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IF THEY KNEW WHAT YOU WERE MISSING

WHY TODAY'S MOTION PICTURE SOUND SYSTEMS FAIL TO MAKE THE GRADE AND WHY THEY CAN'T SOUND BETTER

FROM THE BOXOFFICE MAGAZINE SERIES

By
John F. Allen

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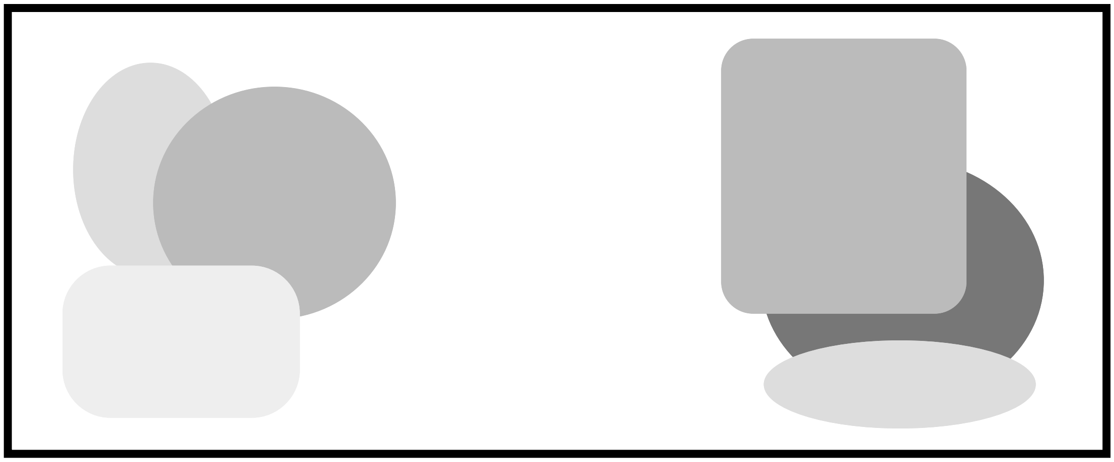

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WHY TODAY'S MOTION PICTURE SOUND SYSTEMS FAIL TO MAKE THE GRADE AND WHY THEY CAN'T SOUND BETTER

BY
JOHN F. ALLEN

Motion picture sound is critically important in setting the emotional atmosphere of a film. Sound alone is often the determining factor in knowing if a scene is a comedy or tragedy. Obviously, the better the theatre's sound presentation, the better the film works. If sound is, as some insist, more than half the show, how can exhibitors best exploit its potential? BOXOFFICE contributing writer John F. Allen offers an important new series exploring the present state of movie theatre sound, along with some valuable guidance.

Motion picture soundtracks are recorded with painstaking detail. It's not unlike the composition and performance of a symphony. Some films have indeed sounded symphonic in their overall effect. Hundreds, even thousands, of sounds are developed, performed, recorded, assembled and carefully mixed together over several labor intensive weeks with

one single goal in mind: to create the believable illusion that everything we in the audience are listening to sounds natural and convincing. Building sound effects is an art-form all its own. We must believe that we are hearing the sound of Jurassic Park's dinosaurs even though no one ever has, and no recording of these extinct animals could possibly exist.

The above title art illustrates what would happen if a motion picture was shown on a screen with certain areas blacked out. Imagine the uproar that would occur in the theatre if the audience was deprived of so much of a film. Yet this is precisely the present situation with the sound systems in the vast majority of today's movie theatres. So much of the sound recorded on modern soundtracks never gets to the audience's ears, it can only be called a disgrace. What often is heard is shrill or so spoiled by colorations and distortion, that audiences could rightly say they had seen *two different movies* if they got to see the same film in two theatres, one with a typical sound system and the other with a fully qualified sound system.

"Big" pictures can and do attract audiences to virtually any theatre, no matter the presentation quality or anything else. Such "block-buster" opportunities to provide a first class entertainment experience, and thus encourage irregular patrons to return to the theatre more often, are lost when they are treated to less than thrilling sound. Many customers will hear better sound in their cars going to and from poorly equipped theatres. This would be a serious problem even if millions of dollars in repeat business were not at stake. But they are!

In my travels, I have encountered too many theatres with poor and even deplorable sound. This marks the beginning of the most comprehensive series of articles which I have written to date. These articles will attempt to describe in some detail the many complex reasons which have contributed to the present "state of the art". Rather than biting the hand that feeds me, it is my endeavor to help it. I shall welcome reader's questions. I do ask, however, that questions be held until the complete series of articles has been published.

WHAT IS BAD SOUND?

Perhaps at this point I should state what qualifies, or at least ought to, as "bad sound". Simply understanding dialogue is certainly essential for telling a story, but it is hardly enough. Any sound reproduction which is unnatural or colored in tone, or is lacking in fullness or dynamic range, or which is unfaithful to the recording in any way, should not be regarded as acceptable. Presentations often encountered in which music or background sounds are too loud, too dull or altogether inaudible, should not be regarded as accept-

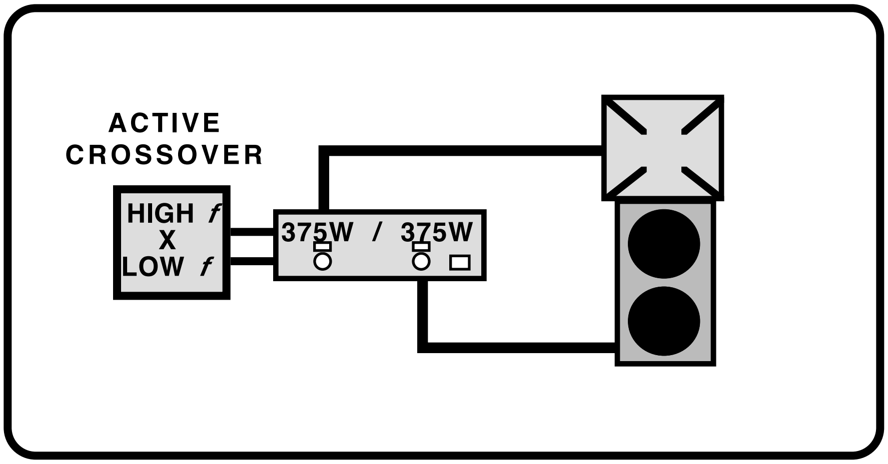
able. Phony, distorted and inadequate bass is widely prevalent in this industry. (Just think of all the subwoofers that have failed). Finally, it must be understood that the typical "honky" dialogue sound so prominent in movie theatre for so many years is BAD SOUND! Voices simply do not sound that way unless someone is speaking through a hose.

> Such "blockbuster" opportunities to provide a first class entertainment experience, and thus encourage irregular patrons to return to the theatre more often, are lost when they are treated to less than thrilling sound.

When Dolby Stereo was introduced 20 years ago, theatre sound systems needed to be upgraded. Thousands of single channel monophonic systems were turned into four channel stereo systems. Many exhibitors proceeded as though just adding speakers and amplifiers would be sufficient, and this is about all that was done. But the dynamic range and inner detail afforded by Dolby Stereo was also greater than had been the case with mono optical soundtracks. This fact has been all but ignored by the exhibition industry. In my opinion, the result has been disastrous for the potential of film sound. Considering this industry's unflattering record in implementing Dolby Stereo, how well can one expect the changes required for digital to be carried out? Where are the real problems which must be addressed for the full potential of digital sound to be realized?

THEATRE LOUD-SPEAKERS

Let us begin by examining the most important as well as the weakest link in the entire audio chain - the speakers. With the widespread use of two-way, relatively inefficient loudspeakers, today's motion picture theatres, not to mention some dubbing stages, are simply incapable of accurately reproducing modern film sound, be it analog or digital. As typically installed, these speakers are just too small to do the job in a room the size of a theatre. See Figure 1. One need only hear a film in a theatre with a large and powerful enough sound system to prove this. The difference can be shocking. The sad truth is that most of the speaker manufacturers have simply marketed their public address products to movie theatres - almost as an afterthought. At least one manufacturer publicly justified their strategy by noting that their two-way system exhibited a frequency response similar to the "older" theatre speakers of the 1940's and '50's: an amazing admission. Exhibitors as well have often been unwilling to make the investment necessary for sound systems powerful enough for stereo, let alone digital.



MAXIMUM OUTPUT AT 50 FT / 16.5 M = 105 dB SPL

TOTAL LOW FREQUENCY RADIATING AREA = 1.6 SQ FT

Figure 1

With few exceptions, today's theatres have not been equipped with speakers designed to be placed behind movie screens. (Surround speakers are a separate subject. More later). This is not to say that motion picture sound systems cannot be built with such components. They can. But because of their limited size, it simply requires more of them than anyone installs in theatres, or ever has as far as I know.

In 1980, I began writing for BOXOFFICE as well as marketing three-way and later even four-way theatre loudspeakers. I publicly stated that separate super-tweeters were required to overcome the effects of movie screens and to evenly deliver the highest quality sound throughout a theatre. Frankly, standing alone in this position as I was, I was subject to plenty of argument (though no proof), and even ridicule from competitors as well as others who had either nothing similar to offer or better to say. This is important to note as now at least two manufacturers are finally beginning to introduce three-way screen speakers. So I guess I can now say "I told you so." (Indeed, my customers are smiling all the way to the bank).

> Finally, it must be understood that the typical "honky" dialogue sound so prominent in movie theatre for so many years is BAD SOUND!

My work with three-way and four-way systems was not born of whim or a desire to be a little different. There are several genuine weaknesses in the two-way speaker approach and particularly the way they have been used in movie theatres. In typical two-way systems, all the high frequencies from 500 Hertz (Hz) on up are delivered by a single diaphragm of a compression driver. The weight of this diaphragm limits its high frequency capability. In order to reproduce the highest frequencies, the diaphragm must be very light. Light or heavy as the case may be, the high frequency output of all high frequency compression drivers begins to fall off above approx-

imately 2,000 Hz. Without some form of equalization, we wouldn't hear any treble frequencies at all in loudspeakers using compression drivers.

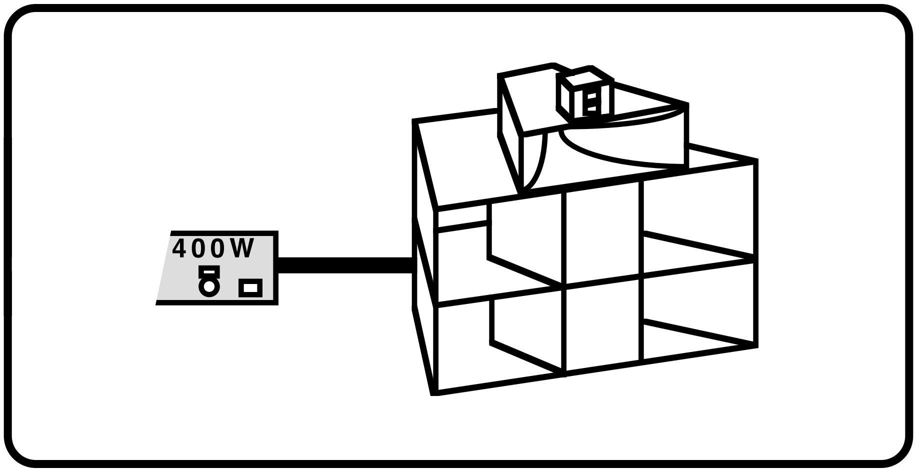
This natural high frequency loss of the driver is made worse by the addition of the high frequency losses encountered by placement behind a screen. Measurements of the losses due to the screen vary with the speaker used, but it is never less than 2 dB and has been reported by some to be significantly greater.

Whatever the screen-loss factor, it must be added to the high frequency equalization required to make the compression driver's diminishing output become the same at all frequencies, or "flat" as it arrives at our ears. Done electrically, the amount of high frequency boosting required to accomplish this can be as much as 15 to 16 dB at 16,000 Hz. Since each 3 decibels is a full doubling of needed amplifier power, this becomes a very, very large amount of equalization. So large, in fact, it can stress the diaphragm, causing distortion, shrillness and sometimes outright failure of the compression driver. By designing the system to be acoustically self-equalized, the high frequency boost is reduced to no more than 3 dB, eliminating driver stress. With the introduction of more three-way screen speakers, things should improve somewhat, at least in new theatres. Unfortunately, the industry must now face the issue of the existing theatres.

WOOFERS

The bottom half of typical two-way theatre loudspeakers has evolved from rather large vented cabinet / limited bass horn combinations, to much smaller and simpler vented direct radiator constructions. There is much debate about the use of these direct radiator woofers. Manufacturers love them because they are so simple to build: six pieces of plywood, two drivers, some fasteners and a connector. What could be easier? As usual, I alone (though not without considerable support and precedence) have opted to build all of my theatre systems with fully horn loaded woofer sections.

The differences in these speaker constructions, their sound quality, their power and the way they are usually employed, are substantial. First, of course, is the matter of speaker efficiency and thus total output. A well designed horn woofer is about 20 percent efficient, while the direct radiator is about 2 1/2 percent. This means the direct radiator will require 800 percent more amplifier power than the horn to play at the same loudness. Since both devices are limited by the power handling capacity of the drivers, and since drivers with the same capacity can be built and installed in either cabinet, the power output of the horn woofer will always be eight times greater than the direct radiator when



MAXIMUM OUTPUT AT 50 FT / 16.5 M = 111 dB SPL

TOTAL LOW FREQUENCY RADIATING AREA = 10.25 SQ FT

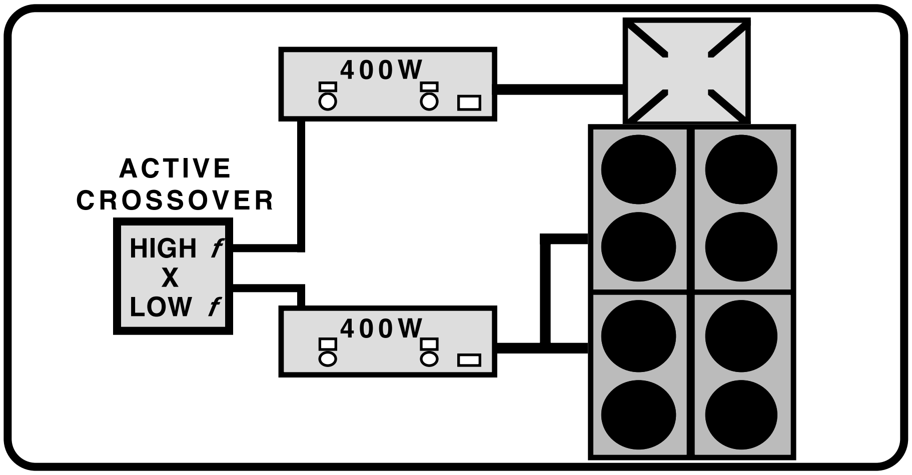
Figure 2

both are at their maximum power.

Second, is the often ignored, and sometimes scoffed at, issue of radiating area. This can also be described as coupling area. This is the area of the loudspeaker which is coupled to, or acts on the air in the room. Intuitively, we know this is very important. Otherwise a transistor radio with a two inch speaker could sound like a symphony orchestra. Speakers are nothing more than air pumps. If you imagine a piston sloshing alone up and down in a pond, then imagine adding a cylinder around the piston, you can immediately see that the cylinder makes the piston a more effective pump. This is because the cylinder allows the piston to control more water with each stroke. The same holds true for loudspeakers.

The total radiating area of a direct radiator type loudspeaker is confined to the piston area of the moving paper cone(s). In a direct radiator theatre woofer with the usual compliment of two 15 inch drivers, this area is about 1.6 square feet. In other words, if only one such cabinet is used per screen channel, two pieces of paper, each .8 square feet in area, is all each channel will have flailing away at all the tens of thousands of cubic feet of air in the theatre. See Figure 1. The same is true if the cabinet is built as a subwoofer. In fact, this is true no matter how large the cabinet is.

A fully horn loaded woofer is a completely different approach. The horn is an acoustical transformer. Using a sort of leverage, if you will, the cones of the drivers do not act directly on the air in the room. Rather, they act on the air in the throat of the horn. As the sound waves travel down the path of the horn, the horn's cross-sectional area expands at a determined rate. Recalling the cylinder / piston analogy, one can see how the drivers of a horn control a considerably larger mass of air than does a direct radiator. It's this large mass which then acts on the air in the room. The radiating area of a horn type woofer is the area of the mouth of the horn. This can be over ten square feet per cabinet, or six times greater per pair of 15 inch drivers. See Figure 2. This is a huge acoustic difference and is why the Senn-surround® systems were built with horn loaded woofers.

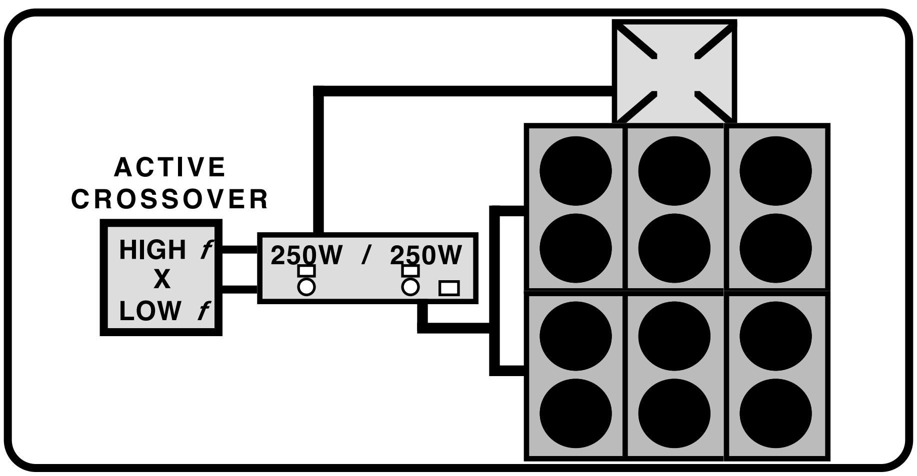


MAXIMUM OUTPUT AT 50 FT / 16.5 M = 111 dB SPL

TOTAL LOW FREQUENCY RADIATING AREA = 6.4 SQ FT

Figure 3

Another advantage with the well designed horns is their reduction in non-harmonically related distortion products. This kind of distortion is generally referred to as modulation distortion or inter-modulation distortion. Though "IM" distortion is usually listed in the specifications and reviews for amplifiers as well as other electronic audio devices, it is virtually *never* mentioned by loudspeaker manufacturers. This is because loudspeakers produce such high amounts of this kind of distortion. A direct radiator device will often exhibit ten times the distortion than is produced by a horn playing at the same level. This is often and sometimes vehemently disputed. However, if one listens carefully to those who scream the loudest that this isn't true, they only talk about harmonically related distortion products which, it turns out, are indeed roughly equivalent in both types of speaker systems. (See TOTAL DISTORTION IN MODERN THEATRE WOOFER SYSTEMS. BOXOFFICE October, 1992. pp 90).



MAXIMUM OUTPUT AT 50 FT / 16.5 M = 111 dB SPL

TOTAL LOW FREQUENCY RADIATING AREA = 9.6 SQ FT

Figure 4

In my experience and opinion, one of the most important reasons that motion picture sound systems cannot sound better than they do is a critical lack of low frequency radiating area. Much of the inner detail and sense of spaciousness recorded in the soundtrack is effectively eliminated. Over-tones and low level bass sounds are stripped away. Louder bass sounds lack punch as well as suffer from coloration, distortion and a phony quality. "Real bass" is replaced by the sound of two rather small and totally overwhelmed .8 square foot pieces of paper which are working much too hard.

This is not to disparage these speaker systems, as these sound system deficiencies are not caused by the use of direct radiator low frequency cabinets. Rather, it is because there is not enough of them. When such cabinets are selected for use in movie theatres, there simply must be more of them, and at the present time there isn't. A good rule of thumb for theatres over 80 feet long would be to use at least four double 15 inch direct radiator woofers for every single unit in use now. Six woofer sections per channel would make the direct radiator based system equivalent to a horn based system and result in a significant improvement in sound quality as well as reliability over what is possible with single cabinet installations. See Figures 3 and 4. Monophonic theatres can get by with a single direct radiator, but digital and Dolby SR equipped theatres need much more. My general rule about woofers is that if you can lift them, they're too small.

CHAPTER 2

SUBWOOFERS, SURROUNDS AND AMPLIFIER POWER

Chapter one was devoted to a detailed analysis of the present state of the sound systems in today's movie theatres and some of the many complex reasons which preclude them from being able to reproduce digital soundtracks. Much of this chapter covered speakers used behind motion picture screens and explained why the majority of these loudspeakers are simply too small.

While all the visual action takes place on the screen, the sound system is installed throughout the theatre. The all important surround speakers are often overlooked as one of the most vital components of the experience which attending a theatre is supposed to be. In this chapter, I shall explain why the surrounds usually fail to deliver what they should, as well as discuss subwoofer and power amplifier deficiencies which audiences are also to likely to endure.

WHAT IS BAD SOUND?

Perhaps I should once again state what I believe should qualify as "bad sound". Simply understanding dialogue is certainly essential for telling a story, but it is hardly enough. Any sound reproduction which is unnatural or colored in tone, or is lacking in fullness or dynamic range or which is unfaithful to the recording in any way, should not be regarded as acceptable. Presentations often encountered in which music or background sounds are too loud, too dull or altogether inaudible, should not be regarded as acceptable. Phony, distorted and inadequate bass is widely prevalent in this industry. (Just think of all the subwoofers that have failed). Finally, it must be understood that the typical "honky" dialogue sound so prominent in movie theatre for so many years is BAD SOUND! Voices simply do not sound that way unless someone is speaking through a hose.

SURROUND SPEAKERS

It's hard to imagine a mistake one could make in designing or installing a surround array or surround speakers, that is not commonplace in today's movie theatres. Many, all too many, surround speakers have required replacement, sometimes repeatedly, over the years. It would almost seem that we are now quite used to hearing of such failures with virtually every opening of a new action picture, particularly with a digital stereo track.

Surround speakers serve a critical role by bringing the audience into the film. Surrounds create the atmosphere. In addition, films like TWISTER, EXECUTIVE DECISION and INDEPENDENCE DAY use the surrounds for some enormous sound effects. These effects can demand bass levels which exceed that produced at the same time by the subwoofers. Yet surround speakers typically fail to produce anything beyond some kind of noise during the loudest scenes. The rest of the time they hardly sound like they're on at all even though they are supposed to be. (How often has that complaint been heard)? The sound of the surrounds should match the sound from the screen.

> **If a sound system is properly designed and equipped, its loudspeakers should never fail. I repeat, never!**

Of course, the final issue which must be faced is that due to poor placement, among other things, most surround systems don't ultimately surround anything. Listeners all too often localize to, and can even feel attacked by, the surround speaker or group of speakers they are closest to. (See WHY SURROUND SYSTEMS DON'T USUALLY WORK. BOXOFFICE, March, 1983. pp 68).

Returning to the theme that most theatre speakers are too small, the vast majority of surround systems installed today are also lacking in size and performance. For theatres equipped for either Dolby SR or digital, I would advise that surround speakers with anything smaller than a 12 inch woofer should not be considered.

Beyond that, surround presentations cannot improve until far more attention is paid to speaker placement. The goal should be that no localization to individual speakers or wall of speakers should occur from any seat in the house.

Due to their height restrictions, theatres with stadium seating and balconies require a far greater level of skill and understanding of coverage geometries than is generally available to this industry at this time. The usual practice of locating surround speakers in theatres by habit and mere guessing needs to go the way of the hand cranked projector. The bottom line is, if you're in a theatre where you can only "feel surrounded" in the center seats, the surround system in that theatre, by definition, fails to surround everyone not seated in the center. This is, of course, virtually the entire audience for every show, every day, week after week...

Surround speakers of sufficient size, output and quality, properly placed for zero locali-

zation can and do significantly, almost magically, enhance the motion picture experience for all films, large and small.

SUBWOOFERS

As noted earlier, the number of subwoofer failures this industry has experienced is very high indeed. Frankly, there is no excuse for this. If a sound system is properly designed and equipped, its loudspeakers should never fail. I repeat, never! As with both the screen and surround speakers, most theatres are presently outfitted with terribly inadequate subwoofer systems. How inadequate depends on the theatre. We do know that subwoofers are required to deliver peak levels of at least 115 dB sound pressure level (SPL) in the center of a theatre. To do this in say a 100 foot long theatre, the subwoofer system must be able to deliver 139 dB SPL at 1 meter, according to the inverse square law and actual measurements done in a theatre. Adding a 6 dB safety margin is a good design practice. This protects the drivers from damaging overloads and also allows for real world signal conditions which will actually push the subwoofer higher than the theoretical peak levels. This brings the total output requirement at one meter to 145 dB SPL in a theatre 100 feet long. Subwoofer amplifiers must also be equipped with clipping protection or limiting for those occasions when even this isn't enough. Believe me, it does happen.

> There ought to be no debate that a safety margin of some amount is mandatory.. But there is debate as to how much the safety margin should be.

Since typical subwoofers quit at around 124 dB, theatres need more than one or two to do the job. In fact, a 500 seat, 100 foot long theatre requires ten standard subwoofers or two high efficiency subwoofers. Either approach will provide the power output required. The radiating area of ten standard subwoofers is 16 square feet vs. over 20 for the two high efficiency units, but they are at least closer. See Figure 1.

If one is using direct radiator subwoofers, systems with 18 inch drivers would make a better choice. Most theatres are equipped with only one or two standard subwoofers if they have them at all. So the shortfall in subwoofer power in these theatres is truly severe. (See DIGITAL SUBWOOFERS. BOXOFFICE June, 1995. pp 48).

AMPLIFIERS

Another of the more important factors contributing to the lack of performance in motion

picture theatre sound systems is the power amplifiers. As with most of the installed loudspeakers, the amplifiers found driving them are too small for their task.

Determining the power required for any channel in any sound system is a very straight forward exercise. Using the speaker's one watt, one meter sensitivity, the maximum peak sound pressure level (SPL) of the program material involved and the distance at which that level must be delivered, we can quickly calculate the power in watts required. We then add 6 dB or multiply the watts by four. This adds a safety margin so that the amplifiers never run out of power and clip. This is critically important in assuring a long life for the speakers as well as, obviously, keeping the sound clean.

There ought to be no debate that a safety margin of some amount is mandatory. But there is debate as to how much the safety margin should be. Some have said as little as 3 dB, which is twice the power demanded by the peak levels. In the real world this is not enough for at least two good reasons. The first is that due to its complex nature, real program material can frequently use more power than theoretical calculations indicate. Second, and just as important, is that we are dealing with equalized sound systems. If the equalization requires the bass control to be turned up just 3 dB, as is often the case, that 3 dB immediately doubles the amplifier power required. Some common surround speakers need a 6 dB bass boost. These equalizations cannot be ignored. So when designing a sound system, one must factor in the typical amount of equalization anticipated by the speakers employed, and increase the amplifier power accordingly.

SO HOW LOUD DO MOVIES GET?

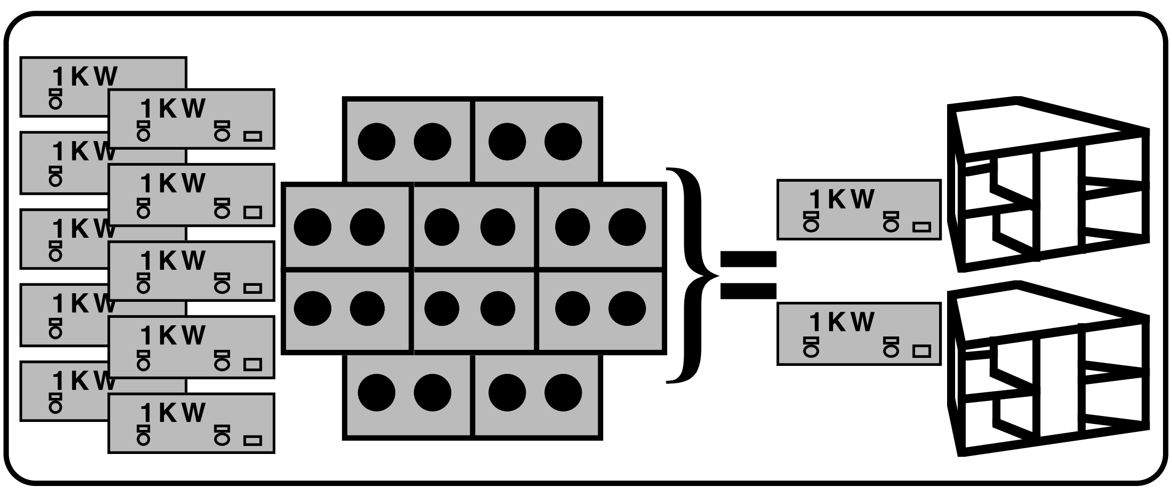
The peak levels for digital motion picture soundtracks is 105 dB SPL for each screen channel, 102 dB SPL for each surround channel and, as stated earlier, 115 dB SPL for the subwoofer channel. Adding 6 dB brings the design criteria up to 111 dB SPL, 108 dB SPL and 121 dB SPL respectively as measured in the center of the theatre. Sound systems built to these specifications will not clip and can be considered reliable.

Unfortunately, these common sense practices are seldom followed. As an example, one 500 seat theatre I visited advertised its sound as "state-of-the-art". In some sense I suppose you could say it was as it just poured out distortion with films like TWISTER and INDEPENDENCE DAY. Doing the math, I calculated that the clipping levels for this sound system were 102 dB SPL for the screen channels, 99 dB SPL for the surround channels and 103 dB SPL for the subwoofer. At a minimum this meant that the screen and surround channels were 50 percent too small. The subwoofer channel was a whopping 94

percent too small. If one were to include a 6 dB safety margin, these shortfalls become four times worse.

Clearly this is an appalling situation for this industry when such a system can be sold as a quality digital-ready package. One reason this continues to happen has been a reluctance on the part of some to own up to the real power demands of digital stereo. This, even though anyone with a calculator could figure it out for themselves. On separate occasions, two manufacturers have stated to me their feeling that if they told the truth, “no one would buy” their processors. I strongly disagree. The industry is far better served by the most honest and forthcoming advice. Without it everyone on both sides of the boxoffice loses out.

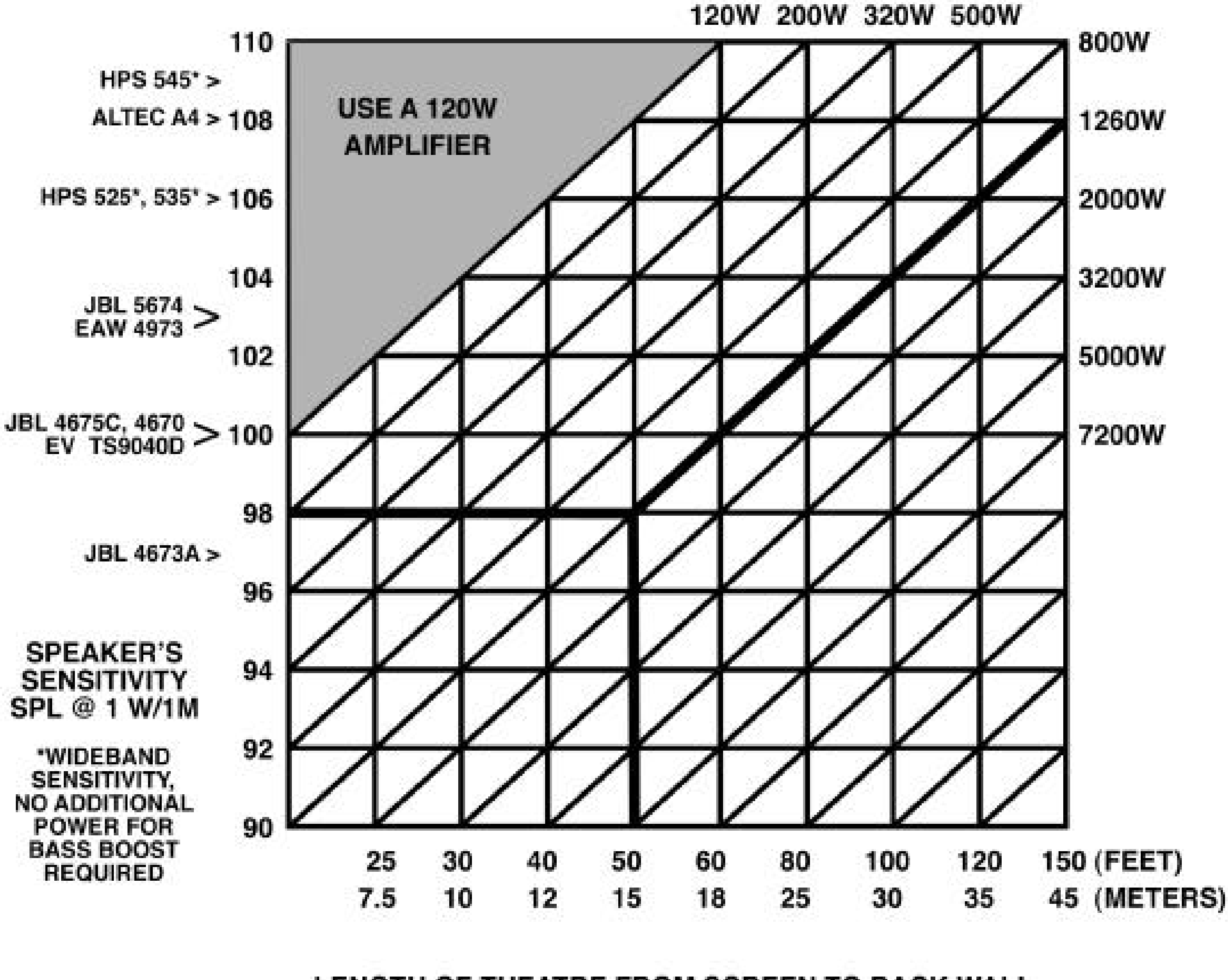
The following text is offered as an amplifier power specification for exhibitors and others responsible for installing motion picture sound systems. And, published for the first time anywhere, tables one, two and three provide a quick reference for the minimum amplifier power requirements for cinema sound systems. Please refer to the end of this chapter for these tables.



MAXIMUM OUTPUT AT 50 FT / 16.5 M = 121 dB SPL

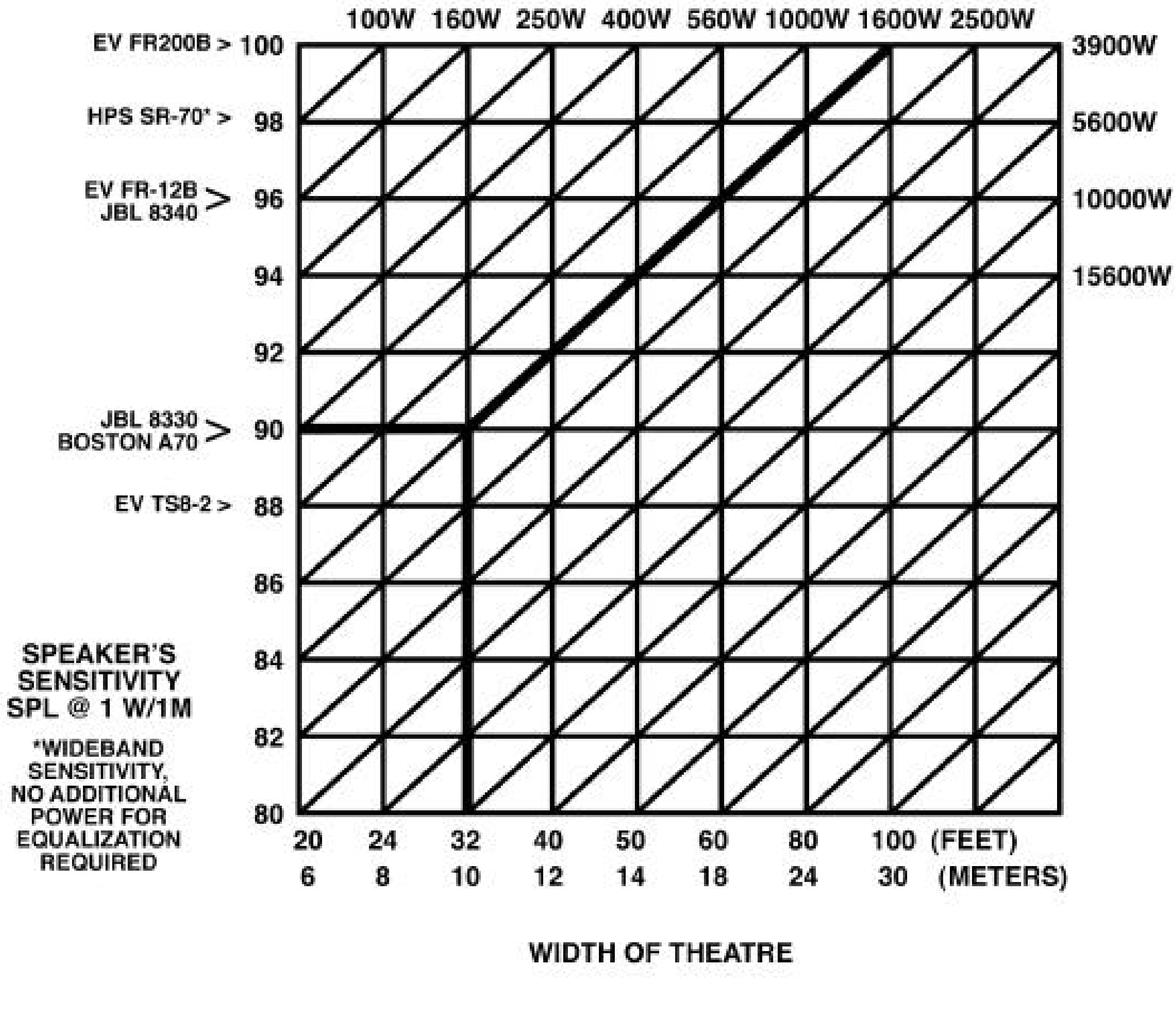
Figure 1

RECOMMENDED STAGE SPEAKER POWER REQUIREMENTS 6 dB HEADROOM, SPEAKERS & AMPLIFIERS SAFE



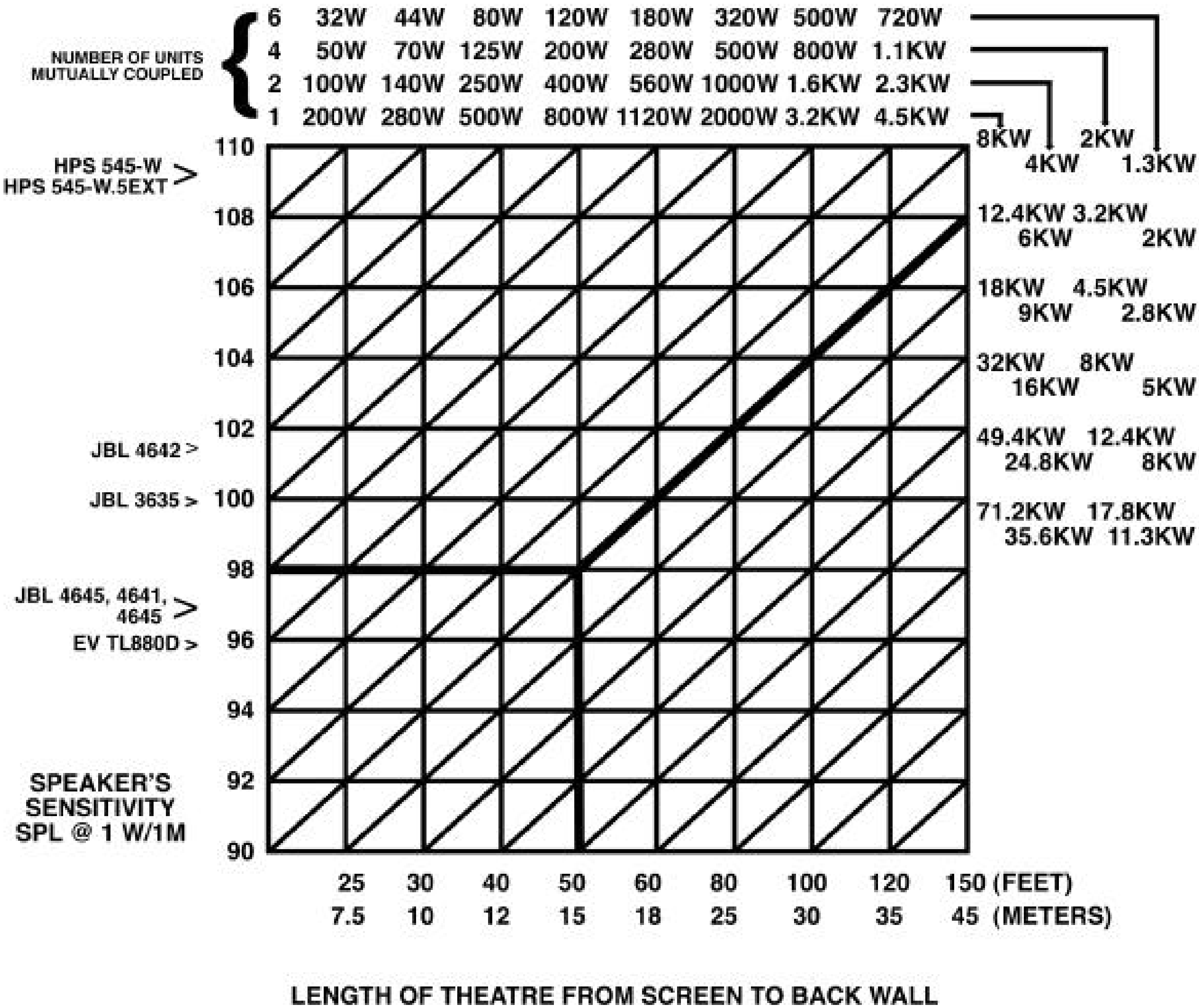
SINGLE SCREEN CHANNEL POWER REQUIREMENTS
FOR 111 dB SPL @ 1/2 BACK FROM SCREEN

RECOMMENDED SURROUND CHANNEL POWER REQUIREMENTS 6 dB HEADROOM, SPEAKERS & AMPLIFIERS SAFE



SINGLE SURROUND CHANNEL (LEFT OR RIGHT) POWER REQUIREMENTS FOR 108 dB SPL AT THE CENTER OF A THEATRE

MINIMUM SUBWOOFER POWER REQUIREMENTS
6 dB HEADROOM, SPEAKERS & AMPLIFIERS SAFE



SUBWOOFER CHANNEL POWER REQUIREMENTS
FOR 121 dB SPL @ 1/2 BACK FROM SCREEN

AMPLIFIER POWER SPECIFICATION

The power amplifier requirements in (name of theatre circuit) Theatres' sound systems shall be calculated solely using the inverse square law. Tests have shown that, in the center of the theatre, the peak sound pressure level (SPL) for a single screen channel is 105 dB, 102 dB SPL for each surround channel and 115 dB SPL for the subwoofer channel. An additional 6 dB of headroom shall also be required to provide the loudspeakers with sufficient power headroom to prevent amplifier clipping.

Therefore, each full range screen channel shall be powered to produce levels in the center of the theatre of at least 111 dB SPL as the amplifier(s) reach(es) maximum power. Each left and right surround channel shall be powered to deliver levels of at least 108 dB SPL in the center of the seating area as the amplifier(s) reach(es) maximum power.

The subwoofer channel shall be powered to deliver a level of at least 121 dB SPL in the center of the theatre as the amplifier(s) reach(es) maximum power. No power compression, self protection limiting action or bandwidth limiting action shall occur in a subwoofer channel at levels less than 121 dB SPL in the center of a theatre as calculated using the inverse square law.

A note about speaker sensitivity: Some speaker manufacturers provide a sensitivity specification as measured with a 1 watt input. Others show a 2.83 Volt input. There is a significant difference which must be taken into consideration.

If a speaker under consideration is specified at 2.83 Volts, the speaker's minimum impedance specification must checked. If the minimum impedance is 8 ohms, the speaker's rated sensitivity may be used directly when calculating the required power according to the inverse square law.

If the minimum impedance is found to be around 4 ohms, then a 2.83 Volt input is actually 2 watts. In this case, a 3 dB deduction shall be made from the given 2.83 Volt sensitivity specification to get the speaker's true 1 watt sensitivity.

CHAPTER 3

MEASUREMENTS AND EQUALIZATION

We have reviewed the inadequacies of typical loudspeakers found in motion picture theatres and covered the amplifier power required by all types of loudspeakers for proper presentation of digital soundtracks. These discussions detailed why, without investments in upgrading or replacing most of the speakers and amplifiers presently installed in theatres, audiences simply will not hear the true quality available from digital films. Exhibition will also miss a golden opportunity to redefine what the moviegoing experience can be.

Rather than concentrating further on sound system components or equipment, this chapter covers sound system equalization or tuning. As hard as it may be to believe, I will explain why virtually every motion picture sound system in existence is mistuned and, more often than not, severely mistuned.

How can this be? Don't technicians use real-time sound analyzers? Don't they equalize every channel of every sound system according to "industry standards?" Well, yes they do. Sort of. And therefore don't all stereo sound systems sound perfect no matter what equipment is used? Further more, don't they all sound the same? Well, no they don't.

> In over ten years, no technician has ever set the equalizers the same way twice!

The fact is that theatre sound systems do not sound the same even when they are outfitted with identical equipment in identical theatres. The problem is that the measurements technicians rely on to equalize movie theatre sound systems are hopelessly inaccurate and totally unrepeatable. Indeed, regardless of the quality and performance of the speakers and amplifiers installed or even the room's acoustics, one of the major reasons that movie theatres can't sound better than they do is poor tuning.

The sound systems which get "tuned" the most have the distinction of not only sounding

worse than they should, but each time they are re-equalized, audiences get to hear a different example of mistuning. In my own experience, one of the most ridiculous examples of this concerns the HPS-4000® systems which I designed and installed for the Century Plaza theatres #'s 2, 3 and 4 in Los Angeles. From day one, the largest of these theatres (#2) has been hailed by critics and producers alike as "the best in the area, if not the country."

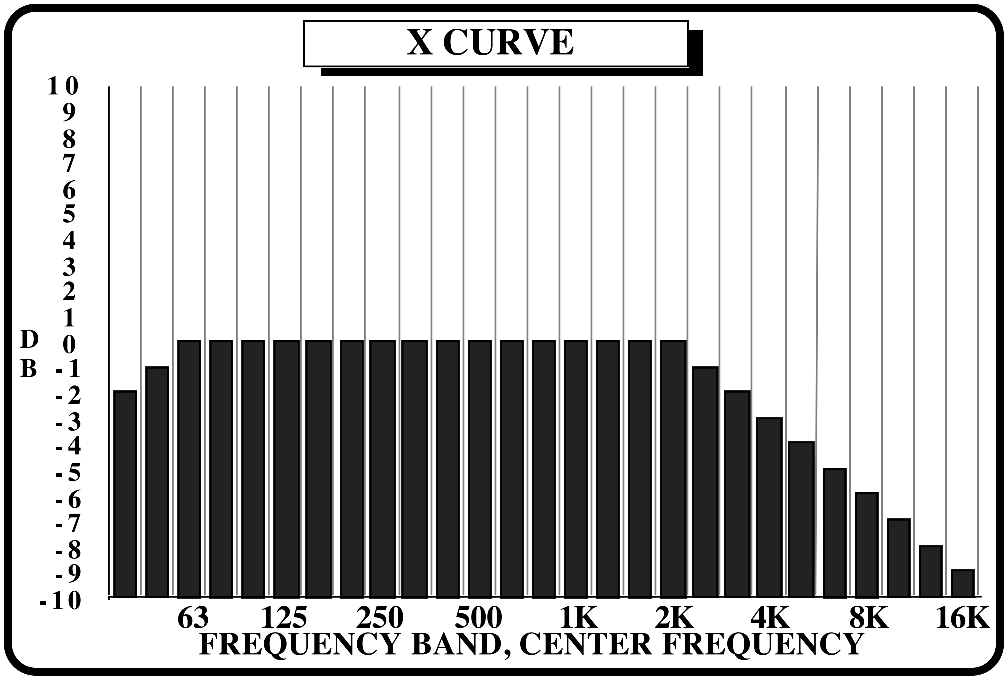
> Sound systems are routinely equalized to "correct" these differences. In the process some rather huge distortions are actually introduced to the frequency response of the direct sound heard by the audience.

Since these theatres are often used for premieres, the sound systems are constantly being checked. Normally one might think this would be a good thing. But such is not the case. One technician after another has marched in, set up his microphones and before listening to anything, totally changed the equalization. This, even if they had been there the week before and done the same thing. Seals I installed on the equalizer modules are ripped apart and ignored. When all is done, the sound systems usually end up sounding shrill with no bass - in other words, ruined. The technicians then listen and complain that it doesn't sound good even though their measurements "look good". Mostly they don't complain at all, which is even worse.

The situation became so bad the theatre purchased a second set of equalization modules for everyone else to use. The equalizers I set, the so-called house cards, are sealed and should be left alone. For ten years now, technicians have had their own equalizer modules with which they may do what they will. As soon as they leave, it is understood that the house cards will be reinstalled. If ever proof is required that the measurements these well meaning technicians are making are inaccurate and unrepeatable, consider this: In ten years, no technician has ever set the second set of equalizers the same way twice. For ten years, no technician has been able to achieve a sound quality as good as, let alone better than, that which is available by simply using the house cards as is.

Why is this so and what can be done? There are actually several complex factors at work here. I will attempt to deal with some of them one at a time.

When measuring the frequency response of a speaker in a theatre, a technician typically sets up anywhere from one to four microphones in the rear 2/3 rds of the theatre. Pink



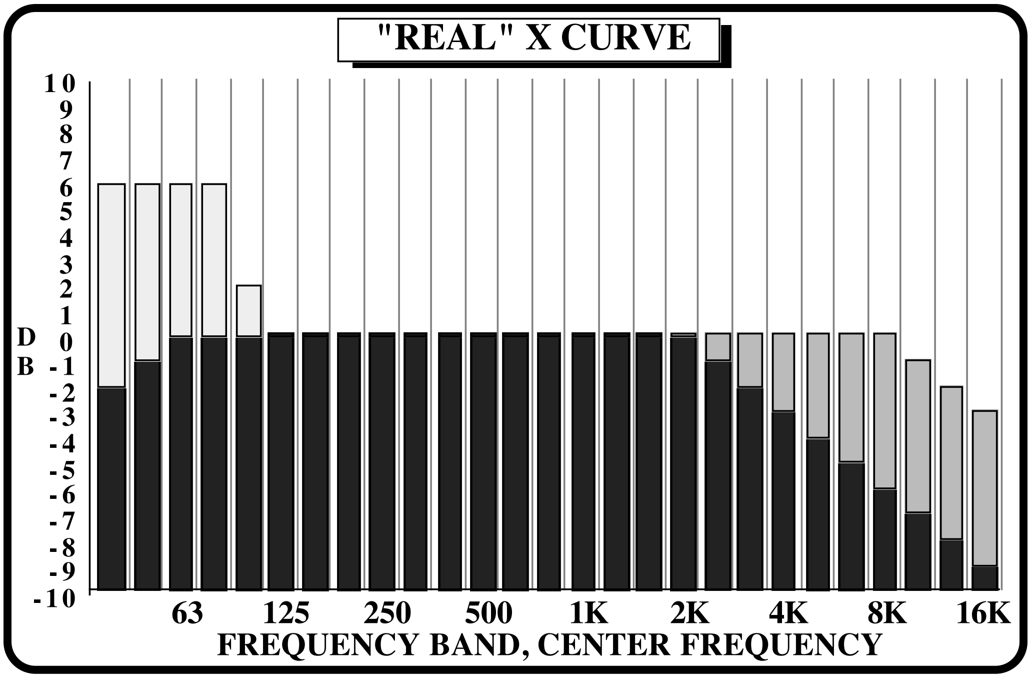
"X" Curve, showing how a presumably flat loudspeaker measures on a real-time analyzer in a theatre, through a screen, with pink noise playing.

The roll off in the bass indicates the lack of deep bass response typical of the older speakers used in early tests.
Figure 1

noise is played through each speaker or group of surround speakers. The noise is, of course, picked up by the microphones and graphically displayed by the analyzer in 27 one third octave bands.

According to what has now become industry practice, motion picture sound systems are equalized so that their measured frequency response matches the "X" curve. See Figure 1. The frequency response characteristic of this curve is flat from 100 Hertz (Hz) to 2000 Hz and declining -3 dB per octave from 2000 Hz and above. At first glance, one might look at this and wonder why there is a curve at all, when what we are supposed to be listening to is a sound system with a flat frequency response, ie. no curve. After all, when the pink noise is connected directly to the analyzer the measured response is equal at all frequencies, or flat.

In actuality, once pink noise is played through a loudspeaker and becomes airborne in a room the size of a theatre, it will no longer measure flat on a real-time analyzer, even when it is. This is primarily due to that amount of room reverberation which the microphone sees which is also added to the measurement. Since there is a relatively large



"REAL" "X" Curve, showing how a truly flat loudspeaker should measure on a real-time analyzer in a theatre, through a screen, with pink noise playing.

Note the additional low frequency level (in light gray). This indicates the typical measurement of a modern theatre loudspeaker designed and constructed for full bass response. The amount of this "additional" bass as measured will vary with the size and acoustics of the theatre and does not indicate excessive bass.

The dark gray areas above 2 kHz show the difference between the actual frequency response of a flat speaker behind a screen in a theatre and what a real-time analyzer may show. These gray areas show the potential measurement errors of this measurement system, depending on the size of the theatre being measured.

Figure 2

amount of low frequency reverberation and very little high frequency reverberation, we see a rolled off response on the analyzer showing more total lows than highs.

Were we able to completely remove the reverberation from this measurement technique, we should see a frequency response characteristic which is flat to around 8000 Hz and down around -3 dB at 16000 Hz. See Figure 2. This high frequency loss above 8000 Hz is due to the insertion loss of the screen as well as the high frequency absorption of the air. Yet the "X" curve shows that the frequencies from 2000 Hz to 8000 Hz are also attenuated. So what's going on? It turns out to be a characteristic of this measurement system to show such a response which begins falling off above 2000 Hz when we are in fact hearing a

response which is flat out to as much as 8000 Hz before falling off. We're in trouble already.

The ISO 2969 and SMPTE 202M standards, which now encompass this measurement approach, take the size of the theatre into account and provide for a higher rate of high frequency roll off for larger and more reverberant theatres, and a somewhat reduced rate for smaller theatres. What they do not take into account is that the "knee" of the curve, where the roll off begins, also varies with room size and acoustics. This is clearly seen when one uses loudspeakers with a flat frequency response in different theatres. Unfortunately, most speakers used in theatres are not flat and have a significant high frequency roll off themselves. Indeed, unless one uses flat speakers, there is no possible way to know where the knee of the curve should be for any particular theatre.

As we are beginning to see, there are many shortcomings with this approach. Any one of them is enough to completely mislead a technician. The most important issue we must understand is the difference in the way we hear and process sound, versus the way microphones work. When sound happens, it travels directly from the source to our ears. Assuming we are indoors, it also bounces off the walls, ceiling, floor as well as everything and everyone else. Echoes of the sound reverberate throughout the room until they die out. The first arrival of the direct sound at our ears is very important. The first arrival is what our brains use to characterize the tone as well as the direction of the sound. It also triggers our brains to suppress the earliest reverberations of the sound so that we do not hear them. This is critical to our hearing process. Our ear-brain hearing mechanism makes a clear distinction between the initial direct sound and later reverberant sound.

> The technicians then listen and complain that it doesn't sound good even though their measurements "look good". Mostly they don't complain at all, which is even worse.

We experience one example of this reverberation suppression, or rather its absence, when we listen to someone speaking to us over a speakerphone. They sound like they are in an echo chamber. In fact, we hear so much reverberation of their voice and the room they are in, we can have trouble understanding them. Yet, if we were standing next to them in that room, we would not hear the reverberation even if we tried. Our brains suppress it very effectively.

Of course, the reason it's so easy to hear the reverberation through the speakerphone is because its microphone doesn't have a brain. Measurement microphones and real-time analyzers don't have brains either. And unless we take this into account, neither do we.

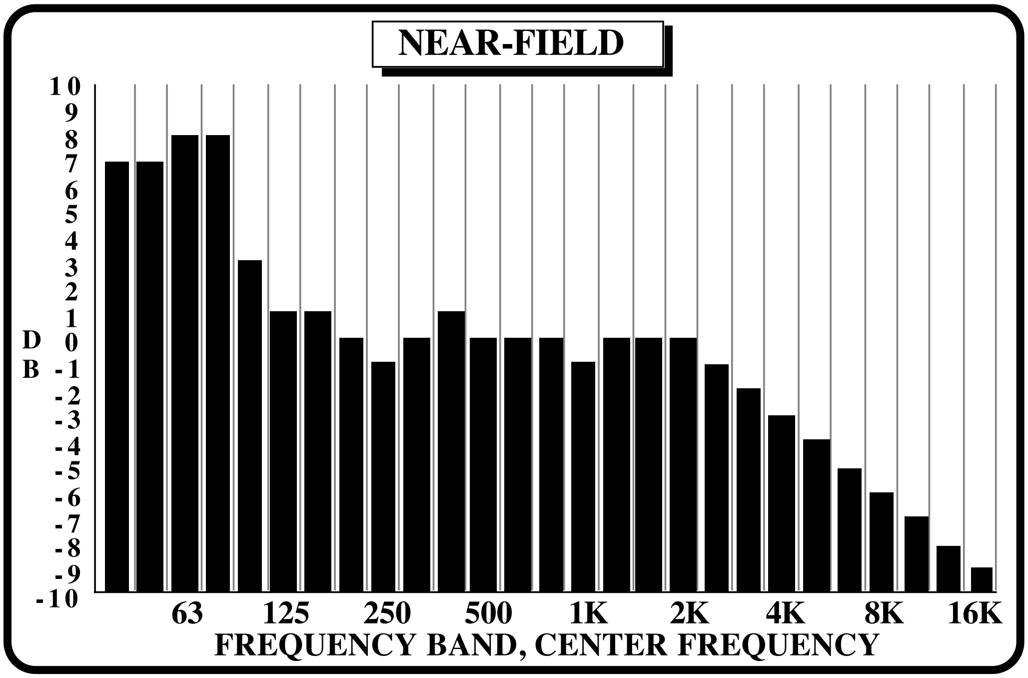
Not only do microphones respond to the first sound arrivals, they also pick up all the reverberation in the room and add it to the direct sound without distinguishing one from the other. The result is a totally contaminated measurement. This mess is then displayed on the analyzer and is generally mistaken as representing the frequency response of what we will hear in the theatre, when nothing could be further from the truth. Unfortunately, virtually all of today's motion picture sound systems have been equalized with these distorted measurements and as a result fail to deliver their best possible performance, whatever it may be.

The sad fact is there is no technology available that can measure what something sounds like. However, with measurements more heavily weighted to the direct sound and away from the theatre's reverberation, we can get far better results. Until we have a new measurement system, simply moving the micro-phone(s) to the front of the theatre, typically around the third row, will dramatically increase credibility of the display on the analyzer. See Figures 3, 4 and 5. See also chapter 5.

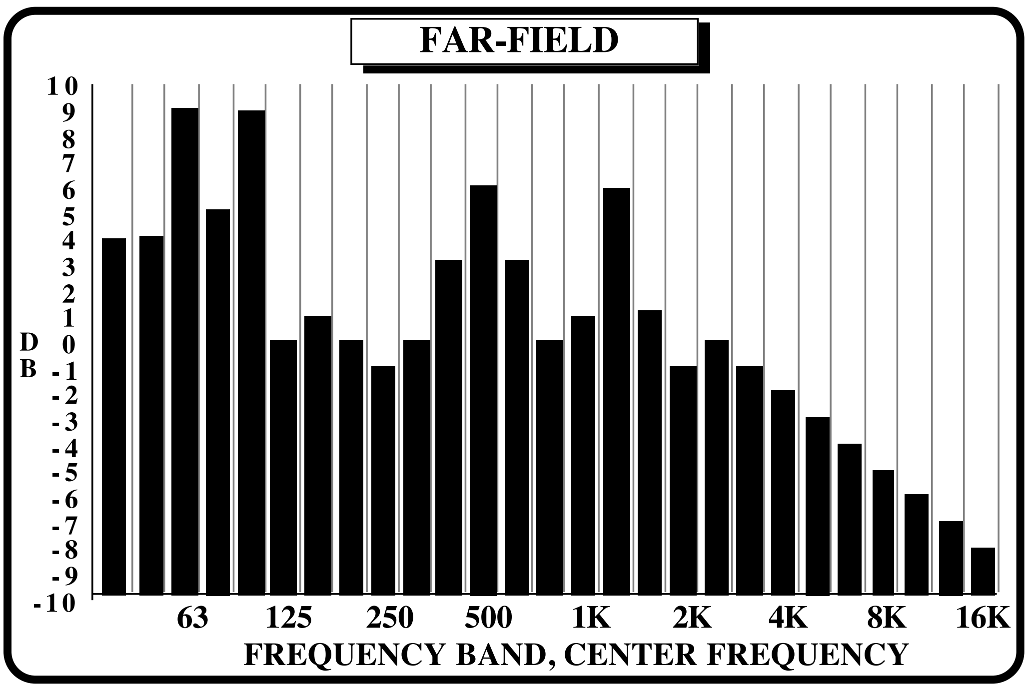
To illustrate, Figure 3 shows a third row, or "near-field", measurement of a full range, fully horn loaded loudspeaker located behind the screen of a 600 seat theatre. This excellent theatre is large enough for the high frequency roll off to begin at 2000 Hz and conform nicely to the theoretical "X" curve. The low frequencies appear elevated. But this is actually a normal measurement for a speaker system like this which, with a 10 1/4 square foot low frequency radiating area, is fully coupled to the air in the room down to frequencies below the 40 Hz range. In other words, don't try this with ordinary speakers.

Figure 4 is the measurement of the same speaker in the same theatre at the same time, but with the microphone in several locations 2/3 rds back in the house. Note the differences as seen in Figure 5, particularly the 5 dB peaks at 500 and 1250 Hz. These "measured" peaks are most curious as they do not exist when we actually listen to the sound system. In fact, it is quite impossible for a loudspeaker to have such a radically different frequency response simply by standing 30 or 40 feet farther away.

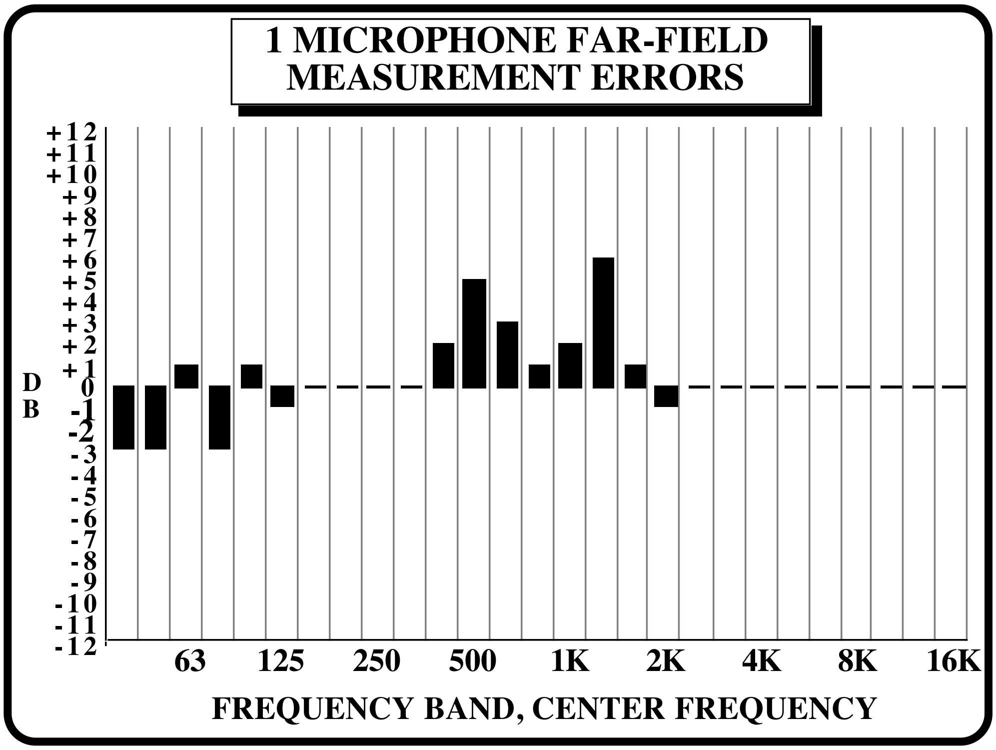
Differences of the kind seen in Figures 3, 4 and 5 are often seen between a theatre's separate screen speakers as well. Though they are only 15 to 20 feet away from each other and in the same room, differences of as much as 8 dB in one or more of the 1/3 rd octave bands are regularly seen. This again is completely impossible unless the speakers are defective.



HPS® "Near-field" measurement on a real-time analyzer of a full range loudspeaker playing pink noise in a 600 seat theatre.
Figure 3

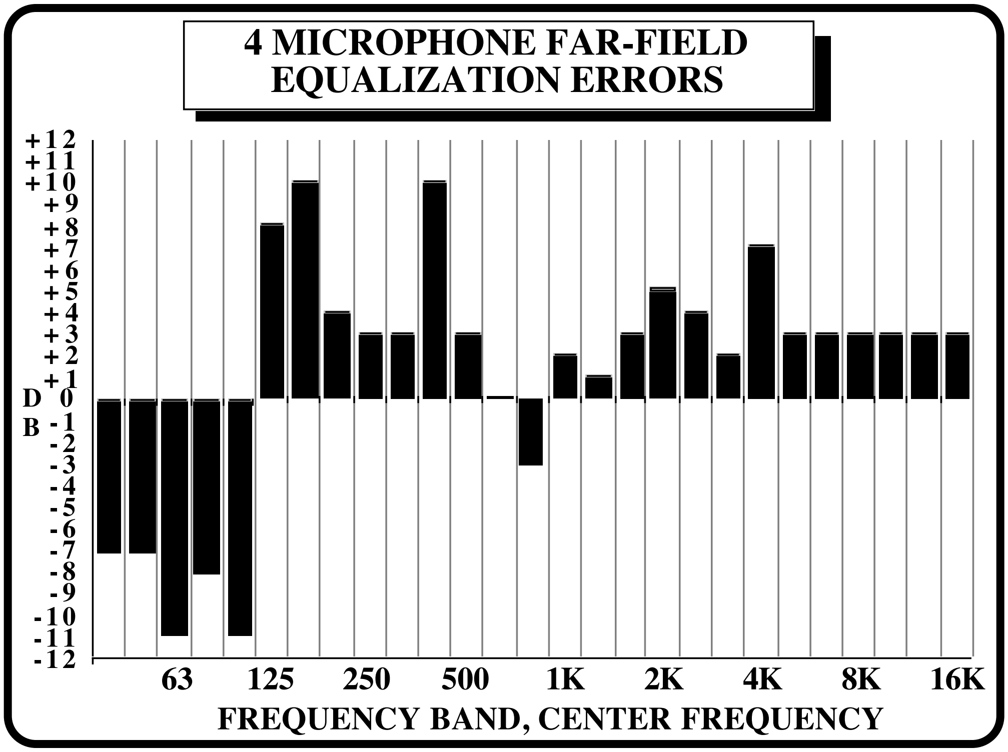


"Far-field" measurement of the same loudspeaker seen in Figure 3, in the same theatre at the same time. The differences represent measurement errors due to the larger amount of room reverberation being picked up by the microphone and contaminating the measurement. Equalizing a sound system using this measurement will result in severe errors in equalization.
Figure 4

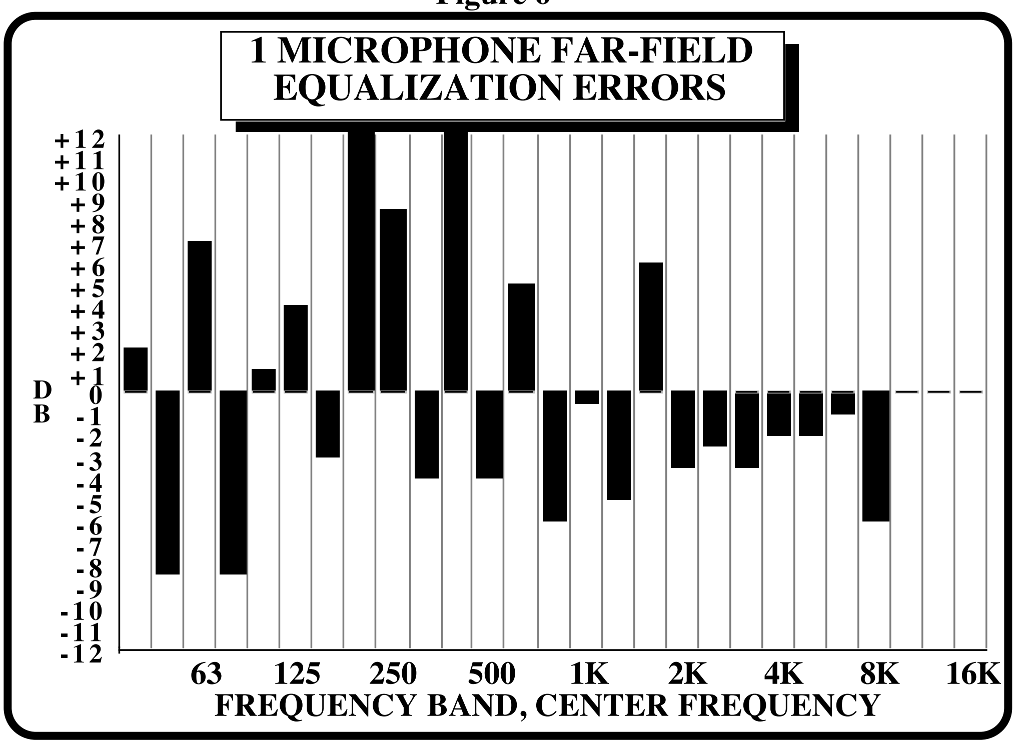


Typical measurement errors encountered when moving the measurement area from the "near-field" to the rear two thirds, or "far-field" of the theatre in Figure 3.
Figure 5

Unfortunately, many technicians have been trained to believe such measurements, even though they defy common sense. Sound systems are routinely equalized to "correct" these differences. In the process some rather huge distortions are actually introduced to the frequency response of the direct sound heard by the audience. Papers about this problem started appearing in the early 1970's, prior to the introduction of real-time analyzers to the movie theatre industry. These papers have been all but ignored, for reasons I have never been able to understand. A further note about the lowest frequency bands. Looking again at the bands from 40 to 100 Hz in Figures 2, 3 and 4, it needs to be understood that when using pink noise, the measured level of these bands is dependent of the size of the theatre and of the speaker systems.



Typical of equalization errors resulting in the use of a "far-field" multiplexed 4-microphone pickup.
Figure 6



Typical of equalization errors resulting in the use of a "far field" single microphone pickup.
Figure 7

Suffice it to say that the "X" curve appears to show that the speakers used in the 1970's, when the curve was researched, lacked deep bass. For when a full range flat speaker playing continuous steady state pink noise happens to measure with an elevated low end, the tone of actual program material sounds balanced. If the bass of such a large speaker is turned down, the sound becomes decidedly thin and unnatural. Unfortunately, there is no real way to know where these lower frequencies should measure relative to the mid frequencies. So unless a problem can be heard when listening to films, it's probably best not to equalize screen speakers below 80 to 100 Hz.

One of the arguments used in defense of the present theatre sound system measurement and setup practices is that they allow the technician to "equalize the room." This is a misnomer as there are no adjustments to the room at all. It might be better referred to as equalizing for certain effects of the room. Indeed there is some validity to this, as room acoustics do alter the perceived tone of what we hear from a loudspeaker. However, the effect is primarily limited to the frequencies below 400 to 500 Hz.

Unfortunately, steady state pink noise based measurements do a terrible job detecting these room effects no matter where the microphones are located. Even in the front of the theatre, room effects can be completely missed. This is due to the steady state nature of the pink noise and the conditions of acoustic equilibrium thus created in which the measurements are taken. These conditions very often mask these important room effects. Real sound, particularly speech, is transient and dynamic. So we can easily hear these (now unmasked) effects even though the analyzers tell us they aren't there. The moral is, if the ears say there is a problem and the analyzers say there isn't - the ears win.

So, how poorly tuned are today's theatre sound systems? Unfortunately, pretty poorly! In August 1995, I demonstrated the differences in sound quality resulting from three different equalization and measurement techniques - my own, plus the two methods outlined in the ISO and SMPTE standards. The program was produced for the International Theatre Equipment Association's annual convention and took place at General Cinema's highly successful Framingham, Massachusetts facility. I repeated this program in April 1996, for an audience of over 330 local members of the SMPTE, the Audio Engineering Society, the Boston Audio Society and the Acoustical Society of America.

The program consisted of selected recordings and film clips, played four times each. First, with the sound system equalized according to my own proprietary High Performance Stereo (HPS®) near-field tuning techniques. See Figure 3. Second, with the system equalized to show how it would sound using the typical far-field four-microphone measurements. See Figure 6. These settings were done by a senior industry sound technician. For

the third example, the sound system was equalized using a single microphone in several locations 2/3 rds back from the screen. See Figure 7. And fourth, the clips were again played back through the normal HPS® near-field tuning. Again, see Figure 3. To everyone's ears the HPS® near-field tuning sounded best by far. Here's why.

Figure 3 shows the normal response, typical for a theatre of this size with the HPS® near-field tuning. Figure 6 shows the changes to this equalization when four microphones placed in the far-field are used to measure the system. Figure 7 represents the changes made when one microphone is used in the far-field.

Just imagine what happens to clean smooth sound when it is passed through such equalizations as shown in Figures 6 and 7. As you can see, neither had any bass. The four-mike tuning was also excessively shrill due to the erroneous boosts above 1000 Hz. The boosts of as much as 10 dB in the 160 and 400 Hz range gave the sound a "honky' quality making everyone sound like they were speaking in a phone booth or through a fire hose. This "honky" characteristic, commonly associated with movie theatre sound as well as horn loaded loudspeakers, is bad sound pure and simple. Yet it has been so prevalent in theatres for over 60 years, that I've actually run onto one or two who thought there was something wrong when the sound was so natural, they didn't hear it. So, while there are some poorly designed speakers (horn loaded and otherwise) which can produce a honky quality, this aberration is also caused and exaggerated by improper equalization, as well as technicians who would seem to be all too forgiving.

The sound quality resulting from the single-mike far-field tuning (Figure 7) was also unacceptable. The high and low frequencies were essentially gone. The rest of the sound was pure mud with a heavy dose of mid bass.

In both of the far-field tunings the background sounds were diminished or wiped out altogether. The stereo image was narrowed. Music quality was also severely impacted. The sound from the improperly equalized surrounds all but vanished as the entire soundtrack collapsed into the screen.

The important thing to understand out of all this is that all three equalizations done for this presentation measured the same on a real-time analyzer and "conformed" to the ISO and SMPTE standards, or at least looked like they did. Yet the sound of each was *radically* different. The other important realization is that thousands and thousands of today's motion picture theatres are routinely mis-equalized with the kinds of errors shown in Figures 6 and 7.

CHAPTER 4

MAINTENANCE AND SETTING LEVELS

Chapter one was devoted to the common industry practice of using loudspeakers too small for their task, and the negative impact that this has on the presentation of digital soundtracks. Chapter two covered the deficiencies vs. the requirements of surround speakers and subwoofers, as well as the true amplifier power needs of digital motion picture sound systems. Chapter three departed from equipment issues and described how sound systems are routinely and often radically mistuned, due to the inaccuracy of the measurement techniques relied upon by today's technicians.

The obvious point of this paper has been to explore the often deficient "state of the art" exhibited in the majority of motion picture sound systems as well as to suggest what can and should be done to bring these installations up to par.

Without proper and competent attention to the aforementioned matters, no sound system can possibly be considered capable of meeting the extraordinary demands of both digital and analog motion pictures, let alone motivating patrons to return more often. Yet even such attention would not be enough. Among other things, there are still far too many weaknesses in the way sound levels are set, as well as the quality of the maintenance performed after the initial installation. I'll discuss the latter first.

MAINTENANCE

The sound system maintenance provided by this industry's (rather overworked and often under-appreciated) technicians needs to be dramatically improved. This is not at all due to either the quality of these technicians or their commitment to their jobs. Rather the improvement required is in the areas of training and, especially, the quality of the equipment provided to the technicians. An accurate, stable and easy to read real-time-analyzer is the primary sound instrument technicians must use. I have been constantly amazed at some of the absolute junk I have seen technicians struggle with over the years, when attempting to align sound systems. Try as they do, technicians cannot be certain of the accuracy of the results obtained, when their real-time-analyzers have been purchased on

the basis of price instead of performance. The sound-pressure-level (SPL) meters typically employed are often nothing more than the unreliably calibrated $40.00 units available at most shopping centers. Can anyone really take such equipment seriously at professional levels?

To be certain of my own work, I use an Ivie IE-30 real-time-analyzer with Ivie's handmade model 1134 random incidence microphone. I also carry a Bruel and Kjaer microphone calibrator which I use every day to ensure the accuracy of sound-pressure-level measurements. Barring a recording level problem, all of my sound systems operate with their faders at their normal positions and the sound levels in the auditoriums are correct.

No technician, it seems to me, should be expected to be able to deliver quality work unless he or she carries equipment equal or superior to this. Indeed, I insist that technicians servicing my sound systems be equipped with IE-30's, which I have calibrated. If they wish to carry their own microphone calibrator, I personally check these units as well before they are placed into service. As a result, we have achieved very consistent and accurate levels throughout our installations around the world. When necessary, I have provided this equipment to my clients at a substantial discount as I consider it so imperative that they have it.

As if managers, let alone ushers, don't have enough on their plate, maintaining booth equipment is not a priority.

When checking out sound systems not calibrated with reliable equipment, I typically find that the slit loss correction is often set too high, resulting in excessively bright sound. I also find that the sound levels can be anywhere from 2 to 10 dB high. Even worse, these level discrepancies are not consistent. Not all channels in a sound system are off by the same amount. Imagine what audiences must endure when surround levels are 6 dB too high, subwoofers are 10 dB too loud and the speakers are either being, or already have been destroyed.

Movie theatre technicians typically have learned their trade by apprenticeship. It seems to take about two years before one is "comfortable" in the field. In addition, some manufacturers have offered valuable training seminars to instruct technicians in the proper ways to install and maintain their equipment. Some of these sessions have been open to all, while others have been restricted to customers only.

The subject of training seems more acute now as the number of screens has increased

faster than the number of trained technicians. Because of this, theatre technicians are sometimes being stretched beyond reason. Maintenance, particularly preventive maintenance, can fall behind. This problem has been aggravated even more by new projectionists who lack experience and sufficient instruction as well as an increasing number of manager operated projection booths. As if managers, let alone ushers, don't have enough on their plate, maintaining booth equipment is not a priority. Personnel turnover is sometimes high and many are reported to lack the required skills. Technicians find themselves being called (sometimes at screaming levels) to theatres for the most routine matters, such as an exciter lamp replacement or something being unplugged, even the improper lacing of a projector. Often, technicians are not allowed to perform proper maintenance. When equipment of poor quality keeps breaking down and ought to be replaced, technicians are told to keep it going somehow, even though they know it will continue to fail.

All this gives technicians too little time to do their jobs. Presentation quality suffers.

> Large peaks that don't exist are "equalized out", resulting in actual holes in the frequency response.

Unfortunately, I have also encountered some examples where technicians did not follow the manufacturer's instructions and left a mess. Recently I visited a theatre with one of my installations and discovered that half the subwoofers were turned off. The subwoofer level (playing through the other half of the subwoofers that were working) was 10 dB too high. Surround levels are almost always set incorrectly in this theatre. Wires have been cut. Short circuits have been introduced and left in place. I could go on, but I won't. That particular theatre simply gets terrible service and always has. Frankly, being in Los Angeles, of all places, I expect better.

SETTING SOUND LEVELS

One of the most frustrating problems with modern cinema sound systems is measuring, setting and maintaining proper levels. I cannot say how many theatres actually play films at their correct levels. I can say, however, that far too many are too loud and even more (I suspect) are too soft. We do know that in a large number of theatres, films are much too loud if they are played at the "standard" fader settings. Once this happens, it becomes anyone's guess where the fader should be and often the guess is wrong.

As we know, the volume controls, or faders, on cinema sound processors are supposed to

be set at "7", or "0.0" for SDDS. When sound system levels are calibrated at these fader positions, the films are supposed to play at the correct level when the faders are left at these positions. Yet when one looks around at the fader settings in operating theatres, we very often see Dolby faders at around "4 1/2" to "5 1/2" and SDDS faders at "-5" to "-10". The sound levels in the theatres may be normal, or near so, but the faders are set anywhere from 4 to 10 dB below the positions where the sound systems were calibrated. What's going on?

Actually, this is a very complicated problem brought about, among other things, by a combination of poor measurement techniques, improper sound system setup procedures, room acoustics and even loud trailers. Let's look at a typical Dolby based installation first. Quite often, we find that rather than "7", we are forced to run the fader at "5" or "5 1/4" for Dolby encoded features, and 4 1/4" or "4 1/2" for DTS encoded features. These represent sound level calibration errors of about 6 dB for the Dolby films and about 8 dB for DTS. These are very large errors, and very common ones. It means that when the technician's SPL meter reads 85 dB with pink noise, a film will actually play at 90 to 91 dB. DTS films would run at 92 to 93 dB. These are excruciating levels.

STONE-AGE EQUALIZATION

These errors can be accounted for. The first 1 to 2 dB is commonly a mis-calibrated SPL meter. In randomly checking meters used by technicians over the years, I typically find their calibrations 1.5 to 2 dB low. So when one reads 85, it is really 87. Further error is caused by improper sound system equalization. As I pointed out in chapter 3, the common practice of placing measurement microphones in the rear 2/3 rds of the theatre results in major measurement errors and, subsequently, equalization errors. Though an analyzer indicates a proper equalization has been achieved, the frequency response of the system is actually misadjusted, and usually severely misadjusted. These mis-adjustments can account for sound-pressure-level measurement errors of 2 to 4 dB in most cases.

Here's why: Suppose we have a perfectly flat loudspeaker playing pink noise at 85 dB SPL in a 400 seat theatre. If we were to turn off the woofer, the SPL meter reading would drop about 3 dB. Though the measured pink noise level is now lower, the level of speech played through the speaker would change very little. In other words the output levels of the middle and high frequencies would not change. We only turned off the woofer. If we then increase the output level of our woofer-less speaker so that our SPL meter would again read 85, we will also increase the speech level by 3 dB. So it's easy to see how reducing the bandwidth of a loudspeaker will fool an SPL meter, and a technician if we are not

careful.

It turns out that mis-equalized loudspeakers can cause the same effect. Recalling again from part 3, equalization errors of as much as 8 to 11 dB in various 1/3 octave bands are common results of the current outdated microphone placement practices. Large peaks that don't exist are "equalized out", resulting in actual holes in the frequency response. (See Figure 6 in the previous chapter). This, in turn, causes SPL meters to display readings that are about 2 to 4 dB too low.

The never ending menace of distortion also comes into play when experiencing digital sound levels.

Let's consider a theatre where the measurement error caused by such mis-equalization happens to be 3 dB. When added to the 2 dB error of the SPL meter itself, we have a total error of 5 dB. We will read 85 dB on our meter with pink noise, but the films will play at a level equivalent to 90 dB. In such a theatre, when we calibrate the sound system with the fader at "7", films will run at "5 1/4", as each point on the Dolby fader scale is equal to about 3 dB. This indeed is the situation in many theatres.

In addition to equalization and SPL meter errors, many, including myself, have encountered difficulties with the levels of both DTS and SDDS soundtracks. As an example, I have consistently found that DTS films play 2 dB too loud when the DTS player is calibrated with the fader at "7". My conclusion has to be that either the soundtracks (including dialog) recorded on the release discs are all 2 dB high, or the pink noise levels on the DTS setup discs are 2 dB low. I have spoken with DTS about this. It seems that the procedures they followed when recording their reference pink noise levels were correct. But, for me at least, there is a 2 dB discrepancy somewhere (and it may indeed not be anything to do with DTS's procedures). DTS disputes this pointing out that they are merely duplicating the master recording for each film. However true this is, and I certainly accept DTS's ability to do this, I simply cannot listen to films played at the normal DTS levels, nor can I find a theatre that is not forced to turn down the faders for these presentations.

Since I wish to avoid the level setting free-for-all that occurs when faders must be turned down, I have elected to do what is needed to ensure that all the levels of all sound formats are equal in all my theatres. The best way I have found to compensate for DTS is to increase the fader setting by 3/4 of a point (.7 on CP-500's) when calibrating a DTS player. The calibration levels for each channel stay the same as recommended by DTS, only the fader's setting for DTS calibration is changed. After returning the fader to its normal

position, both Dolby and DTS features will then play at the same levels without changing the fader. (No one, including producers or DTS executives, has ever listened to these levels and told me that they were too soft).

Failing to do this will add 2 dB to our previously accumulated errors of 5 dB (for Dolby presentations) and becomes 7 dB for DTS. In our example theatre above where Dolby encoded films play at fader settings of 5 1/4, DTS films would need to run at around "4 1/2" to "4 3/4". Again, we regularly encounter this situation in theatres.

Since I wish to avoid the level setting free-for-all that occurs when faders must be turned down, I have elected to do what is needed to ensure that all the levels of all sound formats are equal in all my theatres.

SDDS faders use a different scale and are supposed to run at "0.0". They provide an adjustment range of ± 10 dB. Technicians have complained that when SDDS processors are calibrated at "0.0", some films are so loud, even at a fader setting of -10, that they cannot turn them down enough. This can also be accounted for. When setting levels for SDDS processors, we are vulnerable to the same accumulated errors of around 5 dB, attributed to SPL meter and equalization errors. Occasionally, features can be released with soundtracks which are recorded at excessive levels. Played at reduced fader settings, these films usually, though not always, sound normal with normal dynamic range. None of the digital soundtrack formats has been immune to this problem.

When an SDDS feature is released with the soundtrack recorded 3 to 4 dB too loud, it can cause special difficulties in theatres. As examples, last summer's VOLCANO and CON AIR both suffered from this problem. Also unfortunate is that virtually all SDDS trailers are recorded 5 to 6 dB too loud. Ordinarily, this would be a simple matter of turning down the SDDS fader to "-4" to "-6". But when it is already running at "-5" for normal films due to calibration errors, one may need to be able to set the fader below "-10", and that exceeds the range of the SDDS fader.

ROOM ACOUSTICS

As if all these potential accumulated errors were not enough, it is also possible for room acoustics to cause an SPL meter to mislead us. An example of this can occur in older or larger theatres with longer reverberation times. In such theatres a pink noise reading of 85 dB may actually correspond to a program level equivalent of 83 dB. In this case films

would play too low.

The opposite effect can occur in a smaller theatre with poor bass response or a theatre equipped with speakers with small low frequency radiating areas. An SPL meter / pink noise reading of 85 dB may correspond to a program level of 86 or 87 dB, causing films to play too loud.

DISTORTION MAKES IT WORSE

The never ending menace of distortion also comes into play when experiencing digital sound levels. Distortion makes sound seem louder. In part one of this special series, I wrote about the inadequacies of typical two-way theatre speaker systems. One of the major problems with these systems is that the high frequency drivers of such configurations often cannot and do not have the output required of the highest frequencies of motion picture sound. This is especially true in rooms the size of movie theatres.

As noted in chapter one, when pushed too hard, these drivers cause distortion and the familiar harsh sound so many have complained about for so long. Add to this, the excessive treble brightness which often results from the improper equalization caused by the inaccurate measurement techniques employed today, and/or the distortion caused by inadequate amplifiers, and we have a pretty hopeless mess.

Whether caused by the speakers or otherwise, distortion can make the sound in a theatre seem too loud even when it isn't. This is very important. Imagine the effect it has in theatres where the sound is indeed too loud. Is there any wonder why there are so many complaints about loud movies?

LOUD TRAILERS

It's hard to write about the issue of sound levels without further mentioning the obvious problem of loud trailers. "Plague" might be a better description. For whatever the reason, trailers are believed, at least by those responsible for them, to sell better when they are very loud, uncomfortably loud or simply too damn loud. Anyone who has mixed sound for live audiences, as I have (once for a concert so large, it was listed in the GUINNESS BOOK OF RECORDS), or anyone with an ounce of sense, knows that the best way to get the attention of an audience, is to make the sound just a little too soft. Loud trailers have caused more customer complaints than is possible to count. Yet they persist. The tragedy is that when managers and projectionists are forced to lower faders due to loud trailers, the features tend to get played at the lower settings, completely ruining the presentation.

Chapter 5

GETTING A BETTER EQ

While the original cinema sound system far-field measurements and equalization procedures seem to work well with the older speakers in use when the "X" curve was researched, modern installations require a more critical approach. Since no current technology exists which can measure what something sounds like, we must learn to get more accuracy out of the real-time analyzers we have and also learn to better interpret their displays.

To that end, the following suggestions are offered to technicians responsible for equalizing motion picture sound systems. Some of these suggestions may seem like heresy. But they're worth a try and certainly won't hurt. Sound system tuning is as much an art as balancing a symphony orchestra. It takes years to develop the skills required. Even then it's still an art. The following should be a good beginning.

1. Set the real-time analyzer for maximum averaging time and minimum resolution (2 or 3 dB per division), whenever speakers are measured.
2. Place all the measurement microphones in the third row of the theatre. If using a single microphone, place it in the middle third of the third row where the frequency response displayed looks the worst in the 100 to 500 Hz range.

3. If the screen speakers are all the same, as is usually the case, equalize the center channel for a smooth response, but not better than ± 2 dB, Avoid boosting. Use cuts only if at all possible. Then adjust the controls for the other screen channels to match the settings of the center. Ignore the analyzer's display of the frequency response of the other speakers. However, the analyzer may be useful in balancing the high and low frequency sections of a bi-amplified speaker system. Setting the equalization for all the screen channels the same as the center will ensure that they will sound the same. Do not adjust any 1/3 rd octave bands below 80 Hz. If the low frequency bands below 100 Hz look elevated, do not be concerned. They can be left alone for now.

A special note about third row measurements of speaker systems with constant directivity horns: When these horns are placed behind a screen, the coverage angles of the higher frequencies are increased around 20° in all directions beyond the screen. This directs an

excessive amount of these high frequencies towards the front rows. The sound in these seats may normally be too bright when the rest of the theatre sounds normal. In such a case, the "X" curve will not be seen when the microphones are in the near-field and the real-time analyzer's display will show a more nearly flat high frequency response.

4. Move the microphones. If using four microphones, place them along the center line of the theatre, starting from the center of the seating area to about 10 feet from the rear wall. If using a single mike, place it in the center of the seating area.

5. Adjust the equalization of the surrounds for a flat response ± 2 dB from 100 to 10000 or 12000 Hz. The equalization adjustments should be the same for both surround channels.

6. Set the optical surround delay so that it equals, in milliseconds, the total length of the theatre plus 10. A 70 foot long theatre would therefore have a delay of 80 milliseconds.

7. Using only the microphone located in the center of the seating area, set the processor to the stereo optical format "04". Adjust the equalization of the subwoofer to cut everything above 80 Hz.

8. Set the fader to "7". Adjust the sound pressure levels (SPL) for each channel using the one microphone placed in the center of the seating area. This location is the most symmetrical between all the speakers and will provide the best channel to channel balance. The optical surround level is best set with the Dolby CAT-151 film and the optical surround delay at "0".

9. When finished, listen to a good 20 minutes of familiar feature film material - not trailers. Make equal adjustments to each channel's treble as your ears require. If peaks in the frequency response can be positively identified, make adjustments to all three channels accordingly. Also, adjust the fader for a normal <u>dialog</u> level. In terms of SPL, normal dialog (not shouting or whispering) peaks at around 80 dBc, with occasional peaks to 85 or 86 dBc. Note the new fader setting. If other than "7", reset the fader to a point equal on the other side of "7". (If the fader is at 6 1/4, reset to 7 3/4). Readjust all SPL levels at this fader setting and note it as the calibration setting for future servicing. Recheck the reference film <u>dialog</u> level. The fader should be at "7" when the level is normal.

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