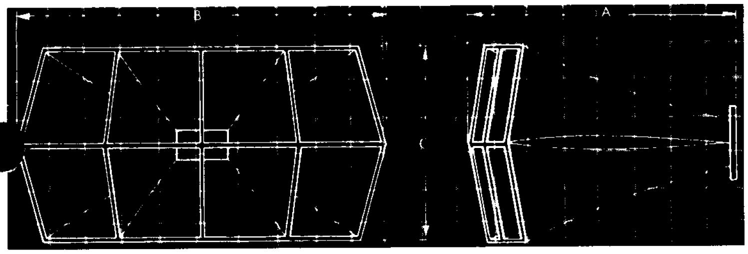


ALTEC ENGINEERING NOTES

TECHNICAL LETTER NO. 230

APPLICATION OF COMPONENT LOUDSPEAKER POWER CAPACITY RATINGS TO THE DESIGN OF TWO-WAY SYSTEMS

By

Mark E. Engebretson

Sound contractors are called upon regularly to design loudspeaker clusters for which a meaningful system power capacity rating is required. The purpose of this paper is to provide guidelines that will enable a sound designer to accurately predict system power capacities and requirements.

LOUDSPEAKER FAILURE MODES

In recent years, a great deal of experience has been accumulated on the nature of loudspeaker failures. Manufacturing defects will not be discussed, as properly built products will meet or exceed the ratings shown in Figure 2, and are **miniscule** when compared to field failure as a result of product misapplications.

Three types of field failure are experienced; mechanical deterioration of the component due to excessive cone/diaphragm excursion, mechanical failure due to mishandling or improper installation, and voice coil (electrical) failure.

EXCESSIVE CONE/DIAPHRAGM EXCURSION

This failure problem is common to both low-frequency loudspeakers and high-frequency drivers, although more common in high-frequency components. Excessive cone/diaphragm excursion occurs **only** when the prescribed frequency/power limits are exceeded. Guitar speakers fare better in this respect than high fidelity types (411/416/515), due to their inherent mechanical stiffness and limited excursion capability; however, large scale reinforcement systems should **always** include appropriate high pass filters. When bass loudspeakers are driven to the limit (or beyond) of their linear travel capability, voice coils may become deformed or out of parallel with the voice coil gap, resulting in voice coil rubs.

Altec high-frequency drivers are available in three construction types; phenolic diaphragms, aluminum diaphragms and composite (symbiotik) diaphragms. Phenolic diaphragms are not subject to mechanical failure. Aluminum diaphragms most often fail due to mechanical fatigue, which is the direct result of work hardening from excessive excursion at high power. At frequencies over 5 kHz, type 288 and 291 drivers have substantially identical power capacity; however, the rating of the 288 has been reduced to allow for excursion requirements below 1 kHz. An evaluation of field failures of aluminum diaphragms over 2 years has yielded virtually zero voice coil failures.

Composite diaphragm/voice coil assemblies have exhibited few mechanical failures other than separation of the voice coil from the diaphragm due to excessive heat (excessive power) and separation of the aluminum dome from the voice coil/surround assembly due to unusual excursion. These unusual excursions are invariably due to lack of proper protection between the power amplifiers and the HF driver. Examples

Litho in USA CP-474-2.5K

have been retrieved from the field wherein a direct-coupled (full-range) DC amplifier has been connected directly to the drivers without any protection, allowing subsonic turn-on and turn-off transients to be transmitted.

Biamplification (other than the Altec 1609A) requires the use of high pass filters between the power amplifier and HF drivers.

MISHANDLED AND IMPROPERLY INSTALLED COMPONENTS

Low-frequency loudspeakers are subject to mishandling and improper installation defects. The voice coil centering tolerances employed in the manufacture of Altec bass loudspeakers place these loudspeakers in the precision-instrument category. Great care must be exercised in installation and mounting bolt torquing to ensure that the frames do not twist and result in a limitation of linear excursion capability or voice coil rubs.

High-frequency drivers must be protected from mechanical shock prior to, and during, installation. Precision voice coil gaps are maintained in production; however, a short drop to a hard surface will alter the pole piece/top plate spacing sufficiently to induce rocking of the diaphragm under excitation, even if the voice coil does not rub.

Contractors are urged to bench check each and every component to ensure that no freight damage has been sustained prior to installation.

VOICE COIL FAILURES

Voice coil failures are usually a direct result of excessive power application. Exceptions are voice coil failures resulting from rubs, which can be attributed to mechanical problems previously described.

If failure problems are encountered, carefully consider the following conditions:

1. Is the device failing due to excessive excursion? If so, provide appropriate protection.

2. Is the device failing due to an improperly centered pole piece? If so, replace.

3. Is the driving amplifier clipping excessively? If so, replace with **greater** power, provided driver capacities are not exceeded.

4. Is the device failing due to single-frequency (sine wave or acoustical feedback) excitation? If so, **reduce** the amplifier power to a reasonable system-component, power-level rating (described within this Tech Letter).

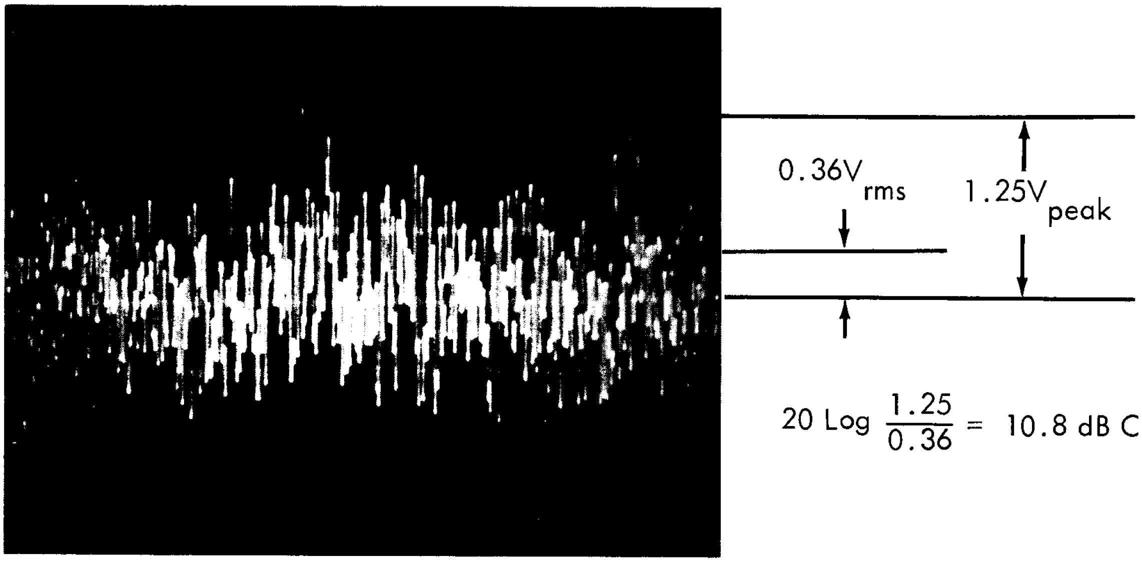
5. All of the above.

DESCRIPTION OF POWER CAPACITY RATINGS

Four methods of rating power capacity are in use at Altec for industrial and professional loudspeaker products. These differ significantly from ratings employed for consumer products, and bear little resemblance to those employed by competitors.

At Altec, band-limited pink noise (constant energy per octave) is employed as a test signal. The peak-to-rms ratio of the test signal voltages closely approximates the crest factor observed in typical program material. Pink noise, therefore, represents an accurate indication of the heating capacity of the device under test and, due to the crest factor present in the signal, an indication of the loudspeaker's transient power capacity.

To establish a power rating, the loudspeaker mechanism/system must sustain the test signal for a minimum of 24 hours. For the purpose of power capacity measurement, watts are measured on the basis of **voltage** times **current**. Figure 1 is an oscilloscope photo of pink noise, indicating the rms and peak voltage values for a typical signal.



$$20 \text{ Log } \frac{1.25}{0.36} = 10.8 \text{ dB CREST FACTOR}$$

Figure 1. Oscilloscope Photo of Pink Noise

A. Loudspeaker Systems

Full-range loudspeaker systems are subjected to a 20 Hz to 20 kHz band of pink noise. The signal is attenuated 12 dB/octave below 20 Hz and above 20 kHz. Dividing networks that employ adjustable HF shelving controls are set to the top (maximum) of the *normal* operating range during life test.

B. Low-Frequency Loudspeakers

Low-frequency loudspeakers are subjected to a 20 Hz to 1000 Hz band of pink noise for the purpose of rating power capacity. High pass and low pass filters with 12 dB/octave slope rates are employed.

C. High-Frequency Compression Drivers

The test signal is band-limited pink noise, as above, from 500 Hz to 20 kHz in the measurement of compression drivers.

D. Special Cases

Special cases consist of devices designed to operate over a limited bandpass. An example of such a device is the 409-8C loudspeaker. The 409-8C is an 8-inch coaxial loudspeaker designed to operate from 60 Hz to 12 kHz in distributed sound system applications. Any attempt to gain useful output substantially below 60 Hz will result in excessive cone excursion, and the subsequent premature failure of the loudspeaker. Such devices have the power bandpass specified. Attenuation of the input test signal at 12 dB/octave below and above the specified limiting frequencies is understood. Where a limited bandpass is specified, sound contractors are urged to limit the bandpass of the program material accordingly. Variants of 814A and 815A also belong to this category.

We believe the foregoing provides an accurate and meaningful indication of the continuous power capacity of loudspeakers. To compare this method of rating power capacity to *peak power, music power, program power* or *warble tone* power ratings would require the compounding of monumental data files, and life testing of each and every component so rated. For comparison, however, a competitor's 4-inch voice coil/ metal diaphragm driver (rated at 60 watts *continuous program*) failed at 12, 14, 15 and 17 watts of 500 Hz to 20 kHz pink noise when four samples were evaluated.

DETERMINATION OF TWO-WAY SYSTEM PROGRAM POWER CAPACITIES

The first consideration that must be evaluated in the determination of two-way system power capacities is the bandwidth the system is to reproduce. Careful attention must be given to **low-frequency cutoff** for both low-frequency (bass) loudspeakers and high-frequency (treble) drivers. Figure 2 tabulates pink noise power ratings and power bandwidths for standard Altec low- and high-frequency components.

Item	Rated Power Bandwidth (Hz)	Watts (E x I)
288-8G	500 – 20K	15
288-16G	500 – 20K	15
290-4G	300 – 20K	100
291-16B	500 – 20K	40
292-8A	300 – 20K	100
403A	60 – 12K	12
405-8G	60 – 12K	10
409-8C	60 – 12K	16
411-8A	20 – 1K	100
414-8B	20 – 1K	60
416-8A	20 – 1K	75
419-8B	20 – 20K	50
421A	20 – 1K	100
421-8H	20 – 1K	150
515B	20 – 1K	75
604-8G	20 – 20K	65
616-8A	20 – 20K	40
730C	300 – 20K	50
802-8D	500 – 20K	10
806-8A	500 – 20K	10
807-8A	500 – 20K	30
808-8A	500 – 20K	30
814A	100 – 1K	100

Figure 2. Pink Noise Power Ratings for Altec Components

Designers are urged to employ high pass filters for all systems that might be subjected to power demands at frequencies below the specified low-frequency power rating limit. Above all, recognize that live reinforcement of modern music **demands** the use of a high pass filter if rated power capacities are to be realized, due to significant amounts of subsonic and extreme low-frequency energy present.

When two-way systems are divided at 500 Hz or 800 Hz, the power is divided approximately equally between low and high frequencies (one decade either direction). Therefore, **half** of the available power will be delivered to the low-frequency section and **half** of the available power will be delivered to the high-frequency section on full-range program material.

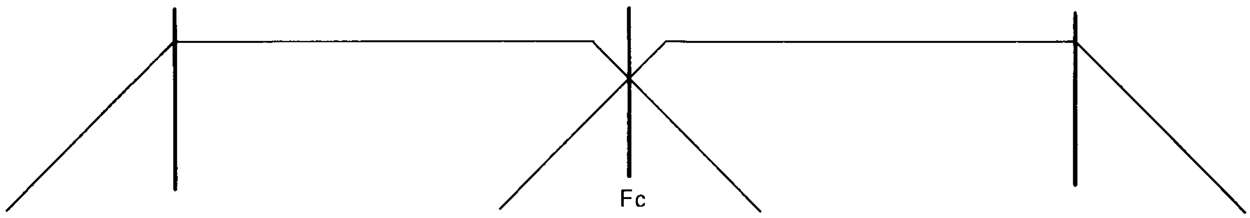


Figure 3. Decades Above and Below 500 Hz/800 Hz Crossover Points

When combining elements in systems, a reasonable assumption to make is that the system power capacity for **program** material should be predicated on the percentage of the input signal that would be impressed upon the **weakest** element of the system, typically the HF component. In addition, if attenuation of the HF element is required to match sensitivity with the LF element, the power-handling capacity of the HF element would be **increased** by the amount of attenuation employed.

EXAMPLE: Find the **program** power rating for a two-way system consisting of the following components:

1 – 210 LF Horn
2 – 515B LF Speakers
1 – 288-8G Driver
1 – 311-90 HF Horn
1 – N501-8A Network

The following table is useful in determining system program power capacity rating:

Horn/Drivers	1 Watt/4 Ft. Pink Noise Sensitivity	Power Capacity (from Fig. 2)	Attenuation Required	Weighting in dB (1)	System Component Rating (2)
2 515B LF speakers in 1 210 Horn	107.0 dB	150W	None	3 dB	300W (3 dB above 150W)
1 288-8G HF driver on 1 311-90 Horn	110.0 dB	15W	3 dB	3 dB	60W (6 dB above 15W)

(1) Since the spectrum is divided approximately equally between LF and HF elements, the power delivered to each section is **one-half** or 3 dB less than the total input power.

(2) Power rating for system, using components specified, with wide-range program material applied. This will **always** be the lower of the two figures calculated.

For this example, the **program** power rating would therefore be 60 watts, because the **broadband** signal must exceed 60 watts before damage to the HF driver will be sustained.

CONCLUSION

Program power defined in the above example is not to be confused with *program power* ratings displayed on competitive specification sheets. This rating implies the **rms voltage** multiplied by the **rms current** flowing when excited by broadband program material or pink noise. The sine wave capacity of the system will be affected **only** by the attenuation required in shelving the weaker, more sensitive, high-frequency element. In the example presented, the sine wave power capacity would be 30 watts at frequencies above 500 Hz.

Headroom calculations need not reduce the operating levels of systems so calculated, since the original pink noise power capacity ratings **included** a crest factor of at least 10 dB for compression drivers.

Caution should be exercised though, to ensure the system is operated in a mode that does not clip the input signal. For any given voltage, a square wave contains **twice** the power of its sine wave counterpart. Additionally, if 10 dB of amplifier headroom is available, sine wave testing will rapidly exceed the capacity of the device, and acoustical feedback will cause **CERTAIN** and almost **INSTANT** death. Where inexperienced operators are suspect, the designer is urged to provide **ONLY** that power which the system can sustain on a continuous, single-frequency basis.