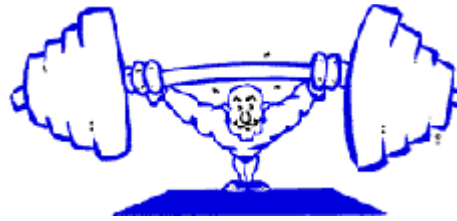


# Compression



## Part I - Technical Guidelines for the Uses of Compressors

We define compression, and give technical guidelines for its use in mixing and mastering.

## Part II - The Perils of Compression

The esthetic ramifications of compression, the current loudness race, the bleak future of DVD audio quality, and more to the point, what to do about it!

## Part III - Tools To Help Keep Us From Overcompressing

Including an honor roll of CDs that sound very good and aren't overcompressed.

### Part I

#### Technical Guidelines for Use of Compressors

A U.K. engineer who discovered our web site wrote.

*I had a look at your web page and what a page! Exactly a page I have been looking for! Could you add something about using compression, like how much to do by yourself and how much to leave to the mastering lab?*

#### First, let's define:

**Com-pres'-sion** 1) Reduction of audio dynamic range, so that the louder passages are made softer, or the softer passages are made louder, or both. Examples include the limiters used in broadcasting, or the compressor/limiters used in recording studios.

2) Digital Coding systems which employ data rate reduction, so that the bit rate (measured in kilobits per second) is less. Examples include the MPEG (MP3) or Dolby AC-3 (now called *Dolby Digital*) systems.

This article is about #1 above, *dynamic range compression*. To avoid confusion, please encourage people to stop using the word *compression* and use the proper terms "Data Reduction System" or "Coding system" for definition #2.

#### Now, for the basic two rules:

Rule #1: **There are no rules.** If you want to use a compressor/limiter of any type, shape and size in your music, then go ahead and use it.

Rule #2: **When in doubt, don't use it!**

#### How can you tell when you have *enough* compression?

- Discussing sound in print is like describing colors to a blind person, but let me try. Here's a simplistic example... supposing there are two sonic qualities of music, one called *punchy*, the other *smooth*... Let's say that some music sounds better *punchy*, other music sounds better *smooth*. Let's also assume for this example that you can achieve *punchy* or *smooth* sound through different amounts and types of compression, or not using compression at all.
- In general, *try to avoid overall compression in the mix stage if:*
  - you're mixing *punchy* music (the type of music that needs *punch*), perhaps using some individual compression on certain instruments or singers--and the mix already sounds

*punchy* (good) to you.

- you're mixing *smooth* music, and your mix already sounds *smooth*.
- you play a well-recorded CD of similar music, and your CD in the making already sounds good (or better than) the CD in the player.
- your music already seems to accomplish the sound you are looking for.

We'll discuss compression *esthetics* in more detail in [Part II](#).

### **Technical reasons to avoid overall compression on your album**

Save decisions on overall compression and individual tune equalization for an expert CD mastering house because:

1. The mastering house will have a more appropriate compressor with the proper attack, ratio, and release times exactly right for your music. If you mixed to digital tape, they will probably use a 24-bit digital compressor for the purpose.
2. They will likely be more experienced than you about the compromises, advantages and disadvantages of applying overall compression.
3. The mastering house can program that compressor with precision, adjusting it optimally for each tune in question. You're working out of context (without having the perspective of the entire album) by attempting these sorts of decisions during mixing.
4. The mastering house will be able to monitor your "CD in the making" using a calibrated monitoring system so that they know exactly how loud your "CD in the making" is compared to other CDs of similar music. For more information on *loudness*, see my article [Level Practices in Digital Audio](#).
5. A good mastering house will be able to do all of this in a non-destructive, non-cumulative manner. In other words, after making a reference CD, they will be able to undo anything you are unhappy with, whether it be compression, EQ or levels. Whereas, most digital audio editing stations can only perform destructive EQ or compression, only with 16-bit word length, with a consequent loss of resolution as long internal words are either dithered (resulting in a veil if further processed), rounded (slightly better than truncated), or truncated to 16 bit. For further information, see my article [The Secrets of Dither](#).
6. For the same technical reasons, it is not a good idea to use a digital compressor (or any digital processor) on your material before sending it for mastering. If you do feel the need to insert one of these boxes, for example, to give a demo CD to your client, be sure to also make a non-processed version to prepare for the mastering house. It is likely that the mastering house will have a fresher-sounding, more effective approach at polishing your material, and it's self-defeating if they have to try to undo what was done.
7. If you apply overall compression to your music, and your choice of compressor was wrong (e.g., the compressor you chose caused subtle pumping or breathing, loss of transients, loss of life or liveliness, etc. These are typical symptoms of "compressor misuse" on tapes I have received), the mastering house will have a difficult or impossible time attempting to undo the damage. As I've mentioned, mastering is like whittling soap; it is hard to undo compression. However, I do have some tricks up my sleeve (grin) that can restore some life to squashed tapes.

## **Part II**

### **The Perils of Compression**

or

### **The Ghost of CD Past**

#### **Introduction**

24-bits, 96kHz, multichannel sound. These are some of the exciting features of the upcoming super audio disc. Before we can use these new capabilities to their fullest, we must learn not to repeat our past mistakes. Some of our engineering practices with the CD have done a serious disservice to the consumer. This article looks at one of those practices--overcompression of dynamics, and makes some recommendations that will turn the DVD (and new 16-bit CDs) into the true media of the future.

### **Dynamic Range - The Ups and Downs of Music**

Before we can study the art of compression, we must learn to appreciate the power of music's dynamic range. How does music grab our interest? For short periods (about the length of a "single" played on the radio or in the disco), power and loudness can grab our initial attention. But at home, *variety of dynamics maintains our interest* for long periods of time. Good music written for a long-term musical experience contains a judicious mixture of variety and similarity in dynamics. A production which is relentlessly loud (or relentless in its sameness) can become boring very fast. At the age of 10, I learned the lesson of Franz Joseph Haydn's *Surprise Symphony*, the first composition to teach the importance of dynamic contrast. Musical genres that depend on constant sameness become old very fast. Disco died because it became boring, and I'm convinced that overcompression (which eliminates dynamic contrast) contributed to its death, by creating a continuously loud, boring dynamic. I wonder if the current slack in music sales is related to overcompression and its tendency to give everything a monotonous loudness--is the public voting against compression with its pocketbook?

Any genre that does not grow in musicality will quickly die, and dynamic contrast plays a big role in musicality. Today's Rap music has taken a 250-year-old lesson from classical composition, by beginning to incorporate a melodic and harmonic structure. The genre can further grow and avoid sounding tiresome by expanding its dynamic range, adding surprises. Silence and low level material creates suspense that makes the loud parts sound even more exciting. Five big firecrackers in a row just don't sound as exciting as four little cherry bombs followed by an M80. This is what we mean by dynamic range. Radio, TV and Internet distribution are currently too compressed to transmit the joy of wide dynamic range, but it sure turns people on at home, and also in the movie theater.

Films provide an ideal framework to study the creative use of dynamic range. The public is not consciously aware of the effect of sound, but it plays a role in a film's success. I think the movie *The Fugitive* succeeded because of its drama, but despite an aggressive, compressed, fatiguing sound mix. From the beginning bus ride, with its super-hot dialog and effects, all the crashes were constantly loud and overstated, completely destroying the impact of the big train crash. I can hear the director shouting, "more more more" to the mix engineers. Haven't they heard of the term "suspense?" In contrast, the sound mix of *Titanic*, is a masterpiece of natural dynamic range. The dialog and effects at the beginning of the movie are played at natural levels, truly enhancing the beauty, drama and suspense for the big thrills at the end. Kudos to director James Cameron and the Skywalker Sound mix team for their restraint and incredible use of dynamic range. That's where the excitement lies for me.

### **Compressors as Tools To Manipulate Dynamic Range**

Compression is a tool; when used by skilled hands, it has produced some of the most beautiful recordings in the world. A lot of music genres are based on the sound of compression, from Disco to Rap to Heavy Metal. And a skilled engineer may intentionally use creative compression to paint a mix and form new special effects; this *intended distortion* has been used in every style of modern music. This is analogous to the work of the greatest visual artists; many painters are quite capable of producing a natural-looking landscape, but have abandoned that medium to create abstractions which at first glance look like the fingerpaint work of a six-year-old. But a skilled observer realizes what the master artist is communicating. The keys here are *intent and skill*. Too often, in music, unskilled *compression* can *squash* sound, remove the life, vigor and impact, and replace it with boring mush. Many engineers don't know what uncompressed, natural-sounding

audio sounds like. It actually takes more work and skill to make a natural-sounding recording than an artificial one. In audio as in the visual arts, first learn to paint naturally; then and only then can you truly understand the art of creating distortion. Learn where compression is useful, and where it does a disservice to the music. A compressed production may sound good on a boombox, but when reproduced on a high-fidelity system, it can sound overbearing and ultimately lifeless. That's why we may need to separately mix "single" and album cuts.

Compressors are commonly used in recording (tracking), mixdown, and in mastering. Everyone has his own style of working with compressors and there are no rules. However, before you make *your* rules, start by working *without any* compressors! This learning process will teach you to make better-sounding music later on; the compressor becomes a tool to handle problems, not a crutch or substitute for good recording techniques. First, learn about the natural dynamics and impact of musical instruments, then begin to alter them with compressors (which can include using compression to create special effects). Every 5 years or so, give yourself a reality check...try making a recording or mix with little or no compression. You'll rediscover what I call the *microdynamics* of music. It's a real challenge, but a refresher course may point out that *less compression* will buy you a more open, more musical sound than you've previously been getting.

### **Watch For These Compression-related Pitfalls**

#### **Tracking**

When tracking vocalists (who have a habit of belting now and then), a well-adjusted compressor can sound reasonably transparent, and most engineers agree the cure is better than the disease. But watch out for a "closed-in" sound, "clamping down" when the vocalist gets loud, or loss of clarity or transparency. Compare IN versus BYPASS before committing to tape. Match levels to make a fair comparison. If you notice too much degradation, maybe it's time to consider a different compressor or change the settings you are using. The sound should be open and clear... remember that no amount of equalization in the mixdown can substitute for capturing a clear sound quality in the first place. This is true for all the lead instruments, including trumpets and electric guitars. If possible, put the uncompressed sound on a spare track--it may save your life. If there's any "rule," most engineers would agree to save the decision on drum and percussion compression until mixing. There are always exceptions--every piece of music is unique. Just remember, you cannot undo the damage of overcompression, so be careful about compression during tracking.

#### **Mixdown**

There are two possible places to apply compressors during mixdown. The first is on individual instruments or stereo pairs; the other is on the console mix buss.

*For individual tracks:* The same precautions apply to the use of compressors in mixing as in tracking. Start fresh each time--free yourself of preconceptions. Although you compressed the bass on 9 out of the last 10 albums, maybe this time you won't need a compressor. Each musician is an individual. In general, the better the bass player, the less compression you will need to use, and the greater the chance that compression will "choke up" his sound. Get to know the sound of your instrumentalists. What is your mixing philosophy? Are you trying to capture the sound of your instrumentalists or intentionally creating a new sound? While more and more music is created in the control room, it's good practice to know the real sound of instruments; learn how to capture natural sound before moving into the abstract.

In pop music, compressors are often used to create a tighter band sound, making the rhythm instruments sit in a good, constant place in the mix. But when misused or overused, compressors can take away the sense of natural breathing and openness that makes music swing and sway. Thus, I recommend that during mixing, after you've inserted a few compressors on certain instruments (e.g., the bass, rhythm guitar, vocal) and listened for a while, try comparing with the compressors bypassed (automation makes that process easy; store two fader snapshots so you can switch between them). Many times you'll find the

compression was hurting the mix, and not helping the sound, by losing the subtleties of the musician's performance. Learn the negative as well as the positive effects of compressors by proving to yourself that you really needed the compressor, or that degree or type of compression. The process of refining a mix should always include revisiting your compression (and EQ) settings and questioning your work. Most music these days is recorded in overdubbed sections, but some performances are still captured at once. An engineer once told me that the best sound he got was the monitor mix on the recording day. By the time he got through slicing and dicing and remixing, all the life was taken out of it (what I call *the loss of microdynamics*). So remember the sound you got during the recording...did you lose the magic in the mix?

### **Avoid Wimpy Loud Sound**

Some of you may say that my conservative advice only applies to acoustic genres like country music or jazz. However, Rock and Roll music is often a casualty of compressor abuse. I receive rock mixes from well-meaning engineers that should be getting louder and louder and reach a climax, but which have lost their intensity, producing *wimpy loud sound*. The dynamics of choruses and verses are reversed. Instead of the chorus sounding lively and dramatic, it's been pulled back. When you go against the natural dynamics of the music, the results are less pleasant, and *less exciting*. I strive to put that kind of life back into sound during the mastering, and my clients are delighted by the results. You can make the mastering engineer's job easier. When you mix rock, listen closely to the climaxes; is it possible that you are killing the music with your compressor? This is a very common problem and only the most skilled mix engineers are able to overcome it, maintaining excitement all the way to the highest peaks. Many mix engineers have trouble handling the duality of rock; they find compressors give them power at mid levels, but they have trouble handling the climaxes; they want them to be loud, but can't seem to do it without overload or overcompression. If you're having those kinds of troubles, don't despair. Mastering engineers dislike getting squashed material, because the damage is really hard to fix (though some of the tools I apply are pretty darn effective). Better to send material that's mixed well and powerfully at the mid levels but at the high levels is not squashed. Even if the climaxes don't sound loud enough, consider it a "work in progress." Let the mastering engineer take it to the next level of performance. Using specialized and unique tools, I can remix your material, giving it the punch it needs at mid levels and strength and volume at high levels.

### **Buss processors**

Let me be a bit dogmatic. Reserve "buss compression" or "overall compression" for the mastering stage. As a mastering engineer, I can unequivocally say that the most frequently abused compressor is in the console mix buss. Lately I've been receiving a lot of mixes that have been squashed to death by unintentional misuse or overuse of buss compression.

### **Overuse of buss compression**

Properly-used buss compressors *can* make music sound louder and more powerful, possibly without deteriorating its character, but is the console mix buss the right place to be working on the loudness character of your music? *Absolutely not*. If you already have a great-sounding mix without buss compression, then don't add buss compression just to "beef it up." More often than not, the buss compressor you have available will *take away the life of* your music. Turn up the monitor level if the music doesn't sound loud enough! By all means, leave questions of loudness character out of the mixing process and save them for the mastering stage, where they can be dealt with correctly and effectively (more about that in a moment).

Recently a potential client told me that he was using a little bus compression on his mix. I asked him why he was doing that. He said, "because I think the levels are a little too low." Please don't compress for that reason; if the "levels are too low," then turn them up! The only possible reason to bus compress during a mix is because "it sounds better" to you. I hope that in this article I have provided some useful ways of how you can judge that the mix really "sounds better" before you overall compress. Mixing "to the compressor"

is also a bit like cheating. Your whole judgment becomes geared to what the compressor is doing rather than the act of mixing itself. When in doubt (and even when not in doubt), mix two versions, one with and one without bus compression, and send both to the mastering house. You may be surprised which version the mastering engineer chooses, and which one sounds better after mastering. Also remember, that not all compressors sound that good. The mastering house might be able to employ a digital compressor like the Weiss, which uses 40 bit floating point internal processing, double sampling, has extraordinary attack and release time flexibility. Or an analog compressor, like the Manley Vari-Mu. Both of these are examples of specialized mastering compressors with extraordinary sound.

One possible proper use of a buss compressor is to "tighten" a mix when individual compressors couldn't do the job. However, be careful not to squash the mix. Tuning a buss compressor is an art born of technical knowledge and experience. As always, compare IN and OUT very carefully, and don't be afraid to patch it OUT if that sounds better. Buss compression causes all the instruments to be modulated by the attack and transients of the loudest instrument. A rim shot or cymbal crash can take down the reverberation and the sound of all the other instruments. There are very few console compressors that are capable of doing buss compression without screwing up transparency, transient response or musical dynamics. Excellent circuit design is required, as well as attack and release characteristics idealized for the job of buss compression. Very few outboard compressors can handle that job. If you want to tighten the mix, first try using submix compression on the rhythm section alone. That way you won't abuse the clarity of the drums and vocal.

### **Stop Emulating Squashed CDs**

Many mixing engineers compare their mixes against already-pressed CDs, but be careful what you choose as a standard. Ironically, mastered CDs often do not sound like what comes out of the mix, so how can you emulate something which can only be done post-mix? What you really need is to hear the sound of a good mix *before* it was sent for mastering. But since that's not available, choose from the plenitude of pop records that have been well-mixed and mastered, as listed in the [CD Honor Roll](#). When choosing a reference album, don't pick it because it's "hotter" than everyone else; instead, listen for impact, clarity, transparency, ambience, warmth, space, depth, beauty, openness, naturalness, and (sometimes) punch. But "punch" is an ambiguous term; any so-called "mastering engineer" with a \$2000 processor can give an album a kind of "punchy" sound, but often sacrificing all the other character that makes music worth listening to. Remember this: when two CDs are presented at equal loudness, nine out of ten musicians prefer the sound of an uncompressed presentation to a compressed one. For the first few seconds, a louder presentation may grab you, but relentless sound quickly becomes fatiguing. Many of today's compact discs have already exceeded the loudness limit--the level above which the sound quality goes down hill while the sound "quantity" goes up. You can't get something for nothing.

### **If You Can't Make It Sound Good, Make it Loud?**

Contrary to some people's beliefs, mastering is *not* supposed to be the process of making a record hotter than the competition. Mastering should be the process of making a record *better* than the competition. Currently there is a lot of pressure on mastering engineers to make a record hotter than its neighbor. I'm really surprised that more recording engineers are not up in arms about how mastering engineers (on producer's orders?) are ruining their recordings. I'm quite flattered that one recording engineer called me the first mastering engineer to make his recordings sound *better*. If you're a mastering engineer, wear the red badge of courage; strive for good sound, even if you have to sacrifice a few dB of loudness.

*Clients often complain when they have to turn the volume control up when switching CDs. Why aren't they complaining that they have to turn the volume down when a hot disc comes on? One client told me that she loved the sound of her master, but her test CDR was not hot enough when played in rotation on the CD changer in a local bar. This upset me, because it turned out she was comparing her CD against rather trashy-sounding competition and I didn't want to trash up her sound. In the bar, you can't tell the difference*

in sound quality, but we're making CDs to sound good at home. I told her that she would sacrifice quality if I made her CD any hotter. Ironically, it was already a hot CD, by the standards of last year and the year before, but obviously not this year! Oh, by the way, eventually I compromised, using my best skills to raise the volume on her CD slightly without sacrificing too much in sound quality, but it saddened me that this had to occur. Her CD would have sounded better if it were not as compressed.

### **The PARTY Button**

CD changers present a real problem in client education. I had to tailor the apparent loudness of this client's CD to work with 5 other hand-picked CDs, but I could pick dozens more that are much louder or softer than hers. We have to teach clients that CDs will always differ in volume and that a CD changer is not a radio station. The restaurant CD changer really needs a live DJ, but that's not practical. The solution: put a compressor in the restaurant, the car, and the jukebox, and reserve quality listening for the home, without compression. We should lobby manufacturers to put a compressor button on receivers and future DVD players; with DSP technology this is a snap. They could label it the **Party Button**! There should be three compression settings--for background listening at low levels, for moderate listening in a noisy environment, and for parties, where you want to switch discs without adjusting the volume control. Panasonic and Sony will sell a million of them, and we engineers will be eternally grateful! The button may be misused by ignorant consumers, but no more than the loudness button I find permanently pushed in 6 out of 10 homes.

### **Save it for the Mastering**

When you're through mixing, your recording is a diamond in the rough, it's not supposed to sound like a "record" until it is mastered. Just make sure the mixes sound great and wait for mastering to add any post-mix processes. When you make copies for your clients, if they have any problems, tell them to turn up their monitors and wait for the mastering. Don't be tempted to use so-called "mastering processors" ("maximizers") before the mastering begins. As mastering engineers, we want to receive the cleanest, highest resolution, unprocessed, original mix tape or disc. In mastering, the individual songs will be levelled (not "normalized"), and elements of your music defined and clarified, turning your record into a work of art. The mastering engineer objectively looks at every song in context in a controlled, familiar acoustic environment, using superior tools, monitoring, experience, and artistry.

### **The Vicious Circle of Loudness Envy**

The practice of overcompression is part of a vicious circle of loudness envy. Sadly, the current crop of CDs is louder and even more squashed than its predecessors because few people have stood up to fight the problem. Participants in this unwitting vicious circle include mix engineers, musicians, producers, mastering engineers, and radio program directors, but the problem is introduced during the mastering process. Many people blame the program director for the problem, but I think we're all partly at fault. Regardless of the cause, we all have to participate in a solution before our music turns into mush.

Program directors should realize that the sound on their office CD player has little to do with the disc's on-air quality. PD's may think the loudest record they hear is the best, but they forget that when it gets to the air, on-air processors will squash it (drop the volume) more than other records. Producers are afraid that the PD will reject their record if they have to turn up the volume. But by now, hot CDs have put the PD's volume control at the bottom of its travel, so where do we go from here? Well, let's get the program directors to make decisions on the merits of the music, not on its loudness character. One way to solve that is to install a compressor in the PD's audition system, one that'll squash music as much as his radio station does. We could call it **The Ecumenical Button**. Send me suggestions to see how we can get this one done (no kidnapping, please).

### **From The Sublime to the Ridiculous**

Producers don't seem to like making a CD that's even a little softer than the competition, so each succeeding CD is often a little bit hotter. Just how much hotter can CDs get? I can cut a CD that's **16 dB**

**louder** than the ones we made in the early 90's, before digital limiters became popular, but it'll look like a square wave and soundlike audio cream of wheat! Imagine the consumer problems caused by large variations in loudness--switching CDs has literally become Russian Roulette, shooting out our speakers and ears! But ultimately, your hot CD doesn't get any louder for the public; they just turn their monitor down, and scream in disgust at the increasing range they have to move the knob when they change CDs. In addition, sound quality is suffering by an unjustifiable demand for hotter CDs. A fellow mastering engineer reminds me that in the early days of CDs, we didn't have any pressure to make them hotter (because there was little competition), and early pop CDs had good, open sound. They're much softer than current CDs, but if you turn up your volume control you'll see their dynamics are much better-sounding. Why do we have to go backwards in sound quality? We mustn't repeat this mistake with the DVD. Part II of my article on [Levels](#) discusses 21st century solutions to this problem.

Let's review the basics. The loudness war may have begun with analog records, but the current problem is many decibels worse than it was in analog. LPs were mixed largely with VU meters, which created a degree of monitoring consistency, but today's peak level meters give entirely too much more room for mischief, and today's digital limiters provide the tools to do the mischief. The net result: great consistency problems in CD level. The peak meter is currently being seriously misused. Remember that *the upper ranges of the peak meter were designed for headroom, not for level*. A compressed piece of music peaking to -6 dBFS can sound much louder than an uncompressed work peaking to 0. Mixing and mastering engineers, use compression for creative purposes, but why not master the CD at a lower peak level, and monitor at the same gain you used for your last CD? There's no reason to fill up all those bits if the CD sounds loud enough. Or, useless limiting if you insist on peaking to 0 dBFS. Too many producers are unskilled meter readers; they seem to need all those lights flashing. Try working at a fixed monitor level, with the meter hidden from view. It'll be a very educational experience.

It's come to the point where mastering engineers should think about working differently. In [Part II of my article on Levels](#), I discuss the 21st century solution to this problem, because the future of our DVD Audio is at stake. Only education can stop this vicious spiral. It's time to fight for quality, not quantity. Sound lower than XYZ hit record? Turn up the monitor!

### **Part III**

#### **Tools To Help Keep Us From Overcompressing**

**How can you tell when *proper compression* is becoming *overcompression*?** If you don't have good monitors, it's not easy to know when you've crossed the line. The first sign that you're probably going too far is if you start playing with the compressors simply to achieve overall program "loudness" rather than to help you make a great sound. Remember, the mix room is for mixing. If you know you've got a great sound when the monitor is turned up, then all is ok, the mastering engineer can do the rest. The second sign you're probably overcompressing is if you find you're leaning too much on the compressors to make your mix. A program shouldn't mix itself. It takes a lot of work to mix, and depending on the compressors to do that work for you will probably result in a squashed, lifeless sound.

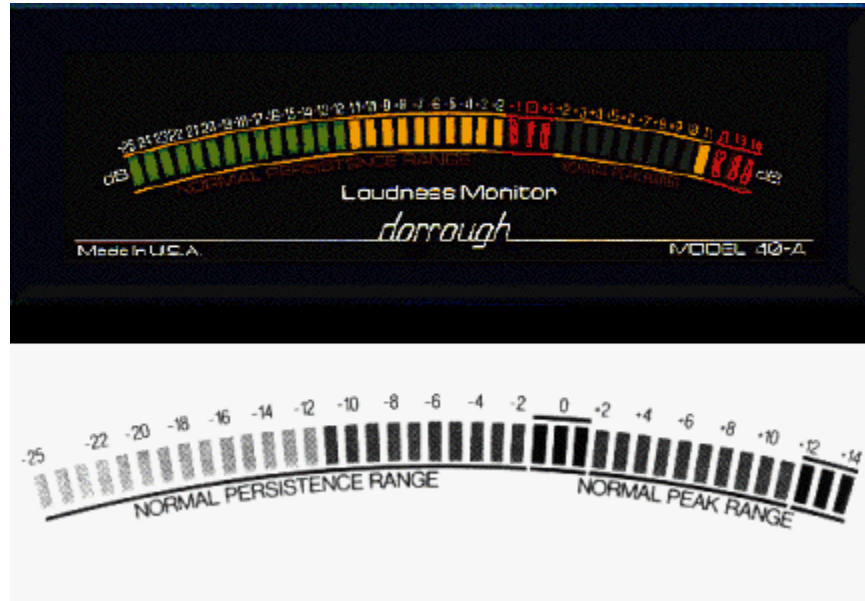
Here are some practical tools you can use to make better-sounding recordings to send to the mastering studio.

- 1) As mentioned above, install a *Dolby-level-calibrated monitor control, connected via a single, high-quality D/A converter*. Visit Part II of my article on [Levels](#) for more details.
- 2) *Metering*. Meters with combined peak and average readings are some of the best protections against overcompression. The [Dorrough](#) meter is a good example, as are meters from DK and Pinguin. Part II of my article on [Levels](#) discusses how to make best use of these meters. In summary, when mastering, try to keep the "average level" on this meter's average scale from exceeding 0, with occasional "high average levels" to +3 (equivalent to +3 on a VU meter). If you do, you will have obtained approximately a 14dB peak to



average ratio. (Peak to average ratio is also known as *Crest Factor*). The meter is also a good visual aid for visiting producers.

3) *Monitoring*. A clean, high-headroom monitor system is essential. If your monitor speakers or amplifier saturate, how can you possibly tell if your material is saturating?



I'd like to thank all my friends on the Sonic Solutions Maillist, [The Mastering Webboard](#), the [Pro Audio List](#), and many of my fellow mastering engineers, for support and ideas. We've been preaching to the converted. Now it's time to transmit these points to the rest of the world.

For further reference, see my articles:  
[Mastering engineers discuss compression in mixing](#)

---

Copyright Digital Domain, Inc. We invite you to link to our site, which will be periodically revised.