POWER RATINGS of LOUDSPEAKER SYSTEMS

FACTS, FIGURES, AND FUSING (IF NECESSARY) TO ALLAY YOUR FEARS OF BLOW-OUT

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THOUGH it sometimes appears that modern household-appliance technology has made us into a nation of expert switch-flickers, button-pushers, and dial-twiddlers, there are moments when confidence and courage fail us and our electronic servants seem to be either slightly confusing or downright dangerous. And that is why manufacturers of stereo components quite often receive letters from new customers who are intimidated by their latest audio acquisition—they aren't sure just how to install a unit or to operate its controls without damaging something.

Loudspeaker manufacturers probably get the bulk of this anxiety-motivated correspondence, perhaps because many people are mystified by loudspeaker power ratings and their relationship to amplifier power ratings. To clear the air at the start, the timid should be assured that unless a stereo rig is plagued by loose jacks and plugs, or is being used by unsupervised teen-agers (whose notions of reasonable loudness approach the threshold of pain), the chances of blowing out loudspeakers are really very slight. Since high-quality loudspeakers are generally far more rugged than the cheaper types, you really have to go out of your way to damage the usual hi-fi speaker. Most mishaps simply never would have happened if audiophiles had been careful to observe the following *don'ts*:

1. Don't use ordinary household a.c.-line plugs for speaker connections. If you do, sooner or later someone will plug one of your loudspeakers into a wall outlet. The resulting sound output is highly dramatic, but short-lived and expensive.

2. Don't turn up the bass control *and* switch on the loudness compensation *and* crank up the volume all at once. Because of the ear's relative insensitivity to very low frequencies, greatly amplified turntable rumble doesn't sound very loud. But it can overdrive and possibly damage your speakers. For the same reason, be careful when you use test records with low-frequency test tones. Cone excursion doubles for every octave reduction in frequency, and it is therefore very easy to overdrive a speaker in an attempt to achieve an adequately loud signal at the very lowest frequencies.

3. Don't plug or unplug tubes or audio-cable connectors while the system is turned on. The sudden loud ZAP may be the last sound your speakers ever produce.

It seems logical to assume that accidental damage can be avoided by matching your amplifier to your speakers, so that a loudspeaker rated at 30 watts is used with a 30-watt amplifier, and so on. But things aren't that simple. To understand why, let's look at a few facts about loudspeaker *vs.* amplifier ratings.

Loudspeaker power ratings actually refer to two separate factors: (1) the minimum amount of amplifier power that is required to bring out the best in a speaker under average playing conditions, and (2) the maximum amount of power that can be applied to a speaker without the risk of electrical or mechanical damage. We will discuss the latter point first.

Technically minded readers are probably aware that a loudspeaker presents a complex reactive load to the amplifier. Because the magnitude and phase angle of a speaker's impedance varies so widely over its frequency range, the actual power drawn while reproducing program material is very difficult to measure. However, for our purposes, it really doesn't matter how much actual power is involved. We can calculate power on the basis that a loudspeaker's impedance is equivalent to a simple resistor of the same value. This is valid because the frequency range in which the peak program energy occurs is the same frequency range in which a loudspeaker's actual impedance is nearly equal to its rated impedance.

By common agreement, loudspeaker power ratings are calculated using the rated impedance of the speaker at 1,000 Hz. "But," you say, "I don't listen to 1,000-Hz tones, I listen to music. My speakers are rated at '35 watts program.' Exactly what does that mean?" Chances are it doesn't mean *exactly* anything. There is no standard method for rating a loudspeaker's power capacity, and each manufacturer has his own notions of how to arrive at meaningful (or suitably impressive) figures. Here are a few typical examples of loudspeaker power ratings taken from ads and specification sheets: "8 watts program" (measuring method not specified); "30 watts integrated program material" (measuring method not specified); "recommended amplifier power—10-50 watts"; and "150 watts instantaneous peak power" (how long is "instantaneous"?).

It is obvious that such ratings serve only as general guides (see the box "Loudspeaker Power-Rating Terminology" on page 58). But at best, power *capacity* is only half the story. After all, we really are not as interested in what can be put into a loudspeaker as in what comes out. And so we get into the question of efficiency —which is a measure of what percentage of the electrical power input to the speaker is converted to acoustical power output from the speaker. High-quality loudspeaker systems designed for home use run from about 0.25 per cent efficient to perhaps 20 per cent. Most bookshelf systems average around 0.5 to 1 per cent efficiency, while the larger systems are usually 3 to 5 per cent. Considered only in terms of the amount of sound it will put out, and all other factors being equal, a 3 per cent efficient loud-

Figure 1. A normal speaker with its cone and voice coil assembly in the "at-rest" position is shown at (A). When the speaker is overdriven by excessive amplifier signals, the mechanical centering elements (inner and outer suspensions) are stressed as shown at (B). As the cone is driven outward, the voice coil may leave the gap; as the cone is driven inward, the voice coil may "bottom," striking parts of the magnetic assembly. A less extreme overload may not cause damage, but will result in excessive distortion.

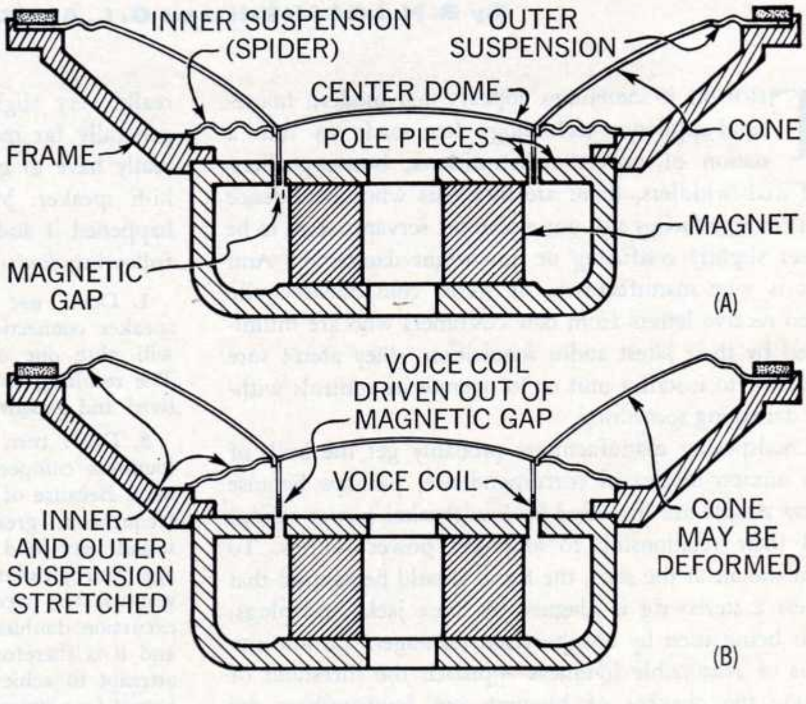
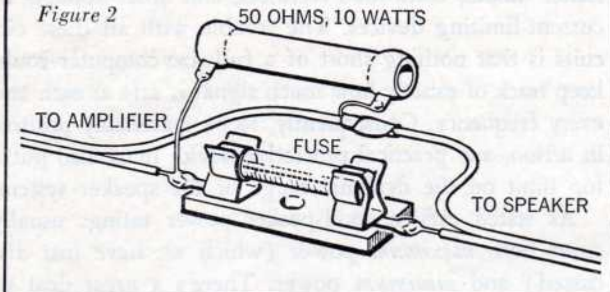


Figure 2



Speaker power rating		Fuse rating in amperes 4-ohm speaker	8-ohm speaker	16-ohm speaker
7-10 watts	Safest	½	¼	⅛
	Good	1	½	¼
	Maximum	2	1	½
10-15 watts	Safest	¾	⅜	¼
	Good	1½	¾	⅜
	Maximum	3	1½	¾
15-25 watts	Safest	1	½	¼
	Good	2	1	½
	Maximum	4	2	1
25-35 watts	Safest	1½	¾	⅜
	Good	3	1½	¾
	Maximum	6	3	1½
35-50 watts	Safest	2	1	½
	Good	4	2	1
	Maximum	8	4	2
50-75 watts	Safest	2½	1½	¾
	Good	5	3	1½
	Maximum	10	6	3

Use standard 3AG fuses, not slow-blow types. Start with the "safest" recommended value. If this blows on loud passages, substitute the corresponding "good" value. If you try to use a fuse of higher amperage than "maximum," chances are that it will offer no protection at all.

speaker system capable of handling 20 watts of power will put out more usable sound than a 0.5-per cent system that can take 40 watts of amplifier power.

Your high-fidelity dealer can provide rough comparisons between efficiencies of the various loudspeakers he sells. He knows from experience that brand A, for example, generally requires an amplifier twice as powerful for equivalent undistorted loudness as brand B, and that, on the other hand, brand C is more efficient than A *or* B, but distorts badly before it reaches even a moderate loudness level.

While a loudspeaker's maximum power rating is usually based on the strongest short-term signal that can be handled without permanent damage, an amplifier's power rating is based (or should be) on its long-term power output at a specified distortion. A good 50-watt amplifier can produce 50 watts at low distortion through the full audible-frequency range. In the 1,000-Hz region it probably can produce 60 watts before clipping. If a strong signal drives the amplifier into the clipping region, it may conceivably feed 85 watts of power—mostly distortion, but power nonetheless—into the loudspeaker! This is why the power rating of an amplifier cannot be relied upon to protect the associated loudspeaker system. Under certain conditions, a loudspeaker system can be damaged when driven by a signal *below* its rated power capacity. This can occur when there is sufficient single-frequency energy fed to one of the drivers in a two- or three-way system, such as when an amplifier oscillates ultrasonically and burns out a tweeter, or when high-level sine-wave test tones are fed to a system.

So much for "matching" the power ratings of loudspeakers and amplifiers. As a matter of fact, many audiophiles use very powerful amplifiers with speakers rated at only 25 or 30 watts so that there is sufficient amplifier power reserve to handle fleeting transient peaks without distortion. As long as normal precautions are observed, such combinations are perfectly safe.

WHAT happens to a loudspeaker when things go wrong? Since only a small part of the electrical power fed to a speaker is converted to sound, it follows that most of the power is dissipated as heat. Excessive heat may expand or physically distort the voice coil until it touches the pole pieces (see Figure 1), it may weaken the bond between the voice coil and the cone assembly, and in extreme cases actually melt solder connections or a portion of the voice coil itself.

Heavy-duty woofers, with their large copper voice coils and massive magnetic assemblies (which act as heat sinks) can dissipate considerably more heat than smaller, more delicate tweeters. Fortunately, ordinary musical material has relatively little energy above 2,000 Hz or so, and a tweeter doesn't need to handle as much power as a woofer. But if something other than normal program material is amplified—say, test tones, spurious oscillations, or the signal produced when a tape is rewound at high speed without being lifted from the playback head—a high-frequency loudspeaker may burn out without warning.

The woofer has its own problems at very low frequencies, where a comparatively small signal results in long cone travel. If the cone is repeatedly forced beyond its normal limit, mechanical damage results (Figure 1B). The cone may develop cracks or tears, the voice coil may be driven out of the magnetic gap and "freeze," or the cone can be deformed so that the voice coil is forced out of concentricity and scrapes against the pole pieces.

In regard to protecting your loudspeakers, make sure to observe the three "don'ts" at the beginning of this article. If possible, it is a good idea to check the low-frequency-loudspeaker cone visually when the system is operating at high volume levels. Remove the grille-cloth frame or shine a strong light through it so that you can observe the motion of the cone. You may be surprised to find that even with a quiet turntable, it doesn't take much bass boost to produce substantial cone excursions. A good low-frequency loudspeaker can stand occasional cone excursions that you might think were impossible if

Loudspeaker Power-Rating Terminology

LOUDSPEAKER power ratings are even more confused than amplifier ratings. If a loudspeaker is rated at 30 watts with such qualifications as "program power," "integrated program material," or "continuous program," this is not the same thing as 30 watts of continuous sine-wave signal. Music and speech are made up of irregular bursts of high-level energy separated by longer stretches of relatively low-level material which gives the speaker a chance to "cool off." Therefore, the program-power rating of a loudspeaker is two to ten times its maximum safe sine-wave input. However, if a manufacturer rates a loudspeaker at "30 watts" with no qualifying phrases, you can be pretty sure that it is a program-power rating.

If "peak power" or "instantaneous peak power" is given, this may be exactly twice the program-power figure (using the most common definition of peak power), or it may be several times the program-power rating. In the latter instance, the manufacturer may state that his program-power rating is based on measurements of program-power taken with a standard VU meter. Since program peaks too brief to be indicated by the meter are 6 to 10 dB greater than what is shown, the seeming discrepancy can be defended.

There is also the question of power *vs.* frequency. The greatest energy in speech or music is concentrated within a few octaves of 1,000 Hz. A loudspeaker that can easily handle 30 watts of normal program material may nonetheless be damaged if this much power is fed to it at very low or very high frequencies.

It can be seen that a given loudspeaker might legitimately be rated at 10 watts (steady-state sine-wave), 40 watts (continuous program), 80 watts (peak program), or as much as 150 watts (momentary peak or instantaneous peak), but it would be helpful to users if manufacturers were to spell out the basis of their ratings. It would also make things much easier if all loudspeakers were rated for power input *vs.* distortion, but there are just too many problems in setting up uniform loudspeaker measuring techniques to make such a rating method feasible at present.

you hadn't actually seen them. But if you discover that, for one reason or another, the woofer cone *continually* strains at its moorings, you may be sure that it is only a question of time before it finally tears loose. If the cone constantly pumps back and forth a quarter of an inch or so when in normal use, there may be excessive turntable rumble, poor turntable shock mounting, acoustic feedback from loudspeakers to phono pickup, amplifier instability, or a combination of these ailments.

What about fuses? Fusing offers some protection, although massive overloads can blow out a speaker and its associated fuse simultaneously. Moreover, to fully protect against overload, the fuse may also blow on loud musical passages that the speaker could have safely reproduced. However, if you want to take every possible precaution, follow the recommendations in Figure 2.

From time to time, special speaker-protection circuits are published in audio journals. These may use relays, Zener diodes, controlled rectifiers, and other voltage- or current-limiting devices. The trouble with all these circuits is that nothing short of a full-size computer could keep track of exactly how much signal is safe at each and every frequency. Consequently, to be reasonably positive in action, any practical protective device must also put a top limit on the dynamic range of the speaker system.

As stated earlier, loudspeaker power ratings usually cover both *maximum* power (which we have just discussed) and *minimum* power. There's a great deal of misunderstanding about the relationship of the two ratings. Simply stated, it is the difference between how much power the speaker will take without damage, and how much power the speaker needs in order to perform at its best. The second factor has to do with efficiency, the first does not. There is no reason why a 5-watt amplifier can't be used to drive a loudspeaker system with a 50-watt-maximum rating. If a loudspeaker manufacturer recommends that some particular model be used with amplifiers having an output of at least 20 watts, it means that a less powerful amplifier may produce excessive distortion or loss of low bass and high treble when the combination is played very loudly. It does *not* mean that 20 watts are needed to get any sound at all from the speaker system.

Ten years ago, a 15-watt amplifier was thought to be a very powerful amplifier indeed, and only a few eccentrics insisted on having brutes capable of producing 25 or 30 watts at less than 5 per cent distortion. Today's loudspeaker systems have in general sacrificed efficiency for smoother and more extended response, and at the same time the dynamic range of records and tapes has steadily increased. This means that amplifiers and loudspeakers must reproduce momentary peaks of considerably greater intensity than were likely to be encountered a decade ago. If you like to play your stereo system at concert-hall intensity now and then, your amplifier should be able to put out at least 25 watts per channel with less than 1 per cent distortion. If you expect to run additional extension loudspeakers throughout the house, proportionally more available power is desirable.

In conclusion, it should be emphasized that loudspeakers are rarely overdriven in home-music installations. Playing your system every day at loud levels (within reason) won't "tire" the loudspeaker systems. A fine loudspeaker is, in many ways, like a fine piano or other musical instrument. It thrives on continued usage, and occasional overloads will not change its performance qualities. As long as you use a little care in the operation of your stereo installation, you simply don't have to worry about blowing out your loudspeakers.

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