Tape Format Issues

Do people still use reel-to-reel formats? People still use C format because of their extensive libraries.

Helical and Longitudinal

Helical is in a helix. Longitudinal is in a line (linear).

Diagram 1.

Quad records straight-up-and-down (transversely/perpendicularly), not helically. Quad is very much a dinosaur today.

Longitudinal

Advantages

- single head
- straightforward mechanism
- mechanically simpler.

Disadvantages:

Helical

Some formats go to both edges of the tape, so could have the same disadvantage as longitudinal since tape edges get more wear.

Advantages.

- cover more surface area of the tape than does longitudinal
- better stop/slow/fast motion
- tape doesn't have to move as fast to record more information

Tape writing speed: speed of tape determines frequency response. What limits: how fast tape particles can change magnetic orientation. By speeding up tape, can put out more information, which increases bandwidth and thus frequency response.

Helical vs. Longitudinal Scan Recording

Susceptibility of recording to loss as result of dimensional changes in backing is dependent on recording format.

Videotape which uses helical scan recording format, is more sensitive to disproportionate dimensional changes in the backing than analog audio tape, which uses longitudinal recording. Very narrow track in video recording requires more precise alignment.

Helical tracks recorded diagonally on helical scan tape at small scan angles. When dimensions of

backing change disproportionately, track angle will change for helical scan recording.

Scan angle for record/PB head is fixed. If angle that the recorded tracks make to tape edge do not correspond with scan angle of head, mis-tracking and information loss can occur.

One of biggest scan angles was at IVC (previous employer of Steve). Drew single scan over 12 inches of tape; this is a large angle. They put a full field of video in one scan.

As time continued, were able to use smaller angles. *Diagram* 2.

Displays diagram of helical recording head. 1800 rpm on **scanner**/**drum**/**headwheel** carrying the video heads. *Diagram* 3.

When record over previously-recorded tape, get color bands at home. See old information before it gets erased.

Erase with a full width eraser.

If a mastering machine, will use tape that is new or bulk-erased, so don't have to worry about erasing tape.

Others like editors have heads built into scanner that erase track before it records the track.

How many fields can put down per revolution? 1800 rpm / 60 secs/min / 30 frames/sec / 2 fields/frame. So, can record 2 fields (60 * 30 = 1800). Can stop and get a full still picture.

One field per head on this two-recording-head wheel. Head is synch'd to the vertical frame rate. Scanner knows when to start: during vertical interval. This minimizes chance of losing valuable data (the active video). Can replace most of the data in the vertical interval.

Head Transport

How are these heads driven? Belt, chain, direct? Most are directly driven by the motor today. Used to be belt driven earlier (when didn't have good DC motors that would keep constant speed).

Mistracking

Distortion of helical scan videotape can result in two types of mistracking: trapezoidal, curvature.

Trapezoidal: tracks remain linear, track angle changes so the playback head can't follow them

Curvature: can be more serious type – where recorded heads become curved as result of nonlinear deforming of the tape backing.

Mistracking results in video image where some or all of screen is snowy or distorted. For example, in trapezoidal, the upper portion of the TV screen may appear normal, whereas the lower portion may be static.

Appearance on screen similar to playback of good tape where tracking adjustment control purposely misadjusted.

VHS always possibility of cross-track interference.

Diagram 4 on errors.

Will have a master alignment tape, expensively available from manufacturer, recorded on the master machine at the manufacturer. That tape should agree with everybody else's master alignment tape, so should be able to plug in your tape into anybody else's machine and it will work.

Curvature error can occur when the damage is in the middle of the tape. Trapezoidal can occur when one edge is damaged more than the other.

In longitudinal tape system, heads arranged along fixed head stack – one head per track – and tracks always remain parallel to tape edge. Mistracking not as great a problem in longitudinal recording for this reason. *Diagram* 5.

Distortion of longitudinal audio recording tape will appear as temporary muffling, change in pitch, or loss of audio track. Tape moving away from and closer to the head. Constant distance lost due to the irregularities of the tape surface.

Distortion of tape backing can impart slight curve to normally linear tape. When distorted portion of tape passes over playback head, recorded tracks can move out of alignment with head gap, causing temporary reduction in sound volume and quality.

Diagram 5 with erase head. Erase head has one gap, but is across the entire tape width.

Longitudinal recording

A moving tape passes across a tape recording head. Recorded tracks parallel to edge of tape and run full length of tape. A nine track tape is shown (*diagram* 6).

Analog Vs. Digital Storage

Analog Recording

In analog recording, signal recorded on audio or video tape represents signal originally heard/seen by mic/camera.

Volume of sound recording or intensity of color of video image directly related to strength of magnetic signal recorded on the tape.

Digital Recording

In digital recording the audio or video source signal is digitized. The signal is sampled at specific points in time and converted to a number that reflects the intensity of the signal at the time of sampling (analog-to-digital conversion). *Diagram* 7 (shows a sample A to D conversion).

If decrease frequency of the wave, get a different set of numbers at the same sampling frequency.

Analog and digital recorders are physically the same (tape, heads). They just record data differently.

These numbers, in binary form, are written to the tape, instead of writing the analog signal to the tape as in analog recording.

On playback, numbers are read and used to reconstruct a signal that is representative of the original signal (digital-to-analog conversion).

Chief advantage of analog recording for archival purposes is that the deterioration over time is gradual and discernible. This allows tape to be transcribed before reaches point where recording quality degraded to unusable level. Even in instances of severe tape degradation, where sound/video quality compromised by tape squealing or high rate of dropouts, some portion of original recording will still be perceptible.

A digitally recorded tape will show little if any deterioration in quality up to time of catastrophic failure when large sections of recorded information will be completely missing. None of original material will be detectable in these missing sections. This is the **cliff effect**.

Bit Error Rate. There is a gauge on some recorders that shows how much correction it is doing. Can watch this to watch aging of tape.

Loss and Noise

The chief advantage of a digital recording is that copies of the original tape can be made without any loss in recording quality. A copy of a digital tape can be made that is truly identical to the original source tape.

When an analog tape is copied, the original information signal is actually copied along with any tape noise inherent in the tape and any electronic noise inherent in the recording device. This is called **generational loss**. No generational loss in digital recording.

This will be written to a new tape that also has its own level of inherent tape noise. Therefore, the noise level on the dubbed copy will always be greater than that on the original tape, or the sound quality of the original recording will be altered as it is filtered to reduce noise. Lots of noise on VHS tapes, recording degrades significantly at one generation because of low resolution and high noise.

Presence of noise in recording makes recorded information less distinct to see/hear.

Recording engineers refer to a **signal-to-noise ratio**, which defines the quality of the recording with a higher value being better.

Sidebar: talk about signal and the noise on the signal. 1 kHz reference tone. Talking about signal plus noise to noise. (S+N) / N. A good digital audio might run at 90 dB S/N. A good analog audio might run 54 dB. Government audio in one place was 34 dB. S/N in a reel to reel tape recorder probably about 25 dB. Would measure signal and noise in volts.

20-20000 Hz +/- 3 dB – what does this mean? When look at passband, can vary +/- 3 dB on the response curve. Pro gear could have a spec of +0 -0.5 dB.

Digital tape recordings are virtually unaffected by tape noise even though digital tapes are not noise free. In digital recordings, binary numbers (0's and 1's) read from and written to the tape. Ones and zeros easily distinguished from the background noise.

In analog recording, recorder can't distinguish between recorded signal and tape noise so that both are read and reproduced on playback.

In addition, digital recordings usually have an error correction system that uses redundant bits to reconstruct areas of lost signal.

First time (master) analog recording is more faithful than first-time (master) digital recording.

Recording Digital and Analog

Analog recording continuously records the complete signal heard or seen by mic/camera. However, distortion in both recording and playback varies with quality of electronic components used.

In digital recording, the source signal is quantized to a fixed number of allowed signal levels. For example, a video image quantized at 8 bits/color would only allow for 256 distinct colors to be reproduced, whereas an analog image would allow an infinite number of colors. By increasing the number of bits/color used, the number of color levels that can be reproduced will increase. For example, an image quantized at 24 bits/color will allow 16,777,216 distinct colors. We use a maximum of 10 bits/color in cameras.

With digital recording, higher quality video images require greater storage volumes. Some audiophiles with highly trained ears claim they can hear limitations in a digital CD audio recording (16-bit quantization permitting 65,536 distinct sound levels and a maximum frequency of 22 kHz) when compared to an analog recording of the same sound source.

Steve's friend takes CD players and guts them and replaces the sound amplification circuits with analog circuitry. $5K CD player and $5K worth of upgrades.

Analog tape recordings do not require expensive equipment for recording/playing. Digital audio and video equipment which records high frequencies at high speeds and performs the complex tasks of analog-to-digital and D-A conversion and error correction is relatively expensive.

Magnetic Tape Recorders

Audio and video recorders must be maintained in excellent condition in order to produce high quality recordings and to prevent damage to tapes on playback.

These Betacam VTRs are still the workhorses of the industry. Sony BVW = broadcast video workhorse.

Dirty recorders can ruin tape by distributing debris across tape surface and scratching tape.

Recorders not mechanically aligned can tear and stretch tape, produce poor tape packs, and write poorly placed tracks. Recorders poorly aligned electrically can cause signal problems resulting in inferior playback. Follow the manufacturers instructions for good recorder maintenance in order to protect recordings.

Diagram 8 on tape problems.

Handling Tape

Handle tape in no smoking, no food, clean areas. Do not let tape or leader ends trail on the floor. Do not drop or subject to sudden shock. Keep tape away from magnetic fields. Tape storage areas should be cool/dry, not exposed to sun.

Avoid subjecting tapes to rapid temperature changes. If storage and operating area temperatures differ by more than 15F 8C allow an acclimatization time within the operating area of four hours for every 18F/10C difference. Shuttling tape from end to end can speed up this process.

Store open reel and cassette tapes with the reels or tape packs vertical. Reels should be supported by the hub. Tapes should be stored like books on a library shelf – on end; they should not be stored laying flat.

Use high quality reels or cassettes, boxes/containers, and accessories.

Return tapes to their containers when not in use.

Cut off damaged tape or leader/trailer ends from open reel tapes.

For open-reel tapes, use protecting collars if available. What is a protective collar? Collar holds the tape in so it doesn't unravel; it's about the same size as the tape.

(20-)50% humidity, 65F temperature is good tape storage conditions. This is too cool and too humid for people's comfort.

Do not use general purpose adhesive tapes to secure the tape end or for splicing. If necessary, use adhesive products designed for the purpose.

Minimize tape handling.

Don't touch tape surface or the edge of the tape pack unless absolutely necessary and then wear lint-free gloves.

Clean the recorder tape path thoroughly at the recommended intervals (rated in hours).

Discard tapes with scratches or any other surface damage, which causes significant debris to be left in the recorder tape path.

Ensure tapes to be reused are thoroughly bulk erased before they are put back into service.

Stray Magnetism

This is less of a problem than often thought. Devices such as walk-through metal detectors use small fields that have absolutely no effect.

Hand-held detectors are best avoided as high local fields may be present.

X-rays have no effect on unrecorded or recorded tapes.

Similarly, radiation from radar antennas can be disregarded, unless the field strengths are sufficient to injure people.

Some detectors used to screen luggage in airports use powerful magnetic fields that may partially erase recorded information on tapes.

Prudent to keep tapes away from transformers, heavy electrical machinery, other very strong magnets.

Magnetic field problems are very rare, even for tapes shipped internationally without special precautions. The best protection for shipping is a minimum of 2 inches of nonmagnetic material all around. The inverse square law ensures that the fields from even heavy electrical equipment will not affect tape at 2 inches distance.

Tape Edge Quality

Tape is slit to precise widths with smooth straight edges. These qualities must be preserved if the tape is to perform well, since most recorders edge guide the tape (use the edges to guide the tape). Quad uses tape edges to seal a vacuum chamber that guides/pulls on the tape.

Modern recorders use narrow tracks. If tape edge is nicked, dented, bent, stretched the recorder head will not properly track over the recorded signal (mistracking).

Bent/nicked reels should be promptly discarded before significant tape edge damage results.

If an uneven tape pack is noted within a cassette, it may be appropriate to copy it.

Tape Pack/Wind Quality

Tape is least vulnerable to external damage when wound in a smooth, even pack.

Popped strands, where a few turns of tape stand away from the majority, are very easily damaged and should be avoided by using good quality tape and properly adjusted recorders.

Vertical storage prevents pack slip.

Supporting reels by their hubs ensures the flanges are not deflected. In the ideal case, the flanges will then not contact the tape.

Flange packing is a condition that occurs when the tape is either wound up against one flange by a poorly aligned recorder or has fallen against the flange due to a loose wind and flat storage.

Flange packing often leads to damaged edges from tape scraping against edge of flange as it unwinds through recorder. With poor wind with popped strands, strands that stick out of pack can be severely bent when tape is flange packed.

Embossing

Reels should have smooth tape take-up surfaces.

Even small bumps close to the hub will produce impressions in the tape repeating for several tens of meters. This embossing effect applies for lumps as small as 30 mm high, and the impressions produce measurable tape-from-head separation.

Note that even well-made splices stand higher than 30 mm so the embossing effect applies.

A wrinkled tape end on the hub can cause similar problems. A wrinkled/frayed end at the beginning of a tape is likely to deposit debris in the recorder tape path before embossing the tape as it winds onto the take-up reel.

Winding Speed and Tension

About 8 ounces for most recorders (1 inch tape with nominal thickness 25 mm given as an example here). For other widths/thicknesses, tension may be adjusted.

At slow winding speeds (15 inches/sec), very little air trapped in the pack as it is wound, and there is a negligible air lubrication effect. In these conditions, lower tension may be desirable. High speeds can result in more air trapped.

Excessive tension (at any speed) leads to a tape pack showing radial lines known as spokes. Result from pressure from outer layers in the pack compressing inner layers so that the turns develop a small kink. These kinks align radially and appear as a spoke.

In severe cases, periphery of tape pack may lose its smooth round form and become lumpy.. Should rewind immediately.

Several different winding tension controls popular. Most tape leaving factory would with **constant torque**.

Many recorders wind with **constant tension**. There is also the **programmed wind** tension. In this case the tape is wound with low tension close to the hub. Increased tension applied mistape and then the tension reduces again as the outer diameter is approached.

This special technique yields a pack with certain types of tape that survives a particular sequence of temperature and humidity cycles very well, but either constant tension or constant torque winding is perfectly satisfactory for normal applications and storage conditions.

Periodic Rewinding

For long-term storage, it is helpful to rewind tapes at an interval of not more than three years. This relieves tape pack stresses and provides early warning of any problems.

Tape Scratches and Head Clogging

Tape scratches may be inflicted by damaged heads or a sharp surface somewhere along the tape path (usually the head though). Sometimes a tape clog can get hardened and scratch the tape.

Head clog cleaning. Take Q-tip with alcohol, break tip to get sharp point, scrape alcohol and melted-on mix on the head until you get it off. Use a microscope to see what you are doing and when you get the melted-on stuff off.

Scratches can also be caused by mobile debris reaching the spinning head area. High temperatures can result in the head-to-tape interface, and a blob of molten debris can become welded to the head.

This solidifies and inflicts more damage on the tape as it spins on the head. Such a head neither records no properly reduces and is said to be clogged. It is therefore very important to be scrupulous in following the cleaning procedure recommended by the recorder manufacturer.

Heads are ferrite. They are brittle. They can't take much abuse. Head is very thin where it hits the tape. It is mounted in a head wheel. It protrudes a little bit. If you move the head up and down, you'll break it, but moving it side-to-side won't, so that's how you clean a head (left-to-right). Taking a Q-tip to a head, do it across the head.

If there is any suspicion of tape scratching, the recorder tape path and heads should be cleaned immediately to avoid risk of damage to other tapes.

Similarly, a scratched tape should be taken out of use as soon as possible to avoid the risk of clogged heads and damage to other tapes. Once a tape is scratched, its surface integrity is lost, and it will tend to clog on even the most perfect recorder.

Steve passes around a head wheel out of a scanner. It spins, the tape contacts the spinning drum. Also passes around a complete scanner, and a smaller complete scanner.

Qtip will leave a lot of cotton debris. Microscope is good to see the debris so you can remove it. Break the Q-tip, take the sharp edge, can knock off stuff that is clogging a head. Don't do it in the center because it won't be sharp. Want a long sliver.

Cinching

The wrinkling or folding over of tape on itself, usually when a loose tape pack is stopped suddenly. It can cause creasing of the tape, which contributes to peeling or shedding tape and (because of bad tape-to-head contact) to dropouts.

Stretched Tape

The elongation of parts of the tape, across the full width of the tape or (most likely) on one or the other side of the tape, usually results from either improper wind or from faulty equipment.

May cause long-edge or curvature problems, and distort the signal, but data can be retrieved from an analog tape usually with a decrease in signal quality.

Breaking

Separation of tape into two or more parts, usually resulting from very sloppy handling.

Blocking

Sticking together of two or more winds in a tape pack, most often resulting from deterioration of the binder, storage at high temperature and/or under excessive pack pressure.

Creasing

Folding of sections of tape such that it is ridged or wrinkled. Can be caused by hub-slots, cinching, mishandling of tape. Creasing can cause oxide loss and/or tape-to-head contact problems (leading to dropouts and data loss).

Mistracking

Inaccurate adaption of tape to its intended path through the tape machine, usually because of some physical deformation or damage to the base or edge of the tape, such as curvature. If severe, the tape will not play properly – or at all – and recorded information may either be distorted or lost.

Rewinding and environmental staging of the tape may help. In some cases improperly slit tape (during manufacture) can produce hardbands which can cause the tape to mistrack. This isn't often since a reel of 1 inch tape was about $200, so there was enough money for quality control.

Oxide Loss

Separation of oxide from base. Poor binder adhesion, friction, scratching, other stuff. Not correctable; considered tape failure.

Magnetic Particles

Primary problems which occur with recorded signals during storage are demagnetization and the introduction of magnetization other than that originally recorded.

Print-through

Recording of low-frequency signals from one or more windings of tape onto adjacent layers. Described as a ghost signal heard slightly before the actual audio recording. Heard this on vinyl; this is probably from the master tape.

Strength of signal generally proportional to strength of original signal.

Demagnetization

Loss or recorded signal, generally be dismissed fairly easily for tape in storage, occurs but not common. Affects high frequencies first, but not its intelligibility. If tape properly recorded/stored, amount of mag field decrease not noticed.

Dropouts

Brief signal losses from tape head clog, missing oxide, defect in tape, debris on tape or machine, or other situation reducing tape-head contact. Even smallest airborne particle can cause a dropout. Keep tape a clean as possible, storing and using it only in a clean environment, and cleaning/maintaining equipment as recommended by manufacturer. Tip of tape head about the size of a dust particle, and is affected by the size of a fingerprint stain.

Playing

To play/inspect, stage it out of storage for 1 to 50 days, dependent on tape width and storage environment. Audio cassette can acclimate in about 6 hours, 1/4" open reel tape in 24 hours, 2" reel to reel tape will require up to 50 days. This is ideal.

Keep your playback area clean cool dry. Temperature should never exceed 75F and 60% RH, prefer 65F 55% RH, RH about 20% to insure against static discharge problems and drying.

Tape from container only when needed, return promptly.

Use time tape is out to inspect for problems.

Tape Noise

Cause is in tape. In fully erased tape magnetic particles in random order, but still allows a statistical distribution of particles having similar polarity, inducing signal in playback head causing random noise signal. Select high quality tape. Influenced by:

- Track width – wider track, more magnetic particles are in front of the gap and the bigger chance that a random magnetic fields will cancel out to zero. Wider track produces higher useful signal flux giving better S/N ration.

- Tape speed – increased tape speed, random noise shifted toward higher frequencies and out of audio range, thus no longer contributes to total noise power.
- Recording level – tape noise level is fixed. Recording signal at highest possible level will increase signal-to-noise ratio of the recording.