Data Interchange on 90 mm Optical Disk Cartridges - Capacity: 385 Megabytes per Cartridge
Data Interchange on 90 mm Optical Disk Cartridges - Capacity: 385 Megabytes per Cartridge
Brief History

Technical committee ECMA TC31 for Optical Disk Cartridges (ODC) was set up in 1984. The committee made major contributions to ISO/IEC JTC1/SC23 for the development of standards for 90 mm, 120 mm, 130 mm, 300 mm and 356 mm ODCs. ECMA produced camera-ready copies for most International ODC Standards. In addition, ECMA published the following ODC Standards:

ECMA-130 (1988) Data Interchange on Read-only 120 mm Optical Data Disks (CD-ROM)
ECMA-153 (1991) Information Interchange on 130 mm Optical Disk Cartridges of the Write Once, Read Multiple (WORM) type, using the Magneto-Optical effect.
ECMA-154 (1991) Data Interchange on 90 mm Optical Disk Cartridges, Read-Only and Rewritable M.O.
ECMA-183 (1992) Data Interchange on 130 mm Optical Disk Cartridges - Capacity: 1 Gbyte
ECMA-184 (1992) Data Interchange on 130 mm Optical Disk Cartridges - Capacity: 1.3 Gbytes
ECMA-189 (1993) Information Interchange on 300 mm ODCs of the WORM type using the SSF Method.
ECMA-190 (1993) Information Interchange on 300 mm ODCs of the WORM type using the CCS Method.
ECMA-195 (1993) Data Interchange on 130 mm Optical Disk Cartridges - Capacity: 2 Gbytes
ECMA-201 (1994) Data Interchange on 90 mm Optical Disk Cartridges - Capacity: 230 Mbytes

Most of these ECMA Standards have been adopted under the fast-track procedure of ISO/IEC.

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The present ECMA Standard is a standard in the 90 mm ODC series. It specifies the GCR recording code and unlike any previous ODC standard, it allows both user data areas and headers to be written by drives in the field. It provides a capacity of 385 MB per cartridge.

Accepted as an ECMA Standard by the General Assembly of June 1995.
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Section 1 - General

1 Scope
This ECMA Standard specifies the characteristics of 90 mm Optical Disk Cartridges, (ODCs) with a capacity of 385 Mbytes per cartridge. The Standard specifies one type of such cartridge, viz.

Type R/W Provides for data to be written, read and erased many times over the whole of the recording surface of the disk using the thermo-magnetic and magneto-optical effects.

This ECMA Standard specifies:

- the conditions for conformance testing and the Reference Drive;
- the environments in which the cartridges are to be operated and stored;
- the mechanical and physical characteristics of the cartridge, so as to provide mechanical interchangeability between data processing systems;
- the format of the information on the disk, both embossed and user written; including the physical disposition of the tracks and sectors, the error correction codes and the modulation method used;
- the characteristics of the embossed information on the disk;
- the magneto-optical characteristics of the disk, enabling processing systems to write data onto the disk;
- the minimum quality of user-written data on the disk, enabling data processing systems to read data from the disk.

This ECMA Standard provides for media interchange between optical disk drives. Together with a Standard for volume and file structure, it provides for full data interchange between data processing systems.

2 Conformance

2.1 Optical disk cartridge (ODC)
A 90 mm optical disk cartridge claiming conformance with this ECMA Standard shall be in conformance if it meets all mandatory requirements specified herein.

Annex R specifies the zones of the disk in which the requirements for the signal characteristics given in the body of this ECMA Standard shall be met, and the zones in which a relaxation of these requirements is permitted.

2.2 Generating system
A system generating an ODC for interchange shall be entitled to claim conformance with this ECMA Standard if it meets all of the mandatory requirements of this Standard.

2.3 Receiving System
A system receiving an ODC for interchange shall be entitled to claim conformance to this ECMA Standard if it is able to process any recording made on the cartridge according to 2.1.

2.4 Compatibility Statement
A claim of conformance by a Generating or Receiving system with this ECMA Standard shall include a statement listing any other ECMA and/or International Standard(s) supported. This statement shall specify the number of the Standard(s), the ODC type(s) supported (where appropriate) and whether support includes reading or both reading and writing.

3 References
The following Standards contain provisions which, through reference in this text, constitute provisions of this ECMA Standard. At the time of publication, the edition indicated was valid. All Standards are subject to revision, and parties
to agreements based on this ECMA Standard are encouraged to investigate the possibility of applying the most recent edition of the Standards listed below.

ECMA-129 (1994), Information Technology Equipment - Safety
ECMA-201 (1994) Data Interchange on 90 mm Optical Disk Cartridges - Capacity: 230 Megabytes

4 Definitions

For the purpose of this ECMA Standard the following definitions apply.

4.1 band
Part of the Data Zone comprising a fixed number of consecutive physical tracks.

4.2 case
The housing for an optical disk, that protects the disk and facilitates disk interchange.

4.3 Channel bit
The smallest element of data on a disk. It is recorded as either a space or a mark. Nine Channel bits are used to represent eight input bits.

4.4 clamping zone
The annular part of the disk within which the clamping force is applied by the drive media clamping device.

4.5 control track
A track containing the information on media parameters and format necessary for reading, writing and erasing the remaining tracks on the optical disk.

4.6 Cyclic Redundancy Check (CRC)
A method for detecting errors in data.

4.7 defect management
A method for handling the defective areas on the disk.

4.8 disk reference plane
A plane defined by the perfectly flat annular surface of an ideal spindle onto which the clamping zone of the disk is clamped, and which is normal to the axis of rotation.

4.9 embossed mark
A mark so formed as to be unalterable by magneto-optical means.

4.10 entrance surface
The surface of the disk on to which the optical beam first impinges.

4.11 Error Correction Code (ECC)
An error-detecting code designed to correct certain kinds of errors in data.

4.12 field
A subdivision of a sector.

4.13 format
The arrangement or layout of information on the disk.

4.14 fully rewritable disk
An optical disk in which all fields in the Data Zone can be rewritten by an optical beam.

4.15 groove
See land and groove
4.16 hub
The central feature on the disk which interacts with the spindle of the disk drive to provide radial centring and the clamping force.

4.17 interleaving
The process of allocating the physical sequence of units of data so as to render the data more immune to burst errors.

4.18 Kerr rotation
The rotation of the plane of polarization of an optical beam upon reflection from the recording layer, as caused by the magneto-optical effect.

4.19 land and groove
A trench-like feature of the disk, applied before the recording of any information, and used to define the track location. The groove is located nearer to the entrance surface than the land with which it is paired to form a track.

4.20 logical track
A contiguous length of 25 sectors that may be less than one complete revolution of the disk. The first sector of each logical track is assigned sector number 0.

4.21 mark
A feature of the recording layer which may take the form of a magnetic domain, a pit, or any other type or form that can be sensed by the optical system. The pattern of marks represents the data on the disk.

Note
Subdivisions of a sector which are named 'mark' are not marks in the sense of this definition.

4.21.1 Mark edge recording
A recording method which uses a mark edge to represent a Channel bit.

4.22 optical disk
A disk that will accept and retain information in the form of marks in a recording layer, that can be read with an optical beam.

4.23 optical disk cartridge (ODC)
A device consisting of a case containing an optical disk.

4.24 physical track
The path which is followed by the focus of the optical beam during one revolution of the disk.

4.25 physical track group
A fixed number of consecutive physical tracks in the Data Zone.

4.26 pitch
The distance between adjacent physical track centrelines, measured in a radial direction.

4.27 polarization
The direction of polarization of an optical beam is the direction of the electric vector of the beam.

4.28 read power
The optical power, incident at the surface of the disk, used when reading.

Note
It is specified as a maximum power that may be used without damage to the written data. Lower power may be used provided that the Signal-to-Noise Ratio, (SNR) and other requirements of this ECMA Standard are met.
4.29 recording layer
A layer of the disk on, or in, which data is written during manufacture and/or use.

4.30 Reed-Solomon code
An error detection and/or correction code which is particularly suited to the correction of errors which occur in bursts or are strongly correlated.

4.31 re-writable optical disk
An optical disk in which data in specified areas can be written, erased and rewritten by an optical beam.

4.32 sector
The smallest addressable part of a track in the Information Zone of a disk that can be accessed independently of other addressable parts of the zone.

4.33 spindle
That part of the disk drive which contacts the disk and hub.

4.34 substrate
A transparent layer of the disk, provided for mechanical support of the recording layer, through which the optical beam accesses the recording layer.

4.35 ZCAV format
A recording format for a disk in which each group of adjacent tracks is written using an increasing Write Clock frequency when moving from groups at the ID to those at the OD of the disk.

4.36 zone
An annular area of the disk.

5 Conventions and notations

5.1 Representation of numbers
A measured value is rounded off to the least significant digit of the corresponding specified value. It implies that a specified value of 1,26 with a positive tolerance of +0,01, and a negative tolerance of -0,02 allows a range of measured values from 1,235 to 1,275.

- Letters and digits in parentheses represent numbers in hexadecimal notation.
- The setting of a bit is denoted by ZERO or ONE.
- Numbers in binary notation and bit combinations are represented by strings of ZEROs and ONEs.
- Numbers in binary notation and bit combinations are shown with the most significant bit to the left.
- Negative values of numbers in binary notation are given in TWO's complement.
- In each field the data is recorded so that the most significant byte (byte 0) is recorded first. Within each byte the least significant bit is numbered 0 and is recorded last, the most significant bit (numbered 7 in an 8-bit byte) is recorded first. This order of recording applies also to the data input of the Error Detection and Correction circuits and to their output.
- Unless otherwise stated, all track numbers refer to logical tracks.
- Unless otherwise stated, groups of decimal digits of the form xx...x/yy...y indicate that the value xx...x applies to 1 024-byte sectors and that the value yy...y applies to 512-byte sectors.

5.2 Names
The names of entities, e.g. specific tracks, fields, etc., are given with a capital initial.
6 List of acronyms

AM Address Mark
CCS Continuous Composite Servo (tracking method)
CRC Cyclic Redundancy Check
DDS Disk Definition Structure
DMA Defect Management Area
ECC Error Correction Code
FA1 Functional Area 1
FA2 Functional Area 2
GCR Group Code Recording
ID Identifier
LSB Least Significant Byte
MO Magneto Optic
MSB Most Significant Byte
ODC Optical Disk Cartridge
PA Postamble
PDL Primary Defect List
RLL Run Length Limited (code)
R/W Rewritable
SDL Secondary Defect List
SM Sector Mark
VFO Variable Frequency Oscillator
ZCAV Zoned Constant Angular Velocity

7 General description of the optical disk cartridge

The optical disk cartridge which is the subject of this ECMA Standard consists of a case containing an optical disk.

The case is a protective enclosure for the disk. It has access windows covered by a shutter. The windows are automatically uncovered by the drive when the cartridge is inserted into it.

The optical disk is recordable on one side. Data can be written onto the disk as marks in the form of magnetic domains in the recording layer and can be erased from it with a focused optical beam, using the thermo-magnetic effect. The data can be read with a focused optical beam, using the magneto-optical effect. The beam accesses the recording layer through the transparent substrate of the disk.

Part of the disk may contain read-only data in the form of pits embossed by the manufacturer. This data can be read using the diffraction of the optical beam by the embossed pits.

8 General requirements

8.1 Environments

8.1.1 Testing environment

The test environment is the environment where the air immediately surrounding the optical disk cartridge has the following properties:

- temperature: 23 °C ± 2 °C
- relative humidity: 45 % to 55 %
- atmospheric pressure: 60 kPa to 106 kPa
- air cleanliness: Class 100 000 (see annex M)

No condensation on or in the optical disk cartridge shall occur. Before testing, the optical disk cartridge shall be conditioned in this environment for 48 h minimum. It is recommended that, before testing, the entrance surface of the optical disk shall be cleaned according to the instructions of the manufacturer of the disk.

Unless otherwise stated, all tests and measurements shall be made in this test environment.
8.1.2 Operating environment

This ECMA Standard requires that an optical disk cartridge which meets all requirements of this ECMA Standard in the specified test environment provides data interchange over the specified ranges of environmental parameters in the operating environment.

The operating environment is the environment where the air immediately surrounding the optical disk cartridge has the following properties:

- temperature: 5 °C to 55 °C
- relative humidity: 3 % to 85 %
- absolute humidity: 1 g/m³ to 30 g/m³
- atmospheric pressure: 60 kPa to 106 kPa
- temperature gradient: 10 °C/h max.
- relative humidity gradient: 10 %/h max.
- air cleanliness: Office environment (see annex Q)

Magnetic field strength at the recording layer:
- for any condition under which a beam is in focus: 32 000 A/m max.
- Magnetic field strength at the recording layer during any other condition: 48 000 A/m max.

No condensation on or in the optical disk cartridge shall occur. If an optical disk cartridge has been exposed to conditions outside those specified in this clause, it shall be acclimatized in an allowed operating environment for at least 2 h before use, (see also annex L)

8.1.3 Storage environment

The optical disk cartridge without any protective enclosure shall not be stored in an environment outside the range allowed for storage. The storage environment is defined as an environment where the air immediately surrounding the optical disk cartridge has the following properties:

- temperature: -10 °C to 55 °C
- relative humidity: 3 % to 90 %
- absolute humidity: 1 g/m³ to 30 g/m³
- atmospheric pressure: 60 kPa to 106 kPa
- temperature gradient: 15 °C/h max.
- relative humidity gradient: 10 %/h max.
- air cleanliness: Office environment (see annex Q)
- magnetic field strength at the recording layer: 48 000 A/m max.

No condensation on or in the optical disk cartridge shall occur.

8.1.4 Transportation

This ECMA Standard does not specify requirements for transportation; guidance is given in annex P.

8.2 Temperature shock

The optical disk cartridge shall withstand a temperature shock of up to 20 °C when inserted into, or removed from, the drive.

8.3 Safety requirements

The cartridge shall satisfy the safety requirements of ECMA-129, when used in the intended manner or in any foreseeable use in an information processing system.

8.4 Flammability

The cartridge and its components shall be made from materials that comply with the flammability class for HB materials, or better, as specified in ECMA-129.

9 Reference Drive

The Reference Drive is a drive several critical components of which have well defined properties and which is used to test write, read and erase parameters of the disk for conformance to this ECMA Standard. The critical components
9.1 **Optical system**

The basic set-up of the optical system of the Reference Drive used for measuring the write, read and erase parameters is shown in figure 1. Different components and locations of components are permitted, provided that the performance remains the same as that of the set-up in figure 1. The optical system shall be such that the detected light reflected from the entrance surface of the disk is minimized so as not to influence the accuracy of the measurements.

![Diagram](image)

A  Laser diode  
B  Collimator lens  
C  Optional shaping prism  
Ch.1 Channel 1  
Ch.2 Channel 2  
D  Beam splitter  
E  Polarizing beam splitter  
F  Objective lens  
G  Optical disk  
H  Optional half-wave plate  
I  Phase retarder  
J  Polarizing beam splitter  
K₁, K₂ Photodiodes for Channels 1 and 2  
K₃ Split photodiode  
L₁, L₂ d.c.-coupled amplifiers  
M  Tracking Channel (see 20.3)

**Figure 1 - Optical system of the Reference Drive**

In the absence of polarization changes in the disk, the polarizing beam splitter J shall be aligned to make the signal of detector K₁ equal to that of detector K₂. The direction of polarization in this case is called the neutral direction. The phase retarder I shall be adjusted such that the optical system does not have more than 2.5° phase retardation between the neutral polarization and the polarization perpendicular to it. This position of the retarder is called the neutral position.

The phase retarder can be used for the measurement of the narrow-band signal-to-noise ratio (see 26.2).
The beam splitter J shall have a p-s intensity reflectance ratio of at least 100.

The beam splitter E shall have an intensity reflectance $R_s$ from F to H of nominally 0.30 for the neutral polarization direction. The reflectance $R_s$ for the polarization perpendicular to the neutral direction shall be nominally 0.95. The actual value of $R_s$ shall not be smaller than 0.90.

The imbalance of the magneto-optical signal is specified for a beam splitter with nominal reflectances. If the measurement is made on a drive with reflectances $R_p$ and $R_s'$ for beam splitter E, then the measured imbalance shall be multiplied by

$$\frac{R_s R'_p}{\sqrt{R_p R'_s}}$$

to make it correspond to the nominal beam splitter E.

The output of Channel 1 is the sum of the currents through photodiodes $K_1$ and $K_2$, and is used for reading embossed marks. The output of Channel 2 is the difference between photodiode currents, and is used for reading user-written marks with the magneto-optical effect.

### 9.2 Optical beam

The focused optical beam used for writing, reading and erasing data shall have the following properties:

a) Wavelength ($\lambda$)  
   780 nm $\pm 15$ nm $-10$ nm

b) Wavelength ($\lambda$) divided by the numerical aperture of the objective lens (NA)  
   $\lambda / NA = 1,423 \mu m \pm 0,023 \mu m$

c) Filling $D/W$ of the aperture of the objective lens  
   1,0 max.

d) Variance of the wavefront of the optical beam near the recording layer  
   $\lambda^2 / 180$ max.

e) Polarization  
   Linear, parallel or perpendicular to the groove, where appropriate

f) Extinction ratio  
   0,01 max.

g) The optical power and pulse width for writing, reading and erasing, and the magnetic field shall be as specified in 20.2.2, 24.2.2, 24.3, 24.4, and 28.2.2.

$D$ is the diameter of the lens aperture and $W$ is the beam diameter of the Gaussian beam where the intensity is $1/e^2$ of the maximum intensity.

The extinction ratio is the ratio of the minimum over the maximum power observed behind a linear polarizer in the optical beam, which is rotated over at least 180°.

### 9.3 Read channels

Two read channels shall be provided to generate signals from the marks in the recording layer. Channel 1 shall be used for reading the embossed marks, using the diffraction of the optical beam by the marks. Channel 2 shall be used for reading the user-written marks, using the rotation of the polarization of the optical beam due to the magneto-optical effect of the marks. The read amplifiers after the photo-detectors in Channel 1 and Channel 2 shall have a flat response within $\pm 1$ dB from 100 kHz to 22,3 MHz.

### 9.4 Tracking

The Tracking Channel of the drive provides the tracking error signals to control the servos for the axial and radial tracking of the optical beam. The method of generating the axial tracking error is not specified for the Reference Drive. The radial tracking error is generated by a split photodiode detector in the tracking Channel. The division of the diode runs parallel to the image of the tracks on the diode.
The requirements for the accuracy with which the focus of the optical beam must follow the tracks is specified in 20.2.4.

9.5 Rotation of the disk

The spindle shall position the disk as specified in 12.4. It shall rotate the disk at 30.0 Hz ± 0.3 Hz. The direction of rotation shall be counter-clockwise when viewed from the objective lens.
Section 2 - Mechanical and physical characteristics

10 Dimensional and physical characteristics of the case

10.1 General description of the case (see figure 2)

The case is a rigid protective container of rectangular shape. It has a spindle window on Side A to allow the spindle of the drive to clamp the disk by its hub. Both Side A and Side B of the case have a head window, the one on Side A for the optical head of the drive, the other one on Side B for the magnetic head providing the necessary magnetic fields. A shutter uncovers the windows upon insertion into the drive, and automatically covers them upon removal from the drive. The case has features that enable a drive to reject a mis-inserted cartridge, write-inhibit and reflectance detection features, and gripper slots for an autochanger.

10.2 Reference planes of the case

The dimensions of the case shall be referred to three orthogonal reference planes X, Y and Z. The case shall be constrained such that four reference surfaces S₁ to S₄ on Side A of the case lie in plane Z when measuring those dimensions of the case in 10.3 which are referenced to this plane. The intersection of the three planes defines the centre of the location hole. The centre of the alignment hole shall lie in the X plane (see annex N). A dimension of a feature referenced to one of the planes is the shortest distance from the feature to the plane.

10.3 Dimensions of the case

The dimensions of the case shall be measured in the test environment. The dimensions of the case in an operating environment can be estimated from the dimensions specified in this clause.

10.3.1 Overall dimensions (see figure 3)

The total length of the case shall be

\[ L₁ = 94,0 \text{ mm} \pm 0,3 \text{ mm} \]

The distance from the top of the case to reference plane X shall be

\[ L₂ = 76,0 \text{ mm} \pm 0,2 \text{ mm} \]

The distance from the bottom of the case to reference plane X shall be

\[ L₃ = 18,0 \text{ mm} \pm 0,2 \text{ mm} \]

The total width of the case shall be

\[ L₄ = 90,0 \text{ mm} \pm 0,4 \text{ mm} \]

The distance from the left hand side of the case to reference plane Y shall be

\[ L₅ = 85,0 \text{ mm} \pm 0,3 \text{ mm} \]

The distance from the right hand side of the case to reference plane Y shall be

\[ L₆ = 5,0 \text{ mm} \pm 0,1 \text{ mm} \]

The corner at the top shall be rounded with a radius

\[ R₁ = 1,5 \text{ mm} \pm 0,2 \text{ mm} \]

and the two corners at the bottom with a radius

\[ R₂ = 2,0 \text{ mm} \pm 0,2 \text{ mm} \]

In the zones extending

\[ L₇ = 8,6 \text{ mm min.} \]

from the left-hand and right-hand edges of the case, the thickness of the case shall be

\[ L₈ = 6,0 \text{ mm} \pm 0,2 \text{ mm} \]
The eight long edges of the case shall be rounded with a radius
\[ R_3 = 0,3 \text{ mm} + 0,2 \text{ mm} - 0,0 \text{ mm} \]

10.3.2 Location hole (see figure 3)
The centre of the location hole shall coincide with the intersection of the planes X, Y and Z. The diameter of the hole shall be
\[ D_1 = 3,60 \text{ mm} + 0,00 \text{ mm} - 0,06 \text{ mm} \]

held to a depth
\[ L_9 = 1,5 \text{ mm} \text{ min.} \]
The location hole shall extend below plane Z by
\[ L_{10} = 4,0 \text{ mm} \text{ min.} \]
with a diameter equal to, or greater than \( D_1 \).
The location hole shall not extend through Side B.
The lead-in edges shall be rounded with a radius
\[ R_4 = 0,5 \text{ mm} \text{ max.} \]

10.3.3 Alignment hole (see figure 3)
The centre of the alignment hole shall lie in the X plane at a distance
\[ L_{11} = 80,0 \text{ mm} \pm 0,2 \text{ mm} \]
from reference plane Y.
The alignment hole shall have a substantially rectangular shape. Its dimensions shall be
\[ L_{12} = 3,60 \text{ mm} + 0,00 \text{ mm} - 0,06 \text{ mm} \]
\[ L_{13} = 4,4 \text{ mm} + 0,2 \text{ mm} - 0,0 \text{ mm} \]

held to a depth \( L_9 \), below which the alignment hole shall extend to \( L_{10} \), with dimensions equal to, or greater than, \( L_{12} \) and \( L_{13} \), respectively.
The alignment hole shall not extend through Side B.
The lead-in edges shall be rounded with radius \( R_4 \).

10.3.4 Reference surfaces (see figure 4)
Side A of the case shall contain four reference surfaces \( S_1 \), \( S_2 \), \( S_3 \) and \( S_4 \).
Surfaces \( S_1 \) and \( S_2 \) shall be circular with a diameter
\[ D_2 = 7,0 \text{ mm} \text{ min.} \]
\( S_1 \) shall be centred on the location hole, and \( S_2 \) shall be centred on the alignment hole.
Surfaces \( S_3 \) and \( S_4 \) shall be circular with a diameter
\[ D_3 = 6,0 \text{ mm} \text{ min.} \]
with their centres located at
\[ L_{14} = 54,0 \text{ mm} \pm 0,2 \text{ mm} \]
\[ L_{15} = 1,0 \text{ mm} \pm 0,2 \text{ mm} \]
\[ L_{16} = 81.0 \text{ mm} \pm 0.2 \text{ mm} \]

No portion of the case or of the shutter mechanism (see 10.3.8) shall protrude more than

\[ L_{17} = 0.15 \text{ mm max.} \]

beyond plane Z.

10.3.5 Detents (see figure 5)

The case shall have two symmetrical detents intended for autoloading. Each detent shall extend from plane Z up to

\[ L_{18} = 5.0 \text{ mm min.} \]

and shall not extend through Side B.

Each detent is defined by a semi-circular section with a radius

\[ R_5 = 2.1 \text{ mm} \pm 0.1 \text{ mm} \]

which stretches out to the side of the case along two straight lines extending from the semi-circle. The radii of the two detents originate from

\[ L_{19} = 65.5 \text{ mm} \pm 0.2 \text{ mm} \]

\[ L_{20} = 4.0 \text{ mm max.} \]

\[ L_{21} = 84.0 \text{ mm max.} \]

The outside edges of the detents shall be rounded off by a radius

\[ R_6 = 0.5 \text{ mm} \pm 0.2 \text{ mm} \]

10.3.6 Functional Areas (see figure 6)

The case shall have an opening in Side A the length of which shall be

\[ L_{22} = 8.2 \text{ mm min.} \]

Its width shall be at least equal to \( L_{23} \), and its centreline shall be located on the intersection of planes Y and Z.

Functional Area FA1 shall have the dimensions

\[ L_{23} = 4.4 \text{ mm min.} \]

\[ L_{24} = 3.6 \text{ mm min.} \]

Its centreline shall be in plane Z, and parallel to plane X at a distance

\[ L_{25} = 7.8 \text{ mm} \pm 0.2 \text{ mm} \]

from plane X. Side B shall have an opening corresponding to the surface of Functional Area FA1.

Functional Area FA2 shall have the dimensions \( L_{23}, L_{24} \) and

\[ L_{26} = 4.0 \text{ mm min.} \]

Its centreline shall be in plane Z, and parallel to plane X at a distance

\[ L_{27} = 12.8 \text{ mm} \pm 0.2 \text{ mm} \]

There shall be no opening in Side B corresponding to Functional Area FA2.

The cartridge shall have a device capable of

- either closing FA1 or FA2,
- or closing both FA1 and FA2.

The two Functional Areas shall indicate the reflectance of the disk in the cartridge and whether or not writing on the disk is permitted, as specified in table 1 (see also figure 6).
Table 1 - Use of the Functional Areas FA1 and FA2

<table>
<thead>
<tr>
<th>FA1</th>
<th>FA2</th>
<th>Writing</th>
<th>Reflectance</th>
<th>Type of Cartridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>Closed</td>
<td>Inhibited</td>
<td>Low</td>
<td>R/W</td>
</tr>
<tr>
<td>Closed</td>
<td>Open</td>
<td>Permitted</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Closed</td>
<td>Closed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>Open</td>
<td>Not permitted by this</td>
<td>ECMA Standard</td>
<td></td>
</tr>
</tbody>
</table>

The surface of the device shall be at a distance

$L_{28} = 0.3 \text{ mm max.}$

from plane Z.

10.3.7 Spindle and head windows (see figure 7)

Side A of the case shall have a window to enable the spindle and the optical head of the drive to access the disk. The dimensions of the window are referenced to a centreline, located at a distance

$L_{29} = 40.0 \text{ mm} \pm 0.2 \text{ mm}$

from plane Y. The width of the window shall be given by

$L_{30} = 11.0 \text{ mm} + 0.2 \text{ mm} - 0.0 \text{ mm}$

and

$L_{31} = 11.0 \text{ mm} + 0.2 \text{ mm} - 0.0 \text{ mm}$

The top of the window shall be given by radius

$R_7 = 43.7 \text{ mm min.}$

originating from $L_{29}$ and

$L_{32} = 27.0 \text{ mm} \pm 0.2 \text{ mm}$

The area bounded by $R_7$ and the top of the case shall be recessed from plane Z by

$L_{33} = 2.0 \text{ mm} + 0.2 \text{ mm} - 0.0 \text{ mm}$

over the width of the window.

The bottom of the window shall be the arc of the semi-circle which smoothly joins the sides of the window. The centre of the semi-circle shall be defined by $L_{29}$ and $L_{32}$.

Side B of the case shall have a window to enable the magnetic head of the drive to access the disk. The dimensions of the window are referenced to a centreline, located at a distance $L_{29}$ from plane Y. The width of the window shall be given by $L_{30}$ and $L_{31}$. The window shall extend from

$L_{34} = 40.0 \text{ mm max.}$

to the arc of $R_7$, originating from $L_{29}$ and $L_{32}$.

The area bounded by $R_7$ and the top of the case shall be, over the width of the window, at a distance

$L_{35} = 4.2 \text{ mm} + 0.0 \text{ mm} - 0.4 \text{ mm}$

from plane Z.

The two inside corners shall be rounded with a radius
\( R_8 = 2,0 \text{ mm max.} \)

10.3.8 Shutter (see figure 8)

The case shall have a spring-loaded shutter designed to completely cover the spindle and head windows when closed. When open, the shutter shall expose the windows up to at least the minimum size allowed by the following dimensions, given in 10.3.7:

- on Side A: from the semi-circle at the bottom of the window up to the top of the case, and from \( L_{30} \) to \( L_{31} \);
- on Side B: from \( L_{34} \) up to the top of the case, and from \( L_{30} \) to \( L_{31} \);
- on the top: from plane \( Z \) to \( L_{33} \), from \( L_{30} \) to \( L_{31} \), from \( L_{35} \) up to Side B, and from \( L_{30} \) to \( L_{31} \).

The shutter shall be free to slide in a recessed area of the case in such a way as to ensure that the overall thickness of the case and shutter does not exceed \( L_8 \) by more than \( L_{17} \).

The shutter shall have one edge against which the shutter opener of the drive can push to open the shutter. When the shutter is closed, this edge shall be

\[
L_{36} = 79,0 \text{ mm } + 0,0 \text{ mm } - 0,3 \text{ mm}
\]

from plane \( Y \). A movement of the edge to

\[ L_{37} = 55,5 \text{ mm min.} \]

shall be sufficient to open the windows to the minimum size specified in 10.3.8. It shall be possible to move the edge to

\[ L_{38} = 54,7 \text{ mm max.} \]

without exceeding the shutter opening force as specified in 10.4.5, while leaving the minimum size window open.

10.3.9 Path for shutter opener and shutter sensor notch (see figure 9)

The profile on the top of the case provides a path over which the shutter opener of the drive can travel.

The path shall run from

\[ L_{39} = 81,0 \text{ mm } \pm 0,3 \text{ mm} \]

to

\[ L_{40} = 57,5 \text{ mm } + 0,3 \text{ mm } - 0,0 \text{ mm} \]

at a distance

\[ L_{41} = 74,0 \text{ mm } \pm 0,3 \text{ mm} \]

from plane \( X \).

The lead-in edge at \( L_{39} \) shall be a ramp to the top of the case with an angle

\[ A_1 = 45^\circ \pm 5^\circ \]

The path shall end in a notch with a width at the bottom from \( L_{40} \) to

\[ L_{42} = 54,7 \text{ mm max.} \]

and a depth

\[ L_{43} = 3,3 \text{ mm } \pm 0,2 \text{ mm} \]

below \( L_{41} \). The lead-in edge at the right-hand side of the notch shall be rounded with a radius

\[ R_9 = 1,2 \text{ mm } \pm 0,2 \text{ mm} \]

When the shutter edge is moved to \( L_{37} \), a length of at least (\( L_{40} - L_{37} \)) of the notch shall be exposed. This enables a drive to confirm that the shutter is fully open.
10.3.10 **Mis-insert protections (see figure 10)**

The profile on the top of the case shall have two features to prevent the case from being inserted in the drive upside-down.

The first feature is a notch intended to capture and block the shutter opener of the drive if the case is loaded upside-down. It shall have a width from

\[ L_{44} = 4.6 \text{ mm} \pm 0.2 \text{ mm} \]

to

\[ L_{45} = 1.0 \text{ mm} \pm 0.2 \text{ mm} \]

and a depth

\[ L_{46} = 3.1 \text{ mm} \pm 0.2 \text{ mm} \]

below the top of the case.

The right-hand edge of the notch shall be

\[ L_{47} = 75.4 \text{ mm} \pm 0.2 \text{ mm} \]

above plane X.

The corners of this notch shall be rounded off by radii

\[ R_{10} = 0.3 \text{ mm max.} \]

\[ R_{11} = 0.5 \text{ mm} \pm 0.3 \text{ mm} \]

The second feature is a chamfer and a tooth. If the case is correctly loaded, the chamfer pushes aside a possible pawl in the side of the sledge of the drive. If the case is loaded upside-down, the pawl catches the tooth and prevents further insertion of the case. The tooth is formed by the ramp specified in 10.3.10. The chamfer shall have an angle

\[ A_2 = 45^\circ \pm 2^\circ \]

and a height

\[ L_{48} = 5.0 \text{ mm} \pm 0.3 \text{ mm} \]

10.3.11 **Gripper slots (see figure 11)**

The case shall have two symmetrical gripper slots. The slot shall have a depth of

\[ L_{49} = 2.5 \text{ mm} \]

\[ +0.3 \text{ mm} \]

\[ -0.0 \text{ mm} \]

from the edge of the case and a width of

\[ L_{50} = 4.0 \text{ mm} \]

\[ +0.3 \text{ mm} \]

\[ -0.0 \text{ mm} \]

The lower edge of a slot shall be

\[ L_{51} = 23.0 \text{ mm} \]

\[ +0.0 \text{ mm} \]

\[ -0.3 \text{ mm} \]

above the bottom of the case.

The corners of the gripper slots shall be rounded off by radii

\[ R_{12} = 0.4 \text{ mm} \pm 0.2 \text{ mm} \]

\[ R_{13} = 0.5 \text{ mm} \pm 0.2 \text{ mm} \]
10.3.12 **Label area (see figure 12)**
The case shall have one connected label area on Side A, the bottom and Side B, with dimensions

\[
L_{52} = 4,0 \text{ mm} \pm 0,3 \text{ mm}
\]

\[
L_{53} = 76,0 \text{ mm} \pm 0,3 \text{ mm}
\]

\[
L_{54} = 30,0 \text{ mm} \pm 0,2 \text{ mm}
\]

and

\[
L_{55} = 1,2 \text{ mm} \pm 0,2 \text{ mm}
\]

The four corners of the area shall be rounded with a radius

\[
R_{14} = 2,0 \text{ mm} \text{ max.}
\]

When there is no label, the area shall be recessed by

\[
L_{56} = 0,2 \text{ mm} \text{ min. on all three sides.}
\]

10.4 **Mechanical characteristics**

All requirements of this clause shall be met in the operating environment.

10.4.1 **Material**
The case shall be constructed from any suitable materials such that it meets the requirements of this ECMA Standard.

10.4.2 **Mass**
The mass of the case without the optical disk shall not exceed 50 g.

10.4.3 **Edge distortion**
The cartridge shall meet the requirement of the edge distortion test defined in annex A.

10.4.4 **Compliance**
The cartridge shall meet the requirement of the compliance (flexibility) test defined in annex B. The requirement guarantees that a cartridge can be constrained in the proper plane of operation within the drive.

10.4.5 **Shutter opening force**
The spring force on the shutter shall be such that the force required to open the shutter does not exceed 1,5 N. It shall be sufficiently strong to close a free-sliding shutter, irrespective of the orientation of the case.
Figure 1 - General view of the case
Figure 3 - Overall dimensions, viewed on Side A
Figure 4 - Reference surfaces on Side A
Figure 6 - Functional Areas FA1 and FA2, seen on Side A and in cross-section
Figure 7 - Spindle and head windows on Side A (bottom) and B (top) of the case without shutter
Figure 8 - Shutter in just open position (top) and maximum open position (bottom). The dashed line indicates the position of the shutter edge when the shutter is closed.
Figure 9 - Path for the shutter opener, seen from Side B without shutter
Figure 10 - Mis-insert protections, seen from Side B of the case without shutter
Figure 11 - Gripper slots seen from Side B of the case without shutter
11 Dimensional, mechanical and physical characteristics of the disk

11.1 General description of the disk
The disk shall consist of a circular substrate with a hub on one side and a recording layer coated on the other side. The recording layer can be protected from environmental influences by a protective layer. The Information Zone of the substrate is transparent to allow an optical beam to focus on the recording layer through the substrate. The circular hub is in the centre of the disk on the side opposite to the recording layer. The hub interacts with the spindle of the drive, and provides the radial centring of the disk and the clamping force.

11.2 Reference axis and plane of the disk
Some dimensions of the hub are referred to a disk reference plane P. The disk reference plane P is defined by the perfectly flat annular surface of an ideal spindle onto which the clamping zone of the disk is clamped, and which is normal to the axis of rotation of this spindle. This axis A passes through the centre of the centre hole of the hub, and is normal to plane P.

11.3 Dimensions of the disk (see figure 13)
The dimensions of the disk shall be measured in the test environment. The dimensions of the disk in an operating environment can be estimated from the dimensions specified in this clause. The outer diameter of the disk shall be

\[ 86,0 \text{ mm} \pm 0,5 \text{ mm} \]

Excluding axial deflection (see 11.4.5), the total thickness of the disk without the hub shall not exceed 1,4 mm.

The diameter of the center hole of the disk without the hub shall be

\[ D_4 = 6,0 \text{ mm min.} \]

11.3.1 Hub dimensions (see figure 13)
The diameter of the centre hole of the hub shall be

\[ D_5 = 4,004 \text{ mm} \pm 0,012 \text{ mm} \]

The outer diameter of the hub shall be

\[ D_6 = 15,0 \text{ mm} \pm 0,2 \text{ mm} \]

The height of the hub shall be

\[ h_1 = 1,2 \text{ mm} \pm 0,2 \text{ mm} \]

The position of the top of the magnetizable surface shall be

\[ h_2 = 1,20 \text{ mm} \pm 0,15 \text{ mm} \]

The height of the centring hole above reference plane P shall be

\[ h_3 = 0,8 \text{ mm min.} \]

The centring length at a diameter \( D_5 \) shall be

\[ h_4 = 0,15 \text{ mm min.} \]

The lead-in edge of the centre hole shall have chamfer \( c_1 \) of 45° by 0,2 mm ± 0,1 mm or shall be rounded off by radius

\[ R_{15} = 0,2 \text{ mm} \pm 0,1 \text{ mm} \]

The outer edge of the centre hole shall have a chamfer \( c_2 \) of 45° by 0,4 mm ± 0,1 mm or shall be rounded off by radius
\[ R_{16} = 0.4 \text{ mm} \pm 0.1 \text{ mm} \]

The hub shall have any suitable magnetizable material for clamping the disk. Its dimensions shall be

\[ D_9 = 13.0 \text{ mm min.} \]

\[ D_{10} = 6.0 \text{ mm max.} \]

and its adsorbent force measured by the test device specified in annex K shall be in the range of 3.0 N to 4.5 N.

11.3.2 **Clamping zone (see figure 13)**

The outer diameter of the clamping zone shall be

\[ D_7 = 21.0 \text{ mm min.} \]

The inner diameter of the clamping zone shall be

\[ D_8 = 16.0 \text{ mm max.} \]

11.4 **Mechanical characteristics**

All requirements in this clause shall be met in the operating environment.

11.4.1 **Material**

The disk shall be made from any suitable materials such that it meets the requirements of this ECMA Standard. The only material properties specified by this ECMA Standard are the magnetic properties of the magnetizable zone in the hub (see 11.3.1) and the optical properties of the substrate in the Information Zone (see 11.5).
Figure 13 - Hub dimensions and clamping zone

11.4.2 Mass
The mass of the disk shall not exceed 24.0 g.

11.4.3 Moment of inertia
The moment of inertia of the disk relative to axis A shall not exceed 0.020 g·m².

11.4.4 Imbalance
The imbalance of the disk relative to axis A shall not exceed 0.006 g·m.

11.4.5 Axial deflection
The axial deflection of the disk is measured as the axial deviation of the recording layer. Thus it comprises the tolerances on the thickness of the substrate, on its index of refraction and the deviation of the entrance surface from plane P. The nominal position of the recording layer with respect to reference plane P is determined by the nominal thickness of the substrate.

The deflection of any point of the recording layer in the Information Zone from its nominal position, in a direction normal to plane P, shall not exceed ± 0.22 mm for rotational frequencies of the disk up to 30 Hz.
11.4.6 Axial acceleration

The maximum allowed tracking error $e_{\text{max}}$ (see annex C) shall not exceed $\pm 1.0 \, \mu m$, measured using the Reference Servo for axial tracking of the recording layer. The rotational frequency of the disk shall be $30.0 \, \text{Hz} \pm 0.18 \, \text{Hz}$. The stationary part of the motor is assumed to be motionless (no external disturbances). The measurement shall be made using a servo with the transfer function

$$H_s(i\omega) = \frac{1}{3} \left( \frac{\omega_0}{i\omega} \right)^{3} \frac{1+\frac{3i\omega}{\omega_0}}{1+\frac{i\omega}{3\omega_0}}$$

where

$\omega = 2\pi f$

$\omega_0/2\pi = 870 \, \text{Hz}$

$i = \sqrt{-1}$

or any other servo with $|1+H|\text{ within } 20\% \text{ of } |1+H_0|$ in the bandwidth of $30 \, \text{Hz}$ to $100 \, \text{kHz}$. Thus, the disk shall not require an axial acceleration of more than $10 \, \text{m/s}^2$ at low frequencies from the servo motor of the Reference Servo.

11.4.7 Radial runout

The radial runout of the tracks in the recording layer in the Information Zone is measured as seen by the optical head of the Reference Drive. Thus it includes the distance between the axis of rotation of the spindle and reference axis A, the tolerances on the dimensions between axis A and the location of the track, and effects of non-uniformities in the index of refraction.

The runout, defined as the difference between the maximum and minimum distance of the centre of any track from the axis of rotation, measured along a fixed radial line over one revolution of the disk, shall not exceed $50 \, \mu m$ at a rotational frequency of the disk of $30.0 \, \text{Hz} \pm 0.18 \, \text{Hz}$.

11.4.8 Radial acceleration

The maximum allowed tracking error $e_{\text{max}}$ (see annex C) shall not exceed $\pm 0.15 \, \mu m$, measured using the Reference Servo for radial tracking of the tracks. The rotational frequency of the disk shall be $30.0 \, \text{Hz} \pm 0.18 \, \text{Hz}$. The stationary part of the motor is assumed to be motionless (no external disturbances). The measurement shall be made using a servo with the transfer function

$$H_s(i\omega) = \frac{1}{3} \left( \frac{\omega_0}{i\omega} \right)^{3} \frac{1+\frac{3i\omega}{\omega_0}}{1+\frac{i\omega}{3\omega_0}}$$

where

$\omega = 2\pi f$

$\omega_0/2\pi = 1230 \, \text{Hz}$

$i = \sqrt{-1}$

or any other servo with $|1+H|\text{ within } 20\% \text{ of } |1+H_0|$ in the bandwidth of $30 \, \text{Hz}$ to $100 \, \text{kHz}$. Thus, the disk shall not require a radial acceleration of more than $3 \, \text{m/s}^2$ at low frequencies from the servo motor of the Reference Servo.

11.4.9 Tilt

The tilt is the angle which the normal to the entrance surface, averaged over an area of $1 \, \text{mm}$ in diameter, makes with the normal to plane P. It shall not exceed $5 \, \text{mrad}$ in the Information Zone.
11.5 Optical characteristics

11.5.1 Index of refraction
The index of refraction of the substrate in the Information Zone shall be within the range from 1.46 to 1.60.

11.5.2 Thickness of the substrate
The thickness of the substrate, from the entrance surface to the recording layer, in the Information Zone shall

\[ \frac{0.509 \times \frac{n^3}{n^2 - 1} \times \frac{n^2 + 0.265}{n^2 + 0.593}}{mm} \pm 0.050\ mm \]

where \( n \) is the index of refraction.

11.5.3 Birefringence
The effect of the birefringence of the substrate is included in the measurement of the imbalance of the signals in Channel 2 of the Reference Drive (see 25.2).

11.5.4 Reflectance
The reflectance of the recording layer is the value of the reflectance of an unrecorded, grooved area of the Data Zone of the disk, measured through the substrate and does not include the reflectance of the entrance surface. The nominal value \( R \) of the reflectance shall be specified by the manufacturer in byte 3 and byte 19 of the Control Tracks (see annex F).

The value of \( R \) at the wavelength specified in 9.2 shall lie within the range from 0.12 to 0.25 for partially embossed or fully rewritable disks and for low reflectance fully embossed disks. The value of \( R \) shall lie within the range from 0.50 to 0.90 for high reflectance fully embossed disks (see annex R).

The measured value \( R_m \) shall be obtained under conditioned a) to f) of clause 9.2. Measurement shall be made in the Data Zone in any track without embossed data fields. At any point in the Data Zone of disks with the value \( R \) in the Control Track, the value \( R_m \) shall be equal to \( R(1 \pm 0.15) \) and lie within the allowed range. At any point in the Data Zone of one disk, the following requirement shall be met, (see annex R).

\[ \frac{(I_{OL_{max}} - I_{OL_{min}})}{(I_{OL_{max}} + I_{OL_{min}})} \leq 0.12 \]

See clause 20.3 for the definition of \( I_{OL} \).

12 Interface between cartridge and drive

12.1 Clamping method
When the cartridge is inserted into the drive, the shutter of the case is opened and the drive spindle engages the disk. The disk is held against the spindle by an axial clamping force, provided by the magnetizable material in the hub (see annex K) and the magnets in the spindle. The radial positioning of the disk is provided by the centring of the axis of the spindle in the centre hole of the hub. A cup-shaped turntable of the spindle shall support the disk in its clamping zone, determining the axial position of the disk in the case.

12.2 Clamping force
The clamping force exerted by the spindle on the hub shall not exceed 5 N.

12.3 Capture cylinder (see figure 14)
The capture cylinder is defined as the volume in which the spindle can expect the centre of the hole in the hub to be, just prior to capture, with the cartridge constrained as in 10.4.4. The centre of the hole is defined as the point on axis A at a distance \( a_1 \) below plane P (see 11.3.1 and figure 13).

The size of the cylinder defines the permissible play of the disk inside its cavity in the case. The cylinder is referred to perfectly located and perfectly sized alignment and location pins in the drive; it includes the tolerances of those dimensions of the case and the disk which are between the two pins mentioned and the centre of the hub.

The bottom of the cylinder is parallel to plane Z, and shall be located a distance
\( L_{57} = 0.7 \text{ mm min.} \)

above plane Z. The top of the cylinder is located a distance
\( L_{58} = 2.3 \text{ mm max.} \)

above plane Z. The radius of the cylinder shall be
\( R_{17} = 1.4 \text{ mm max.} \)

and its centre shall be given by the nominal values of \( L_{29} \) and \( L_{32} \) in the drive.

12.4 **Disk position in operating condition (see figure 14)**

When the disk is in the operating condition within the drive, the position of plane \( P \) of the disk shall be
\( L_{59} = 2.4 \text{ mm} \pm 0.1 \text{ mm} \)

above plane Z of the case, and the axis of rotation shall be within a circle with a radius
\( R_{18} = 0.1 \text{ mm max.} \)

and a centre given by the nominal values of \( L_{29} \) and \( L_{32} \).

The torque to be exerted on the disk in the operating condition in order to maintain a rotational frequency of 30 Hz shall not exceed 0.01 N\( \cdot \)m.
Figure 14 - Capture cylinder and disk position in operating condition
Section 3 - Format of information

13 Geometry of physical tracks

13.1 Track shape

The Information Zone shall contain tracks intended for the Continuous Servo tracking method.

A physical track consists of one revolution of the disk of a groove-land-groove combination, where each groove is shared with a neighboring physical track. A groove is a trenchlike feature, the bottom of which is located nearer to the entrance surface of the disk than is the land. The centre of the physical track, i.e. where the recording is made, is the centre of the land. The grooves shall be continuous. The shape of the groove is determined by the requirements in clause 21.

This ECMA Standard distinguishes between physical and logical tracks. A physical track forms a 360° turn of a continuous spiral. A logical track comprises a fixed number of consecutive sectors; it may form part of a physical track but it may also extend over more than one physical track.

13.2 Direction of track spiral

The disk shall rotate counter-clockwise as viewed from the optical head. The physical track shall spiral outward from the inner diameter to the outer diameter.

13.3 Physical track pitch

The Physical Track Pitch is the distance between adjacent track centrelines, measured in a radial direction. It shall be 1.39 µm ± 0.08 µm.

The width of a band of 10 000 tracks shall be 13.90 mm ± 0.10 mm.

14 Track format

14.1 Track number

Each logical track shall be identified by a track number. Unless otherwise stated, all track numbers refer to logical tracks only. Both logical track 0 and physical track 0 shall begin with sector 0 of track 0.

Track 0 shall be the first track of the Data Zone. It shall be located at a radius of 22.90 mm ± 0.10 mm.

The track numbers located at radii larger than that of track 0 shall be increased by 1 for each track.

The track numbers located at radii smaller than that of track 0 shall be negative, and decrease by 1 for each track. Their value is given in the ID field of the Header in TWOs complement notation, thus track -1 is indicated by (FFFF).

14.2 Track layout

Physical tracks shall be grouped into a number of Bands, (see 18.0 and Tables 2 and 3).

Within each of these Bands there shall be a fixed number of sectors in each physical track. This number ranges from 21/38 to 38/70 for the different Bands.

There shall be 25 sectors in each logical track.

For disks with 1 024-byte sectors, each sector shall comprise 1 349 bytes. A byte is represented on the disk by 9 Channel bits. Hence, the length of one Channel bit is determined by the requirement that there are (21 to 38) x 1

\[ 349 \times 9 = 254 \, 961 \] to 461 358 Channel bits in a physical track. The sectors shall be equally spaced over a track in such a way that the distance between the first Channel bit of a sector and the first Channel bit of the next sector shall be 9 216 Channel bits ± 3 Channel bits.

For disks with 512-byte sectors, each sector shall comprise 721 bytes. A byte is represented on the disk by 9 Channel bits. Hence, the length of one Channel bit is determined by the requirement that there are (38 to 70) x 721

\[ 9 = 246 \, 582 \] to 454 230 Channel bits in a physical track. The sectors shall be equally spaced over a track in such a way that the distance between the first Channel bit of a sector and the first Channel bit of the next sector shall be 6 525 Channel bits ± 3 Channel bits.
### Note

All calculations of the number of Channel bits in physical tracks do not include the Sector Mark, (SM), as this redundant frequency pattern is not written in GCR recording code and is not measured in Channel bit times. For all tracks in all bands the Sector Mark is written at a fixed frequency of 8,700 mHz.

### 14.3 Clock frequencies and periods

The nominal Channel clock frequency for each data band at the rotational speed of 30 Hz is shown in tables 2 and 3 below. These values are for reference only. The absolute frequency and period shall be adjusted so that there are the correct number of Channel bits in one physical track by the formulas below.

**For 1 024 byte sector format:**

\[(20 + B) \times 9 \times 1349 = \text{Number of Channel bits in each physical track}\]

where B= odd Data Band numbers > 1.

Even numbered Data Bands have the identical number of Channel bits as the preceding Band. Data Band 1 is a special case.

**For 512 byte sector format:**

\[(37 + \text{Data Band Number}) \times 9 \times 721 = \text{Number of Channel bits in each physical track}\]

### 14.4 Sector number

The sectors on a logical track shall be numbered consecutively from 0 to 24.
<table>
<thead>
<tr>
<th>Zone or Band</th>
<th>Nominal radius Start-end (mm)</th>
<th>Number of Sectors</th>
<th>Sectors per physical track</th>
<th>Number of logical tracks</th>
<th>Physical track number Start-end</th>
<th>Number of physical tracks per zone</th>
<th>Chan elk. MHz (1 800 rpm) Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Zone Aquire Zone Lead-in</td>
<td>22.60 - 22.65</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Focus</td>
<td>22.66 - 22.70</td>
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<td>N/A</td>
<td>N/A</td>
<td>-172 to -141</td>
<td>32</td>
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<td>22.71 - 22.74</td>
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<td>N/A</td>
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<td>N/A</td>
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<td>000 - 356</td>
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<td>357 - 731</td>
<td>375</td>
<td>7,932</td>
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<td>22</td>
<td>330</td>
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<td>375</td>
<td>8,118</td>
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<td>8 250</td>
<td>22</td>
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<td>1 107 - 1 481</td>
<td>375</td>
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<td>23</td>
<td>345</td>
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<td>375</td>
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<td>3 357 - 3 731</td>
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<td>3 732 - 4 106</td>
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<td>4 107 - 4 481</td>
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<td>27</td>
<td>405</td>
<td>4 482 - 4 856</td>
<td>375</td>
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<td>27</td>
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<td>5 232 - 5 606</td>
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<td>10 107 - 10 481</td>
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<td>10 482 - 10 856</td>
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<td>10 857 - 11 231</td>
<td>375</td>
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<tr>
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<td>11 232 - 11 606</td>
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<td>36</td>
<td>540</td>
<td>11 607 - 11 981</td>
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<td>37</td>
<td>555</td>
<td>12 357 - 12 731</td>
<td>375</td>
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<td>Test Zone Drives</td>
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<td>N/A</td>
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<td>12 916 - 13 015</td>
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<td>13 016 - 13 035</td>
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<td>Lead Out</td>
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<td>N/A</td>
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<td>13 036 - 13 115</td>
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</tr>
<tr>
<td>Zone or Band</td>
<td>Nominal radius Start-end (mm)</td>
<td>Number of Sectors</td>
<td>Sectors per physical track</td>
<td>Number of logical tracks</td>
<td>Physical track number Start-end</td>
<td>Number of physical tracks per zone</td>
<td>Chan Clk. MHz (1 800 rpm)</td>
</tr>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>22.70 - 22.70</td>
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<td>Drives</td>
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<td>N/A</td>
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<td>-116 to -017</td>
<td>100</td>
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<td>Inner Ct.</td>
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<td>15</td>
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<td>22.90 - 23.12</td>
<td>5 966</td>
<td>38</td>
<td>236.64</td>
<td>000 - 156</td>
<td>157</td>
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<td>23.12 - 23.67</td>
<td>15 600</td>
<td>39</td>
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<td>157 - 556</td>
<td>400</td>
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<td>23.67 - 24.24</td>
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<td>557 - 956</td>
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<td>24.24 - 24.77</td>
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<td>957 - 1 356</td>
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<td>24.79 - 25.35</td>
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<td>42</td>
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<td>1 757 - 2 156</td>
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<td>47</td>
<td>752</td>
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<td>5 757 - 6 156</td>
<td>400</td>
<td>10,537</td>
</tr>
<tr>
<td>Band 17</td>
<td>31.46 - 32.01</td>
<td>21 600</td>
<td>54</td>
<td>864</td>
<td>6 157 - 6 556</td>
<td>400</td>
<td>10,737</td>
</tr>
<tr>
<td>Band 18</td>
<td>32.01 - 32.57</td>
<td>22 000</td>
<td>55</td>
<td>880</td>
<td>6 557 - 6 956</td>
<td>400</td>
<td>10,941</td>
</tr>
<tr>
<td>Band 19</td>
<td>32.57 - 33.12</td>
<td>22 400</td>
<td>56</td>
<td>896</td>
<td>6 957 - 7 356</td>
<td>400</td>
<td>11,142</td>
</tr>
<tr>
<td>Band 20</td>
<td>33.13 - 33.68</td>
<td>22 800</td>
<td>57</td>
<td>912</td>
<td>7 357 - 7 756</td>
<td>400</td>
<td>11,348</td>
</tr>
<tr>
<td>Band 21</td>
<td>33.68 - 34.24</td>
<td>23 200</td>
<td>58</td>
<td>928</td>
<td>7 757 - 8 156</td>
<td>400</td>
<td>11,547</td>
</tr>
<tr>
<td>Band 22</td>
<td>34.24 - 34.79</td>
<td>23 600</td>
<td>59</td>
<td>944</td>
<td>8 157 - 8 556</td>
<td>400</td>
<td>11,750</td>
</tr>
<tr>
<td>Band 23</td>
<td>34.79 - 35.35</td>
<td>24 000</td>
<td>60</td>
<td>960</td>
<td>8 557 - 8 956</td>
<td>400</td>
<td>11,963</td>
</tr>
<tr>
<td>Band 24</td>
<td>35.35 - 35.90</td>
<td>24 400</td>
<td>61</td>
<td>976</td>
<td>8 957 - 9 356</td>
<td>400</td>
<td>12,154</td>
</tr>
<tr>
<td>Band 25</td>
<td>35.90 - 36.46</td>
<td>24 800</td>
<td>62</td>
<td>992</td>
<td>9 357 - 9 756</td>
<td>400</td>
<td>12,357</td>
</tr>
<tr>
<td>Band 26</td>
<td>36.46 - 37.02</td>
<td>25 200</td>
<td>63</td>
<td>1008</td>
<td>9 757 - 10 156</td>
<td>400</td>
<td>12,558</td>
</tr>
<tr>
<td>Band 27</td>
<td>37.02 - 37.57</td>
<td>25 600</td>
<td>64</td>
<td>1024</td>
<td>10 157 - 10 556</td>
<td>400</td>
<td>12,766</td>
</tr>
<tr>
<td>Band 28</td>
<td>37.57 - 38.13</td>
<td>26 000</td>
<td>65</td>
<td>1040</td>
<td>10 557 - 10 956</td>
<td>400</td>
<td>12,965</td>
</tr>
<tr>
<td>Band 29</td>
<td>38.13 - 38.68</td>
<td>26 400</td>
<td>66</td>
<td>1056</td>
<td>10 957 - 11 356</td>
<td>400</td>
<td>13,171</td>
</tr>
<tr>
<td>Band 30</td>
<td>38.68 - 39.24</td>
<td>26 800</td>
<td>67</td>
<td>1072</td>
<td>11 357 - 11 756</td>
<td>400</td>
<td>13,371</td>
</tr>
<tr>
<td>Band 31</td>
<td>39.24 - 39.80</td>
<td>27 200</td>
<td>68</td>
<td>1088</td>
<td>11 757 - 12 156</td>
<td>400</td>
<td>13,577</td>
</tr>
<tr>
<td>Band 32</td>
<td>39.80 - 40.35</td>
<td>27 600</td>
<td>69</td>
<td>1104</td>
<td>12 157 - 12 556</td>
<td>400</td>
<td>13,784</td>
</tr>
<tr>
<td>Band 33</td>
<td>40.35 - 40.83</td>
<td>28 940</td>
<td>70</td>
<td>958</td>
<td>12 557 - 12 999</td>
<td>342</td>
<td>13,982</td>
</tr>
<tr>
<td>Buffer</td>
<td>40.83 - 40.83</td>
<td>70</td>
<td>70</td>
<td>N/A</td>
<td>N/A</td>
<td>12 900 - 12 900</td>
<td>1</td>
</tr>
<tr>
<td>Outer Ct.</td>
<td>40.83 - 40.86</td>
<td>375</td>
<td>25</td>
<td>N/A</td>
<td>N/A</td>
<td>12 901 - 12 915</td>
<td>15</td>
</tr>
</tbody>
</table>

**Table 3 Parameters of the Zones, (512 Byte sector size)**
15 Sector format

15.1 Sector layout (data zone)

A sector shall comprise a Header and a Recording field in which 1024/512 user data bytes can be recorded. All sectors in the Data Zone shall be of the same size. The Header of each sector shall be written at the first time the data field is written. The Recording field can be empty or user-written. The length of the sector shall be 1349/721 bytes nominally. Tolerances allowed by 14.2 are taken up by the Buffer, i.e., the last field of the sector. The length of the Header field is 48 bytes and the length of the Recording field is 1301/673 bytes. All Data Zone sectors on a given disk shall be the same size.

The layout of a sector is shown in figures 15 and 16. The numbers under each field name indicate the length of the field in bytes. The Sector Mark, (SM) field is not written in GCR recording code and is a frequency pattern that may vary in length. Headers and Sector Marks in the Data Zone are written using the thermo-magnetic effect in GCR code.

<table>
<thead>
<tr>
<th>Track No.</th>
<th>ID No.</th>
<th>Sector No.</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

ID Field

<table>
<thead>
<tr>
<th>SM</th>
<th>GAP1</th>
<th>VFO1</th>
<th>A M</th>
<th>ID1</th>
<th>VFO2</th>
<th>A M</th>
<th>ID2</th>
<th>VFO2</th>
<th>A M</th>
<th>ID3</th>
<th>P A</th>
<th>GAP2</th>
<th>VFO3</th>
<th>Sync</th>
<th>Data Field</th>
<th>PA</th>
<th>Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>1</td>
<td>12</td>
<td>1</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>12</td>
<td>3</td>
<td>1259</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

Header
48 bytes

Recording Field
1301 bytes

Sector
1349 bytes

Figure 15 - Sector Field Layout, 1024 byte Sectors

* = Sector Mark not counted as part of sector byte count because it is a pattern.
<table>
<thead>
<tr>
<th>Track No.</th>
<th>ID No.</th>
<th>Sector No.</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**ID Field**

<table>
<thead>
<tr>
<th>SM</th>
<th>GAP1</th>
<th>VFO1 A</th>
<th>M</th>
<th>ID1 VFO2 A</th>
<th>M</th>
<th>ID2 VFO2 A</th>
<th>M</th>
<th>ID3 P</th>
<th>GAP2 VFO3 Sync</th>
<th>Data Field</th>
<th>PA</th>
<th>BUF</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>1</td>
<td>12</td>
<td>1</td>
<td>5 8 1 5 8 1</td>
<td>1</td>
<td>5 1 6 12 3</td>
<td>639</td>
<td>1</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 16 - Sector Field Layout, 512 Byte Sectors**

* = Sector Mark not counted as part of sector byte count because it is a pattern.

### 15.2 Sector Mark

The Sector Mark in the Data Zone shall consist of a pattern written by a drive that does not occur in GCR code nor in RLL 2,7 code and is intended to enable the drive to identify the start of the sector without recourse to a phase-locked loop. The Sector Mark is written at a fixed frequency of 8.7 MHz, independent of all zones or sector sizes for a disk rotating at 30 Hz. Sector Marks in zones other than the Data Zone are embossed.

The Sector Mark shall have a length of 80 Channel bits and shall consist of written, continuous long marks of different length followed by a one byte gap field. The timing pattern of the Sector Mark shall be as shown in figure 17, where \( T \) is the period of one Channel bit. The signal obtained from a mark is less than a signal obtained from no mark. The lead-in shall have the Channel bit pattern:

![Sector Mark Timing Pattern](image)

**Figure 17 - Pattern of the Sector Mark**
15.3 VFO fields

There shall be three VFO fields, (VFO₁, VFO₂, and VFO₃) in the Header and one, (VFO₃) in the Recording field to give the voltage-frequency-oscillator of the phase-locked loop of the read Channel Channel bit synchronization. The information in VFO₁ and VFO₃ shall have the same length of 108 Channel bits. Both VFO₂ fields shall have a length of 72 Channel bits. All VFO fields shall have the identical pattern.

The continuous Channel bit pattern for the VFO fields shall be:

VFO₁ + VFO₃: 118 Channel bits:1010101010101010................101010 (GCR)

VFO₂: 72 Channel bits:1010101010101010................101010 (GCR)

15.4 Address Mark (AM)

The Address Mark shall consist of a pattern that does not occur in GCR code nor in RLL 2,7 code. The field is intended to give the drive byte synchronization for the following ID field. It shall have a length of 9 Channel bits with the following pattern:

1100 0010 1

15.5 ID fields

The three ID fields shall each contain the address of the sector, i.e. the physical track number and the sector number of the sector, and CRC bytes. Each field shall consist of five bytes with the following contents:

1st and 2nd bytes MSB, LSB of the physical track number

3rd byte

bits 7 and 6 00 shall indicate the ID₁ field
            01 shall indicate the ID₂ field
            10 shall indicate the ID₃ field

bit 5 shall be set to ZERO

bits 4 to 0 sector number in binary notation

4th and 5th bytes CRC field containing the CRC bits computed over the first three bytes according to annex D.

15.6 Postambles (PA)

The Postamble field shall be equal in length to 9 Channel bits. There shall be a Postamble following ID₃ and a Postamble following the Data field. The Postamble is necessary to be able to start the following field in a predictable manner.

The Postamble Field shall have the following pattern:

1000 1000 1

15.7 Gap₁

Gap₁ shall be a field with a nominal length of 9 Channel bits. Its contents are not specified and shall be ignored on interchange, but shall not be embossed. It is the first field of the Recorded Header, and gives the drive some time for processing after it has finished reading the Sector Mark and before it has to erase, write or read the VFO₁ field.

15.8 Gap₂

Gap₂ shall be a field with a nominal length of 54 Channel bits. Its contents are not specified and shall be ignored on interchange, but shall not be embossed. It is the first field of the Recording field, and gives the drive some time for processing after it has finished reading the header and before it has to erase, write or read the VFO₃ field.

The length of Gap₂ has a tolerance of ± 4,5 Channel bits, i.e. the following VFO₂ field can start between 49,5 and 58,5 Channel bits after the Postamble. Moreover, it need not start exactly on a Channel bit position as extrapolated from the header. The tolerance is subtracted from the length of the Buffer field, e.g. a Gap length of 58,5 Channel bits results in a reduction of the Buffer length by 4,5 Channel bits.
15.9 Sync

The Sync field is intended to allow the drive to obtain byte synchronization for the following Data field. It shall have a length of 27 Channel bits and be recorded with the following Channel bit pattern:

1010 0011 1110 1100 0111 1000 111

15.10 Data field

The Data field is intended for recording user data. It shall have a length of 1259/639 bytes and shall comprise:

<table>
<thead>
<tr>
<th>Type of data</th>
<th>1 024 byte sector format</th>
<th>512 byte sector format</th>
</tr>
</thead>
<tbody>
<tr>
<td>User data</td>
<td>1 024 bytes</td>
<td>512 bytes</td>
</tr>
<tr>
<td>Not specified</td>
<td>12 bytes</td>
<td>4 bytes</td>
</tr>
<tr>
<td>CRC</td>
<td>4 bytes</td>
<td>4 bytes</td>
</tr>
<tr>
<td>ECC</td>
<td>160 bytes</td>
<td>80 bytes</td>
</tr>
<tr>
<td>Resync</td>
<td>59 bytes</td>
<td>39 bytes</td>
</tr>
</tbody>
</table>

The disposition of these bytes in the Data field with their 10-way/5-way interleave and the contents of the last three categories is specified in annex E.

15.10.1 User data bytes

The User data bytes are at the disposal of the user for recording information.

15.10.2 CRC and ECC bytes

The Cyclic Redundancy Check bytes and Error Correction Code bytes are used by the error detection and correction system to rectify erroneous data. The ECC is a Reed-Solomon code of degree 16, (1 024-byte sectors) or 5 (512-byte sectors). The sectors in the Control Zone shall always be 512 bytes long and have ECC degree 5. The bytes shall be as specified in annex E.

15.10.3 Resync bytes

The Resync bytes enable a drive to regain byte synchronization after a large defect in the Data field. Their location in the Data field shall be as specified in annex E. The content of the Resync bytes shall be the pattern:

1000 1000 1

15.10.4 Buffer field

The Buffer field shall have a length of 189/108 Channel bits ± 27 Channel bits and shall not contain any data. The tolerance is needed for four reasons. Firstly, the tolerance on the header-to-header distance as specified in 14.1. Secondly, the tolerance in the start of the VFO₃ field as specified in 14.5. Thirdly, the actual length of the written data, as determined by the runout of the track and the speed variations of the disk during writing of the data. Fourthly, erasing these entire written data whose length has the tolerance explained above, (see 14.2 and 15.7).

16 Recording code

The 8-bit bytes in the three Address fields and in the Data field, except for the Resync bytes, shall be converted to Channel bits on the disk according to annex S. All other fields in a sector have already been defined in terms of Channel bits. Each ONE Channel bit shall be recorded as a mark produced by a write pulse of the appropriate power and width.

The recording code used to record all data in the Information Zone on the disk shall be the code known as GCR. All 8 bit byte to 9 bit GCR code conversions are shown in annex S.

The coding shall start at the first bit of the first byte of the field to be converted. After a Resync field the GCR coding shall start again with the first bit of the next byte of input data.
17 Format of the Information Zone

17.1 General description of the Information Zone

The Information Zone shall contain all information on the disk relevant for data interchange. The information comprises embossed tracking provisions, embossed headers and embossed data for the Control Zones and headers written by a drive and user data in the Data Zone. In this clause, the term 'data' is reserved for the content of the data field of a sector, which in general is transferred to the host system. This clause defines the layout of the information; the characteristics of signals obtained from this information are specified in section 4.

17.2 Division of the Information Zone

The Information Zone is divided into three parts; a Lead-in Zone, a Data Zone and a Lead-out Zone. The Data Zone is intended for the recording of user data. The lead-in and Lead-out Zones contain control information for the drive and zones for performing tests by the manufacturer or the drive.

The division of the Information Zone shall be as given in Tables 2 and 3. The tolerance on the inner radius of the Data Zone is specified in 14.1; the tolerance on other radii is determined by the tolerance on the track pitch as specified in 13.3. The Data Zone shall have Header information for every sector written during the initialization and certification process. The Lead-in and Lead-out Zones have embossed header information in every sector, but no data recorded in the data field.

17.2.1 Initial Zone

The Initial Zone is intended to enable a drive to lock its axial tracking (focusing) servo. It shall have either a flat reflective layer, or such a layer with uninterrupted grooves over complete tracks as specified in clause 21 or such tracks with embossed Headers or any combination of the above.

17.2.2 Acquire Zone

The Acquire Zone shall consist of two parts, each containing embossed grooves and Headers. The first part shall be a band of Lead-in tracks with no data in the Recording fields of the sectors.

The second part shall be a band of focus tracks with a repeated RLL 2,7 Channel bit pattern 100100...embossed in the VFO3, SYNC and the data fields of each sector. These tracks are intended to enable a drive to remove focus offsets by maximizing the read signal from the Channel bit pattern.

17.2.3 Test Zones

There shall be an inner Test Zone and an outer Test Zone, each containing embossed grooves and Headers. Each of these zones shall consist of a Test Zone for drives and a Test Zone for the manufacturer.

The Test Zone for drives is intended for tests to set a drive's write power and shall not consist of embossed data. The tracks used for testing should be chosen from the Test Zone for drives in a random way so as to insure a gradual degradation of the zone due to use. Then each track in this Zone will remain representative of characteristics of tracks in the Data Zone of the disk.

The Test Zone for the manufacturer is intended for quality tests by the media manufacturer. The Test Zone for drives shall not be used by media manufacturers for testing as it may cause serious degradation of the zone.

17.2.4 Control Zones

There shall be an Inner Control Zone and an Outer Control Zone. Each Control Zone shall contain 15 physical tracks with embossed grooves, headers and sectors formatted according to Standard ECMA 201, clause 15, (RLL 2,7 modulation) and one track, called Buffer track with an embossed groove and headers according to clause 15 of Standard ECMA 201. In the Inner Control Zone, physical track -1 is the Buffer track, in the Outer Control Zone, physical track 12 900 is the Buffer track. The data fields of all sectors in the two Control Zones, except in the Buffer tracks, shall be identical and contain embossed control data for the drive. The control data in a data field is specified in annex F.

The recording fields of all sectors of the two Buffer tracks shall be without embossed data.

Note

For purposes of backwards compatibility, the Control Track information is always recorded in RLL 2,7 modulation and in accordance with Standard ECMA 201 rules for sector format. This is the only area on the media not recorded in GCR modulation.
17.2.5 Data Zone

The Data Zone shall contain embossed grooves. The headers and data fields can be user written or contain embossed data, in the format of clause 15. The layout of the Data Zone is specified in clause 18.

The data zone shall be divided into 35/33 bands numbered 1 to 35/33. The Bands shall comprise the physical tracks specified in tables 2 and 3. Within any band, the angular recording density shall be constant.

The data zone shall start with physical track 0 and end with physical track 12 899.

17.2.6 Buffer Zone

The Buffer Zone shall contain embossed grooves and Headers.

18 Format of the Data Zone

The Data Zone shall contain four Defect Management Areas (DMAs), two at the beginning of the zone and two at the end. The area between the two sets of DMAs is called the User Area. The User Area shall contain a Rewritable Zone.

The layout of the Data Zone and adjacent zones is shown in table 4, where the tracks marked R/W are rewritable.

Table 4 - Layout of the Data Zone, the Control Zones and the Buffer Tracks

<table>
<thead>
<tr>
<th>Zone or Area</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Zone</td>
<td>Inner Control Zone</td>
</tr>
<tr>
<td></td>
<td>Buffer Track</td>
</tr>
<tr>
<td></td>
<td>DMA1 Gap</td>
</tr>
<tr>
<td></td>
<td>DMA2</td>
</tr>
<tr>
<td>User Area</td>
<td>Rewritable Zone</td>
</tr>
<tr>
<td></td>
<td>DMA3 Gap</td>
</tr>
<tr>
<td></td>
<td>DMA4</td>
</tr>
<tr>
<td>Zone</td>
<td>Buffer Track</td>
</tr>
<tr>
<td></td>
<td>Outer Control Zone</td>
</tr>
</tbody>
</table>

18.1 Defect Management Areas (DMAs)

The four Defect Management Areas contain information on the structure of the Data Zone and on the defect management. The length of each DMA shall be 34 sectors. Two of the DMAs, DMA1 and DMA2, shall be located near the inner diameter of the disk; two others, DMA3 and DMA4, shall be located near the outer diameter of the disk. The logical track boundaries of the DMAs are indicated in tables 5 and 6.
Table 5 - Locations of the DMAs (1024-byte sector format)

<table>
<thead>
<tr>
<th></th>
<th>Beginning</th>
<th></th>
<th>Ending</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logical Track</td>
<td>Sector No.</td>
<td>Logical Track</td>
<td>Sector No.</td>
</tr>
<tr>
<td>DMA1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Reserved</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>DMA2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>DMA3</td>
<td>15023</td>
<td>17</td>
<td>15025</td>
<td>0</td>
</tr>
<tr>
<td>Reserved</td>
<td>15025</td>
<td>1</td>
<td>15025</td>
<td>23</td>
</tr>
<tr>
<td>DMA4</td>
<td>15025</td>
<td>24</td>
<td>15027</td>
<td>7</td>
</tr>
<tr>
<td>Reserved</td>
<td>15027</td>
<td>8</td>
<td>15027</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 6 - Locations of the DMAs, (512-byte sector format)

<table>
<thead>
<tr>
<th></th>
<th>Beginning</th>
<th></th>
<th>Ending</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logical Track</td>
<td>Sector No.</td>
<td>Logical Track</td>
<td>Sector No.</td>
</tr>
<tr>
<td>DMA1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Reserved</td>
<td>2</td>
<td>16</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>DMA2</td>
<td>3</td>
<td>18</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>DMA3</td>
<td>27969</td>
<td>0</td>
<td>27971</td>
<td>15</td>
</tr>
<tr>
<td>Reserved</td>
<td>27971</td>
<td>16</td>
<td>27973</td>
<td>4</td>
</tr>
<tr>
<td>DMA4</td>
<td>27973</td>
<td>5</td>
<td>27975</td>
<td>20</td>
</tr>
<tr>
<td>Reserved</td>
<td>27975</td>
<td>21</td>
<td>27975</td>
<td>24</td>
</tr>
</tbody>
</table>

Each DMA shall contain a Disk Definition Structure (DDS), a Primary Defect List, (PDL) and a Secondary Defect List (SDL). The contents of the four PDLs shall be identical and the contents of the four SDLs shall be identical. The only differences between the contents of the four DDSs shall be the pointers to each associated PDL and SDL.

After initialization of the disk, each DMA shall have the following content:

- The first DMA sector shall contain the DDS.
- The second DMA sector shall be the first sector of the PDL.
- The SDL shall be located immediately after the PDL.

The lengths of the PDL and SDL are determined by the number of entries in each.

The content of the DMA sectors following the SDL is not specified and shall be ignored in interchange. The bytes of the Data fields of the DMA sectors following the DDS shall be set to (FF).

The contents of the DDS are specified in 18.2, those of the PDL and SDL are specified in 19.1.7 and 19.1.8.
18.2 Disk Definition Structure (DDS)

The DDS shall consist of a table with a length of one sector. It specifies the method of initialization of the disk, the division of the rewritable zone into groups, and the start addresses of the PDL and SDL. The DDS shall be recorded in the first sector of each DMA at the end of initialization of the disk.

The following information on the disk structure shall be recorded in each of the four DDSs.

Table 7 - Byte Assignment of the DDS

<table>
<thead>
<tr>
<th>Byte</th>
<th>DDS Content</th>
<th>Mandatory settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>DDS Identifier</td>
<td>(0A)</td>
</tr>
<tr>
<td>1</td>
<td>DDS Identifier</td>
<td>(0A)</td>
</tr>
<tr>
<td>2</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>3</td>
<td>Disk has been certified</td>
<td>(01)</td>
</tr>
<tr>
<td></td>
<td>Disk has not been certified</td>
<td>(02)</td>
</tr>
<tr>
<td>4</td>
<td>Number of R/W Groups MSB</td>
<td>(00)</td>
</tr>
<tr>
<td>5</td>
<td>Number of R/W Groups LSB</td>
<td>(01)</td>
</tr>
<tr>
<td>6</td>
<td>Group 1 Type</td>
<td>(01)</td>
</tr>
<tr>
<td>7</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>8</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>9</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>10</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>11</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>12</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>13</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>14</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>15</td>
<td>Reserved</td>
<td>(00)</td>
</tr>
<tr>
<td>16</td>
<td>Start Address of PDL, Track MSB</td>
<td>-</td>
</tr>
<tr>
<td>17</td>
<td>Start Address of PDL</td>
<td>-</td>
</tr>
<tr>
<td>18</td>
<td>Start Address of PDL, Track LSB</td>
<td>-</td>
</tr>
<tr>
<td>19</td>
<td>Start Address of PDL, Sector</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>Start Address of SDL, Track MSB</td>
<td>-</td>
</tr>
<tr>
<td>21</td>
<td>Start Address of SDL</td>
<td>-</td>
</tr>
<tr>
<td>22</td>
<td>Start Address of SDL, Track LSB</td>
<td>-</td>
</tr>
<tr>
<td>23</td>
<td>Start Address of SDL, Sector</td>
<td>-</td>
</tr>
<tr>
<td>24</td>
<td>(00)</td>
<td>(00)</td>
</tr>
<tr>
<td>511</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In table 9,
the symbol hyphen (-) means that the appropriate value is to be entered in the DDS, and
"n.a." means "not applicable".

For bytes 6 to 15, the setting (01) means rewritable, (02) embossed and (00) not applicable.
18.3 Media types
This standard allows only media type R/W.
The user area of fully rewritable disks shall contain a Rewritable Zone. The Rewritable Zone is intended for the user to write data into. The sectors of this zone shall contain no embossed information, neither in the Headers nor in the Data fields.
The Rewritable Zone shall extend from sector 0 of logical track 5/8 to sector 3 of logical track 14 859/27 805. Every band shall be recorded in bytes 6 to 15 of the DDS as being rewritable.

18.4 Partitioning
During initialization of the disk, the Rewritable Zone shall be partitioned into 1 group of tracks and it shall span the entire user area, (371 371/694 929 sectors). It is followed by 4 096 spare sectors. The group shall comprise full logical tracks of data sectors followed by full logical tracks of spare sectors.

19 Defect management
19.1 Rewritable groups: Spare sectors
Defective Sectors in the Rewritable Zone shall be replaced by good sectors according to the defect management method described below. The disk shall be initialized before use. This ECMA Standard allows initialization with or without certification. Defective Sectors are handled by a Linear Replacement Algorithm and optionally, a sector Slipping Algorithm. The total number of Defective Sectors replaced shall not be greater than 4 096.

19.1.1 Initialization of the disk
During initialization of the disk, the four DMAs are recorded prior to the first use of the disk. The Rewritable Zone shall be partitioned into one group because the disk is fully rewritable, (371 371/694 929) Data Sectors and 4 096 Spare Sectors as specified in 18.4.1. The spare sectors can be used as replacements for defective data sectors. Initialization can include certification of the Rewritable Zone, in which defective sectors are identified and skipped.

All DDS parameters shall be recorded in the four DDS sectors. The PDL and SDL shall be recorded in the four DMAs.

19.1.2 Certification
If a disk is to be certified, the certification shall be applied to the data sectors and to the spare sectors in the rewritable group. The method of certification is not stated by this ECMA Standard. It may involve erasing, writing, and reading all sectors in the group. Defective sectors found during certification shall be handled by the Slipping Algorithm or, where applicable by the Linear Replacement Algorithm (see 19.1.3). Defective sectors shall not be used for reading or writing. Guidelines for replacing Defective sectors are given in annex G.

19.1.3 Slipping Algorithm
The Slipping Algorithm shall be applied to the entire rewritable group in the rewritable zone when ever certification is performed.

A defective data sector found during certification shall be replaced by the first good sector following the defective sector, and so causes a slip of one sector towards the end of the group. The last data sectors will slip into the spare sector area of the group. The address of the defective sector is written into the PDL. If no defective sectors are found during certification, an empty PDL is recorded.

The addresses of spare sectors, beyond the last data sector slipped into the spare area, (if any) which are found to be defective during certification shall be recorded in the PDL. Thus, the number of available spare sectors is diminished accordingly.

If the spare sector area of a group becomes exhausted during certification, the disk shall be deemed defective. The space sector area has 4 096 spare sectors ands once all of these are used, the disk is no longer capable of reliable operation.

19.1.4 Linear Replacement Algorithm
The Linear Replacement Algorithm is used to handle Defective Sectors found after certification.
The defective sector shall be replaced by the first available good spare sector of the group. If there are no spare sectors left in the group, the disk shall be deemed defective. The addresses of the defective sector and of the replacement sector shall be recorded in the SDL.

The addresses of sectors already recorded in the PDL shall not be recorded in the SDL.

If a replacement sector listed in the SDL is later found to be defective, it shall be dealt with by making a new entry in the SDL indicating a replacement sector for that defective sector.

19.1.5 Disks not certified

The Linear Replacement Algorithm is also used to handle sectors found defective on disks which have not been certified.

A defective sector shall be replaced by the first available good sector of the group. If there are no spare sectors left in the group, the disk shall be deemed defective. The addresses of the Defective Sector and of the Replacement Sector shall be recorded in the SDL.

If there exists a list of addresses of defective sectors in the PDL, these sectors shall be skipped for use even if the disk is not certified. This process is the same as the process specified in Clause 19.1.2 for certified disks.

19.1.6 Write procedure

When writing data in the sectors of a group, a Defective Sector listed in the PDL shall be skipped and the data shall be written in the next data sector, according to the Slipping Algorithm. If a sector to be written is listed in the SDL, the data shall be written in the spare sector pointed to by the entry in the SDL, according to the Linear Replacement Algorithm.

19.1.7 Primary Defect List, (PDL)

A PDL shall always be recorded; it may be empty.

Note

The disk formatted according to ECMA-201 may not have a PDL.

A list of defective sectors may be obtained by means other than certification of the disk.

The PDL shall contain the addresses of all defective sectors identified at initialization. The addresses shall be listed in ascending order. The PDL shall be recorded in the minimum number of sectors necessary, and it shall begin in the forth user data byte of the first sector. All unused bytes of the last sector in the PDL shall be set to (FF). The information in Table 10 shall be recorded in each PDL.

In the case of a multiple sector PDL, the list of addresses of the defective sectors shall continue with the first byte of the user area of the second and subsequent sectors. Thus, the PDL Identifier and the Number of Addresses of the PDL shall be present only in the first sector.

In an empty PDL bytes 2 and 3 shall be set to (00) and bytes 4 to 511 shall be set to (FF).
19.1.8 Secondary Defect List (SDL)

The Secondary Defect List (SDL) is created during initialization and used during and after certification. All disks with a Rewritable Zone shall have an SDL recorded during initialization.

The SDL shall contain entries in the form of addresses of defective data sectors and addresses of the spare sectors which replace them. Each entry in the SDL contains 8 bytes, viz. four each for the address of a defective sector and for the address of its replacement sector.

The list of addresses shall contain the addresses of the defective sectors and their replacement sectors. The addresses of the defective sectors shall be in ascending order.

The SDL shall be recorded in the minimum number of sectors necessary, and it shall begin in the 16th user data byte of the first sector. All unused bytes of the last sector of the SDL shall be set to (FF). Table 9 describes the information that shall be recorded in each of the four SDLs.

The addresses of sectors already recorded in the PDL shall not be recorded in the SDL.

If a replacement sector listed in the SDL is later found to be defective, a new entry shall be made in the SDL indicating a replacement sector for that defective sector.

In the case of a multiple-sector SDL, the list of addresses of defective and of replacement sectors shall continue with the first byte of the second and subsequent sectors. Thus, the contents of bytes 0 to 15 in table 9 shall be present only in the first sector.
<table>
<thead>
<tr>
<th>Byte</th>
<th>SDL Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(00), SDL Identifier</td>
</tr>
<tr>
<td>1</td>
<td>(02), SDL Identifier</td>
</tr>
<tr>
<td>2</td>
<td>(00)</td>
</tr>
<tr>
<td>3</td>
<td>(01)</td>
</tr>
<tr>
<td>4</td>
<td>List Length in bytes in the SDL, MSB</td>
</tr>
<tr>
<td>5</td>
<td>List Length in bytes in the SDL, LSB</td>
</tr>
<tr>
<td></td>
<td>(The list starts at byte 6)</td>
</tr>
<tr>
<td>6-7</td>
<td>(00)</td>
</tr>
<tr>
<td>8</td>
<td>(02)</td>
</tr>
<tr>
<td>9</td>
<td>(01)</td>
</tr>
<tr>
<td>10-13</td>
<td>(00)</td>
</tr>
<tr>
<td>14</td>
<td>Number of Entries in the SDL, MSB</td>
</tr>
<tr>
<td>15</td>
<td>Number of Entries in the SDL, LSB</td>
</tr>
<tr>
<td></td>
<td>(Each entry is 8 bytes long)</td>
</tr>
<tr>
<td>16</td>
<td>Address of the First Defective Sector (Track Number, MSB)</td>
</tr>
<tr>
<td>17</td>
<td>Address of the First Defective Sector (Track Number)</td>
</tr>
<tr>
<td>18</td>
<td>Address of the First Defective Sector (Track Number, LSB)</td>
</tr>
<tr>
<td>19</td>
<td>Address of the First Defective Sector (Sector Number)</td>
</tr>
<tr>
<td>20</td>
<td>Address of the First Replacement Sector (Track Number, MSB)</td>
</tr>
<tr>
<td>21</td>
<td>Address of the First Replacement Sector (Track Number)</td>
</tr>
<tr>
<td>22</td>
<td>Address of the First Replacement Sector (Track Number, LSB)</td>
</tr>
<tr>
<td>23</td>
<td>Address of the First Replacement Sector (Sector Number)</td>
</tr>
<tr>
<td>24</td>
<td>Address of the Last Defective Sector (Track Number, MSB)</td>
</tr>
<tr>
<td>25</td>
<td>Address of the Last Defective Sector (Track Number)</td>
</tr>
<tr>
<td>26</td>
<td>Address of the Last Defective Sector (Track Number, LSB)</td>
</tr>
<tr>
<td>27</td>
<td>Address of the Last Defective Sector (Sector Number)</td>
</tr>
<tr>
<td>28</td>
<td>Address of the Last Replacement Sector (Track Number)</td>
</tr>
<tr>
<td>29</td>
<td>Address of the Last Replacement Sector (Track Number, LSB)</td>
</tr>
<tr>
<td>30</td>
<td>Address of the Last Replacement Sector (Sector Number)</td>
</tr>
</tbody>
</table>

...
Section 4 - Characteristics of embossed information

20 Method of testing

The format of the embossed information on the disk is defined in clause 17. Clauses 21 to 23 specify the requirements for the signals from grooves and embossed data, as obtained when using the Reference Drive defined in clause 9.

Clauses 21 to 23 specify only the average quality of the embossed information. Local deviations from the specified values, called defects, can cause tracking errors, erroneous Headers or errors in the Data fields. These errors are covered by section 6.

20.1 Environment

All signals in clauses 21 to 23 shall be within their specified ranges with the cartridge in any environment in the range of allowed operating environments defined in 8.1.2.

20.2 Use of the Reference Drive

All signals specified in clauses 21 to 23 shall be measured in the indicated channels of the Reference Drive. The drive shall have the following characteristics for the purpose of these tests.

20.2.1 Optics and Mechanics

The focused optical beam shall have the properties defined in 9.2 a) to f). The disk shall rotate as specified in 9.5.

20.2.2 Read Power

For the wavelength of 780 nm, the optical power incident on the entrance surface of the disk (used for reading the information) shall be in the range from $1.0 \text{ mW}$ to $P_{\text{max}}$:

$$1.3 \text{ mW} \leq P_{\text{max}} \leq 1.7 \text{ mW}$$

$P_{\text{max}}$ shall be specified in bytes 21 and 135 of the Control Zone.

For other wavelengths the values for this range are not specified by this ECMA Standard.

Note

The recommended values for $P_{\text{max}}$ at other rotational frequencies are given in annex J.

20.2.3 Read Channels

The drive shall have a read Channel, in which the total amount of light in the exit pupil of the objective lens is measured. This Channel can have the implementation as given by Channel 1 in 9.1.

20.2.4 Tracking

During the measurement of the signals, the axial tracking error between the focus of the optical beam and recording layer shall not exceed

$$e_{\text{max}}(\text{axial}) = 0.8 \mu m$$

and the radial tracking error between the focus of the optical beam and the centre of a track shall not exceed

$$e_{\text{max}}(\text{radial}) = 0.09 \mu m$$

The radial tracking servo used for this measurement requires a higher performance than that specified in 11.4.8.

20.3 Definition of signals

All signals are linearly related to currents through a photo-diode detector, and are therefore linearly related to the optical power falling on the detector.

The signals from the two halves of the split photo-diode detector in the tracking Channel are indicated by $I_1$ and $I_2$. The signals in the tracking Channel are referenced to the signal $(I_1 + I_2)_{\text{OL}}$, which is the maximum level of the sum of the signals in the user zone when the beam crosses the tracks without embossed marks.
The signals in Channel 1 are referenced to the signal \( I_{OL} \), which is the signal in Channel 1 from an unrecorded, grooved area in the Information Zone.

Figure 18 shows the signals specified in clauses 21, 22 and 23.
Signals from grooves in the tracking channel

Signals from Headers in Channel 1

Signals from Recording fields in Channel 1

Figure 18 - Signals from embossed areas
21 **Signals from grooves**

The signals \((I_1 + I_2)\) and \((I_1 - I_2)\) shall be filtered in order that frequencies above 1 MHz are attenuated by at least 40 dB thereby eliminating the effect of modulation due to embossed marks. This condition shall not apply to the measurement of the signal \((I_1 + I_2)_{OL}\). The requirements in this clause for the signals refer to conditions in which the plane of polarization of the incident beam is parallel to the track.

The shape of the grooves and the embossed information shall be such that the following requirements are met (see annex R).

21.1 **Cross-track signal**

The cross-track signal is the sinusoidal sum signal \((I_1 + I_2)\) in the tracking Channel, when the focus of the optical beam crosses the tracks. The signal can be used by the drive to locate the centre of the tracks. The peak-to-peak value of the cross-track signal shall meet the following requirements:

a) in Control Tracks containing embossed headers and embossed Recording fields:

\[
0.14 \leq \frac{(I_1 + I_2)_{pp}}{(I_1 + I_2)_{OL}} \leq 0.59
\]

b) in Rewritable grooved areas in the Information Zone without embossed Recording fields:

\[
0.254 \leq \frac{(I_1 + I_2)_{pp}}{(I_1 + I_2)_{OL}} \leq 0.71
\]

The uniformity of the cross-track signal shall be such that the above ratio shall not vary by any more than 15% over any grooved area in the Information Zone without embossed Recording fields.

21.2 **Cross-track minimum signal**

The cross-track minimum signal is the minimum of the sum signal \((I_1 + I_2)_{min}\) in the tracking Channel, when the optical beam crosses the tracks.

The Cross-track minimum signal is obtained by the following formula.

\[
\text{Cross-track minimum} = 1 -(\text{Cross-track signal})
\]

21.3 **Push-pull signal**

The push-pull signal is the sinusoidal difference signal \((I_1 - I_2)\) in the tracking Channel, when the focus of the optical beam crosses the tracks. The signal can be used by the drive for radial tracking. The peak-to-peak value of the push-pull signal shall meet the following requirements:

a) in grooved areas with embossed data in the Information Zone:

\[
0.38 \leq \frac{(I_1 - I_2)_{pp}}{(I_1 + I_2)_{OL}} \leq 0.71
\]

b) in grooved areas in the Information Zone without embossed Recording fields:

\[
0.52 \leq \frac{(I_1 - I_2)_{pp}}{(I_1 + I_2)_{OL}} \leq 0.71
\]
21.4 Divided push-pull signal

The first term of the divided push-pull signal is the peak-to-peak amplitude derived from the instantaneous level of the differential output \((I_1 - I_2)\) from the split photodiode detector when the light beam crosses the unrecorded or preformatted data area of grooved tracks divided by the instantaneous level of the sum output \((I_1 + I_2)\) from the split photodiode detector when the light beam crosses these areas.

The second term of the divided push-pull signal is the ratio of the minimum peak-to-peak amplitude derived from the instantaneous level of the differential output \((I_1 - I_2)\) divided by the instantaneous level of the sum output \((I_1 + I_2)\) from the split photodiode detector when the light beam crosses the preformatted data area of grooved tracks to the maximum peak-to-peak amplitude derived from the instantaneous level of the differential output \((I_1 - I_2)\) divided by the instantaneous level of the sum output \((I_1 + I_2)\) from the split photodiode detector when the light beam crosses the preformatted data area of grooved tracks.

The split photodiode detector separator shall be parallel to the projected track axis. In this measurement, the \(I_1\) and \(I_2\) signals shall be provided by the split photodiode detector. The tracking servo shall be operating in open-loop mode during this measurement.

The first term shall meet the following requirements:

\[
0,74 \leq \left( \frac{I_1 - I_2}{I_1 + I_2} \right)_{pp} \leq 1,05
\]

The second term shall satisfy:

\[
\frac{\left( \frac{I_1 - I_2}{I_1 + I_2} \right)_{pp\min}}{\left( \frac{I_1 - I_2}{I_1 + I_2} \right)_{pp\max}} \geq 0,7
\]

21.5 Phase depth

The phase depth of the grooves shall be less than 180°.

21.6 Track location

The tracks are located at those radii on the disk where the push-pull signal equals 0 and the cross-track signal has its maximum value.

22 Signals from embossed Headers

The signals from recorded Headers in the Data Zone shall meet the same requirements specified in clause 21 as Headers in the Data Zone are not embossed in this format. Headers and data fields in the Control Zone are embossed.

The signals from embossed headers shall be measured in Channel 1 of the Reference Drive.

The signal from an embossed mark in the recording layer is defined as the peak-to-peak value of the modulation of the signal in Channel 1 caused by the mark when the beam follows a track in the Control Zone (see annex R).

The level of all signals from embossed marks shall be lower than \(I_{OL}\).

22.1 Embossed Sector Mark

The signal ISM from the embossed sector mark shall meet the following requirements:

\[
I_{SM}/I_{OL} \geq 0,55
\]

22.2 Embossed VFO\(_1\) and VFO\(_2\) Fields

The signal \(I_{vfo}\) from the marks in the VFO\(_1\) and VFO\(_2\) fields shall meet the following requirements:

\[
I_{vfo}/I_{OL} \geq 0,15
\]
In addition the condition
\[
I_{vfo} I_{hmax} \geq 0.35
\]
shall be satisfied within each header, where \( I_{hmax} \) is the maximum signal from marks of that header in the fields defined in 23.3.

22.3 Embossed Address Mark, ID and Postamble

The signal \( I_h \) from marks in the Address Mark, ID and Postamble fields shall meet the following requirements:
\[
I_h / I_{OL} \geq 0.15
\]
\[
I_{hmin} / I_{hmax} \geq 0.35
\]

The last requirement applies over any embossed Header. \( I_{Hin} \) and \( I_{Hax} \) are the signals with minimum and maximum amplitude in those fields of a sector mentioned above.

23 Signals from embossed Recording fields

The Control Zone of the disk is always embossed. The Recording field of all sectors in this Zone shall contain embossed marks. The signals from these marks shall be measured in Channel 1 (see 9.1 and annex R). Acceptable defects of the marks are specified in section 6. The signal from all embossed Recording fields is defined as the peak-to-peak value of the modulation of the signal.

The signal \( I_d \) from marks in the Recording fields of the Embossed Zone shall meet the following requirements:
\[
I_d / I_{OL} \geq 0.17
\]
\[
I_{dmin} / I_{dmax} \geq 0.35
\]

The last requirement applies over Recording fields. \( I_{dmin} \) and \( I_{dmax} \) are the signals with minimum and maximum amplitude in the Recording field of a sector.

For the Focus tracks in the Acquire Zone, only \( I_d / I_{OL} \) is defined.
Section 5 - Characteristics of the recording layer

24 Method of testing
Clauses 25 to 27 describe a series of tests to assess the magneto-optical properties of the recording layer, as used for writing and erasing data. The tests shall be performed only in the Recording field of the sectors in the Rewritable Zone. If there is no Rewritable Zone for user recording, clauses 26 to 28 shall not apply. The write, read and erase operations necessary for the tests shall be made on the same Reference Drive (see also annex J).

Clauses 25 to 27 specify only the average quality of the recording layer. Local deviations from the specified values, called defects, can cause write or erase problems. These defects are covered by section 6.

24.1 Environment
All signals in clauses 25 to 27 shall be within their specified ranges with the cartridge in any environment in the range of allowed operating environments defined in 8.1.2.

24.2 Reference Drive
The write and erase tests described in clauses 25 to 27 shall be measured in Channel 2 of the Reference Drive. The drive shall have the following characteristics for the purpose of these tests.

24.2.1 Optics and mechanics
The focused optical beam shall have the properties defined in 9.2 a) to f). The disk shall rotate as specified in 9.5.

24.2.2 Read power
The optical power incident on the entrance surface of the disk and used for reading the information shall be in the range from 1,4 mW to 1,6 mW ($P_{\text{max}}$).

24.2.3 Read Channel
The Reference Drive shall have a read Channel which can detect magneto-optical marks in the recording layer. This Channel shall have an implementation equivalent to that given by Channel 2 in 9.3.

24.2.4 Tracking
During the measurement of the signals, the focus of the optical beam shall follow the tracks as specified in 20.2.4.

24.3 Write conditions
Marks are written on the disk by pulses of optical power superimposed on a bias power, in the presence of a magnetic field.

24.3.1 Write pulse
The shape of the write pulse shall be as given in figure 19. Figure 20 defines the relationship between the Write pulse signals and the signals for encoded Data, Write clocks and idealized marks on the media.

24.3.2 Write power and pulse width
The write power is the optical power incident on the entrance surface of the disk and used for writing marks.

The bias power $P_b$ shall be set between 0,9 mW and 1,1 mW.

The tests shall be carried out at a temperature of 23 °C ± 2 °C, at either

- one of the two constant pulse widths $T_p$ and a write power $P_w$ appropriate to the bands, as given in bytes 22 to 27 and 136 to 141 of the Control data (see annex F).
- a constant pulse power $P_w$ given in bytes 31 and 145, and a pulse width appropriate to the bands given in bytes 32 to 34 and 146 to 148 respectively, of the Control data (see annex F).

For bands other than those specified the values shall be linearly interpolated. The actual power and pulse width used shall be within ± 5 % of those selected.
For other temperatures, the values should be compensated as shown in annex J, in which recommended maximum write powers for two optional rotational frequencies are also shown.

The required write power shall not exceed

\[
K \left( \frac{1}{T_p} + \frac{1}{\sqrt{T_p}} \right) \text{mW for } 10 \text{ ns} \leq T_p \leq 44 \text{ ns}
\]

\[ \begin{align*}
K &= 24.0 \text{ at radius 24.0 mm} \\
K &= 27.5 \text{ at radius 40.0 mm} \\
T_p &= 20 \text{ n sec} \pm 5\%
\end{align*} \]

24.3.3 Write magnetic field

The requirements of all tests shall be met for all magnetic field intensities at the recording layer during writing in the range from 16 000 A/m to 32 000 A/m.

The write magnetic field, pointing in the North to South direction, shall be within 15° from the normal to the disk reference plane P, in the direction of the incident beam, i.e. from the entrance surface to the recording layer.

![Diagram of write pulse](image)

- \( P_w \): write power
- \( P_b \): bias power
- \( T_r \): rise time
- \( T_f \): fall time
- \( T_p \): write pulse width
- \( P \): \( P_w - P_b \)

**Figure 19 Shape of write pulse**

The rise and fall times \( T_r \) and \( T_f \) shall each be less than \((0.1 \times T_p + 5)\) ns.
Raw data = AD (H)
Raw Data = 1010 1101 (Binary)

GCR Data 1 0 1 0 1 1 1 0 1
WRT CLK
GCR DATA (NRZI)
WRITE Pulse (Laser Pulse)
Marks (idealized)

Figure 20 - Relationship of Write Pulse to data and marks

24.4 **Erase conditions**

Marks are erased from the disk by a constant optical power in the presence of a magnetic field.

24.4.1 **Erase power**

The erase power is the optical power incident on the entrance surface of the disk and used for erasing marks. The erase power shall not exceed the value calculated according to the formula in 24.3.2.

The tests shall be carried out at a temperature of 23 °C ± 2 °C and with an erase power appropriate to the radius given in bytes 45 to 47 and 159 to 161 of the Control data (see annex F). For radii other than those specified the values shall be linearly interpolated. The actual power used shall be within ± 10% of that selected.

For other temperatures the values should be compensated as shown in annex J, in which recommended maximum erase powers for two optional rotational frequencies are also shown.

24.4.2 **Erase magnetic field**

The requirements of all tests shall be met for all magnetic field intensities at the recording layer during erasing in the range from 16 000 A/m to 32 000 A/m.

The erase magnetic field, pointing in the North to South direction, shall be within 15° from the normal to the disk reference plane P, in the direction of the reflected beam, i.e. from the recording layer to the entrance surface.

24.5 **Definition of signals**

The signals in Channel 2 are linearly related to the difference between the currents through the photo-diode detectors $K_1$ and $K_2$, and are therefore linearly related to the optical power falling on the detectors (see 9.1).

25 **Magneto-optical characteristics**

25.1 **Figure of merit**

The figure of merit $F$ of the recording layer is a measure of the magnitude of the signal obtained from magneto-optical marks. It is defined as $R \sin \theta \cos \beta$, where $R$ is the reflectance of the disk expressed as a decimal fraction, $\theta$ is the Kerr rotation of the optical polarization between a mark and no-mark, and $\beta$ is the ellipticity of the reflected beam, averaged over the aperture. The polarity of the figure of merit is defined to be negative for a
magneto-optical mark written in an Fe-rich Fe-Tb alloy recording layer with the write magnetic field in the
direction specified in 22.3.3. In this case the direction of the Kerr rotation is counter-clockwise as seen from the
incident beam.

The polarity and magnitude of the value of the figure of merit shall be as specified in byte 10 and 11 of the Control
data (see annex F). The figure of merit shall comply with

0.0025 < |F| < 0.0050

The measurement of the actual value Fm shall be made according to annex H. This value shall be within 12% of the
nominal value.

25.2 Imbalance of the magneto-optical signal

The imbalance of the magneto-optical signal is the d.c. offset of the signal from Channel 2 of the Reference Drive,
which can be due to birefringence of the substrate. The offset can be measured by writing marks on the disk in the
low-frequency region where the modulation transfer function of the optical system is one, as in annex H. One can
also use a series of marks that give a 50% duty cycle read signal. The offset is now the signal level halfway
between the extremes of the signal.

The imbalance shall be such that the offset in Channel 2 divided by the signal in Channel 1 shall not exceed 0.06 in
the Recording field of any sector in the Rewritable Zone. The imbalance shall be measured in a bandwidth from
d.c. to 40 kHz. The imbalance is specified for a Reference Drive with a beam splitter E with nominal values for the
reflectances, the phase retarder shall be in the neutral position (see 9.1).

26 Write characteristics

26.1 Resolution

The resolution is the ratio of the signal amplitude from a high-density pattern of marks to the signal amplitude from
a low-density pattern of marks. It shall be measured as follows.

Write two series of marks, 1T marks spaced 1T apart and 4T marks spaced 4T apart. The write conditions shall be
as specified in 24.3.

Read the signals in Channel 2 under the conditions specified in 24.2.2 and 24.2.3. IL is the peak-to-peak value of
the signal obtained from the widely spaced marks. IH is the peak-to-peak value of the signal obtained from the
narrowly spaced marks.

The resolution IH/IL shall not be less than 0.12 within any sector in the Rewritable Zone for all allowed values of
the write magnetic field. It shall not vary more than 0.2 over a track.

26.2 Narrow-band signal-to-noise ratio

The narrow-band signal-to-noise ratio is the ratio of the signal level to the noise level of a specified pattern,
measured in a 30 kHz bandwidth. It shall be determined as follows.

Write a series of marks 1T marks spaced 1T apart and 4T marks spaced 4T apart. The write conditions shall be as
specified in 24.3.

Read the Recording fields in Channel 2 under the conditions specified in 24.2.2 and 24.2.3, using a spectrum
analyser with a bandwidth of 30 kHz. Measure the amplitudes of the signal from the 1T pattern of marks and
spaces at the frequency appropriate to the band and the noise at this frequency as indicated in figure 21. The
narrow-band signal-to-noise ratio is

\[ 20 \log_{10} \left( \frac{\text{signal level}}{\text{noise level}} \right) \]

The narrow-band signal-to-noise ratio after correction for any instrumentation error shall be greater than 36 dB in
any sector in the Rewritable Zone for all allowed values of the write magnetic field and for all phase differences
between -15° and +15° in the optical system as defined in 9.1.
26.3 Cross-talk

The test on cross-talk shall be carried out on any group of five adjacent unrecorded tracks, designated \((n-2), (n-1), n, (n+1), (n+2)\), in the Rewritable Zone according to the following procedure:

- Erase the Recording field of each of the sectors in these tracks.
- Write a series of 1T marks spaced 1T apart in the Recording fields of the sectors in track \(n\). The write conditions shall be as specified in 24.3.
- Read the Recording fields of the sectors in the tracks \((n-1), n, (n+1)\) under the conditions specified in 24.2.2 and 24.2.3.

The cross-talk from a track \(n\) to track \((n-1)\) and to track \((n+1)\) shall be lower than -30 dB.

27 Erase characteristics

Procedure:

a) Write a series of 1T marks spaced 2T apart in the Recording fields of any series of sectors in the Rewritable Zone. The write conditions shall be as specified in 24.3.

b) Read the Recording fields under the conditions specified in 24.2.2 and 24.2.3, using a spectrum analyzer with a bandwidth of 30 kHz. Note the amplitude of the signal (as specified in 26.2).

c) Erase under the conditions specified in 24.4.

d) Repeat a) and c) 1 000 times.

e) Repeat a).

f) Repeat b); note the amplitude of the signal and the noise (as specified in 26.2).

g) Repeat c); note the amplitude of the residual signal of the written mark at the same frequency as in f).
Requirements:

1) The narrow-band signal-to-noise ratio calculated from the readings in f) shall be greater than 36 dB.

2) The residual signal in g) shall be less than -33 dB relative to the signal level of the written marks in b).
Section 6 - Characteristics of user data

28 Method of testing

Clauses 29 and 30 describe a series of measurements to test conformance of the user data on the disk with this ECMA Standard. It checks the legibility of both embossed and user-written data. The data is assumed to be arbitrary. The user-written data may have been written by any drive in any environment. The read tests shall be performed on the Reference Drive.

Whereas clauses 20 to 27 disregard defects, clauses 29 and 30 include them as an unavoidable deterioration of the read signals. The gravity of a defect is determined by the correctability of the ensuing errors by the error detection and correction circuit in the read Channel defined below. The requirements in clauses 29 and 30 define a minimum quality of the data, necessary for data interchange.

28.1 Environment

All signals in clauses 29 to 30 shall be within their specified ranges with the cartridge in any environment in the range of allowed operating environments defined in 8.1.2. It is recommended that before testing the entrance surface of the optical disk shall be cleaned according to the instructions of the manufacturer of the disk.

28.2 Reference Drive

All signals specified in clauses 29 to 30 shall be measured in the indicated channels of the Reference Drive. The drive shall have the following characteristics for the purpose of these tests:

28.2.1 Optics and mechanics

The focused optical beam shall have the properties already defined in 9.2 a) to f). The disk shall rotate as specified in 9.5.

28.2.2 Read power

The optical power incident on the entrance surface of the disk (used for reading the information) shall be in the range from 1.0 mW to $P_{\text{max}}$.

28.2.3 Read amplifiers

The read amplifiers after the photo-detectors in Channels 1 and 2 shall be as specified in 9.3.

28.2.4 Analog-to-binary converters

The signals from both read amplifiers shall be converted from analog-to-binary with a pulse width detector.

The converter for Channel 1 shall operate correctly for analog signals from embossed marks with amplitudes as determined by clauses 20 and 21.

The converter for Channel 2 shall operate correctly for analog signals from user-written marks with an amplitude as determined by clauses 25 and 26.

28.2.5 Error correction

Correction of errors in the data bytes shall be carried out by an error detection and correction system based on the definition in E.3 of annex E. There shall be an additional correction system for the embossed data, based on the Parity Sectors as defined in 19.2

28.2.6 Tracking

During measurement of the signals, the focus of the optical beam shall follow the tracks as specified in 20.2.4.

29 Minimum Quality of a Sector

This clause specifies the minimum quality of the Header and Recording field of a sector as required for interchange of the data contained in that sector. The quality shall be measured on the Reference Drive specified in 28.2.

A byte error occurs when one or more bits in a byte have a wrong setting, as detected by the ECC and/or CRC circuits.
29.1 Headers

29.1.1 Sector Mark
At least three of the five long marks of the Sector Mark shall have the timing specified in 15.2 and the signal amplitude shall not be less than that obtained from a series of 4T marks spaced 4T apart in that band.

29.1.2 ID fields
At least one of the three ID fields in a Header read in Channel 1 shall not have any byte errors, as checked by the CRC in the field.

29.2 User-written data
The user-written data in a sector as read in Channel 2 shall not contain any byte errors that cannot be corrected by the error correction defined in 28.2.5.

30 Data interchange requirements
A disk offered for interchange of data shall comply with the following requirements.

30.1 Tracking
The focus of the optical beam shall not jump tracks unintentionally.

30.2 User-written data
Any sector written in the Rewritable Zone that does not comply with 29.1 and 29.2 shall have been replaced according to the rules of the defect management as defined in clause 19.

30.3 Quality of disk
The quality of the disk is reflected in the number of replaced sectors in the Rewritable Zone. This ECMA Standard allows a maximum of 4 096 replaced sectors.
Annex A
(normative)

Edge distortion test

A.1 The distortion test checks if the case is free from unacceptable distortions and protrusions along its edges. The test is made by causing the cartridge to pass through the vertical slot of a gauge while applying a specified force including the gravitational pull.

A.2 The gauge shall be made of a suitable material, e.g. of chrome-plated carbon steel. The inner surfaces shall be polished to a surface finish of 5 µm peak-to-peak.

A.3 The dimensions shall be as follows (see figure A.1):

\[
\begin{align*}
L_a & = 96.0 \text{ mm min.} \\
L_b & = 91.0 \text{ mm } \pm 0.1 \text{ mm} \\
L_c & = 8.6 \text{ mm } +0.1 \text{ mm} -0.0 \text{ mm} \\
L_d & = 6.30 \text{ mm } \pm 0.01 \text{ mm} \\
L_e & = 6.80 \text{ mm min.}
\end{align*}
\]

A.4 When the cartridge is inserted vertically into the gauge, a vertical downward force $F_1$ of 0.8 N maximum applied to the centre of the top edge of the cartridge shall cause the cartridge to pass through the gauge.

Figure A.1 Distortion Gauge
Annex B
(normative)

Compliance test

B.1 The compliance test checks the flatness and flexibility of the case by forcing the four reference surfaces of the case into a plane. The test is made by placing the cartridge on the supports of a gauge and applying forces on the cartridge opposite to the supports.

B.2 The location of the four reference surfaces S1, S2, S3 and S4 is defined in 10.3.4 and figure 4.

B.3 The test gauge consists of a base plate on which four posts P1, P2, P3 and P4 are fixed so as to correspond to the four surfaces S1, S2, S3 and S4, respectively (see figure B.1). The dimensions are as follows (see figure B.2):

Posts P1 and P2

\[ D_a = 6.50 \text{ mm} \pm 0.01 \text{ mm} \]
\[ D_b = 3.50 \text{ mm} \quad +0.00 \text{ mm} \quad -0.02 \text{ mm} \]
\[ H_a = 1.0 \pm 0.1 \text{ mm} \]
\[ H_b = 2.0 \text{ mm max.} \]

Posts P3 and P4

\[ D_c = 5.50 \text{ mm} \pm 0.01 \text{ mm}. \]

The top area \((H_b - H_a)\) of posts P1 and P2 has a chamfer.

After assembly, the upper annular surfaces of the four posts shall lie between two horizontal planes spaced 0.01 mm apart.

B.4 The cartridge shall be placed with its reference surfaces onto the posts of the horizontal gauge. A vertical downward force \(F_c\) of 0.4 N shall be exerted on the cartridge opposite each of the four posts.

B.5 Requirements

Under the conditions of B.4, three of the four surfaces S1 to S4 shall be in contact with the annular surface of their respective posts, and any gap between the remaining surface S and the annular surface of its post shall not exceed 0.1 mm.
Figure B.1 - Compliance gauge

Figure B.2 - Detail of posts
Annex C
(informative)

Track deviation measurement

The deviation of a track from its nominal location is measured in the same way as a drive sees a track, i.e. through a tracking servo. The strength of the reference servo used for the test is in general less than the strength of the same servo in a normal drive. The difference in strength is intended for margins in the drive. The deviation of the track is related to the tracking error between the track and the focus of the optical beam, remaining after the reference servo. The tracking error directly influences the performance of the drive, and is the best criterion for testing track deviations.

The specification of the axial and radial track deviations can be described in the same terms. Therefore, this annex applies to both axial and radial track deviations.

C.1 Relation between requirements

The acceleration required by the motor of the tracking servo to make the focus of the optical beam follow the tracks on the disk (see 11.4.6 and 11.4.8) is a measure for the allowed deviations of the tracks. An additional measure is the allowed tracking error between the focus and the track (see 20.2.4). The relation between both is given in figure C.1, where the maximum allowed amplitude of a sinusoidal track deviation is given as function of the frequency of the deviation. It is assumed in the figure that there is only one sinusoidal deviation present at a time.

![Graph showing log(x_max) vs log(f)]

Figure C.1 - Maximum allowed amplitude of a single, sinusoidal track deviation

At low frequencies, the maximum allowed amplitude $x_{\text{max}}$ is given by

$$x_{\text{max}} = a_{\text{max}} / (2\pi f)^2,$$

where $a_{\text{max}}$ is the maximum acceleration of the servo motor. At high frequencies we have

$$x_{\text{max}} = e_{\text{max}},$$

where $e_{\text{max}}$ is the maximum allowed tracking error. The connection between both frequency regions is given in C.3.
C.2 Reference Servo

The above restriction of the track deviations is equal to the restriction of the track deviations for a Reference Servo. A Reference Servo has a well-defined transfer function, and reduces a single, sinusoidal track deviation with amplitude \( x_{\text{max}} \) to a tracking error \( \epsilon_{\text{max}} \) as in figure C.1.

The open-loop transfer function of the Reference Servo shall be

\[
H_s(i\omega) = \frac{1}{c} \times \left( \frac{\omega_0}{i\omega} \right)^2 \times \frac{1 + \frac{\omega_0}{i\omega}}{1 + \frac{1}{c\omega_0}}
\]  

(3)

Where \( i = \sqrt{-1} \), \( \omega = 2\pi f \) and \( \omega_0 = 2\pi f_0 \), with \( f_0 \) the 0 dB frequency of the open-loop function. The constant \( c \) gives the cross-over frequencies of the lead-lag network of the servo: the lead break frequency \( f = f_0 / c \) and the lag break frequency \( f_s = f_s \times c \). The reduction of a track deviation \( x \) to a tracking error \( \epsilon \) by the reference servo is given by

\[
\frac{\epsilon}{x} = \frac{1}{1 + H_s}
\]  

(4)

If the 0 dB frequency is specified as

\[
\omega_0 = \frac{a_{\text{max}}}{\epsilon_{\text{max}}}
\]  

(5)

then a low-frequency track deviation with an acceleration \( a_{\text{max}} \) will be reduced to a tracking error \( \epsilon_{\text{max}} \), and a high-frequency track deviation will not be reduced. The curve in figure C.1 is given by

\[
x_{\text{max}} = \epsilon_{\text{max}} \times |1 + H_s|
\]  

(6)

The maximum acceleration required from the motor of this reference servo is

\[
a_{\text{max}}(\text{motor}) = \epsilon_{\text{max}} \omega_0^2 \times |1 + H_s|
\]  

(7)

At low frequencies \( f < f_0 / c \) applies

\[
a_{\text{max}}(\text{motor}) = a_{\text{max}}(\text{track}) = \frac{\omega_0^2 \epsilon_{\text{max}}}{c}
\]  

(8)

Hence, it is permitted to use \( a_{\text{max}}(\text{motor}) \) as specified for low frequencies in 11.4.6 and 11.4.8 for the calculation of \( \omega_0 \) of a reference servo.

C.3 Requirement for track deviations

The track deviations shall be such that, when tracking with a Reference Servo on a disk rotating at the specified frequency, the tracking error shall not be larger than \( \epsilon_{\text{max}} \) during more than 12 \( \mu \)s.

The open-loop transfer function of the Reference Servo for axial and radial tracking shall be given by equation (3) within an accuracy such that \( 1 + H_s \) does not differ by more than \( \pm 20 \% \) from its nominal value in a bandwidth from 30 Hz to 100 kHz. The constant \( c \) shall be 3. The 0 dB frequency \( \omega_0 (2\pi) \) shall be given by equation (5), where \( a_{\text{max}} \) and \( \epsilon_{\text{max}} \) for axial and radial tracking are specified in 20.2.4, 11.4.6 and 11.4.8.

C.4 Measurement implementation

Three possible implementations for an axial or radial measurement system have been given below. \( H_s \) is the open-loop transfer function of the actual tracking servo of the drive, \( H_s \) is the transfer function for the Reference Servo as given in equation (3), \( x \) and \( y \) are the position of the track and the focus of the optical beam. \( \epsilon_s \) is the tracking error after a Reference Servo, which signal has to be checked according to the previous paragraph.
Figure C.2 - Implementation of a Reference Servo by filtering the track position signal with the reduction characteristics of the Reference Servo

Figure C.3 - Implementation of a Reference Servo by changing the transfer function of the actual servo

Figure C.4 - Implementation of a Reference Servo by changing the tracking error of the actual servo
The optimum implementation depends on the characteristics of $H_a$ and $H_e$. Good results for motors in leaf springs are often obtained by using separate circuits in a low and high frequency Channel. The implementation of figure C.2 is used in the low-frequency Channel, while that of figures C.3 or C.4 is used in the high-frequency Channel. The signals from both channels are added with a reversed cross-over filter to get the required tracking error. In the low-frequency Channel one can also use the current through the motor as a measure of the acceleration of the motor, provided the latter is free from hysteresis. The current must be corrected for the transfer function of the motor and then be converted to a tracking error with a filter with a transfer function $el_a = el(xo')$, derived from equation (4).
Annex D
(normative)

CRC for ID fields

The 16 check bits of the CRC of the ID field shall be computed over the first three bytes of this field. The generator polynomial shall be

\[ G(x) = x^{16} + x^{12} + x^5 + 1 \]

The residual polynomial is defined by

\[ R(x) = \left( \sum_{i=8}^{i=23} b_i x^i + \sum_{i=0}^{i=7} \bar{b}_i x^i \right) x^{16} \mod G(x) \]

where \( b_i \) denotes a bit of the first three bytes and \( \bar{b}_i \) an inverted bit. Bit \( b_{23} \) is the highest order bit of the first byte.

The contents of the 16 check bits \( c_k \) of the CRC are defined by

\[ R_c(x) = \sum_{k=0}^{k=15} c_k x^k \]

\( c_{15} \) is recorded in the highest order bit of the fourth byte in the ID field.
Annex E
(normative)

Format of the Data field of a sector

E.1 Contents of the Data field and Interleaving

The bytes in the Data field constitute an ordered sequence $A_n$. The elements of $A_n$ for a 1 024 byte sector are, depending on the value of $n$:

\begin{align*}
1 \leq n \leq 1024: & \quad A_n = D_n \quad \text{user data bytes} \\
1025 \leq n \leq 1036: & \quad A_n = F_m \quad \text{bytes with non-specified content} \\
1077 \leq n \leq 1040: & \quad A_n = C_k \quad \text{CRC check bytes} \\
1041 \leq n \leq 1200: & \quad A_n = E_{st} \quad \text{ECC check bytes},
\end{align*}

where

\begin{align*}
h &= \text{int} \left( \frac{n - 1025}{4} \right) + 1 \\
m &= [(n - 1025) \mod 4] + 1 \\
k &= n - 1036 \\
s &= [(n - 1041) \mod 10] + 1 \\
t &= \text{int} \left( \frac{n - 1041}{10} \right) + 1
\end{align*}

The notation $\text{int}[x]$ denotes the largest integer not greater than $x$.

Before the ECC and CRC bytes are calculated, the bytes in the Data field are ten-way interleaved. For that purpose, the first three sub-groups of $A_n$ are mapped onto a two dimensional matrix $B_{ij}$ with 104 rows and 10 columns. Thus for $1 \leq n \leq 1 040$:

\[ B_{ij} = A_n \]

where:

\begin{align*}
t &= 103 - \text{int} \left( \frac{n - 1}{10} \right) \\
j &= (n - 1) \mod 10
\end{align*}

The order of the user data bytes $D_n$ is the same as the order in which they are input into the controller of the drive, i.e. $D_1$ comes first. The Resync bytes are not included in $A_n$.

The elements of $A_n$ for a 512 byte sector are, depending on the value of $n$:

\begin{align*}
1 \leq n \leq 512: & \quad A_n = D_n \quad \text{user data bytes} \\
513 \leq n \leq 516: & \quad A_n = F_m \quad \text{bytes with non-specified content} \\
517 \leq n \leq 520: & \quad A_n = C_k \quad \text{CRC check bytes} \\
521 \leq n \leq 600: & \quad A_n = E_{st} \quad \text{ECC check bytes},
\end{align*}

where

\begin{align*}
m &= n - 512 \\
k &= n - 516
\end{align*}
\[ s = \left( \frac{n - 521}{5} \right) + 1 \]
\[ t = \text{int} \left( \frac{n - 521}{5} \right) + 1 \]

The notation \( \text{int}[x] \) denotes the largest integer not greater than \( x \); \( (x \mod y) \) denotes the remainder of the integer division \( x/y \).

The order of the user data bytes \( D_n \) is the same as the order in which they are input into the controller of the drive, i.e. \( D_1 \) comes first. The Resync bytes are not included in \( A_n \).

Before the ECC and CRC bytes are calculated, the bytes in the Data field are five-way interleaved. For that purpose, the first three sub-groups of \( A_n \) are mapped onto a two dimensional matrix \( B_{ij} \) with 104 rows and 5 columns. Thus for \( 1 \leq n \leq 520 \): \( B_{ij} = A_n \)

where
\[ i = 103 - \text{int} \left( \frac{n - 1}{5} \right) \]
\[ j = (n - 1) \mod 5 \]

E.2 CRC and ECC

E.2.1 General

The CRC and ECC shall be computed over the Galois field based on the primitive polynomial
\[ G_p(x) = x^8 + x^5 + x^3 + x^2 + 1 \]

E.2.2 CRC

The generator polynomial for the CRC bytes shall be
\[ G_c(x) = \prod_{i=1}^{139} (x + \alpha^i) \]

The four check bytes of the CRC shall be computed over the user data and the four \( F_m \) bytes. The information polynomial for a 1024 byte sector shall be
\[ I_c(x) = \left[ \sum_{i=1}^{103} \sum_{j=0}^{9} (B_{ij}) x^i \right] + \sum_{j=0}^{5} (B_{0,j}) x^0 \]

The elements of the field are \( \alpha^i = (\beta)^{88} \), where \( \beta \) is a primitive root of \( G_p(x) \). The value of the \( n \)-th bit in a byte is the coefficient of the \( n \)-th power of \( \beta \), where \( 0 \leq n \leq 7 \), when \( \beta \) is expressed on a polynomial basis.

The information polynomial for a 512 byte sector shall be
\[ I_c = \left[ \sum_{i=1}^{103} \sum_{j=0}^{4} B_{ij} x^i \right] + B_{0,0} x^0 \]

The contents of the four check bytes \( C_k \) of the CRC are defined by the residual polynomial
\[ R_c(x) = I_c(x) x^4 \mod G_c(x) \]

The storage locations for the coefficients of the polynomial are specified by
\[ R_c(x) = \sum_{k=4}^{k=k} C_k x^{4-k} \]
E.2.3 ECC

The primitive polynomial and the elements shall be as specified in E.2.1. The generator polynomial for the check bytes of the ECC shall be

\[ G_{E}(x) = \prod_{i=120}^{i=25} (x + \alpha^i) \]

This polynomial is self reciprocal. This property can be used to reduce the hardware size. The initial setting of the ECC register shall be all ZEROs. The bits of the computed check byte shall be inverted before they are encoded into Channel bits.

The 160 or 80 check bytes of the ECC shall be computed over the user data, the four \( F_m \) bytes and the four CRC bytes. The corresponding ten information polynomials shall be:

\[ I_{E_j}(x) = \sum_{i=0}^{i=103} (B_{ij})x^i \]

where \( 0 \leq j \leq 9 \) for 1K sectors or where \( 0 \leq j \leq 4 \) for 512-byte sectors.

The contents of the 16 check bytes \( E_{ij} \) for each polynomial \( I_{E_j}(x) \) are defined by the five residual polynomials

\[ R_{E_j}(x) = I_{E_j}(x)x^{16} \mod G_{E}(x) \]

The storage locations for the coefficients of the polynomials are specified by

\[ R_{E_j}(x) = \sum_{t=1}^{t=16} E_{(j+1)t}x^{16-t} \]

The bits of the computed check bytes shall be inverted before they are encoded into Channel bits, as indicated by the use of \( E \) in the above formula and \( E \) in table E.1.

E.3 Resync

The Resync fields shall be inserted in the Data field to prevent loss of byte synchronization and to limit the propagation of errors in the user data. Whilst they are numbered consecutively, all Resync fields are identical. They contain the following pattern in Channel bits which does not occur in user data

1000 1000 1.

For 1024-byte sectors, the Resync field \( RS_n \) shall be inserted between bytes \( A_{15n} \) and \( A_{15n+1} \), where \( 1 \leq n \leq 59 \).

For 512-byte sectors, the Resync field \( RS_n \) shall be inserted between bytes \( A_{20n} \) and \( A_{20n+1} \), where \( 1 \leq n \leq 39 \).

E.4 Recording Sequence

The bytes of the Data field shall be recorded on the disk immediately after the Sync field. Their order shall be according to the sequence \( A_n \) with the Resync bytes inserted as specified in E.3.

Table E.1 shows in matrix form the arrangement of the bytes. The sequence of recording is from left to right and top to bottom. The first three bytes \( SB_1, SB_2 \) and \( SB_3 \) form the Data Sync field, which precedes the Data field. The first 104 rows of the Data field contain 1024/512 bytes of user data, \( (D_n) \), 12 bytes with unspecified contents, \( (F_n) \) and 4 bytes of CRC data, \( (C_n) \). The last 16 rows contain the ECC check bytes.
Table E.1 - Data field configuration for 1024 byte Format. The indices \( i \) and \( j \) of bytes \( B_y \) are given along the sides of the matrix

<table>
<thead>
<tr>
<th>Column No. ( j \rightarrow )</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Row No. ( i ) ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB1</td>
<td>SB2</td>
<td>SB3</td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
<td>D4</td>
<td>D5</td>
<td>D6</td>
<td>D7</td>
<td>D8</td>
<td>D9</td>
</tr>
<tr>
<td>RS1</td>
<td>D11</td>
<td>D12</td>
<td>D13</td>
<td>D14</td>
<td>D15</td>
<td>D16</td>
<td>D17</td>
<td>D18</td>
<td>D19</td>
<td>D20</td>
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</tr>
<tr>
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<td>D21</td>
<td>D22</td>
<td>D23</td>
<td>D24</td>
<td>D25</td>
<td>D26</td>
<td>D27</td>
<td>D28</td>
<td>D29</td>
<td>D30</td>
<td>101</td>
</tr>
<tr>
<td>RS3</td>
<td>D31</td>
<td>D32</td>
<td>D33</td>
<td>D34</td>
<td>D35</td>
<td>D36</td>
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<td>D39</td>
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</tr>
<tr>
<td>RS4</td>
<td>D41</td>
<td>D42</td>
<td>D43</td>
<td>D44</td>
<td>D45</td>
<td>D46</td>
<td>D47</td>
<td>D48</td>
<td>D49</td>
<td>D50</td>
<td>99</td>
</tr>
<tr>
<td>RS5</td>
<td>D51</td>
<td>D52</td>
<td>D53</td>
<td>D54</td>
<td>D55</td>
<td>D56</td>
<td>D57</td>
<td>D58</td>
<td>D59</td>
<td>D60</td>
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</tr>
<tr>
<td>RS6</td>
<td>D61</td>
<td>D62</td>
<td>D63</td>
<td>D64</td>
<td>D65</td>
<td>D66</td>
<td>D67</td>
<td>D68</td>
<td>D69</td>
<td>D70</td>
<td>97</td>
</tr>
</tbody>
</table>

104 Rows

| RS49 | D981 | D982 | D983 | D984 | D985 | D986 | D987 | D988 | D989 | D990 | 5 |
| RS50 | D991 | D992 | D993 | D994 | D995 | D996 | D997 | D998 | D999 | D1000 | 4 |
| RS51 | D1001 | D1002 | D1003 | D1004 | D1005 | D1006 | D1007 | D1008 | D1009 | D1010 | 3 |
| RS52 | D1011 | D1012 | D1013 | D1014 | D1015 | D1016 | D1017 | D1018 | D1019 | D1020 | 2 |
| RS53 | D1021 | D1022 | D1023 | D1024 | F1 | F2 | F3 | F4 | F5 | F6 | 1 |
| RS54 | F7 | F8 | F9 | F10 | F11 | F12 | C1 | C2 | C3 | C4 | 0 |

16 Rows

| RS55 | E1,1 | E2,1 | E3,1 | E4,1 | E5,1 | E6,1 | E7,1 | E8,1 | E9,1 | E10,1 | -1 |
| RS56 | E1,2 | E2,2 | E3,2 | E4,2 | E5,2 | E6,2 | E7,2 | E8,2 | E9,2 | E10,2 | -2 |
| RS57 | E1,3 | E2,3 | E3,3 | E4,3 | E5,3 | E6,3 | E7,3 | E8,3 | E9,3 | E10,3 | -3 |

| RS58 | E1,14 | E2,14 | E3,14 | E4,14 | E5,14 | E6,14 | E7,14 | E8,14 | E9,14 | E10,14 | -14 |
| RS60 | E1,16 | E2,16 | E3,16 | E4,16 | E5,16 | E6,16 | E7,16 | E8,16 | E9,16 | E10,16 | -16 |
Table E.2 Data field Configuration for 512 byte format.
The indices $i$ and $j$ of bytes $B_{ij}$ are given along the sides of the matrix.

<table>
<thead>
<tr>
<th>Column no. $j \rightarrow$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Row No. $i \downarrow$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB1</td>
<td>SB2</td>
<td>SB3</td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
<td>D4</td>
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<td>D6</td>
<td>D7</td>
<td>D8</td>
<td>D9</td>
<td>D10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D11</td>
<td>D12</td>
<td>D13</td>
<td>D14</td>
<td>D15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RS1</td>
<td>D16</td>
<td>D17</td>
<td>D18</td>
<td>D19</td>
<td>D20</td>
<td></td>
</tr>
<tr>
<td>D21</td>
<td>D22</td>
<td>D23</td>
<td>D24</td>
<td>D25</td>
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<td></td>
</tr>
<tr>
<td>D26</td>
<td>D27</td>
<td>D28</td>
<td>D29</td>
<td>D30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RS2</td>
<td>D31</td>
<td>D32</td>
<td>D33</td>
<td>D34</td>
<td>D35</td>
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</tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>D507</td>
<td>D508</td>
<td>D509</td>
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<td></td>
</tr>
<tr>
<td>RS34</td>
<td>D511</td>
<td>D512</td>
<td>F1</td>
<td>F2</td>
<td>F3</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>C1</td>
<td>C2</td>
<td>C3</td>
<td>C4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>E1,1</th>
<th>E2,1</th>
<th>E3,1</th>
<th>E4,1</th>
<th>E5,1</th>
<th></th>
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</thead>
<tbody>
<tr>
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<td>E3,2</td>
<td>E4,2</td>
<td>E5,2</td>
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<tr>
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<td>E2,3</td>
<td>E3,3</td>
<td>E4,3</td>
<td>E5,3</td>
<td></td>
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</tbody>
</table>

<table>
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<tr>
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<th>E3,14</th>
<th>E4,14</th>
<th>E5,14</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>RS39</td>
<td>E1,15</td>
<td>E2,15</td>
<td>E3,15</td>
<td>E4,15</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>E1,16</td>
<td>E2,16</td>
<td>E3,16</td>
<td>E4,16</td>
<td>E5,16</td>
<td></td>
</tr>
</tbody>
</table>
Annex F
(normative)

Contents of the Control Zones

Each sector in the two Control Zones shall be pre-recorded, (embossed) in the standard sector format specified by ECMA-201, (RLL 2,7 modulation). Each sector shall contain the same 512 bytes of Control data provided by the manufacturer of the media. The Control data is divided into four groups in the following way.

1) The media characterization data gives a general characterization of the disk. It specifies the type of disk, the ECC, the tracking method, etc. The data is recorded in bytes 0 to 17. Bytes 0 to 12 are mandatory.

2) The Recording Control data specifies the settings of the drive for reading, writing and erasing. Space is allocated for the following sets of data:
   - three wavelengths $L_1, L_2$ and $L_3$,
   - for each wavelength the reflectance $R$ of the disk,
   - for each wavelength four rotational frequencies $N_1, N_2, N_3$ and $N_4$,
   - for each value of $N$:
     the maximum read power
     one set of erase conditions
     three sets of write conditions: viz. two sets for constant pulse width and one set for constant pulse power, (each set may contain three values for the inner, middle and outer radius of the Information Zone).

The Recording Control data can be divided into two sub-groups, one for the conformance tests described in clauses 18 to 27, and one for control of user drives.

a) The conformance test data specifies the settings for the Reference Drive. They can also be used as reference data for user drives. The conformance test data shall be recorded in bytes 18 to 34, 44 to 47, 132 to 148 and 158 to 161, and are mandatory for rewritable and partially embossed media.

b) The user reference test data contains the recommendation of the media manufacturer for the settings of a user drive for operating the disk in the test environment. This data is recorded in bytes 48 to 131, and 162 to 359 and is optional, except in those bytes listed in c) below.

c) The following bytes are reserved for future standardization and shall be set to (FF):

<table>
<thead>
<tr>
<th>28 to 30</th>
<th>35 to 43</th>
<th>198 to 200</th>
</tr>
</thead>
<tbody>
<tr>
<td>56 to 58</td>
<td>84 to 86</td>
<td>226 to 228</td>
</tr>
<tr>
<td>112 to 114</td>
<td>142 to 144</td>
<td>256 to 258</td>
</tr>
<tr>
<td>149 to 157</td>
<td>170 to 172</td>
<td>263 to 271</td>
</tr>
<tr>
<td></td>
<td></td>
<td>284 to 286</td>
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<tr>
<td></td>
<td></td>
<td>312 to 314</td>
</tr>
<tr>
<td></td>
<td></td>
<td>340 to 342</td>
</tr>
</tbody>
</table>

3) Bytes 400 to 428 are mandatory.

4) The last group contains unspecified data, recorded in bytes 480 to 511.

Optional bytes shall either contain the prescribed data or shall be set to (FF).
F.1 Media characterization data

Byte 0: Format Descriptor 1
This byte shall be set to 01100001, indicating Continuous Composite Servo tracking, Constant Angular Velocity of the disk and GCR mark width modulation Recording code.

Byte 1: Format Descriptor 2
For the 1024 byte format, this byte shall be set to 00000010, indicating Reed-Solomon Long Distance Error Correction Code of degree 16 with a 10-way interleave, 1024 bytes user data per sector. For the 512 byte format this byte will be set to 00010001 indicating Reed-Solomon Long Distance Code of degree 16 with 5-way interleave and 512 bytes per sector.

Byte 2: Sectors per logical track
This byte shall be set to 00011001 to indicate that the number of sectors per track is 25.

Byte 3: Reflectance
This byte shall specify the disk manufacturer's specification of the reflectance $R$ of the disk, expressed as a fraction, when measured at a nominal wavelength of 780 nm. It is specified as a number $n$ such that

$$ n = 100 \times R $$

Byte 4: On-land or in-groove recording
This byte shall be set to 00000000, indicating on-land recording.

Byte 5: Reserved
This byte shall be set to (FF).

Byte 6: Maximum read power
This byte shall specify the lowest of the values specified in Bytes 21, 135 and 249 of the Control Zones. It specifies the maximum read power $P_w$, in milliwatts, permitted for reading the Control Zones. It is specified as a number $n$ such that

$$ n = 20 \times P_w $$

Byte 7: Media Type
The allowed setting of this byte shall be

0010 0000: indicates fully rewritable MO media

Other settings of this byte are prohibited by this ECMA Standard, they are reserved for future standardization.

Bytes 8, 9: Last track in the Data Zone
These bytes shall be set to 00110101/00101101 and 10110110/01001010, respectively, indicating the MSB, LSB of the logical track number of the last track in the Data Zone, viz. 15 030/27 978.

Byte 10: Polarity of the figure of merit
This byte shall be set to 00000001, indicating that the polarity is negative.

Byte 11: Magnitude of the figure of merit
This byte shall indicate the magnitude of the figure of merit $F$, specified as a number $n$, such that

$$ n = 10000 \times F $$

Byte 12: Track Pitch
This byte shall indicate the track pitch in $\mu$m time 100. It shall be set to 10001011 representing a track pitch of 1.39 $\mu$m.
Byte 13: Reserved
This byte shall be set to (FF).

Bytes 14 to 17: Unspecified
These bytes may be used for manufacturer identification. They shall be ignored in interchange.

F.2 Recording control data

Byte 18: Wavelength
This byte shall specify the wavelength $L_1$, in nanometers, of the drive as a number $n$ such that

$$n = 1/5 \ L_1.$$

This byte shall be set to $n = 156$.

Byte 19: Reflectance
This byte shall specify the reflectance $R_1$ of the disk measured at wavelength $L_1$ as a number $n$ such that

$$n = 100 \ R_1.$$

The value of $n$ shall be equal to that recorded in byte 3.

Byte 20: Rotational frequency
This byte shall specify the rotational frequency $N_1$ in hertz of the disk as a number $n$ such that

$$n = N_1.$$

This byte shall be set to $n = 30$.

Byte 21: Maximum read power
This byte shall specify the maximum read power $P_1$, in milliwatts, in the Information Zone under condition $L_1$ and $N_1$, expressed as a number $n$ such that

$$n = 20 \ P_1$$

where $24 \leq n \leq 26$

Bytes 22 to 27: Write power at constant pulse width
Bytes 22 to 27 shall specify the write powers $P_w$ in milliwatts, for two values of a pulse width $T_p$ under condition $L_1$ and $N_1$, where $T$ is the period of one Channel bit. $P_w$ is expressed as a number $n$ such that

$$n = 5 \ P_w$$

Byte 22 Write power at $T_p = 1.00 \ T$ ns and Band 1
Byte 23 Write power at $T_p = 1.00 \ T$ ns and Band 16
Byte 24 Write power at $T_p = 1.00 \ T$ ns and Band 31
Byte 25 Write power at $T_p = 0.50 \ T$ ns and Band 1
Byte 26 Write power at $T_p = 0.50 \ T$ ns and Band 16
Byte 27 Write power at $T_p = 0.50 \ T$ ns and Band 31

Bytes 28-30 Reserved
These bytes shall be set to (FF).

Bytes 31 to 34: Write pulse width at constant write power
Bytes 31 to 34 shall specify the write pulse width $T_p$ in nanoseconds, at a write power $P_w$ under condition $L_1$ and $N_1$. $T_p$ is expressed as a number $n$ such that

$$n = T_p$$

Byte 31 Write power
Byte 32 Write pulse width at Band 1
Byte 33 Write pulse width at Band 16
Byte 34 Write pulse width at Band 31

**Bytes 35 to 43: Reserved**
These bytes shall be set to (FF).

**Bytes 44 to 47: D.C. erase power**
Byte 44 shall be set to (00). Bytes 45 to 47 shall then specify erase powers \( P_e \), in milliwatts, for a d.c. erase at three radii, under condition \( L_1 \) and \( N_1 \). \( P_e \) is expressed in the same way as \( P_w \) in bytes 22 to 30.

Byte 45 Erase power at Band 1
Byte 46 Erase power at Band 16
Byte 47 Erase power at Band 31

**Byte 48: Rotational frequency**
This byte shall specify the rotational frequency \( N_2 \), in hertz, of the disk, expressed in the same way as \( N_1 \) in byte 20.
If this byte is not set to (FF), \( n \) shall be set to 50.

**Bytes 49 to 75**
These bytes shall specify the same parameters as in bytes 21 to 47, but under the condition \( L_1 \) and \( N_2 \), except bytes 56 to 58 which shall be set to (FF).

**Byte 76: Rotational frequency**
This byte shall specify the rotational frequency \( N_3 \), in hertz, of the disk, expressed in the same way as \( N_1 \) in byte 20.
If this byte is not set to (FF), \( n \) shall be set to 60.

**Bytes 77 to 103**
These bytes shall specify the same parameters as in bytes 21 to 47, but under the condition \( L_1 \) and \( N_3 \), except bytes 84 to 86 which shall be set to (FF).

**Byte 104: Rotational frequency**
This byte shall specify the rotational frequency \( N_4 \), in hertz, of the disk, expressed in the same way as \( N_1 \) in byte 20.
If this byte is not set to (FF), \( n \) shall have a value other than 40, 50 or 60.

**Bytes 105 to 131**
These bytes shall specify the same parameters as in bytes 21 to 47, but under the condition \( L_1 \) and \( N_4 \), except bytes 112 to 114 which shall be set to (FF).

**Byte 132: Reserved**
This byte shall specify the wavelength \( L_2 \) of the drive, in nanometers, as a number \( n \) such that

\[
    n = \frac{1}{5} L_2
\]

**Byte 133: Reflectance**
This byte shall specify the reflectance \( R_2 \) of the disk measured at wavelength \( L_2 \) as a number \( n \) such that

\[
    n = 100 R_2
\]

**Byte 134: Rotational frequency**
This bytes shall specify the rotational frequency \( N_1 \) of the disk, in hertz, as a number \( n \) such that

\[
    n = N_1
\]
This byte shall be set to \( n = 30 \).
Byte 135: Maximum read power
This byte shall specify the maximum read power \( P_2 \) in the Information Zone, in milliwatts, under condition \( L_2 \) and \( N_1 \), expressed as a number \( n \) such that
\[
n = 20 P_2
\]
where \( 24 \leq n \leq 26 \)

Bytes 136 to 141: Write power at constant pulse width
These bytes shall specify the write powers \( P_w \) in milliwatts for two values of a pulse width \( T_p \), under condition \( L_2 \) and \( N_1 \) for three radii, where \( T \) is the period of one Channel bit. \( P_w \) is expressed as a number \( n \) such that
\[
n = 5 P_w
\]

Byte 136 Write power at \( T_p = 1,000 \) ns and Band 1
Byte 137 Write power at \( T_p = 1,000 \) ns and Band 16
Byte 138 Write power at \( T_p = 1,000 \) ns and Band 31
Byte 139 Write power at \( T_p = 0,500 \) ns and Band 1
Byte 140 Write power at \( T_p = 0,500 \) ns and Band 16
Byte 141 Write power at \( T_p = 0,500 \) ns and Band 31

Bytes 142-144 Reserved
These bytes shall be set to (FF).

Bytes 145 to 148: Write pulse width at constant write power
These bytes shall specify the write pulse width \( T_p \), in nanoseconds, at a write power \( P_w \) under condition \( L_2 \) and \( N_1 \) for three radii. \( T_p \) is expressed as a number \( n \) such that
\[
n = T_p
\]

\( P_w \) is expressed in the same way as in bytes 136 to 144.

Byte 145 Write power
Byte 146 Write pulse width at Band 1
Byte 147 Write pulse width at Band 16
Byte 148 Write pulse width at Band 31

Bytes 149 to 157: Reserved
These bytes shall be set to (FF).

Bytes 158 to 161: D.C. erase power
Byte 158 shall be set to (00). Bytes 159 to 161 shall then specify erase powers \( P_e \), in milliwatts, for a d.c. erase at three radii, under condition \( L_2 \) and \( N_1 \). \( P_e \) is expressed in the same way as \( P_w \) in bytes 136 to 144.

Byte 159 Erase power at Band 1
Byte 160 Erase power at Band 16
Byte 161 Erase power at Band 31

Byte 162: Rotational frequency
This byte shall specify the rotational frequency \( N_2 \) of the disk, in hertz, expressed in the same way as \( N_1 \) in byte 134.

If this byte is not set to (FF), \( n \) shall be set to 50.

Bytes 163 to 189
These bytes shall specify the same parameters as in bytes 135 to 161, but under the condition \( L_2 \) and \( N_2 \), except bytes 170 to 172 which shall be set to (FF).
Byte 190: Rotational frequency
This byte shall specify the rotational frequency \( N_3 \) of the disk, in hertz, expressed in the same way as \( N_1 \) in byte 134.
If this byte is not set to (FF), \( n \) shall be set to 60.

Bytes 191 to 217
These bytes shall specify the same parameters as in bytes 135 to 161, but under the condition \( L_2 \) and \( N_3 \), except bytes 198 to 200 which shall be set to (FF).

Byte 218: Rotational frequency
This byte shall specify the rotational frequency \( N_4 \) of the disk, in hertz, expressed in the same way as \( N_1 \) in byte 134.
If this byte is not set to (FF), \( n \) shall have a value other than 30, 50 or 60.

Bytes 219 to 245
These bytes shall specify the same parameters as in bytes 135 to 161, but under the condition \( L_2 \) and \( N_4 \), except bytes 226 to 228 which shall be set to (FF).

Byte 246: Wavelength
This byte shall specify the wavelength \( L_3 \) of the drive, in nanometers, expressed in the same way as \( L_2 \) in byte 132.

Bytes 247 to 359
These bytes shall specify the same parameters as in bytes 133 to 245, but under the condition \( L_3 \), except bytes 256 to 258, 263 to 271, 284 to 286, 312 to 314 and 340 to 342 which shall be set to (FF).

Bytes 360 to 379: Reserved
These bytes shall be set to (FF).
Summary of Recording Control data

Table F.1 summarizes the requirements for bytes 18 to 359. In this table:

- numbers on light shaded background are those of the bytes containing mandatory data, see 2a);
- numbers on darkly shaded background are those of the bytes which shall always be set to (FF), see 2c);
- numbers on white background are those of the bytes the content of which is optional. These bytes shall either contain the value specified for them in F.1 or be set to (FF), see 2b).

F.3 System data

Bytes 380 to 387: Reserved
These bytes shall be set to (FF).

Bytes 388 and 389: Number of tracks in the first data Band
Byte 388 shall be set to 00000001/00000000 and byte 389 shall be set to 00101011/11101100 respectively, indicating the MSB and LSB of the number of logical tracks in the first data Band, viz. 299/236. The number includes DMA tracks.

Byte 390: Number of Bands
This byte shall be set to 00100101/00100001, indicating the number of Bands is 35/33

Byte 391: Banding constant for the media
This byte is not used and shall be set to (FF).

Bytes 392 to 393: Number of physical tracks per data Band
These bytes shall be set to the number of physical tracks per data Band except for the first and last data Bands on the disk. Byte 392 shall be set to 00000001/00000000 and byte 393 shall be set to 01110111/10010000.

Bytes 394 to 399: Reserved
These bytes shall be set to (FF).

Bytes 400 to 423: Control bytes for partially embossed disks
These bytes shall be set to (FF).

Bytes 424 to 479: Reserved.
These bytes shall be set to (FF).

F.4 Unspecified data

Bytes 480 to 511
The contents of these bytes are not specified in this ECMA Standard. They may contain an identification of the manufacturer. They shall be ignored in interchange.
<table>
<thead>
<tr>
<th>( L_1 )</th>
<th>( L_2 )</th>
<th>( L_3 )</th>
<th>( L_4 )</th>
<th>( L_5 )</th>
<th>( L_6 )</th>
<th>( L_7 )</th>
<th>( L_8 )</th>
<th>( L_9 )</th>
<th>( L_{10} )</th>
</tr>
</thead>
<tbody>
<tr>
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<td>( N_2 )</td>
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<td>( N_4 )</td>
<td>( N_5 )</td>
<td>( N_6 )</td>
<td>( N_7 )</td>
<td>( N_8 )</td>
<td>( N_9 )</td>
<td>( N_{10} )</td>
</tr>
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</tr>
<tr>
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<td>48</td>
<td>76</td>
<td>104</td>
<td>134</td>
<td>162</td>
<td>190</td>
<td>218</td>
<td>248</td>
<td>276</td>
</tr>
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<td>275</td>
<td>303</td>
</tr>
</tbody>
</table>

See F.1 for specification of the contents of each byte

Legend for Table F.1

- **Mandatory**: Set bytes to (FF)
- **Mandatory**: Set bytes as specified
- **Not Mandatory**
Annex G  
(informative)

Guidelines for sector replacement

Clause 19 assumes that a sector is defective and will be replaced by the defect management, for instance when any of the following conditions exist:

a) a sector has two or three ID fields with each an error as detected by the CRC check;

b) the Sector Mark cannot be recognized;

c) a column in the Data field (see table E.1) contains more than three defective bytes $A_n$. 
Annex H
(normative)

Measurement of the figure of merit

H.1 The figure of merit enables a drive designer to determine the amplitude of the signal in Channel 2 of the drive from magneto-optical marks recorded on the disk at a low spatial frequency in both the radial and tangential direction.

Determination of the figure of merit using a drive as the Reference Drive specified in clause 9 will not measure media properties only but also the optical retardation of the optical system of the drive. Therefore, a calibration of the drive is needed with a conventional determination of the figure of merit by measuring the reflectance, Kerr rotation and ellipticity. This calibration can only be executed reliably on media with low coercivity.

H.2 The drive shall be calibrated as follows. A test disk with negligible birefringence, e.g. a glass disk, and a low-coercivity magneto-optical layer is used for a conventional determination of the reflectance $R$, the Kerr rotation of the polarization between both opposite states of magnetization of the layer, and the Kerr ellipticity $\beta$. The figure of merit of the media is then

$$F_L = R \sin \theta \cos 2\beta .$$

A low-frequency test pattern is written on the same disk. The written domains shall be substantially larger than the focal spot, so as to work in the low spatial frequency region where the modulation transfer function of the optical system is one. This implies that for a disk rotating at 30 Hz, a pattern of long domains with a frequency lower than 100 kHz has to be written on several consecutive tracks, while keeping the marks in neighbouring tracks radially aligned and overlapping.

The pattern is read with the drive to be calibrated. The resulting peak-to-peak amplitude $VL$ of the signal in Channel 2 of the drive is the required calibration constant for this drive.

H.3 The figure of merit of any low- or high-coercivity disk can now be determined on the calibrated drive by writing the above test pattern and reading the peak-to-peak amplitude $V$ of the signal in Channel 2. The figure of merit $F$ of this disk is then

$$F = \frac{V}{VL}$$
Annex J
(informative)

Read power, write power and erase power

J.1 Read power
The values of $P_{\text{max}}$ for two further rotational frequencies are defined in table J.1. The value contained in the Control Zone may not exceed these values for a specific rotational frequency.

<table>
<thead>
<tr>
<th>Rotational Frequency</th>
<th>Maximum Read Power $P_{\text{max}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Hz</td>
<td>$1,6 \text{ mW} \leq P_{\text{max}} \leq 1,7 \text{ mW}$</td>
</tr>
<tr>
<td>60 Hz</td>
<td>$1,8 \text{ mW} \leq P_{\text{max}} \leq 2,0 \text{ mW}$</td>
</tr>
</tbody>
</table>

J.2 Write power and erase power
The values of write power and erase power contained in the Control Zones are described as the values at the temperature of 23 °C only and should not exceed the values for the following two rotational frequencies as follows:

<table>
<thead>
<tr>
<th>Rotational Frequency</th>
<th>Maximum Write Power and Maximum Erase Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Hz</td>
<td>$P_{w,e} = 5 \left( \frac{1}{T_p} + \frac{1}{\sqrt{T_p}} \right) \text{ mW} \quad T_p \leq 33 \text{ ns}$</td>
</tr>
<tr>
<td></td>
<td>$P_{w,c} = 10,4 \text{ mW} \quad T_p &gt; 33 \text{ ns}$</td>
</tr>
<tr>
<td>60 Hz</td>
<td>$P_{w,e} = 5 \left( \frac{1}{T_p} + \frac{1}{\sqrt{T_p}} \right) \text{ mW} \quad T_p \leq 27 \text{ ns}$</td>
</tr>
<tr>
<td></td>
<td>$P_{w,c} = 11,6 \text{ mW} \quad T_p &gt; 27 \text{ ns}$</td>
</tr>
</tbody>
</table>

where $P_{w,e}$ is the write power ($P_w$) or erase power ($P_e$) and $T_p$ is the numeric value in nanoseconds of the write pulse width.

The write power and erase power should be compensated for the temperature of the disk according to the formula:

$$P_t = P_{23} \cdot [0,03 \ (T_{\text{op}} - 23)]$$

where

$P_t$ is the compensated power,

$P_{23}$ is the value described in the Control Zone, and

$T_{\text{op}}$ is the numeric value in degree Centigrade (°C) of the temperature of the disk.
Annex K
(normative)

Test method for measuring the adsorbent force of the hub

K.1 The purpose of this test is to determine the magnetic characteristic of the magnetizable material of the hub.

K.2 The test device (see figure K.1) consists of a spacer, a magnet, a back yoke and a centre shaft. The dimensions of the test device are as follows:

\[ D_a = 7,0 \text{ mm } \pm 0,1 \text{ mm} \]
\[ D_c = 14,0 \text{ mm } \pm 0,1 \text{ mm} \]
\[ D_f = 13,0 \text{ mm } \text{max.} \]
\[ D_g = 3,9 \text{ mm } \pm 0,0 \text{ mm} \]
\[ H_c = 0,40 \text{ mm } \pm 0,01 \text{ mm} \]
\[ H_d = 1,00 \text{ mm } \pm 0,05 \text{ mm} \] (Typical, to be adjusted to meet the requirement of K.4)

K.3 The material of the test device shall be:

- Magnet : Sm-Co
- Back yoke : Any suitable magnetizable material
- Spacer : Non-magnetizable material or air gap
- Centre shaft : Non-magnetizable material

K.4 The characteristics of the magnet with back yoke are as follows:

- Number of poles : 4
- Maximum energy product \( (BH_{max}) \) : \( 175 \text{ kJ/m}^3 \pm 16 \text{ kJ/m}^3 \) (typical)

The characteristics of the magnet with back yoke shall be adjusted by the use of a pure nickel plate with the following dimensions (see figure K.2), and the adsorbent force of this plate at the point of \( H_c = 0,4 \) mm when spaced from the magnet surface shall be \( 3,3 \text{ N } \pm 0,2 \text{ N} \).

\[ D_h = 6,0 \text{ mm } \pm 0,1 \text{ mm} \]
\[ D_l = 15,0 \text{ mm } \pm 0,1 \text{ mm} \]
\[ H_c = 1,00 \text{ mm } \pm 0,05 \text{ mm} \]

K.5 The test condition for temperature shall be as specified in 8.1.1.
Figure K.1 - Test device for the clamping characteristic of the hub

Figure K.2 - Calibration plate of the test device
Annex L
(informative)

Derivation of the operating climatic environment

This annex gives some background on how some of the conditions of the operating environment in clause 8.1.2 have been derived.

L.1 Standard climatic environment classes

The conditions of the ODC operating environment are, with a few exceptions mentioned below, based on parameter values of the IEC Standard climatic environment class 3K3 described in IEC publication 721-3-3:1987 1). This publication defines environmental classes for stationary use of equipment at weather-protected locations.

The IEC class 3K3 refers to climatic conditions which

"... may be found in normal living or working areas, e.g. living rooms, rooms for general use (theatres, restaurants, etc.), offices, shops, workshops for electronic assemblies and other electrotechnical products, telecommunication centres, storage rooms for valuable and sensitive products."

L.2 Overtemperature considerations

While IEC class 3K3 defines the limits for the room climate only, the ODC operating environment specification in this ECMA Standard takes into consideration also system and drive overtemperature. This means that when inserted in a drive, the ODC will sense a temperature which is above the ambient room temperature. The figures in the operating environment specification have been calculated from the assumption that this overtemperature may be up to 20°C.

L.3 Absolute humidity

The introduction of the parameter

\[
\text{absolute humidity} \quad \text{[unit: g water} \, / \, \text{m}^3 \text{of air]}
\]

is very useful when studying overtemperature. When the temperature rises inside a drive, the relative humidity goes down but the absolute humidity remains substantially constant. So, making room for overtemperature in the operating environment specification affects not only the upper temperature limit but also the lower relative humidity limit. The relationship between these parameters is shown in the climatogram (the relative humidity versus temperature map) of the ODC operating environment, figure L.1.

The absolute humidity restrictions influence the operating environment in the following two ways:

a) Combinations of high temperatures and high relative humidities are excluded. Such combinations could have negative influence on the performance and the life of ODCs.

b) Combinations of low temperatures and low relative humidities are excluded. Such combinations are very unlikely to occur in worldwide normal office environments.

L.4 Deviations from the IEC Standard environment class

Apart from the changes introduced by the overtemperature considerations mentioned above, there are a few more parameter values which are not based on IEC class 3K3. These are:

---

1) Classification of environmental conditions - Part3: Classification of groups of environmental parameters and their severities. Stationary use at weatherprotected locations.
- Atmospheric pressure
  The IEC 3K3 lower limit of 70 kPa has been extended to 60 kPa. ODCs show no intrinsic pressure sensitivity and 70 kPa excludes some possible markets for ODCs.

- Absolute humidity
  The IEC 3K3 value for the upper limit of 25 g/m³ has been raised to 30 g/m³ in view of some expected operation in portable devices outside the controlled office environment.

- Temperature
  The maximum temperature around the ODC, i.e. room temperature plus overtemperature, has been limited to 55 °C (while IEC 3K3 + 20 °C would have become 60 °C). For ODCs according to this ECMA Standard, however, the 55 °C limit is considered to be a physical limit above which operation (as well as storage) is not safe.
  This means that equipment designers may want to ensure adequate cooling inside the drive especially when the room temperature approaches the upper IEC 3K3 limit of 40 °C.

- Further
  The rates of change (the gradients) of temperature and relative humidity are not according to IEC 3K3.

L.5 Wet bulb temperature specifications
Instead of specifying limits for the absolute humidity, some of the earlier Standards for ODCs as well as those for other digital data storage media often used restrictions of the parameter

  wet bulb temperature [unit: °C]

in order to avoid too severe combinations of high temperatures and high relative humidities.

In order to facilitate comparisons between different specifications, figure L.2 shows wet bulb temperatures of interest for the ODC operating environment, as well as for the testing and storage environments. Since wet bulb temperatures vary slightly with the atmospheric pressure, the diagram is valid for the normal pressure of 101.3 kPa only.
Figure L.1 - Climatogram of IEC Class 3K3 and the ODC operating environment
Note - Temperature(°C) - Relative humidity(RH%) - Wet bulb temperature(°C wb)

Figure L.2 - Wet bulb temperatures of the operating and storage environments
Annex M
(normative)

Air cleanliness class 100 000

The classification of air cleanliness is based on a particle count with a maximum allowable number of specified minimum sized particles per unit volume, and on a statistical average particle size distribution.

M.1 Definition

The particle count shall not exceed a total of 3 500 000 particles per cubic metre of a size 0,5 μm and larger. The statistical average particle size distribution is given in figure M.1. Class 100 000 means that 3 500 000 particles per cubic metre of a size of 0,5 μm and larger are allowed, but only 25 000 particles per cubic metre of a size of 5,0 μm and larger.

It should be recognized that single sample distribution may deviate from this curve because of local or temporary conditions. Counts below 350 000 particles per cubic metre are unreliable except when a large number of samplings is taken.

M.2 Test method

For particles of sizes of the 0,5 μm to 5,0 μm, equipment employing light-scattering principles shall be used. The air in the controlled environment is sampled at a known flow rate. Particles contained in the sampled air are passed through an illuminated sensing zone in the optical chamber of the instrument. Light scattered by individual particles is received by a photo detector which converts the light pulses into electrical current pulses. An electronic system relates the pulse height to particle size and counts the pulses such that the number of particles in relation to particle size is registered or displayed.

![Figure M.1 - Particle size distribution curve](image-url)
Annex N
(normative)

Position of the cartridge relative to the reference planes

This annex shows the position of the cartridge relative to the reference planes, as specified in 10.2.

Figure N.1 - Position of the cartridge
Annex P
(informative)

Transportation

P.1 General
As transportation occurs under a wide range of temperature and humidity variations, for differing periods, by many methods of transport and in all parts of the world it is not possible to specify conditions for transportation or for packaging.

P.2 Packaging
The form of packaging should be agreed between sender and recipient or, in the absence of such agreement, is the responsibility of the sender. It should take account of the following hazards.

P.2.1 Temperature and humidity
Insulation and wrapping should be designed to maintain the conditions for storage over the estimated period of transportation.

P.2.2 Impact loads and vibration
a) Avoid mechanical loads that would distort the shape of the cartridge.
b) Avoid dropping the cartridge.
c) Cartridges should be packed in a rigid box containing adequate shock-absorbent material.
d) The final box should have a clean interior and a construction that provides sealing to prevent the ingress of dirt and moisture.
Annex Q
(informative)

Office environment

Due to their construction and mode of operation optical disk cartridges have considerable resistance to the effects of dust particles around and inside the disk drive. Consequently it is not generally necessary to take special precaution to maintain a sufficiently low concentration of dust particles.

Operation in heavy concentrations of dust should be avoided, e.g. in a machine shop or on a building site.

Office environment implies an environment in which personnel may spend a full working day without protection and without suffering temporary or permanent discomfort.
Annex R
(normative)

Relaxation by zones of the requirements for signals

Table R.1 shows the zones in which the requirements specified in the body of this ECMA Standard shall be satisfied and those in which they are relaxed.

indicates the zones in which the values of the signals shall be within the range specified.

indicates the zones in which the range is extended from 80% of the lower limit to 120% of the upper limit. The requirement for uniformity is extended from ± 12% to ± 20%.

No marking indicates the zones for which the requirements are not applicable.

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<th>CLAUSE</th>
<th>SIGNAL</th>
<th>INITIAL</th>
<th>TEST</th>
<th>CONTROL</th>
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CH-1204 Geneva
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Internet: helpdesk@ecma.ch