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Glossary of Terms used in Magnetic Tape Recording

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A Glossary of Terms used in Magnetic Recording

by Eric D. Daniel,

This monograph is intended to fulfill a need for a glossary which is both reasonably comprehensive and scientifically accurate. Its aim is to define or explain the more fundamental terms common to a wide range of magnetic recording applications. Many of the terms listed in the Glossary are defined for the first time. Whenever possible, however, careful attention has been given to recognized definitions promulgated by the Institute of Electrical and Electronics Engineers and the American Society for Testing Materials.

AC bias The alternating current, usually of frequency several times higher than the highest signal frequency, that is fed to a record head in addition to the signal current. *AC bias* serves to linearize the recording process and is universally used in *analog recording*. Generally, a large *ac bias* is necessary to achieve maximum *long-wavelength output* and *linearity*, but a lower value of bias is required to obtain maximum *short-wavelength output*. The mechanism of *ac bias* can best be explained in terms of *anhysteresis*.

AC erasure See *erasure*

Acicular Needle-shaped.

Additive Any material in the coating other than the *oxide* and the *binder* resins, for example *plasticizers* (materials used to soften an otherwise hard or brittle binder), *lubricants* (materials used to lower the coefficient of friction of an otherwise high-friction binder), *fungicides* (materials used to prevent fungus growth) and dyes. In principle, the presence of materials which do not chemically combine with the binder constituents are undesirable in that such materials may migrate causing variations of properties (e.g. hardening) with time and deposits on heads and guides.

Amplitude—frequency response See *frequency response.*

Analog recording In the broadest sense, *analog recording* is a method of recording in which some characteristic of the record current, such as amplitude or frequency, is continuously varied in a manner analogous to the time variations of the original signal. *Direct recording* usually refers to *analog recording* in which continuous amplitude variations are linearily recorded using *ac bias.*

Anchorage The degree to which the *coating* adheres to the *base film*. Anchorage may be checked by measuring the force required to separate the *coating* from the *base film* by means of a specially designed plow blade or, more simply, by determining whether the *coating* can be peeled from the *base film* by means of ordinary pressure-sensitive adhesive tape.

Anhysteresis The process whereby a material is magnetized by applying a unidirectional field upon which is superposed an alternating field of gradually decreasing amplitude. One form of this process is analogous to the recording process using *ac bias.*

Anisotropy Directional dependence of magnetic properties, leading to the existence of easy or preferred directions of magnetization. Anisotropy of a particle may be related to its shape, to its crystalline structure or to the existence of strains within it. Shape *anisotropy* is the dominant form in *acicular* particles.

Asperities See *surface asperities.*

Azimuth Alignment Alignment of the recording and reproducing gaps so that their centerlines lie parallel with one another. Misalignment of the gaps causes a loss in *output* at *short wavelengths.* For example, using a *trackwidth* of 50 mil a misalignment of only 0.05 degrees will cause a 3 db loss at a wavelength of 0.1 mil.

Background noise See *noise.*

Backing See *base film.*

Bandwidth The range of frequency within which the performance of a recorder with respect to some characteristics, usually *frequency response*, falls within specified limits, or within which some performance characteristics, such as *noise*, is measured.

Base film The plastic substrate that supports the *coating.* The *base film* of most instrumentation and computer tapes is made of *polyester.* For less critical uses, cellulose acetate and polyvinyl chloride are employed.

BH loop tracer See *BH meter.*

BH meter A device for measuring the *intrinsic hysteresis loop* of a sample of magnetic material. Usually the sample is magnetized in a 60 c field supplied by a solenoid and the *intrinsic flux* is detected by integrating the emf produced in an opposing pair of search coils, one of which surrounds the sample. The hysteresis loop may be displayed on an oscilloscope by feeding the X and Y plates with voltages proportional to the magnetizing coil current and the integrated search coil emf respectively.

Bias See *ac bias.*

Bias-induced noise See *noise.*

Binder The material, usually composed of organic resins, used to bond the *oxide particles* in the *coating.*

Bit As applied in magnetic recording *bit* is usually an abbreviation of *binary digit.*

Bit density See *packing density.*

Blocking See layer-to-layer adhesion.

Break elongation The relative elongation of a specimen of tape or *base film* at the instant of breaking when it has been stretched at a given rate.

Buckling Deformation of the circular form of a *tape pack* which may be caused by a combination of improper winding tension and/or adverse storage conditions.

Bulk degausser See *bulk eraser.*

Bulk erased noise See *noise.*

Bulk eraser Equipment for erasing a *roll* of tape. The *roll* is usually rotated while a 60 c ac erasing field is decreased either by withdrawing the *roll* from an electromagnet or reducing the ac supply to an electromagnet.

Bulk erasure See *erasure.*

Certified tape *Computer tape* that is checked on all *tracks* throughout each and every *roll* and is certified by the supplier to have less than a certain total number of *errors* or, more usually, to have zero *errors.*

Cinching Longitudinal slippage between the layers of tape in a *tape pack* when the *roll* is accelerated or decelerated.

Coating The magnetic layer, consisting of *oxide particles* held in a *binder*, that is applied to the *base film.*

Coating resistance The electrical resistance of the *coating* measured between two parallel electrodes spaced a known distance apart along the length of the tape. *Coating resistance* is normally quoted in megohms per square (the dimensions of the square are immaterial). The *resistance* of *conductive magnetic coatings* is usually 100 megohms/square or less, compared with several thousand megohms/square for *non-conductive coatings.*

Coating thickness, c The thickness of the magnetic coating applied to the *base film.* Modern tape coatings range in thickness from 170 to 650 microinches with a preponderance of coatings being approximately 400 microinches thick.
In general, thin coatings give good *resolution* at the expense of reduced output at *long wavelengths*; thick coatings give a high output at *long wavelengths* at the expense of degraded *resolution.*

Coating-to-backing adhesion See *anchorage.*

Coefficient of friction The tangential force required to maintain (dynamic coefficient), or initiate (state coefficient), motion between two surfaces, divided by the normal force pressing the two surfaces together. The most frequently specified value corresponds to the dynamic *coefficient of friction* between the surface of the coating and that of a standard metal rod over which the tape is wrapped.

Coefficient of hygroscopic expansion The relative increase in the linear dimension of a tape or base material per percent increase in relative humidity, measured in a given humidity range.

Coefficient of thermal expansion The relative increase in the linear dimension of a tape or base material per degree rise in temperature (usually Fahrenheit), measured in a given temperature range.

Coercive force See *intrinsic coercive force.*

Coercivity See *intrinsic coercivity.*

Conductive coatings Coatings that are specially treated to reduce the *coating resistance*, and thus prevent the accumulation of static electrical charge. Untreated, *non-conductive coatings* may become highly charged, causing transport, noise and dust-attraction problems.

Cupping Curvature of a tape in the *lateral direction.* Cupping may occur because of improper drying or curing of the coating or because of differences between the *coefficients of thermal* or *hygroscopic expansion* of coating and base film. *Cupping* is usually measured

in terms of the angle formed by the conjunction of lines drawn perpendicular to the tape surface at opposite edges.

DC erasure See *erasure.*

DC noise See *noise.*

Decibel, db A dimensionless unit for expressing the ratio of two powers or, more usually, voltages or currents, on a logarithmic scale. If A and B represent two voltages or currents, the ratio A/B corresponds to 20 $\log_{10}$ (A/B) decibels. 1 db represents a difference of approximately 11% between A and B. Other values are:

Ratio:	1	1.4	2	4	10	100	1000
db:	0	3	6	12	20	40	60

Defect An imperfection in the tape leading to a variation in *output* or a *dropout.* The most common *defects* take the form of surface projections, consisting of oxide agglomerates, imbedded foreign matter, or redeposited *wear products.*

Digital recording A method of recording in which the information is first coded in a digital form. Most commonly, a binary code is used and recording takes place in terms of two discrete values of residual flux. In *non-return-to-zero* (NRZ) *recording,* the two values correspond to saturating the tape in opposite directions. In *return-to-zero* (RZ) *recording,* the tape is either saturated in one direction or is in a neutral or biased state. The most frequently used method is a form of *non-return-to-zero recording* in which a change in flux polarity represents a "one" and the absence of a change in flux during a *bit* interval indicates a "zero".

Direct recording See *analog recording.*

Dispersion Distribution of the oxide particles within the binder. A good *dispersion* can be defined as one in which equal numbers of particles would be found in equal, vanishingly small volumes sampled from different points within the coating. The quality of dispersion affects many tape properties, including orientability, surface smoothness, and *modulation noise.*

Distortion See *harmonic distortion.*

Dropout A temporary reduction in *output* of more than a certain amount, expressed in terms of the percentage reduction (usually 50%) below the average *output* of either the *roll* of tape under test or a *reference* tape. The duration of the reduction in output may also be specified.

Dropout count The number of *dropouts* detected in a given length of tape. In *digital recording,* the length specified is normally that of the complete *roll.*

Durability index A measure of the durability of a tape expressed as the number of passes that can be made before a significant degradation of *output* occurs divided by the corresponding number that can be made using a reference tape. Measurements are usually made by shuttling a given length back and forth over a transport and monitoring the *dropout count* and/or decrease in *output.*

Dynamic range See *signal-to-noise-ratio.*

Dynamic tape skew See *tape skew.*

Equipment noise See *noise.*

Erase field strength The minimum initial amplitude of a decreasing alternating field (normally applied in the *longitudinal direction*) required to reduce the *output* of a given recorded signal by a specified amount.

Erasure A process by which a signal recorded on a tape is removed and the tape made ready for rerecording. Erasure may be accomplished in two ways: in ac erasure, the tape is demagnetized by an alternating field which is reduced in amplitude from an initially high value; in dc erasure the tape is *saturated* by applying a primarily unidirectional field. AC erasure may be carried out by passing the tape over an *erase head* fed with high frequency ac or by placing the whole roll of tape in a decreasing 60 c field (*bulk erasure*). *DC erasure* may be carried out by passing the tape over a head fed with dc or over a permanent magnet. Additional stages may be included in *dc erasure* in order to leave the tape in a more nearly unmagnetized condition.

Error In digital recording, either a *dropout* or a *noise pulse* that exceeds a certain limit is usually termed an *error.* In instrumentation recording, an error has no commonly accepted meaning but is defined in relation to the particular system requirements.

E value The difference in inches between the radii of the outside layer of tape in a *roll* and the outside edge of the *reel* flange.

Ferric oxide See *gamma ferric oxide.*

Frequency response The variation of *sensitivity* with signal frequency. Usually, the *frequency response* of a tape is given in db relative to that of a *reference tape* measured under the same conditions.

Fungicide See *additive.*

Gamma ferric oxide (γFe_2O_3) The magnetic constituent of practically all present-day tapes, in the form of a *dispersion* of fine *acicular particles* within the coating. The prefix *gamma* distinguishes the ferromagnetic form (inverse spinel crystal structure) from the nonferromagnetic *alpha* ferric oxide (rhombohedral crystal structure). At room temperature the basic magnetic constants of γFe_2O_3 are: *specific magnetic moment* 75 emu/gm, *saturation flux density* 4700 gauss.

Gap depth The dimension of the gap measured in the direction perpendicular to the surface of a head.

Gap length The dimension of the gap of a head measured from one pole face to the other. In longitudinal recording, the *gap length* can be defined as the dimension of the gap in the direction of tape travel.

Gap loss The loss in output attributable to the finite *gap length* of the reproduce head. The loss increases as the *wavelength* decreases, amounting to

approximately 4 db when the *wavelength* is equal to twice the *gap length*, and subsequently increases rapidly towards a complete extinction of output when the *wavelength* is approximately equal to 1.15 times the *gap length*.

Gap width The dimension of the gap measured in the direction parallel to the head surface and pole faces. The *gap width* of the record head governs the *track width*. The *gap widths* of reproduce heads are sometimes made appreciably less than those of the record heads to minimize tracking errors.

Gauss The cgs unit of magnetic *flux density*, equal to 1 maxwell per square centimeter.

Harmonic distortion *Non-linearity* characterized by the appearance in the *output* of harmonics other than the fundamental when the input signal is sinusoidal. *Total harmonic distortion* is the rms sum of the harmonic voltages divided by the rms voltage of the fundamental. *Third harmonic* distortion is the rms value of the third harmonic voltages divided by the rms voltage of the fundamental. *Third harmonic distortion* is often used as a measure of distortion in essentially symmetrical systems such as *ac biased* recording.

HF bias See *ac bias*.

Head-to-tape contact The degree to which the surface of the *magnetic coating* approaches the surface of the record or replay heads during normal operation of a recorder. Good *head-to-tape contact* minimizes *separation loss* and is essential in obtaining high *resolution*.

Heavy duty tape A classification of tape implying a high *durability index* and high reliability under conditions of prolonged use.

Hysteresis loop See *intrinsic hysteresis loop*.

Intermodulation distortion Non-linearity characterized by the appearance of frequencies in the *output* equal to the sums and differences of integral multiples of the component frequencies present in the input signal. Harmonics are usually not included as part of the *intermodulation distortion*.

Intrinsic coercive force, H_{ci} (See footnote, page 8.) The *magnetizing field strength* at which the *intrinsic flux density* is zero when a sample of magnetic material is in a *symmetrically, cyclically magnetized condition*. Normally, the *intrinsic coercive force* of a tape is measured in the *orientation direction* using a peak *magnetizing field strength* of 1000 oe. *Coercive force* is one of the factors governing the field strengths, or head currents, required to record, bias or erase a tape.

Intrinsic coercivity (See footnote, page 8.) The maximum value of the *intrinsic coercive force* corresponding to the *saturation flux density* for the material.

Intrinsic flux Φ_i (See footnote, page 8.) In a uniformly magnetized sample of magnetic material, the product of the *intrinsic flux density* and the cross-sectional area.

Intrinsic flux density B_i (See footnote, page 8.) In a sample of magnetic material, for a given value of the *magnetizing field strength*, the excess of the normal flux density over the flux density in vacuum. Using the cgs system of units the *intrinsic flux density* is numerically equal to the ordinary flux density minus the *magnetizing field strength* ($B_i = B - H$)

Intrinsic hysteresis loop (See footnote, page 8.) A curve showing the relation between *intrinsic flux density* and *magnetizing field strength*, when the *magnetizing field* is cycled between equal negative and positive values. *Hysteresis* is indicated by the fact that the ascending and descending branches of the loop do not coincide.

Intrinsic induction See *intrinsic flux density*.

Impact strength A measure of the work done in breaking a test sample of tape or base film by subjecting it to a sudden stress. Commonly used methods of applying the stress are by means of a free-falling or pneumatically driven projectile.

Iron oxide See *gamma ferric oxide*.

Lateral direction Across the width of the tape.

Layer-to-layer adhesion The tendency for adjacent layers of tape in a *roll* to adhere, particularly after prolonged storage under conditions of high temperature and/or humidity.

Layer-to-layer signal transfer The magnetization of a layer of tape in a *roll* by the field from a nearby recorded layer. The magnitude of the induced signal tends to increase with storage time and temperature, and to decrease after the tape is unwound, these changes being a function of the *magnetic instability* of the oxide.

Linearity The extent to which the magnitude of the reproduced *output* is directly proportional to the magnitude of the signal applied to the input of the recorder. Good *linearity* is synonymous with low *distortion*.

Longitudinal curvature A term used to describe any deviation from straightness of a length of tape. The most usual method of specifying *longitudinal curvature* is in terms of the maximum lateral displacement of a given length of tape when unrolled on to a flat surface under zero, or a given small amount, of tension.

Longitudinal direction Along the length of the tape.

Lubricant See *additive*.

Magnetic coating See *coating*.

Magnetic instability The property of a magnetic material that causes variations in the *residual flux density* of a tape to occur with temperature, time and/or mechanical flexing. *Magnetic instability* is a function of *particle size*, magnetization and *anisotropy* and tends to increase *layer-to-layer signal* transfer and cause decreases in *short-wavelength output* with time and/or use.

Magnetic tape With a few exceptions magnetic tape consists of a *base film* coated with magnetic particles held in a *binder*. The magnetic particles are usually of *acicular* shape, approach *single domain* size and are composed of *gamma ferric oxide*.

Magnetizing field strength, H The instantaneous strength of the magnetic field applied to a sample of magnetic material.

Magnetizing force See *magnetizing field strength*.

Maximum flux See *maximum intrinsic flux*.

Maximum flux density See *maximum intrinsic flux density*.

Maximum induction See *maximum intrinsic flux density*.

Maximum intrinsic flux, Φ_{mi} In a uniformly magnetized sample of magnetic material, the product of the *maximum intrinsic flux density* and the cross-sectional area.

Maximum intrinsic flux density, B_{mi} The maximum value, positive or negative, of the *intrinsic flux density* in a sample of magnetic material which is in a *symmetrically, cyclically magnetized condition*. Normally, the *maximum intrinsic flux density* of a tape is measured in the *orientation direction*, using an alternating *magnetizing field* of amplitude 1000 oe.

Maxwell The cgs unit of magnetic *flux*.

Modulated carrier recording In many recording applications, the information is recorded in the form of a modulated carrier. Common examples are *amplitude modulation* (AM), *frequency modulation* (FM), *pulse amplitude modulation* (PAM), *pulse duration or width modulation* (PDM or PWM) and pulse code modulation (PCM). Combinations of these modulation techniques are also used, particularly in the form of frequency modulation of a carrier using pulses which are themselves modulated by the information (PAM/FM, PDM/FM, and PCM/FM).

Modulation noise See *noise*.

Mylar A registered trademark of E.I. du Pont de Nemours & Co. designating their *polyester* film.

Noise Any unwanted electrical disturbances, other than crosstalk or distortion components, that occur at the output of the reproduce amplifier. *System noise* is the total noise produced by the whole recording system including the tape. *Equipment* noise is the noise produced by all the components of the system, with the exception of the tape. *Tape noise* is the noise that can be specifically ascribed to the tape. The more important types of tape noise are: 1) *Bulk-erased noise*—the noise arising when reproducing a *bulk-erased* tape with the erase and record heads completely de-energized. Ideally, this noise is governed by the number of magnetic particles that pass by the head in unit time. 2) *Zero-modulation noise*—the noise arising when reproducing an erased tape with the erase and record heads energized as they would be in normal operation, but with zero input signal. This noise is usually 3 to 4 db higher than the *bulk-erased noise*. The difference between bulk-erased and zero-modulation noise is sometimes termed *bias-induced noise*. 3) *Saturation noise*—the noise arising when reproducing a uniformly saturated tape. This is often some 15 db higher than the *bulk-erased noise* and is associated with imperfect particle *dispersion*. 4) *DC noise*—the noise arising when reproducing a tape which has been non-uniformly magnetized by energizing the record head with dc, either in the presence or absence of bias. This noise has pronounced long wavelength components which can be as much as 20 db higher than those obtained from a *bulk-erased* tape. At very high values of dc, the *dc noise* approaches the *saturation noise*. The additional noise associated with non-uniform magnetization of the medium can be explained in terms of fluctuations in *head-to-tape contact* caused by minute surface projections, or *asperities*. 5) *Modulation noise*—the noise arising when reproducing a tape which has been recorded with a given signal, and which is a function of the instantaneous amplitude of the signal. This is related to *dc noise* and arises from the same causes—poor *dispersion* and *surface asperities*.

Noise peak See *noise pulse*.

Noise pulse A spurious signal of short duration that occurs during reproduction of a tape and is of magnitude considerably in excess of the average peak value of the ordinary *system noise*.

Noise spike See *noise pulse*.

Non-return-to-zero recording, NRZ recording See *digital recording*.

Oersted The cgs unit of magnetic *field strength*, abbreviated oe.

Orientation See *particle orientation*.

Orientation direction The direction in which *particle orientation* takes place. Except in tapes designed for rotating head applications, the *orientation direction* is *longitudinal*.

Orientation ratio In a material composed of oriented particles, the orientation ratio is the ratio of the *residual flux density* in the *orientation direction* to the *residual flux density* perpendicular to the *orientation direction*. The *orientation ratio* of conventional tapes is typically about 1.7.

Oxide build-up The accumulation of *oxide* or, more generally, *wear products* in the form of deposits on the surface of the heads. *Oxide build-up* causes a loss in *output*, particularly at *short wavelengths*, and accelerates tape wear.

Oxide shed The loosening of particles of oxide from the tape coating during use. The term is often used to denote the production of *wear products* in general.

Output The magnitude of the reproduced signal voltage, usually measured at the output of the reproduce amplifier. The *output* of an instrumentation tape is normally specified in terms of the maximum output that can be obtained for a given amount of

harmonic distortion, and is expressed in db relative to the output that can be obtained from a *reference tape* under the same conditions. The *output* of a computer tape is normally specified in terms of the average pulse height produced by replaying a series of *ones*, and is expressed as a percentage of the output obtained from a *reference tape* under the same conditions.

Oxide See *gamma ferric oxide.*

Oxide coating See *coating.*

Oxide loading A measure of the density with which *oxide* is packed into a *coating.* It is usually specified in terms of the weight of oxide per unit volume of the coating. Typical values are in the range 1.3 to 1.7gm cc.

Packing density The amount of digital information recorded along the length of a tape measured in bits per inch (bpi). Commonly used *packing densities* are 200, 556, and 800 bpi. Much higher packing densities are also in use or are contemplated.

Parity check A self-checking code employing *binary digits* in which the total number of *ones* (or zeros) in each code expression is always even or always odd. A check may be made for even or odd *parity* as a means of detecting errors in the system.

Particle orientation The process by which *acicular particles* are rotated so that their longest dimensions tend to lie parallel to one another. Orientation takes place in magnetic tape by a combination of the sheer force applied during the coating process and the application of a magnetic field to the coating while it is still fluid. *Particle orientation* increases the *residual flux density* and hence the *output* of a tape, and improves performance in several other ways.

Particle shape The particles of *gamma ferric oxide* used in conventional magnetic tape are *acicular* with a dimentional ratio of about 6 to 1. Early magnetic tapes made from non-acicular particles of *gamma ferric oxide* had a *coercive force* of only about 100 oe. The use of *acicular* particles increases the *anisotropy*, resulting in a *coercive force* of approximately 250 oe.

Particle size The average volume of the magnetic particles used in conventional tape is about 0.5×10^{-14} cc. This size approaches the value required for *single domain* behavior. The particle size is important in relation to many tape properties, including *zero-modulation tape noise* and *layer-to-layer signal transfer.*

Peak magnetizing field strength, H_m, The positive or negative limiting value of the *magnetizing field strength* associated with a *symmetrically, cyclically magnetized condition.* The *peak magnetizing field strength* most commonly used in measuring tape properties is 1000 oe.

Permanent elongation The percentage elongation remaining in a tape or length of base film after a given load, applied for a given time, has been removed and the specimen allowed to hang free, or lightly loaded, for a further period.

Perpendicular direction Perpendicular to the plane of the tape.

Plasticizer See *additive.*

Polyester An abbreviation for polyethylene glycol terephthalate, the material most commonly used as a *base film* for precision magnetic tape. The chief advantages of *polyester* over other *base film* materials lie in its humidity and time stability, its solvent resistance and its mechanical strength.

Print-through See *layer-to-layer signal transfer.*

Reel The flanged hub, made of metal or plastic, on which tape is wound. Computer tape is usually wound on plastic reels conforming with computer manufacturers' specifications. Instrumentation tape is usually wound on *NAB-reels*—metal reels conforming to standards published by the National Association of Broadcasters or on *precision reels*—metal reels conforming to very stringent specifications. *Precision reels* have either *flat* or *tapered flanges*, the main purpose of the latter being to impart a lower moment of inertia to the reel.

Reference tape A tape used as a reference against which the performances of other tapes are compared. The use of a *reference tape* is necessary in specifying most performance characteristics because of the difficulty of expressing these characteristics in absolute terms.

Remanence The magnetic flux density that remains in a magnetic circuit after removal of applied magnetomotive force. Note: *remanence* is not necessarily equal to *residual flux density* and is deprecated as a synonym for the *residual flux density* of a tape.

Residual flux, Φ_r In a uniformly magnetized sample of magnetic material, the product of the residual flux density and the cross-sectional area. Residual flux is indicative of the output that can be expected from a tape at long wavelengths.

Residual flux density, B_r, gauss The magnetic flux density at which the *magnetizing field strength* is zero when a sample of magnetic material is in a *symmetrically cyclically magnetized condition.* Normally, the *residual flux density* of a tape is measured in the *orientation direction*, using an alternating magnetizing field of amplitude 1000 oe. Residual flux density is indicative of the *output* that can be expected from a tape at *short-wavelengths.*

Residual induction See *residual flux density.*

Residual-to-maximum flux ratio, Φ_r/Φ_m In tapes consisting of oriented, *acicular particles*, this ratio is an indication of the degree of *particle orientation.* Theoretically, the ratio varies from 0.5 for randomly oriented particles to 1.0 for completely oriented particles. In practice, oriented tapes typically have ratios between 0.70 and 0.76.

Resolution The degree to which the distance between differing states of magnetization recorded along a tape can be reduced and these states still be usefully distinguished on reproduction.

Retentivity, B_{rs} The maximum value of the *residual flux density* corresponding to *saturation flux density*.

Roll A *reel* wound with a standard length of tape.

RZ recording See *digital recording*.

Saturation flux density, B_s The maximum *intrinsic flux density* possible in a sample of magnetic material. The *intrinsic flux density* asymptotically approaches the *saturation flux density* as the *magnetizing field strength* is increased. A *magnetizing field strength* in excess of 5000 oe is necessary to obtain an accurate measure of the *saturation flux density* of a typical tape.

Saturation moment, M_s The maximum *magnetic moment* possible in a sample of magnetic material. The relation between *saturation moment* and *saturation flux density* is given by $M_s = VB_s/4\pi$ where V is the sample volume.

Saturation noise See *noise*.

Self-demagnetization The process by which a magnetized sample of magnetic material tends to demagnetize itself by virtue of the opposing fields created within it by its own magnetization. Self-demagnetization inhibits the successful recording of *short wavelengths* or sharp transitions in a recorded signal.

Sensitivity The magnitude of the *output* when reproducing a tape recorded with a signal of given magnitude and frequency. The *sensitivity* of an instrumentation tape is normally expressed in db relative to the *sensitivity* of a *reference tape* measured under the same recording conditions.

Separation loss The loss in output that occurs when the surface of the *coating* fails to make perfect contact with the surfaces of either the *record* or *reproduce* head. *Separation loss* may be caused by poor guiding, by the use of cupped or otherwise distorted tape, by the presence of projections, dust or *wear products* on the tape surface, by the accumulation of *wear products* on the head surface and, ultimately, by the imperfect smoothness of the tape surface.
The magnitude of the loss introduced by separating the tape from the record head depends upon the method of recording. The use of high record currents in digital recording, or high *ac bias* in analog recording, tends to reduce the loss.
The corresponding loss at the reproduce head is a strong function of wavelength, λ, and is governed accurately by the law: Loss in db = $54.5\ d/\lambda$, where d is the distance separating the surface of the head and tape. The following table serves to illustrate this law.

Signal frequency, kc:	6	60	120	240	600
Wavelength at 60 ips, mil:	10	1	0.5	0.25	0.1
Separation for 1 db loss, μ inch:	180	18	9	4.5	1.8

Shock tensile strength See *impact strength*.

Signal-to-noise ratio, S/N The ratio of the *power output* of a given signal to the *noise power* in a given *bandwidth*. More usually the *signal-to-noise ratio* is measured in terms of the corresponding rms signal and noise voltages appearing across a constant output resistance.

Single domain particle All ferromagnetic materials are composed of permanently magnetized regions in which the magnetic moments of the atoms are ordered. These *domains* have a size determined by energy considerations. When a particle is small enough, it cannot support more than one domain and is called a *single-domain particle*.

Specific magnetic moment (σ_s) The value of the *saturation moment* per unit weight of a magnetic material, expressed in emu/gm. The *specific magnetic moment* is the most convenient quantity in which to express the saturation magnetization of fine-particle materials. The *specific magnetic* moment of pure *gamma ferric oxide* is approximately 75 emu/gm at room temperature.

Spoking A form of *buckling* in which the pack is deformed into an approximately polygonal shape.

Spool See *reel*.

Static tape skew See *tape skew*.

Surface asperities Small, projecting imperfections on the surface of the *coating* that limit and cause variations in *head-to-tape* contact. A term useful in discussions of friction and *modulation noise*.

Squeal Audible tape vibrations, primarily in the longitudinal mode, caused by frictional excitation at heads and guides.

Surface treatment Any process by which the surface smoothness of the *coating* is improved after it has been applied to the *base film*. A smooth coating improves *head-to-tape contact* and reduces *separation loss* and *modulation noise*.

Symmetrically, cyclically, magnetized condition A magnetic material is in this condition when, under the influence of a *magnetizing field* cycled between equal but opposite values, its successive *hysteresis loops* coincide.

System noise See *noise*.

Tape pack The form taken by the tape wound on to a reel. A good pack is one that has a *uniform wind*, has an acceptable *E value* and is free from *spoking*, *cinching* and *layer-to-layer adhesion*.

Tape skew The deviation of a tape from following a linear path when transported across the heads, causing a time displacement between signals recorded on different tracks and amplitude differences between the *outputs* from individual tracks owing to variations in *azimuth alignment*. The adjectives *static* and *dynamic* are used to distinguish between the steady and fluctuating components of tape skew.

Tape speed The speed at which tape is transported from feed to take-up reels during normal recording or reproduction. See also *tape-to-head speed.*

Tape-to-head speed The relative speed of tape and head during normal recording or replay. The *tape-to-head speed* coincides with the *tape speed* in conventional longitudinal recording, but is considerbly greater than the *tape speed* in systems where the heads are scanned across or along the tape.

Tear strength The force, usually in gm, required to initiate and/or propagate a tear in a specially shaped specimen of tape or base film.

Total thickness Normally, the sum of the thicknesses of the *base film* and the *magnetic coating*. The *total thickness* governs the length of tape that can be wound on a given reel.

Track An area of tape surface that coincides with the location of the recorded magnetization produced by one record gap.

Track spacing The distance between the centerlines of adjacent *tracks*. In the typical case of longitudinal tracks of 50 mils *track width*, the *track spacing* is 70 mils.

Track width The width of the *track* corresponding to a given record gap. The most common track widths encountered in longitudinal recording are 48 or 50 mils, seven such *tracks* being accommodated on a half-inch wide tape.

Ultimate tensile strength The force per unit cross-sectional area required to break a tape or length of base film, usually given in pounds per square inch (psi). Ultimate tensile strength is also quoted in terms of pounds per tape sample of given width and base thickness.

Uniformity The extent to which the *output* remains free from variations in amplitude. *Uniformity* is usually specified in terms of the positive and negative deviations from the average *output* within a roll, and in terms of the deviations in the average *outputs* between one roll and another. *Uniformity* is normally quoted in percent or db.

Vibrating-sample magnetometer, VSM A device for determining the magnetic properties of a sample of magnetic material by vibrating it in a magnetic field and measuring the emf induced in search coils in close proximity to the sample. The VSM is particularly useful in determining the *specific magnetic moment* of oxides and the *oxide loading* of tapes, since it can be designed to provide much higher *magnetizing field strengths* (10,000 oe or more) than can be conveniently obtained in a B-H meter.

Wavelength The distance along the length of a sinusoidally recorded tape corresponding to one cycle. The *wavelength* is equal to the tape speed during recording divided by the frequency of the recorded signal. The terms *long* and *short wavelengths* are used to describe *wavelengths* that are large or small compared to *coating thickness* and/or *gap lengths*. *Wavelength* is usually given in mils.

Wear ability See *durability index.*

Wear product Any material that is detached from the tape during use. The most common *wear products* are oxide particles or agglomerates, portions of coating, and material detached from the edges of the tape.

Wind The way in which tape is wound onto a *reel.* An *A wind* is one in which the tape is wound so that the coated surface faces towards the hub; a *B wind* is one in which the coated surface faces away from the hub. A *uniform*, as opposed to an *uneven wind* is one giving a flat-sided *tape pack* free from laterally displaced, protruding layers.

Wow and flutter Terms used to describe changes in signal output frequency caused by *tape speed* variations occurring at relatively low and relatively high rates, respectively.

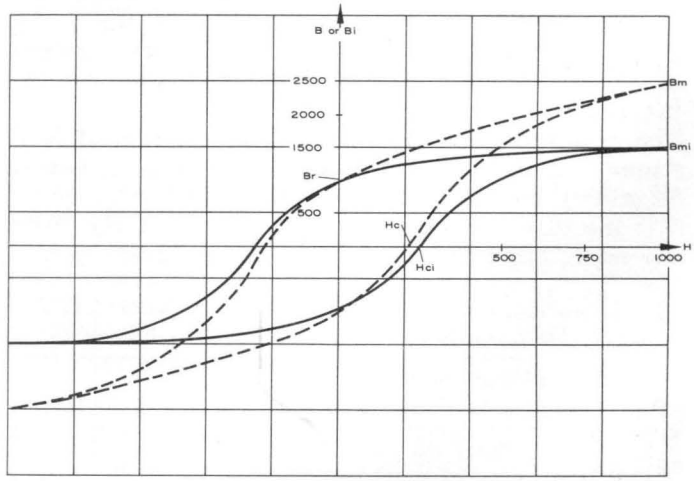
Yield strength The minimum force per unit cross-sectional area at which the tape or base film deforms without further increase in the load. Some materials (e.g. tensilized polyester) do not exhibit a clearly defined yield point, and in these cases it is common practice to express *yield strength* in terms of the force per unit cross-sectional area required to produce a certain elongation (usually 5%). Units are pounds per square inch (psi) or pounds per tape sample of given width and base film thickness.

FOOTNOTE

The relation between the *ordinary* and *intrinsic* values of flux density and coercive force are best described with reference to the hysteresis loops shown in the figure.

The *ordinary* value of flux is continuous throughout any region of space occupied by magnetic bodies. For this reason, it is the convenient value to use in electromagnetic theory, particularly when dealing with soft, weakly magnetized materials. When permanent magnetic materials are treated, as is the case in magnetic recording, the *intrinsic* value of flux is more appropriate. As its name implies, the *intrinsic flux* more aptly describes conditions within the magnetic material itself, particularly when saturation conditions are approached.

When there is no possibility of confusing *intrinsic* with the ordinary values of *flux, flux density* and *coercive force,* the adjective *intrinsic* and the suffix *i* are frequently dropped.



COMPARISON OF ORDINARY (DASHED) & INTRINSIC (SOLID) HYSTERESIS CURVES