

INTERNATIONAL STANDARD

ISO/IEC 9171-2

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Information technology — 130 mm optical disk cartridge, write once, for information interchange —

Part 2: Recording format

*Technologies de l'information — Cartouche de disque optique de 130 mm,
non-réinscriptible, pour l'échange d'information —*

Partie 2: Format d'enregistrement



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FOREWORD

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 9171-2 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

ISO/IEC 9171 consists of the following parts, under the general title: *Information technology — 130 mm optical disk cartridge, write once, for information interchange*:

Part 1: Unrecorded optical disk cartridge

Part 2: Recording format

Annexes B and C form an integral part of this of this part of ISO/IEC 9171. Annexes A and D are for information only.

INTRODUCTION

ISO/IEC 9171 specifies the characteristics of 130 mm optical disk cartridges (ODC) of the type providing for information to be written once and read many times.

ISO/IEC 9171-1 specifies

- definitions of the essential concepts;
- the environment in which the characteristics are to be tested;
- the environment in which the cartridge is to be operated and stored;
- the mechanical, physical and dimensional characteristics of the case and of the optical disk;
- the optical characteristics and the recording characteristics for recording the information once and for reading it many times, so as to provide physical interchangeability between data processing systems.

ISO/IEC 9171-1 and ISO/IEC 9171-2, together with a standard for volume and file structure, provide for full data interchange between data processing systems.

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Information technology — 130 mm optical disk cartridge, write once, for information interchange —

Part 2: Recording format

1 Scope

This part of ISO/IEC 9171 specifies two formats for the physical disposition of the tracks and sectors, the error correction codes, the modulation methods used for recording and the quality of the recorded signals.

2 Conformance

An optical disk is in conformance with Part 2 of this International Standard if it meets all mandatory requirements of clause 4 and either those of clause 5 or those of clause 6.

A prerequisite for conformance with this part of ISO/IEC 9171 is conformance with ISO/IEC 9171-1.

3 Conventions and notations

The following conventions and notations apply in this part of ISO/IEC 9171.

- a) In each field the information is recorded so that the most significant byte (byte 0) is recorded first. Within each byte the least significant bit is numbered bit 0, the most significant bit (i.e. bit 7 in an 8-bit byte) is recorded first. This order of recording applies also to the data input of the error-correcting codes, to the cyclic redundancy code, and to their code output.
- b) Unless otherwise stated, numbers are expressed in binary notation. Where hexadecimal notation is used, the hexadecimal digits are shown between parentheses.
- c) Bit combinations are shown with the most significant bit to the left.
- d) Negative values are expressed in TWO's complement notation.
- e) The setting of bits is denoted by ZERO and ONE.
- f) The name of entities, e.g. specific tracks, fields, etc., is shown with a capital initial.
- g) List of Acronyms

ALPC	Auto Laser Power Control
AM	Address Mark
CAV	Constant Angular Velocity
CRC	Cyclic Redundancy Check
DDS	Disk Definition Structure
DMP	Defect Management Pointers
DMT	Defect Management Track
ECC	Error Correction Code
ID	Identifier
ODC	Optical Disk Cartridge
ODF	Offset Detection Flag
PA	Postamble
PEP	Phase-Encoded Part
RLL (2,7)	Run Length Limited (Code)

R-S	Reed-Solomon (Code)
R-S/LDC	Reed-Solomon Long Distance Code
SFP	Standard Formatted Part
SM	Sector Mark
VFO	Variable Frequency Oscillator
4/15(Modulation)	Conversion table of 8-bit bytes to 15-Channel bit representation on the disk

4 Features common to both formats

4.1 Track Geometry

4.1.1 Track shape

Each track shall form a 360° turn of a continuous spiral.

4.1.2 Direction of rotation

The disk shall rotate counter-clockwise as viewed by the objective lens. The tracks shall spiral outward.

4.1.3 Track pitch

Except in the PEP Zone, the track pitch shall be:

For Format A : 1,60 μm $\pm$ 0,10 μm

For Format B : 1,50 μm $\pm$ 0,08 μm

4.1.4 Track number

Each track shall be identified by a track number.

Track 0 shall be located at radius 30,00 mm $\pm$ 0,10 mm.

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

The track numbers of tracks located at radii smaller than that of track 0 shall be negative and decrease by 1 for each track. Track-1 shall be identified by (FFFF).

4.2 Formatted Zone

The Formatted Zone shall extend from radius 27,00 mm to radius 61,00 mm and shall be divided as follows. The following dimensions are given as reference only and are nominal values.

- Reflective Zone	27,00 mm to 29,00 mm
- Control Track PEP Zone	29,00 mm to 29,50 mm
- Transition Zone For SFP	29,50 mm to 29,52 mm
- Inner Control Track SFP Zone	29,52 mm to 29,70 mm
- Inner Manufacturer Zone	29,70 mm to 30,00 mm
. Guard Band	29,70 mm to 29,80 mm
. Manufacturer Test Zone	29,80 mm to 29,90 mm
. Guard Band	29,90 mm to 30,00 mm
- User Zone	30,00 mm to 60,00 mm
- Outer Manufacturer Zone	60,00 mm to 60,15 mm
- Outer Control Track SFP Zone	60,15 mm to 60,50 mm
- Lead-Out Zone	60,50 mm to 61,00 mm

This part of ISO/IEC 9171 does not specify the format of the Reflective Zone, except that it shall have the same recording layer as the remainder of the Formatted Zone.

The Transition Zone For SFP is an area in which the format changes from the PEP Zone without servo information to a zone including servo information.

The Inner Manufacturer Zone is provided to allow the media manufacturer to perform tests on the disk, including write operations, in an area located away from recorded information. In this zone the information in the tracks from track-1 to track-8 is not specified by this part of ISO/IEC 9171 and shall be ignored in interchange, except when using format B where track-2 is used for defect management.

The purpose of the Guard Bands is to protect and buffer the areas that contain information from accidental damage when the area between the Guard Bands is used for testing or calibration of the optical system.

The User Zone shall start with track 0 and end with track N.

The Outer Manufacturer Zone shall comprise 95 tracks and shall begin one track after the last user track (track N, see bytes 384 and 385 of the SFP Zone). In this zone the information in the tracks from track (N + 1) to track (N + 8) is not specified by this part of ISO/IEC 9171 and shall be ignored in interchange.

The Outer Control Track SFP Zone shall begin at track N + 96 (see bytes 8 and 9 in the SFP Zone) and shall continue up to radius 60,5 mm.

The Lead-Out Zone is used for the manufacturing purposes and shall not be used for write, read or positioning purposes.

From radius 29,52 mm to radius 61,00 mm the Formatted Zone shall be provided with tracks containing servo and address information.

4.3 Control tracks

The three zones

- Control Track PEP Zone
- Inner Control Track SFP Zone
- Outer Control Track SFP Zone

shall be assigned for recording control track information.

The control track information shall be recorded in two different formats, the first format in the Control Track PEP Zone, and the second in the Inner and Outer Control Track SFP Zones.

The Control Track PEP Zone shall be recorded using low frequency phase-encoded modulation.

The Inner and Outer Control Track SFP Zones shall each consist of a band of tracks recorded by the same modulation method and format as is used in the User Zone.

4.4 Control Track PEP Zone

This zone shall not contain any servo information. All information in it shall be pre-recorded in phase-encoded modulation. The marks in all tracks of the PEP Zone shall be radially aligned, so as to allow information recovery from this zone without radial tracking being established by the drive.

4.4.1 Recording in the PEP Zone

In the PEP Zone there shall be 561 to 567 PEP bit cells per revolution. A PEP bit cell shall be 656 ± 1 Channel bits long. A PEP bit is recorded by writing marks in either the first or the second half of the cell.

A mark shall be nominally two Channel bits long and shall be separated from adjacent marks by a space of nominally two Channel bits.

A ZERO shall be represented by a change from marks to no marks at the centre of the cell and a ONE by a change from no marks to marks at this centre.

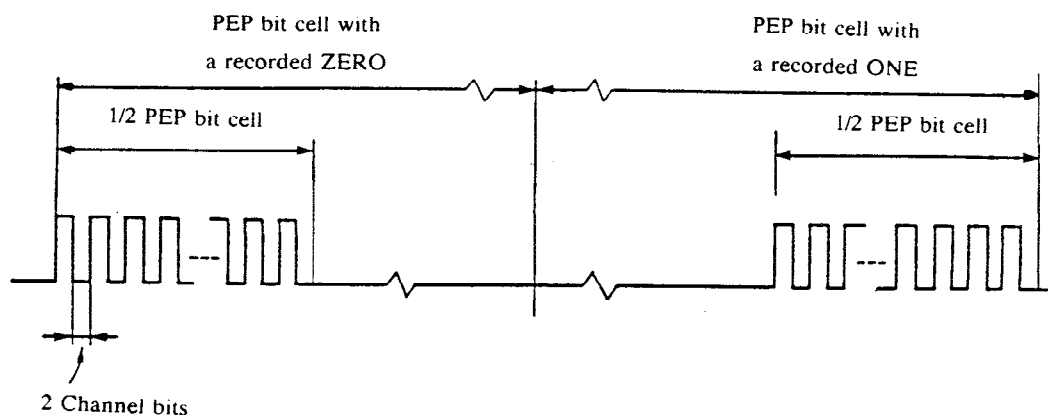


Figure 1 - Example of phase-encoded modulation in the PEP Zone

4.4.2 Cross-track loss

The density of tracks and the shape of marks in the PEP Zone shall be such that the cross-track loss shall meet the requirements:

$$\left(\frac{I_{m\max}}{I_{m\min}} \right) < 2,0$$

The signal I_m is the maximum amplitude in a group of three successive marks. $I_{m\max}$ is the maximum value and $I_{m\min}$ is the minimum value of I_m obtained over one revolution. $I_{m\max}$ shall be greater than $0,4 I_0$. The effect of defects shall be ignored.

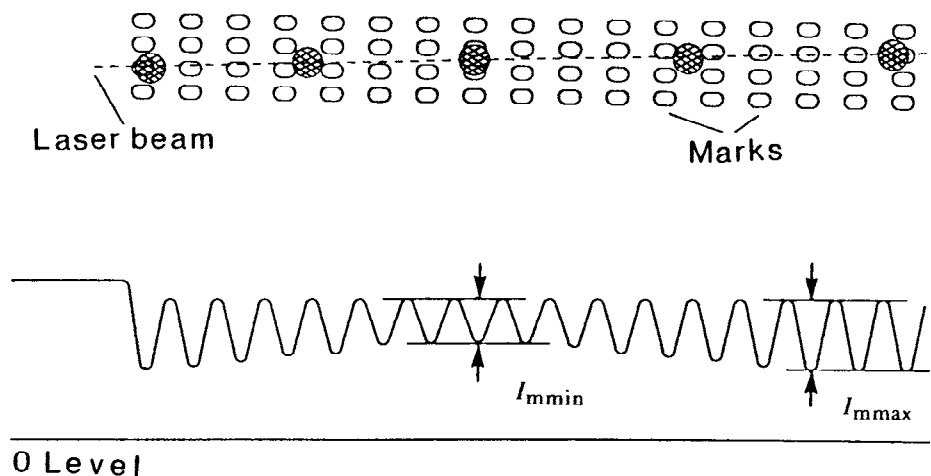


Figure 2 - Path of the laser beam crossing tracks, and the resulting PEP signals

4.4.3 Format of the tracks of the PEP Zone

Each track in the PEP Zone shall have three sectors as shown in figure 3. The numbers below the fields indicate the number of PEP bits in each field.

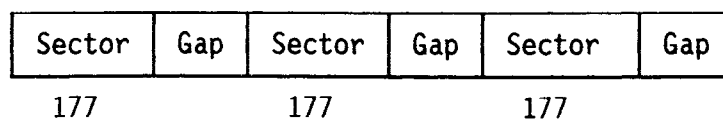


Figure 3 - Track format in the PEP Zone

The gaps between sectors shall be unrecorded areas having a length corresponding to 10 to 12 PEP bit cells.

4.4.3.1 Format of a sector

Each sector of 177 PEP bits shall have the following layout.

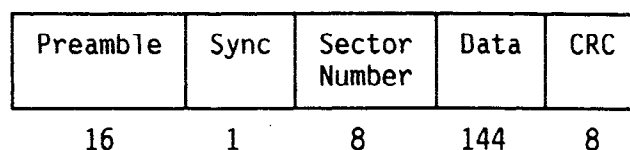


Figure 4 - Sector Format in the PEP Zone

4.4.3.1.1 Preamble

This field shall consist of 16 ZERO bits.

4.4.3.1.2 Sync

This field shall consist of 1 ONE bit.

4.4.3.1.3 Sector Number

This field shall consist of eight bits specifying the sector number in binary notation from 0 to 2.

4.4.3.1.4 Data

This field shall comprise 18 8-bit bytes numbered 0 to 17. These bytes shall specify the following.

Byte 0

Bit 7 when set to ZERO shall mean Format A,
 when set to ONE shall mean Format B.

Bits 6 to 4 shall be set to 000 indicating a constant angular velocity (CAV).

Other settings of these bits are prohibited by this part of ISO/IEC 9171 (see also Annex A).

Bit 3 shall be set to ZERO

Bits 2 to 0 when set to 000 shall mean RLL (2,7) mark position modulation,
 when set to 100 shall mean 4/15 modulation.

Other settings of these bits are prohibited by this part of ISO/IEC 9171.

Byte 1

Bit 7 shall be set to ZERO

Bits 6 to 4 specify the error correction code:
 when set to 000 shall mean R-S LDC degree 16, and 10 interleaves,
 when set to 001 shall mean R-S LDC degree 16, and 5 interleaves,
 when set to 100 shall mean R-S product code (48,44,5) x (14,12,3)

Other settings of these bits are prohibited by this part of ISO/IEC 9171.

Bit 3 shall be set to ZERO

Bits 2 to 0 these bits shall specify in binary notation the power n of 2 in the following formula which expresses the number of user bytes per sector

$$256 \times 2^n$$

Values of n other than 1 or 2 are prohibited by this part of ISO/IEC 9171.

Byte 2

This byte shall specify in binary notation the number of sectors in track 0.

Byte 3

This byte shall specify the manufacturer's specification for the base line reflectance R of the disk when measured according to 13.2.1 of ISO/IEC 9171-1. It is specified as a number n between 0 and 100, such that

$$n = 100 R$$

Byte 4

This byte shall specify whether the recording is on-land or in-groove, and shall indicate the signal amplitude and the polarity of the pre-recorded marks.

The absolute value of the signal amplitude is given as a number n either between -50 and -20 or between +20 and +50, such that:

$$n = 50 I_p / I_0$$

where I_p is the signal from the low frequency pre-recorded marks and I_0 is the signal from an unrecorded, ungrooved area (see 13.4 of ISO/IEC 9171-1).

Bit 7 when set to ZERO shall mean on-land recording,
 when set to ONE shall mean in-groove recording.

Bits 6 to 0 shall express this number n . If bit 6 is set to ZERO this number is positive. If bit 6 is set to ONE this number is negative and expressed in TWO's complements.

If this number is positive it indicates low-to-high recording, if it is negative it indicates high-to-low recording.

Byte 5

This byte shall specify the amplitude and polarity of user-written marks as a number n between -50 and +127 such as

$$n = 50 I_u / I_{0t}$$

where I_u is the signal of the low frequency user-written marks and I_{0t} is the on-track signal from an unrecorded track.

Bits 7 to 0 shall express this number n . If bit 7 is set to ZERO this number is positive. If bit 7 is set to ONE this number is negative, and expressed in TWO's complements.

If this number is positive it indicates low-to-high recording, if it is negative it indicates high-to-low recording.

Byte 6

This byte shall specify in binary notation a number n representing 20 times the maximum read power expressed in milliwatts which is permitted for reading the SFP Zone at a rotational frequency of 30 Hz and a wavelength of 825 nm. This number n shall be between 0 and 40.

Byte 7

The byte shall specify the media type.

0001 0000 shall mean an optical disk cartridge according to this part of ISO/IEC 9171.

Other settings of this byte are prohibited by this part of ISO/IEC 9171 (see also Annex A).

Byte 8

This byte shall specify the most significant byte of the track number of the track in which the Outer Control Track SFP Zone starts.

Byte 9

This byte shall specify the least significant byte of the track number in which the Outer Control Track SFP Zone starts.

Bytes 10 to 13

These bytes shall be set to (FF).

Bytes 14 to 17

The contents of these bytes are not specified by this part of ISO/IEC 9171. They shall be ignored in interchange.

4.4.3.1.5 CRC

The CRC character shall be computed over the Sector Number field and the Data field. The generator polynomial shall be

$$G(x) = x^8 + x^4 + x^3 + x^2 + 1$$

The residual polynomial $R(x)$ shall be

$$R(x) = \left(\sum_{i=144}^{i=151} \bar{a}_i x^i + \sum_{i=0}^{i=143} a_i x^i \right) x^8 \mod G(x)$$

where a_i denotes a bit of the input data and $\bar{a}_i$ an inverted bit. The highest order bit of the Sector Number field is a_{151} .

The eight bits of the CRC are defined by

$$R_C(x) = \sum_{k=0}^{k=7} C_k x^k$$

where C_7 is recorded as the highest order bit of the CRC byte of the PEP sector.

4.4.3.2 Summary of the format of the Data Field of a sector of the PEP Zone

Table 1 - Summary of the format of the Data field of a sector of the PEP Zone

Byte	Bit	7	6	5	4	3	2	1	0
0		Format	0	0	0	0	Modulation Code		
1		0	ECC			0	Number of user bytes		
2		Number of sectors in track 0							
3		Baseline reflectance at 825 nm							
4		L or G	Amplitude and polarity of pre-formatted data						
5		Amplitude and polarity of user-recorded data							
6		Max. read power for the SFP Zone at 30 Hz and 825 nm							
7		0	0	0	1	0	0	0	0
8		Start track of Outer SFP Zone, MSB of track number							
9		Start track of Outer SFP Zone, LSB of track number							
10		1	1	1	1	1	1	1	1
11		1	1	1	1	1	1	1	1
12		1	1	1	1	1	1	1	1
13		1	1	1	1	1	1	1	1
14		Not specified, ignored in interchange							
15		Not specified, ignored in interchange							
16		Not specified, ignored in interchange							
17		Not specified, ignored in interchange							

4.5 Control Track SFP Zones

The two Control Track SFP Zones shall be pre-recorded in the Standard User Data Format (see clauses 5 and 6).

Each sector of the SFP Zones shall include 512 bytes of information numbered 0 to 511 and grouped in five sections:

- a duplicate of the PEP information (18 bytes),
- media information (366 bytes),
- system information (64 bytes),
- bytes reserved for future standardization (32 bytes),

- unspecified contents (32 bytes).

In the case of 1024-byte sectors these first 512 bytes shall be followed by 512 (FF)-bytes.

Both SFP Zones are filled with such sectors which all contain the same information. The DMP bytes (see 5.2.11.2 and 6.2.5) of each sector may not conform to this part of ISO/IEC 9171.

4.5.1 Duplicate of the PEP information

Bytes 0 to 17 shall be identical with the 18 bytes of the Data field of a sector of the PEP Zone.

4.5.2 Media information

Bytes 18 to 359 specify read and write parameters at three laser wavelengths L_1 , L_2 and L_3 . The base line reflectance R_1 , R_2 and R_3 is specified for each wavelength. The read and write powers are specified for four different rotational frequencies N_1 , N_2 , N_3 and N_4 for each wavelength. For each N four sets of write powers are given: three sets for constant pulse width and one set for constant power. Each set contains three values for the inner, middle and outer radius.

Bytes 18 to 27 and 31 to 34 are mandatory. They specify the conditions for $L_1 = 825$ nm and $N_1 = 30$ Hz. Bytes 28 to 30 and 48 to 359 are optional. They shall either specify the information indicated or be set to (FF).

All values specified in bytes 18 to 359 shall be such that the requirements of clause 13 of ISO/IEC 9171-1 are met.

Bytes 360 to 383 shall be set to (FF).

Byte 18

This byte shall specify the wavelength L_1 in nanometres as a number n between 0 and 255 such that

$$n = 1/5 L_1$$

This byte shall be set to $n = 165$ for optical disk cartridges according to this part of ISO/IEC 9171.

Byte 19

This byte shall specify the baseline reflectance R_1 at wavelength L_1 as a number n between 0 and 100 such that

$$n = 100 R_1$$

Byte 20

This byte shall specify the rotational frequency N_1 in hertz as a number n such that

$$n = N_1$$

This byte shall be set to $n = 30$ for optical disk cartridges according to this part of ISO/IEC 9171.

Byte 21

This byte shall specify the maximum read power P_1 in milliwatts for the user zone as a number n between 0 and 40 such that

$$n = 20 P_1$$

The following bytes 22 to 30 specify, at constant pulse width, the write power P_w in milliwatts indicated by the manufacturer of the disk. P_w is expressed as a number n between 0 and 255 such that

$$n = 5 P_w$$

In these bytes T stands for the constant pulse width, T for the time length of one Channel bit and r for the radius considered.

Byte 22

This byte shall specify P_w for:

$$T = T \times 1,00$$

$$r = 30 \text{ mm}$$

Byte 23

This byte shall specify P_w for:

$$T = T \times 1,00$$

$$r = 45 \text{ mm}$$

Byte 24

This byte shall specify P_w for:

$$T = T \times 1,00$$

$$r = 60 \text{ mm}$$

Byte 25

This byte shall specify P_w for:

$$T = T \times 0,50$$

$$r = 30 \text{ mm}$$

Byte 26

This byte shall specify P_w for:

$$T = T \times 0,50$$

$$r = 45 \text{ mm}$$

Byte 27

This byte shall specify P_w for:

$$T = T \times 0,50$$

$$r = 60 \text{ mm}$$

Byte 28

This byte shall specify P_w for:

$$T = T \times 0,25$$

$$r = 30 \text{ mm}$$

Byte 29

This byte shall specify P_w for:

$$T = T \times 0,25$$

$$r = 45 \text{ mm}$$

Byte 30

This byte shall specify P_w for:

$$T' = T \times 0,25$$

$$r = 60 \text{ mm}$$

Byte 31

This byte shall specify a constant write power P_w in milliwatts as a number n between 0 and 255 such that

$$n = 5 P_w$$

Byte 32

This byte shall specify the write pulse width T_p in nanoseconds expressed by a number n between 0 and 255 such that

$$n = T_p$$

for the constant write power specified by byte 31 and at a radius $r = 30 \text{ mm}$.

Byte 33

This byte shall specify the write pulse width T_p in nanoseconds expressed by a number n between 0 and 255 such that

$$n = T_p$$

for the constant write power specified by byte 31 and at a radius $r = 45 \text{ mm}$.

Byte 34

This byte shall specify the write pulse width T_p in nanoseconds expressed by a number n between 0 and 255 such that

$$n = T_p$$

for the constant write power specified by byte 31 and at a radius $r = 60 \text{ mm}$.

Bytes 35 to 47

These bytes shall be set to (FF).

(See also Annex A).

Byte 48

This byte shall specify, at wavelength L_1 , the rotational frequency N_2 in hertz as a number n between 0 and 255 such that

$$n = N_2$$

Byte 49

This byte shall specify the maximum read power P_2 in milliwatts for the User Zone as a number n between 0 and 255 such that

$$n = 20 P_2$$

Bytes 50 to 62

For the values specified in bytes 18, 19, 48 and 49, bytes 50 to 62 shall specify the parameters indicated in bytes 22 to 34.

Bytes 63 to 75

These bytes shall be set to (FF).

Byte 76

This byte shall specify, at wavelength L_1 , rotational frequency N_3 in hertz expressed as a number n between 0 and 255 such that

$$n = N_3$$

Byte 77

This byte shall specify the maximum read power P_3 in milliwatts for the user zone, as a number n between 0 and 255 such that

$$n = 20 P_3$$

Bytes 78 to 90

For the values specified in bytes 18, 19, 76 and 77, bytes 78 to 90 shall specify the parameters indicated in bytes 22 to 34.

Bytes 91 to 103

These bytes shall be set to (FF).

Byte 104

This byte shall specify, at wavelength L_1 , rotational frequency N_4 in hertz as a number n between 0 and 255 such that

$$n = N_4$$

Byte 105

This byte shall specify the maximum read power P_4 in milliwatts for the user zone as a number n between 0 and 255 such that

$$n = 20 P_4$$

Bytes 106 to 118

For the values specified in bytes 18, 19, 104 and 105, bytes 106 to 118 shall specify the parameters indicated in bytes 22 to 34.

Bytes 119 to 131

These bytes shall be set to (FF).

Byte 132

This byte shall specify wavelength L_2 in nanometres as a number n between 0 and 255 such that

$$n = 1/5 L_2$$

Byte 133

This byte shall specify the baseline reflectance R_2 at wavelength L_2 as a number n between 0 and 100 such that

$$n = 100 R_2$$

Bytes 134 to 245

The allocation of information to, or the setting of, these bytes shall correspond to those of bytes 20 to 131. The values specified shall be for L_2 (byte 132) and R_2 (byte 133).

Byte 246

This byte shall specify wavelength L_3 in nanometres as a number n between 0 and 255 such that

$$n = 1/5 L_3$$

Byte 247

This byte shall specify the baseline reflectance R_3 at wavelength L_3 as a number n between 0 and 100 such that

$$n = 100 R_3$$

Bytes 248 to 359

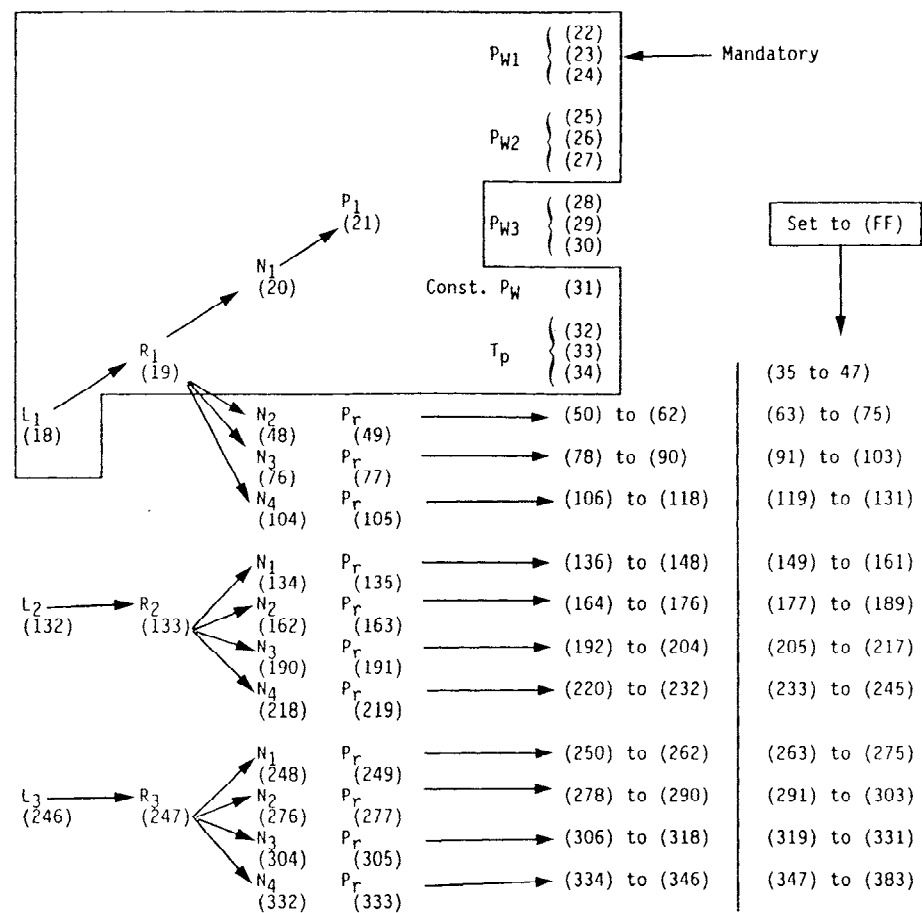
The allocation of information to, or the setting of, these bytes shall correspond to those of bytes 20 to 131. The values specified shall be for L_3 (byte 246) and R_3 (byte 247).

Bytes 360 to 383

These bytes shall be set to (FF).

(See also Annex A).

Table 2 - Summary of media information in the SFP Zone



4.5.3 System Information

Bytes 384 and 385 specify in binary notation the track number N of the last track in the User Zone. The total number of tracks in this zone is $(N + 1)$.

Byte 384

This byte shall specify the most significant byte of this number.

Byte 385

This byte shall specify the least significant byte of this number.

Bytes 386 to 479

These bytes shall be set to (FF).

(See also Annex A).

4.5.4 Unspecified Content

The contents of bytes 480 to 511 are not specified by this part of ISO/IEC 9171. They shall be ignored in interchange.