ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-65

MAGNETIC DISK FOR
DATA STORAGE DEVICES
107 500 FLUX TRANSITIONS PER TRACK
266 mm AND 356 mm DIAMETER

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BRIEF HISTORY

In 1976 ECMA decided to undertake a new project for the stand-ardization of individual rigid magnetic disks intended for mount-ing in data storage devices. The basic consideration for this de-cision was the wish to limit the number of types of disks required by the industry, thereby simplifying manufacturing and stock con-trol of such disks as well as the design and maintenance of data storage devices using them, thus ultimately reducing the price of such devices for the benefit of their end-users.

The work of ECMA TC16 resulted in three drafts which were pre-sented to ISO/TC97/SC10 and taken over by this committee as drafts for international standards. Thanks to the co-operation of the Japanese and US experts in SC10 considerable progress was achieved. Whilst not all problems related to these disks have been complete-ly clarified, it was felt by ECMA that there is an urgent need to publish the first results already available. Therefore, the first two of a series of standards:

ECMA-64 : Magnetic Disk for Data Storage Devices, 160 000 Flux
          Transitions per Track, 356 mm Diameter

ECMA-65 : Magnetic Disk for Data Storage Devices, 107 500 Flux
          Transitions per Track, 266 mm and 356 mm Diameter

have been adopted by the General Assembly of ECMA on June 19, 1980.

Further work is in progress within ECMA and ISO. Should it lead to modifications of the presently adopted figures and/or to additions to these standards, new, up-dated versions will be issued.

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1. GENERAL

   1.1 Scope

   This Standard ECMA-65 specifies the mechanical, physical and magnetic properties of a non-lubricated magnetic disk intended for mounting in data storage devices.

   Two types are specified, Type A and Type B, which have the same magnetic characteristics and are related to the same Standard Reference Surface. They differ only with regard to their outer diameter and some related numeric values.

   1.2 Conformance

   A disk is in conformance with this Standard when it satisfies all requirements for Type A or all requirements for Type B.

2. GENERAL REQUIREMENTS

   2.1 Operation and Storage Environment

   2.1.1 Operation

   The operating temperature of the air surrounding the disk shall be within the range 15 °C to 57 °C at a relative humidity of 8% to 80%. The wet bulb temperature shall not exceed 26 °C. The air surrounding the disk shall be of cleanliness Class 100 (Appendix I).

   2.1.2 Storage

   The storage temperature shall be within the range -40 °C to 65 °C at the relative humidity of 8% to 80%. The wet bulb temperature shall not exceed 30 °C. Under no circumstances shall condensation on the disk be allowed to occur.

   Storage under the extreme conditions of the above range is not recommended. A temperature gradient of more than 10 °C per hour should be avoided.

   The ambient stray magnetic field intensity shall not exceed 4000 A/m.

   2.2 Test Conditions

   Unless otherwise stated, measurements shall be carried out at (23 ± 3) °C, 40% to 60% RH, after a period of acclimatization during which condensation on the disk shall not be allowed to occur. Tests requiring the use of heads shall be performed in air of cleanliness Class 100.

   2.3 Material

   The disk may be constructed from any suitable material so long as the dimensional, inertia and other functional requirements of this Standard are maintained.

   2.4 Coefficient of Thermal Expansion

   The coefficient of thermal expansion of the disk material shall be:

$$\frac{\Delta L}{L \cdot \Delta t} = \frac{1}{L} \cdot \frac{L57-L15}{42} \text{ per } ^{\circ}C = (24 \pm 1) \cdot 10^{-6} \text{ per } ^{\circ}C$$

The sample length L is equal to $\frac{L57+L15}{2}$

2.5 Surface Identification

The direction of relative motion between head and disk shall be consistent, requiring identification of the disk surface which rotates counter-clockwise.

3. DIMENSIONS (Fig. 1 to 3)

For measurement of the radii indicated hereafter, the disk shall be mounted on a Reference Hub (Fig. 1) having a diameter, measured at $(23,0 \pm 0,5)$ $^{\circ}C$, of:

$$d1 = 168,270 \text{ mm} \begin{array}{l} + 0,000 \text{ mm} \\ - 0,010 \text{ mm} \end{array}$$

and an outer radius

$$r1 = 90,5 \text{ mm} \pm 0,1 \text{ mm}$$

All radii are referred to the axis of symmetry of this Reference Hub. The coefficient of thermal expansion of the material of the Reference Hub shall be that specified in 2.4. Where both types are not specifically mentioned, the dimension indicated applies for both.

3.1 Inner Diameter

The inner diameter of the disk, measured at $(23,0 \pm 0,5)$ $^{\circ}C$, shall be:

$$d2 = 168,28 \text{ mm} \begin{array}{l} + 0,08 \text{ mm} \\ - 0,00 \text{ mm} \end{array}$$

The circumference of the inner edge shall be contained between two concentric circles 10 um apart.

3.2 Outer Diameter

The outer diameter shall be:

For Type A: d3 = 356,26 mm ± 0,13 mm

For Type B: d3 = 266,70 mm ± 0,13 mm

The circumference of the outer edge shall be contained between two concentric circles 10 um apart.

3.3 Concentricity

The centre of the circumference of the outer edge of the disk shall be contained in a circle of diameter 50 um concentric with the centre of the circumference of the inner edge.

3.4 Thickness

The thickness of the disk shall be:

$$e = 1,905 \text{ mm} \pm 0,025 \text{ mm}$$

3.5 Edge Chamfers

For a distance

$$l = 1,3 \text{ mm max}$$

from the edges of the disk, the disk contour shall be re-
lieved within the extended boundaries of the disk surfaces.
In order to avoid unbalance, the chamfer shall be uniform
at all points on the circumference.

3.6 Clamping Area

The clamping area shall be an area free of magnetic coating,
limited by the inner edge and a radius r_2

$$r_2 = 91,0 \text{ mm min.}$$

3.7 Location of Magnetic Surfaces

The area of magnetic surface of the disk, over which heads
may fly, shall extend from an inside radius r_3 to an out-
side radius r_4:

$$r_3 = 94,0 \text{ mm max}$$

For Type A: $r_4 = 176,0 \text{ mm min}$

For Type B: $r_4 = 131,4 \text{ mm min}$

4. PHYSICAL CHARACTERISTICS

4.1 Moment of Inertia

The moment of inertia of the disk shall not exceed:

For Type A: $8,0 \text{ g.m}^2$

For Type B: $2,5 \text{ g.m}^2$

4.2 Maximum Speed

The disk shall be capable of withstanding the effect of
stress at a speed of 4000 rpm.

4.3 Runout

For measuring the axial runout, the velocity and the acce-
leration of runout, the disk shall be clamped and driven
according to 4.3.1.

4.3.1 Test spindle requirements and clamping conditions

The disk shall be clamped on the Reference Hub by a force

$$F = 1500 \text{ N} \pm 200 \text{ N}$$

evenly applied over the whole disk on an annular surface
defined by:

$$r_5 = 86,5 \text{ mm}$$
$$r_6 = 88,0 \text{ mm}$$

The finish of the surface of the Reference Hub on which
the disk rests shall be of class N 5 (max arithmetical
deviation 0,4 um).

At any speed up to the maximum speed (see 4.2) the axial runout of the Reference Hub shall not exceed 1,0 um.

The radial runout of the Reference Hub, i.e. the total indicator reading, as referenced to the centre of rotation of the Reference Hub is included in the tolerance of r1.

4.3.2 Axial runout

The axial runout at any speed up to the maximum allowable speed (see 4.2) shall not exceed 0,10 mm, total indicator reading.

Moreover, every point of each surface of the disk shall be located between two planes perpendicular to the axis of the Reference Hub and distant from each other by 0,10 mm.

4.3.3 Velocity of axial runout

With the disk revolving at (3600 ± 72) rpm, the velocity of axial runout of the recording disk surfaces in the area between radius r3 and radius r4 shall not exceed 51 mm/s. It shall be measured within the measurement bandwidth defined by a low-pass filter with a cutoff frequency of 2,2 kHz and a high-frequency roll-off of 18 dB/octave. The probe diameter shall be 1,7 mm.

4.3.4 Acceleration of axial runout

The acceleration of axial runout shall not exceed a peak acceleration from the base line of 51 m/s^2 within the measurement bandwidth defined by a low-pass filter with a cut frequency of 5 kHz and a high-frequency roll-off of 18 dB/octave.

4.3.5 Radial runout

The radial runout of the disk depends on the concentricity and circularity of the inner and outer edges, as well as o the clamping conditions in the device in which it is mount ed. It is therefore not specified by this Standard.

4.4 Surface Roughness

4.4.1 Magnetic surfaces

The finished magnetic surfaces shall have a surface roughness less than 0,035 um, arithmetic average, with a maximum deviation in height of 0,28 um from the average, when measured with a 2,5 um stylus and a 750 um cutoff range. The finished magnetic surface shall have an undulation profile with a peak-to-peak amplitude of less than 0,1 um, when measured over a radial length of 4,8 mm with a 2,5 um stylus having a lower cutoff range of 250 um.

4.4.2 Clamping area

The finished surfaces of the clamping area shall have a surface roughness less than 0,8 um, arithmetic average, with a maximum deviation in height of 2,0 um from the average, when measured with a 2,5 um stylus and a 750 um cutoff range.

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4.5 Cleaning of the Magnetic Surfaces

The magnetic surfaces of the disk shall not be adversely affected by a 91% solution of isopropyl alcohol (made from reagent grade isopropyl alcohol mixed with 9% distilled or deionized water by volume) when used for cleaning.

4.6 Durability of the Magnetic Surfaces

The nature of the coating shall be such as to assure wear resistance under operating conditions and maintenance of adhesion and abrasive wear resistance.

4.7 Discharge Path

The disk shall allow flow of electrical charges from the magnetic surface to the clamping surface.

5. TESTING OF MAGNETIC CHARACTERISTICS

5.1 General Conditions

5.1.1 Rotational speed

The rotational speed shall be (3600 ± 72) rpm in any test period. Rotation shall be counterclockwise when viewed from above.

5.1.2 Ambient stray magnetic field

The intensity of the ambient stray magnetic field shall not exceed 800 A/m.

5.2 Track and Recording Conditions

5.2.1 Width of tracks

The recorded track width shall be:

51 um ± 4 um

A suggested method of measuring the track width is contained in Appendix II.

5.2.2 Track spacing

For testing purposes, the track centreline spacing shall be:

51 um ± 2 um

5.2.3 Tested area

All functional tests and all track quality tests shall be performed between an innermost track located at a radius r7 and an outermost track located at a radius r8.

$$r7 = 101,2 \text{ mm}$$

For Type A: r8 = 166,4 mm

For Type B: r8 = 124,7 mm

5.2.4 Location of the line of access

The line of access shall be radial.

5.2.5 Recording offset angle

At the instant of writing or reading a magnetic transition, the angle between the transition and the line of access may be 60' maximum.

5.3 Standard Reference Surface

5.3.1 Characteristics

The Standard Reference Surface shall be characterized at the three following test radii:

$$R1 = 107,96 \text{ mm}$$
$$R2 = 124,00 \text{ mm}$$
$$R3 = 163,69 \text{ mm}$$

When recorded at 1f (see 5.9), using a test head, the track average amplitude (see 5.8) shall be:

2,20 mV at radius R1

2,75 mV at radius R2

3,80 mV at radius R3

When recorded at 2f (see 5.9), using a test head, the track average amplitude shall be:

1,70 mV at radius R1

2,15 mV at radius R2

3,00 mV at radius R3

5.3.2 Secondary Standard Reference Surface

This is a surface the output of which shall be related to the Standard Reference Surface via calibration factors C_{D1} (for 1f) and C_{D2} (for 2f).

These calibration factors C_D are defined by:

$$C_D = \frac{\text{Standard Reference Surface output}}{\text{Secondary Standard Reference Surface output}}$$

The measurements for both C_{D1} and C_{D2} shall be made at radii R1, R2 and R3.

To qualify as a Secondary Standard Reference Surface, the calibration factors C_D for such disks shall satisfy $0,90 \leq C_D \leq 1,10$ at the measured tracks for both frequencies.

NOTE:

It is expected that a Standard Reference Surface for Signal Amplitude will be established by the Physikalisch-Technische Bundesanstalt (PTB) Braunschweig, Germany. Secondary Signal Amplitude Reference Surfaces or a calibration service would then also be made available.

5.4 Test Head

The Test Head shall be calibrated to the Standard Reference Surface, and used for amplitude measurement and testing of the magnetic surfaces.

NOTE:

A suitable test head is for example the 4040-NT-2 test head of Information Magnetics Corp., 5743 Thornwood Drive, Goleta (Ca. 93017).

5.4.1 Gap width

The width of the recording gap (measured optically) shall be:

$$50,0 \text{ um} \pm 2,5 \text{ um}$$

5.4.2 Gap length

The length of the recording gap shall be:

$$2,54 \text{ um} \pm 0,51 \text{ um}$$

5.4.3 Gap offset angle

The angle between the recording gap in the ferrite core and the relevant mounting surface of the head shall be $0^\circ \pm 30'$.

5.4.4 Flying height

When flying over the track at radius R1, the test head shall have a flying height at the gap of:

$$0,89 \text{ um} \pm 0,05 \text{ um}$$

5.4.5 Inductance

The total head inductance shall be 23,0 uH $\pm$ 2,3 uH measured in air at 1 MHz. Each leg shall have an inductance of 6,0 uH $\pm$ 0,6 uH.

5.4.6 Resonant frequency

As measured at the head cable connector, the resonant frequency of the total read/write coil of the head shall be: 10,7 MHz $\pm$ 1,3 MHz.

5.4.7 Resolution

The test head shall have a resolution of (76 $\pm$ 5)% at radius R1 and (78 $\pm$ 5)% at radius R3. Resolution is defined as:

$$\frac{2f \text{ Amplitude}}{1f \text{ Amplitude}} \cdot 100\%$$

5.4.8 Head loading force

The net head loading force shall be such as to achieve the flying height (5.4.4) and shall be:

$$3,4 \; N \pm 0,4 \; N$$

5.4.9 Calibration factor

All measurements shall be taken with a suitable test head. To qualify as a test head its calibration factors C_{H1} at 1f, C_{H2} at 2f shall satisfy $0,90 \leqslant C_{Hi} \leqslant 1,10$.

C_H is defined by:

$$C_H = \frac{\text{Standard Reference Surface output}}{\text{Actual head voltage measured}}$$

when measured on a Standard Reference Surface, or by:

$$C_H = \frac{\text{Standard Reference Surface output}}{(\text{Actual head voltage measured}) \cdot C_D}$$

when measured on a Secondary Standard Reference Surface.

5.4.10 Overwrite capability

The overwrite capability of the head shall meet the following requirement.

Procedure

Write with 1f at radius R3 on a Standard Reference Surface and measure the average amplitude of the 1F-signal with a frequency-selective voltmeter. Without DC-erase, overwrite once at 2f, measure the average amplitude of the residual 1f-signal.

Result

The ratio:

$$\frac{\text{Average Amplitude of measured 1f-signal after overwrite with 2f}}{\text{Average Amplitude of measured 1f-signal before overwrite with 2f}}$$

shall be $0,004 \pm 0,001$.

5.5 Conditions for Test Head Measurements

5.5.1 Write current

The 2f write current shall conform to Fig. 4. The current amplitude measured at the head termination connector shall have 7 values:

Radii mm	Write current $(I_{W+} + I_{W-})$ Tolerance: $\pm$ 1% mA
166,5 - 157,1	130
157,1 - 147,8	123
147,8 - 138,5	115
138,5 - 129,2	108
129,2 - 119,9	100
119,9 - 110,5	93
110,5 - 101,2	90

The differences between the positive and negative amplitudes of the quiescent write current $|I_{W+} + I_{W-}|$ shall be less than 2 mA.

T_R = 70 ns $\pm$ 5 ns

T_F = 70 ns $\pm$ 5 ns

Overshoot: $(3,5 \pm 5,5)$% of $I_W = 0,5 (I_{W+} + I_{W-})$

Two consecutive half periods τ_1, τ_2 shall not differ from $\frac{\tau_1 + \tau_2}{2}$ by more than 2%.

5.5.2 DC-erase current

The DC-erase current supplied to one of the two read/write coils when DC-erase is specified shall be:

Radii mm	DC-erase current Tolerance: $\pm$ 1% mA
166,5 - 157,1	65,0
157,1 - 147,8	61,5
147,8 - 138,5	57,5
138,5 - 129,2	54,0
129,2 - 119,9	50,0
119,9 - 110,5	46,5
110,5 - 101,2	45,0

5.6 Read Channel

5.6.1 Input impedance

The differential input impedance of the read channel shall be 1200 Ohm $\pm$ 60 Ohm in parallel with 15 pF $\pm$ 3pF, includ-

ing the preamplifier input impedance and all other dis-
tributed and lumped impedance measured at the head termi-
nation connector.

5.6.2 Frequency and phase characteristics

The frequency response shall be flat within ± 0,25 dB
from 0,10 MHz to 6,45 MHz (0,06 f to 4 f).

The -3 dB roll-off point shall be at 9,675 MHz (6 f).

The attenuation above 9,675 MHz shall not be less than
that given by a line drawn through zero dB at 9,675 MHz
with a slope of -18 dB/octave.

The phase shift shall be linear within ± 5° between
0,10 MHz and 6,45 MHz (0,06 f and 4 f).

5.6.3 Transfer characteristics

For inputs between 0,3 mV and 10,0 mV the transfer char-
acteristics of the read channel shall be linear within
± 3%, or 50 uV, whichever is larger.

5.7 Automatic Gain Controlled Amplifier

The AGC-Amplifier shall produce an output voltage V_{AGC} con-
stant within ± 1% for input voltages from Vin_{min} = 0,3 mV
to Vin_{max} = 10,0 mV (see Fig. 5).

Its response time shall be 3,4 us. All frequencies below
10 kHz shall be attenuated at a rate of 6 dB/octave.

5.8 Track Average Amplitude (V_{TA})

The track average amplitude (V_{TA}) is the average of the peak-
to-peak values of the signals over one revolution of the disk,
measured at the output of the Test Head when electrically
loaded as described in 5.6

5.9 Test Signals

The recording frequencies specified as 1f and 2f shall be:

1f = (3225 ± 3,225) . 10^3 transitions/s

2f = (6450 ± 6,450) . 10^3 transitions/s

5.10 DC Erase

Unless otherwise specified, all write operations shall be
preceded by a DC erase operation.

6. SURFACE TESTS

6.1 Amplitude test

Procedure

Write on any part of the surface at 2f, read back and mea-
sure the V_{TA}.

Result

The upper limit for the track average amplitude of the corrected test head output shall be 2 mV peak-to-peak at r7 and shall increase linearly to the following peak-to-peak values at r8:

For Type A: 4,0 mV

For Type B: 2,7 mV

The lower limit for the track average amplitude shall be 1,2 mV peak-to-peak at radius r7 and shall increase linearly to the following peak-to-peak values at r8:

For Type A: 2,2 mV

For Type B: 1,6 mV

(see Fig. 6).

6.2 Resolution test

Procedure

On any part of the magnetic surface write at 1f. read back and measure the V_{TA}. Then DC erase, write at the same position at 2f, read back and again, measure the V_{TA}.

Result

In all cases, the ratio:

$$\frac{\text{Average Track Amplitude of 2f signal}}{\text{Average Track Amplitude of 1f signal}}$$

shall be 0,75 ± 0,15.

6.3 Overwrite test

Procedure

Write at 1f at radius r8 and measure the average amplitude of the 1f-signal with a frequency-selective voltmeter. Without DC erase, overwrite once at 2f, measure the average amplitude of the residual 1f-signal with the frequency-selective voltmeter.

Result

The ratio:

$$\frac{\text{Average Amplitude of 1f-signal after overwrite}}{\text{Average Amplitude of 1f-signal before overwrite}}$$

shall be less than 0,01.

6.4 Residual noise test

Procedure

DC erase a 5-track band with radius r7 in its middle. Write at radius r7 at 2f, read back and measure the RMS

value (V_{RMS}), using a true RMS-voltmeter with a bandwidth of 10 MHz at the -6 dB point.

Then DC erase once, read back and measure the RMS value (V_{DCRMS}), unload the head and measure the RMS value of the noise due to all other noise sources (V_{NRMS}).

Result

The ratio:

$$\sqrt{\frac{V_{DCRMS}^2 - V_{NRMS}^2}{V_{RMS}}}$$

shall be less than 0,05.

7. TRACK QUALITY TEST

7.1 Positive Modulation Test

Procedure

Write on any track at 2f, read back and measure the V_{TA}. With a delay of td = 1,55 us ± 0,15 us after detecting a read pulse exceeding 125% of 0,5 V_{TA}, count all further such read pulses during a time period tpm = 3,10 us ± 0,15 us (see Fig. 7).

Result

Positive amplitude modulation occurs if the number of the counted pulses exceeds 16.

7.2 Negative Modulation Test

Procedure

Write on any track at 2f, read back and measure the V_{TA}. With a delay of td = 1,55 us ± 0,15 us after detecting a read pulse not reaching 75% of 0,5 V_{TA}, count all further such read pulses, during a time period tnm = 60 us ± 1 us (see Fig. 7).

Result

Negative amplitude modulation occurs if the number of counted pulses exceeds 256.

7.3 Missing Pulse Test

Procedure

Write in each track at 2f and read back using the AGC-amplifier.

Result

A missing pulse shall be any read pulse whose amplitude is less than 55% of the AGC output voltage (V_{AGC}).

7.4 Extra Pulse Test

Procedure

Write on each track at 2f, read back and measure the V_{TA}.
Then DC erase once and read back over one revolution.

Result

An extra pulse shall be any spurious read pulse exceeding
35% of 0,5 V_{TA}.

8. ACCEPTANCE CRITERIA FOR MAGNETIC SURFACES

8.1 Surface Test Criteria

The disk shall meet the requirements of all tests specified
in 6.

8.2 Track Quality Criteria

Modulation criteria

Positive or negative amplitude modulation as defined in 7.1
and 7.2 shall not occur in any track.

9. DEFECTS OF THE MAGNETIC SURFACES

9.1 Single Defect

A single defect is the occurrence of a missing pulse (7.3) or
of an extra pulse (7.4).

9.2 Defect Criteria

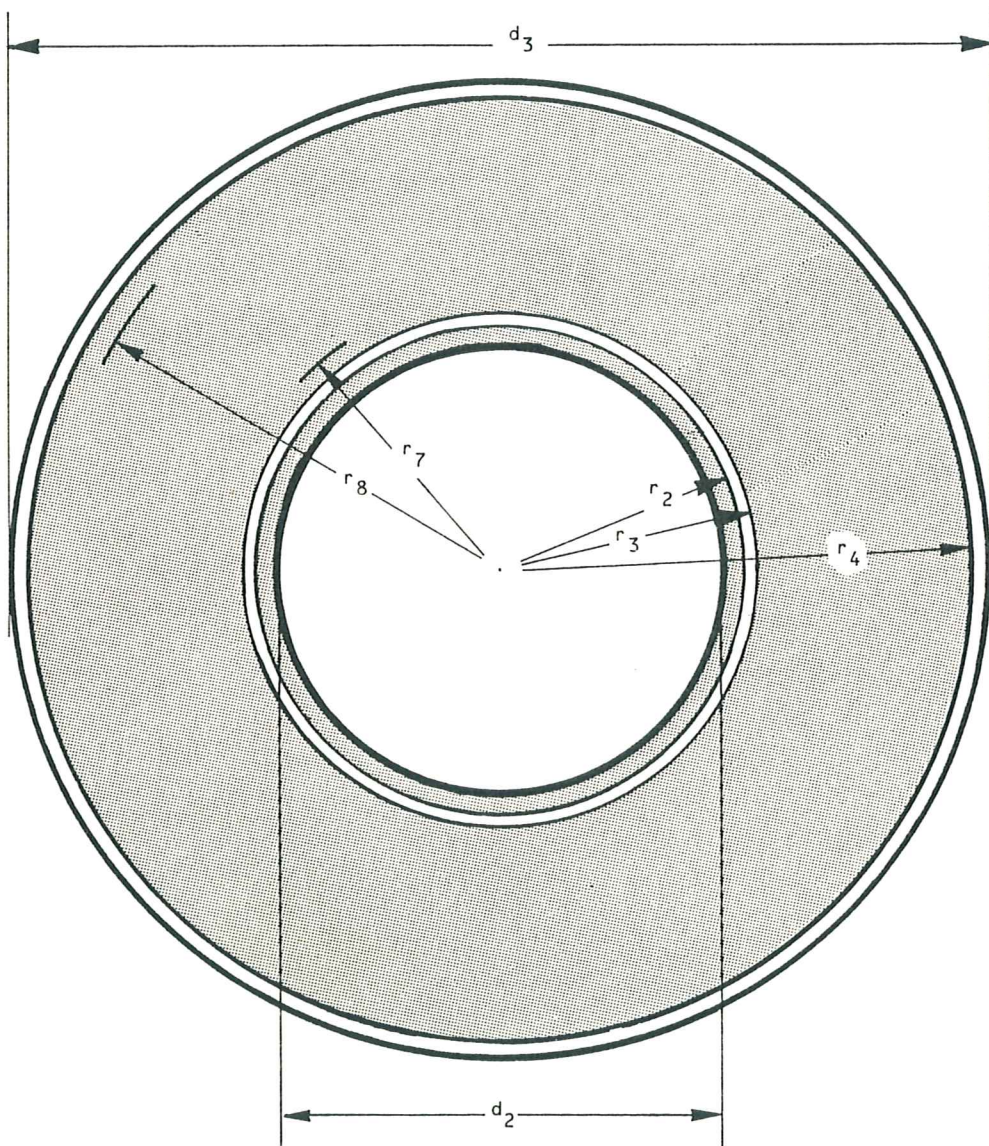The defect criteria are subject to agreement between supplier
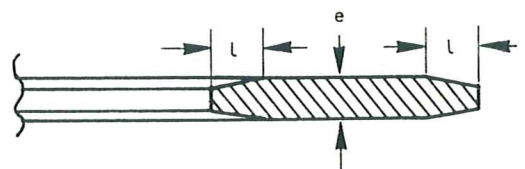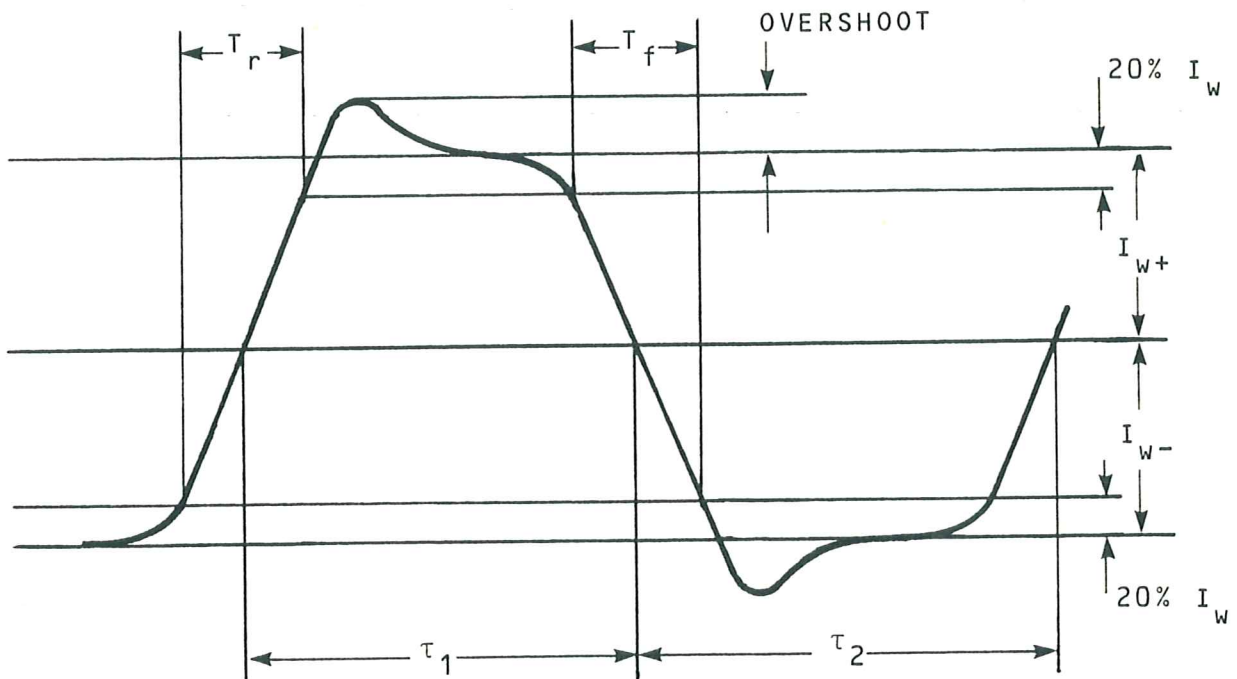and purchaser.
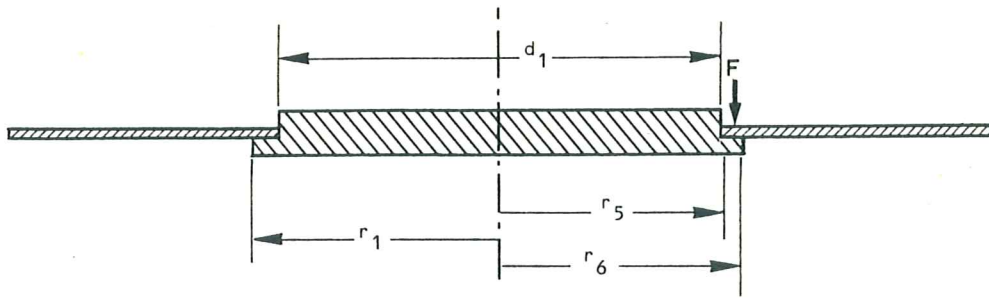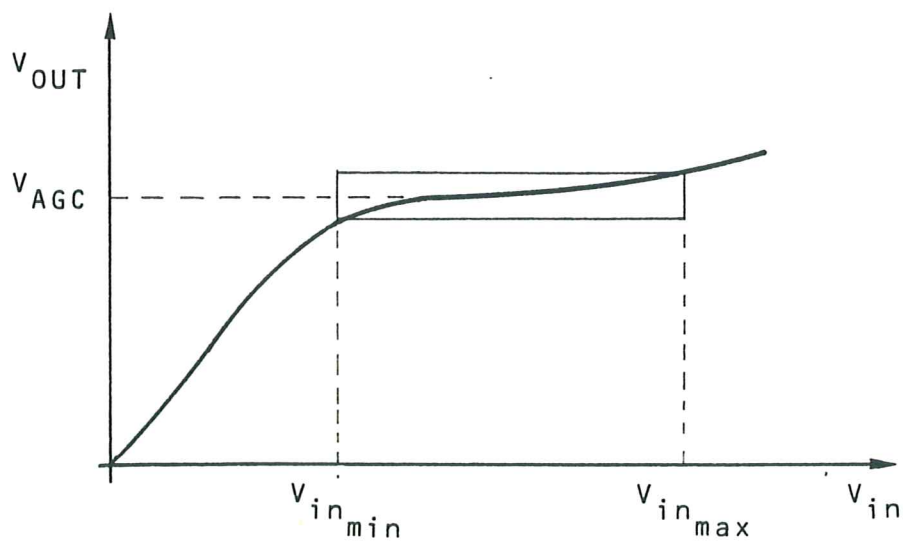
Fig. 1

Fig. 2

Fig. 3
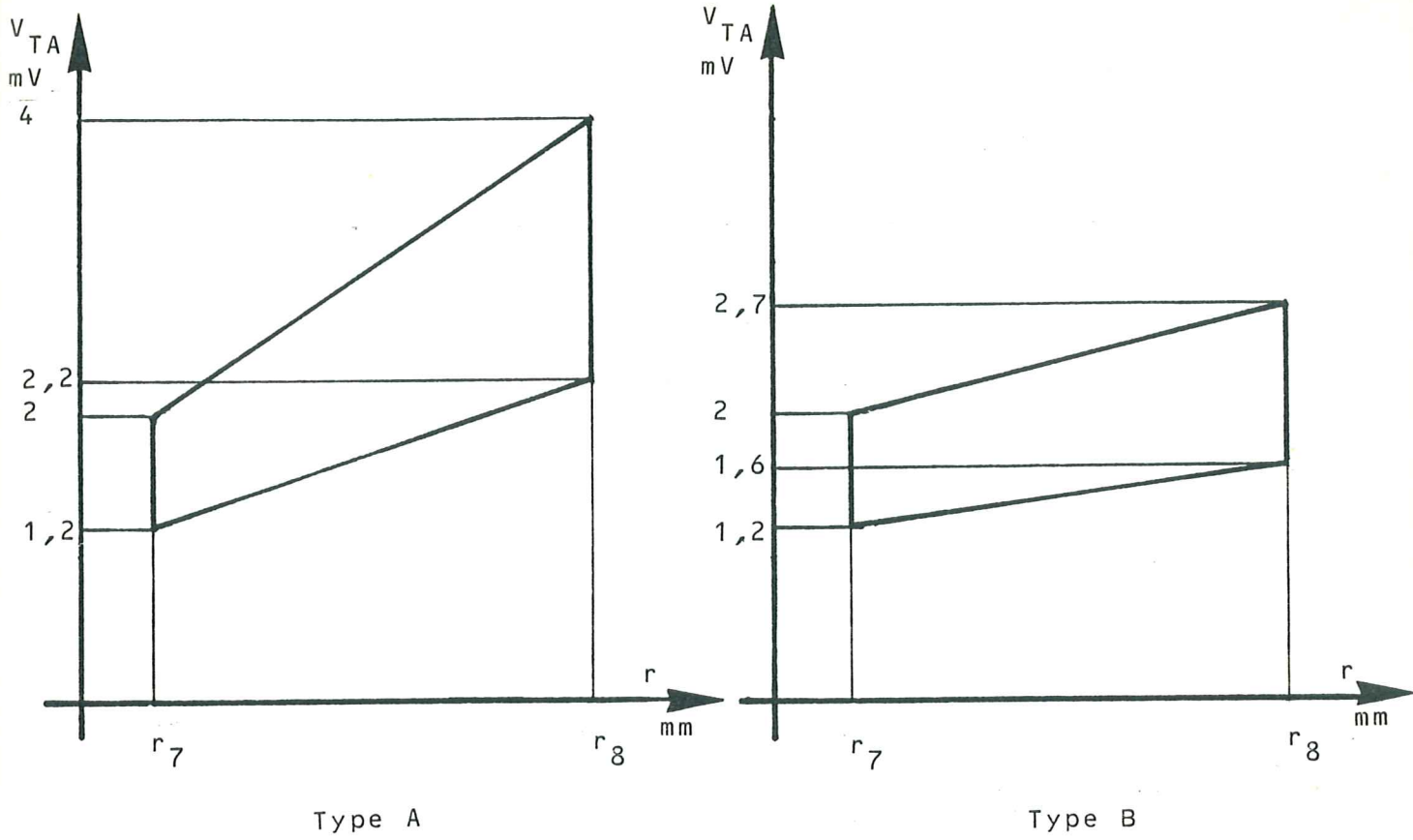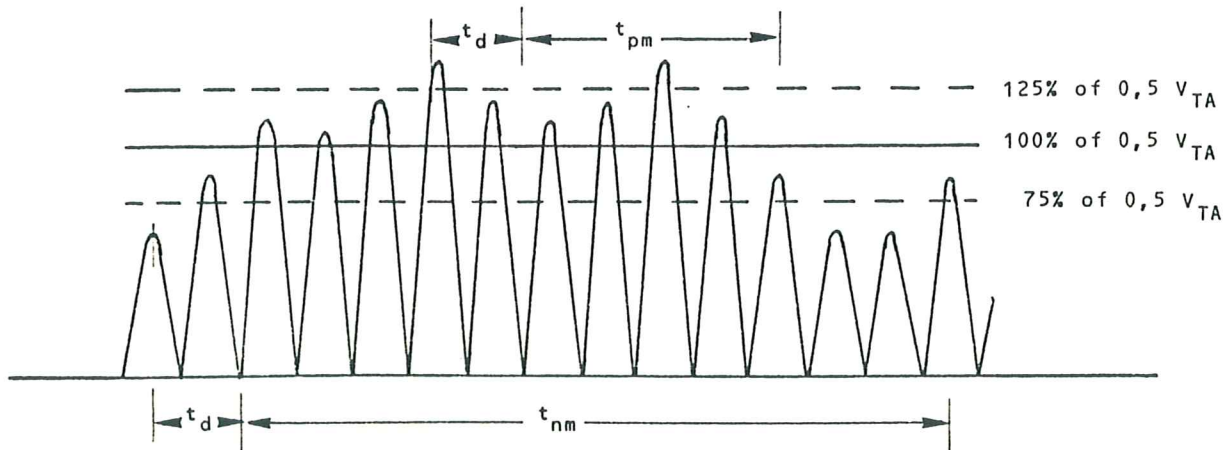
Fig. 4

Fig. 5

Type A

Type B

Fig. 6

Fig. 7

APPENDIX I

AIR CLEANLINESS CLASS 100

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

Definition of Class 100*

The particle count shall not exceed a total of 3,5 particles of size 0,5 um or larger per liter.

The statistical average particle size distribution is represented below. Class 100 means that 3,5 particles per liter of a size 0,5 um are allowed, but only 0,035 particles per liter of a size 4,0 um.
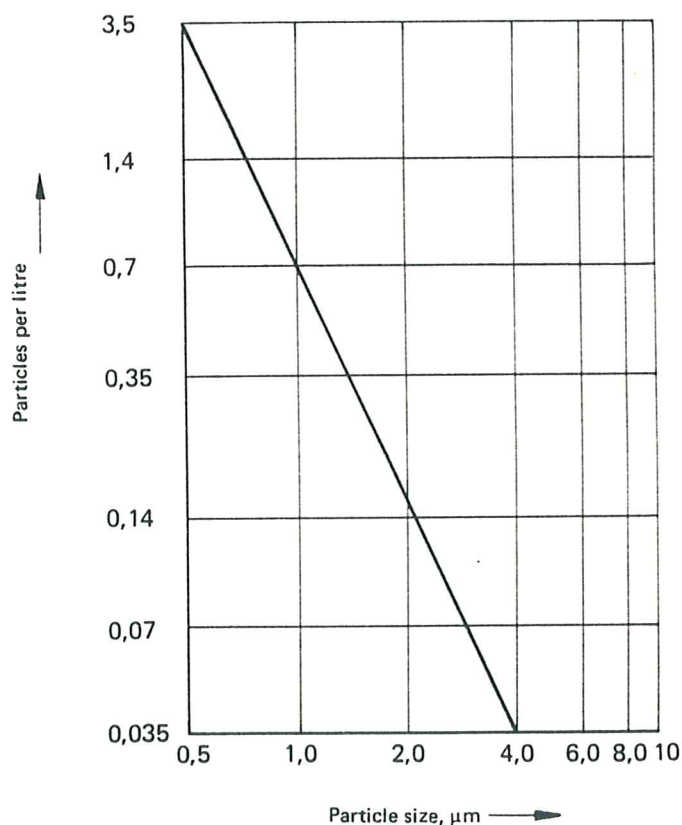
*) USA Federal Standard Fed. Std. No. 209 B,
   available from the General Services Administration,
   Specific Activity, Printed Materials Supply Division,
   Building 197, Naval Weapons Plant,
   Washington, D.C. 20407, USA.

It should be recognized that single sample distribution may deviate from this curve because of local or temporary conditions. Counts below 0,35 particles per liter are unreliable except when a large number of samplings is taken.

Test Method **)

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

**) *American Society for Testing and Materials,*
   Standard ASTM *F 50, 1916 Race St.,*
   Philadelphia, PA 19103, USA

APPENDIX II

MEASUREMENT OF THE EFFECTIVE TRACK WIDTH

DC-erase a 7-track wide band with radius r7 in the centre of the band and write with 1f frequency at radius r7 using the head to be tested, then read back.

The read back signal amplitude in this position is called 100%. Then move the head along its line of access over the disk in increments not greater than 0,005 mm to the left or to the right of radius r7 until the read back signal becomes zero. Determine the read back signal amplitude at each incremental move and plot the relative amplitude (Y axis) versus the displacement (X axis).

See diagram for reading the effective track width.

The fringing of the curve at the low level end of the curve shall be ignored for determining the track width.