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Information technology — Digitally recorded media for information interchange and storage — 120 mm triple layer (100,0 Gbytes per disk) BD rewritable disk

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National foreword

This British Standard is the UK implementation of ISO/IEC 30193:2021. It supersedes BS ISO/IEC 30193:2016, which is withdrawn.

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Information technology — Digitally recorded media for information interchange and storage — 120 mm triple layer (100,0 Gbytes per disk) BD rewritable disk

Technologies de I'information — Supports enregistrés numériquement pour échange et stockage d'information — Disques BD réinscriptibles de 120 mm triple couche (100,0 Go par disque)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 23, *Digitally recorded media for information interchange and storage*.

This fourth edition cancels and replaces the third edition (ISO/IEC 30193:2020), which has been technically revised.

The main changes are as follows:

— The missing condition of pulse width regarding residual errors has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

In March 2002, the Blu-ray Disc Founders (BDF) came together to create optical-disk formats with large capacity and high-speed transfer rates that would be needed for recording and reproducing high-definition video content. This joint effort turned out to be fruitful and the first version of its Blu-ray Disc™[1)] Rewritable format Part 1 version 1.0, with cartridge, was issued in June 2002.

The Blu-ray Disc Association (BDA) issued version 2.1 of the Blu-ray Disc™ Rewritable format Part 1 in October 2005 and version 3.0, without cartridge, in June 2010.

To maintain compatibility of the removable medium in the market, a standard alone is not enough. It is necessary to check that the disks and devices can satisfy the specifications. The BDA also conducts verification activities for both disks and devices and has established more than 10 testing centers in Asia, Europe and the USA.

Blu-ray™ disks, players, recorders and PC drives/software based on BDA standards became popular all over the world. The BDA gave consumer applications the highest priority in the first few years. But it was known, of course, that international standardization would be required before many government entities and their contractors would be allowed to use Blu-ray Disc™. In January and February 2011, the chairs of ISO/IEC JTC 1/SC 23 and JIIMA (Japan Image and information Management Association) formally requested the BDA to consider international standardization. The reason for this was to enable the inclusion of writable BDs along with DVDs and CDs in an international standard specifying the test methods for the estimation of a lifetime of optical storage media for long-term data storage. In October 2011, the President of the BDA responded that the organization had decided to pursue international standardization for the basic physical formats for the recordable and rewritable Blu-ray™ Formats.

In December 2011, the BDA sent project proposals for international standardization of four formats to ISO/IEC JTC 1/SC 23 via the Japanese national body. They are 120 mm single layer (25,0 Gbytes per disk) and dual layer (50,0 Gbytes per disk) BD recordable disks, 120 mm single layer (25,0 Gbytes per disk) and dual layer (50,0 Gbytes per disk) BD rewritable disks, 120 mm triple layer (100,0 Gbytes per disk) and quadruple layer (128,0 Gbytes per disk) BD recordable disks and 120 mm triple layer (100,0 Gbytes per disk) BD rewritable disk.

This document specifies the mechanical, physical and optical characteristics of a 120 mm rewritable optical disk with a capacity of 100,0 Gbytes.

A few additional specifications are required in order to write and read video-recording applications, such as BDAV format which had been specified by the BDA for use on BD rewritable disks. These specifications, which are related to the BD application (BDAP), the file system or the content-protection system, are required for the disk, the generating system and the receiving system. For more information about the BDAP, the content-protection system and the additional requirements for the Blu-ray™ Format specifications, see http://www.blu-raydisc.info.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of a patent.

ISO and IEC take no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured ISO and IEC that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO and IEC. information may be obtained from the patent database available at www.iso.org/patents.

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Information technology — Digitally recorded media for information interchange and storage — 120 mm triple layer (100,0 Gbytes per disk) BD rewritable disk

1 Scope

This document specifies the mechanical, physical and optical characteristics of a 120 mm rewritable optical disk with a capacity of 100,0 Gbytes. It specifies the quality of the recorded and unrecorded signals, the format of the data and the recording method, thereby allowing for information interchange by means of such disks. User data can be written, read and overwritten many times using a reversible method. This disk is identified as a BD rewritable disk.

This document specifies the following:

— the one disk type;

— the conditions for conformance;

— the environments in which the disk is to be operated and stored;

— the mechanical and physical characteristics of the disk, in order to provide mechanical interchange between data processing systems;

— the format of the information on the disk, including the physical disposition of the tracks and sectors;

— the error-correcting codes and the coding method used;

— the characteristics of the signals recorded on the disk, enabling data processing systems to read data from the disk.

This document provides for interchange of disks between disk drives. Together with a standard for volume and file structure, it provides for full data interchange between data processing systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO 9352, *Plastics — Determination of resistance to wear by abrasive wheels*

IEC 60068-2-2, *Environmental testing — Part 2-2: Tests — Test B: Dry heat*

IEC 60068-2-30, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60950-1, *Information technology equipment — Safety — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
BD
disk having a *cover layer* (3.4) around 0,1 mm thick and a *substrate* (3.43) around 1,1 mm thick on which data is read or recorded by an optical pick-up unit (OPU) using 405 nm laser diode and numerical aperture, NA = 0,85 lens

Note 1 to entry: User data recorded on a disk is formatted using 17PP modulation and an LDC+BIS Code.

3.2
BD application
BDAP
contents standard specified for a *BD* (3.1), e.g. a video application, which requires area for a content-protection system and for its own defect-management system on the disk

3.3
channel bit
cbs
element by which the binary value ZERO or ONE is represented by *pits* (3.27), *marks* (3.19) and *spaces* (3.42) on a disk

3.4
cover layer
transparent layer with precisely controlled optical properties that covers the *recording layer* (3.33) closest to the *entrance surface* (3.10) of a disk

3.5
data zone *n*
area between the inner zone and the outer zone on *layer Ln* (3.17)

3.6
defective cluster
cluster in a *user-data area* (3.47) that has been registered in a defect list as unreliable or uncorrectable

3.7
DSV
digital-sum value
arithmetic sum obtained from a bit stream by assigning the decimal value +1 to *channel bits* (3.3) set to ONE and the decimal value −1 to channel bits set to ZERO

3.8
disk reference plane
plane defined by the perfect flat annular surface of an ideal spindle, onto which the clamping zone of a disk is clamped, that is normal to the axis of rotation

3.9
embossed HFM area
area on a disk where information has been stored by means of an *HFM groove* (3.13) during manufacturing of the disk

3.10
entrance surface
surface of a disk onto which the optical beam first impinges

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3.11
erased groove
blank *groove* (3.12) on a disk that has been erased by irradiating the *track* (3.44) using only erase power level, P_{EO}, as determined by the OPC algorithm

3.12
groove
trench-like feature of a disk connected to a *recording layer* (3.33)

Note 1 to entry: In case of triple-layer disk, one groove can be carried by the *substrate* (3.43) and other grooves can be carried by the *spacer layer* (3.41) or the *cover layer* (3.4) (see Figure 1) grooves are used to define the *track* (3.44) locations.

In the BD rewritable system, there are 3 types of grooves:

— *wobbled groove* (3.49) in rewritable area containing address information;

— *HFM groove* (3.13) in *embossed HFM area* (3.9) containing permanent information and control data;

— straight groove without any modulation in the BCA zone.

3.13
HFM groove
high-frequency modulated groove
groove (3.12) modulated in the radial direction with a rather high bandwidth signal

Note 1 to entry: HFM groove creates a data channel with sufficient capacity and data rate for replicated information.

3.14
information area
area on a disk in which information can be recorded

3.15
information zone
recorded part of the *information area* (3.14)

3.16
land
surface of a *recording layer* (3.33) between successive windings of a *groove* (3.12)

3.17
layer L*n*
one *recording layer* (3.33) of a disk identified by *n*

Note 1 to entry: layer L(*n*+1) is closer to the *entrance surface* (3.10) of a disk than layer L*n*.

3.18
layer type
identification of a disk using the number of layer(s)

Note 1 to entry: In case of triple-layer disk, the layer type is TL (see Clause 7).

3.19
mark
feature of a *recording layer* (3.33), which can take the form of an amorphous domain in the crystalline recording stack due to recording, that can be sensed by an optical read-out system

Note 1 to entry: The pattern of marks and *spaces* (3.42) represents the data on a disk.

3.20
mark polarity
polarity of reflectivity change when *marks* (3.19) are recorded

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3.21
measurement velocity
linear velocity at which a disk is measured during reading

Note 1 to entry: The *n*x measurement velocity means the measurement velocity of *n* times the *reference velocity* (3.36).

3.22
modulation bit
alternative form representing the data, that is more suited to be transmitted via a communication channel or to be stored on a storage system

3.23
NRZI conversion
method of converting modulation-bit stream into a physical signal

3.24
on-groove
geometry where *grooves* (3.12) are nearer to the *entrance surface* (3.10) of a disk than the *lands* (3.16)

3.25
padding
process in a drive to fill up the missing sectors in a 64K cluster, which consists of 32 *sectors* (3.40), with all 00h data when the host supplies less than the 32 sectors and needs to fill up the cluster

3.26
phase change
physical effect by which an area of a *recording layer* (3.33) is irradiated by a laser beam and heated in order to change from a crystalline state to an amorphous state and vice versa

3.27
pit
feature of a *recording layer* (3.33), which can take the form of a depression in or elevation on the *land* (3.16) surface, that can be sensed by the optical read-out system

Note 1 to entry: The pattern of pits and *spaces* (3.42) represents the data on a disk.

3.28
polarization
direction of the electric field vector of an optical beam

Note 1 to entry: The plane of polarization is the plane containing the electric field vector and the direction of propagation of the beam.

3.29
pre-recorded area
area on a disk where information has been recorded by the manufacturer/supplier of the disk by applying standard recording techniques after finishing of the replication process

3.30
protective coating
optional additional layer on top of the *cover layer* (3.4) provided for extra protection against scratches and other types of damage

3.31
reading velocity
linear velocity at which a disk is actually read

Note 1 to entry: The *n*x reading velocity means the reading velocity of *n* times the *reference velocity* (3.36).

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3.32
read-modify-write
R-M-W
process in a drive to read full content of a 64K cluster, which consists of 32 *sectors* (3.40), to replace the sector(s) concerned and to write back the full cluster to a disk when one or more, but less than 32, sector(s) in a cluster is(are) rewritten

3.33
recording layer
part of a disk consisting of a stack of films of specific materials on or in which data is written during manufacture and/or use

3.34
reference servo
servomechanism of a reference drive with parameters defined for measuring disks

3.35
recording velocity
linear velocity at which a disk is recorded

Note 1 to entry: The *n*x recording velocity means the recording velocity of *n* times the *reference velocity* (3.36).

3.36
reference velocity
linear velocity that results in the nominal channel-bit rate of 66 000 Mbit/s

3.37
reserved
<value> value(s) not used in this document

3.38
reserved
<field> field(s) not specified in use, to be ignored in interchange and to be set to ZERO as value

3.39
rewritable area
area on a disk where information can be recorded by means of *marks* (3.19) and *spaces* (3.42) using the phase-change effect and during the manufacture and/or use of the disk

3.40
sector
minimum-size addressable data part of a *track* (3.44) in the *information zone* (3.15)

3.41
spacer layer
transparent layer with precisely-controlled optical properties separating two *recording layers* (3.33)

3.42
space
area separating *pits* (3.27) or *marks* (3.19) in the tangential direction in the context of HF signals

Note 1 to entry: The pattern of *pits* (3.27), *marks* (3.19) and spaces represents the data on a disk.

3.43
substrate
layer, which can be transparent or not, provided for the mechanical support of a *recording layer* (3.33)

3.44
track
360° turn of a continuous spiral, formed by a *groove* (3.12)

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3.45
track pitch
TP
distance between centrelines of a *groove* (3.12), in adjacent *tracks* (3.44), measured in the radial direction

3.46
transmission stack
TS
set of all layers between the *entrance surface* (3.10) of a disk and the *recording layer* (3.33) concerned

Note 1 to entry: The transmission stack of a specific recording layer consists of all layers that are passed through by the light beam, when accessing that recording layer.

3.47
user-data area
collection of all data zone(s) on a disk, consisting only of the clusters in which user data can be recorded

3.48
virgin groove
blank *groove* (3.12) on a disk which has never been recorded nor erased

3.49
wobbled groove
groove (3.12) that has a periodic sinusoidal deviation from its average centreline

Note 1 to entry: By modulating the sinusoidal deviation, the wobble provides address information and general information about a disk.

3.50
zone
annular area of a disk

4 Symbols and abbreviated terms

ac	alternating current	lsb	least significant bit
ADIP	address in pre-groove	L_{SHD}	second harmonic distortion level
APC	automatic power control	L_{SHL}	second harmonic level
AU	address unit	LSN	logical-sector number
AUN	address unit number	MM	MSK mark
BCA	burst-cutting area	MSB	most significant byte
BIS	burst-indicating subcode	msb	most significant bit
BPF	band-pass filter	MSK	minimum shift keying
CAV	constant angular velocity	MW	monotone wobble
cbs	channel bits	NA	numerical aperture
CNR	carrier-to-noise ratio	NRD	non-reallocatable defect
dc	direct current	NRZ	non-return-to-zero
DCZ	drive calibration zone	NRZI	non-return-to-zero inverting

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DDS	disk definition structure	NWL	nominal wobble length
DFL	defect list	OPU	optical pick-up unit
DI	disk information	PAA	physical ADIP address
DL	dual layer	PAC	physical access control
DMA	disk management area	PBA	possibly bad area
DMS	disk management structure	PIC	permanent information and control data
DOW	direct overwrite	PLL	phase-lock loop
DOW(n)	nth overwrite	PoA	post-amble
DOW(0)	initial recording	PP	push-pull
DSV	digital sum value	pp	peak-to-peak
DWP	disk write-protect	PrA	pre-amble
EB	emergency brake	PSN	physical sector number
ECC	error correction code	R_H	relative humidity
EDC	error detection code	RMTR	repeated minimum-transition run-length
EQ	equalizer	R-M-W	read-modify-write
FAA	first ADIP address (of data zone)	RS	Reed-Solomon (code)
FS	frame sync	R_T	relative thickness
FWHM	full width at half maximum	RSER	random symbol error rate
Gbyte	gigabyte	RUB	recording unit block
HF	high frequency	SER	symbol error rate
HFM	high frequency modulated	S/N	signal-to-noise ratio
HMW	harmonic modulated wave	SPS	start position shift
HPF	high-pass filter	STW	saw-tooth wobble
HTL	high-to-low	Sync	synchronization
I_{NHWS}	normalized HFM-wobble signal amplitude	TL	triple layer
I_{NWS}	normalized wobble signal amplitude	TP	track pitch
LAA	last ADIP address (of data zone)	TS	transmission stack
LDC	long-distance code	V_{ref}	reference velocity
LPF	low-pass filter	wbs	wobbles
LSB	least significant byte	WP	write protect

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5 Conformance

5.1 Optical disk

A claim of conformance with this document shall specify the type implemented. An optical disk shall be in conformance with this document if it meets all the requirements specified for its type.

5.2 Generating system

A generating system shall be in conformance with this document if the optical disk it generates is in accordance with 5.1.

5.3 Receiving system

A receiving system shall be in conformance with this document if it is able to handle the type of optical disk according to 5.1.

5.4 Compatibility statement

A claim of conformance by a generating or receiving system with this document shall include a statement listing any other standards supported. This statement shall specify the numbers of the standards, the optical disk types supported (where appropriate) and whether support includes reading only or both reading and writing.

6 Conventions and notations

6.1 Levels of grouping

Data is often collected into groups where these groups of data can be collected into higher level groups. For the clarity of the grouping hierarchy, in this document the following levels of hierarchy are used:

Frame: the lowest level of grouping. Generally, frames contain bytes of information.

Block: the second level of grouping. Generally, blocks consist of a number of frames.

Cluster: the highest level of grouping. Clusters consist of several blocks.

Fragment: a level of grouping that can be applied by the application. A certain amount of data is allocated to a (fixed) number of consecutive clusters.

6.2 Representation of numbers

A measured value $x_{measured}$ may be rounded off to the least-significant digit of the corresponding specified value x before being compared with this specified value.

EXAMPLE 1

— The specification is: $x = 1{,}26^{+0{,}01}_{-0{,}02}$:
(nominal value = 1,26 with a positive tolerance of +0,01 and a negative tolerance of –0,02)
  — a measured value in the range $1{,}235 \leq x_{measured} < 1{,}275$ fulfills this specification.
— The specification is: $x \leq 0{,}3$:

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  - a measured value $x_{measured} < 0,35$ fulfills this specification (rounding off is applied for $0,30 < x_{measured} < 0,35$: $x_{rounded} = 0,3$);

- The specification is: $x < 0,3$:
  - a measured value $x_{measured} = 0,299$ fulfills this specification (no rounding off needs to be applied);
  - a measured value $x_{measured} = 0,3$ exactly does not fulfil this specification.

In case the specified value is given as "maximum x units" or "minimum x units", the measured value shall not be rounded off before comparing to the specified value. Parameters given in this way shall not be outside of the specified limits set by the exact value of x.

EXAMPLE 2

- The specification is maximum 0,3 mm:
  - a measured value of 0,300 mm fulfills this specification;
  - a measured value of 0,301 mm does not fulfil this specification;
- The specification is minimum 3 dB:
  - a measured value of 3,00 dB fulfills this specification;
  - a measured value of 2,99 dB does not fulfil this specification.

Numbers in decimal notations are represented by the digits 0 to 9. The decimal symbol is "," (comma). In large numbers, the " " (space) can be used as digit grouping symbol.

Numbers in hexadecimal notation are represented by the hexadecimal digits 0 to 9 and A to F in parentheses or followed by lowercase "h". The character x in hexadecimal numbers represents any digit 0 to 9 or A to F.

Numbers in binary notations and bit patterns are represented by strings of digits 0 and 1, with the most significant bit (msb) shown to the left. The character x in binary numbers represents a digit 0 or 1.

Negative values of numbers in binary notation are given as two's complement.

In a pattern of n bits, bit $b_{(n-1)}$ shall be the msb and bit b_0 shall be the lsb. Bit $b_{(n-1)}$ shall be recorded first.

An uninterrupted sequence of m 0's in a bit pattern can be represented by $[0^m]$.

The setting of bits is denoted by ZERO and ONE.

In data fields composed of bytes, the data is recorded so that the most significant byte (MSB), identified as Byte 0, shall be recorded first and the least-significant byte (LSB) last.

In a field of $8n$ bits, bit $b_{(8n-1)}$ shall be the msb and bit b_0 the lsb.

Bit $b_{(8n-1)}$ shall be recorded first.

In data fields composed of nibbles, the data is recorded so that the most significant nibble, identified as Nibble 0, shall be recorded first and the least-significant nibble last.

In a field of $4n$ bits, bit $b_{(4n-1)}$ shall be the msb and bit b_0 the lsb.

Bit $b_{(4n-1)}$ shall be recorded first.

A range of values is indicated as $x \sim y$, where x and y are included in the range.

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A list of integers is indicated as *i* .. *j*. The list contains all numbers between *i* and *j*, including *i* and *j* (e.g. *k* = 0 .. 7). If the step size is different from one, this is indicated as: *i*, (*i*+step) .. *j* (e.g. *k* = 1, 4 .. 16, where step = 3).

A group of parameters is indicated as Param *m*..*n* or P_m .. P_n. The group contains all parameters with an index between *m* and *n*, including *m* and *n* (e.g. byte 16 .. 31, bit 7 .. 4, Add_0 .. Add_{255}).

If *x* is nearly equal to *y*, then it is expressed as $x \approx y$.

6.3 Integer calculus

div(*n*,*d*) represents the integer part of the division of *n* by *d.*

mod(*n*,*d*) represents the remainder of the division of *n* by *d*: $\text{mod}(n,d) = n - d \times \text{div}(n,d)$.

For example:

div(+11, +3) = +3	div(−11, +3) = −3	div(+11, −3) = −3	div(−11, −3) = +3
mod(+11, +3) = +2	mod(−11, +3) = −2	mod(+11, −3) = +2	mod(−11, −3) = −2

7 General description of disk

The 120 mm optical disk that is the subject of this document consists of a substrate of about 1,1 mm nominal thickness. Clamping is performed in the clamping zone.

The recording layer of the disk uses high-to-low (HTL) technology-recorded HTL marks have lower reflection than the unrecorded layer(s).

The recording layer consists of several layers. The three recording layers are separated by two transparent spacer layers whose thicknesses are about 25,0 µm and 18,0 µm, respectively, in this order from the substrate. On top of these recording layer, a transparent cover layer of about 57,0 µm is applied with accurately defined optical characteristics (see Figure 1).

This document provides for one type of such disk, type TL, whose capacity is 100,0 Gbytes. To improve the scratch resistance, the cover layer optionally can be protected with an additional hard coating.

Data can be written onto the disk as amorphous marks in the crystalline recording layer(s) and can be overwritten with a high-power focused optical beam using the phase-change effect between amorphous and crystalline states of the recording material.

The data can be read with a low power focused optical beam, using the difference in the reflectivity of the amorphous and the crystalline states.

Depending on which recording layer is to be accessed, the optical beam passes through the transparent cover layer or through the transparent cover layer, the semi-transparent recording layer(s) and the transparent spacer layer(s).

For reference purposes, all layers together, passed through by the light beam when accessing a certain recording layer, are called the transmission stack (TS) of that specific recording layer.

Data is recorded on the grooves. The wobble of the grooves modulated with addresses serve as a system for positioning and speed control during recording.

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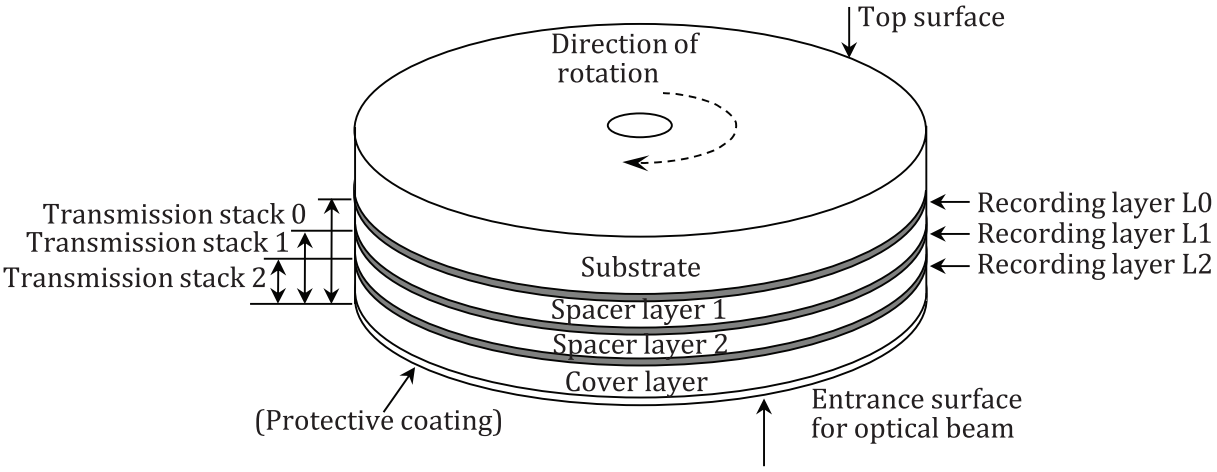


Figure 1 — Outline of triple layer BD rewritable disk

Figure 2 shows the recording velocity requirements.

Disk type	Disk-type parameters			Recording velocity	
	Mark polarity	Push-pull polarity (see 26.1)	Layer type	1x	2x
Type TL	HTL	On-groove [a]	TL	—	M

M Mandatory.
— Not allowed in this document.
[a] Groove geometry is on-groove for all layer L0, layer L1 and layer L2 (see 15.2).

Figure 2 — Recording velocity requirements for disk type

8 General requirements

8.1 Environments

8.1.1 Test environment

8.1.1.1 General

During measurements for testing the conformance of the disk with this document, the disk shall be in the test environment. The test environment is the environment where the air immediately surrounding the disk shall have the following properties:

— temperature, T: (23 ± 2) °C;

— relative humidity, R_H: 45 % to 55 %;

— atmospheric pressure: 86 kPa to 106 kPa.

No condensation on the disk shall occur. Before testing, the disk shall be conditioned in this environment for sufficient time.

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8.1.1.2 Test conditions for sudden change in operating environment

Some parameters can be rather sensitive for changes in the operating environment. Where specified, the following two tests shall be performed. In both cases, the required specifications shall be fulfilled during the time it takes for the disk to acclimatize to the new environment.

Apply a sudden change in relative humidity, while keeping the temperature at a constant level:
RH = 90 %, T = 25 °C → RH = 45 %, T = 25 °C (see Figure 3).

Apply a sudden change in temperature, while keeping the absolute humidity at a constant level (≈10,4 g/m3):
T = 25 °C, RH = 45 % → T = 55 °C, RH = 10 % (see Figure 3).

8.1.2 Operating environment

A disk in conformance with this document shall provide 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 disk shall have the following properties:

— temperature, T: 5 °C to 55 °C;

— relative humidity, R_H: 3 % to 90 %;

— absolute humidity: 0,5 g/m^3 to 30 g/m^3;

— atmospheric pressure: 60 kPa to 106 kPa.

There shall be no condensation of moisture on the disk. If a disk has been exposed to conditions outside those specified above, it shall be acclimatized in an operating environment for at least 2 hours before use.

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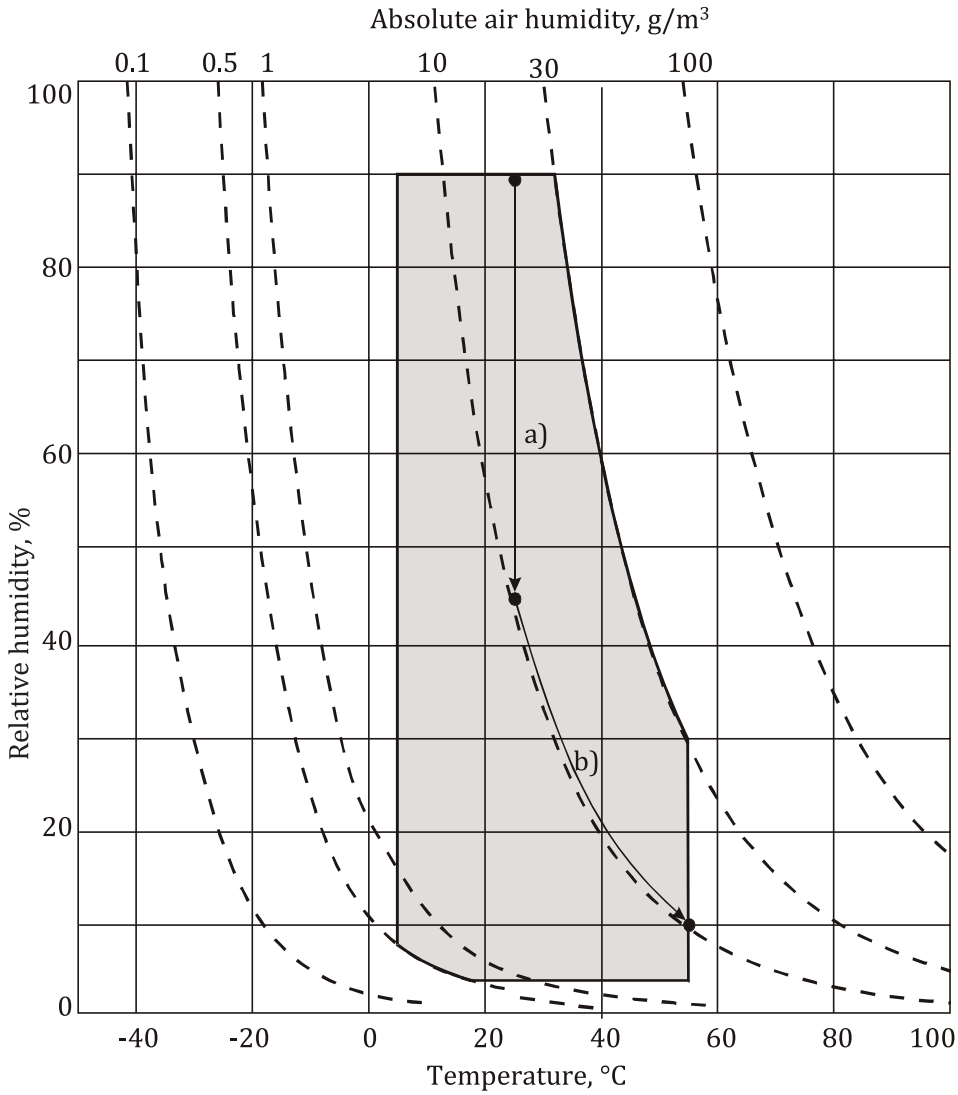


Figure 3 — Operating environment

8.1.3 Storage environment

8.1.3.1 General

The storage environment is the environment where the air immediately surrounding the optical disk shall have the following properties:

— temperature, T: –10 °C to 55 °C;

— relative humidity, R_H: 5 % to 90 %;

— absolute humidity: 1 g/m^3 to 30 g/m^3;

— atmospheric pressure: 60 kPa to 106 kPa;

— temperature variation max.: 15 °C/h;

— relative humidity variation max.: 10 %/h.

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8.1.3.2 Climatic storage tests

To check the environmental stability of the disk, it shall be exposed to the following environments:

— dry heat test according to IEC 60068-2-2 Ba:
T = 55 °C, R_H = 50 %, 96 h;

— damp heat cycle test according to IEC 60068-2-30 Db:
T_{high} = 40 °C, T_{low} = 25 °C, R_H = 95 %, cycle time = (12 + 12) h, 6 cycles.

After exposure to these environmental conditions, allow for some recovery time before measuring (24 h or 48 h).

8.1.4 Transportation

8.1.4.1 General

As transportation occurs under a wide range of temperatures and humidities, for differing periods, by many methods of transport and in all parts of the world, it is not possible to specify mandatory conditions for transportation or for packaging.

8.1.4.2 Packaging

8.1.4.2.1 General

The form of packaging should be agreed between sender and recipient. In the absence of such an agreement, the form of packaging is the responsibility of the sender. The following hazards should be taken into account.

8.1.4.2.2 Temperature and humidity

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

8.1.4.2.3 Impact loads and vibrations

a) Avoid mechanical loads that would distort the shape of the disk.

b) Avoid dropping the disk.

c) Disks 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.

8.2 Safety requirements

The disk shall meet the requirements of IEC 60950-1, when used in the intended manner or in any foreseeable uses in an information system.

8.3 Flammability

The disk shall be made from materials that comply with the flammability class for HB materials, or better, as specified in IEC 60950-1.

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9 Reference drive

9.1 General

A reference drive shall be used for the measurement of optical and electrical signal parameters for conformance with the requirements of this document. The critical components of this device have the characteristics specified in this clause.

9.2 Measurement conditions

During tests, the disk shall be in a test environment as defined in 8.1.1, unless stated otherwise.

9.3 Optical system

The basic set-up of the optical system of the reference drive used for measuring specified (over)write and read parameters is shown in Figure 4. Different components and locations of components are permitted, provided that the performance remains the same as that of the set-up in Figure 4.

The optical system shall be aligned such that the focused optical beam is perpendicular to the recording layer on which the beam is focused at the radius where the measurement is to be performed.

The optical system shall be such that the detected light reflected from the entrance surface of the disk is minimized so as not to affect the accuracy of the measurements.

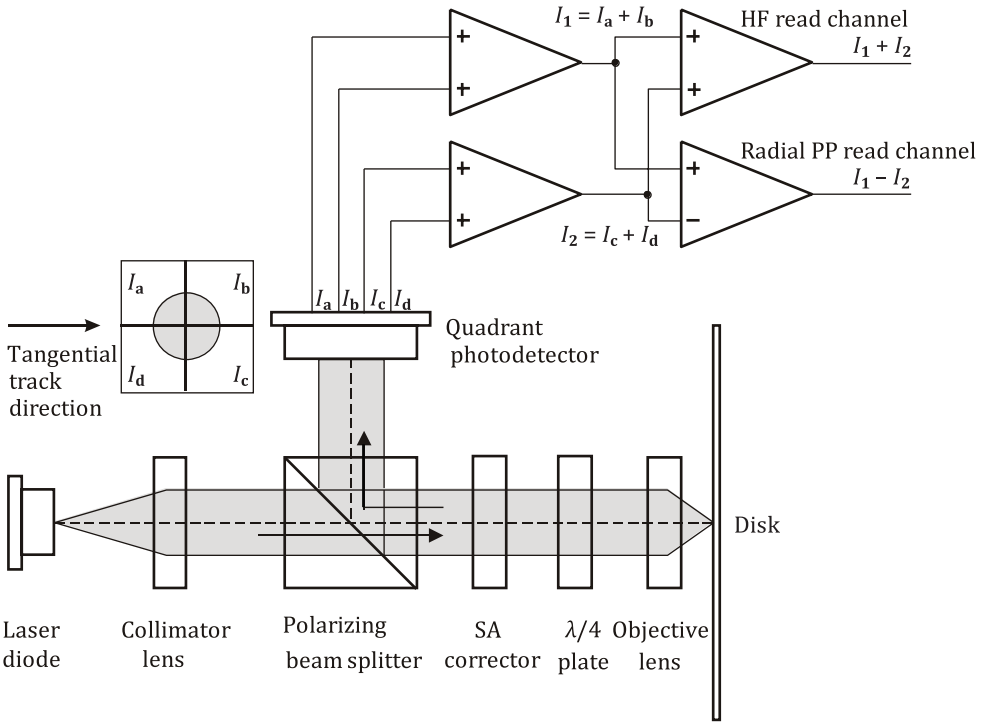


Figure 4 — Optical system of reference drive

A polarizing beam splitter and a quarter-wavelength plate shall be used to separate the entrance light beam coming from the laser diode, and light beam reflected by the optical disk going towards the photodetector. The light beam transmitted through the splitter shall have a p:s intensity ratio of at least 100:1.

The optical beam shall be compensated for spherical aberrations (SA) such that these aberrations are minimized for the thickness of the TS of the recording layer on which the beam is focused at the radius where the measurement is to be performed.

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During measurements on one layer of a multi-layer disk, light reflected from the other layer can influence the measurements on the layer under investigation. To cope with these effects, the photodetector shall have limited dimensions. Its length and width shall be smaller than $M \times 5$ µm, where M is the transversal optical magnification from the disk to its conjugate plane near the quadrant photodetector. For a type TL disk, however, the effect cannot be neglected even if the length and width of photodetector are smaller than $M \times 5$ µm. Therefore, observed reflectivity shall be compensated using the procedure shown in B.4.

9.4 Optical beam

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

— wavelength (λ) of the laser beam: (405 ± 5) nm;

— polarization: circular;

— NA: 0,85 ± 0,01;

— light intensity at the rim of the pupil of the objective lens relative to the maximum intensity:

  — in the tangential direction: (60 ± 5) %;

  — in the radial direction: (65 ± 5) %;

— maximum wave-front aberration at the recording layer(s): 0,033 × λ rms;

  (after correction of tilt and spherical aberrations)

— maximum relative-intensity noise of the laser diode: −125 dB/Hz

$$\left[10\times\lg\left(\frac{P_m}{P_{\mathrm{dc}}}\right)\right]$$

  where

  P_{m} is the ac light density, in Hz;

  P_{dc} is the dc light power.

— normalized detector size: $S/M^2 \leq 25\ \mu m^2$

  where S is the total surface of the 4-quadrant photodetector;

— read power for disk testing (average):

  — layer L0 and layer L1: (1,44 ± 0,10) mW;

  — layer L2: (1,00 ± 0,10) mW;

— write power and pulse shape: See 29.4.2 for the write power. The pulse shape shall follow Annex F.

9.5 HF read channel

The HF read channel is provided to supply a signal from which the user data can be retrieved. The signal is generated by adding all the currents from all four elements of the photodetector (I_a+I_b+I_c+I_d).

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These currents are modulated by the user-written information, due to the difference in reflectivity of the marks and spaces caused by the phase-change effects.

In the frequency range from dc to 44 MHz, the HF read channel including the photodetectors shall have a flat amplitude response within ±1,0 dB relative to its dc gain. The group delay variation shall be maximum 1,5 ns pp. in the frequency range from 6 MHz to 44 MHz.

For measurement of i-MLSE, the characteristics of the signal processing, the Viterbi decoder and the PLL, etc., are specified in Annex H.

9.6 Radial PP read channel

The radial PP read channel provides a tracking-error signal to control the servo for radial tracking of the optical beam. It also provides a wobble signal from which the information modulated on the grooves can be retrieved.

The radial tracking error is generated as a signal $[(I_a+I_b) - (I_c+I_d)]$ related to the difference in the amount of light in the two halves of the exit pupil of the objective lens.

The read amplifiers including the photodetectors in the radial PP read channel shall have a flat amplitude response within ±1,0 dB relative to their dc gain from dc to 16 MHz.

9.7 Disk clamping

While its parameters are being measured, the disk shall be clamped between two concentric rings covering most of the clamping zone (see 10.6). The top clamping area shall have the same inner and outer diameters as the bottom clamping area (see Figure 5).

Clamping shall occur between d_{in} = (23,5 ± 0,5) mm and d_{out} = (32,5 ± 0,5) mm.

The total clamping force shall be F_1 = 2,0 N ± 0,5 N.

In order to prevent warping of the disk under the moment of force generated by the clamping force and the chucking force, which is exerted by the tapered cone on the rim of the centre hole of the disk, F_2 shall not exceed 0,5 N (see Figure 5).

The top angle, θ_a, of the tapered cone for centering of the disk shall be 40,0° ± 0,5°.

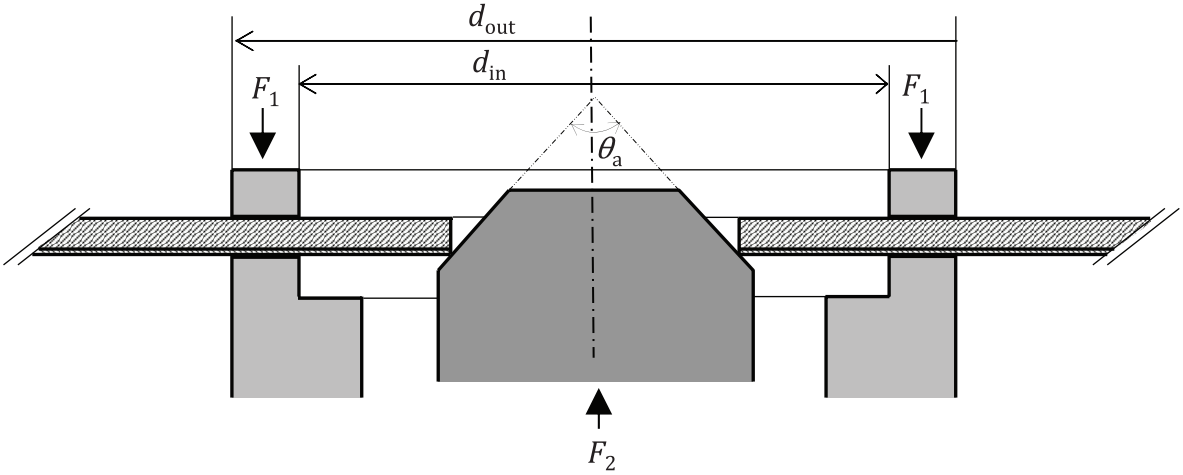


Figure 5 — Clamping conditions for measurement

9.8 Rotation of disk and measurement velocity

The direction of rotation shall be counter-clockwise as viewed from the objective lens.

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All specifications are based on a tangential speed during reading that is equal to two times the reference velocity, unless otherwise specified. This corresponds to a constant linear velocity of 7,375 m/s.

9.9 Normalized servo transfer function

In order to specify the servo systems for axial and radial tracking, a function $H_N(\mathrm{i}\omega)$ is used. It specifies the nominal values of the open-loop transfer function H of the reference servo(s) as Formula (1):

$$H_N(\mathrm{i}\omega) = \frac{1}{3} \times \left(\frac{\omega_0}{\mathrm{i}\omega} \right)^2 \times \frac{1 + \frac{3 \times \mathrm{i}\omega}{\omega_0}}{1 + \frac{\mathrm{i}\omega}{3 \times \omega_0}} \times \left(1 + \frac{\omega_{\mathrm{int}}}{\mathrm{i}\omega} \right)^K \tag{1}$$

where

ω = $2\pi \times f$;

ω_0 = $2\pi \times f_0$;

ω_{int} = $2\pi \times f_{\mathrm{int}}$;

i^2 = –1;

K is order of integrator.

f_0 is the 0 dB crossover frequency of the open-loop transfer function. The crossover frequencies of the lead-lag network of the servo are given by:

— lead break frequency: $f_1 = f_0/3$;

— lag break frequency: $f_2 = f_0 \times 3$.

The term $(1+\omega_{\mathrm{int}}/\mathrm{i}\omega)$ in Formula (1) represents an integrator function. Such an integrator or equivalent function is used to further reduce low-frequency components, especially those due to deviations with frequencies equal to the rotational frequency of the disk or its harmonics.

Also, f_{int} is the 3 dB crossover frequency of the integrator function.

Another frequency of importance is the frequency f_x at which a sinusoidal displacement with an amplitude equal to the maximum allowed residual tracking error, e_{max}, corresponds to the maximum expected acceleration, $\alpha_{\mathrm{max.}}$ This frequency can be calculated with Formula (2):

$$f_x = \frac{1}{2\pi} \sqrt{\frac{\alpha_{\mathrm{max}}}{e_{\mathrm{max}}}} \tag{2}$$

Because the tracking-error signals from the disk can have rather large variations, the tracking-error signal fed into each reference servo loop shall be adjusted to a fixed level (effectively calibrating the total loop gain), which guarantees the specified bandwidth.

9.10 Measurement velocities and reference servos for axial tracking

9.10.1 General

The applicable reference servo and conditions for measuring residual axial errors depend on the measurement velocities under testing: measurement velocities for axial residual errors shall be a half of the recording velocities, a reference servo for 1x measurement velocity refers to 9.10.2. Only if the disk supports reading at 4x reference velocity, measurement velocities for axial residual errors shall be a half of the reading velocities, a reference servo for 2x measurement velocity refers to 9.10.3. The servo for all conditions has the same basics, however with a modified integrator.

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9.10.2 Reference servo for axial tracking for 1x measurement velocity

Regarding the open-loop transfer function $H(f)$ of the reference servo for axial tracking, $|1 + H(f)|$ is limited as shown schematically by the shaded area in Figure 6.

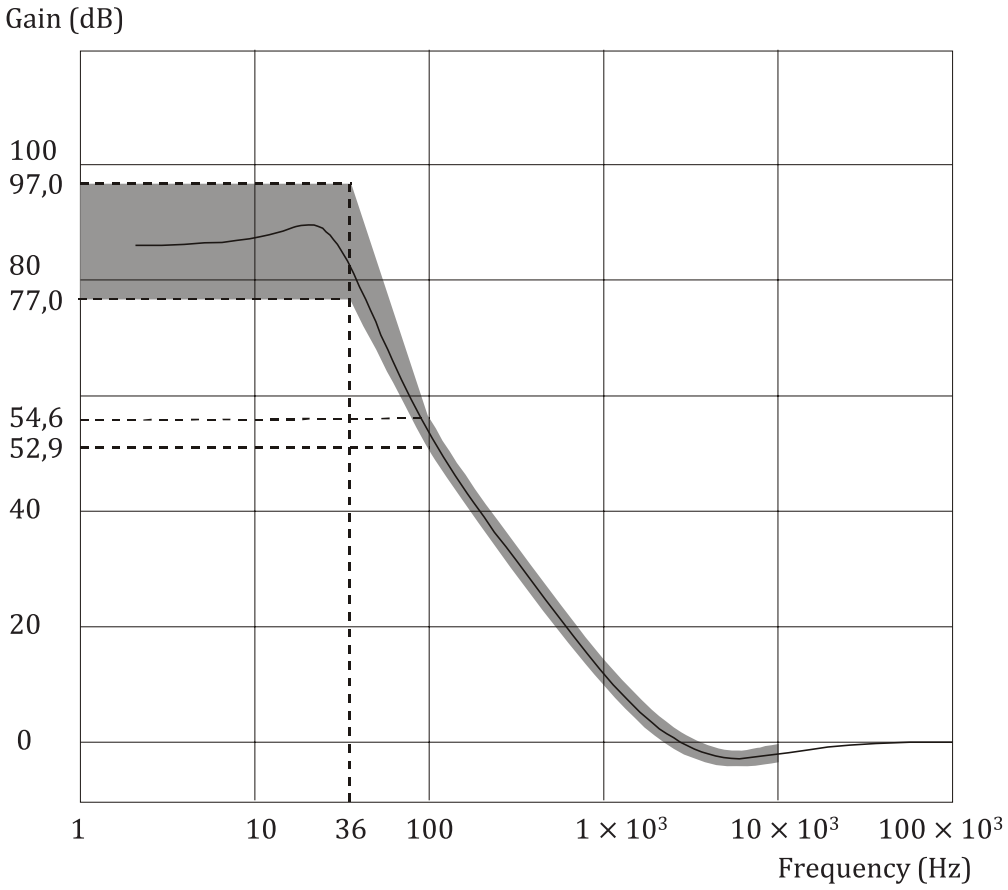


Figure 6 — Servo characteristic for axial tracking for 1x measurement velocity

The crossover frequency, f_0, of $H_N(f)$, in kHz (see 9.9), used to define the limits of $|1 + H(f)|$, is specified by Formula (3), where α_{max} = 6,0 m/s² is the maximum expected axial acceleration due to local disturbances, and α_{max} is multiplied by a factor m = 1,25 for servo margin. The tracking error, e_{max}, caused by this $m \times \alpha_{max}$, shall be 55 nm. Thus, the 0 dB crossover frequency shall be as follows:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3\times m\times \alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{3\times 1{,}25\times 6{,}0}{55\times 10^{-9}}} = 3{,}2 \qquad (3)$$

The integrator shall be first order (K = 1) with a crossover frequency of f_{int} = 100 Hz [see Formulae (4) to (6)].

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In the frequency range 100 Hz to 10 kHz:

$$0,9\times|1+H_N(f)|\leq|1+H(f)|\leq 1,1\times|1+H_N(f)| \tag{4}$$

In the frequency range 36 Hz to 100 Hz:

$$0,9\times|1+H_N(f)|\leq|1+H(f)|\leq 1,1\times|1+H_N(f_{\text{int}})|\times\left(\frac{f_{\text{int}}}{f}\right)^{4,78} \tag{5}$$

In the frequency range up to 36 Hz (in dB):

$$77,0\leq|1+H(f)|\leq 97,0 \tag{6}$$

The frequency, f_x, in kHz, has the value determined by Formula (7):

$$f_x=\frac{1}{2\pi}\sqrt{\frac{\alpha_{\max}}{e_{\max}}}=\frac{1}{2\pi}\sqrt{\frac{6,0}{55\times10^{-9}}}\approx 1,6 \tag{7}$$

9.10.3 Reference servo for axial tracking for 2x measurement velocity

For the open-loop transfer function $H(f)$ of the reference servo for axial tracking, $|1 + H(f)|$ is limited as schematically shown by the shaded area of the Figure 7.

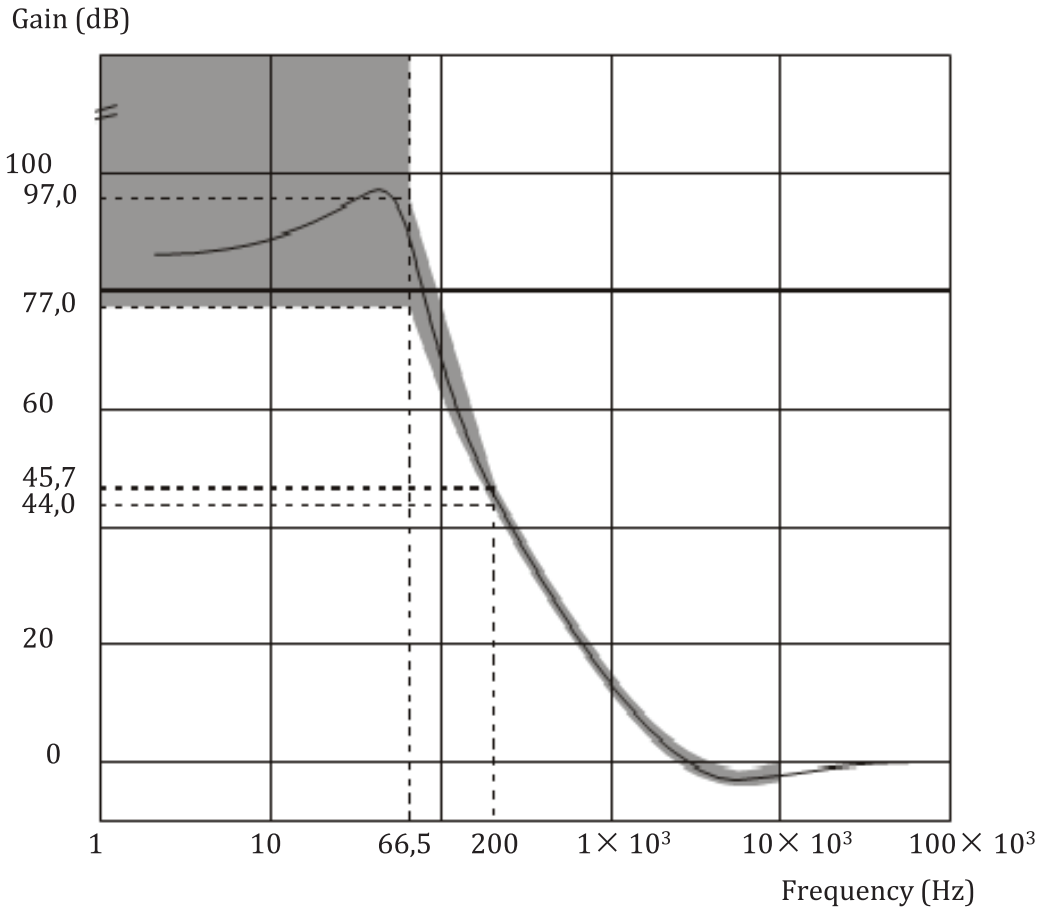


Figure 7 — Servo characteristic for axial tracking for 2x measurement velocity

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The 0 dB crossover frequency, f_0, shall be 3,2 kHz, the same as the 1x measurement condition. For the maximum residual tracking error of 80 nm (see 11.4.2), this corresponds to an acceleration, α_{max} in m/s^2, as per Formula (8):

$$\alpha_{max} = \frac{(2\pi \times f_0)^2}{3} \times e_{max} = \frac{\left(2\pi \times 3{,}2 \times 10^3\right)^2}{3} \times 80 \times 10^{-9} = 10{,}8 \tag{8}$$

For the maximum residual tracking error of 110 nm (see 11.4.3), this corresponds to an acceleration, α_{max} in m/s^2, as per Formula (9):

$$\alpha_{max} = \frac{(2\pi \times f_0)^2}{3} \times e_{max} = \frac{\left(2\pi \times 3{,}2 \times 10^3\right)^2}{3} \times 110 \times 10^{-9} = 14{,}8 \tag{9}$$

The integrator shall be second order ($K = 2$) with the crossover frequency f_{int} = 200 Hz [see Formulae (10) to (12)].

Frequency range 200 Hz to 10 kHz:

$$0{,}9 \times |1 + H_N(f)| \leq |1 + H(f)| \leq 1{,}1 \times |1 + H_N(f)| \tag{10}$$

Frequency range 66,5 Hz to 200 Hz:

$$0{,}9 \times |1 + H_N(f)| \leq |1 + H(f)| \leq 1{,}1 \times |1 + H_N(f_{int})| \times \left(\frac{f_{int}}{f}\right)^{5{,}36} \tag{11}$$

Frequency range up to 66,5 Hz (in dB):

$$|1 + H(f)| \geq 77{,}0 \tag{12}$$

9.11 Measurement velocities and reference servos for radial tracking

9.11.1 General

The applicable reference servo and conditions for measuring residual radial errors depend on the measurement velocities: measurement velocities for radial residual errors shall be a half of the recording velocities, a reference servo for 1x measurement velocity refers to 9.11.2. Only if the disk supports reading at 4x reference velocity, measurement velocities for radial residual errors shall be a half of the reading velocities, a reference servo for 2x measurement velocity refers to 9.11.3. The servo for all conditions has the same basics, however with a modified integrator.

9.11.2 Reference servo for radial tracking for 1x measurement velocity

For the open loop transfer function H(f) of the reference servo for axial tracking, $|1 + H(f)|$ is limited as shown schematically by the shaded area in Figure 8.

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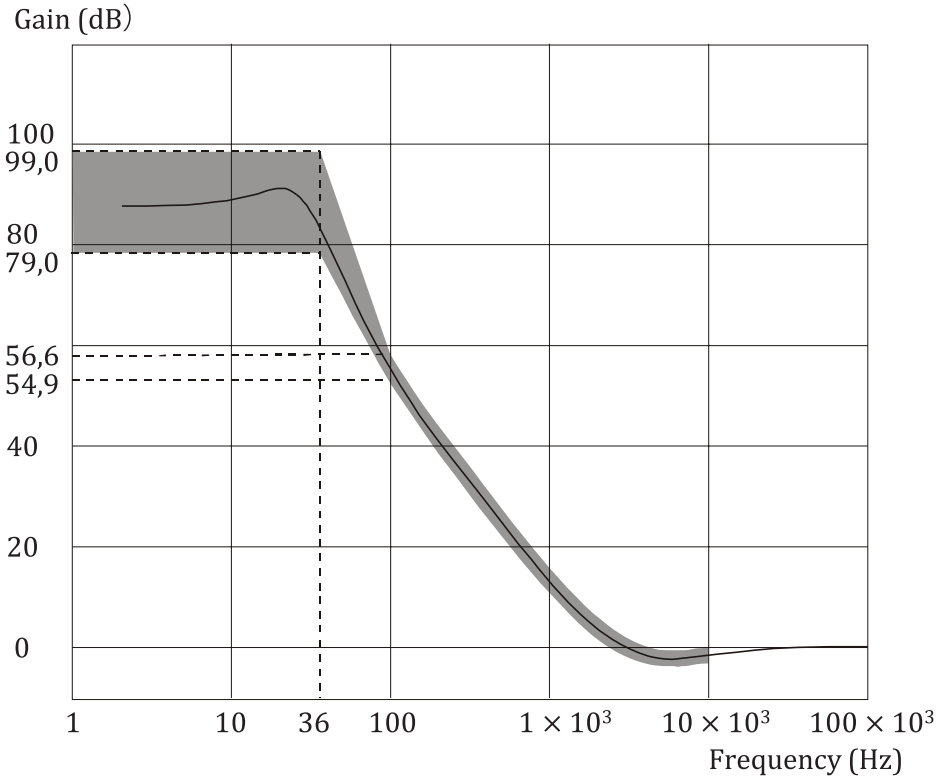


Figure 8 — Servo characteristic for radial tracking for 1x measurement velocity

The crossover frequency, f_0, of $H_N(f)$, in kHz (see 9.9), used to define the limits of $|1 + H(f)|$, is specified by Formula (13), where α_{max} = 2,2 m/s² is the worst-case maximum expected radial acceleration due to local disturbances, and α_{max} is multiplied by a factor m = 1,25 for servo margin. The tracking error, e_{max}, caused by this $m \times \alpha_{max}$, shall be 16 nm. Thus, the 0 dB crossover frequency shall be as follows:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3\times m\times \alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{3\times 1{,}25\times 2{,}2}{16\times 10^{-9}}} = 3{,}6 \tag{13}$$

The integrator shall be first order with crossover frequency f_{int} = 100 Hz [see Formulae (14) to (16)].

In the frequency range 100 Hz to 10 kHz:

$$0{,}9\times|1+H_N(f)| \le |1+H(f)| \le 1{,}1\times|1+H_N(f)| \tag{14}$$

In the frequency range 36 Hz to 100 Hz:

$$0{,}9\times|1+H_N(f)| \le |1+H(f)| \le 1{,}1\times|1+H_N(f_{int})|\times\left(\frac{f_{int}}{f}\right)^{4{,}78} \tag{15}$$

In the frequency range up to 36 Hz (in dB):

$$79{,}0 \le |1 + H(f)| \le 99{,}0 \tag{16}$$

The frequency, f_x, in kHz, has the value by Formula (17):

$$f_x = \frac{1}{2\pi}\sqrt{\frac{\alpha_{max}}{e_{max}}} = \frac{1}{2\pi}\sqrt{\frac{2{,}2}{16\times 10^{-9}}} \approx 1{,}8 \tag{17}$$

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9.11.3 Reference servo for radial tracking for 2x measurement velocity

For the open-loop transfer function $H(f)$ of the reference servo for radial tracking, $|1+ H(f)|$ is limited as schematically shown by the shaded area of the Figure 9.

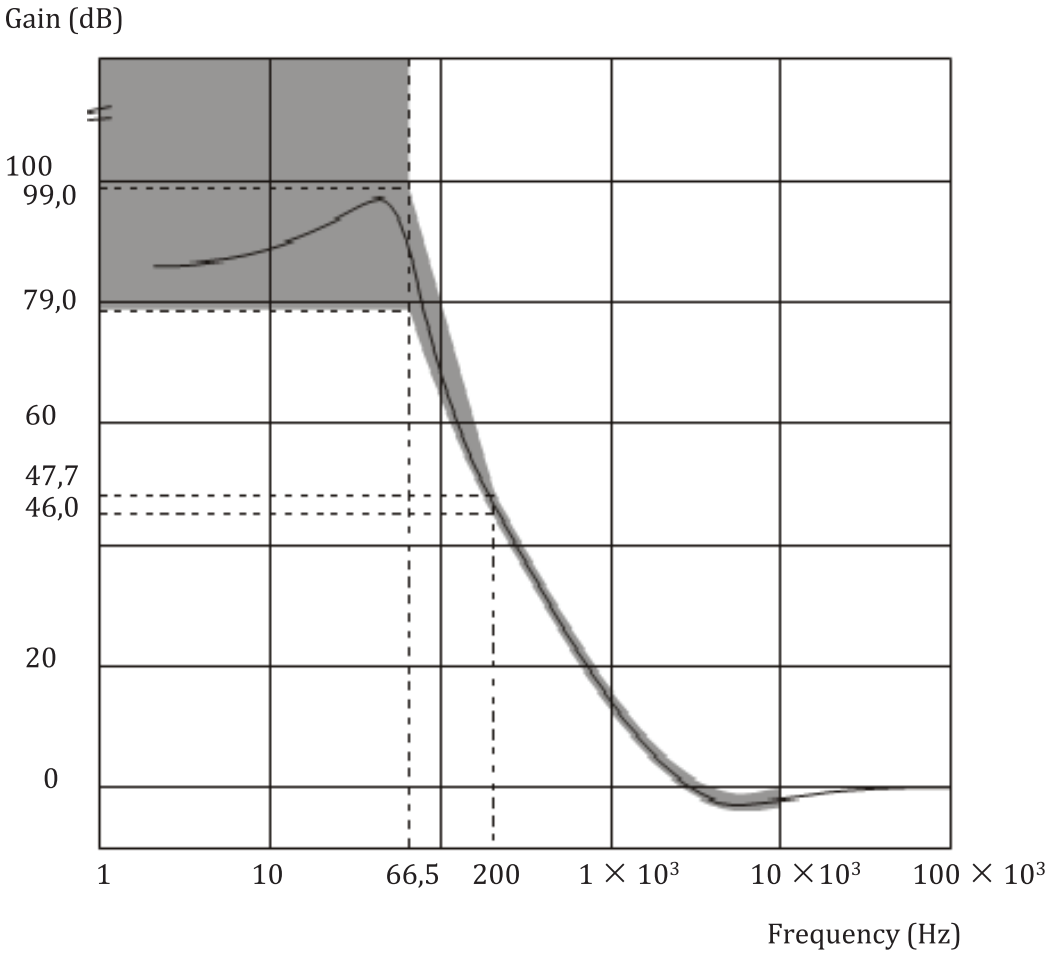


Figure 9 — Servo characteristic for radial tracking for 2x measurement velocity

The 0 dB crossover frequency f_0 shall be 3,6 kHz, the same as the 1x measurement condition. For the maximum residual tracking error of 20 nm (see 11.5.3), this corresponds to an acceleration, α_{max} in m/s^2, as per Formula (18):

$$\alpha_{max} = \frac{(2\pi \times f_0)^2}{3} \times e_{max} = \frac{\left(2\pi \times 3{,}6 \times 10^3\right)^2}{3} \times 20 \times 10^{-9} = 3{,}4 \quad (18)$$

The integrator shall be second order ($K = 2$) with the crossover frequency f_{int} = 200 Hz [see Formulae (19) to (21)].

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Frequency range 200 Hz to 10 kHz:

$$0,9\times|1+H_N(f)|\leq|1+H(f)|\leq 1,1\times|1+H_N(f)| \tag{19}$$

Frequency range 66,5 Hz to 200 Hz:

$$0,9\times|1+H_N(f)|\leq|1+H(f)|\leq 1,1\times|1+H_N(f_{\text{int}})|\times\left(\frac{f_{\text{int}}}{f}\right)^{5,36} \tag{20}$$

Frequency range up to 66,5 Hz (in dB):

$$|1+H(f)|\geq 79,0 \tag{21}$$

10 Dimensional characteristics

10.1 General

Dimensional characteristics are specified for those parameters deemed mandatory for interchange and compatible use of the disk. Where there is freedom of design, only the functional characteristics of the elements described are indicated. The enclosed drawing, Figure 10, shows the dimensional requirements in summarized form. The different parts of the disk are described from the centre hole to the outside rim.

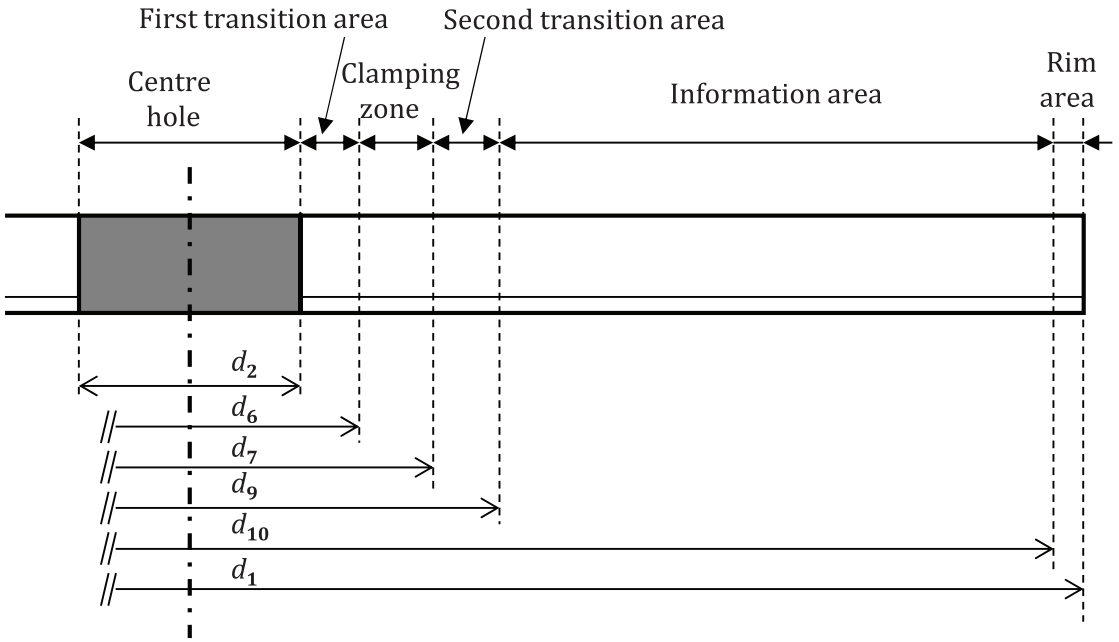


Figure 10 — Overview of disk dimensions

10.2 Disk reference planes and reference axis

(For the disk reference planes see also Figure 11 and Figure 12).

The disk reference plane P is the plane determined by the surface of the clamping zone (see 10.6) at the read-out side of the disk.

The disk reference plane Q is the plane determined by the surface of the clamping zone at the substrate side of the disk.

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The reference axis A is the axis through the middle of the centre hole, perpendicular to the disk reference plane P.

The disk reference plane R is a plane parallel to the disk reference plane P. The distance between disk reference plane R and disk reference plane P shall be e_4 = (100 ± 25) µm towards the inside of the disk (see Figure 11 and Figure 12).

The disk reference plane R shall intersect with recording layer L0 at layer L0's average position between radius r_a = 23 mm and radius r_b = 24 mm (layer L0 is the deepest recording layer on a TL disk).

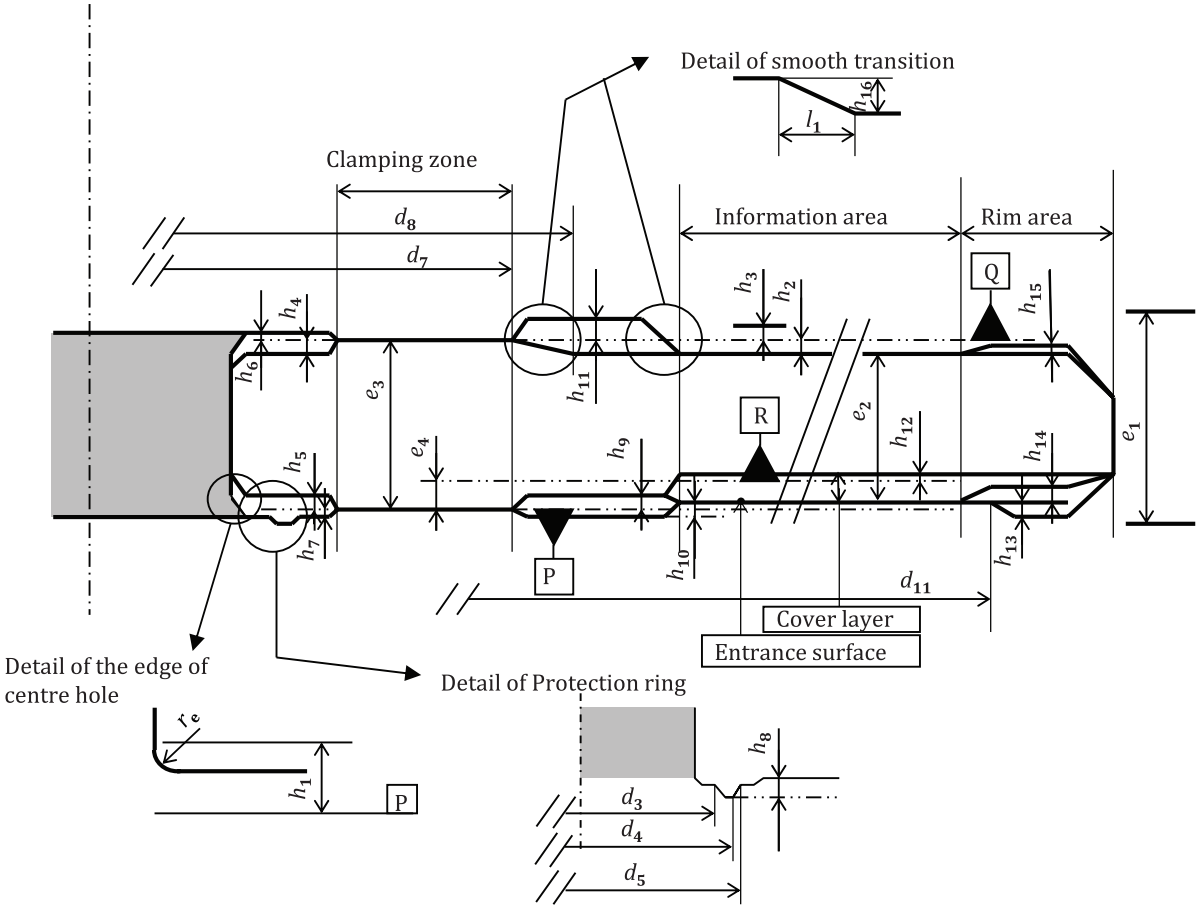


Figure 11 — Details of disk dimensions

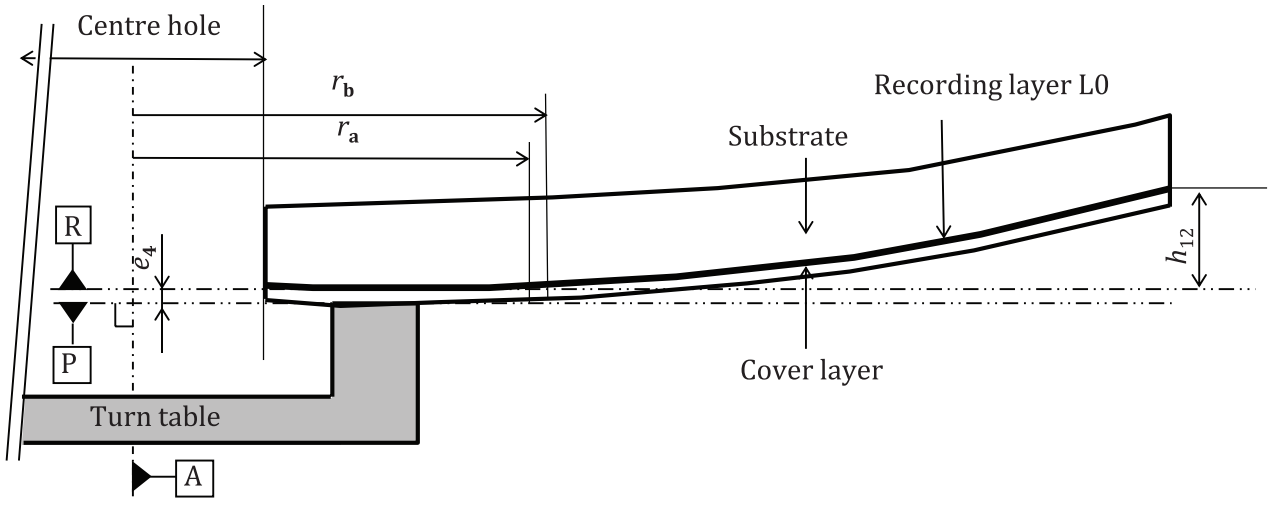


Figure 12 — Details of disk reference planes P and R and recording layer L0

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10.3 Overall dimensions

The overall outer diameter of the disk shall be d_1 = (120,0 ± 0,3) mm (see Figure 10).

The diameter of the centre hole shall be $d_2 = 15{,}00^{+0{,}10}_{0{,}00}$ mm (see Figure 10).

There shall be no burr on the edge of the centre hole at the read-out side.

The edge of the centre hole at the read-out side is the reference for centring the disk and shall be rounded off or chamfered. The rounding radius shall be maximum r_e = 0,1 mm. The height of the chamfer shall be maximum 0,1 mm above the bottom surface of the first transition area. The rounding or chamfer shall be maximum h_1 = 0,25 mm from disk reference plane P (for the details see Figure 11).

The maximum thickness of the disk is defined as the distance in the direction of the reference axis A between the highest structure protruding from the entrance surface of the disk and the highest structure protruding from the top surface of the disk.

The maximum thickness of the disk, including cover layer, protective coating and label printing, at any radius shall be e_1 = 1,40 mm (see Figure 11).

The minimum thickness of the disk in the information area shall be e_2 = 0,90 mm.

Outside the clamping zone, the top surface may be inside the disk reference plane Q by maximum h_2 = 0,4 mm.

Outside the clamping zone the top surface may be outside the disk reference plane Q by maximum h_3 = 0,1 mm (see Figure 11).

10.4 First transition area

In the inner area inside the clamping zone ($d < d_6$), the surfaces may be inside the disk reference planes P and Q by maximum h_5 = 0,20 mm and maximum h_4 = 0,12 mm, respectively. These surfaces may be uneven or have burrs up to maximum h_7 = 0,05 mm and maximum h_6 = 0,05 mm, respectively, outside the disk reference planes P and Q (see Figure 10 and Figure 11).

10.5 Protection ring

An optional ring-shaped protrusion in the inner area of the disk can prevent full contact between the surface of the disk and a surface on which such a disk is laid down. By applying such a ring, the chance for damages to the read-out side of the disk can be minimized.

When applied, the protection ring shall be located between diameter d_3 = 17,5 mm and diameter d_5 = 21,0 mm. Between d_3 and diameter d_4 = 20,5 mm, the height of the protection ring shall be maximum h_8 = 0,12 mm above the clamping surface.

Between d_4 and d_5, the height of the protection ring shall sink gradually to the surrounding surface (see Figure 11).

10.6 Clamping zone

The inner diameter of the disk clamping zone shall be $d_6 \leq 23{,}0$ mm.

The outer diameter of the disk clamping zone shall be $d_7 \geq 33{,}0$ mm (see Figure 10).

The thickness of the disk within the clamping zone shall be $e_3 = 1{,}20^{+0{,}10}_{-0{,}05}$ mm (see Figure 11).

Within the clamping zone ($d_6 < d < d_7$), both sides of the disk shall be flat within maximum 0,1 mm.

Within the clamping zone ($d_6 < d < d_7$), both sides of the disk shall be parallel within maximum 0,1 mm.

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10.7 Second transition area

The second transition area is the area between the clamping zone and the information area: $d_7 < d < d_9$ (see Figure 10).

In the area, the surface at the read-out side of the disk may be inside the disk reference plane P by maximum h_9 = 0,12 mm. This surface may be outside the entrance surface in the information area by maximum h_{10} = 0,01 mm (see Figure 11).

In the area, the top surface of the disk may be outside the disk reference plane Q by maximum h_{11} = 0,2 mm.

The step from the top surface in the area to the top surface in the information area is h_{16}. The distance between the start and the end diameter of the step is l_1. If h_{16} > 0,2 mm, then the slope down to the top surface of the information area shall be smooth and l_1 shall be greater than1,8 mm as indicated in Figure 11. If the top surface in the information area is stepped down from the top surface in the second transition area, then the step shall end within diameter d_8 = 40,0 mm.

10.8 Information area

10.8.1 General

The information area shall extend from diameter d_9 = 42 mm to diameter d_{10} = 117 mm (see Figure 10 and Figure 13).

On each recording layer, the data zone shall be located between the inner diameter, d_{DZIn}, and the outer diameter, d_{DZO}. The data zones on all recording layers shall have the same storage capacity.

The inner diameter, d_{DZI}, on recording layer L*n* shall be $d_{DZIn} = 48{,}0^{\,0{,}0}_{-0{,}2}$ mm and the outer diameter, d_{DZO}, on recording layer L*n* shall be $d_{DZOn} \leq 116{,}2$ mm.

The area between d_9 and d_{DZI} is called the inner zone and the area between d_{DZO} and d_{10} is called the outer zone (see Figure 13).

The total thickness of the disk in the information area is as specified in 10.3.

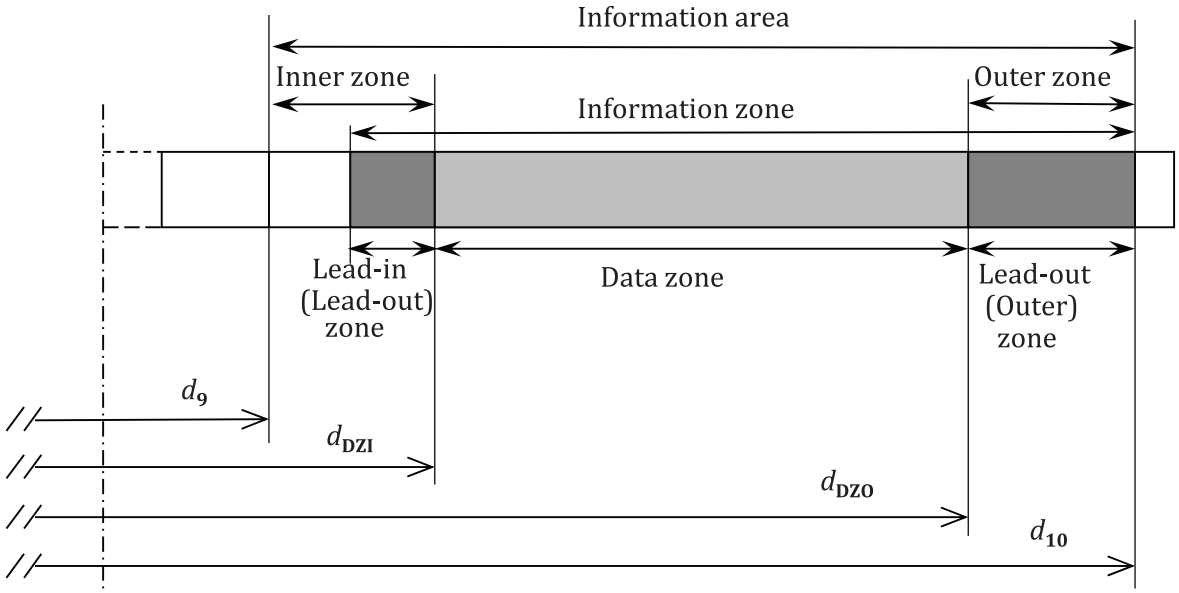


Figure 13 — Division of information area

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10.8.2 Subdivision of information zone on TL disk

The information area is used to record the information zone and is divided over the three recording layers. The information zone is subdivided into the following main parts (see Figure 14):

On recording layer L0:

— lead-in zone (part of the inner zone 0);

— data zone 0;

— outer zone 0.

On recording layer L1:

— outer zone 1;

— data zone 1;

— inner zone 1.

On recording layer L2:

— inner zone 2;

— data zone 2;

Lead-out zone (outer zone 2).

On layer L0, the spiral groove shall run from the inner side of the disk towards the outer side of the disk.

On layer L1, the spiral groove shall run from the outer side of the disk towards the inner side of the disk.

On layer L2, the spiral groove shall run from the inner side of the disk towards the outer side of the disk.

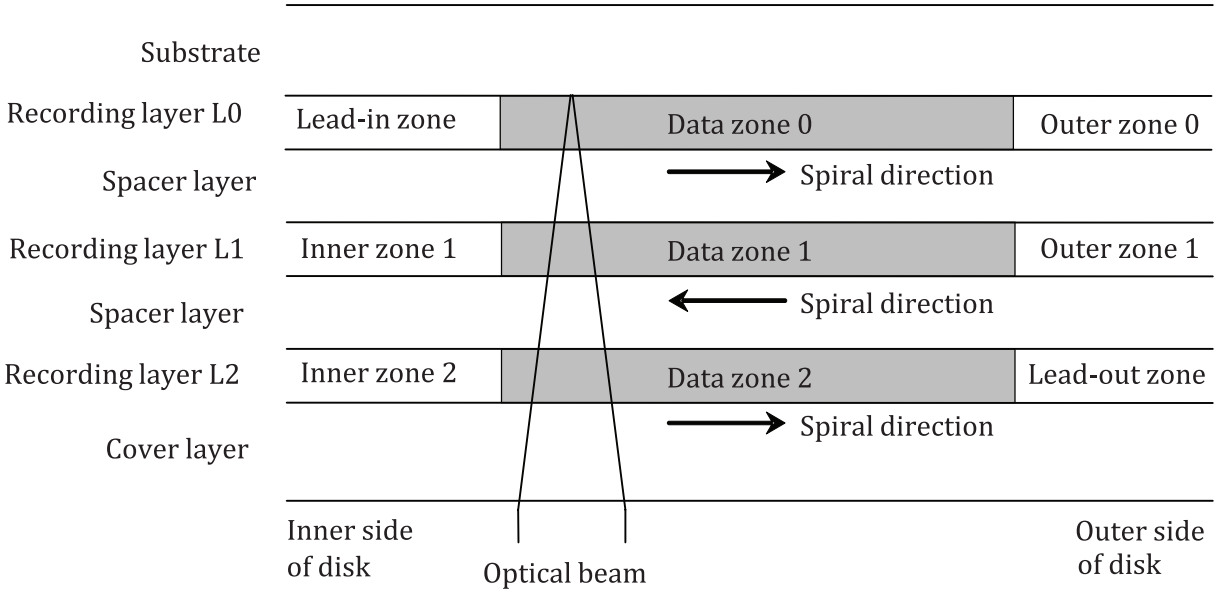


Figure 14 — Subdivision of information zone

The lead-in zone starts in the area extending from diameter 44,0 mm to diameter 44,4 mm and shall end at the beginning of data zone 0 at diameter d_{DZI0}.

Outer zone 0 shall start at the end of the data zone 0 at diameter d_{DZO0} and shall end at diameter minimum 117 mm.

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Outer zone 1 shall start at diameter minimum 117 mm and shall end at the beginning of data zone 1 at diameter d_{DZO1}.

Inner zone 1 shall start at the end of the data zone 1 d_{DZI1} and shall end at the beginning of data zone 1 at diameter d_{DZO1}.

Inner zone 2 starts in the area extending from diameter 44,0 mm to diameter 44,4 mm and shall end at the beginning of the data zone 2 at diameter d_{DZI2}.

Lead-out zone shall start at the end of the data zone 2 at diameter d_{DZO2} and shall end at diameter minimum 117 mm.

10.9 Rim area

The rim area is the area outside the information area, starting at d_{10} and extending to the outer diameter of the disk (see Figure 10).

In the first 0,5 mm of the rim area, the surface at the read-out side of the disk shall not be outside the entrance surface in the information area.

In the remainder of the rim area, the surface at the read-out side of the disk shall not be outside the entrance surface in the information area by maximum h_{13} = 0,05 mm.

In the rim area, the surface at the read-out side of the disk may be inside the entrance surface in the information area by maximum h_{14} = 0,12 mm (see Figure 11).

In the rim area, the top surface of the disk shall not extend outside the top surface in the information area by maximum h_{15} = 0,05 mm (see Figure 11).

11 Mechanical characteristics

11.1 Mass

The mass, m, of the disk shall be 12 g ≤ m ≤ 17 g.

11.2 Moment of inertia

The moment of inertia of the disk shall be ≤0,032 g.m^2.

11.3 Dynamic imbalance

The dynamic imbalance of the disk shall be ≤2,5 g.mm.

11.4 Axial runout

11.4.1 General

When measured by an optical system using the reference servo for axial tracking, and the disk rotating at a half of the recording velocity, the distance between each recording layer and the disk reference plane R (see Figure 11 and Figure 12) in the direction of the reference axis A shall be maximum h_{12} = 0,3 mm over the entire disk.

Within one track (one revolution), the deviation of each recording layer from its average position in the direction of the reference axis A shall be maximum 0,1 mm.

Due to the integrator function in the reference servo (see 9.10.2 and 9.10.3), this component is suppressed sufficiently such that the residual tracking errors as defined in 11.4.2 and 11.4.3 are mainly due to local disturbances.

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11.4.2 Residual axial tracking error for 1x measurement velocity

The residual axial tracking error of each recording layer for frequencies below 1,6 kHz (equals f_x, see 9.10.2), measured using the reference servo for axial tracking as specified in 9.10.2, shall be maximum 45 nm, (displacement of the objective lens needed to move the focal point of the optical beam onto the recording layer) with the disk rotating at 1x reference velocity, 3,688 m/s, and with the read power at (0,70 ± 0,10) mW for any layers of a TL disk. It is recommended to measure the residual axial tracking error signal in a short period to avoid the deterioration of the read stability at 1x reference velocity.

Spikes in the residual axial tracking error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF, with $f_{-3\ dB}$ = 1,6 kHz and slope = –60 dB/decade.

This means that for frequencies <1,6 kHz, the maximum local acceleration of the recording layer in the direction of reference axis A does not exceed 6,0 m/s^2.

The rms noise value of the residual error signal in the frequency band from 1,6 kHz to 10 kHz, measured with an integration time of 20 ms and using the reference servo for axial tracking, shall be maximum 32 nm. The measuring filter shall be a Butterworth BPF from $f_{-3\ dB}$ = 1,6 kHz with slope = +60 dB/decade to $f_{-3\ dB}$ = 10 kHz with slope = –60 dB/decade.

11.4.3 Residual axial tracking error for 2x measurement velocity

The residual axial tracking error of each recording layer for frequencies below 3,2 kHz, measured using the reference servo for axial tracking as specified in 9.10.3, shall be maximum 110 nm (displacement of the objective lens needed to move the focal point of the optical beam onto the recording layer) with the disk rotating at 2x reference velocity, 7,375 m/s, and with the read power refers to 9.4.

Spikes in the residual axial tracking error signal due to local defects, e.g. dust and scratches, shall be excluded. For 2x measurement velocity, local defects that cause large axial tracking errors shall be taken into account as described in I.10.

The measuring filter shall be a Butterworth LPF, with $f_{-3\ dB}$ = 3,2 kHz and slope = –60 dB/decade.

This means that for frequencies <3,2 kHz the maximum local acceleration of the recording layer in the direction of the reference axis A does not exceed 10,8 m/s^2 (see 9.10.3). However, due to the additional reduction of low-frequency components by the second order integrator function, the maximum acceleration at frequencies below about 400 Hz can reach values up to 45 m/s^2. The rms noise value of the residual error signal in the frequency band from 3,2 kHz to 20 kHz, measured with an integration time of 10 ms, using the reference servo for axial tracking, shall be maximum 32 nm. The measuring filter shall be a Butterworth BPF, from $f_{-3\ dB}$ = 3,2 kHz with slope = +60 dB/decade, to $f_{-3\ dB}$ = 20 kHz with slope = –60 dB/decade.

NOTE Residual axial tracking error for 2x measurement velocity defined in 11.4.3 is applied, only if the disk supports reading at 4x reference velocity.

11.5 Radial runout

11.5.1 General

The runout of the outer edge of the disk shall be maximum 0,3 mm pp.

The radial runout of the tracks in each recording layer (including eccentricity and unroundness) shall be measured by an optical system using the reference servo for radial tracking while the disk is rotating at a half of the recording velocity.

The radial runout shall be maximum 75 µm pp.

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Due to the integrator function in the reference servo (see 9.11.2 and 9.11.3), this component is suppressed sufficiently such that the residual tracking errors as defined in 11.5.2 and 11.5.3 are mainly due to local disturbances.

The residual tracking error shall be determined by applying the radial PP read channel ($I_1 - I_2$) signal for both measurement and radial servo control purposes as indicated in Figure 4.

11.5.2 Residual radial tracking error for 1x measurement velocity

The residual radial tracking error for frequencies below 1,8 kHz (equals f_x, see 9.11.2), measured using the reference servo for radial tracking as specified in 9.11.2, shall be maximum 13 nm with the disk rotating at 1x reference velocity, 3,688 m/s, and with the read power at (0,70 ± 0,10) mW for any layer of a TL disk. It is recommended to measure the residual radial tracking-error signal in a short period to avoid deterioration of the read stability at 1x reference velocity.

Spikes in the residual radial tracking error signal due to local defects, such as dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF with $f_{-3\ dB}$ = 1,8 kHz and slope = –60 dB/decade.

This means that for frequencies <1,8 kHz, the maximum local acceleration of the tracks in the radial direction does not exceed 2,2 m/s^2.

The rms noise value of the residual error signal in the frequency band from 1,8 kHz to 10 kHz, measured with an integration time of 20 ms and using the reference servo for radial tracking, shall be maximum 9,2 nm. The measuring filter shall be a Butterworth BPF from $f_{-3\ dB}$ = 1,8 kHz with slope = +60 dB/decade to $f_{-3\ dB}$ = 10 kHz with slope = –60 dB/decade.

11.5.3 Residual radial tracking error for 2x measurement velocity

The residual radial tracking error in each recording layer for frequencies below 3,6 kHz, measured using the reference servo at for radial tracking as specified in 9.11.3, shall be maximum 20 nm with the disk rotating at 2x reference velocity, 7,375 m/s, and with the read power as in 9.4.

Spikes in the residual radial tracking error signal due to local defects, like for instance dust and scratches, shall be excluded.

The measuring filter shall be a Butterworth LPF, with $f_{-3\ dB}$ = 3,6 kHz and slope = –60 dB/decade.

This means that for frequencies <3,6 kHz, the maximum local acceleration in the radial direction does not exceed 3,4 m/s^2, see 9.11.3. However, due to the additional reduction of low-frequency components by the second order integrator function the maximum acceleration at frequencies below about 400 Hz can reach values up to 15 m/s^2. The rms noise value of the residual error signal in the frequency band from 3,6 kHz to 20 kHz, measured with an integration time of 10 ms, using the reference servo for radial tracking, shall be maximum 9,2 nm. The measuring filter shall be a Butterworth BPF, from $f_{-3\ dB}$ = 3,6 kHz with slope = +60 dB/decade, to $f_{-3\ dB}$ = 20 kHz with slope = –60 dB/decade.

NOTE Residual axial tracking error for 2x measurement velocity defined in 11.5.3 is applied, only if the disk supports reading at 4x reference velocity.

11.6 Durability of cover layer

11.6.1 Impact resistance of cover layer

To prevent excessive disk damage in case an object lens hits the entrance surface at the read-out side of the disk, the surface of the disk should have a minimum impact resistance. This impact resistance can be tested by procedures described in Annex L.

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11.6.2 Scratch resistance of cover layer

To prevent excessive scratching, the surface of the disk shall have a minimum hardness.

The scratch resistance shall be tested by a procedure described in Annex C.

11.6.3 Repulsion of fingerprints by cover layer

To prevent excessive contamination, the surface of the disk should repel grime as much as possible.

The repulsion of grime shall be tested by a procedure described in Annex D.

12 Optical characteristics in information area

12.1 General

The following requirements shall be fulfilled within the information area of the disk.

These specifications of the TSs include all possible layers on top of the recording layer concerned (e.g. gluing layers in case of foils, the spacer layers and all the semi-transparent recording stack of layer L*n* in case of TS0, the cover layer and possibly a protective coating).

12.2 Refractive index of transmission stacks (TS)

If the layers making up the total TS have different refractive indexes, then the procedure described in Annex A shall be followed.

The refractive index, n, of the cover layer and spacer layer of the disk shall be as per Formula (22):

$$1{,}45 \leq n \leq 1{,}70 \tag{22}$$

12.3 Thickness of transmission stacks (TS)

The average thickness between radius r_a and radius r_b is called the reference thickness of the related TS (TS0, TS1 or TS2) on the disk (see 10.2 and Figure 12).

The thicknesses of TS0, TS1 and TS2, measured over the whole disk, shall fulfil the requirements in a) to h) below:

In Figure 15, for reference to requirements a) to c), the curves show the thickness ranges with equivalent spherical aberration. The ratio of a thickness with arbitrary refractive index n to that with refractive index 1,60 is expressed by an approximate function of $g(n)$ [see Formula (23)]:

$$g(n) = -1{,}111\ 1 \times n^3 + 5{,}814\ 3 \times n^2 - 9{,}880\ 8 \times n + 6{,}476\ 0 \tag{23}$$

Figure 16 shows a coefficient function for converting the actual thickness to an effective thickness for requirements f). The actual thickness means physical value. The effective thickness means imaginary value when refractive index is assumed to be 1,60.

The actual thickness of arbitrary refractive index n is converted to an effective thickness of standard refractive index of 1,60. Defocus values of the actual and effective thickness are the same. In this subclause, defocus is defined as the focus position movement of the light going through the transparent medium with each thickness and each refractive index.

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The coefficient function of $f(n)$ equals $\tan(\theta_r) / \tan(\theta_o)$, where θ_o and θ_r are the converging angles in the TS with refractive indexes of 1,60 and the arbitrary value of n, respectively. The function $f(n)$ is expressed approximately by Formula (24):

$$f(n) = -1{,}088\,0 \times n^3 + 6{,}102\,7 \times n^2 - 12{,}042 \times n + 9{,}100\,7 \quad (24)$$

a) The thickness of TS0 (all layers on top of layer L0) depends on the refractive index and shall be within the uppermost shaded area in Figure 15 (In case of a refractive index of n, the thickness shall be between $94{,}0 \times g(n)$ µm and $106{,}0 \times g(n)$ µm, and the dashed curve indicates the nominal thickness as a function of the refractive index).

b) The thickness of TS1 (all layers on top of layer L1), as determined by its refractive index, shall be within the middle shaded area in Figure 15 (In case of a refractive index of n, the thickness shall be between $69{,}0 \times g(n)$ µm and $81{,}0 \times g(n)$ µm, and the dashed curve indicates the nominal thickness as a function of the refractive index).

c) The thickness of TS2 (all layers on top of layer L2), as determined by its refractive index, shall be within the undermost shaded area in Figure 15 (In case of a refractive index of n, the thickness shall be between $52{,}0 \times g(n)$ µm and $62{,}0 \times g(n)$ µm, and the dashed curve indicates the nominal thickness as a function of the refractive index).

d) The thickness of spacer layer1 (S_1), sandwiched by layer L0 and layer L1, shall be between 20,0 µm and 30,0 µm.

e) The thickness of spacer layer2 (S_2), sandwiched by layer L1 and layer L2, shall be between 13,0 µm and 23,0 µm.

f) The thickness differences shall meet the requirement $C - (S_1 + S_2) \geq 1{,}0$ µm and $S_1 - S_2 \geq 1{,}0$ µm [C, S_1, S_2 shall be converted from their actual thickness to their effective thickness by being multiplied by $f(n)$ shown in Figure 16, where thickness of TS2 equals the cover-layer thickness (C) and n is refractive index].

g) The maximum deviation, ΔD, of the thickness of TS0 and TS1 from their respective reference thickness shall meet the requirement $|\Delta D| \leq 2{,}5$ µm.

h) The maximum deviation, ΔD, of the thickness of TS2 from its reference thickness shall meet the requirement $|\Delta D| \leq 2{,}0$ µm.

12.4 Example of target thickness of spacer layers for TL disks

In mass production, simple target values of thicknesses are useful.

It is recommended that when the following three requirements are fulfilled, then requirements a) to f) of 12.3 are always fulfilled for a refractive index of 1,60.

a) The thickness of the spacer layer1 (S_1) should be 25,0 µm ± 2,0 µm.

b) The thickness of the spacer layer2 (S_2) should be 18,0 µm ± 2,0 µm.

c) The thickness of TS2 (equals C) should be 57,0 µm ± 2,0 µm.

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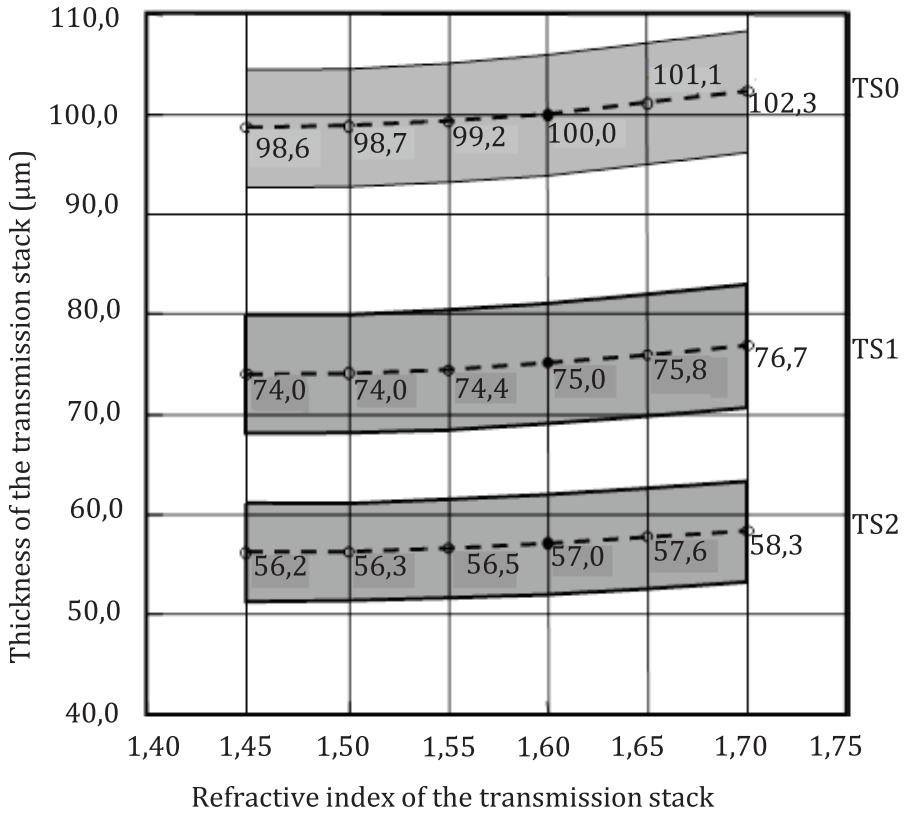


Figure 15 — Thickness of transmission stacks (TS) as function of reflective index

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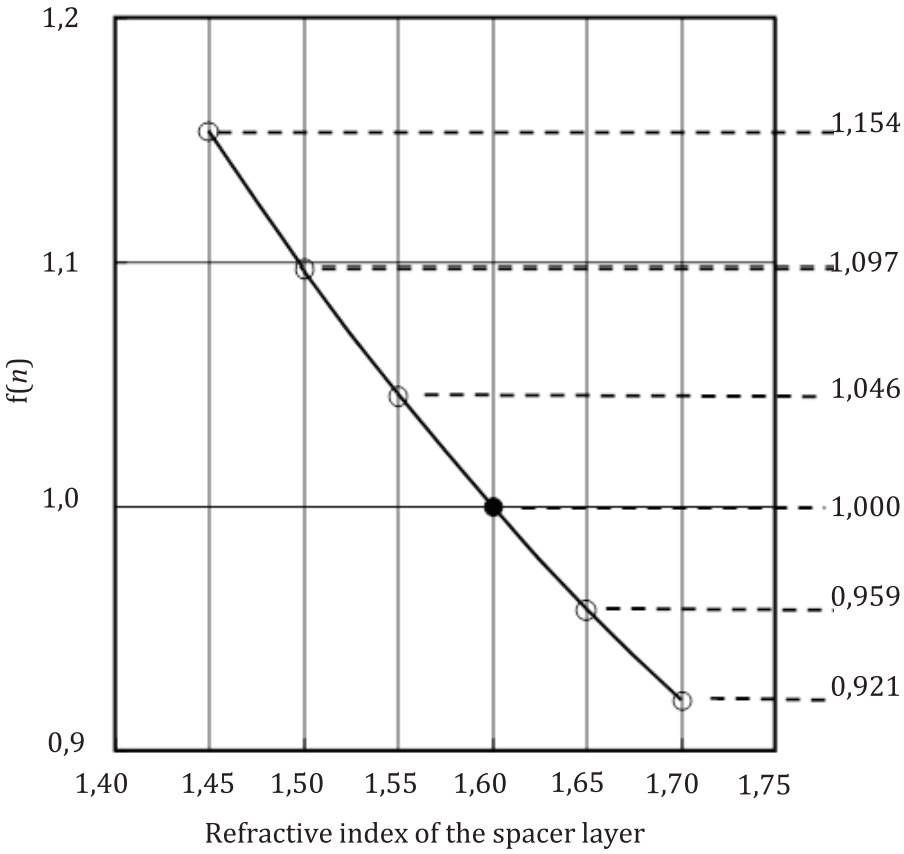


Figure 16 — Ratio of effective thickness with refractive index 1,60 and that with arbitral refractive index, *n*

12.5 Reflectivity of recording layers

The reflectivity of each recording layer in the information zone, including transmission through the TS concerned, shall fulfil the following requirements independent of the recording status of the other recording layers (whether unrecorded, recorded or partially recorded) under the measurement conditions of Annex B as follows:

— in unrecorded virgin grooves:

  — of layer L0 and layer L1: $R_{g\text{-}v}$ = 1,5 %to 4,0 %;

  — and of layer L2: $R_{g\text{-}v}$ = 2,2 %to 4,0 %;

— in unrecorded erased grooves:

  — of layer L0 and layer L1: $R_{g\text{-}e}$ = 1,4 %to 4,0 %;

  — and of layer L2: $R_{g\text{-}e}$ = 2,0 %to 4,0 %;

  — at each location on the disk: $0{,}75 \times R_{g\text{-}v} < R_{g\text{-}e} < 1{,}25 \times R_{g\text{-}v}$;

— in recorded grooves for the first 10 DOW cycles:

  — of layer L0 and layer L1: R_{8H} = 1,4 %to 4,0 %;

  — and of layer L2: R_{8H} = 2,0 %to 4,0 %;

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— at each location on the disk: $0{,}75 \times R_{g\text{-}v} < R_{8H} < 1{,}25 \times R_{g\text{-}v}$.

Written marks shall have a lower reflectivity than the unrecorded layer.

12.6 Birefringence

The in-plane birefringence of the TSs shall be (see Annex J for the detailed definition) as per Formula (25):

$$\Delta n_{//} \leq 1{,}5 \times 10^{-4} \tag{25}$$

The perpendicular birefringence of the TSs shall be (see Annex J for the detailed definition) as per Formula (26):

$$\Delta n_{\perp} \leq 1{,}2 \times 10^{-3} \tag{26}$$

12.7 Angular deviation

The angular deviation is the angle, θ_a, between a parallel incident beam, perpendicular to the disk reference plane P, and the reflected beam. The incident beam shall have a diameter in the range 0,3 mm to 1,0 mm. The angle, θ_a, includes deflections of the entrance surface and lack of parallelism of the cover layer and/or spacer layer (see Figure 17).

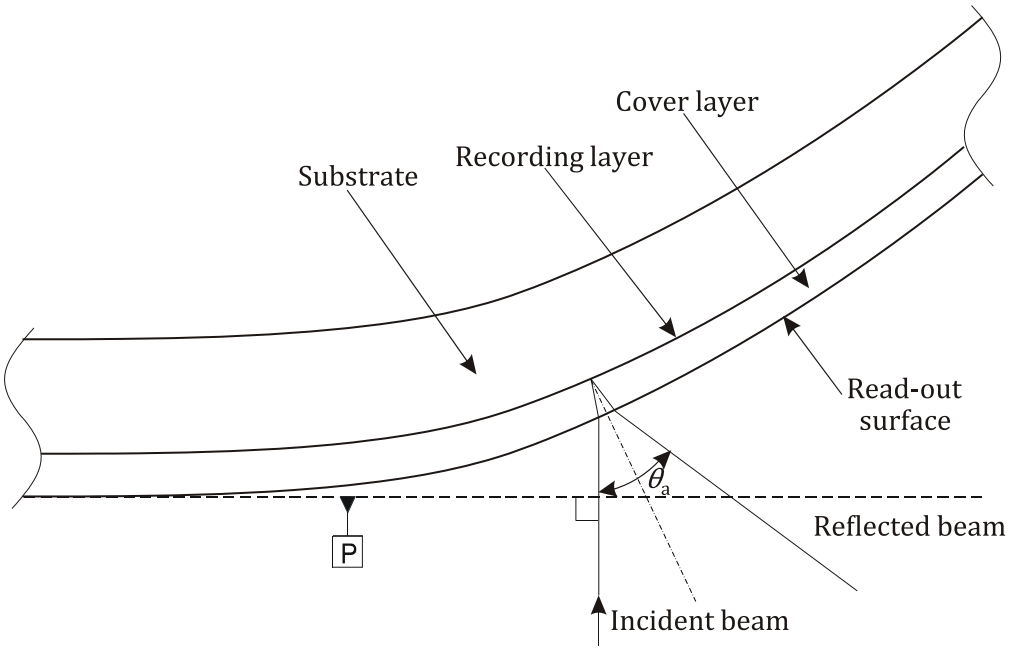


Figure 17 — Definition of angular deviation

The requirements for the angle θ_a are as follows:

— in the radial direction:

  — under the normal test conditions specified in 8.1.1: $|\theta_a|_{max.} = 0{,}60°$;

  — under the "sudden change" test conditions specified in 8.1.1: $|\theta_a|_{max.} = 0{,}70°$;

— in the tangential direction:

  — under the normal test conditions specified in 8.1.1: $|\theta_a|_{max.} = 0{,}30°$.

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