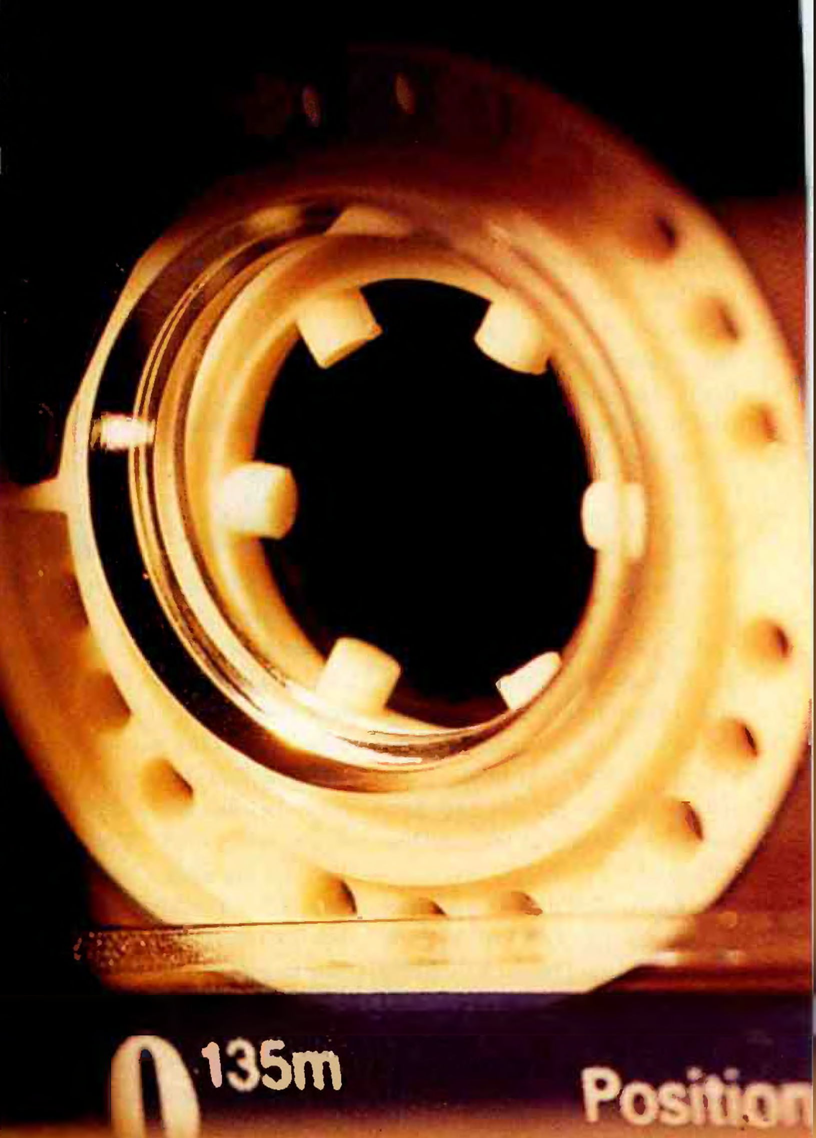
MASS TAPE TEST

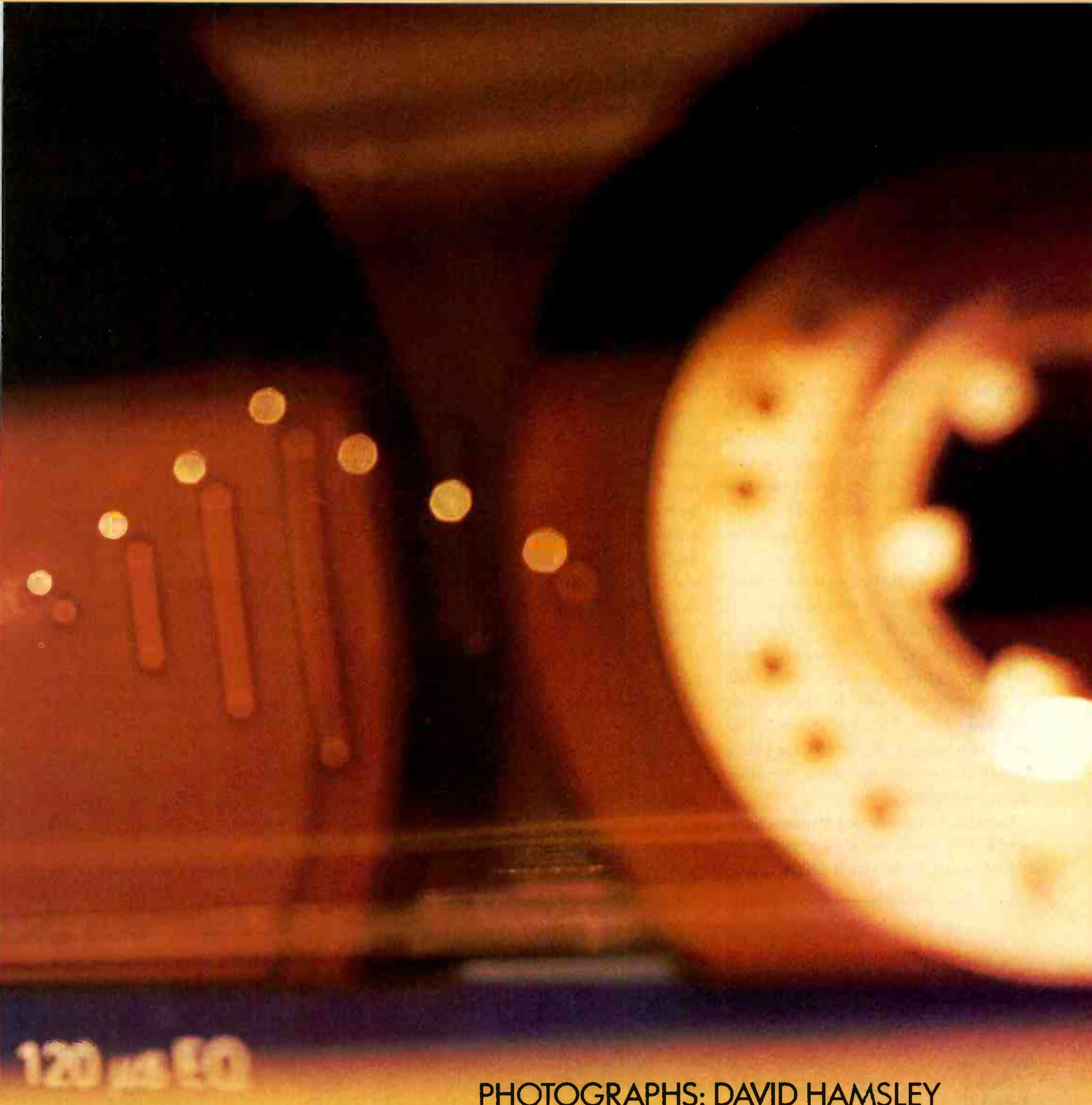
51 CASSETTES

EDWARD J. FOSTER



THE SECOND GREATEST CASSETTE TEST EVER

Approximately every three years, *Audio* reevaluates analog cassette tapes. The field isn't static, and it can be difficult to keep up with improvements—major or minor—or even to tell whether any changes have occurred. Some manufacturers mark every slight change in formulation with a spanking new name, but others—especially those with well-recognized brands—do not. Why jeopardize sales of a well-recognized label, they reason, simply because it's been improved? So, even when *names* don't



PHOTOGRAPHS: DAVID HAMSLEY

change, tape *formulations* may; thus, previous data becomes invalid, and it's time to test again.

Until his passing in 1991, my friend Howard Roberson evaluated tape for *Audio*. I had known Howard for years, both through his work in *Audio* and when he served on the Institute of High Fidelity/Electronic Industries Association (IHF/EIA) Tape Recorder Standards Subcommittee, which I chaired. We both were experienced in evaluating tapes and decks, discussed our procedures at some length, and found that we agreed on many points and disagreed on others—as reasonable engineers are wont to do.

Stepping into Howard's shoes this past year has not been easy. I have pretty strong opinions regarding cassette evaluation, yet some consistency in methodology is important to compare yesterday's results with today's. I was encouraged by *Audio*'s Editor-in-Chief, Gene Pitts, to "call 'em as I see 'em" and, within reason, to make whatever

Some makers change tape names for each new formulation, but others use the old names for new tapes.

procedural changes I felt would be beneficial. In making modifications, I was further encouraged by the changes Howard seems to have made in his own explorations over the years, such as shifting from evaluating high-frequency maximum level by the twin-tone method (1987) to the saturation method (1990). More on that later.

Suffice it to say that, though I have made changes which I will outline in detail, I've tried to maintain the spirit of Howard's approach and, in this light, have agreed to rank tapes numerically—a procedure, I will say up front, about which I have strong misgivings. With so much of Howard's past work continuing in this review, I'd like to dedicate this article, with respect and admiration, to Howard A. Roberson.

From 35 tapes reviewed in *Audio*'s November 1987 issue, the number burgeoned to a whopping 88 in March 1990's "Greatest Cassette Test Ever." These included not only well-recognized brands, widely available in stores, but less well-recognized cassettes, some of which could be obtained only by mail. Gene Pitts and I agreed to limit this year's field to "recognized" well-distributed brands. Thus we came up with the "Second Greatest Cassette Test Ever," with 51 cassettes: 14 Type I tapes ("Normal" bias), 23 Type II tapes ("High" bias or "Chrome"), and 14 Type IV tapes ("Metal"). The "Types," by the way, refer to International Electrotechnical Commission (IEC) designations. Brands represented are BASF, Denon, Fuji, JVC, Maxell, Memorex, Realistic Supertape (available at Radio Shack stores), Scotch (made by 3M), Sony, and TDK.

I will dispense with the recitation of manufacturer's claims and the "Star Wars" verbiage used to distinguish one gamma ferric-oxide particle from another. Even if true, statements like these offer little information or content and usually do nothing to tell you what to expect from a tape. I'd rather take the space to tell you *how* each tape was evaluated, including the similarities and differences between my methodology and Howard's, circa 1990, at least as best I can determine what he did.

TEST METHODS

To put everyone on an equal footing, I requested three C-90 cassettes of each formulation from each manufacturer. The thin coating that's frequently used on longer cassettes (and the thick one that may be used on short cassettes) can affect test results—especially vis-à-vis low-frequency maximum operating level (MOL) and S/N ratio—so I wanted all cassettes to be of the same length. Because C-90 remains the overall best seller, again this seemed to be the best length to use.

I intentionally made two exceptions to this rule. Denon S-PORT High, a Type II formulation, and Denon MG-X Metal, the company's top-of-the-line Type IV formulation, are not available as C-90s, so C-100 cassettes were tested in these two cases. Keep in mind that this probably put these tapes at a competitive disadvantage vis-à-vis low-frequency MOL (and maybe in signal-to-noise ratio) but conceivably could have given them a little extra in the

Type I Measured Data

Tape	Maximum Output Level, dB, re Dolby Level: MOL 40 Hz	MOL 125 Hz	MOL 400 Hz	MOL 1 kHz	MOL 3.15 kHz	SOL 6.3 kHz	SOL 8 kHz	SOL 10 kHz	SOL 12.5 kHz	S/N Ratio, dBA	−3 dB Response Limit at Dolby Level, kHz	Mod. Noise, dB	Bias, dB	Sens., dB
BASF Ferro Extra I	+0.8	+5.2	+5.7	+6.0	+3.8	+1.8	−0.9	−4.1	−8.0	58.3	9.4	−47.7	+0.4	−0.7
Denon DX-1	−0.4	+4.0	+4.4	+4.6	+0.9	+1.7	−0.9	−3.9	−8.0	57.7	9.5	−49.7	+0.1	−1.2
Fuji DR-I	−0.4	+4.0	+4.6	+4.8	+1.5	+1.6	−0.9	−3.9	−7.8	58.2	9.4	−51.3	0.0	−1.0
JVC GI	−1.5	+3.2	+3.5	+4.1	+1.3	+1.2	−1.3	−4.5	−8.4	56.3	9.1	−47.7	−0.1	−1.0
Maxell UR	−1.7	+2.9	+3.5	+5.5	+3.3	+2.0	−0.8	−3.9	−8.1	56.5	9.5	−52.3	+0.6	−1.3
Maxell XLI	+3.9	+8.2	+8.0	+7.1	+3.6	+2.8	+0.2	−3.4	−8.1	63.6	9.8	−51.7	+0.9	0.0
Memorex dBS	−1.8	+3.6	+4.4	+6.5	+4.7	+2.3	−0.2	−3.8	−8.5	55.7	9.7	−50.4	+0.3	−0.1
Realistic Supertape XR	−0.8	+4.1	+5.0	+6.2	+4.0	+2.1	−0.1	−3.5	−7.6	56.6	9.9	−49.5	+0.2	0.0
Scotch BX	−0.6	+3.7	+4.6	+5.1	+1.6	+1.3	−1.1	−4.4	−8.4	56.5	9.3	−49.3	+0.8	−0.3
Scotch CX	−2.2	+2.3	+2.8	+4.3	+2.2	+1.5	−1.0	−4.5	−8.1	54.5	9.1	−48.0	+1.5	−0.6
Sony HF	+0.1	+4.7	+4.8	+4.9	+1.6	+1.7	−0.9	−4.0	−8.2	58.7	9.5	−50.5	0.0	−1.1
Sony ES-I	+2.4	+6.8	+7.1	+7.1	+4.9	+2.7	−0.1	−3.4	−7.7	62.8	9.9	−52.0	+0.3	−0.2
TDK D	+0.4	+4.9	+5.4	+6.3	+4.6	+1.9	−0.7	−3.9	−8.0	58.6	9.6	−51.9	+0.4	−0.5
TDK DS-X	+2.4	+7.0	+7.3	+7.0	+5.0	+2.3	−0.2	−3.6	−7.8	62.3	9.8	−50.5	0.0	+0.8

Note: Modulation noise values are referenced to Dolby level; bias and sensitivity figures show how far each tape's requirements differ from the IEC Standard for its type.

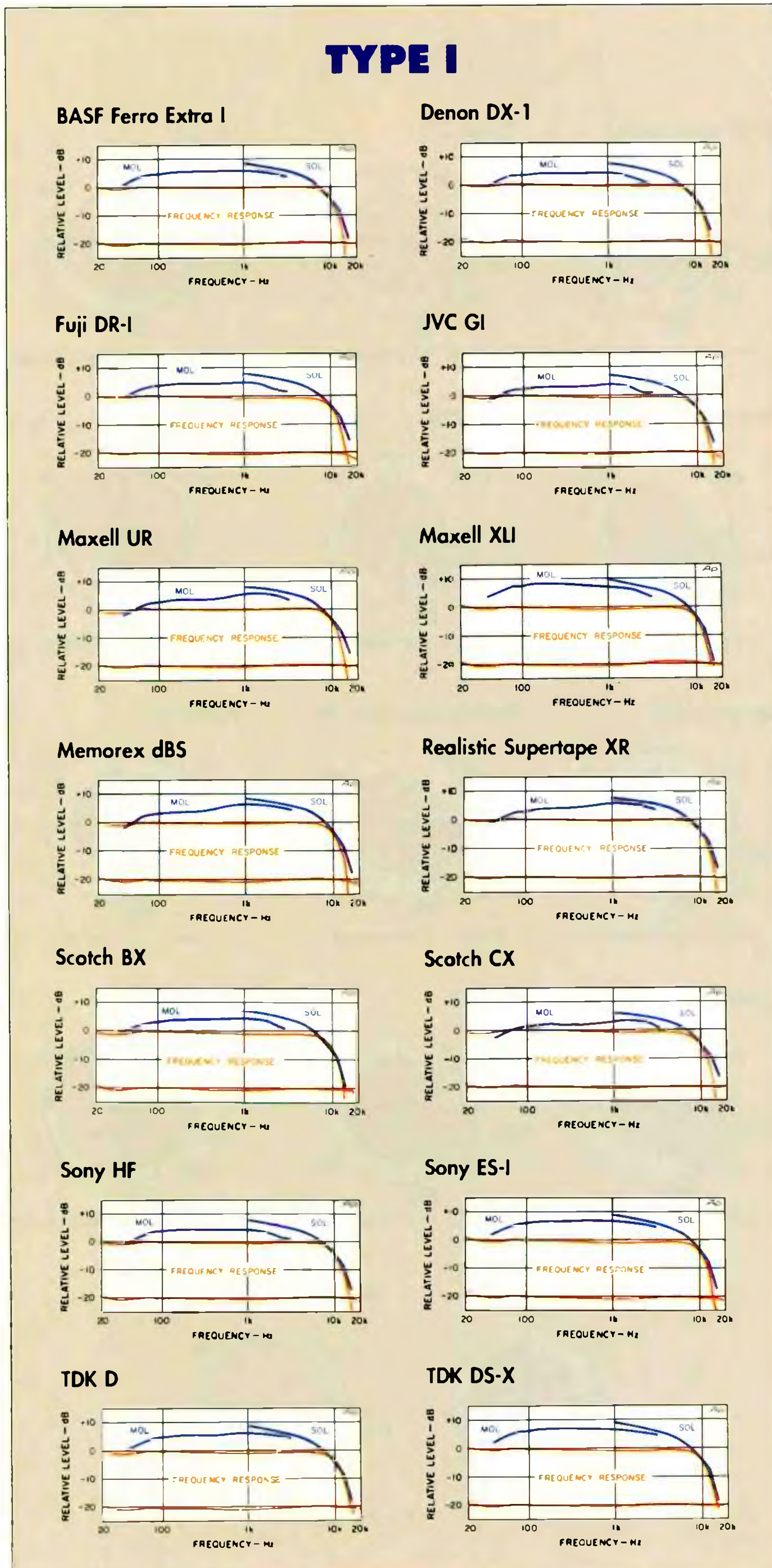
way of high-frequency saturation operating level (SOL).

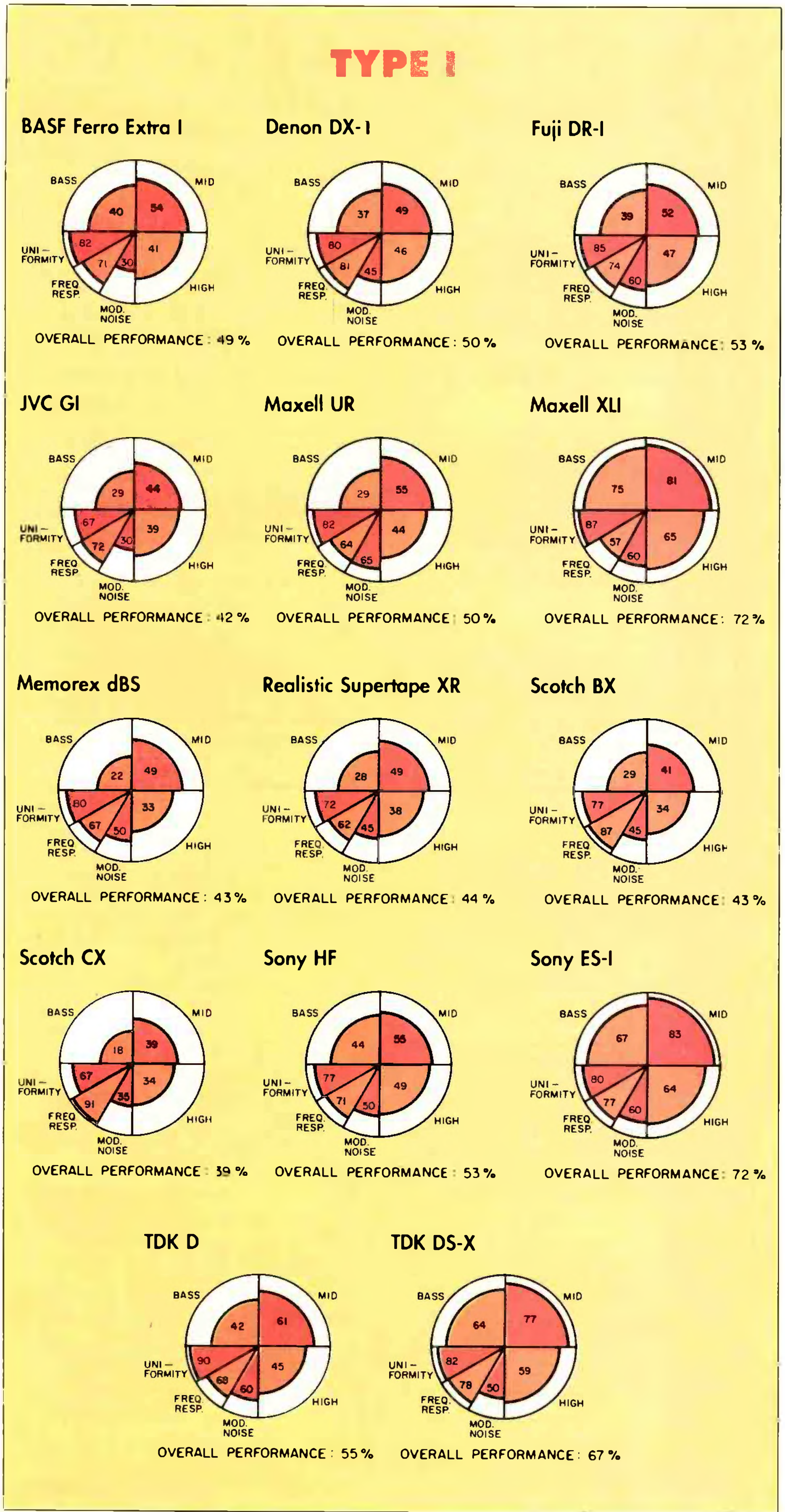
Some manufacturers sent more than the three samples requested, but only three (chosen at random) entered the test phase. In accordance with Howard's practice, each tape was opened (following the pull-tab instructions) and then fast-wound and rewound once in each direction. I made notes of how easy it was to open each tape and how noisy-it was when fast winding. I don't consider the winding noise of any *great* significance since some relatively "noisy-winding" tapes proved better than average in other, more significant, mechanical aspects (including side-to-side tracking and the like).

All measurements were made on a Nakamichi 582 deck. Although long in the tooth, this deck remains, in my opinion, *the* most stable platform on which to make in-cassette tape evaluations. The particular deck I use has been preserved *exclusively* for tape evaluation, so, although it's old, it's seen relatively few hours of use and is in pristine condition.

Side A record-head azimuth was aligned for each sample prior to bias and sensitivity determination or any other measurement. Record-head azimuth was matched to the play head through a multistep procedure: Adjust for maximum output at 15 kHz, refine the adjustment to minimize interchannel phase difference at 15 kHz, and, finally, check that the interchannel phase difference decreases monotonically with decreasing frequency. As the second and third samples of each tape were loaded into the deck, I made a note of the interchannel phase error prior to azimuth alignment and noted how much change in alignment was required. This information played a role in concocting the uniformity score.

Next, bias was adjusted for equal sensitivity (that is, equal output for identical input) at 400 Hz and 15 kHz at a recording level of 20 nWb/m (–20 dB re Dolby level). This is similar to, but not identical with, Howard's 1990 procedure. Howard adjusted for smoothest response at –20 dB re Dolby level, using pink noise and a third-octave real-time analyzer. I understand his reasoning, but I do not feel that the benefits of adjusting for smooth pink-noise response justify the imprecision inherent in making a pink-noise, third-octave analysis.





Other measurements are *strongly* affected by bias setting, so I prefer the precision and repeatability afforded by a two-tone sine-wave adjustment.

After azimuth and bias were adjusted, bias current was measured at the internal monitoring point provided on the Nakamichi 582 for this purpose. The bias for the sample under test was compared with that required to bias the IEC Standard tape for the category (Type I, Type II, or Type IV, as appropriate); the ratio was then expressed in decibels.

In a similar manner, recording sensitivity (the input voltage required to obtain Dolby level) was compared with that required by the corresponding IEC Standard tape, with the ratio expressed in decibels. Bias requirements and recording sensitivity were documented for each of the three samples. I did not determine the bias and sensitivity requirements for the B side of the tape (as Howard did in 1990); I find it inconceivable that they should differ over the tape width, and doing so would have "lost" the A side's azimuth reference that I wanted to maintain to determine side-to-side tracking.

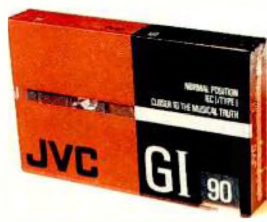
After adjusting azimuth and bias, I plotted record/playback response at 100 points from 20 Hz to 20 kHz, at Dolby level and at 20 dB below Dolby level, using Audio Precision System One test equipment. To obtain the data for the –3 dB response limit listed in the Tables of Measured Data, I repeated the Dolby level measurement over a narrow band of frequencies chosen to determine the –3 dB frequency with greater precision than was possible with a broadband stepped measurement. Response curves for both 0 and –20 dB appear in the graphs this year, for reasons I will go into later. In shifting from the –20 dB level to the 0 dB level, I noted the degree of output compression (or, in a few cases, expansion) at 400 Hz. Although not tabulated, this information entered into my low-frequency rating scheme.

I measured MOL and SOL and plotted them on the same grids as the response curves. The results for MOL (for 3% THD + N) were determined at 20 points, from 40 Hz to 3.15 kHz. This is essentially the same procedure Howard used in 1990, although I increased the number of measurements and went to a higher frequency, for reasons that will become apparent later. Results for SOL were obtained at 13 points from 1 to 16 kHz—the same range but with four more points than Howard used. Again, the reason will become clear later.

Biased-tape noise (that is, the noise level of a tape that has passed over the recording head with bias but no audio signal applied) was measured on an A-weighted basis, using a shorted input and a minimum setting on the record-level control. (I also interposed a high-pass filter to eliminate hum components that might affect the measurement.) Each noise measurement was corrected for the residual noise of the deck. This was done by subtracting the output noise power when playing a "tapeless" cassette from the measured biased-tape noise power and recalculating corrected noise referenced to Dolby level. The A-weighted S/N ratio listed in the Tables is the difference between the tape's MOL at 400 Hz (referenced to Dolby level) and its corrected noise power (also referenced to Dolby level).

I did not measure flutter because, as Howard rightly pointed out in 1990, "The deck has a considerable effect on the exact flutter—for any tape." So much so, in my opinion, that flutter measured on one deck cannot be relied on as a means of evaluating the cassette shell. To get a handle on shell characteristics, I used a 10-kHz tone to measure interchannel phase error for one minute on side A. The max/min phase error was determined and entered into the uniformity score. At the conclusion of all tests, I flipped the tape over and made an interchannel phase measurement on side B, *without* adjusting azimuth, using a 3.15-kHz tone. This suggested how well each tape tracked within its cassette, and performance in this regard was a factor in the uniformity score. Also destined to factor into the score was uniformity of output level at three frequencies: 400 Hz, 3.15 kHz, and 10 kHz.

Finally, I measured modulation noise following the procedure that Howard pioneered: Record a high-level 1-kHz tone, bandpass-filter the output from 500 to 1,500 Hz (to eliminate distortion components and reduce "conventional" noise), and then use a distortion analyzer to notch the 1-kHz tone and measure the residual noise in dB below the tone level. Essentially this methodology totals the energy that exists in any AM and FM sidebands that may have been generated within ±500 Hz of the tone by modulation noise. The average of the maximum and minimum readings over a 20-S period is tabulated, but I must warn you that the "spread" in readings on most tapes is wide (averaging about ±1.5 dB), so small differences in tabulated data are meaningless.



The use of 120-µS EQ raises Type I tapes' noise levels, reducing their overall scores.

USE TESTS

Except for the Denon products, Maxell's UR, and TDK's D and DS-X, most of the cassettes were easily unwrapped, and I may have been fumble-fingered with the aforementioned. Memorex and Radio Shack (Realistic Supertape) wrappers were particularly easy to open, since their pull tabs are slightly extended and you needn't scratch them free with your fingernail. Some tapes did not have pull tabs, but that didn't seem to affect my ability to open them. In any event, most shrink-wraps open easiest if you pull diagonally (not straight across) from the point indicated and in the direction of the arrow (if there is one). Some are quite perverse in that they seem to open "backwards"; always stick with the arrow if there is one.

Rounded-edge cassette cases are "in" this year. Except for their least expensive Type I cassettes, Denon, Maxell, Memorex, Sony, and TDK tapes all use these new smooth cases. Fuji goes a step further in innovative design. Its Extraslim case is designed to hold the cassette wrong way 'round, that is, with the head-opening portion exposed when you open the case. The Fuji Extraslim case is rounded and only 0.55 inch thick—about ⅛ inch slimmer than normal. It's great when taking a pocketful of cassettes on a jog or on the road, but the case rattles around in fixed-width cassette racks, and Fuji is forced to fold the insert card (J-card) to keep it out of the way of the cassette. Denon S-PORT's case also is thinner than normal (just slightly thicker than Fuji's), but it holds the cassette in normal fashion and uses a normal J-card. Perhaps the most high-tech-looking case is the all-black box used for Fuji ZII.

Realistic Supertape cases are flimsier than others. Memorex dBS also has a lightweight case; the premium Memorex products are notably better. Most products come with pressure-sensitive cassette labels, the only exceptions being JVC GI and the Realistic Supertape line. I won't characterize every label and insert card in detail but will provide a thumbnail sketch in each tape's write-up. Suffice it to say that, unfortunately, some labels are too small to write on, others have a treated surface you can't write on with a ballpoint pen, and some insert cards are dolled up with a lot of high-tech-looking doodads that get in the way of the card's purpose.

With one exception (TDK MA-XG), all of the cassette shells were fabricated in two halves and held together by five screws located in the conventional places, one in each corner and one just behind the head opening. The MA-XG's Reference Standard Cassette Mechanism III is assembled from five pieces—two faceplates and three side frames—that are held together by four screws that enter from the edges, rather than from the top of the cassette, and a fifth screw in the conventional location just behind the head opening. TDK claims advantages in vibration reduction from using this design.

Among the pricier tapes, the move is toward anti-resonance cassette shells that are meant to reduce modulation noise by pre-

Type II Measured Data

Tape	Maximum Output Level, dB, re Dolby Level: MOL 40 Hz	MOL 125 Hz	MOL 400 Hz	MOL 1 kHz	MOL 3.15 kHz	SOL 6.3 kHz	SOL 8 kHz	SOL 10 kHz	SOL 12.5 kHz	S/N Ratio, dBA	−3 dB Response Limit at Dolby Level, kHz	Mod. Noise, dB	Bias, dB	Sens., dB
BASF Chrome Extra II	−0.5	+4.5	+4.7	+3.7	−1.4	−1.3	−3.5	−6.4	−11.2	64.4	7.8	−47.7	+0.6	+0.6
BASF Chrome Super II	+0.4	+5.7	+5.5	+3.8	−1.9	−1.3	−3.5	−5.8	−10.3	64.8	7.5	−49.2	+1.4	+1.5
BASF Chrome Maxima II	0.0	+5.3	+5.2	+3.5	−2.1	−1.7	−3.5	−6.4	−10.5	65.0	7.2	−48.4	+1.3	+1.4
Denon S-PORT High	−1.3	+3.7	+4.1	+4.3	−0.6	+0.5	−1.7	−5.2	−9.5	61.0	8.9	−49.5	+0.9	+1.4
Denon HD6	−1.0	+4.2	+4.5	+4.3	−0.6	+0.4	−2.0	−4.9	−9.6	61.5	8.8	−47.9	+0.6	+1.5
Denon HD7	−1.7	+3.8	+4.2	+4.2	+0.2	+1.1	−0.9	−3.7	−7.6	61.7	9.6	−50.6	+1.4	+1.3
Denon HD8	−0.3	+5.0	+5.4	+5.7	+2.6	+3.1	−1.4	−1.0	−3.7	59.6	11.5	−49.2	+0.8	+3.4
Fuji DR-II	−2.0	+3.4	+4.1	+4.7	−0.9	−0.5	−2.5	−5.4	−8.7	64.1	8.2	−51.0	+0.9	+2.3
Fuji FR-IIx	−0.5	+4.4	+4.9	+5.1	−1.0	−0.5	−2.6	−5.4	−9.0	64.8	8.2	−51.6	+0.7	+2.6
Fuji FR-IIx Pro	+0.9	+5.7	+6.2	+5.3	−1.2	−0.1	−2.4	−4.9	−8.8	66.2	8.6	−51.8	+1.0	+2.6
Fuji ZII	+1.0	+6.0	+6.3	+5.0	−0.9	+0.3	−1.8	−4.4	−8.0	66.7	9.1	−51.5	+1.7	+2.0
JVC AFII	−1.2	+3.9	+4.3	+4.4	−0.1	+1.4	−0.8	−3.8	−7.8	59.0	9.6	−52.5	+1.6	+1.1
Maxell XLII	+1.5	+6.5	+6.8	+6.3	−0.2	+1.3	−1.0	−4.4	−9.8	65.3	9.4	−53.3	+1.5	+1.9
Maxell XLII-S	+1.3	+6.2	+6.5	+6.4	−0.1	+1.7	−0.7	−3.7	−8.5	64.0	9.7	−57.0	+1.6	+1.7
Memorex HBSII	+0.4	+5.8	+5.9	+5.7	0.0	+1.4	−1.5	−4.6	−8.3	62.2	9.6	−50.3	+0.9	+1.5
Realistic Supertape HD	−1.7	+3.5	+3.9	+4.6	−0.2	+0.8	−1.5	−4.6	−8.3	60.8	9.1	−50.9	+1.0	+1.2
Realistic Supertape Premium MII	−0.3	+5.3	+6.1	+6.2	+2.4	+3.4	+1.7	−0.4	−3.1	60.2	12.4	−51.0	+1.7	+3.4
Scotch XSII-S	+0.1	+5.3	+5.7	+5.8	+0.3	+1.3	−1.0	−4.1	−8.4	62.1	9.4	−50.7	+0.7	+1.7
Sony UX	−0.1	+4.9	+5.4	+5.1	−1.0	+0.8	−1.4	−4.6	−9.3	65.2	9.1	−50.9	+1.4	+1.4
Sony UX-Pro	+1.0	+6.1	+6.5	+6.1	+1.3	+1.7	−0.5	−3.7	−7.8	64.4	9.6	−53.5	+1.4	+1.8
TDK SD	−1.0	+3.6	+4.1	+3.9	+0.2	+0.6	−1.9	−4.6	−8.6	63.9	9.1	−48.8	+0.6	+1.9
TDK SA	+0.9	+5.8	+6.1	+5.9	+0.9	+1.6	−0.8	−3.8	−8.3	64.4	9.7	−52.3	+1.2	+2.3
TDK SA-X	+1.1	+6.0	+6.8	+6.4	+0.4	+1.1	−0.8	−3.6	−7.4	65.2	9.8	−53.5	+1.3	+3.1

Note: Modulation noise values are referenced to Dolby level; bias and sensitivity figures show how far each tape's requirements differ from the IEC Standard for its type

venting vibration of the housing (and, indirectly, the tape). TDK's MA-XG shell is one approach. More typical are the trends toward using resins that are loaded with fillers to increase mass and/or the internal losses of the plastic (the MA-XG shell is made of Fiberglas-reinforced plastic), using laminated shells (multiple layers designed to damp one another), and using smaller cassette windows. The thought here is that the thin transparent window impairs housing rigidity and damping—so the smaller, the better.

Sony Metal Master, for example, uses a ceramic composite shell and tape guides and has a very tiny window. (Metal Master also shares another structural idea with TDK MA-XG: Both cassettes' shells have replaceable anti-erasure tabs, a nice feature for those who rerecord.) Denon's MG-X uses a "high specific-gravity half," while Maxell Metal Vertex has a pair of solid brass plates (one of which carries a serial number) laminated to the center of the housing. Does it work? Well, Metal Vertex had the lowest measured modulation noise by a *significant* amount. Can't say that that's entirely due to the housing, but it probably didn't hurt!

Although many cassettes have tactile clues to identify sides A and B, they vary widely in usefulness. Some of these clues will be covered when an ID label is applied; I found others too mysterious to identify by touch. Fuji, commended by Howard in 1990 for including Braille markings, has dropped tactile markings entirely. Maxell, whose markings I particularly liked on its lesser products, omits them on Metal Vertex (presumably because they might interfere with shell performance). The same goes for TDK MA-XG and Sony Metal Master. I'm afraid you'll have to check this out on a case-by-case basis.

Although most tapes got a bit noisy when winding at high speed near the end of a side, the noisiest were the three Memorex products (dBS, HBSII, and CDX IV Metal), Fuji DR-I, JVC AFII, and Realistic Supertape MIV. Exceptionally quiet-winding tapes were Maxell's XLI and XLII-S, Sony's ES-I, and TDK's SA, SA-X, MA, and MA-XG. Except for one of the Sony Metal SR cassettes, which jammed and was dropped from the tests, all samples ran smoothly at normal speed and completed the test sequence. Sony Metal SR electrical data is therefore based on two samples.

MEASUREMENTS

Many of the measurements made on these 51 products do not appear directly in this report; some were used just to rate the tapes for uniformity and appear only indirectly in the pie charts. The data that *does* appear is in tabular and/or graphical form. Because much of the data is given in decibels, at this point I want to digress and discuss reference levels and frequencies.

The reference conditions used for this test series—the so-called Dolby level of 200 nWb/m, at a frequency of 400 Hz—are those Howard used in 1987 and 1990. (I'll repeat his admonition that "although there are references to Dolby level, no tests were run with any sort of noise reduction.") While I followed Howard's reference frequency and level, I would point out that there is an internationally accepted *IEC* Standard (sometimes called the DIN Standard), which references a recording level of *250* nWb/m at *315* Hz. My druthers would have been to go with the IEC Standard, as I have in the past; I followed the Dolby level references only to be consistent with Howard's past practice. You can translate to the IEC reference (with reasonable, if not exact, accuracy) by subtracting 1.9 dB from each figure for MOL, SOL, and modulation noise given in the Tables. (Do not convert S/N, since this is a *ratio.*)

As stated earlier, I made response measurements at two levels (0 and –20 dB), and both curves are shown in the graph for each tape. There are several reasons why. Some tape formulations have very flat response at –20 dB with standard equalization. I consider this an advantage and took it into account in my ratings. Others—typically, but not necessarily, multilayer tapes—may exhibit a midrange dip followed by a treble boost and often a roll-off above 15 kHz. These tapes may have other strengths, but uniform response with standard equalization is not one of them, and you should be aware of this fact. You can see the swayback shape in the –20 dB response curves.

Furthermore, a tape with a treble rise in the –20 dB response gets a head start, so to speak, on attaining a seemingly impressive high-level high-frequency response. On such a tape, the –3 dB response limit may occur at a higher frequency than that of a competitive tape *even though the recording may be compressed and distorted.* For this reason, I have not included the response limit in my ranking system or in the pie charts, even though it played a major role

51 CASSETTES

Because of 70-μS playback EQ, Type II tapes are usually quieter than Type I formulations.

in Howard's evaluation. The results are included in the Tables *only* to be consistent with past reports. In evaluating the –3 dB point data, I suggest you compare the shapes of the response curves at –20 and 0 dB. If the curves are parallel over most of the range, the –3 dB figure may be meaningful. But if the 0-dB curve sags in the high-frequency range, the recording is being compressed even at frequencies well below the –3 dB point. This is my rationale for including both response curves.

Next let's discuss MOL and SOL and the differences this year from 1987 and 1990. As you may be aware, above some frequency you cannot validly determine the maximum recorded level characteristics of a tape on the basis of an harmonic distortion measurement (so-called MOL). This is because the playback head cannot resolve the third (predominant) harmonic and therefore yields a distortion figure lower than is proper, leading to inaccurately high apparent MOLs. Instead, methodologies based on output compression, twin-tone intermodulation distortion, or tape "saturation" must be employed. This raises the questions of what high-frequency methodologies should be used and above what frequency the methodologies should change.

Based on research I did in the 1970s for a paper I presented at an Audio Engineering Society Convention, there is no question in my mind that the twin-tone IM method yields the most meaningful and valid results *provided that you take all third-order cross-products into account.* I was able to show that measurements of maximum recorded level using this technique yield virtually identical data to traditional 3% HD_3 MOL evaluations in the low-frequency region and a smooth transition from there to the high-frequency region. The problem with the twin-tone method (which I had used in the past and which Howard used in one form or another in 1987) is that it is devilishly time-consuming.

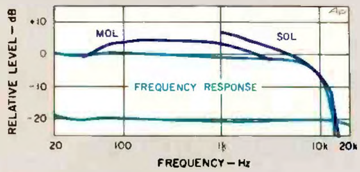
Of the other two methods—compression and SOL—the former arguably is the more meaningful and can be correlated directly with distortion, but it is difficult to make with precision because high-frequency level inconsistency can mask the compression. That leaves us with SOL—simply determining the maximum output level that can be achieved regardless of compression (which will be severe at that point) or distortion (which also will be severe). This is the *practical* method, the one Howard used in 1990, the one that just about everyone uses, and the one I used this year.

This brings us to the frequency at which one should switch from MOL (the maximum recorded level for 3% THD + N) to SOL (recorded level for tape saturation). In 1990, Howard made the switch at 1 kHz. I think it should be higher because MOL is a "better" measurement and because, considering the quality of tapes we are testing and the resolution provided by the Nakamichi 582, I believe valid MOL measurements can be attained to *at least* 3.15 kHz. (When MOL data becomes invalid, it's apparent because the curve no longer slopes downward with increasing frequency but instead flattens out and ultimately may even rise.)

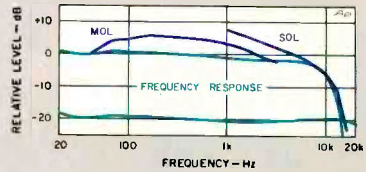
For these tests, I measured MOL at 20 points, one every third octave from 40 Hz to 3.15 kHz. I dropped the lowest octave (20 to 40 Hz) that Howard documented because "head bumps" (the fringing effect of the playback head) affect validity in this region. I extended the upper frequency range by $1^2/_3$ octaves (from 1 to 3.15 kHz) to document MOL to as high a frequency

TYPE II

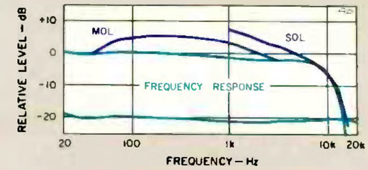
BASF Chrome Extra II



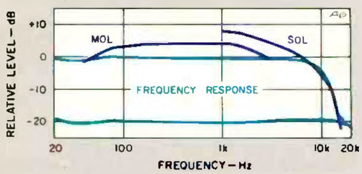
BASF Chrome Super II



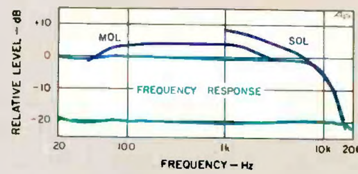
BASF Chrome Maxima II



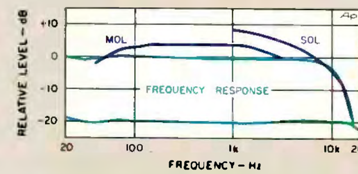
Denon S-PORT High



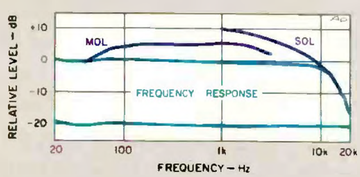
Denon HD6



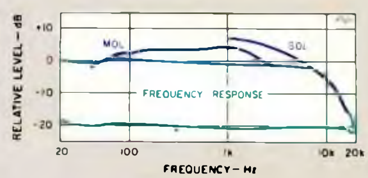
Denon HD7



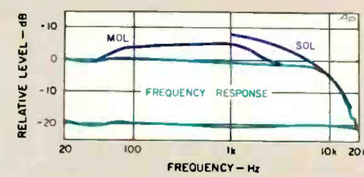
Denon HD8



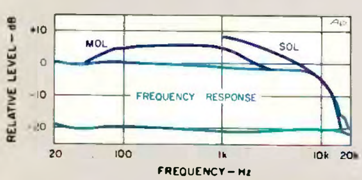
Fuji DR-II



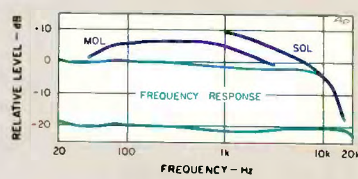
Fuji FR-IIx



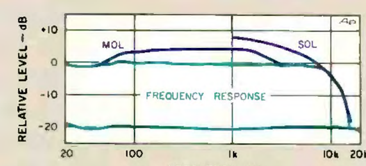
Fuji FR-IIx Pro



Fuji ZII



JVC AFII



as possible, and I increased the number of measurement points from 11 to 20.

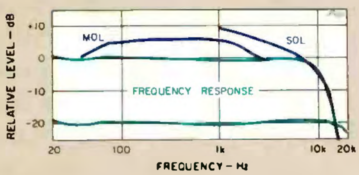
In the Tables, you'll find MOL listed at five of those 20 frequencies. (Of course, all 20 were used for the graphs and in my rating system.) I tabulated data at five, rather than three, frequencies so you can make your own comparisons more precisely than is possible from the small graphs. In the Tables, I switched to the saturation (SOL) methodology above 3.15 kHz and listed data at four frequencies rather than the three used in 1990. For comparison to Howard's data, I measured SOL at 13 points, in third-octave intervals, from 1 to 16 kHz. The full range of MOL and SOL data is plotted in one color in the graphs; the frequency response curves appear in another color. You can identify MOL data by the range over which it extends (40 Hz to 3.15 kHz) and SOL data by its range (1 to 16 kHz). In the overlap region (1 to 3.15 kHz), I advise you to go by the MOL data rather than the SOL data; the former is more conservative.

The remaining columns in the Tables are the same as Howard used in 1990. As previously described, S/N ratio is defined as the difference between the 400-Hz MOL and the corrected A-weighted biased-tape noise. (To derive the A-weighted noise level, subtract the S/N figure from the 400-Hz MOL. You should end up with a *negative* number that is *numerically* smaller than the S/N ratio.) Next comes the data for –3 dB response limit, that is, the frequency at which response has fallen by 3 dB relative to 400-Hz response at Dolby level. (As mentioned, I'd take these results with a grain of salt.) When you look at the results for modulation noise, remember that small differences among them are meaningless; each figure has a range of about ± 1.5 dB. The data for bias and sensitivity requirements relative to the IEC Standard tapes are averages of the results for the three samples of each formulation.

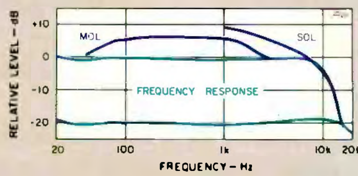
Although my Tables of Measured Data give essentially the same information as did Howard's in 1990 (albeit with a few extra MOL and SOL points), and so serve as a link to the past, my pie charts are quite different from his. You will not find 0-dB response or S/N in my pie—at least not per se—and my uniformity segment includes many of the parameters Howard placed in his smoothness segment. And, I have included modulation noise and frequency response (taken at –20 dB) as separate segments.

TYPE II

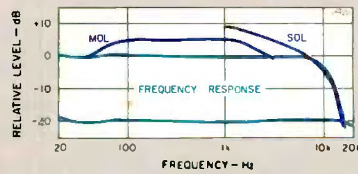
Maxell XLII



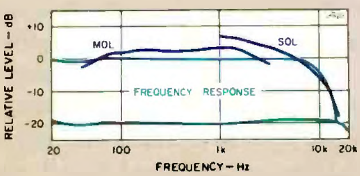
Maxell XLII-S



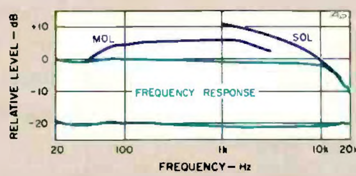
Memorex HBSII



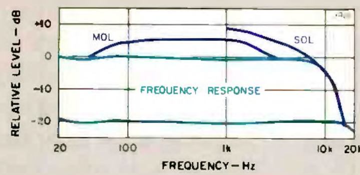
Realistic Supertape HD



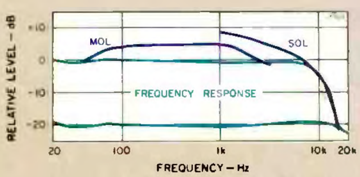
Realistic Supertape MII



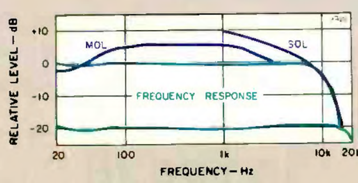
Scotch XSII-S



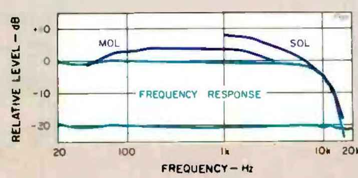
Sony UX



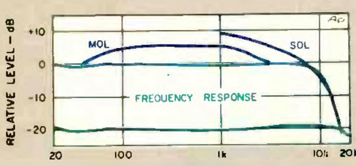
Sony UX-Pro



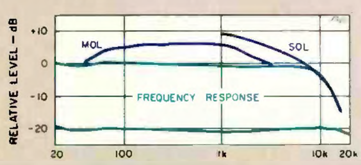
TDK SD



TDK SA



TDK SA-X



I really struggled with [the Editor about] assigning ratings, because as I said early on, I'm philosophically opposed to using them. It's too easy for too many people to read too much importance into a difference of a few rating points. I can assure you that, had I chosen a different (but nonetheless reasonable) rating scheme, I could have come up with quite different scores and different winners. I'm not saying that the lowest rated tape would jump to the top of the heap, but I am sure that tapes within a few ratings points of each other could have come out in different order.

I decided to place major emphasis on what might be called available dynamic range in three regions of the spectrum: From 40 to 400 Hz (which I call the bass and low fundamentals), from 1 to 6.3 kHz (midrange and upper fundamentals), and from 8 to 12.5 kHz (high treble). For each region, I rated each tape in accordance with its MOL and/or SOL performance, *averaged across the region*. This was done to avoid giving an artificially low or high rating to a tape that happened to do particularly poorly or well at, say, 400 Hz (the basis for Howard's low-frequency MOL segment) or 4 kHz (the basis for his high-frequency SOL segment) but did better or less well a half octave or so away.

I then further weighted each rating in accordance with the corrected A-weighted noise data and, finally, scaled the ratings so that the highest score in each region (among all the formulations tested, that is, not segregated by tape type) would be 100%. Thus, *each* of my segments is, in a sense, a relative S/N rating, with the "signal" being the maximum capability of the tape in that frequency region. The figure within the pie segment is the relative score in percent, *not* raw data.

I combined the noise and MOL/SOL data in each band to avoid overrating a tape that happened to have particularly high 400-Hz MOL but marginally higher than average noise. With the old rating scheme, such a tape could have been very highly rated in low-frequency MOL *and*, provided the noise wasn't all *that* bad, well rated in S/N—thereby getting good ratings over 135° of the pie while (possibly) being substantially worse than average in high-frequency SOL and getting "marked down" over only 60° of the pie.

"Double-dipping" was also possible in high-frequency SOL and 0-dB response. A tape with good treble SOL is likely to have good 0-dB response and therefore "doubledip" on the positive side. (Obviously, the reverse is true for a tape with poor treble SOL.) Furthermore, I really had a problem giving emphasis to the 0-dB response figure, for the reasons stated earlier.

I decided to give three-quarters of the pie to the three segments for available dynamic range (90° each) and divide the remaining 90° equally among three other factors: Modulation noise, frequency response, and uniformity. Because the data is imprecise (as described previously), modulation noise was rated in discrete increments that, after scaling, ranged from 30% to 100%. Frequency response was rated in accordance with the maximum total deviation from flat response in the range from 400 Hz to 15 kHz, at 20 dB below Dolby level. This rating also was scaled to give the "best" tape of the group 100%.

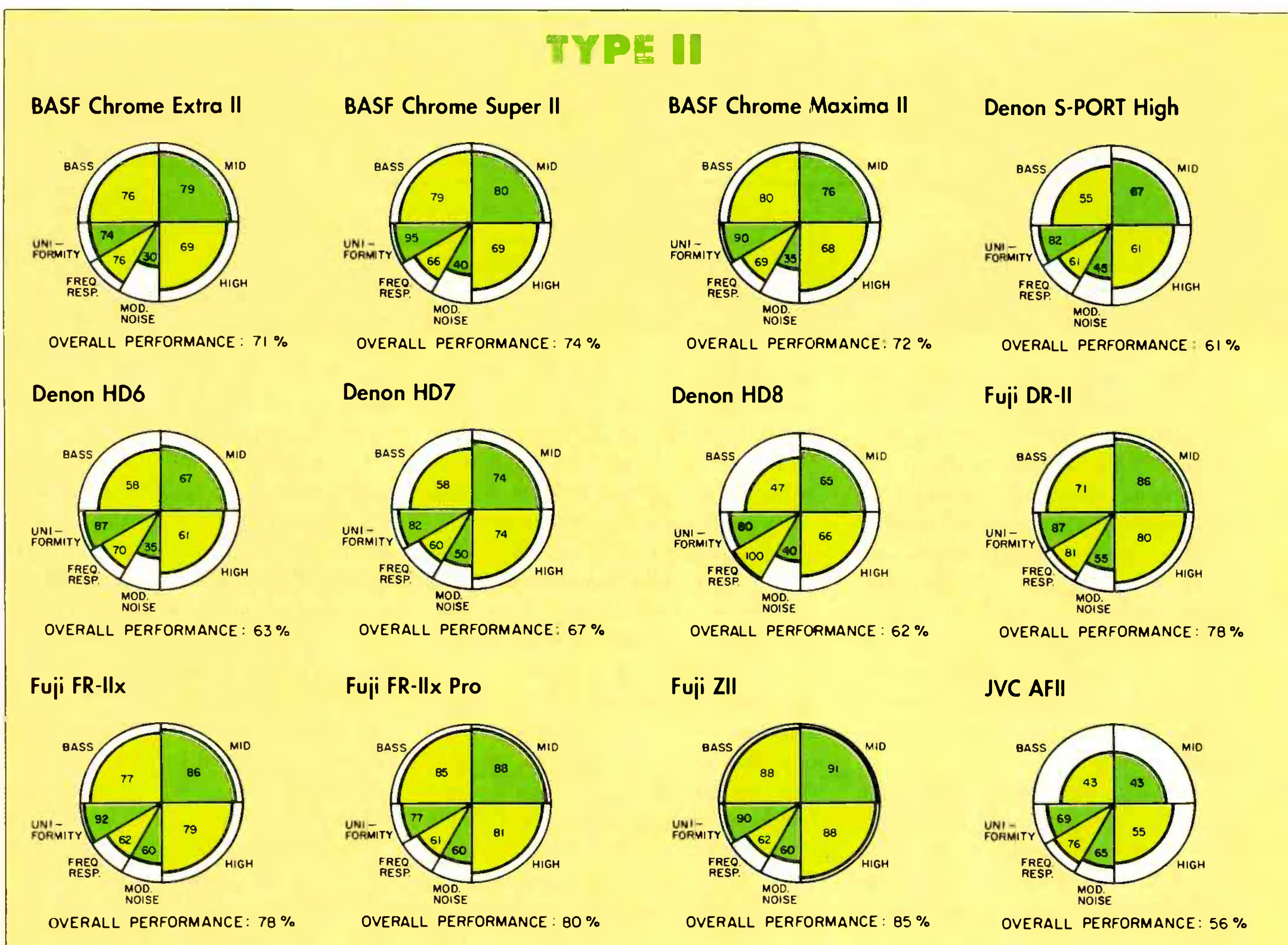
The uniformity segment includes many factors: 400-Hz, 3.15-kHz, and 10-kHz level uniformity; how closely average sensitivity and average bias requirement adhered to the norms; how closely the three samples agreed in sensitivity, bias requirement, and azimuth alignment; tracking of side A, and tracking from side A to side B. All factors did not receive equal weighting, and I did not scale the data. Therefore, you'll not find any tape with a score of 100%.

The numbers within each segment of the pie represent relative ratings in that category, not raw data. You'll find some of the latter (albeit not all of the data that was taken) in the Tables. The overall performance rating (in percent) was calculated by weighting each of the individual ratings in accordance with the area of the pie segment corresponding to it.

The following brief comments on each tape are arranged alphabetically, by brand, within each tape type. Be aware that the rating system is *independent* of type—that is, Type I tapes are competing directly with Type IV formulations—and the ratings are independent of price. Also be advised that one result of including noise over three-quarters of the pie was to decrease the average score of Type I tapes vis-a-vis Howard's ranking system. You may wish to rescore within tape types. References to "noise," below, relate to actual noise power rather than to the A-weighted S/N in the Tables (which is referenced to MOL at 400 Hz).

TYPE I TAPES

It's not unusual to find Type I tapes that have higher MOLs and SOLs than many Type II cassettes. But they're no match for the Type IV tapes (as a group), and, because they use 120-µS equalization, A-weighted noise level typically is higher on Type I than on Type II and Type IV tapes, thereby reducing their overall rating. The average score for the group of 14 Type I tapes is 52%, with individual scores ranging from a minimum of 39% to a maximum of 72%.



BASF Ferro Extra I: Good MOL to 1 kHz and decent SOL. Better high-frequency level stability and lower modulation noise would help performance. Tape tracks well. Good J-card, small label. Overall rating: 49%.

Denon DX-1: Good SOL for a Type I, but MOL could be better. Flat response, good tracking, and good level stability to 3.15 kHz. The 10-kHz stability could be better. Cluttered J-card. Overall rating: 50%.

Fuji DR-I: Lower than average modulation noise for a Type I and good SOL. MOL could be better. Level uniformity better than average at all frequencies. Average tracking. Sparse J-card. Extra-slim case. Overall rating: 53%.

JVC GI: Below average MOL and SOL and relatively high modulation noise and A-weighted noise. Worse than average level stability. Skimpy J card. Permanent label. Not a lot to recommend it. Overall rating: 42%.

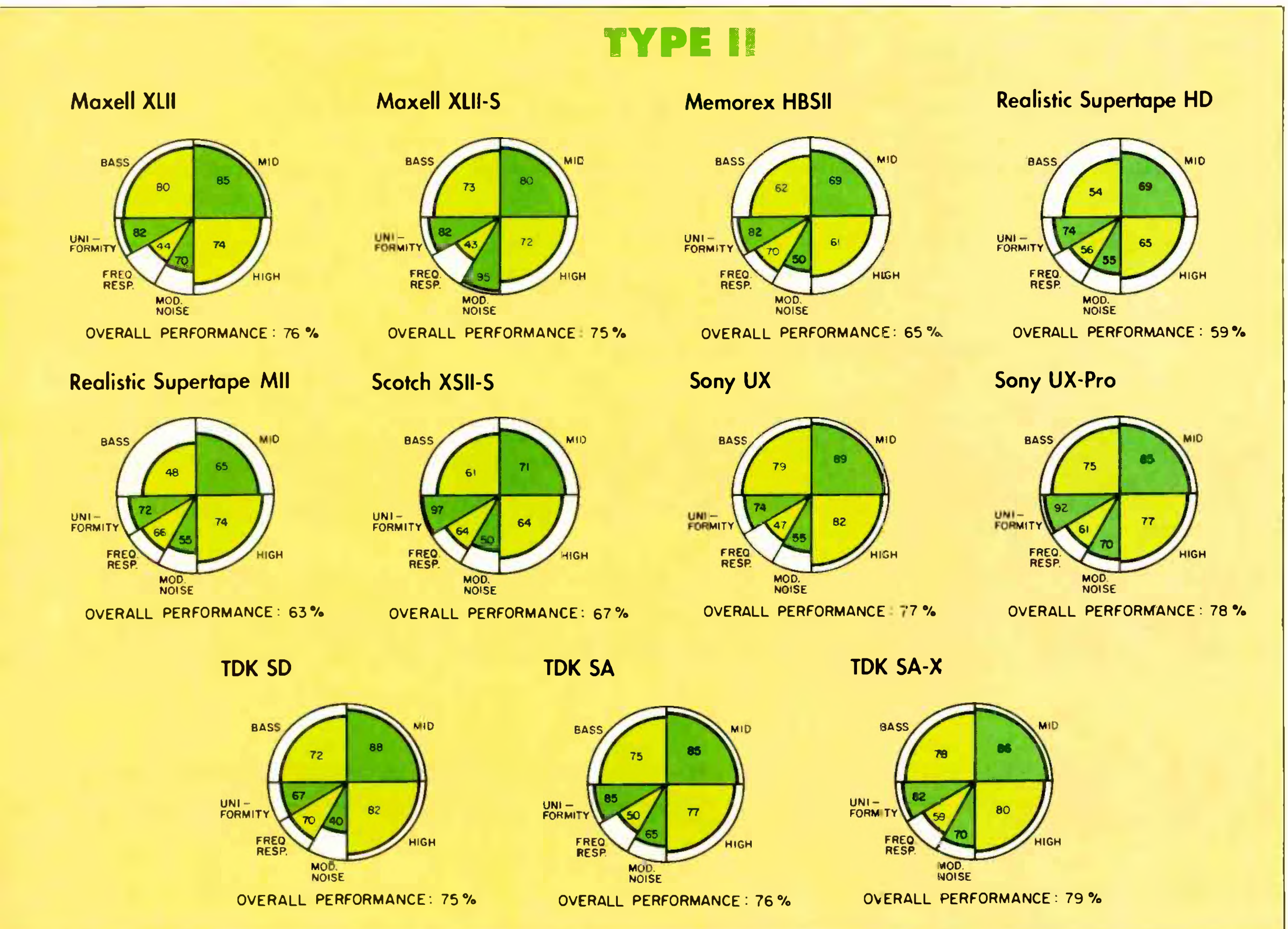
I placed major emphasis on available dynamic range in the bass, midrange, and treble.

Maxell UR: Below average bass MOL up to 400 Hz but improves thereafter. Decent SOL. Lowest modulation noise in Type I. Excellent tracking and level stability. Rudimentary J-card. Overall rating: 50%.

Maxell XLI: Best Type I MOL at 400 Hz and below. Drifts down toward 3.15 kHz. Low A-weighted and modulation noise. Excellent tracking. Response curve more swayback than most. Good packaging. Overall rating: 72%.

Memorex dBS: Relatively poor MOL at 400 Hz and below. Improves strongly at higher frequencies. Good SOL. Worse than average 400-Hz uniformity. Okay at other frequencies. Relatively noisy. Rudimentary J-card. Overall rating: 43%.

Realistic Supertape XR: High noise but decent MOL and excellent SOL. Swayback response and below average level uniformity at all frequencies. Rudimentary J-card, fixed labels. Overall rating: 44%.



Although you pay a premium for Type IV tapes, as a group they outperform the others.

Scotch BX: Relatively low MOL and SOL but reasonably well balanced. Smooth frequency response, decent tracking, and better than average level uniformity. Noise level could be lower. Good labels. Overall rating: 43%.

Scotch CX: Very poor MOLs and SOLs plus relatively high noise, deviant bias requirement, and average level uniformity; little to recommend except flat response. Good labelling. Okay packaging. Overall rating: 39%.

Sony HF: Average MOLs and SOLs but relatively quiet for a Type I. Well-balanced performance and good ratings. Midrange uniformity worse than average. Choice of labels, adequate J-card. Overall rating: 53%.

Sony ES-I: Excellent MOLs and SOLs for Type I. Very quiet. Low modulation noise and flat response. Tape tracks well. Uniformity better than average at 400 Hz, average elsewhere. Good labelling and packaging. Overall rating: 72%.

TDK D: MOLs and SOLs approach premium Type I performance. Low modulation noise and relatively quiet. Level uniformity average to better than average. Good tracking. J-card and labelling okay. Overall rating: 55%.

TDK DS-X: Excellent MOL and SOL, especially at 3.15 kHz. Quiet, with low modulation noise. Perfect side A/B tracking. Excellent 400-Hz uniformity. Elsewhere, average uniformity. Nice J-card and labelling. Overall rating: 67%.

TYPE II TAPES

Thanks to 70-µS playback equalization, Type II tapes are usually quieter than Type I tapes. But with standard Type II tape, 70-µS *playback* equalization requires a substantial high-frequency boost in the *recording* equalizer. The effect this has on SOL varies with the magnetic pigment used to make the tape.

The SOL of typical Type II tapes formulated with cobalt-modified gamma ferric-oxide particles often is less than the SOL of a premium Type I. MOL can be slightly lower as well. Type II tapes formulated from chromium-dioxide particles generally have even lower SOLs than those made from cobalt-modified gamma ferric oxide, but they tend to be quieter too.

Type II tape also can be made using a metal-particle formulation. Such tapes have extraordinarily high SOLs—higher than any Type I and even than most Type IVs—but they tend to be noisy and have very high sensitivity. When used on a deck without record-level calibration facilities, Dolby tracking can be affected, with notable impairment in audible response.

Since I took noise into account in *all* bands in my pie charts and rating system, all Type II tapes are put on an equal footing in the treble region; therefore, those with

Type IV Measured Data

Tape	Maximum Output Level, dB, re Dolby Level: MOL					SOL				S/N Ratio, dBA	−3 dB Response Limit at Dolby Level, kHz	Mod. Noise, dB	Bias, dB	Sens., dB
	40 Hz	125 Hz	400 Hz	1 kHz	3.15 kHz	6.3 kHz	8 kHz	10 kHz	12.5 kHz					
Denon HDM	−0.4	+5.5	+5.8	+5.9	+1.4	+3.0	+1.1	−1.3	−4.6	63.6	11.4	−52.3	+1.1	−0.5
Denon MG-X Metal	+0.1	+5.6	+6.5	+6.7	+1.4	+3.2	+1.2	−1.6	−4.7	64.2	11.7	−52.6	+1.2	−1.0
Fuji FR Metal	+3.4	+8.8	+9.4	+9.7	+3.8	+5.0	+2.9	−0.3	−3.8	65.4	12.2	−51.6	+1.9	+0.6
JVC XFIV	+1.1	+6.9	+7.9	+8.9	+3.1	+4.5	+2.3	−0.6	−5.0	65.0	12.1	−53.8	+2.2	+0.2
Maxell MX	+2.4	+8.0	+8.4	+8.6	+3.1	+4.5	+2.2	−0.7	−4.5	66.1	11.9	−51.9	+1.5	+0.4
Maxell MX-S	+1.2	+6.8	+7.5	+8.3	+2.7	+4.4	+2.0	−0.8	−4.3	65.4	11.9	−55.5	+1.5	+0.4
Maxell Metal Vertex	+1.9	+7.2	+8.0	+8.2	+2.5	+4.4	+2.3	−0.6	−4.0	64.9	12.2	−58.1	+0.9	+0.6
Memorex CDX IV Metal	−0.1	+6.4	+7.0	+8.0	+2.4	+4.0	+1.8	−1.3	−4.7	64.4	11.6	−53.4	+3.0	−1.0
Realistic Supertape MIV	+0.5	+6.4	+7.0	+8.0	+2.4	+4.2	+1.9	−1.1	−4.6	64.2	11.5	−51.2	+2.7	−0.5
Sony Metal SR	+1.9	+7.3	+7.7	+7.5	+2.6	+4.2	+2.1	−0.7	−3.7	65.4	12.2	−53.1	+0.6	+0.6
Sony Metal Master	+3.1	+8.4	+9.5	+8.7	+2.1	+3.4	+1.2	−0.9	−3.7	67.8	12.3	−52.7	+1.8	+1.2
TDK MA	+2.0	+7.5	+8.8	+8.8	+3.1	+4.8	+2.4	−0.3	−4.5	65.9	12.3	−53.9	+1.1	+0.9
TDK MA-X	+2.8	+7.9	+8.8	+9.0	+3.2	+4.9	+2.8	−0.3	−3.9	66.0	12.2	−54.4	+0.9	+1.0
TDK MA-XG	+4.8	+9.9	+10.7	+8.9	+1.5	+3.7	+1.8	−0.8	−3.5	69.1	12.3	−51.8	+1.3	+2.2

Note: Modulation noise values are referenced to Dolby level; bias and sensitivity figures show how far each tape's requirements differ from the IEC Standard for its type.

relatively low SOL *and* comparably low noise will be rated equivalent to those with a greater SOL and comparably greater noise. And those that throw noise considerations to the wind in an attempt for more SOL take the chance of being downgraded accordingly.

There were 23 tapes in the Type II group. Average rating is 71%, with the rating of individual brands ranging from 56% to 85%.

BASF Chrome Extra II: Low noise typical of chrome. Decent MOLs. Treble SOL below average. Poor modulation noise. Superb 400-Hz uniformity. Good tracking. Busy J-card. Fair label. Overall rating: 71%.

BASF Chrome Super II: Better bass MOLs than Extra II, with little increase in hiss and less modulation noise. One-dB more high-treble SOL. Average level uniformity. Superb tracking. Busy J-card. Fair label. Overall rating: 74%.

BASF Chrome Maxima II: Even less hiss than Super II but at loss of 0.25 to 0.5 dB of MOL and SOL. Basically, a wash. More modulation noise and level irregularity reduce score. Similar J-card and label. Overall rating: 72%.

Denon S-PORT High (C-100): Low MOL/SOL, relatively high hiss and modulation noise, and swayback response lower the rating. Average otherwise. Slim case with rudimentary J-card and label. Overall rating: 61%.

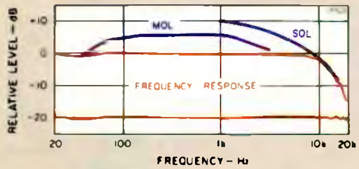
Denon HD6: Similar performance to S-PORT High but with slightly more modulation noise. Better than average level uniformity and response. Busy J-card, tiny label. Overall rating: 63%.

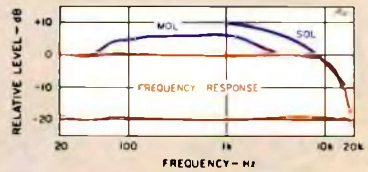
Denon HD7: Better MOL and SOL above 1 kHz, paired with reduced hiss and modulation noise, give HD7 the edge over HD6. Slightly worse level uniformity but excellent side A/B tracking. Busy J-card, tiny label. Overall rating: 67%.

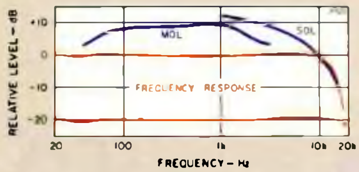
Denon HD8: Exceptionally high MOL/SOL above 1 kHz from this metal-particle Type II, but high residual noise reduces ratings. High sensitivity may be a problem for many decks. Average level uniformity. Denon labelling. Overall rating: 62%.

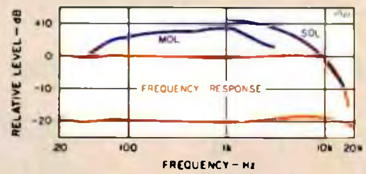
Fuji DR-II: MOL just below average and SOL average, but noise is so low that DR-II gets fine scores. Uniformity is great at 400 Hz and 3.15 kHz, average at 10 kHz. Slim case necessitates tiny J-card. Overall rating: 78%.

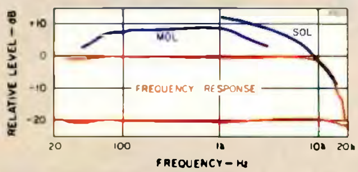
TYPE IV

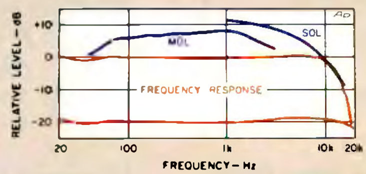
Denon HDM


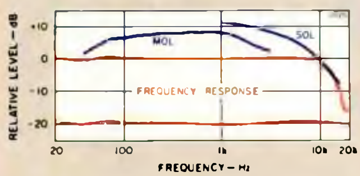
Denon MG-X Metal


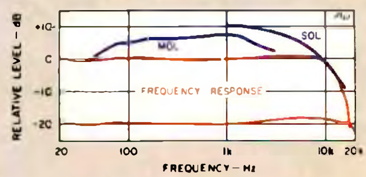
Fuji FR Metal


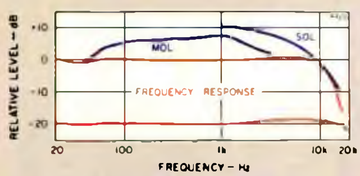
JVC XFIV


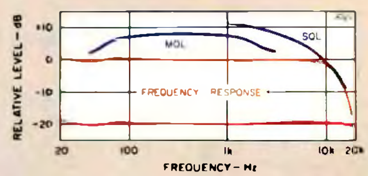
Maxell MX


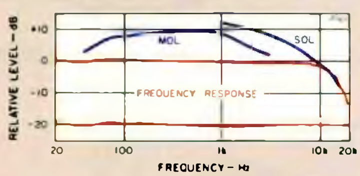
Maxell MX-S


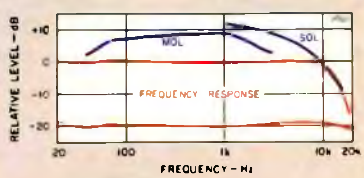
Maxell Metal Vertex


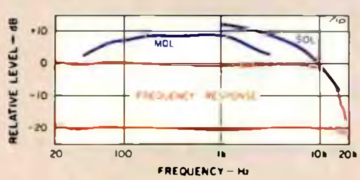
Memorex CDX IV Metal


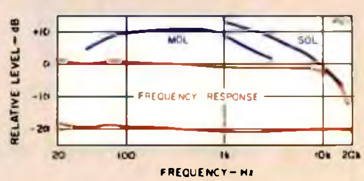
Realistic Supertape MIV


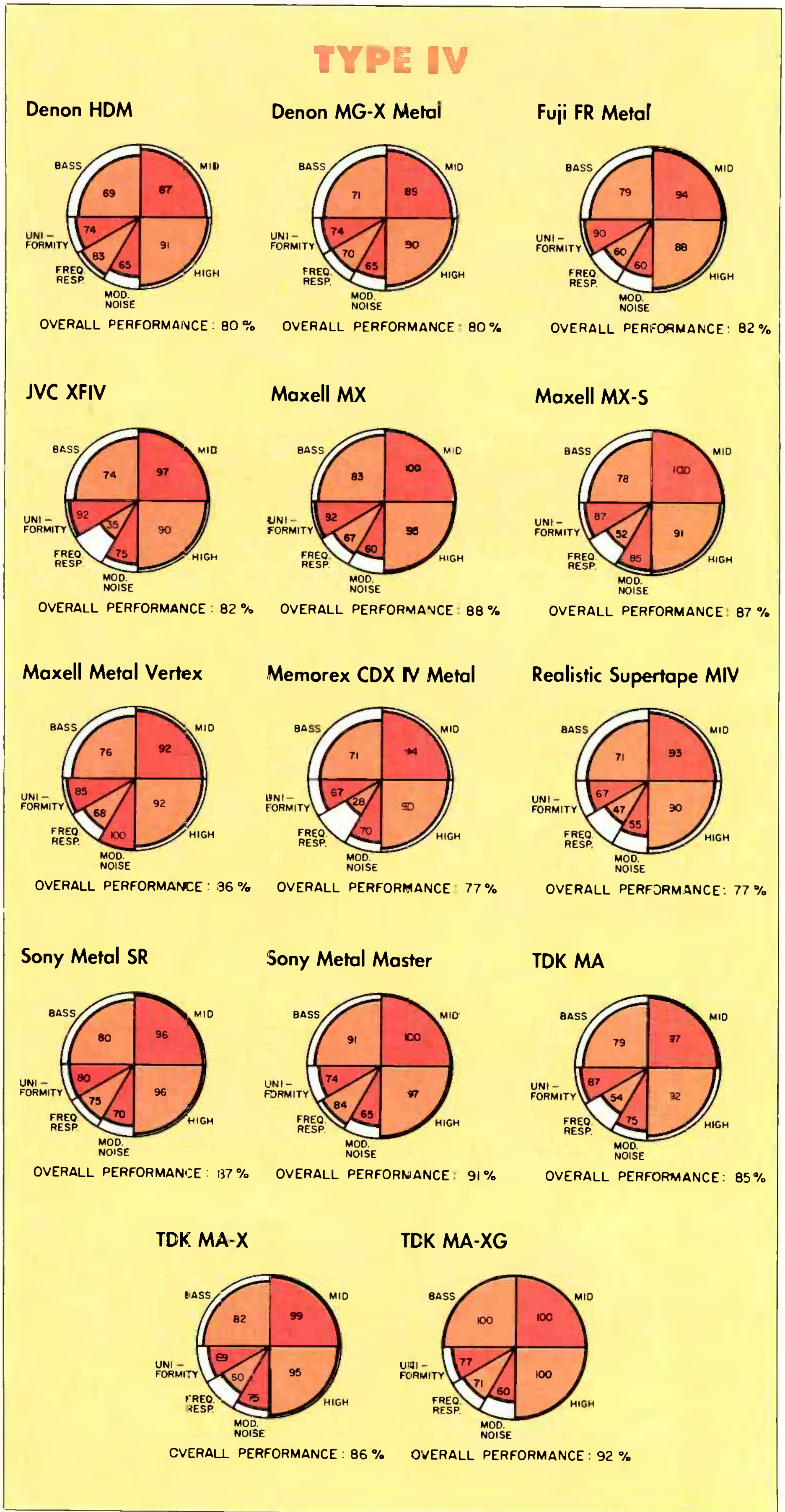
Sony Metal SR


Sony Metal Master


TDK MA


TDK MA-X


TDK MA-XG




Fuji FR-IIx: More bass MOL, slightly less modulation noise, and no increase in hiss (re DR-II). Uniform output at all frequencies, but swayback response and high sensitivity reduce rating. Slim case, tiny J-card. Overall rating: 78%.

Fuji FR-IIx Pro: Further improved bass MOL, a tad lower modulation noise, and same residual noise combine to make Pro score higher than FR-IIx. Level uniformity good but tape downgraded for tracking and sensitivity. Slim case, tiny J-card. Overall rating: 80%.

Fuji ZII: Lowest noise of any Type II, best bass MOL from Fuji, and improved SOL. Sensitivity near normal. Good uniformity and better tracking than Pro improve rating. Slim black case, small J-card. Overall rating: 85%.

JVC AFII: Good SOL, but subpar MOL, high A-weighted noise, and poor level uniformity at all frequencies adversely affect AFII's ratings. Lower than average modulation noise. Adequate J-card and labelling. Overall rating: 56%.

Maxell XLII: Very solid bass and lower midrange MOL. Treble SOL falls off. Lower than average A-weighted and modulation noise. Average uniformity, fair tracking, but swayback response. Clean J-card and label. Overall rating: 76%.

Maxell XLII-S: Trades tad of bass MOL for improved SOL, but higher A-weighted noise reduces *all* scores relative to XLII. Lowest modulation noise by far of any Type II. Good level uniformity. Clean card and label. Overall rating: 75%.

Memorex HBSII: Somewhat better than average MOL and SOL are offset by higher than average noise. Good level uniformity. Fair tracking. Average modulation noise. Adequate J-card and label. Overall rating: 65%.

Realistic Supertape HD: Reasonably good SOLs are outweighed by subpar MOLs, relatively high A-weighted noise, poor tracking, and worse than average level uniformity. Coated J-card and fixed labels. Overall rating: 59%.

Realistic Supertape Premium MII: Metal-particle Type II tape with better than average MOLs and superior SOLs. Higher than average noise reduces ratings, and sensitivity differs widely from the norm. Coated J-card and fixed labels. Overall rating: 63%.

Scotch XSII-S: Well-balanced tape with average/above average MOL and SOL, average modulation noise, but above average A-weighted noise. Good uniformity and tracking. Swayback response. Clean J-card and label. Overall rating: 67%.

Sony UX: Average MOL and SOL aided by very low A-weighted noise. Good level uniformity but downgraded for tracking (side A and A/B) and very swayback response. Adequate label and J-card. Overall rating: 77%.

Sony UX-Pro: Improved MOL and SOL relative to UX, but higher noise more than offsets advantage. Lower modulation noise, slightly smoother response, and better tracking raise rating. Good J-card, tiny label. Overall rating: 78%.

TDK SD: Relatively weak bass MOL improves at 3.15 kHz. Solid SOL and low noise strengthen the ratings. Decent uniformity and tracking but relatively high modulation noise. Versatile J-card and label. Overall rating: 75%.

TDK SA: Has 1 to 2 dB greater MOLs and SOLs than SD at some increase in noise and more swayback response. Substantially lower modulation noise. Excellent uniformity and tracking. Versatile J-card and label. Overall rating: 76%.

TDK SA-X: Further improved MOL and SOL with a tad lower A-weighted noise and measurably lower modulation noise. Excellent uniformity and tracking. Rather high sensitivity. Versatile J-card and label. Overall rating: 79%.

TYPE IV TAPES

You usually pay a premium for metal-particle (Type IV) tapes, but, as a group, they outperform the others. The average score for the 14 tapes tested this year is 84%, 13 points higher than the Type II average and 32 points higher than the Type I average. This is not to say that all Type IVs are the same; scores ranged from a low of 77% to a high of 92%. But even the lowest rated Type IV outranked the best Type I, according to my grading system, although a couple of Type IIs edged out the lower ranking Type IVs.

What you get for your Type IV dollar is more headroom (especially from the midrange up) and, usually (but not necessarily), less modulation noise. On average, A-weighted noise is about 0.5 dB *worse* than the average Type II (almost 0.9 dB worse if I ignore the two "metal" Type IIs), so the better rankings for Type IVs come almost entirely from extra headroom. The moral is clear: To get the most from Type IV tape, record at a level a few dB higher than you would on Type II.

Don't read too much importance into a difference of a few rating points between two cassettes.

Denon HD-M: Relatively weak MOLs and SOLs for a Type IV, but noise is also a bit less than average and modulation noise is about average for a Type IV. Good response, fair uniformity and tracking. Busy J-card, tiny label. Overall rating: 80%.

Denon MG-X Metal (C-100): A bit better bass MOL and tracks better than HD-M, but response is slightly less uniform. Otherwise, C-100 MG-X is comparable to C-90 HD-M, which is admirable. Busy J-card, tiny label. Overall rating: 80%.

Fuji FR Metal: Exceptional MOLs and SOLs from 1 kHz up but ratings reduced by high noise level. Good uniformity at 400 Hz and 3.15 kHz, fair at 10 kHz. Tracks well on side A, fair on B. Slim case, tiny J-card. Overall rating: 82%.

JVC XFIV: Very good MOLs and SOLs from 1 kHz up, with average A-weighted noise and fairly low modulation noise. Good tracking and excellent level uniformity but very swayback response. Clean J-card, small label. Overall rating: 82%.

Maxell MX: Very solid MOLs and SOLs, with below average A-weighted noise. Does very well, especially in midrange and treble. Excellent tracking. Fair level uniformity. Nice J-card, label, and packaging. Overall rating: 88%.

Maxell MX-S: Less noise than MX, but lower MOLs/SOLs negate advantage. Very low modulation noise. Excellent tracking on side A, not on B. Good level uniformity except at 10 kHz. Nice J-card and label. Overall rating: 87%.

Maxell Metal Vertex: Lowest modulation noise of all. Good MOLs and SOLs but more A-weighted noise than most. Below average 10-kHz uniformity and tracking. Unusual J-card and label. Overall: 86%.

Memorex CDX IV Metal: Low sensitivity and an extremely high bias requirement may be a problem on some decks. Good midrange MOL but very swayback response. Average noise. Good treble uniformity. Okay J-card, small label. Overall rating: 77%.

Realistic Supertape MIV: Requires exceptionally high bias. Average A-weighted noise and relatively poor modulation noise. Average level uniformity and tracking. Rudimentary J-card, permanent labels. Overall rating: 77%.

Sony Metal SR: Balanced MOLs and SOLs, with better than average A-weighted noise and average modulation noise. Good bass/midrange level uniformity. Tracks well on side A, not as well on B. Small label, adequate J-card. Overall rating: 87%.

Sony Metal Master: Very solid MOLs/SOLs. Average bass/midrange uniformity, rather poor in treble. Tracks well. Flat response. Heavy shell, nice J-card, unusual labelling. Overall rating: 91%.

TDK MA: Solid MOLs and excellent SOLs. Very low modulation noise, average A-weighted noise. Excellent bass/midrange level uniformity. Good tracking. Swayback response. Versatile J-card and label. Overall rating: 85%.

TDK MA-X: Improved bass MOL and exceptional treble SOL. Slightly less A-weighted and modulation noise than MA. Smoother response but with slightly worse treble uniformity. Versatile J-card and label. Overall rating: 86%.

TDK MA-XG: Best bass MOL, best high treble SOL, lowest noise of any Type IV.

Unusual shell, with excellent tracking on both sides and fairly low modulation noise. Sensitivity possible problem. Nice J-card and label. Overall rating: 92%.

USING THE RESULTS

Although my ratings will distinguish the best tapes from the worst, please don't use them to split hairs. As I said before, the ranking of the top tapes (or the bottom group) would have changed had I rated differently. For example, had I considered consistency or uniformity more or less important than I did, shifted the weighting among my three frequency bands, or made any of a number of other permutations, the relative rankings of the tapes would have changed.

In the pie charts, Tables, and individual write-ups, I've tried to give *you* enough information to adjust the ratings for your personal needs. For example, if you're recording music from the classical or baroque periods, you probably don't need as much treble capability as you would to record synthesized rock or even the more modern classical repertoire (which is likely to make greater use of cymbals, triangles, etc.). In this case, a superior high treble score doesn't buy you much; for this application, look instead for superior performance in the bass and midrange regions.

Use the MOL and SOL figures in the Tables—together with your best idea of the energy distribution of music—to estimate the most appropriate recording level. For example, if you peruse the Tables, you'll find that many Type I tapes have better upper-midrange/lower-treble MOLs and SOLs than the typical Type II tape. This suggests that, for a lot of music, you should record at a *higher* level on a good Type I tape than on a Type II—despite the indications to the contrary that appear in most instruction manuals and on deck level indicators that display "suggested limits." I do this regularly, and I'm rewarded with some fine-sounding tapes.

If your deck has adjustable bias *and* record calibration controls, you should be able to use just about any tape in the list and obtain results that parallel mine. (There are a couple of Type IVs, however, that require *so* much bias, you may have difficulty attaining it on some decks.) If you're not blessed with bias and record calibration controls, it's hard to predict what results you'll get.

Choosing tapes with bias and sensitivity figures close to 0 dB—i.e., close to the IEC reference tape—does *not* guarantee performance, especially when using Type II and Type IV products. The Type II IEC Standard is a *chromium dioxide* formulation, whereas most Type II tapes are formulated from cobalt-treated gamma ferric oxide, which exhibits greater sensitivity and requires more bias than the "reference." And, as the test data indicates, modern Type IV tapes also seem to differ from their IEC reference. I took all this into account when computing uniformity scores, because, for the most part, deck manufacturers do *not* adjust their products to IEC Standards but to their own internal standards: They use the tapes which they consider to be best suited for their decks. If you know a tape that mates well with your deck and you wish to try others, look for those that most resemble it in bias and sensitivity requirements. Don't go by simple agreement with the IEC reference. A