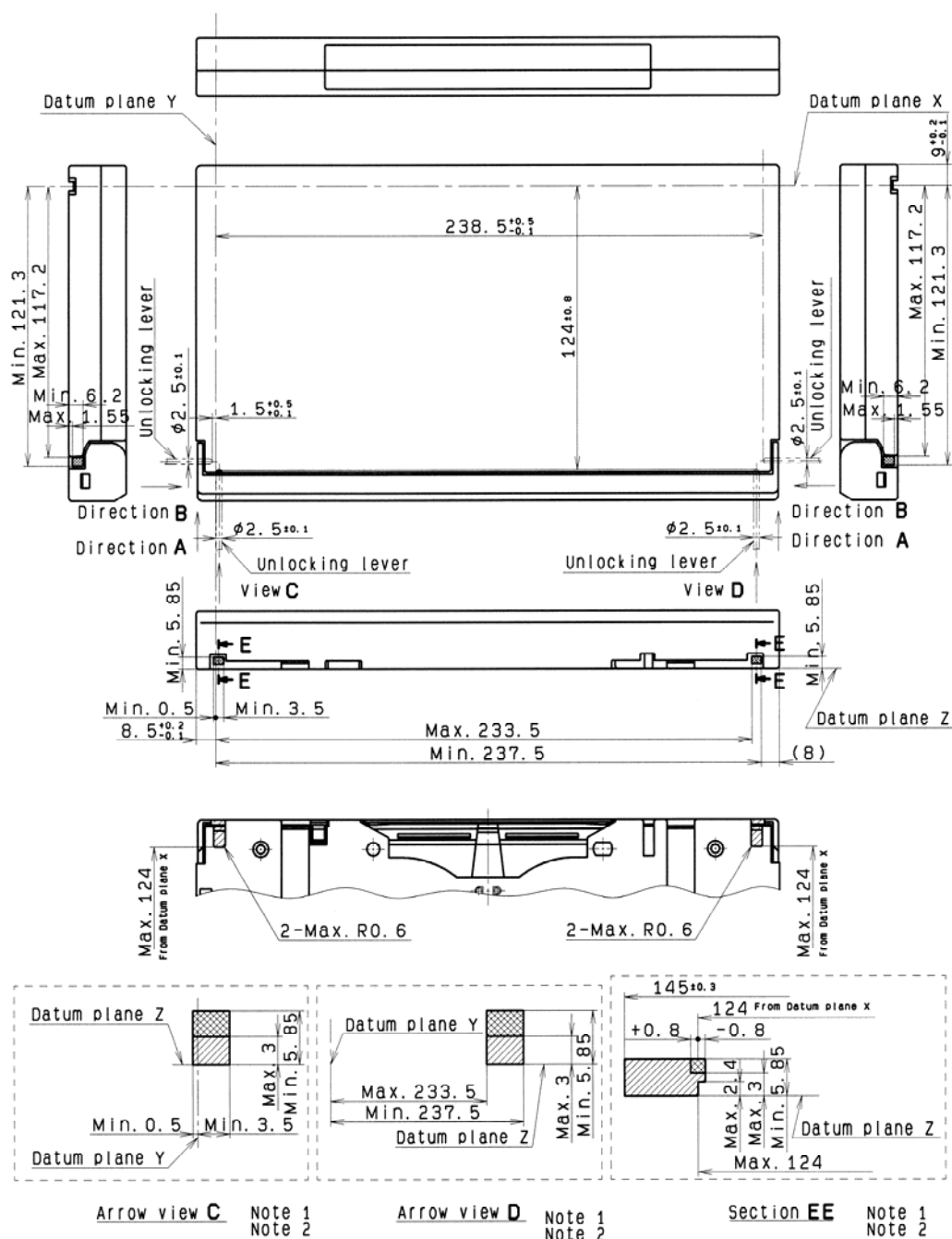
NOTE – The reels with large hubs (hub diameter  $53.3 \text{ mm} \pm 0.2 \text{ mm}$ ) can be used for cassettes whose recording time is less than 34 minutes.

Figure 19 – Reel dimensions (L-cassette)



Dimensions in millimeters

Figure 20 – Reel height in unlocked operation (L-cassette)



Dimensions in millimeters

## NOTES

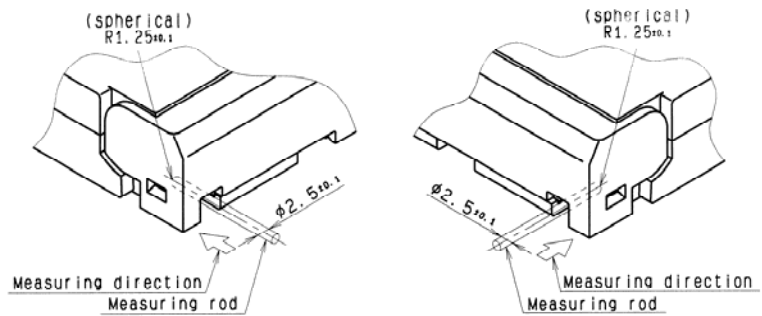
- 1 The crosshatched and hatched area shows the allowable total area where the unlocking lever extending from the video tape recorder and/or player unit can be inserted into a cassette.
- 2 The crosshatched area shows the range of the unlocking lever insertion which permits the lid to be unlocked.
- 3 Allowable range within which the unlocking lever can be inserted in the A direction.
- 4 Allowable range within which the unlocking lever can be inserted in the B direction.
- 5 The tip of the unlocking lever shall be shaped into a semicircle or hemisphere whose radius is half of the unlocking lever width.

Figure 21 – Unlocking lever insertion area (L-cassette)

Direction A

The force to unlock the lid shall be not greater than 1.0 N in the A direction.

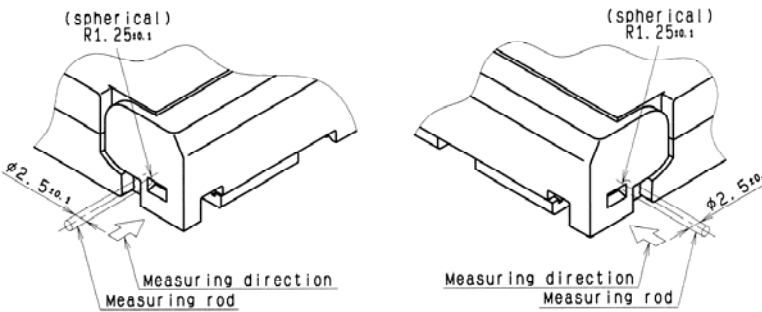
Refer to figure 21 regarding the measuring ranges.



Direction B

The force to unlock the lid shall be less than 1.5 N in the B direction.

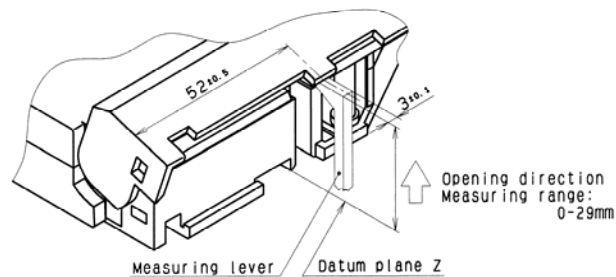
Refer to figure 21 regarding the measuring ranges.



Dimensions in millimeters

Figure 22 – Lid unlocking force (L-cassette)

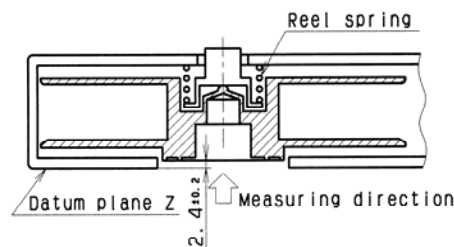
The maximum force to open the lid shall be 1.5 N.



Dimensions in millimeters

Figure 23 – Lid opening force (L-cassette)

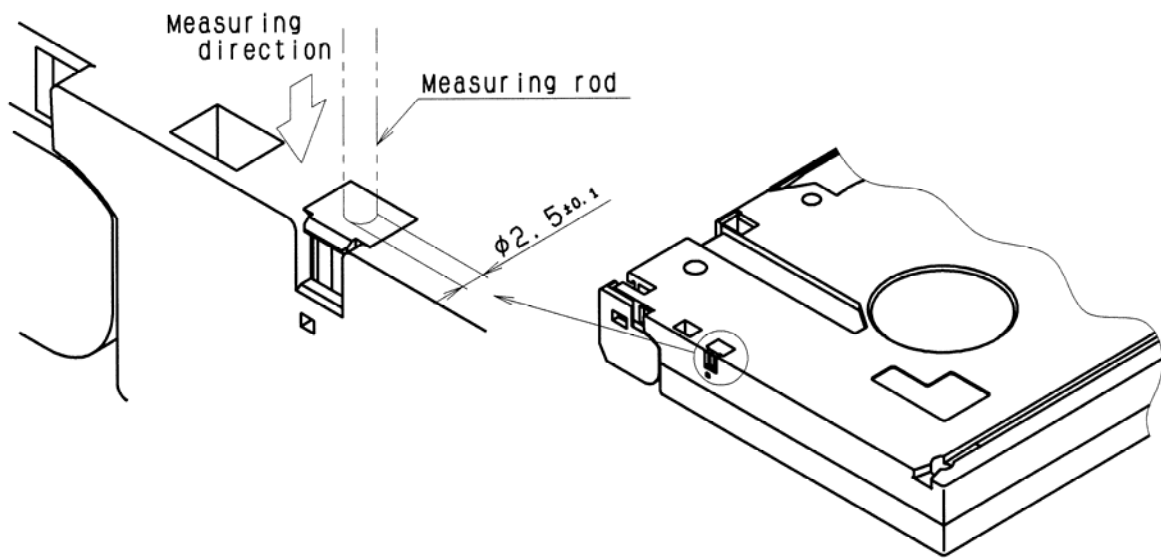
The force of the spring for pushing down the reel shall be  $(3.5 \pm 0.5)$  N.



Dimensions in millimeters

Figure 24 – Reel spring force (L-cassette)





Dimensions in millimeters

Figure 25 – Safety plug strength (L-cassette)

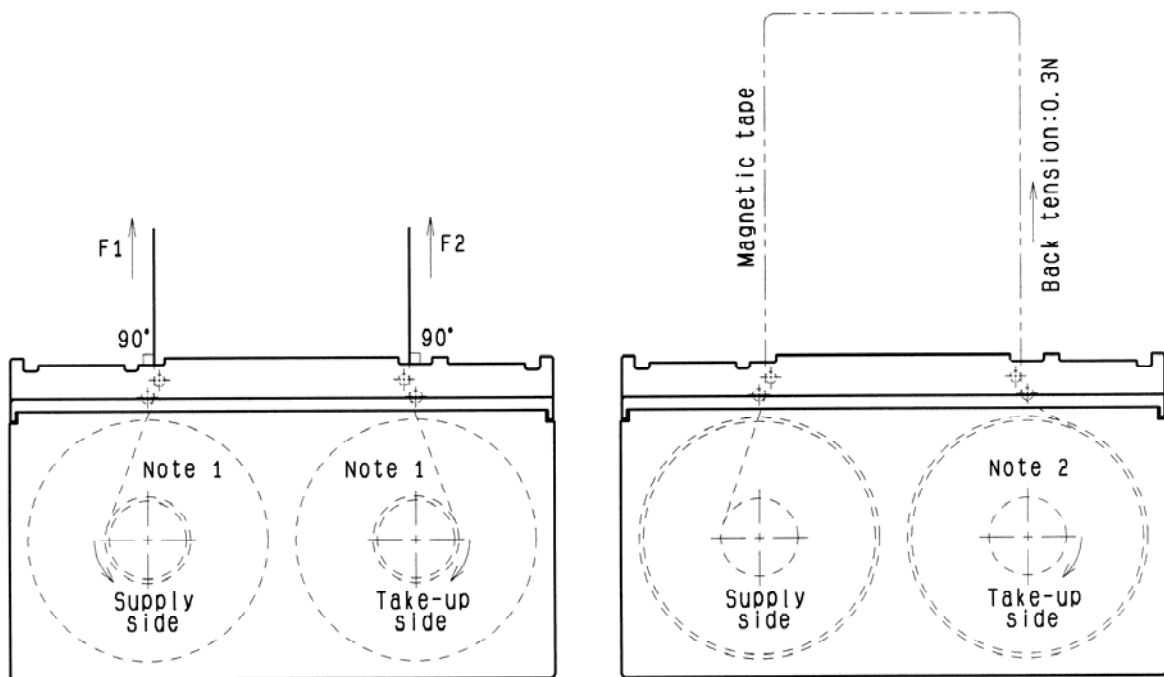


Figure 26a – Extraction force (F1, F2)

Figure 26b – Friction torque

NOTES

- 1 Holdback torque of 1 mN m.
- 2 Friction torque to wind the tape.

Figure 26 – Extraction force (F1, F2) and friction torque (L-cassette)

## 6 Tape record physical parameters

### 6.1 Tape speed

The tape speed shall be 96.7 mm/s for 29.97-Hz frame rates, 80.664 mm/s for 25-Hz frame rates, 77.437 mm/s for 24-Hz frame rates, or 77.36 mm/s for 23.98-Hz frame rates. The tape speed tolerance shall be  $\pm 0.2\%$ .

### 6.2 Helical record physical parameters

#### 6.2.1 Helical record location and dimensions

The reference edge of the tape for the dimensions specified in this standard shall be the lower edge as shown in figure 27. The magnetic coating, with the direction of tape travel as shown in figure 27, is on the side facing the observer.

The program reference point for each video frame is determined by the intersection of a line which is parallel to the reference edge of the tape at the distance Y from the reference edge and the centerline of the first track in each video frame; that is, track 0 of segment 0. The program reference point defines the start of the first video sector in the video frame.

The physical locations and dimensions of the helical recordings on the tape and their relative positions in regard to the time code start bit and the reference edge shall be as specified in figure 27 and table 1.

#### 6.2.2 Helical track record tolerance zones

The lower edges of all four consecutive tracks shall be contained within the pattern of the four tolerance zones defined in figure 28.

Each zone is defined by two parallel lines which are inclined at an angle of  $4.62644^\circ$  with respect to the tape reference edge.

The centerlines of all zones shall be spaced apart by 0.0217 mm. The width of zones 2, 3, and 4 shall be 0.008 mm. The width of zone 1 shall be 0.004 mm. These zones are established to contain track angle errors, track straightness errors, and vertical head offset tolerance.

The measuring techniques shall be as shown in IEC 61237-1 clause 7.

#### 6.2.3 Helical track gap azimuth

The azimuth angle of the head gaps used for recording the helical tracks shall be at an angle of  $\alpha_0$  or  $\alpha_1$  to the line perpendicular to the helical tracks, as specified in figure 27 and table 1.

The azimuth of the first track of every frame, that is the program reference point, shall be orientated in the counterclockwise direction with respect to the line perpendicular to the track direction when viewed from the side of the tape carrying the magnetic recording.

### 6.3 Longitudinal record physical parameters

#### 6.3.1 Longitudinal record location and dimensions

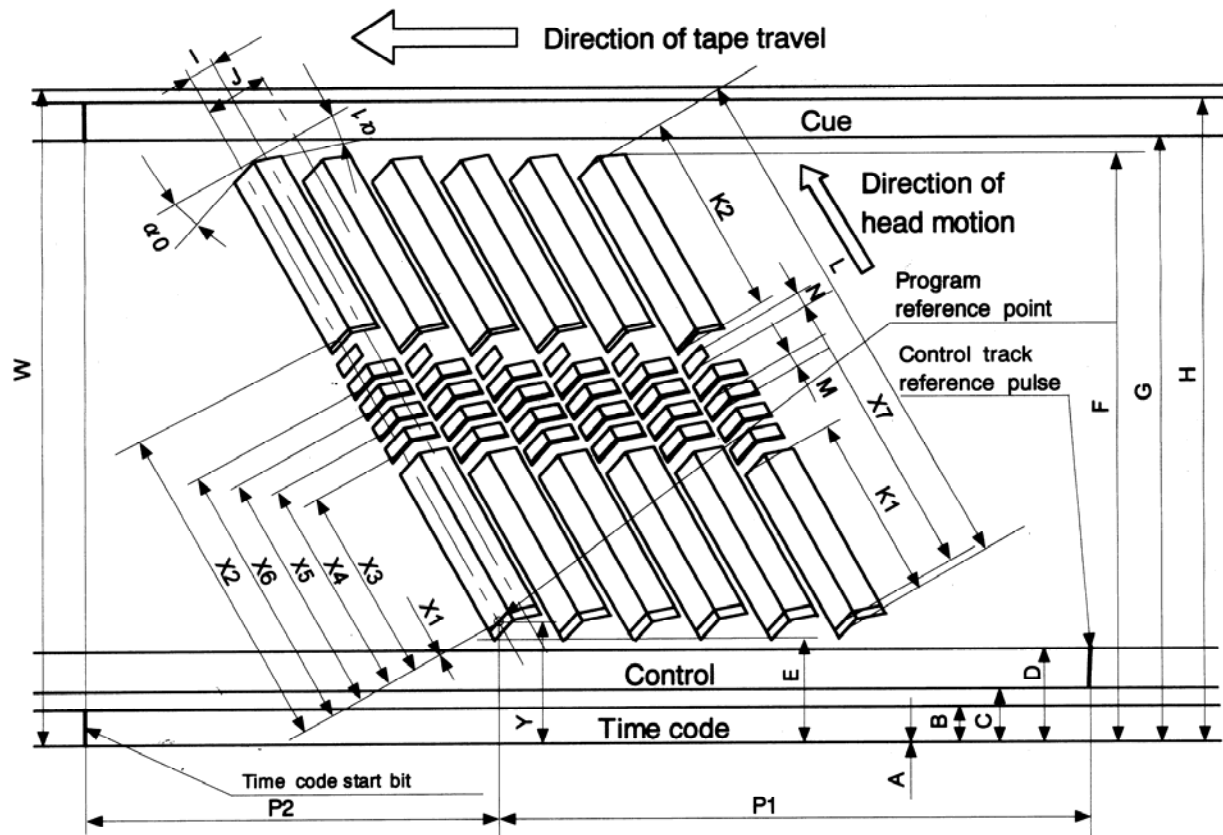
The track widths and tolerances of the cue control and time code tracks shall be as defined in figure 27 and table 1.

### 6.3.2 Longitudinal track gap azimuth

The azimuth angle of the head gaps used for recording the longitudinal tracks shall be perpendicular to the tracks.

**Table 1 - Record location and dimensions (29.97PsF/59.94I, 25PsF/50I, 24 PsF and 23.98PsF systems)**

Dimensions		Dimensions in mm	
		Nominal	Tolerance
A	Time code track lower edge	0	Basic
B	Time code track upper edge	0.4	± 0.065
C	Control track lower edge	0.7	± 0.065
D	Control track upper edge	1.1	± 0.065
E	Program area lower edge	1.388	Derived
F	Program area upper edge	11.518	Derived
G	Cue track lower edge	11.85	± 0.065
H	Cue track upper edge	12.45	± 0.065
I	Helical track pitch (± azimuth)	0.02	Ref.
J	Helical track pitch (± azimuth)	0.0434	Ref.
K1	Video sector 0 length	56.166	Derived
K2	Video sector 1 length	57.985	Derived
L	Helical track total length	125.275	Derived
M	Audio sector length	2.002	Derived
N	Tracking data area length	0.546	Derived
P1	Control track reference to program reference	47.648	± 0.1
P2	TC start bit to program reference	171.899	± 0.2
X1	Location of start of video sector 0	0	± 0.07
X2	Location of start of video sector 1	67.291	± 0.07
X3	Location of start of audio sector 0	56.833	± 0.07
X4	Location of start of audio sector 1	59.107	± 0.07
X5	Location of start of audio sector 2	61.38	± 0.07
X6	Location of start of audio sector 3	63.653	± 0.07
X7	Location of start of tracking data	66.208	± 0.07
Y	Program area reference	1.417	Basic
W	Tape width	12.65	± 0.005
Dimensions		Angles (°)	
		Nominal	Tolerance
θ	Track angle	4.62644	Basic
α0	Azimuth angle	- 15.269	± 0.17
α1	Azimuth angle	15.231	± 0.17
NOTE – The above measurements shall be made under the conditions specified in clause 4.			



NOTE – Not to scale

**Figure 27 – Locations and dimensions of recorded tracks**

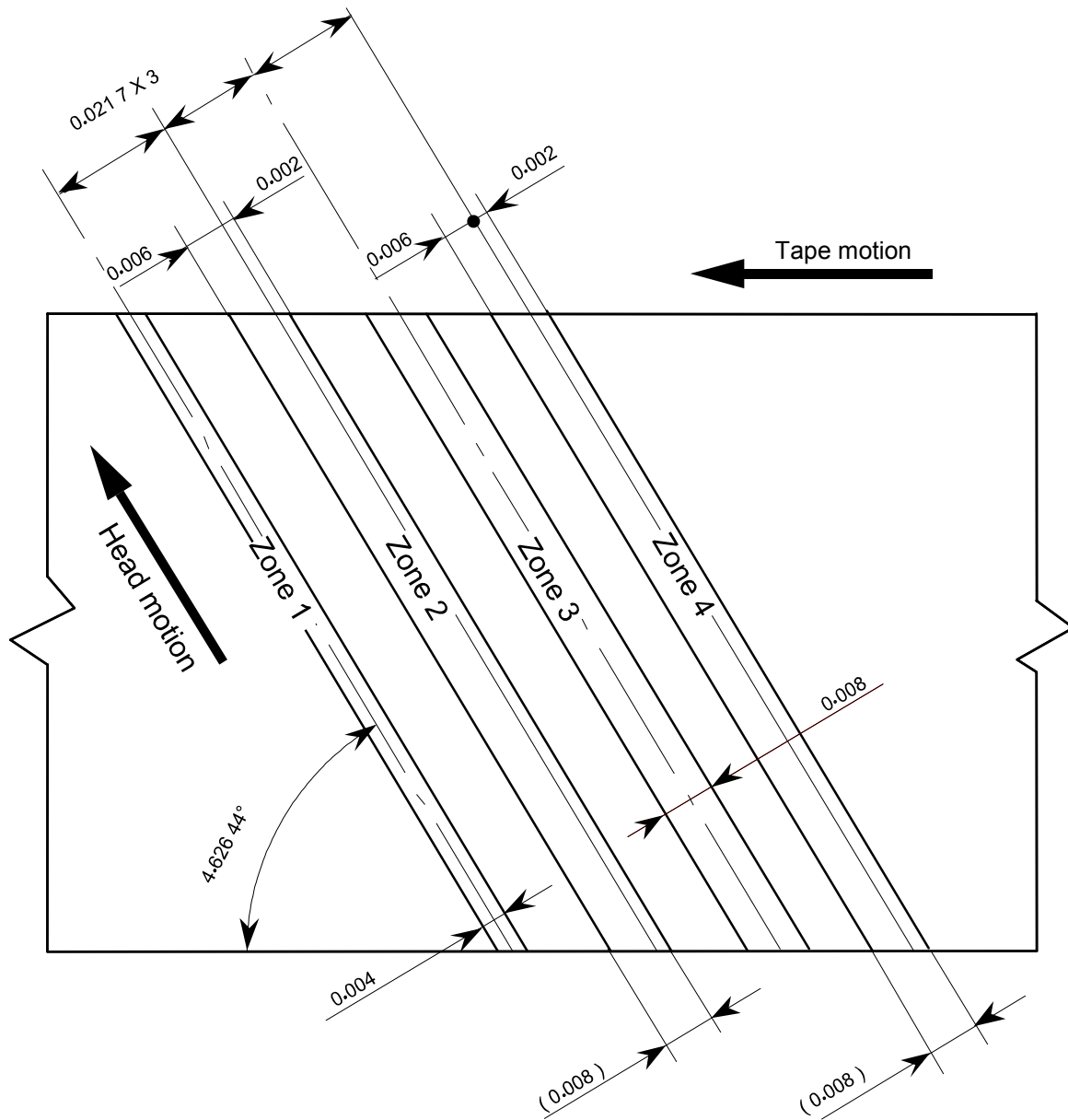


Figure 28 – Locations and dimensions of tolerance zones of helical track records

## **7 Longitudinal track signal and magnetic parameters**

### **7.1 Longitudinal track record parameters**

#### **7.1.1 Method of recording**

The control track and timecode track signals shall be recorded using the hysteretic (nonbias) recording method.

#### **7.1.2 Flux level**

The recording level shall be at saturation of the magnetic domains which is defined as that point above which 0.5 dB increase in output level results from 1 dB increase of input level as indicated on an rms. level meter.

### **7.2 Control track record parameters**

#### **7.2.1 Control track pulse period**

The control track pulse, at the point of recording, shall be a series of pulses with a period of  $16.683 \text{ ms} \pm 6 \mu\text{s}$  (for 29.97-Hz frame rates),  $20.000 \text{ ms} \pm 6 \mu\text{s}$  (for 25-Hz frame rates),  $20.833 \text{ ms} \pm 6 \mu\text{s}$  (for 24-Hz frame rates), or  $20.854 \text{ ms} \pm 6 \mu\text{s}$  (for 23.98-Hz frame rates) as shown in figure 29.

#### **7.2.2 Control track pulse definition**

The rising edge of all control track pulses should be timed to coincide with the input (reference) video.

The frame start point is defined as the midway point of the leading sync edge position which identifies the start of line 1 of the analog video signal represented by the input (reference) signal.

The control track pulses shall have nominal periods of 35T, 50T or 65T between the rising and falling edges where T is equal to 0.1668 ms (for 29.97-Hz frame rates), 0.200 ms (for 25-Hz frame rates), 0.20833 ms (for 24-Hz frame rates), or 0.20854 ms (for 23.98 Hz-frame rates) as shown in figure 29.

#### **7.2.3 Flux polarity**

The polarity of the tracking-control recording flux shall be defined by IEC 61213 clause 5 and figure 29.

### **7.3 Time and control code track record parameters**

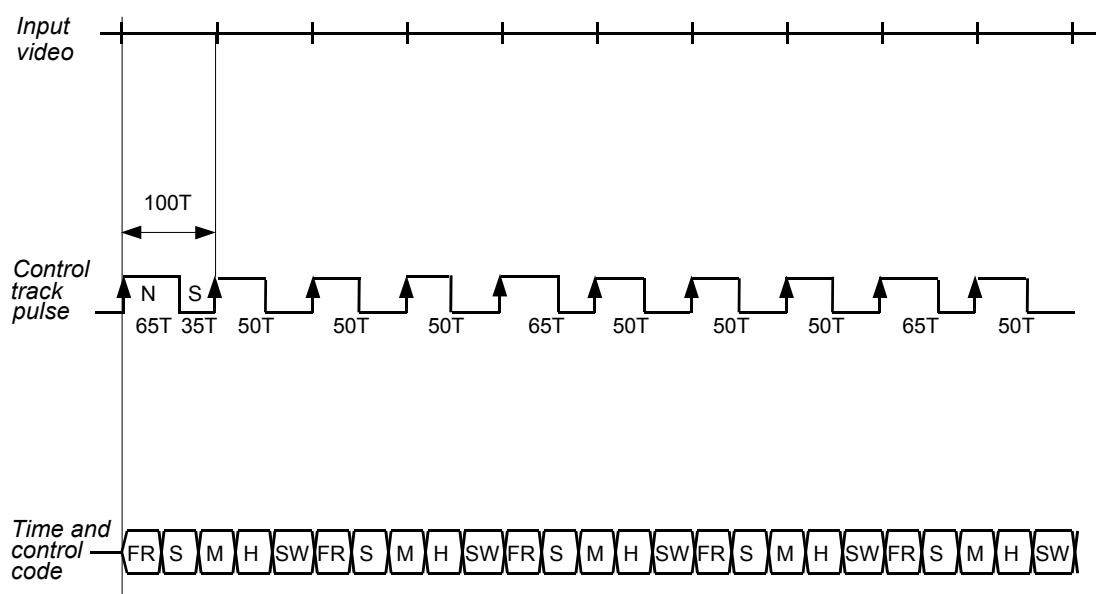
The signal format recorded on the time code track shall be in accordance with SMPTE 12M.

#### **7.3.1 Relationship to the helical track records**

The time and control code information shall refer to the video frame during which it is recorded.

#### **7.3.2 Time and control code signal timing**

An external record time and control code input that meets the specifications described in SMPTE 12M or a time and control code that is internally generated within the recorder shall be timed for recording such that the relationship between the start of address of the time and control code and the program reference point of a track with an even field address (count) for the video data is defined by figure 27 and table 1.



**Figure 29 – Recorded control code waveform**

NOTE – The following definitions are used in figure 29:

FR: frame, S: second, M: minute, H: hour, SW: sync word

## 7.4 Cue recording

### 7.4.1 Method of cue recording

The signals shall be recorded using the anhysteresis (a.c. bias recording) method.

### 7.4.2 Recording polarity

The recording polarity shall be in accordance with IEC 61213.

### 7.4.3 Flux level

The recorded reference audio level shall correspond to an rms magnetic short-circuit flux level of 125 nWb/m  $\pm$  10 nWb/m of track width at 1 kHz.

### 7.4.4 Relative timing

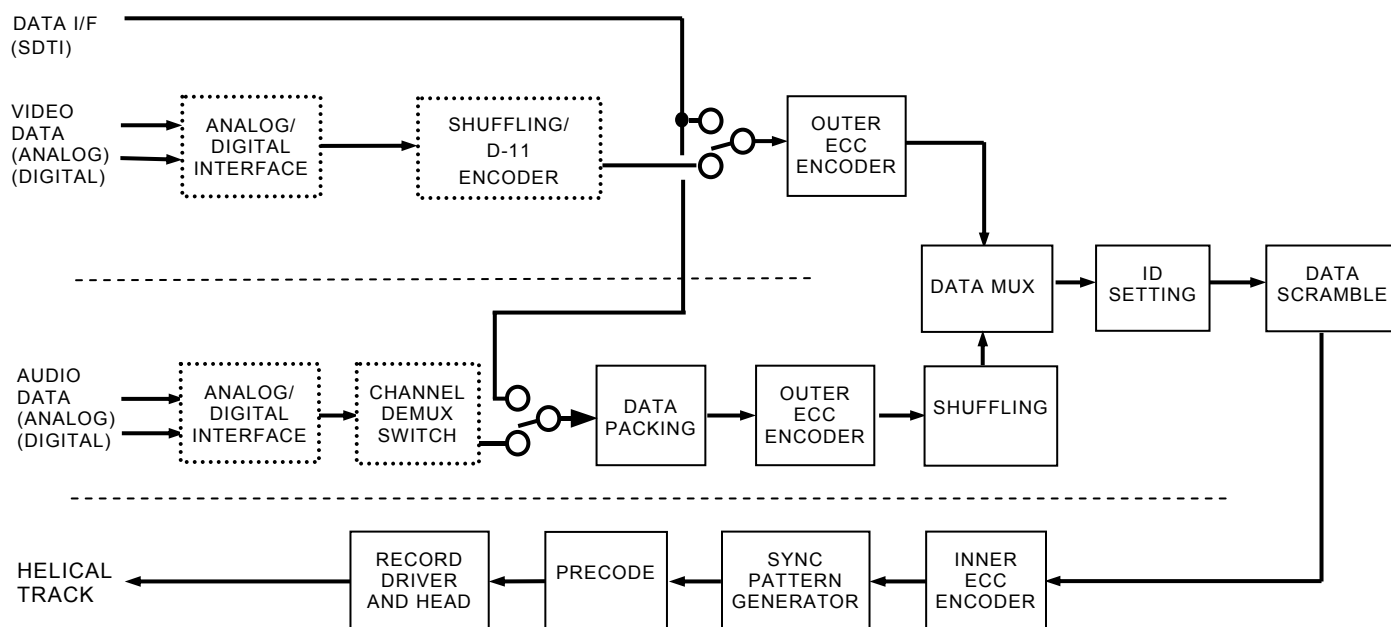
Cue information shall be recorded on the tape at a point referenced to the associated video information as defined by dimension P2 of figure 27 and table 1.

## 8 Helical track signal parameters and magnetization

This clause defines how input signal data streams comprising a type D-11 picture compression data stream and four AES3 data streams are mapped to the helical track records.

### 8.1 Introduction

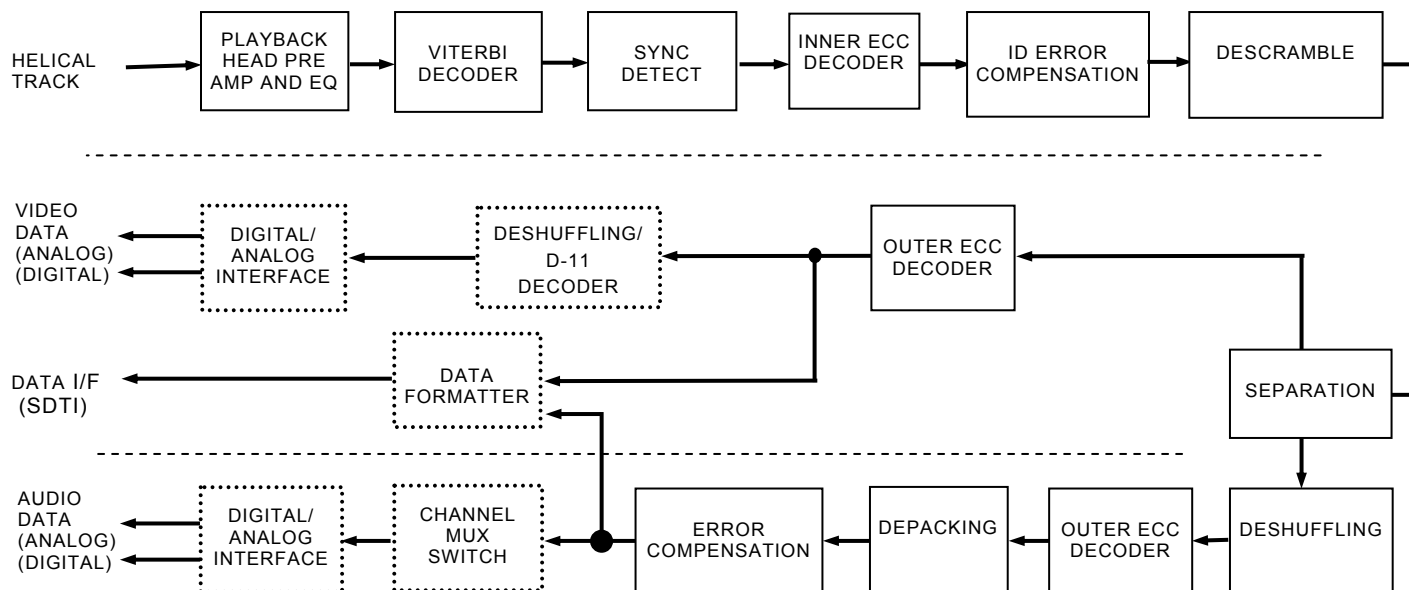
Figure 30 shows the recorder block diagram, identifying the basic schematic signal processing blocks used to map the type D-11 picture compression data and four channels of AES3 data to create the helical track data records. Figure 30 also includes a type D-11 encoder/shuffling block which is defined SMPTE 367M. The data interface is defined in SMPTE 369M.



**Figure 30 – Helical recording block diagram**

Figure 31 shows the playback block diagram, identifying the basic schematic signal processing blocks used to map the helical track records to the type D-11 compressed picture data stream and four AES3 data streams. Figure 31 also includes a type D-11 decoder/deshuffling block which is defined in SMPTE 367M. The data interface is defined in SMPTE 369M.





**Figure 31 – Helical playback block diagram**

### 8.1.1 Labelling convention

The least significant bit is shown on the left and is the first recorded to tape. The lowest numbered byte is shown at the top-left and is the first encountered in the data stream.

A suffix h indicates a hexadecimal value.

### 8.2 Helical track data parameters

The type D-11 compressed picture data is recorded onto six sequential helical track pairs together with the associated AES3 data channels and tracking data.

Each helical track is subdivided into two sectors for video data, four sectors for audio data, and one sector space for servo tracking data with edit guard bands between each sector.

The layout of the sectors and guard bands is shown in figure 27.

Each audio and video sector shall be divided into the following components:

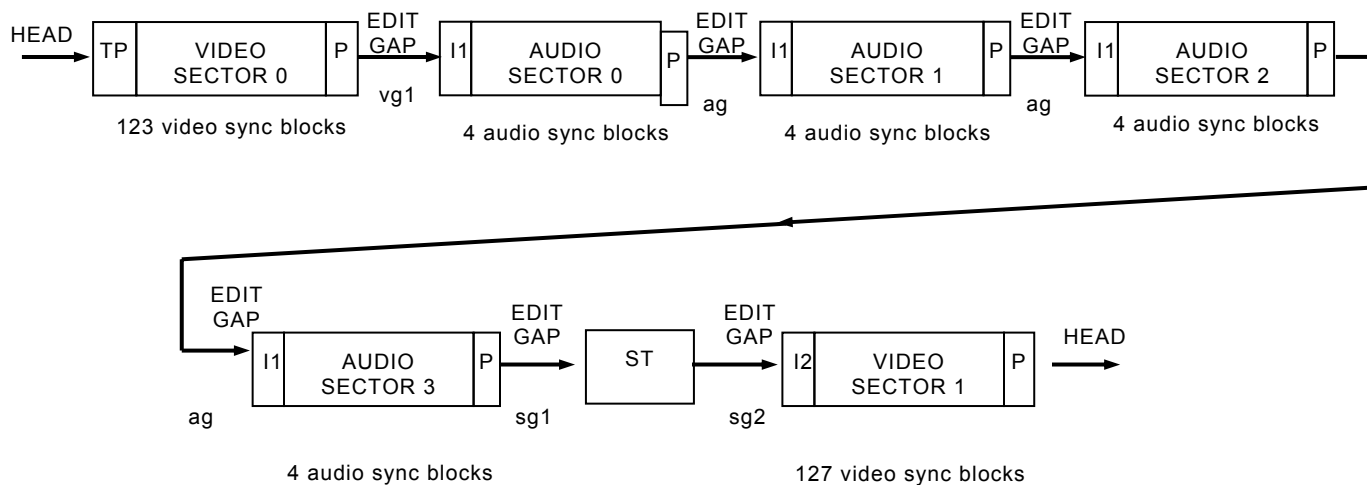
- a) A preamble containing a clock run-up sequence;
- b) A sequence of sync blocks each containing a sync pattern, an identification pattern, a fixed length data block and terminated with an error control block;
- c) A post-amble containing a sync pattern and an identification pattern.

The servo tracking sector is defined in clause 8.2.6 and occurs only on the six tracks with the same azimuth alignment as illustrated in figure 27.

### 8.2.1 Primary data components on the twelve helical tracks

Figure 32 shows the general arrangement of preambles, postambles, sync blocks, edit gaps, and the tracking data blocks (where applicable) as a group for each of the eight helical tracks.

NOTE – The ST block is only present on the six helical tracks as identified in figure 27. Figure 33 shows the specific data arrangement and data sizes.



#### NOTES

- 1 TP: Track preamble (120 bytes)
- 2 I1: In-track preamble 1 (60 bytes)
- 3 I2: In-track preamble 2 (120 bytes)
- 4 P: Postamble (4 bytes)
- 5 vg1: P + edit gap + I 1 (466 bytes)
- 6 vg2: P + edit gap + I 1
- 7 ag: P + edit gap + I 2 (233 bytes)
- 8 sg1: P + edit gap (377 bytes)
- 9 sg2: edit gap + I 1 (273 bytes)
- 10 Video sync block 233 bytes
- 11 Audio sync block 233 bytes
- 12 ST: Servo tracking data (280 bytes)

**Figure 32 – Sector arrangement on helical track**

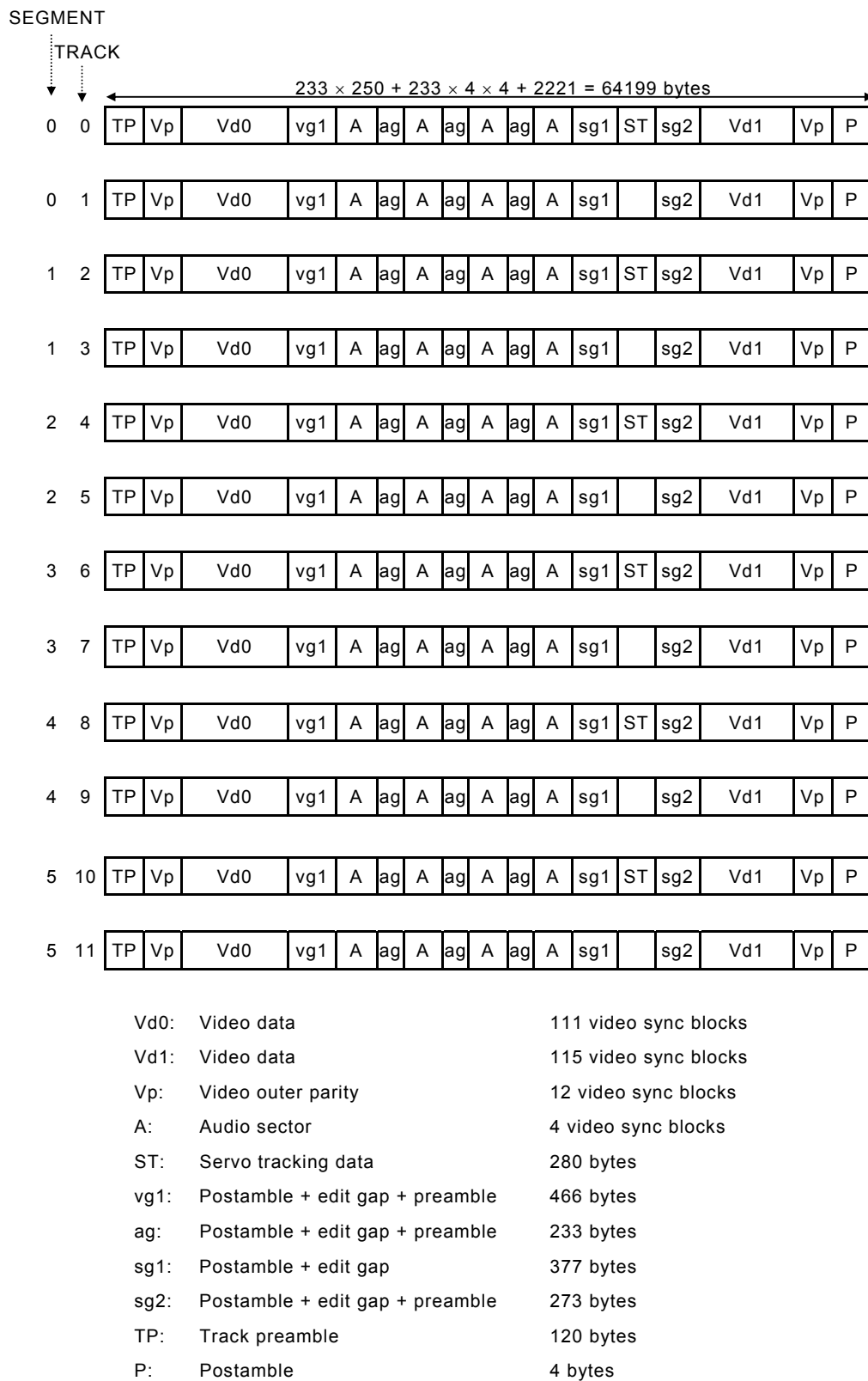


Figure 33 – Sector and segment arrangement on helical track

8.2.2 Segment specification

8.2.2.1 Video sync blocks

The type D-11 picture compression and data stream format provides compressed picture basic blocks and auxiliary basic blocks which shall be mapped into video sync blocks.

Segments 0 to 5 of the type D-11 picture compression and data stream format shall be mapped to Segments 0 to 5 respectively as shown in figure 33.

Channel 0 data from the type D-11 picture compression and data stream format shall be mapped to even-numbered tracks in figure 33 (tracks 0, 2, 4, 6, 8, and 10).

Channel 1 data from the type D-11 picture compression and data stream format shall be mapped to odd-numbered tracks in figure 33 (tracks 1, 3, 5, 7, 9, and 11).

Each basic block specified in SMPTE xxxM shall be mapped into bytes 2 to 220 of a video sync block as defined in figure 34. The value of byte 2 ( $ID_0$ ) is modified according to the algorithm specified in 8.2.2.3.

For each track, the auxiliary basic block and the compressed picture basic blocks numbered 0 to 224 inclusive, specified in SMPTE xxxM, shall be mapped into the video sync blocks numbered according to the algorithm specified in 8.2.3.3.

Every sync block shall contain a sync identification pattern of 2 bytes, 217 bytes of data, and an inner check code of 12 bytes.

In audio sync blocks only, bytes in locations 212 to 220 inclusive shall be set to the value of 0.

Figures 34 and 35 show the sync block format for, respectively, video sync blocks and audio sync blocks.

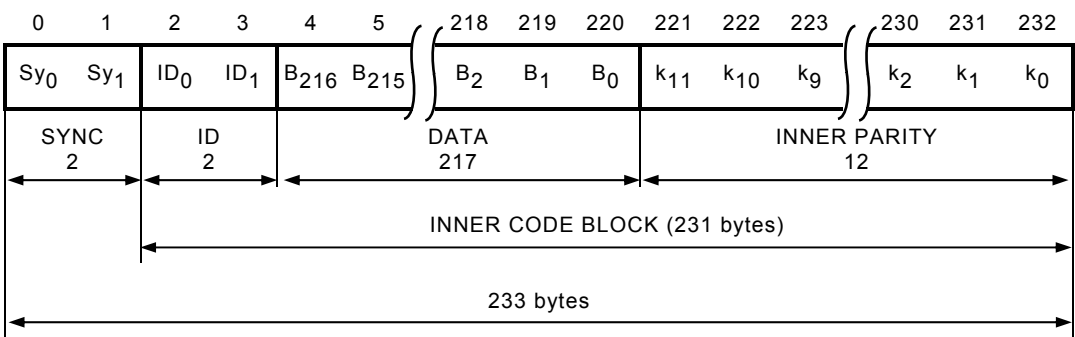


Figure 34 – Video sync block format

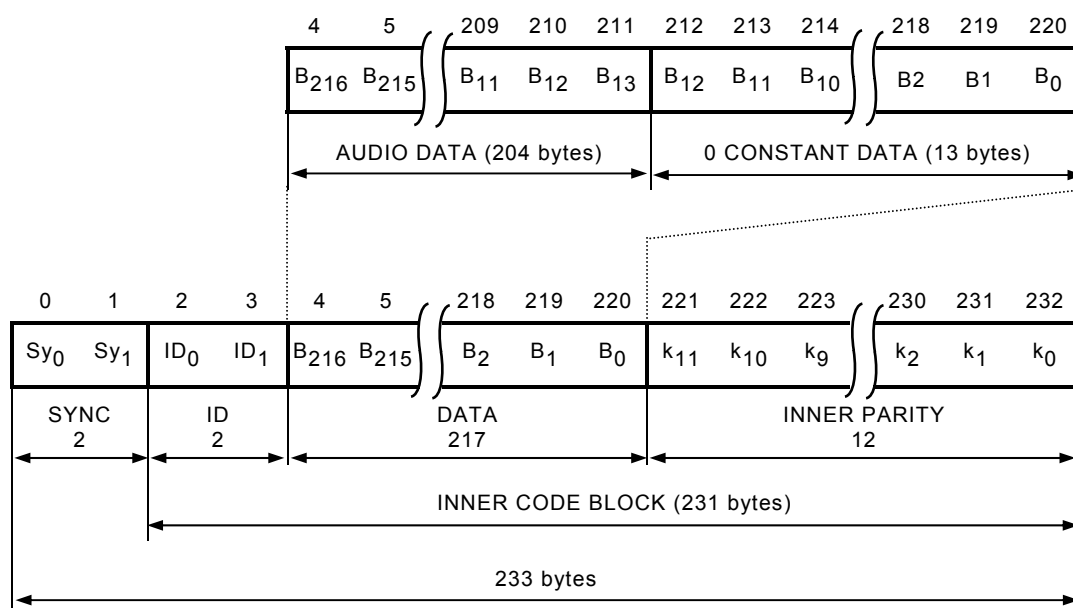


Figure 35 – Audio sync block format

### 8.2.2.2 Sync pattern

The length of the sync pattern shall be 2 bytes. The byte values shall be 2Eh and D3h leading to the bit sequence as shown below.

		MSB							
Byte 0 (Sy0)	0	1	2	3	4	5	6	7	
	0	1	1	1	0	1	0	0	
		LSB							

		MSB							
Byte 1 (Sy1)	0	1	2	3	4	5	6	7	
	1	1	0	0	1	0	1	1	
		LSB							

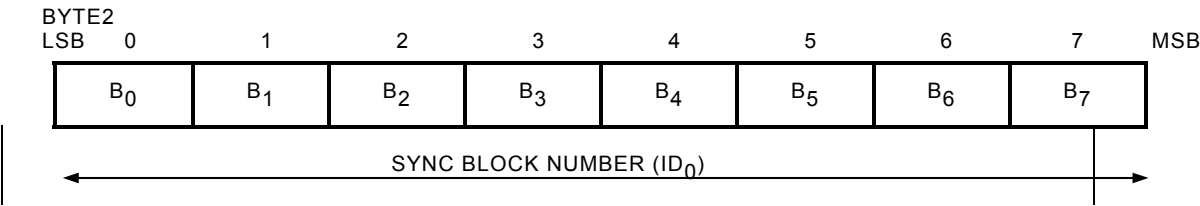
### 8.2.2.3 Sync block identification pattern

The length of the sync block identification (ID) pattern shall be 2 bytes.

NOTE – The ID pattern for video sync blocks is initialized to be the same as the BID pattern for basic blocks defined in SMPTE 367M. However, the value of the first byte of the BID is modified by the algorithm defined in this clause.

The first byte of the ID (ID<sub>0</sub>) shall be used to identify uniquely every sync block within each helical track. The second byte of the ID (ID<sub>1</sub>) shall be used to identify the sector type, channel and segment numbers. Figure 36 shows the pattern of the sync block identification.

SYNC BLOCK NUMBER (ID<sub>0</sub>)



SECTOR ID SYNC BLOCKS (ID<sub>1</sub>)

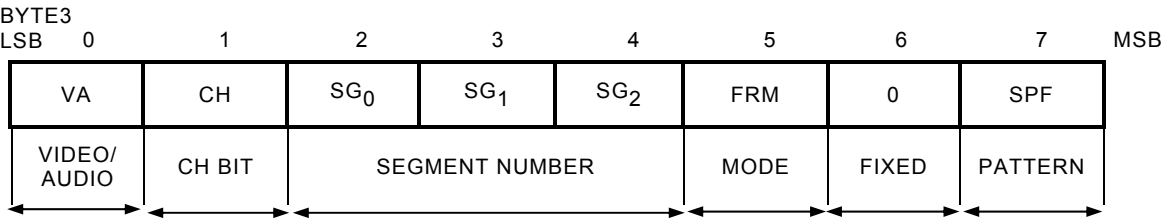
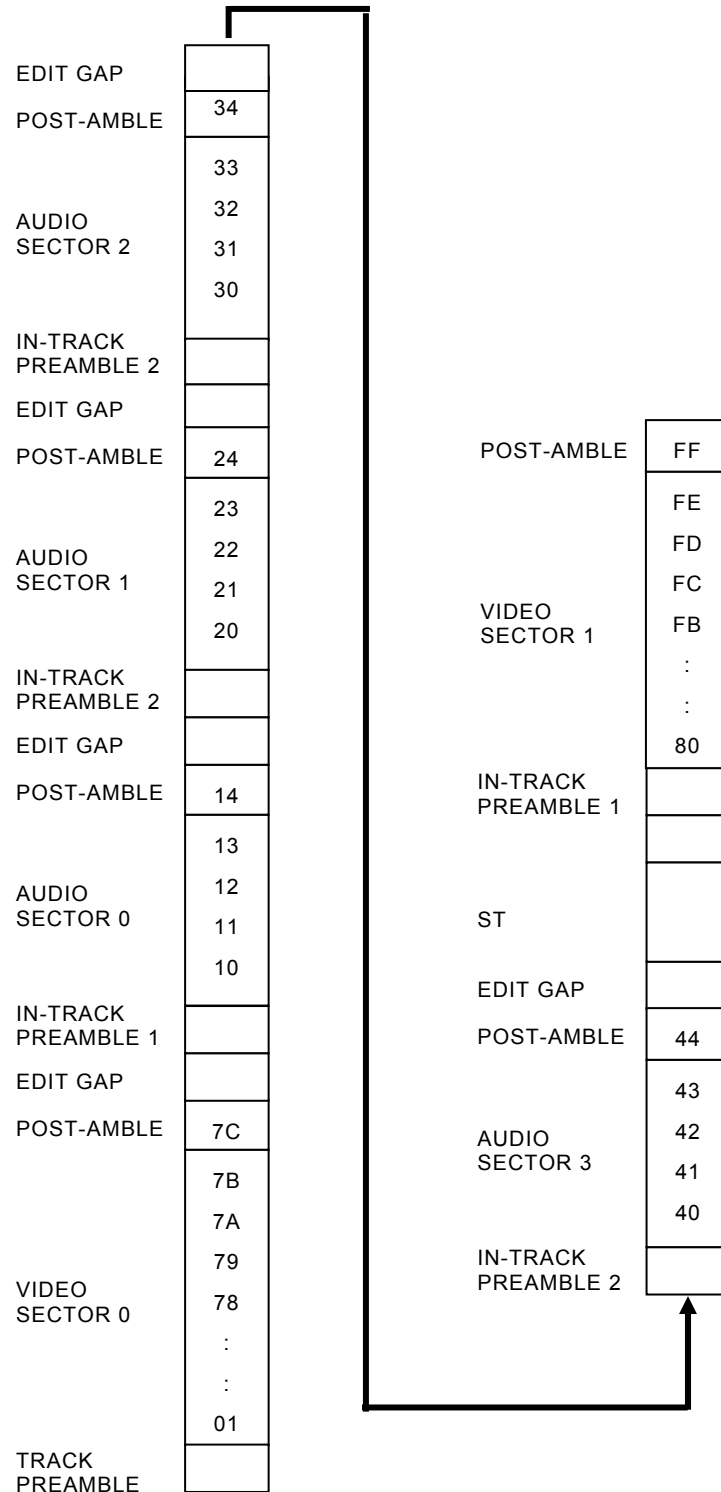


Figure 36 – Sync block identification bytes

The first sync block ID byte (ID<sub>0</sub>) follows a coded sequence, as shown in figure 37 and syntax of the ID<sub>0</sub>. The last ID<sub>0</sub> code of each sector shall be reserved for postamble identification.

Syntax of the ID<sub>0</sub> algorithm for video sync blocks

ID <sub>0</sub> Syntax	Comment
<pre>{   for(Segment=0; Segment&lt;6; Segment++)   {     for(BID<sub>0</sub>=0; BID<sub>0</sub>&lt;256; BID<sub>0</sub>++)     {       if (Segment mod 2)       {         if (BID<sub>0</sub>=255)           ID<sub>0</sub>=13;         else if (BID<sub>0</sub>&gt;=110)           ID<sub>0</sub>= BID<sub>0</sub>+18;         else           ID<sub>0</sub>= BID<sub>0</sub>+14;       }       else       {         if (BID<sub>0</sub>=255)           ID<sub>0</sub>=123;         else if (BID<sub>0</sub>&gt;=110)           ID<sub>0</sub>= BID<sub>0</sub>+18;         else           ID<sub>0</sub>= BID<sub>0</sub>+13;       }     }   } }</pre>	<p>Odd segments Auxiliary sync block</p> <p>Even segments Auxiliary sync block</p>

Figure 37 – ID<sub>0</sub>: Sync block number

**Table 2 - ID<sub>0</sub>: Sync block number**

Sector	Sync block number
Video sector V0	01 <sub>h</sub> to 7B <sub>h</sub>
Video sector V1	80 <sub>h</sub> to fE <sub>h</sub>
Audio sector A0	10 <sub>h</sub> to 13 <sub>h</sub>
Audio sector A1	20 <sub>h</sub> to 23 <sub>h</sub>
Audio sector A2	30 <sub>h</sub> to 33 <sub>h</sub>
Audio sector A3	40 <sub>h</sub> to 43 <sub>h</sub>

The second sync ID byte (ID<sub>1</sub>) shall be used to define several data fields as shown in figure 36.

- The VA bit shall be used to distinguish between audio ( = 1 ) and video ( = 0 ) sectors.

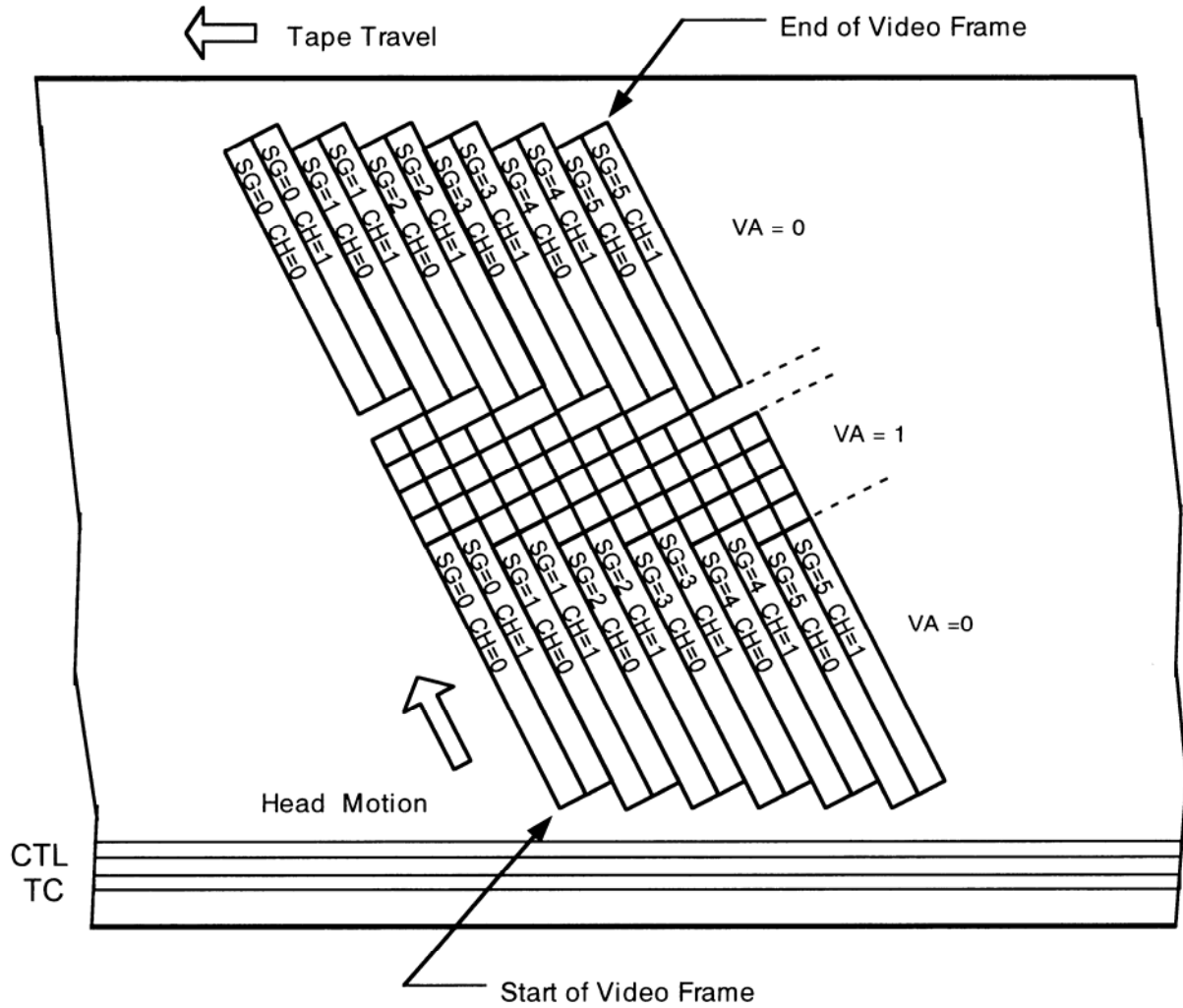
The remaining bits of the second sync ID byte (ID<sub>1</sub>) as shown in figure 36 shall be as defined by BID<sub>1</sub> in SMPTE 367. For information, these bits are described as follows:

- The CH bit is used to distinguish between the two data channels corresponding to channel 0 and channel 1.
- The SG bits (SG0, SG1, SG2) are used to identify among six segments corresponding to segment 0, 1, 2, 3, 4, and 5. The bit assignments for each segment are defined as follows:

	SG0	SG1	SG2
Segment 0:	0	0	0
Segment 1:	1	0	0
Segment 2:	0	1	0
Segment 3:	1	1	0
Segment 4:	0	0	1
Segment 5:	1	0	1

- Bit 5 defines frame mode if set to 1 and field mode if set to 0.
- Bit 6 has a fixed value of 0.
- Bit 7 defines the shuffle pattern flag (SPF).





	Frame											
SG (Segment) :	0	0	1	1	2	2	3	3	4	4	5	5
CH (CH bit) :	0	1	0	1	0	1	0	1	0	1	0	1
Track :	0	1	2	3	4	5	6	7	8	9	10	11

Figure 38 – Segment, channel and track counts

### 8.2.2.4 Data scrambling

Data shall be scrambled before generation of inner ECC as shown in figure 30 by the field generator polynomial:

$$X^8 + X^4 + X^3 + X^2 + 1 \quad \text{Seed: } ID_0 \quad \text{Start: } B_{216}$$

The first term is the most significant and first to enter the division computation.

NOTE – The value of  $ID_0$  is loaded into the scrambler at the timing point defined by the location of the  $B_{216}$  word as identified in figure 34. Thus the  $B_{216}$  word carries the  $ID_0$  value as a seed to preset the field generator polynomial with a unique value for each sync block.

### 8.2.2.5 Inner ECC calculation

Inner ECC blocks are defined as sync blocks without the 2-byte sync pattern. Each inner ECC block is 231 bytes in length with the last 12 bytes forming the inner ECC.

The data content of inner ECC blocks shall be scrambled before generation of the inner ECC, as defined in clause 8.2.2.4.

The inner ECC shall be of the Reed-Solomon (RS) type having 12 check words placed at the end of each Inner ECC block. Details of the RS code common to all inner ECC blocks shall be as follows:

Galois Field: GF(256)

Field generator polynomial:  $X^8 + X^4 + X^3 + X^2 + 1$ ,

- where  $X^i$  are place-keeping variables in GF(2), the binary field. Note that the + sign indicates modulo binary addition.

The code generator polynomial (GF(256)) is defined as:

$$G(X) = (X + \alpha^0)(X + \alpha^1)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)(X + \alpha^8)(X + \alpha^9)(X + \alpha^{10})(X + \alpha^{11})$$

where  $\alpha$  is given by 02h in GF(256). Note that the '+' sign for this and the following equations indicates modulo 256 addition.

The RS check characters are defined as:

$K_{11}, K_{10}, K_9, K_8, K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$  in

$$K_{11}X^{11} + K_{10}X^{10} + K_9X^9 + K_8X^8 + K_7X^7 + K_6X^6 + K_5X^5 + K_4X^4 + K_3X^3 + K_2X^2 + K_1X^1 + K_0$$

obtained as the remainder after dividing the polynomial  $X^{12}D(X)$  by  $G(x)$ , where  $K_i$  are bit-inverted words of the ECC words,  $k_i$ , shown in figures 34 and 35, and  $D(X)$  is the polynomial given by:

a) for video sync blocks:

$$D(X) = ID_0X^{218} + ID_1X^{217} + B_{216}X^{216} + B_{215}X^{215} + B_{214}X^{214} + \dots + B_2X^2 + B_1X^1 + B_0$$

b) for audio sync blocks:

$$D(X) = ID_0X^{218} + ID_1X^{217} + B_{216}X^{216} + B_{215}X^{215} + \dots + B_2X^2 + B_1X^1 + B_0$$

The polynomial full code is defined as:

c) for video sync blocks:

$$ID_0X^{230} + ID_1X^{229} + B_{216}X^{228} + B_{215}X^{227} + \dots + B_2X^{14} + B_1X^{13} + B_0X^{12} + K_{11}X^{11} + K_{10}X^{10} \\ + \dots + K_2X^2 + K_1X^1 + K_0 \equiv 0 \pmod{G(X)}$$

d) for audio sync blocks:

$$ID_0X^{230} + ID_1X^{229} + B_{216}X^{228} + B_{215}X^{227} + \dots + B_2X^{14} + B_1X^{13} + B_0X^{12} + K_{11}X^{11} + K_{10}X^{10} \\ + \dots + K_2X^2 + K_1X^1 + K_0 \equiv 0 \pmod{G(X)}$$

### 8.2.3 Sector preamble

All sectors shall be preceded by data bytes having a value of  $FF_h$ .

NOTE – This value is converted to a sector preamble having a value of  $CC_h$  by the channel coding described in 8.3. This preamble provides a clock run-in sequence.

The preamble which precedes a video sector or the first audio sector in a track shall be 120 bytes long.

The preamble that precedes either the second, the third, or the fourth audio sector in a track shall be 80 bytes long.

#### 8.2.3.1 Track preamble

A track preamble (TP) immediately precedes the first video data sector of every track. The length is 120 bytes.

#### 8.2.3.2 In-track preambles types 1 and 2

An in-track preamble type 1 shall precede the first and fifth audio sectors. The total length shall be 60 bytes long.

An in-track preamble type 2 shall precede the second video sector of every track. The total length shall be 120 bytes long.

### 8.2.4 Sector postamble

All sectors are followed by a postamble, the length of which shall be 4 bytes. Each postamble shall consist of a 2-byte sync pattern and a 2-byte identification pattern.

### 8.2.5 Edit gap

The space between sectors on a track, exclusive of postamble and preamble is used to accommodate timing errors during editing. In an original recording the edit gap shall contain the pattern  $CC_h$  after channel coding. The length of the edit gap varies according to the position on the track.

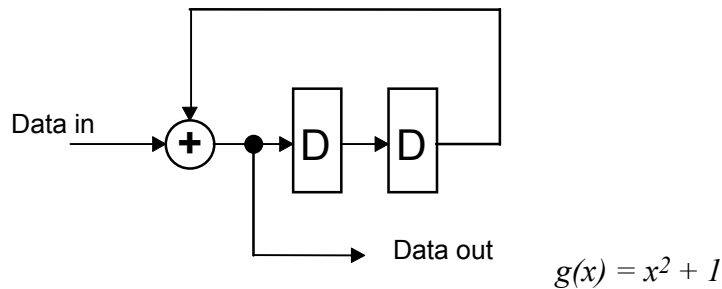
### 8.2.6 Tracking servo signal

Two kinds of tracking servo signals shall be recorded on the helical tracks. Both signals shall be recorded between the fourth audio and second video sectors on azimuth  $\alpha_0$  track as indicated in figure 27, table 1 and figure 32. One signal is a rectangular waveform with an eighth of the Nyquist frequency for track 0 of segment 0, 2, and 4. The frequency of this signal is 5.87 MHz for 29.97/PsF & 59.94I frame rates, 4.89 MHz for 25/PsF and 50/I frame rates, and 4.69 MHz for 23.98/PsF and 24/PsF frame rates. The other signal is a rectangular waveform with an eightieth of the Nyquist frequency for track 0 of segments 1, 3, and 5. The frequency of this signal is 587 KHz for 29.97/PsF and 59.94I frame rates, 489 KHz for 25/PsF and 50/I frame rates, and 469 KHz for 23.98/PsF and 24/PsF frame rates.

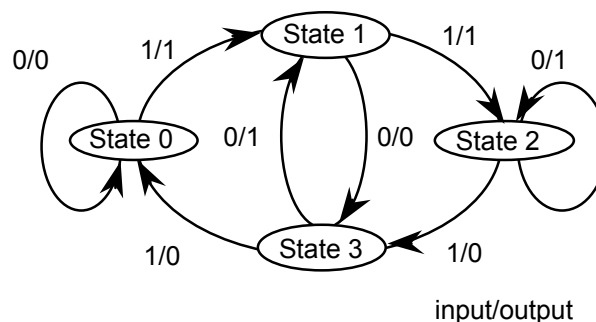
### 8.3 Channel coding

The channel code shall be scrambled I-NRZI modulation code, and partial response class IV precoding shall be employed.

- a) The scrambled, ECC encoded and sync pattern generated data shall be precoded as shown in figure 30. The precoding is established by the polynomial generator  $g(x) = x^2 + 1$  as shown below:



- b) The state transition diagram of I-NRZI is as shown below:



- c) The LSB shall be written first to tape.

### 8.4 Magnetization

#### 8.4.1 Polarity

The channel coding ensures that the recorded flux on the helical tracks is polarity insensitive. Therefore, the flux polarity is not specified.

#### 8.4.2 Record level

The level of the recording current applied to the head of a channel shall be optimized for the best signal-to-noise ratio in reproduction in the range from half the Nyquist frequency to the Nyquist frequency.

#### 8.4.3 Record equalization

The frequency characteristics of the recording current applied to the head shall be such that the Nyquist frequency is emphasized by 3 dB with reference to the response at 1 MHz which is very low frequency compared with the Nyquist frequency.

### 8.5 Video data outer correction

The parameters for the video outer error correction code (ECC) are defined in this clause.

The outer ECC shall be of the Reed-Solomon (RS) type having 24 check bytes placed at the end of each group of 226 video data bytes.

Details of the RS code common to all outer ECC blocks shall be as follows:

Galois Field: GF(256)

Field generator polynomial:  $X^8 + X^4 + X^3 + X^2 + 1$ ,

- where  $X^i$  are place-keeping variables in GF(2), the binary field. Note that the + sign indicates modulo binary addition.

The code generator polynomial (GF(256)) is defined as:

$$G(X) = (X + \alpha^0)(X + \alpha^1)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)(X + \alpha^8)(X + \alpha^9)(X + \alpha^{10})(X + \alpha^{11})(X + \alpha^{12})(X + \alpha^{13})(X + \alpha^{14})(X + \alpha^{15})(X + \alpha^{16})(X + \alpha^{17})(X + \alpha^{18})(X + \alpha^{19})(X + \alpha^{20})(X + \alpha^{21})(X + \alpha^{22})(X + \alpha^{23})$$

where  $\alpha$  is given by  $02_n$  in GF(256). Note that the + sign for this and the following equations indicates modulo 256 addition.

The check characters are defined as:

$P_{23}, P_{22}, P_{21}, P_{20}, P_{19}, P_{18}, P_{17}, P_{16}, P_{15}, P_{14}, P_{13}, P_{12}, P_{11}, P_{10}, P_9, P_8, P_7, P_6, P_5, P_4, P_3, P_2, P_1, P_0$  in

$$P_{23}X^{23} + P_{22}X^{22} + P_{21}X^{21} + P_{20}X^{20} + P_{19}X^{19} + P_{18}X^{18} + P_{17}X^{17} + P_{16}X^{16} + P_{15}X^{15} + P_{14}X^{14} + P_{13}X^{13} + P_{12}X^{12} + P_{11}X^{11} + P_{10}X^{10} + P_9X^9 + P_8X^8 + P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0$$

obtained as the remainder after dividing the polynomial  $X^{24}D(X)$  by  $G(x)$ , where  $P_i$  are bit-inverted words of  $P_{Vi}$  shown in figure 39, and  $D(X)$  is the polynomial given by:

$$D(X) = D_{225}X^{225} + D_{224}X^{224} + D_{223}X^{223} + D_{222}X^{222} + \dots + D_2X^2 + D_1X^1 + D_0$$

The polynomial full code is defined as:

$$D_{225}X^{249} + D_{224}X^{248} + D_{223}X^{247} + \dots + D_1X^{25} + D_0X^{24} + P_{23}X^{23} + P_{22}X^{22} + P_{21}X^{21} + P_{20}X^{20} + \dots + P_9X^9 + P_8X^8 + P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0 \equiv 0 \pmod{G(X)}$$

The distribution of data for each outer error correction code shall be as shown in figure 39.

There are 12 outer ECC blocks per frame where each outer ECC block comprises 250 video data sync blocks which shall be organized as shown in figure 39. The horizontal axis is aligned with the basic block data and the vertical axis is aligned with the outer error correction code.

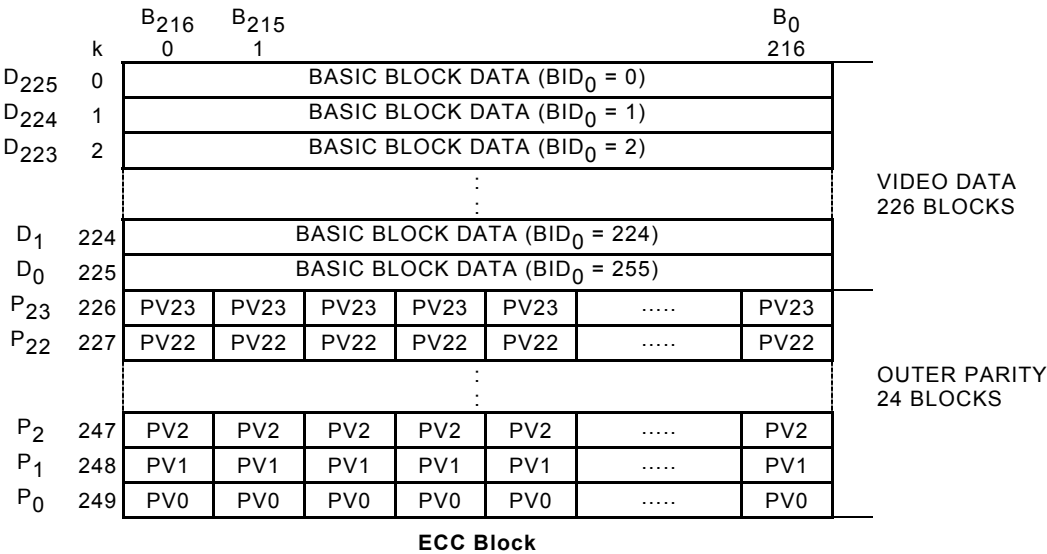


Figure 39 – Video outer ECC

The algorithm for determining the video sync block address (ID<sub>0</sub>) is defined in 8.2.2.3. The ID<sub>0</sub> of outer parity sync blocks shall be as follows:

```
Outer parity syntax
{
  for(k=226; k<250; k++)
  {
    if(k<238)
      ID0=k-225;
    else
      ID0= k+5;
  }
}
```

8.6 Data arrangement in audio data sectors

8.6.1 General

The type D-11 tape format shall provide the capability of recording four channels of AES3 data at 20 bits resolution. Each channel shall be independently editable through assignment to defined audio sectors on the tape. The encoding process is common to all channels except for the recorded position on the tape and the audio sync block identification pattern (ID<sub>0</sub>/ID<sub>1</sub>). The format also provides the capability of recording nonaudio data in some applications.

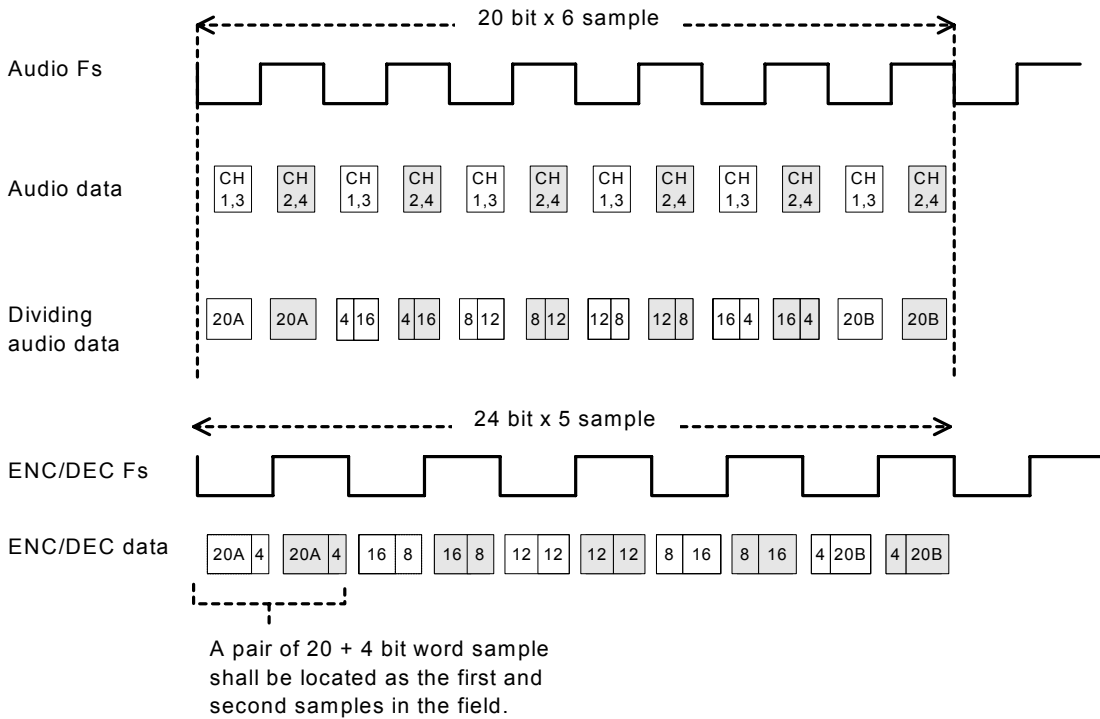
8.6.1.1 Sampling clock

The sample clock frequency of the AES3 data shall be 48 KHz and synchronized to the video frame rate.

8.6.2 AES3 bit packing

The type D-11 format records 1600 words of 24-bits per word for each frame.

At frame rates below 29.97 Hz, the sample resolution is limited to 20 bits per word. Starting at the first 20-bit word of the frame, groups of six 20-bit words are mapped into groups of five 24-bit words. This process maps MSB first so that the MSB of the first 20-bit word in a group is mapped to the MSB of the first 24-bit word. This process is performed for all groups in a frame. The number of data samples in each frame allows an integer number of such groups.



**Figure 40 – 20/24 bit packing sequence**

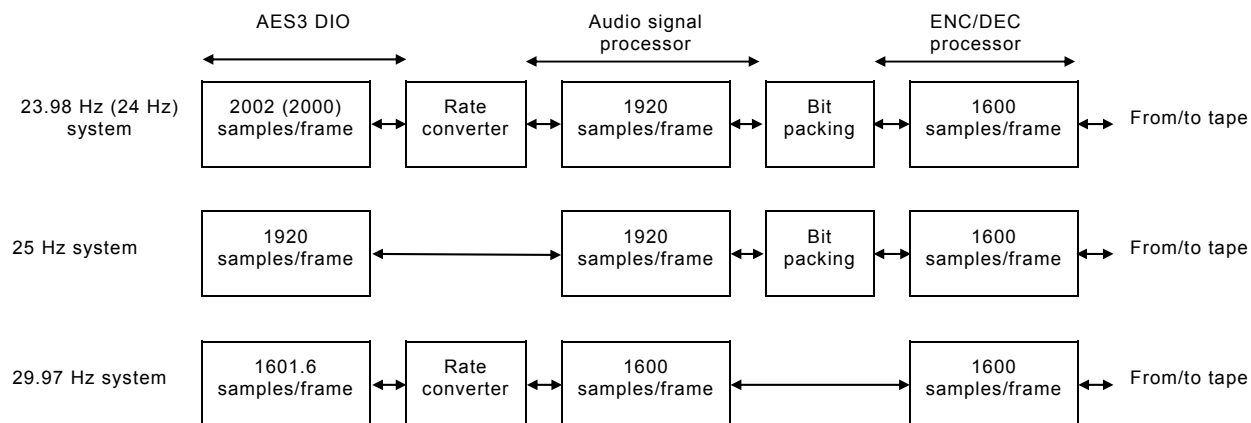
### 8.6.3 Audio processing mode

The type D-11 tape format provides three kinds of audio processing mode. The audio processing modes are identified by setting the AUX 3 bits as shown in figure 44.

#### (1) Normal audio mode

The normal audio mode provides the capability of recording 20 bits resolution audio data. The sample clock frequency of AES3 input and output (DIO) shall be 48 KHz and shall be synchronized to the video frame.

The internal sampling frequency for use on tape is based on a frame rate of 30-Hz having 1600 samples per frame at a resolution of 24 bits per sample. Figure 41 shows the sampling conversion processes for each video frame rate and 20/24 bit packing through the AES3 interface to the ENC/DEC processor.



**Figure 41 – Audio sample conversion block diagram**

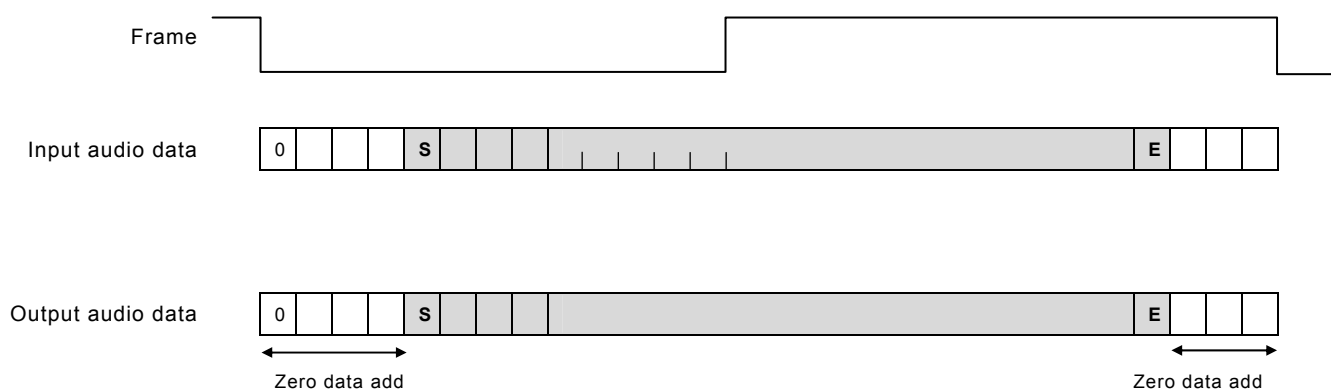
## (2) Burst data mode

The burst data mode provides the capability to record 20-bit samples, which are time-constrained to begin at a defined point after the source picture frame start and to finish at a defined point before the source picture frame end. Figure 42 shows the start and end sample numbers for each frame system in relation to the input (reference) video.

In burst data mode, the rate converter shall be disabled.

Output data shall contain the same number and location of zero data samples as present at the input.





Frame frequency	S	E
23.98 Hz	42	1961
24 Hz	40	1959
25 Hz	0	1919
29.97 Hz	0	1599

NOTE – S: Start sample number of record/playback data

E: End sample number of record/playback data

**Figure 42 – Start and end sample number of burst data mode**

### (3) Continuous data mode

In this mode, the rate converter shall be disabled.

Continuous data mode provides the capability of recording the upper 16 bits of data from each source sample word as shown in the upper part of figure 43.

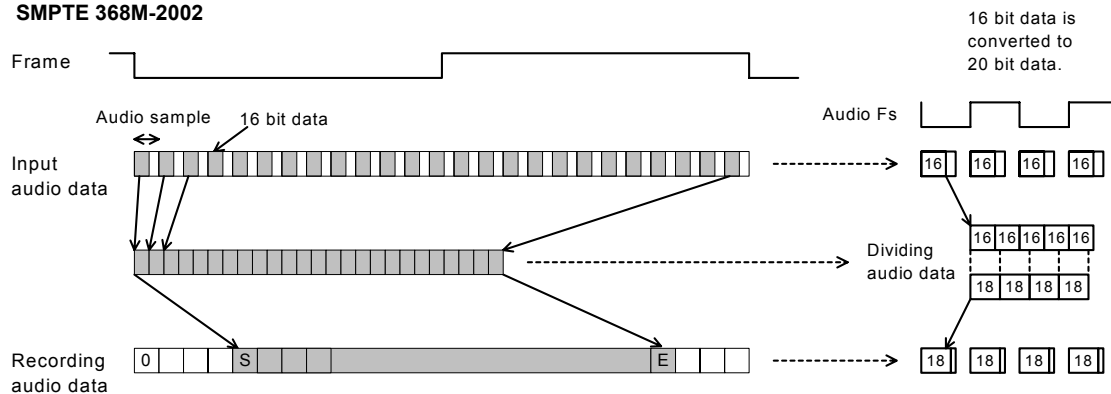
Starting at the first sample of the frame, groups of nine 16-bit words are mapped into groups of eight 18-bit words. This process maps MSB first so that the MSB of the first 16-bit word in a group is mapped to the MSB of the first 18-bit word. The number of data samples in each frame allows this mapping to be made without overflow.

Each resulting 18-bit word is packed into the 18 MSBs of the 20-bit recorded words. The two LSBs of the recorded 20-bit words shall be set to zero.

Starting at the first 20-bit word in the frame, groups of six 20-bit words are mapped into five 24-bit words for recording. This process maps MSB first so that the MSB of the first 20-bit word in a group is mapped to the MSB of the 24-bit word. The number of recorded 24-bit words in each frame allows this mapping to be made without overflow.

At the decoder, the mapping process is reversed. An output data word of 20 bits shall be formed of an upper 16 bit words of sample data and a lower 4 bits of zero data.

# SMPTE 368M-2002



Frame frequency	S	E
23.98 Hz	72	1851
24 Hz	72	1849
25 Hz	0	1919
29.97 Hz	72	1495

NOTE – S: Dividing data start sample number

E: Dividing data end sample number

**Figure 43 – Continuous mode data mapping**

## 8.6.4 Audio auxiliary data words

Audio auxiliary data words shall be recorded to identify the audio system parameters.

The sixteen auxiliary data words shall be specified as shown in figure 44. These sixteen words shall be recorded twice per frame as specified in figure 45.

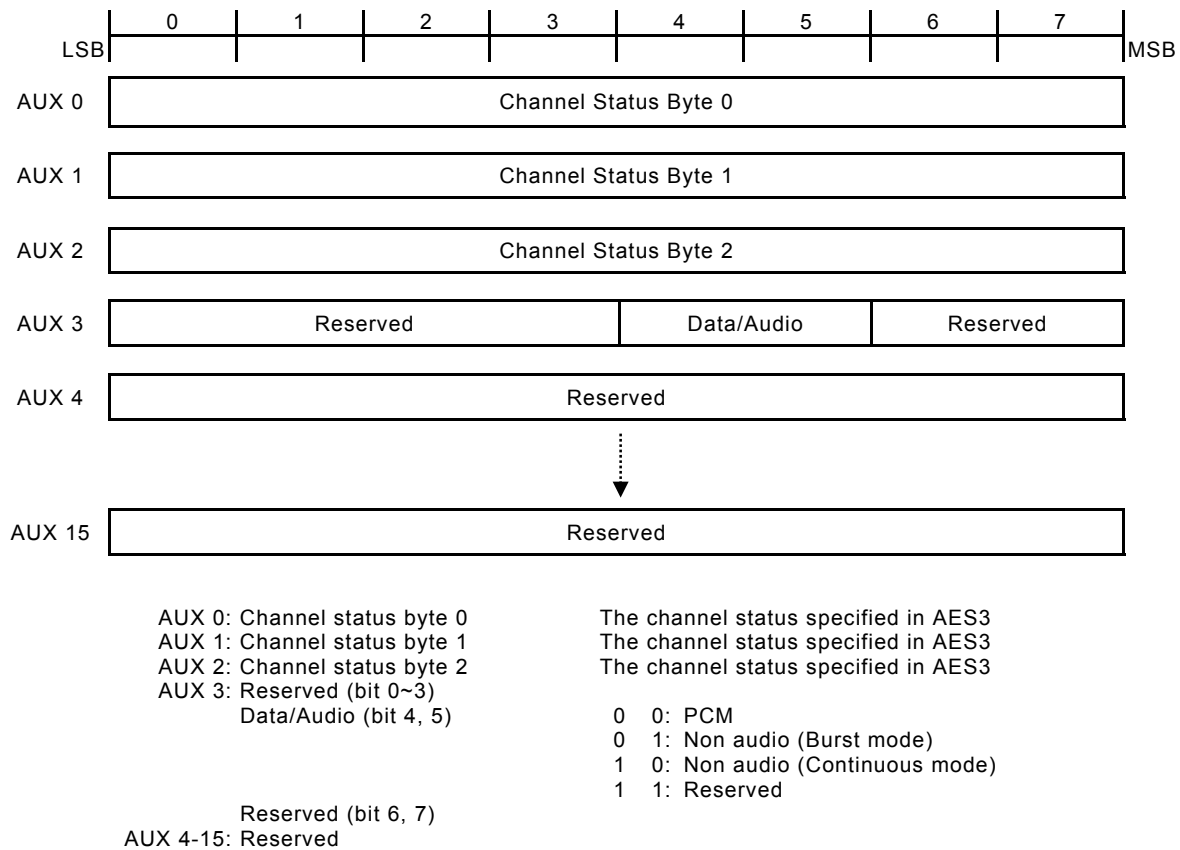


Figure 44 – Audio auxiliary data words

## 8.6.5 AES3 data shuffling

### 8.6.5.1 Intra-field shuffling

For each of the four AES3 data channels in a field, the 800 24-bit data packs together with the 16 packs of auxiliary data shall be arranged into 68 x 12 rectangular outer ECC blocks as shown in figure 45. The top 12 rows of the outer ECC matrix shall be appended with 12 rows of outer error correction (see 8.6.6). There shall be 68 outer error correction codes for each ECC block.

### 8.6.5.2 Sync block shuffling

After calculation of the outer ECC, each row shown in figure 45, makes up the data portion of an audio data sync block as shown in figure 35. The 24 rows in a field shall be mapped to three segments where each segment shall be made up of four audio sync blocks. The three segments shall be mapped to two track pairs as shown in figures 46, 47, 48, and 49. The figures also define the assignment of row numbers to the audio data sync blocks in each of the three segments.

800 24-bit WORDS per FIELD										
ROW NUMBER		0	1	2	3					67 (PACK NB.)
D11	R0	AUX0	AUX12	24	36	---	768	789	792	804
D10	R1	AUX3	AUX15	27	39	---	771	783	795	807
D9	R2	AUX6	18	30	42	---	774	786	798	810
D8	R3	AUX9	21	33	45	---	777	789	801	813
D7	R4	AUX13	25	37	AUX1	---	781	793	805	769
D6	R5	16	28	40	AUX4	---	784	796	808	772
D5	R6	19	31	43	AUX7	---	787	799	811	775
D4	R7	22	34	46	AUX10	---	790	802	814	778
D3	R8	26	38	AUX2	AUX14	---	794	806	770	782
D2	R9	29	41	AUX5	17	---	797	809	773	785
D1	R10	32	44	AUX8	20	---	800	812	776	788
D0	R11	35	47	AUX11	23	---	803	815	779	791
P11	R12	PV0	PV0	PV0	PV0	---	PV0	PV0	PV0	PV0
P10	R13	PV1	PV1	PV1	PV1	---	PV1	PV0	PV1	PV0
P9	R14	PV2	PV2	PV2	PV2	---	PV2	PV1	PV2	PV1
P8	R15	PV3	PV3	PV3	PV3	---	PV 3	PV2	PV3	PV2
P7	R16	PV4	PV4	PV4	PV4	---	PV4	PV3	PV4	PV3
P6	R17	PV5	PV5	PV5	PV5	---	PV5	PV4	PV5	PV4
P5	R18	PV6	PV6	PV6	PV6	---	PV6	PV5	PV6	PV5
P4	R19	PV7	PV7	PV7	PV7	---	PV7	PV6	PV7	PV6
P3	R20	PV8	PV8	PV8	PV8	---	PV8	PV7	PV8	PV7
P2	R21	PV9	PV9	PV9	PV9	---	PV9	PV9	PV9	PV9
P1	R22	PV10	PV10	PV10	PV10	---	PV10	PV10	PV10	PV10
P0	R23	PV11	PV11	PV11	PV11	---	PV11	PV11	PV11	PV11

AUDIO DATA  
12 BLOCKSOUTER  
PARITY  
12 BLOCKS

## NOTES

- 1 ECC block/field.
- 2 Numeric table entries are audio pack numbers.
- 3 PV0 to PV11 present outer check bytes corresponding to audio data of each column.

Figure 45 – Audio data block layout

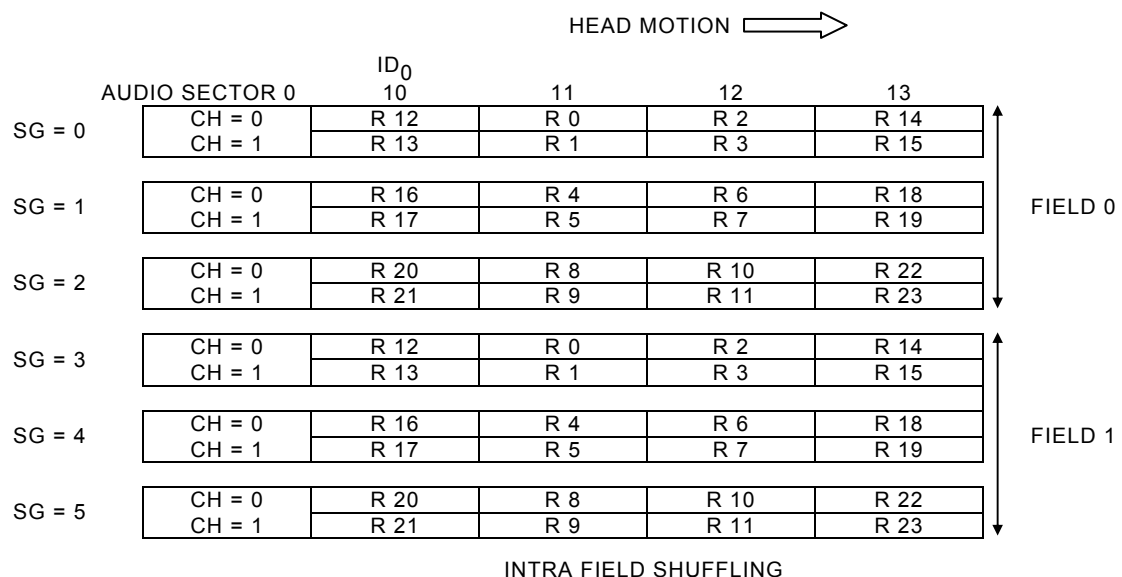


Figure 46 – Sync block shuffling (audio sector 0)

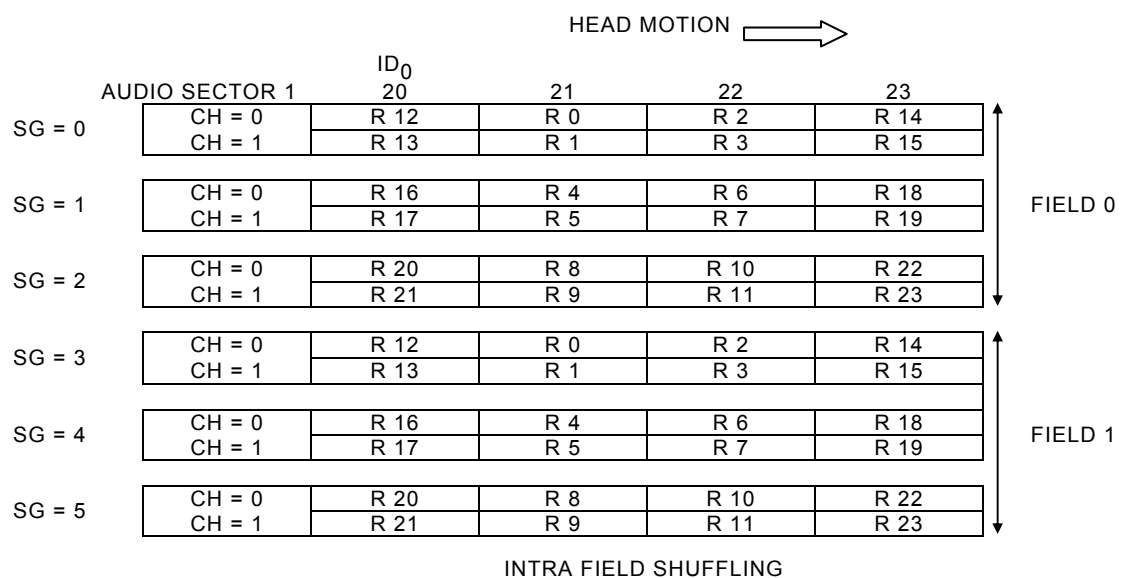


Figure 47 – Sync block shuffling (audio sector 1)

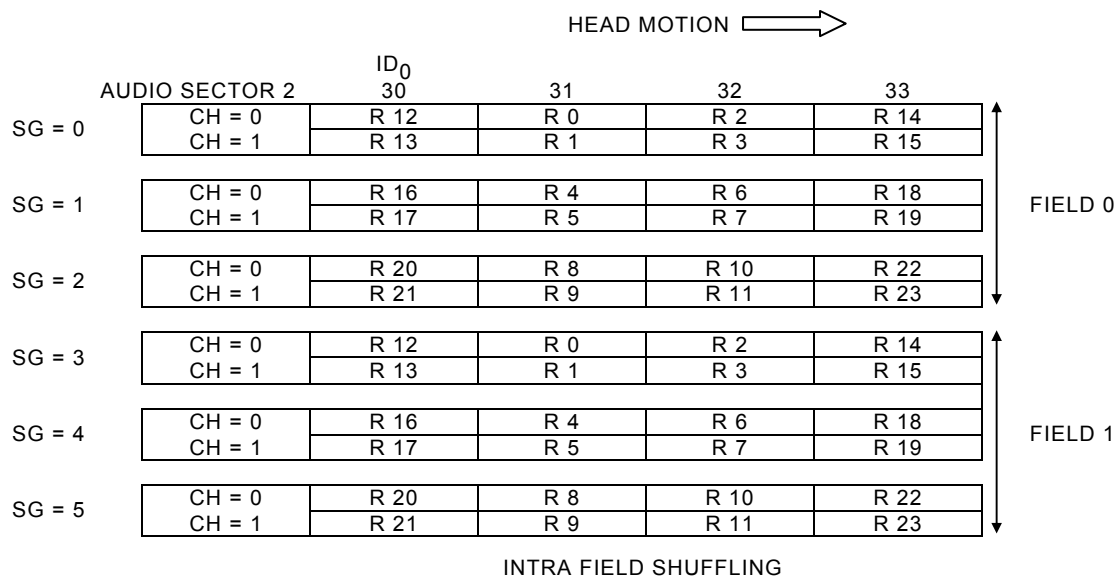


Figure 48 – Sync block shuffling (audio sector 2)

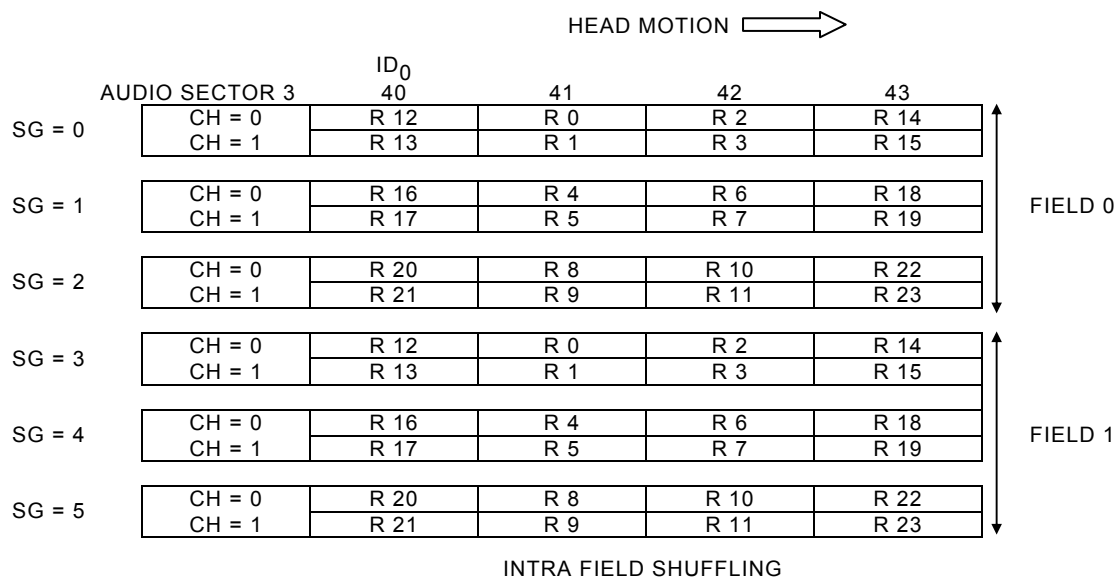


Figure 49 – Sync block shuffling (audio sector 3)

### 8.6.5.3 AES3 channel sector shuffling

In each track, the four channels of AES3 data shall be recorded, with each AES3 channel (ACH) in one sector, as shown in figure 50.

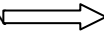
AUDIO SECTOR		HEAD MOTION 			
		0	1	2	3
SG = 0	CH = 0	ACH = 1	ACH = 3	ACH = 2	ACH = 4
	CH = 1	ACH = 1	ACH = 3	ACH = 2	ACH = 4
SG = 1	CH = 0	ACH = 2	ACH = 4	ACH = 1	ACH = 3
	CH = 1	ACH = 2	ACH = 4	ACH = 1	ACH = 3
SG = 2	CH = 0	ACH = 3	ACH = 1	ACH = 4	ACH = 2
	CH = 1	ACH = 3	ACH = 1	ACH = 4	ACH = 2
SG = 3	CH = 0	ACH = 4	ACH = 2	ACH = 3	ACH = 1
	CH = 1	ACH = 4	ACH = 2	ACH = 3	ACH = 1
SG = 4	CH = 0	ACH = 1	ACH = 3	ACH = 2	ACH = 4
	CH = 1	ACH = 1	ACH = 3	ACH = 2	ACH = 4
SG = 5	CH = 0	ACH = 2	ACH = 4	ACH = 1	ACH = 3
	CH = 1	ACH = 2	ACH = 4	ACH = 1	ACH = 3

Figure 50 – AES3 channel sector shuffling

### 8.6.6 Outer ECC

The outer ECC shall be of the Reed-Solomon (RS) type having 12 check bytes placed at the end of each group of 4 AES3 data bytes.

Details of the RS code common to all AES3 outer ECC blocks shall be as follows:

- Galois Field: GF(256)
- Field generator polynomial:  $X^8 + X^4 + X^3 + X^2 + 1$ ,

where  $X^i$  are place-keeping variables in GF(2), the binary field. Note that the + sign indicates modulo binary addition.

- The code generator polynomial (GF(256)) is defined as:

$$G(X) = (X + \alpha^0)(X + \alpha^1)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)(X + \alpha^8)(X + \alpha^9)(X + \alpha^{10})(X + \alpha^{11})$$

where  $\alpha$  is given by  $02_h$  in  $GF(256)$ . Note that the + sign for this and the following equations indicates modulo 256 addition.

The check characters are defined as:

$P_{11}, P_{10}, P_9, P_8, P_7, P_6, P_5, P_4, P_3, P_2, P_1, P_0$  in

$$P_{11}X^{11} + P_{10}X^{10} + P_9X^9 + P_8X^8 + P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0$$

obtained as the remainder after dividing the polynomial:  $X^{12}D(X)$  by  $G(x)$ , where  $P_i$  are bit-inverted words of  $PVi$  shown in figure 46, and  $D(X)$  is the polynomial given by:

$$D(X) = D_{11}X^{11} + D_{10}X^{10} + D_9X^9 + D_8X^8 + D_7X^7 + D_6X^6 + D_5X^5 + D_4X^4 + D_3X^3 + D_2X^2 + D_1X^1 + D_0$$

The polynomial full code is defined as:

$$D_{11}X^{23} + D_{10}X^{22} + D_9X^{21} + D_8X^{20} + D_7X^{19} + D_6X^{18} + D_5X^{17} + D_4X^{16} + D_3X^{15} + D_2X^{14} + D_1X^{13} + D_0X^{12} + P_{11}X^{11} + P_{10}X^{10} + P_9X^9 + P_8X^8 + P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0 \equiv 0 \pmod{G(X)}$$



## Annex A (normative)

### Digital interfaces

#### A.1 Introduction

Figure A.1 represents the relationship between the compression processes described in the document and the associated specifications for a complete type D-11 specification.

- One is the compression specification, SMPTE 367M
- Two is the SD-SDTI specification, SMPTE yyyM
- Three is the VTR specification, SMPTE 368M (this document)

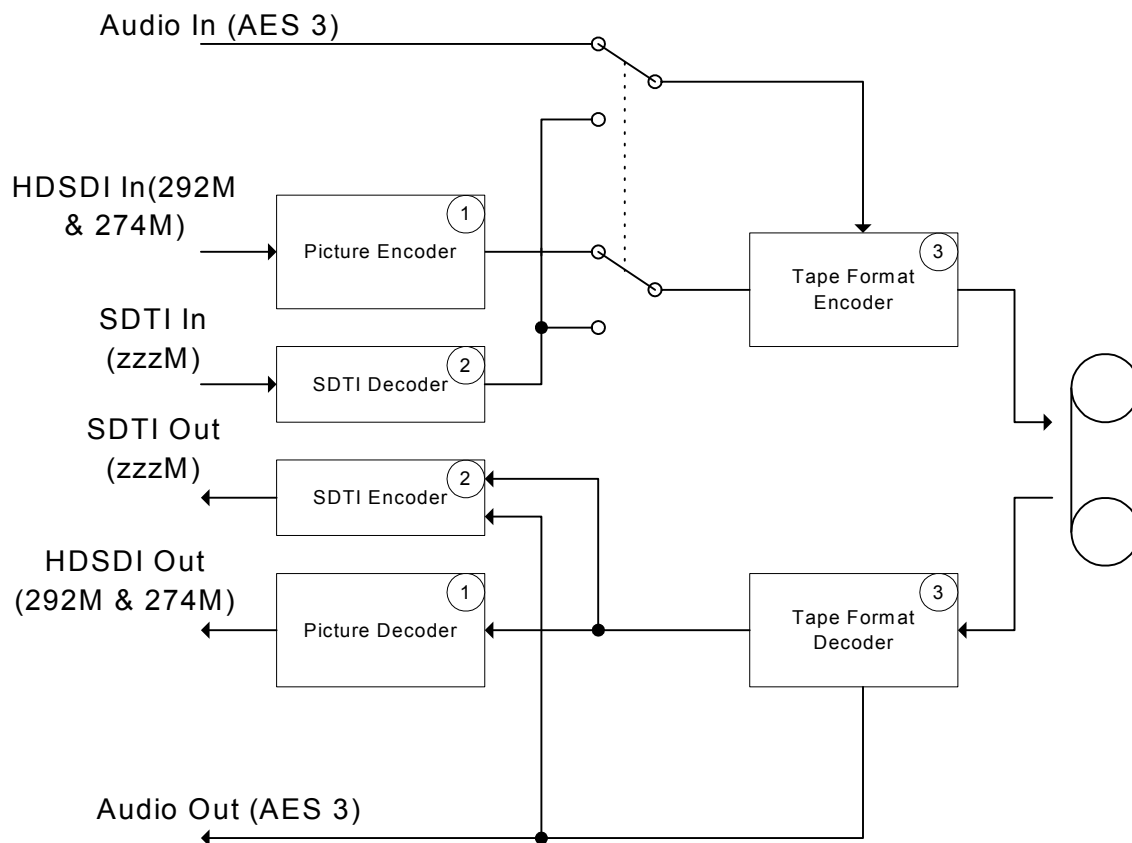


Figure A.1 – System overview

Equipment which provides digital audio, digital video and SDTI interfaces to the type D-11 format recorder shall conform to the following general specifications.

## **A.2 Video interface**

### **A.2.1 Source coding parameters**

The high-definition digital signal using  $1920 \times 1080$  pixels to be processed shall comply with the 4:2:2 encoding parameters as defined in ITU-R BT.709 operating at 74.25 MHz and 74.25/1.001 MHz luminance sampling frequencies.

### **A.2.2 Digital interface**

The high-definition digital video interface, if present, shall conform to the high-definition component serial digital interface format as defined in SMPTE 292M.

## **A.3 Audio interface**

### **A.3.1 Source coding parameters**

The audio interface shall use a clock rate of 48 KHz locked to the horizontal frequency ( $F_H$ ) as follows:

- for the 29.97/PsF & 59.94/I frame rate  
 $F_s = F_H \times 8008/5625 = 48 \text{ KHz}$
- for the 25/PsF & 50/I frame rate  
 $F_s = F_H \times 128/75 = 48 \text{ KHz}$
- for the 24/PsF frame rate  
 $F_s = F_H \times 2000/1125 = 48 \text{ KHz}$
- for the 23.98/PsF frame rate  
 $F_s = F_H \times 2002/1125 = 48 \text{ KHz}$

### **A.3.2 Digital interface**

The digital audio interface, if present, shall conform to the format for two-channel audio as defined in AES3 and SMPTE 276M.

### **A.3.3 Sample Phasing**

For all frame rates, the first sample of AES3 data in a frame shall be defined to coincide with line  $1 \pm 6$  lines of the input high-definition digital video signal.

NOTE – Picture compression encoding may introduce delays in the signal encoding path. These delays may need an equivalent audio delay.

## **A.4 Serial data transport interface**

The serial data transport interface (SDTI), if present, shall conform to SMPTE yyyM for the frame frequencies of 29.97 Hz and 25 Hz. For operation at the frame frequency of 23.98 Hz, the serial data interface, if present, shall conform to SMPTE yyyM, annex A.

## Annex B (informative)

### Tape transport and scanner

The effective drum diameter, tape tension, helix angle, and tape speed taken together determine the track angle. Different methods of design and/or variations in drum diameter and tape tension can produce equivalent recordings for interchange purposes.

A possible configuration of the transport uses a scanner with an effective diameter of 81.400 mm. Scanner rotation is in the same direction as tape motion during normal playback mode. Data are recorded by two head pairs mounted at 180° from each other. Figure B.1 shows a possible mechanical configuration of the scanner and table B.1 shows the corresponding mechanical parameters. Figure B.2 shows the relationship between the longitudinal heads and the scanner.

Other mechanical configurations are allowable, providing the same footprint of recorded information is produced on tape.

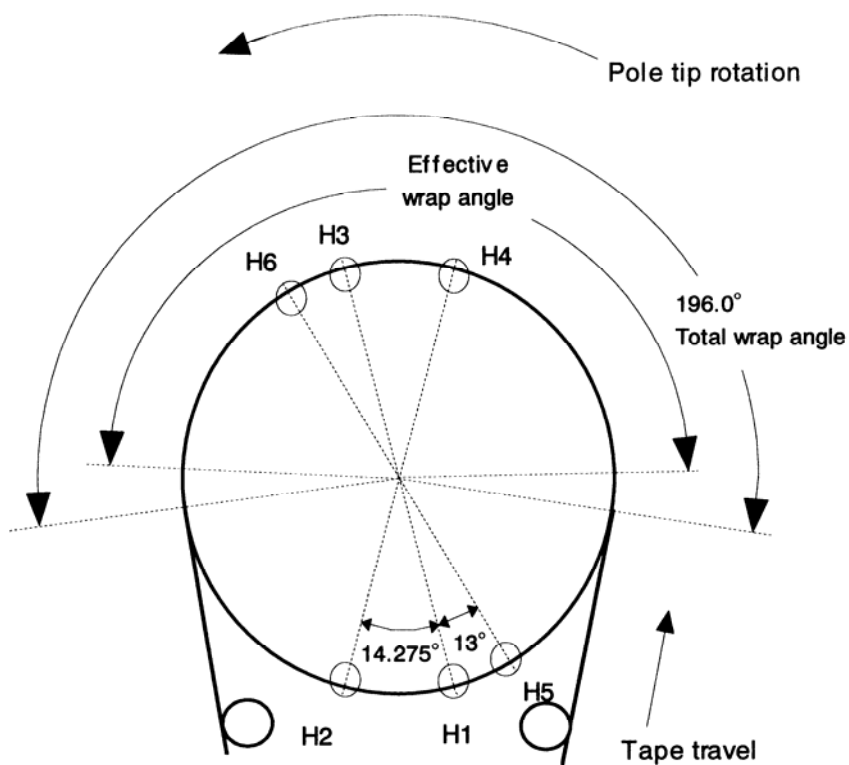
**Table B.1 – Parameters for a possible scanner design**

Parameters		Value		
		29.97-Hz frame rate	25-Hz frame rate	24-Hz frame rate (/1.001)
Scanner rotation speed ( rps )		90/1.001	75	72 (/1.001)
Number of tracks per rotation		4	4	4
Drum diameter ( mm )		81.4	81.4	81.4
Center span tension ( N )		0.3	0.3	0.3
Helix angle ( degrees )		4.607	4.607	4.607
Effective wrap angle ( degrees )		177.1	177.1	177.1
Scanner circumferential speed ( m/s )		23.0	19.2	18.4
H1, H3 over wrap head entrance ( degrees )		16.8	16.8	16.8
H1, H3 over wrap head exit ( degrees )		2.1	2.1	2.1
Angular relationship ( degrees )	H1 - H2:	14.275	14.275	14.275
	H3 - H4:	14.275	14.275	14.275
	H1 - H3:	180.0	180.0	180.0
Vertical displacement ( mm )	H1 - H2:	0.0166	0.0166	0.0166
	H3 - H4:	0.0166	0.0166	0.0166
Maximum tip projection ( $\mu\text{m}$ )		40	40	40
Record head track width ( $\mu\text{m}$ )		20	20	20

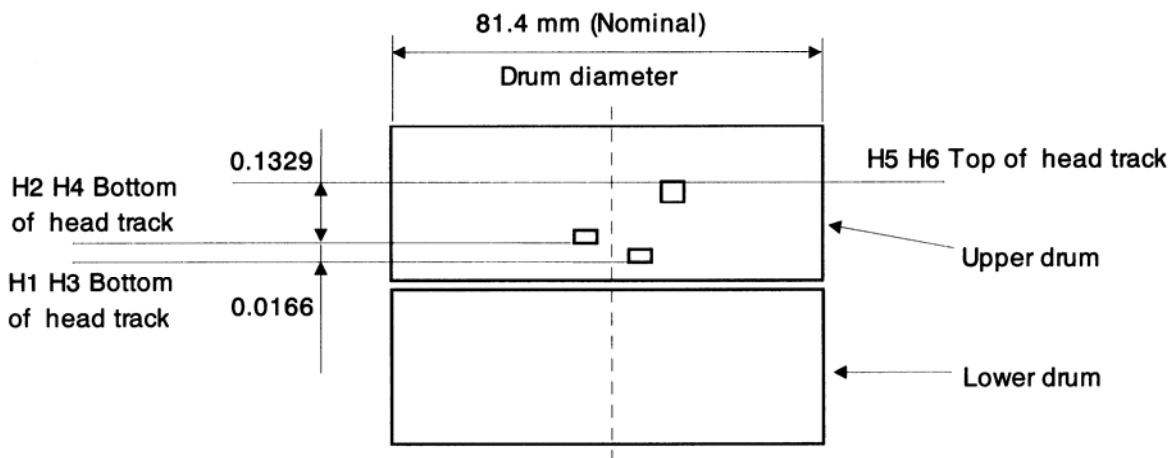
For the scanner configuration defined above, the recorder data rate and the shortest recorded wavelength are given by table B.2, provided for reference only.

**Table B.2 – Data rate and recorded wavelength**

Parameter	29.97-Hz frame rates	25-Hz frame rates	24-Hz frame rates (/1.001)
Total data rate	184.708 Mb/s	154.078 Mb/s	147.910 Mb/s (/1.001)
Instantaneous channel data rate (maximum rate per channel)	93.866 Mb/s	78.300 Mb/s	75.168 Mb/s (/1.001)
Shortest recorded wavelength	0.488 $\mu\text{m}$	0.488 $\mu\text{m}$	0.488 $\mu\text{m}$

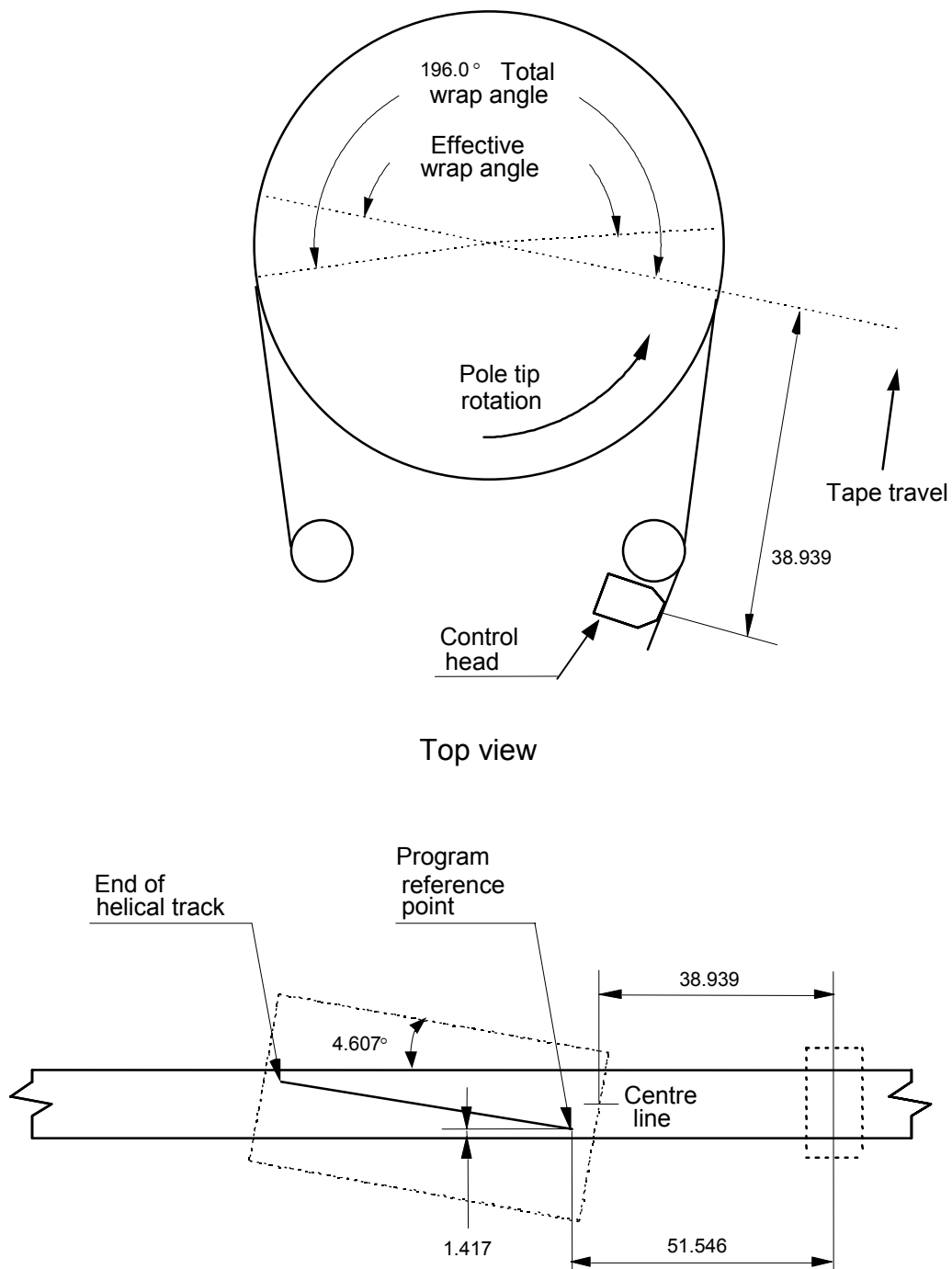


H1-H4: Recording head  
H5-H6: Flying erase head tips  
(Insert editing only)



*Dimensions in millimeters*

**Figure B.1 – Possible scanner configuration**  
(29.97-Hz, 25-Hz, 24-Hz and 23.98-Hz frame rates)



Dimensions in millimeters

**Figure B.2 – Possible longitudinal head location and tape wrap**  
**(29.97-Hz, 25-Hz, 24-Hz and 23.98-Hz frame rates)**

## **Annex C (informative)**

### **Compatibility with other digital formats using type L derivative cassettes**

The physical format parameters selected for the type D-11 digital tape format provide for the possibility of backwards compatibility with other digital formats using format L derivative cassettes.

A scanning drum diameter of 81.4 mm, and associated lead angle of  $4.607^\circ$ , provides the basis for achieving playback compatibility with other formats.

Automatic detection of a given tape format is provided by the cassette tape format identification holes.

## **Annex D (informative)**

### **Compatibility with analog type L**

The possibility of manufacturing hardware that can replay SMPTE type L analog recordings, as well as recording and playing type D-11 formatted tapes, exists. Physical dimensions of the type D-11 format, such as the time and control code track and the control track are in identical locations for both formats.

As a result of differing drum diameters between the analog type L format and the type D-11 formats additional signal processing, beyond the normal TBC functions, is required when replaying analog tapes. These additional functions relate to the handling of the AFM signals that may have been subject to some time compression during the replay process.

Automatic detection of a given tape format is provided by the cassette tape format identification holes. Tape format, and transport parameters such as drum rotational speed, capstan speed, and tape tension control will need to be optimized.

## **Annex E (informative)**

### **Bibliography**

SMPTE 274M-1998, Television — 1920 x 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates

SMPTE RP 211-2000, Implementation of 24P, 25P and 30P Segmented Frames for 1920 x 1080 Production Format

ITU-R BT.709-4 (03/00), Parameter Values for the HDTV Standards for Production and International Programme Exchange