Loudspeaker Power Ratings

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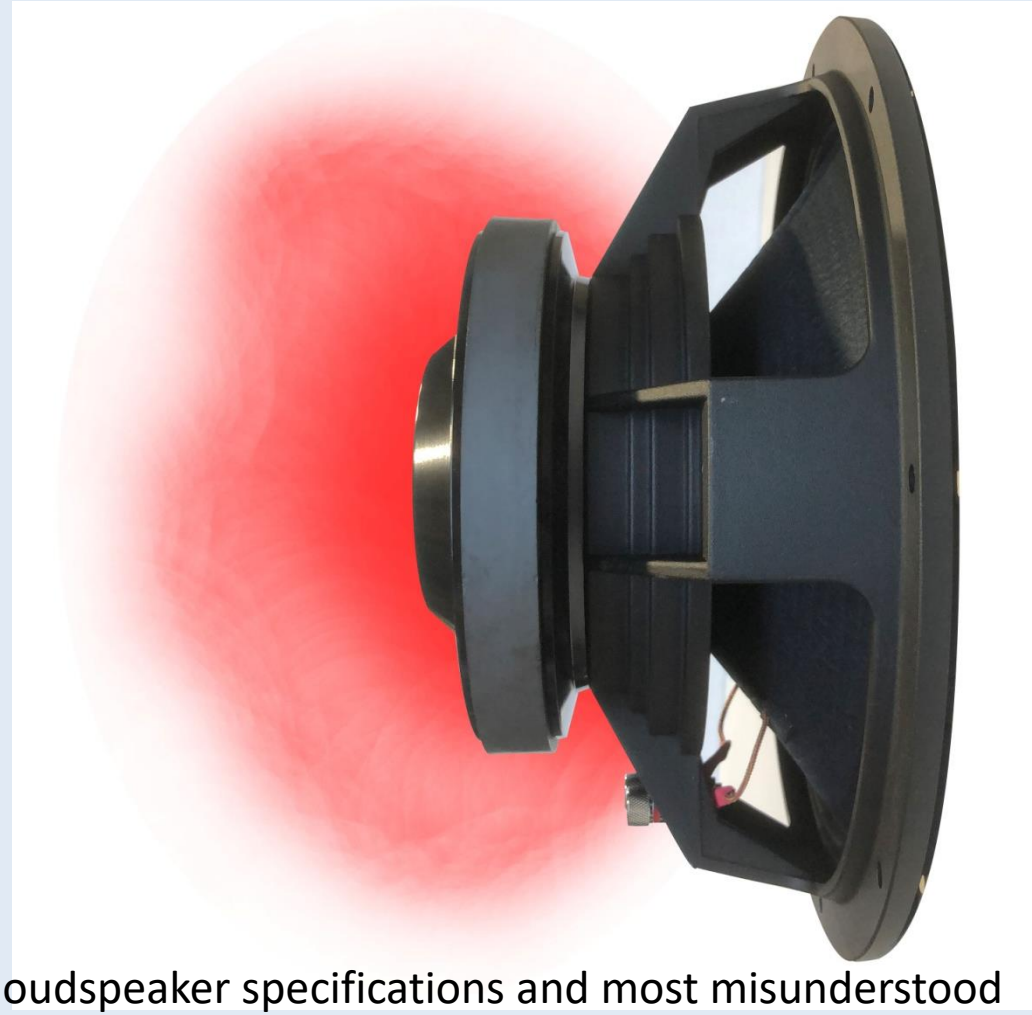
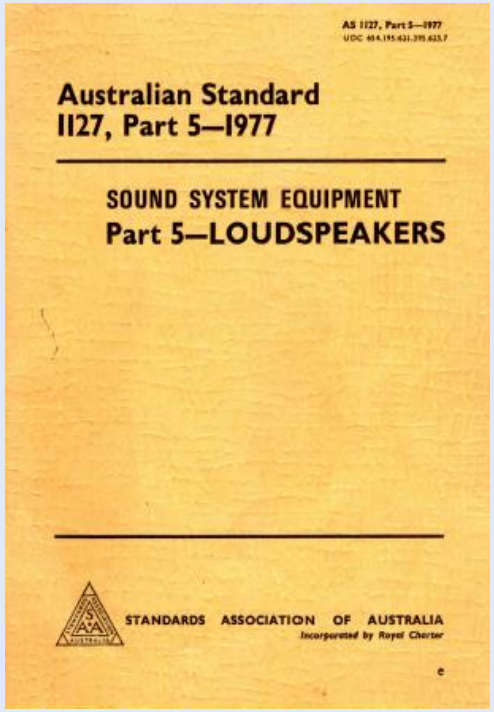
Lorantz Audio Services



One of the most important loudspeaker specifications and most misunderstood is loudspeaker power rating.

Experience

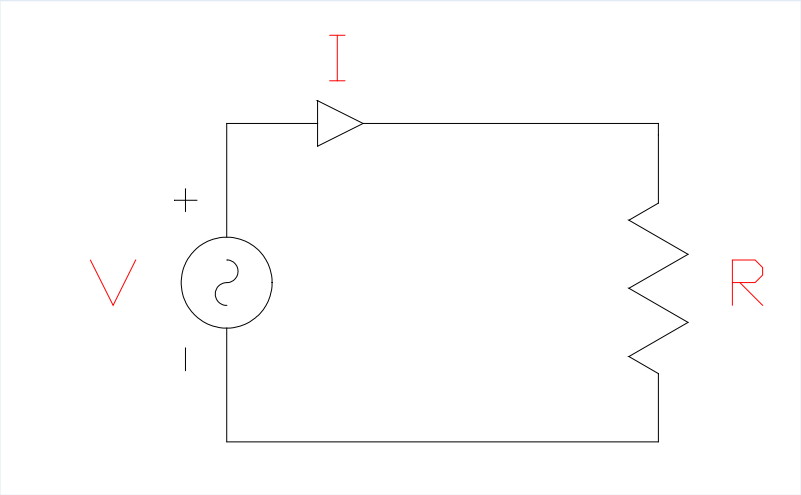


- Plessey Rola <1975
  - Airborne PA system Australian Defense Force
  - Responsible for generating Speaker Datasheets
  - Australian Loudspeaker Standards
- Lorantz Audio Services >1976
  - International Auto Sound Challenge Association
  - Speaker design and product specification

What is a Watt?

Watt is a measure of power.

In electrical terminology



Real $W = V * I * \cos(\theta)$

746 Watt = 1HP

$AES\ \ W = V^2/Zmin$

Example loudspeaker 12”

Specification

AES Rating	400W
Program Rating	800W?
Linear excursion Xpk	9.0 mm
X damage Pk to Pk	34 mm

12” Bass Mid

Lorantz model AC317V-B2-8 ----Why?

Datasheet at www.lorantz.com.au

800W Devices

1 HP Electric motor
746W = 1HP
Fan Cooled
14 kgm

2200W Electric Heater
Duty cycle is 100%

800W Devices continued

Small 1000W/Channel amplifier
Fan forced cooling
Duty Cycle = ?
Can it do an AES power test on the 12” ?

Lab Gruppen FP14000/2 Channel
7000W/2 ohm each channel
60A
Frighting!!!

400W AES Rating
800W Program Rating
No cooling fan
Only 2.37% efficient
Net wt = 6.8 kgm

12” Loudspeaker Diaphragm

Soft loudspeaker parts

Why are Speaker Ratings Important?

Systems used in large Venues require robust operation as any failure can be disastrous.
Integrated defensive Engineering required here.
Duty cycle is typically 10dB

Church?

How do we prevent this happening

Power Rating is limited by:

- Temperature rise of the voice coil or thermal limits of soft parts glue etc.
- Acceptable or perceived distortion
  - Available linear excursion
- Physical diaphragm displacement limits
  - Spider or voice coil impacting upon magnet structure
- Excessive diaphragm stress or fatigue.
- User - OH&S of the audience
- Program material (Guitar, heavy metal)

Standards AES2-1984 Why?

2.b. The AES2-2012 standard

The AES2-1984 standard has now been superseded by AES2-2012. Crest factor for the pink noise signal has been increased to 12 dB (4:1) and nominal impedance is now used for the calculation of power. The latter means that the resulting power level for a given loudspeaker component will now typically be around 20% lower than with the 1984 version of the standard (that used minimum impedance for the calculation of power), which may cause confusion. Also, the band-limiting filtering has now been changed to 24 dB per octave (1984 version used 12 dB/octave, as seen on the graph above).

2.c. The IEC268-5 (1978) standard

This is a standard by the International Electrotechnical Commission from 1978 and reaffirmed in the eighties. It specifies a 6 dB crest factor pink noise signal over which an IEC programme filtering has been applied. This programme spectrum tries to approximate the frequency content of real music, and shows reduced lows and highs. The illustration compares this spectrum to the AES ones. The terms "Rated noise power" and "power handling capacity" are used.

Test duration is 100 hours, after which the speaker should not show appreciable damage.

NOTE: To make matters more confusing, there's another 268-5 standard from 1972 that specifies a different signal spectrum and time, but this is rarely used.

2.d. The EIA RS-426-A (1980) standard

This is a standard by the (USA) Electronic Industries Association. The duration of the test is 8 hours, after which the speaker should not show appreciable damage. The signal is also 6 dB crest factor pink noise signal, but with programme filtering that is different to the IEC standard and is also shown on the previous illustration..

2.e. The EIA RS-426-B (1998) standard

EIA 426-B (also called ANSI/EIA 426-A, later ANSI/CEA-426-B and lately ANSI/CTA-426-B) means quite a deviation from 426-A. The result of this test is not a "power handling" specification anymore but an "optimum amplifier power", which is the maximum input power at which the product under test is rated for acceptability under all three limit categories: a power compression test with a fast variable rate 40-10 kHz sweep sine wave that gets played continuously in a loop, a distortion test and an 8-hour "accelerated life test" with 6 dB crest factor pink noise at half the rated optimum amplifier power and with the spectrum shown on the graph above. None of the tests should result in appreciable damage or change to the unit. The measurement procedure for this standard is rather complex, tedious and subjective at times; at the moment it has not been widely accepted by the sound reinforcement industry and I have serious doubts it will be, with the possible exception of the accelerated life test, which is not significantly different to 426-A except for the wider spectrum.

Add: Australia 1127 Part 5,US, Japan, Brazil, European Community
(nor do they report accurately)

AES 02-1984

The lf driver shall be mounted in free air so that the direction of motion of the diaphragm is in a horizontal plane and so that there is no appreciable air loading from adjacent structures. The driver shall be excited with a band of pink noise extending one decade upward from the manufacturer's stated lf limit of the device.

The noise shall be bandpass filtered at 12dB per octave with Butterworth filter response characteristics, and the peak to-

rms voltage ratio of the noise signal supplied to the lf driver shall be 2:1 (6 dB).

The manufacturer shall state the upper and lower cutoff frequencies (– 3 dB) of the Noise signal.

The rated power of the device shall be that power the device can withstand for 2 h without permanent change in acoustical, mechanical, or electrical characteristics greater than 10%.

AES Power Rating 1984

AES Power rating shall be determined as the square of applied rms voltage, as measured with a “true rms” voltmeter, divided by *Z*min.

The **music program** rating is always twice the continuous rating. It is a higher rating because music has many peaks and dips and is not as abusive as a continuous signal. This is a good rating to select amplifier power for proper headroom in a pro audio application. (800W Example spk)

Raw Music/ Speech has a crest factor 16-20dB

Loudspeaker Failure

- Thermal
  - Voice coil over heating bond failure
  - Adhesive failure
  - Soft parts failing due to excess heat
- Mechanical damage
  - Voice coil or spider striking magnet structure
  - Excessive stress in cone/spider/surround
  - Fatigue

Australian Standard 1127, Part 5 1977 LOUDSPEAKERS

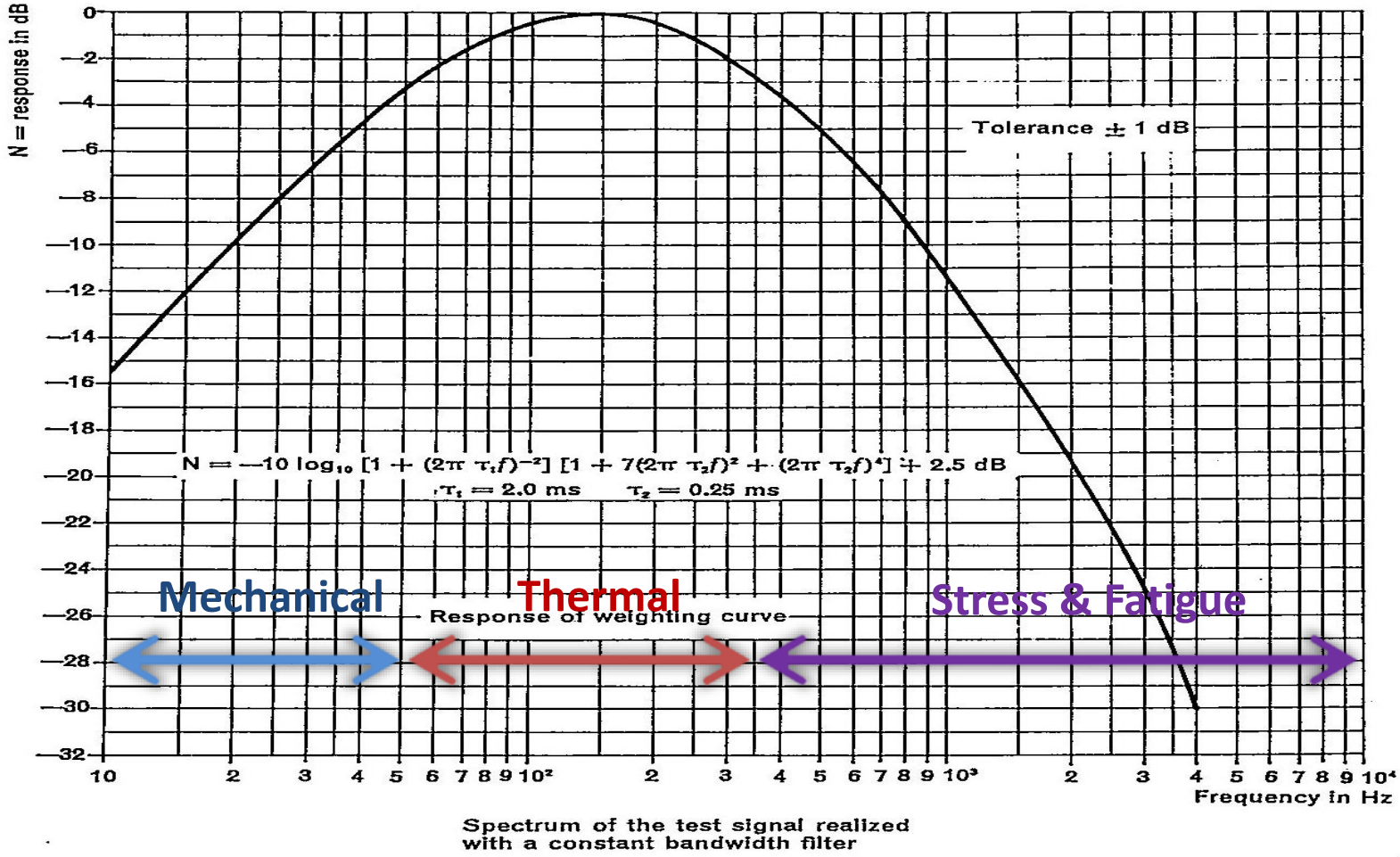


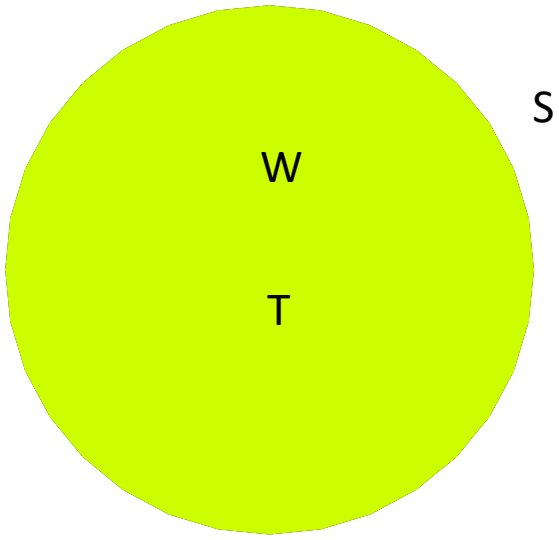
Fig. B1. POWER HANDLING CAPACITY (Clause 3.4.3)

Thermal-Temperature Rise

For a given input power the temperature rise is exponential.

However when t = infinity then:

$$T = W/(\lambda * S)$$

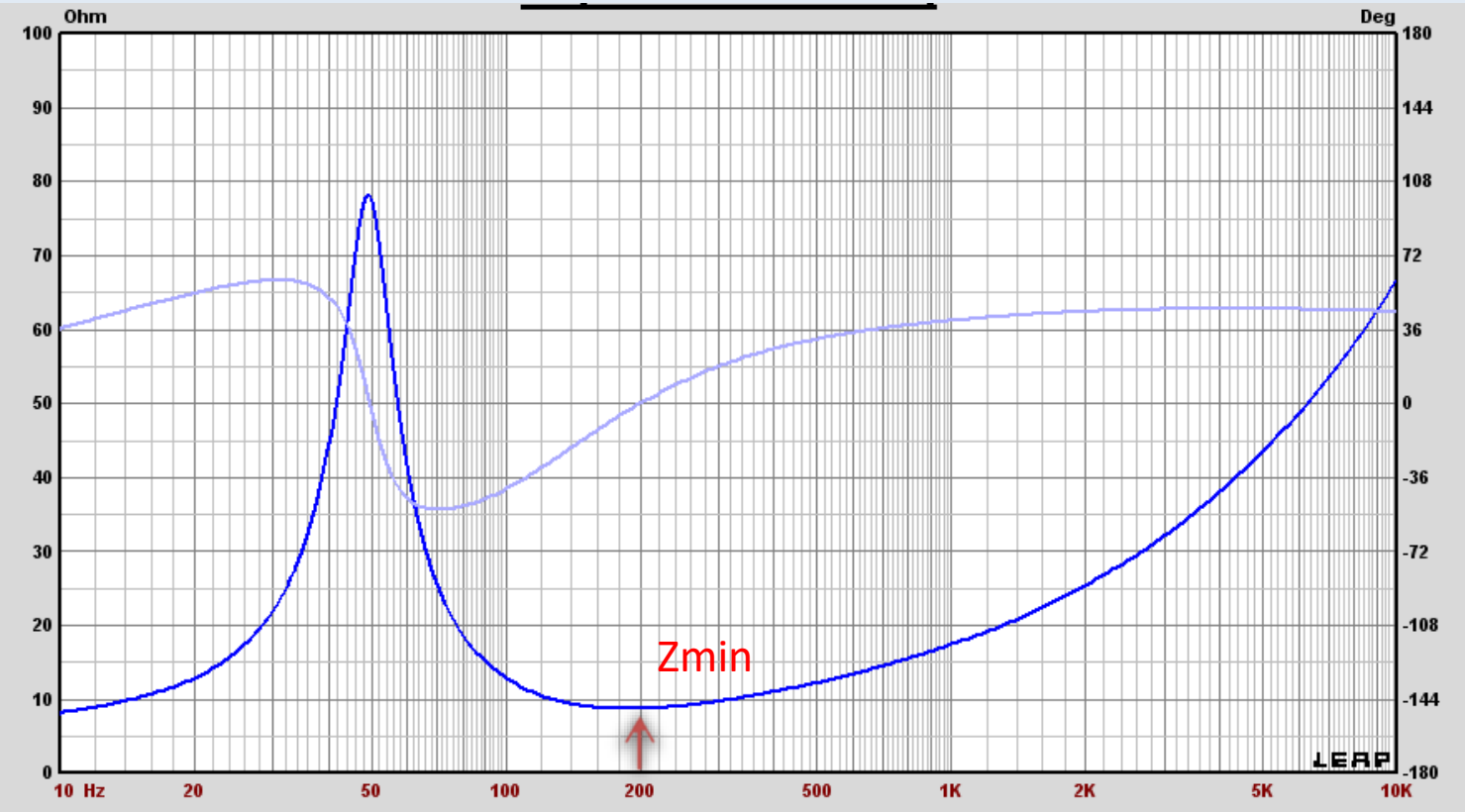


T = Temperature Celsius
W = power in and out
S= Body surface area m^2
λ = Emissivity

Thermal Rating

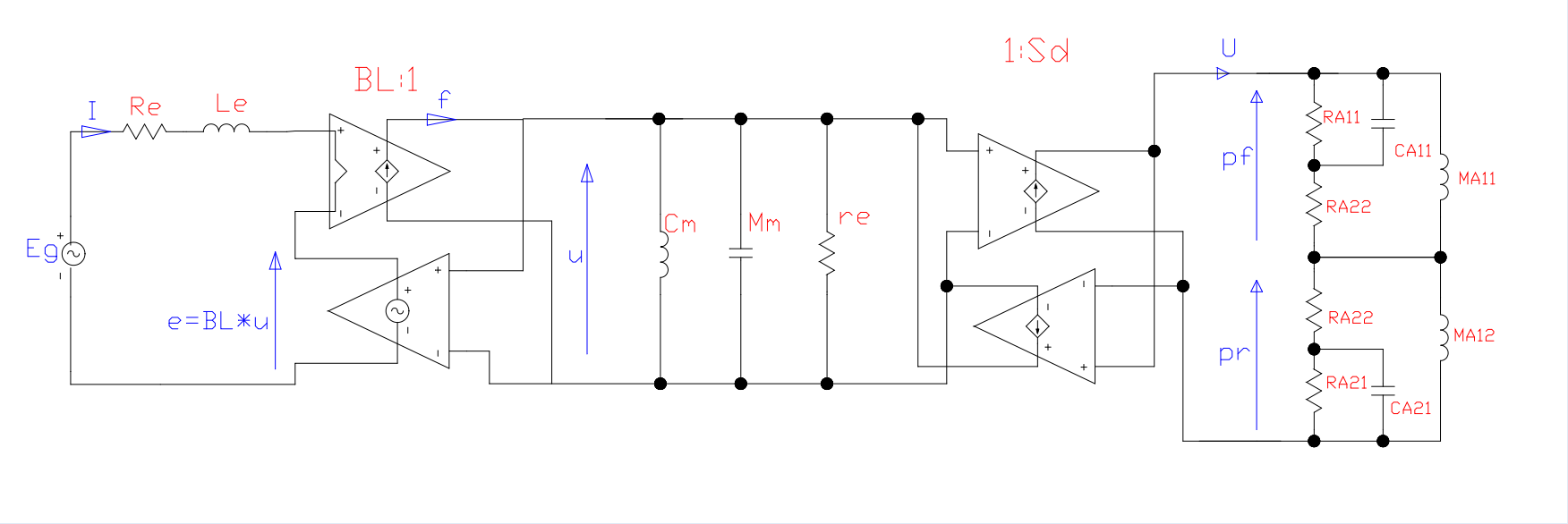
AES Power Rating= V^2/Zmin

The Watts rating is only real where phase is zero –resistive.



Thermal power limit occurs at Zmin and is < AES Rating

Free-air Spk Equiv. Circuit



$$Power\ disipatted\ in\ Voice\ coil\ = I^2 * Re$$

Thermal Temp-Rise (Steady state)

- Conduction through the air-gap
- Radiation
- Forced convection
- Thermal class enamel wire, adhesives, materials.
- Class-F materials can endure 220C for 100hrs
- Class-H materials can endure 280C for 100hrs

Use Class-H materials to maximise thermal rated power

Obtaining Temp from Resistance Change

$$Rt = Ro(1 + \alpha * t)$$

Where:

Rt is the coil resistance at temp (t)

Ro is the coil resistance at 0 degrees Celsius

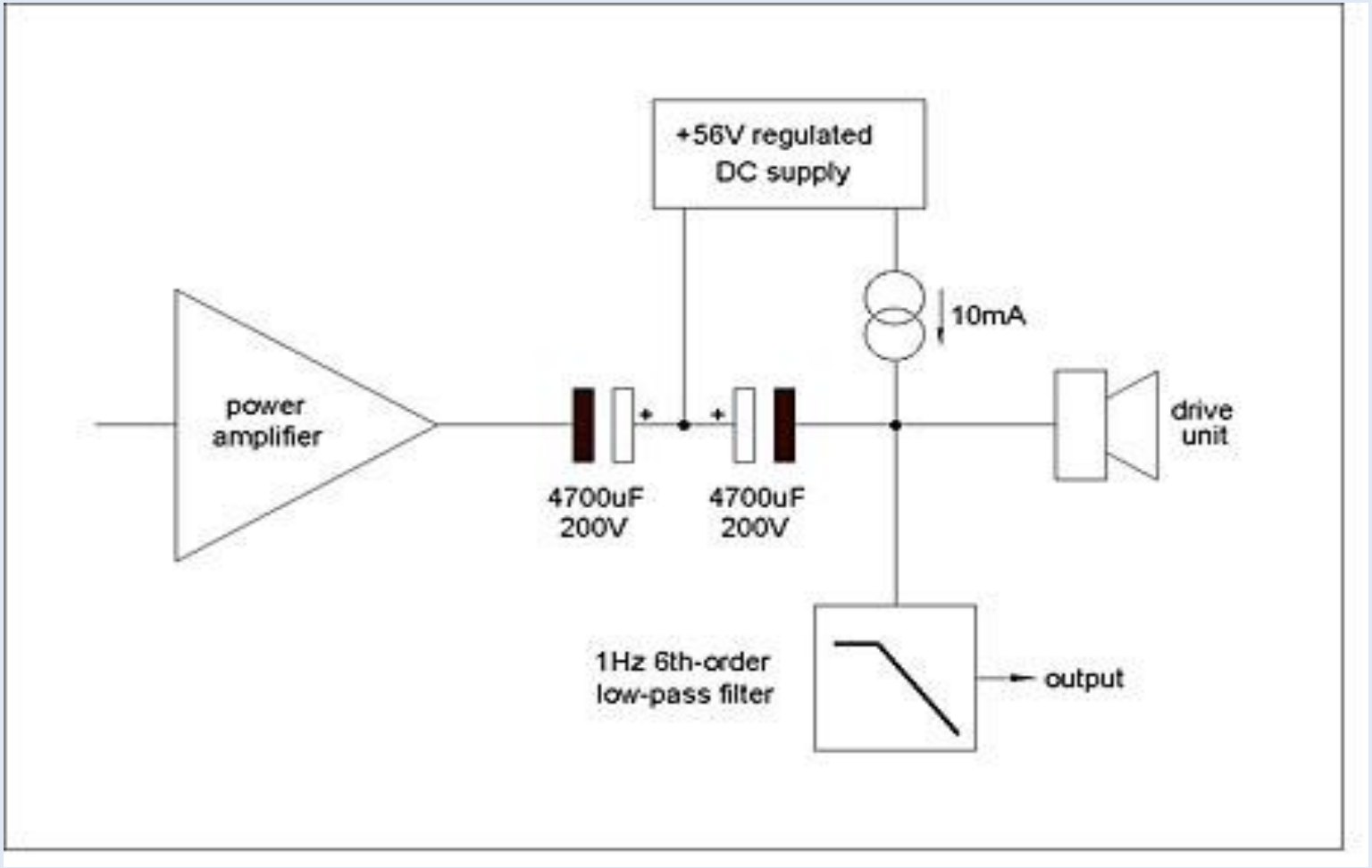
α is Temperature coefficient

α = 42.8*10^-4 ohms/Cel deg. for copper

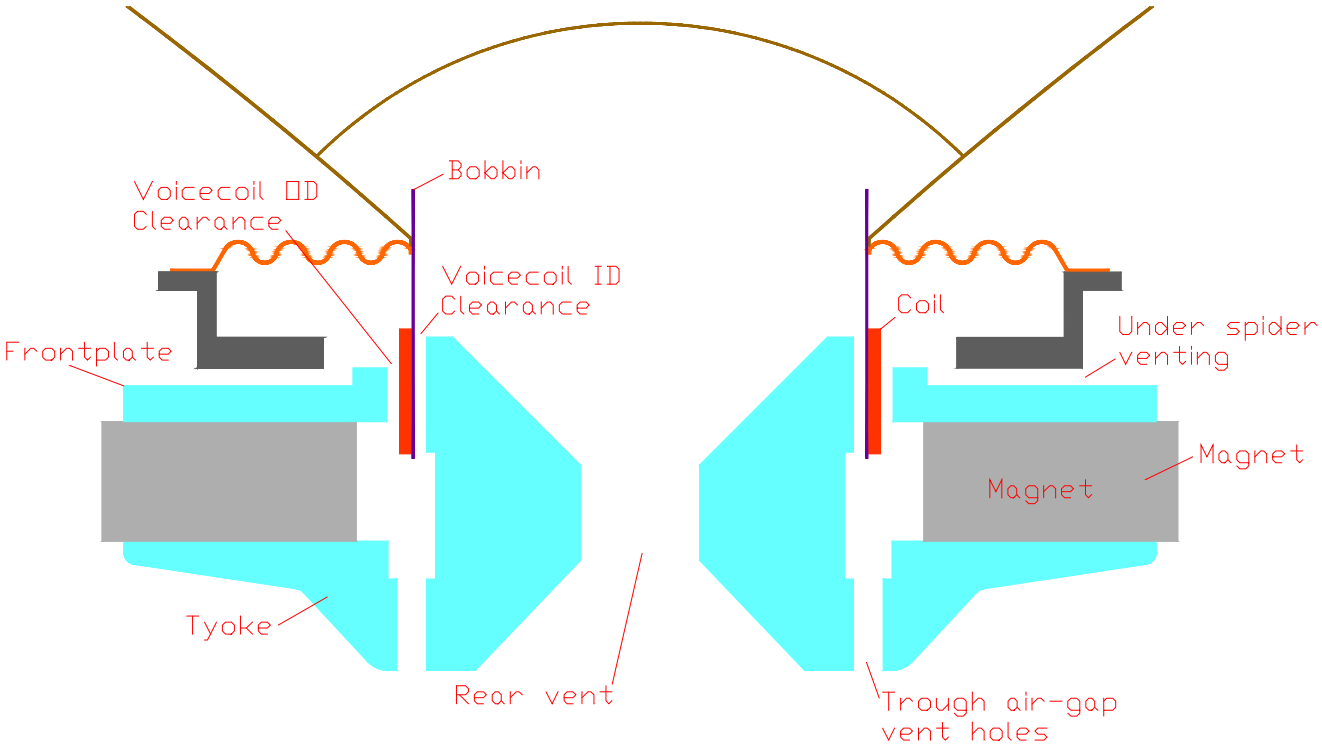
Caveat

It assumes all the coil is at the same temperature

Measuring coil Temperature

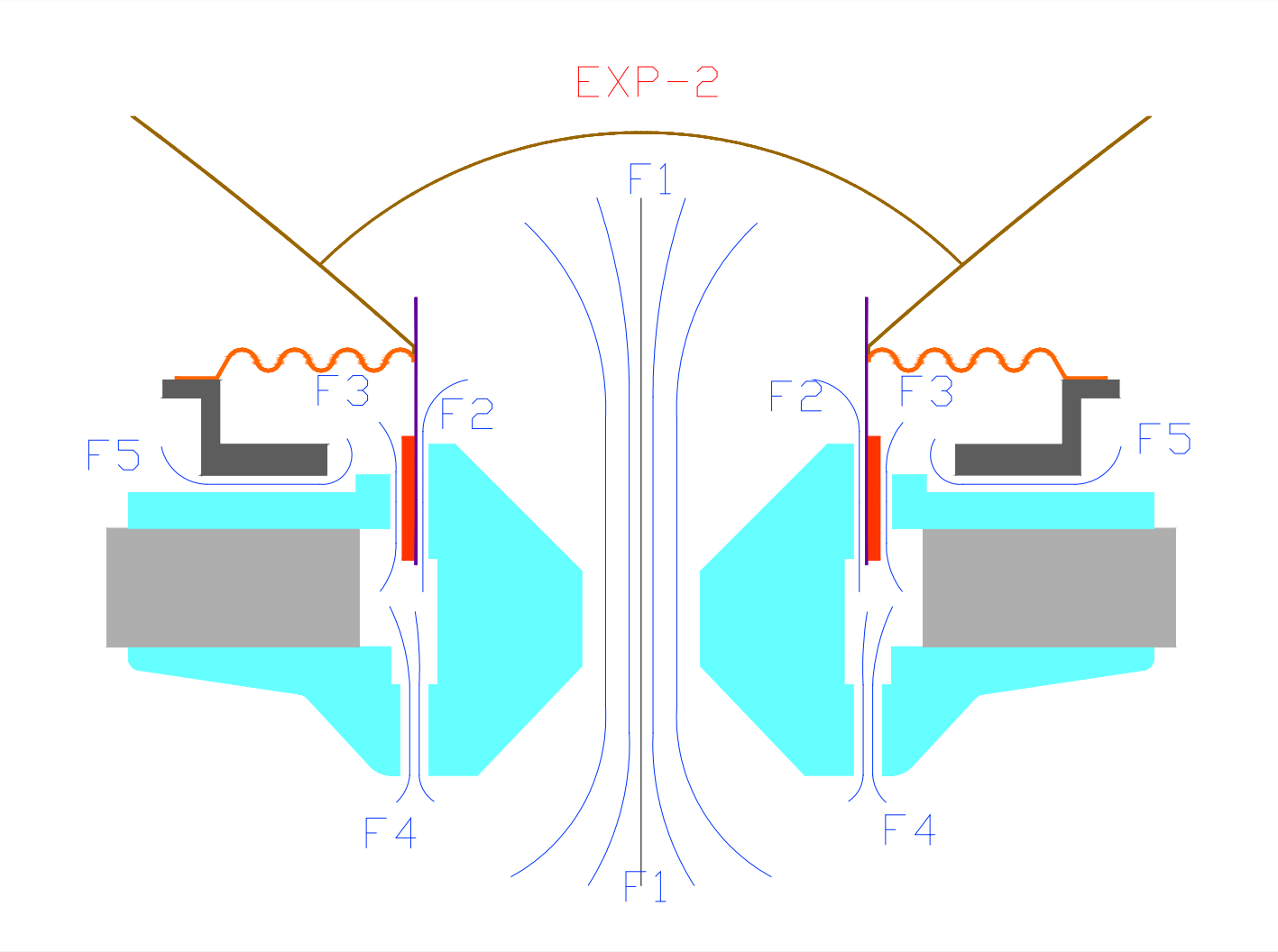


Forced Convection



Describe terminology used

Forced convection



Using forced convection we can increase AES power rating

Discuss compromises?

Summary of Test Results for 12” 800W loudspeaker

Model	Applied signal	Qm	Increase in coil Temperature Celcius	Thermal power compression dB
EXP-1 20mm vent & 8x4mm Bplate vents coil wound on aluminium bobbin	Note-1	3.9	139.9C	3.70 dB
EXP-1 20mm vent & 8x4mm Bplate vents, coil wound on aluminium bobbin	**250Hz Sinusoidal Note-2**	3.9	195C	4.82 dB
EXP-2 20mm vent & 8x4mm Bplate vents & Under spider vents. Coil wound on aluminium bobbin	Note-1	3.36	137.8C	3.66 dB
EXP-3 28.6mm vent & 8x4mm Bplate vents. Coil wound on aluminium bobbin	Note-1	3.9	148.6C	3.89 dB
EXP-4 20mm vent only. Coil wound on aluminium bobbin	Note-1	3.9	144.9C	3.81 dB
EXP-5 20mm vent & 8x4mm Bplate vents and inside/outside coil on TIL Bobbin	Note-1	6.7	144.5C	3.8 dB

Reference assembly 20mm vent

~1degC/W should fail at 280W sinusoidal

Under spider vents added <2.1C

Rear Vent 28mm OD > 8.7C

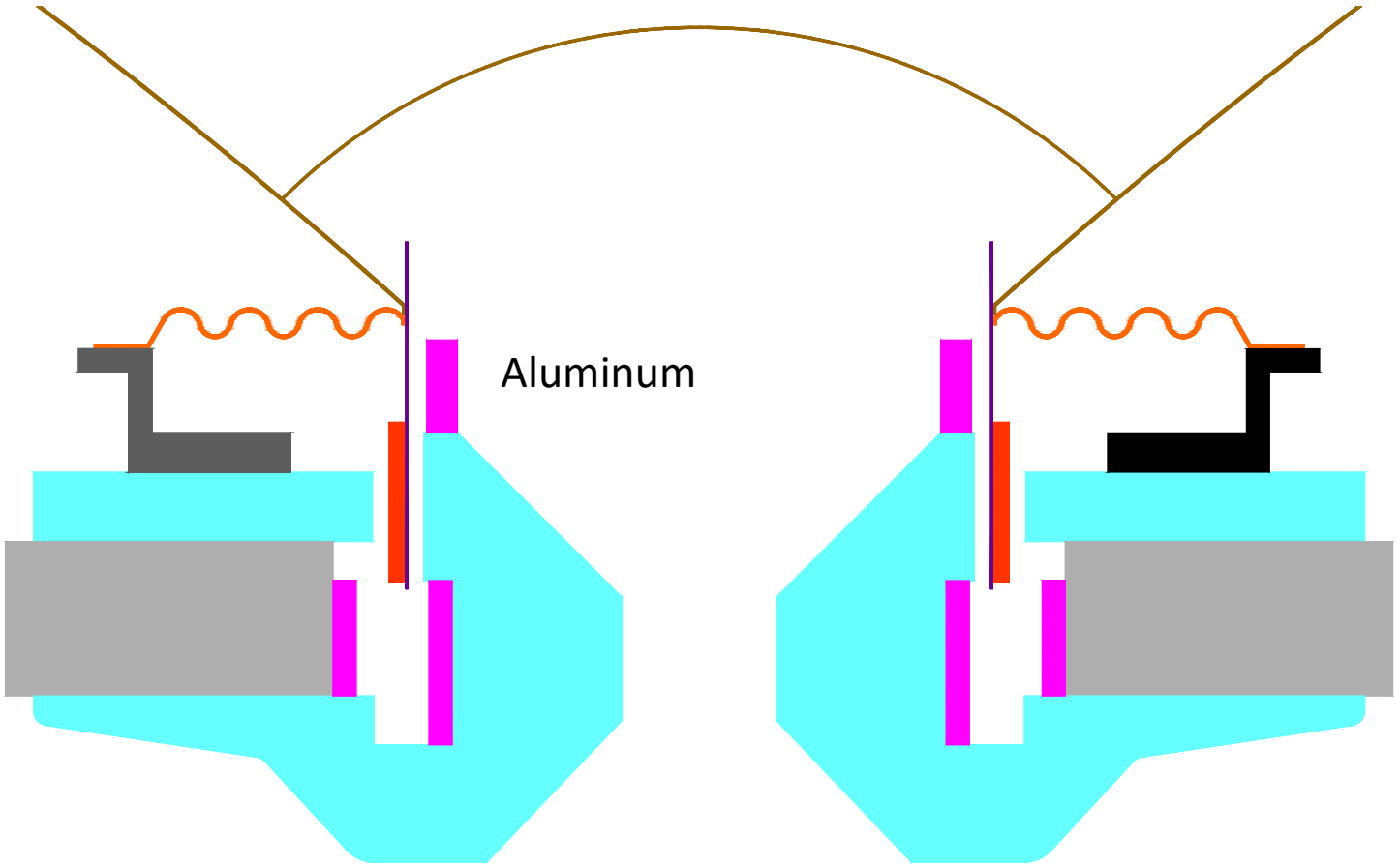
20mm R/vent only >5.0C

Inside/outside v/c >4.6C

Note-1
AES continuous pink noise high-passed at 50Hz slope 12dB/oct and low-passed at 500Hz with slope 12dB/Oct with a crest factor of 6dB and rms level of **40V= Nominal 200W for a period of 2 hours.**
Note-2
Continuous 250Hz sinusoidal signal (at minimum impedance) for a period of 2 hours.

Neodymium magnets experience problems at 130C (class-H is 280C)

Shorting rings act as heatsinks



Finally insert aluminum shorting rings to reduce inductance distortion, improve stability and provide additional thermal conduction

Other improvements

- Experiment also show that (sand blasted steel

components) having rough surfaces dissipate more readily than a smooth one.

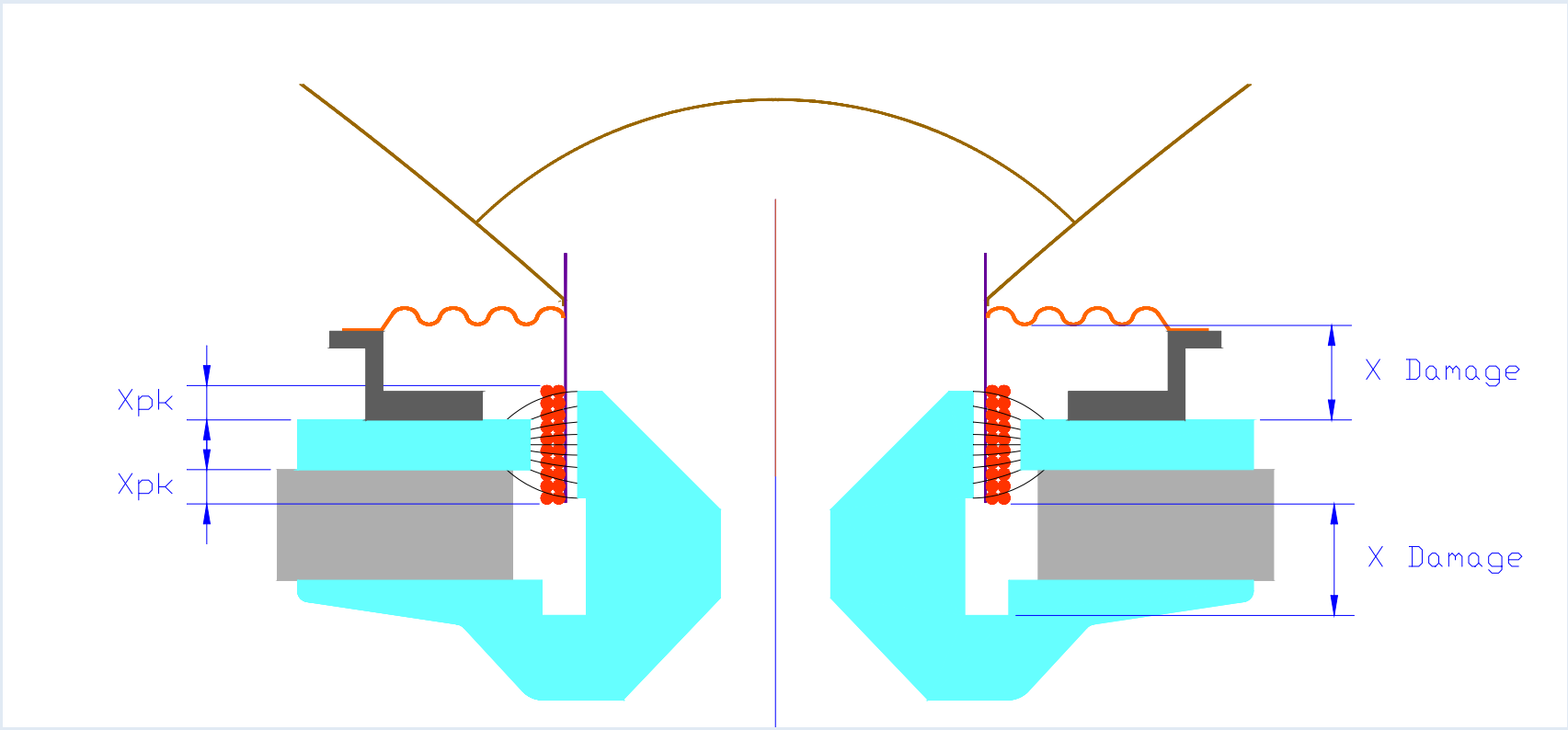
- Also high fluid speeds are essential to obtain turbulence as opposed to stream-line flow.

The eddies and cross-currents of turbulent flow are particularly efficacious in absorbing heat

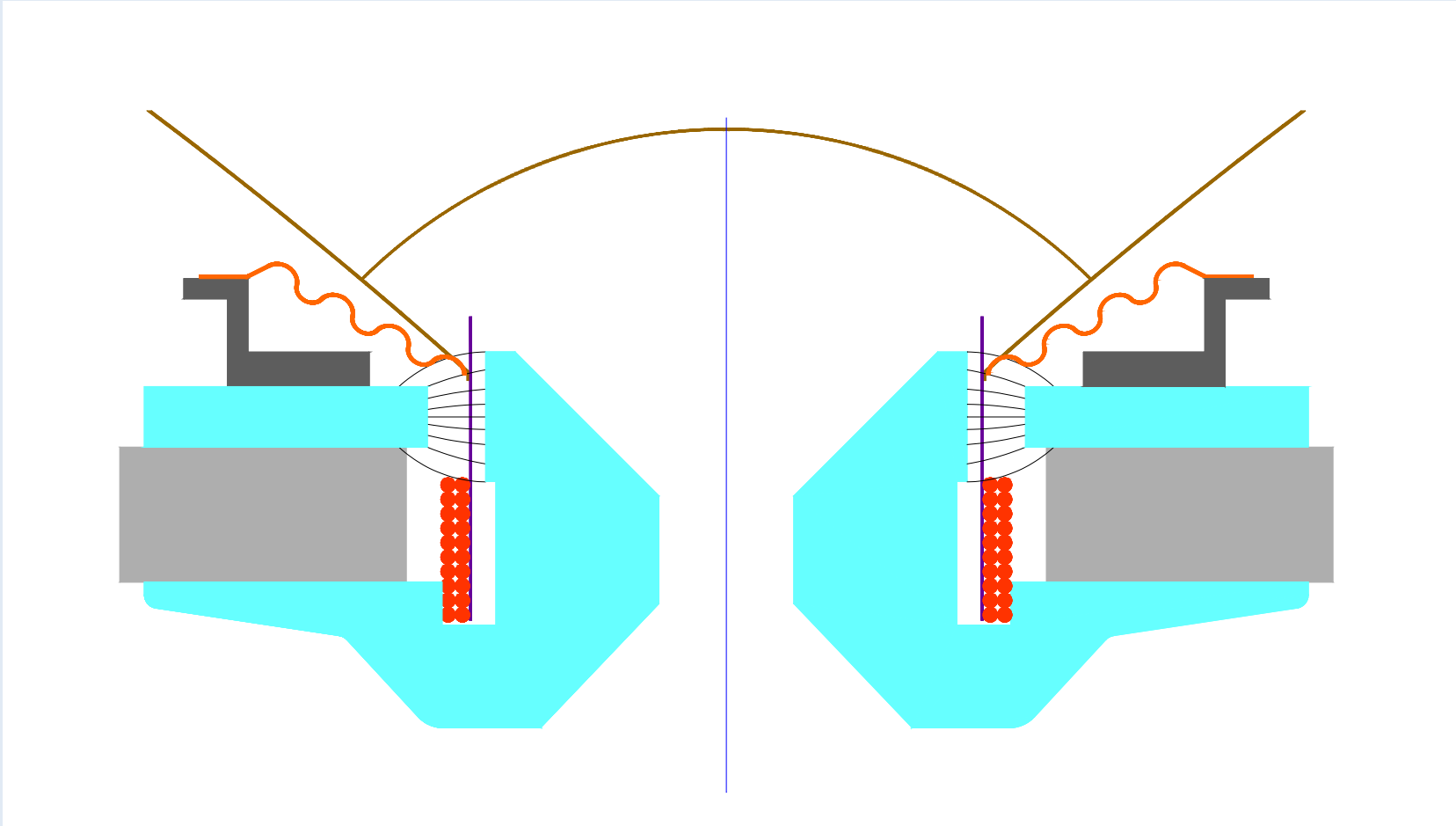
- Blacking the steel components can also improve radiation however the total contribution of radiation to total heat transfer is negligible.
- Beyma Malt Cross woofer's cooling system

Thermal Damage

Mechanical Damage



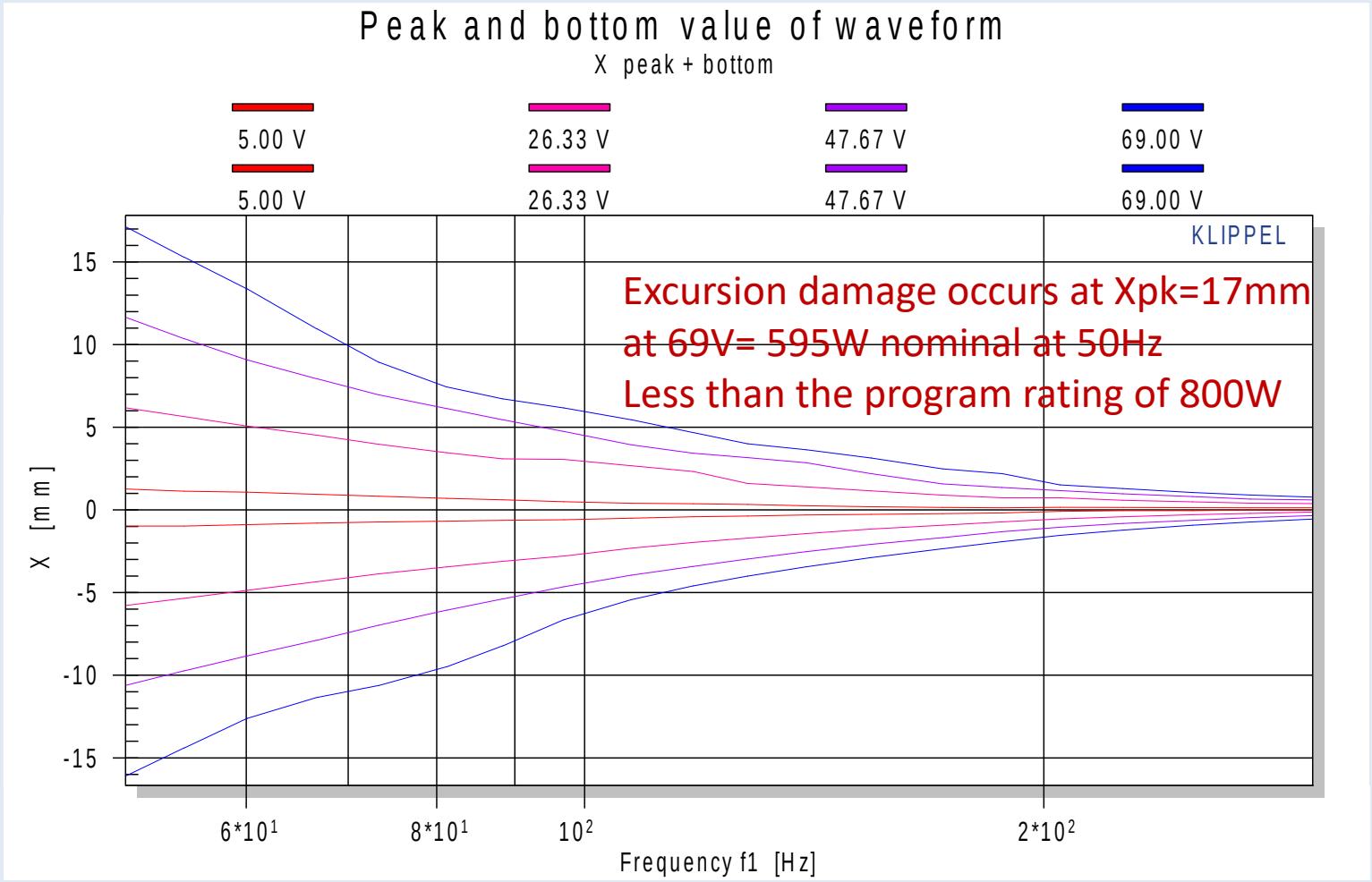
Mechanical Damage



Soft parts impacting upon the magnet structure.

Set the starting frequency such that no mechanical damage occurs at 80V=800W for 12” loudspeaker.

Example 12” Excursion



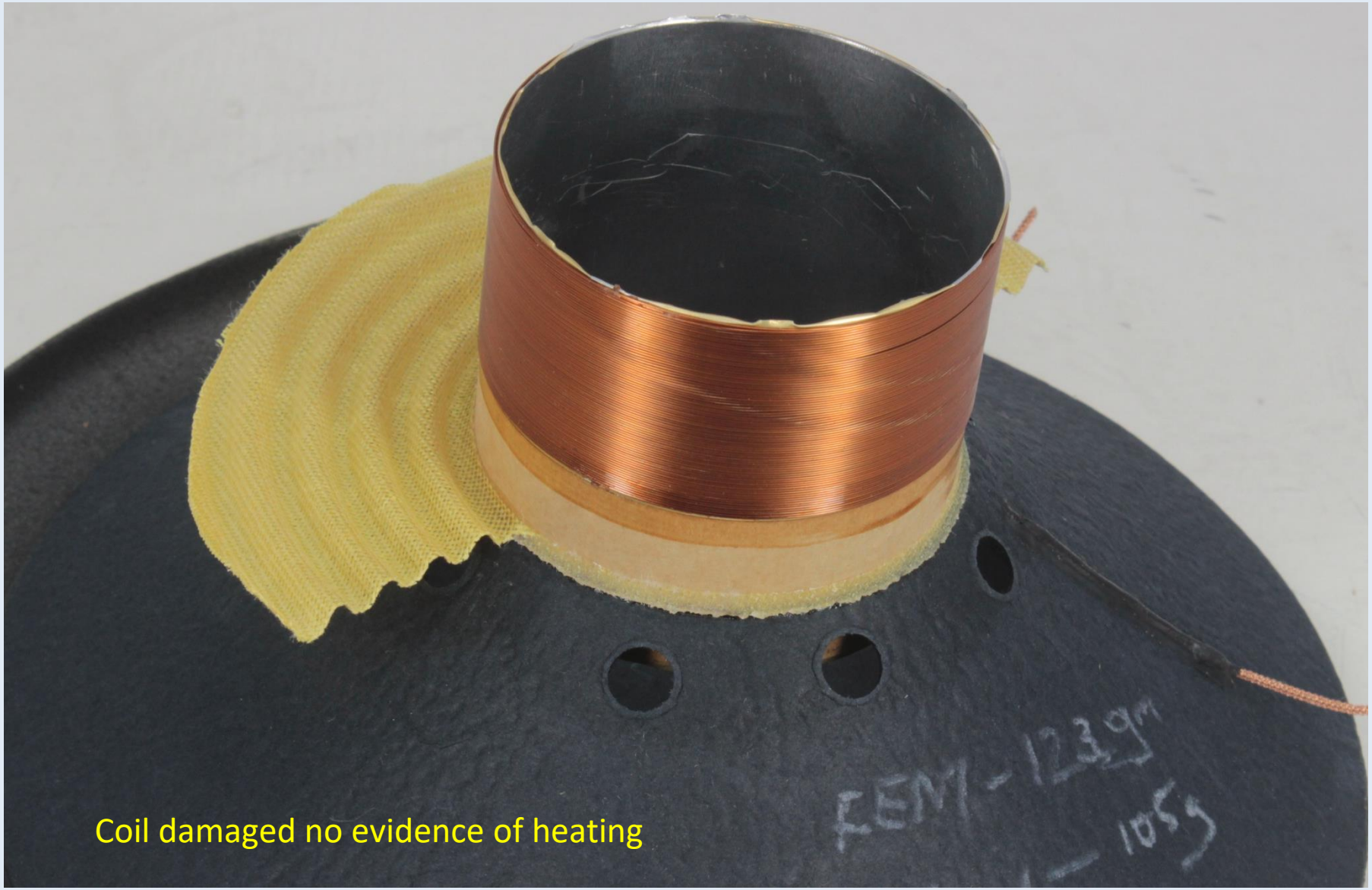
Note: At 200Hz (Zmin) the diaphragm excursion is minimal.

This speaker would suffer mechanical damage if operated at program level 80V

Unbaffled = AES 400W power test

HI-PASS FILTER IS MANDATORY

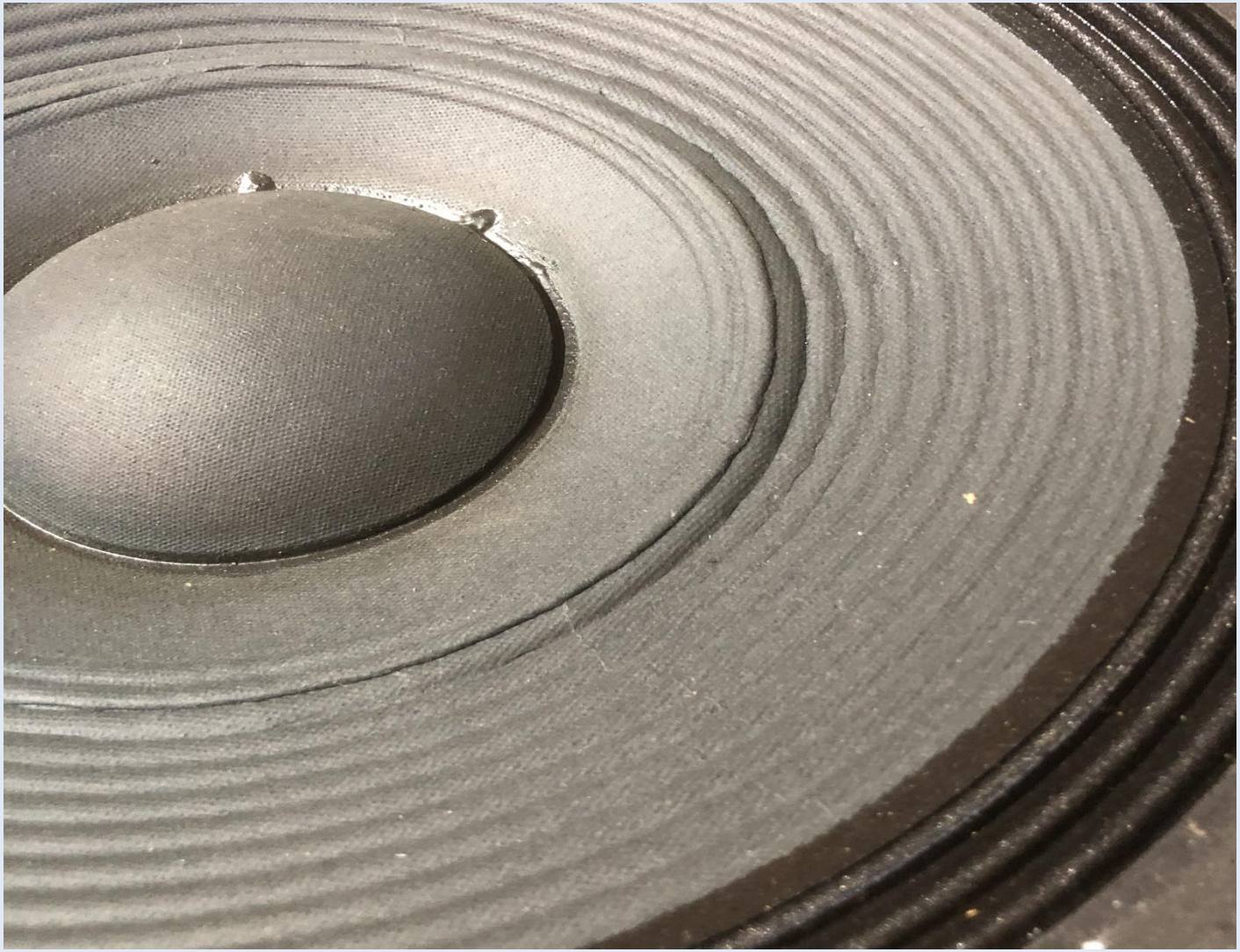
Mechanical Damage



Coil damaged no evidence of heating

Mechanical Damage

Excessive stress



Fatigue

Switch to 15” AC386T-PA-8 Why? AES2 – 1984

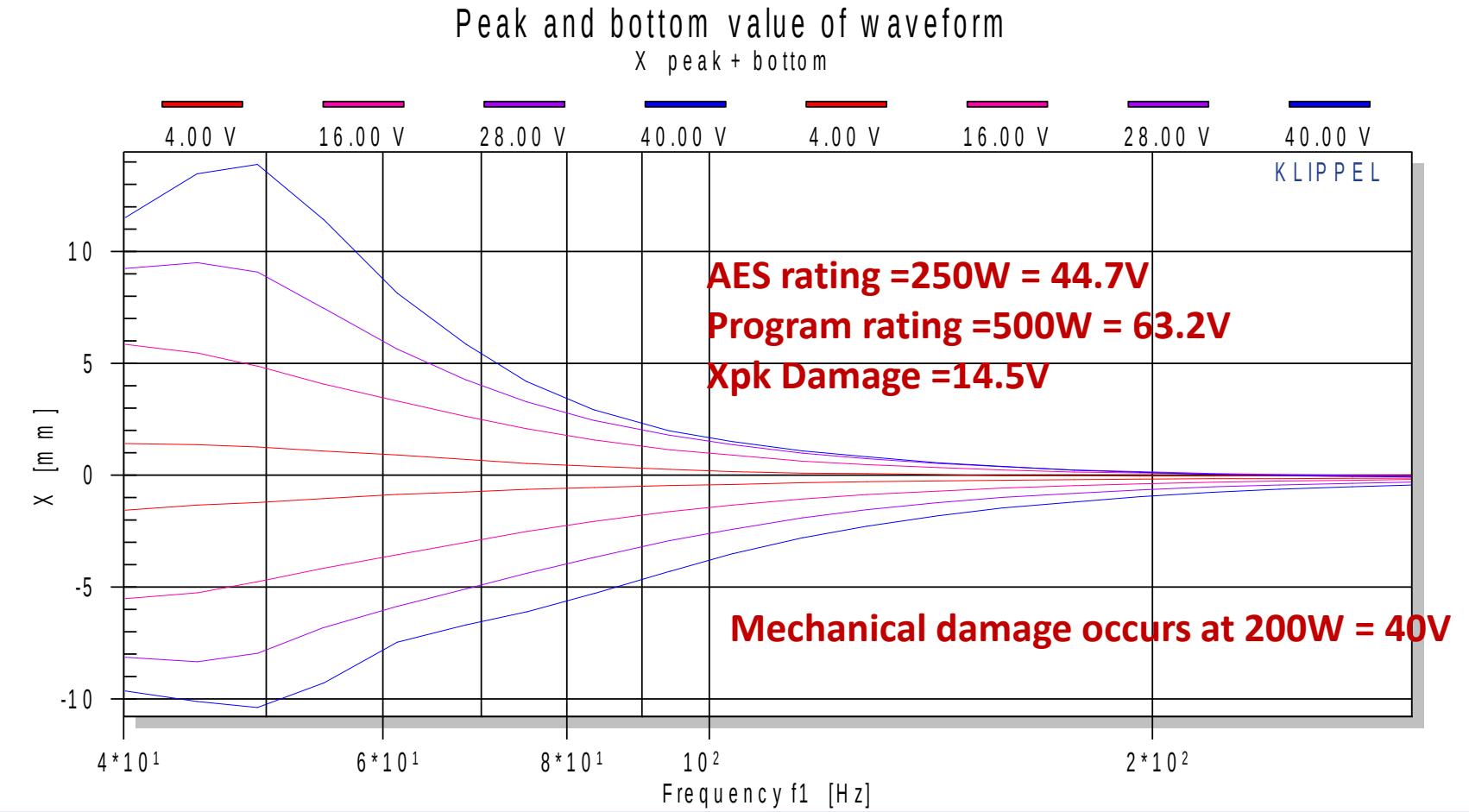
Economical 15” Bass-mid Loudspeaker

Relevent specification

AES power rating =250W
Program Rating =500W
Voicecoil dia = 2.5” (63mm)
Coil Ht = 14mm
Airgap Ht = 8mm
Xpk = 4.2mm
X Damage pk to pk =29mm
Mmd = 60gm

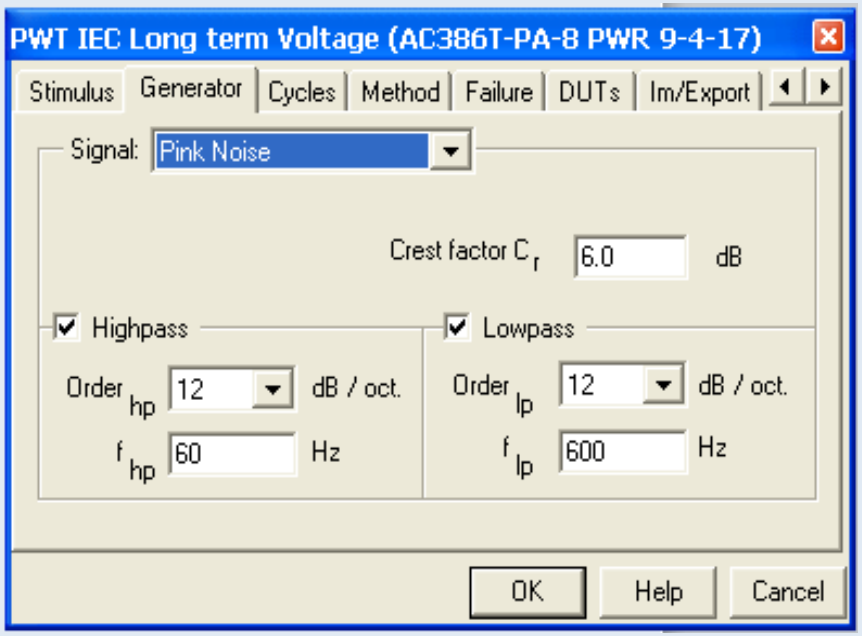
No though magnet cooling vents
No under spider vents
No aluminium shorting ring
Datasheet at www.lorantz.com.au

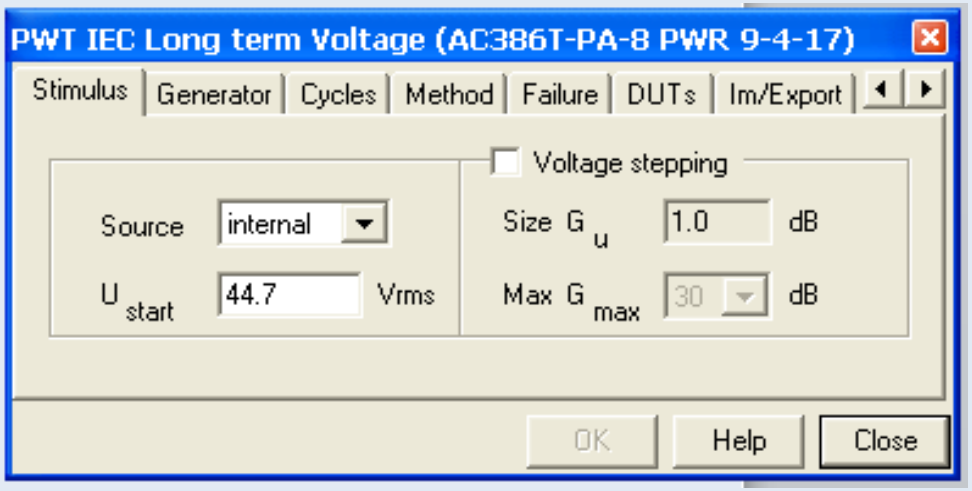
AC386T-PA-8 Excursion limits

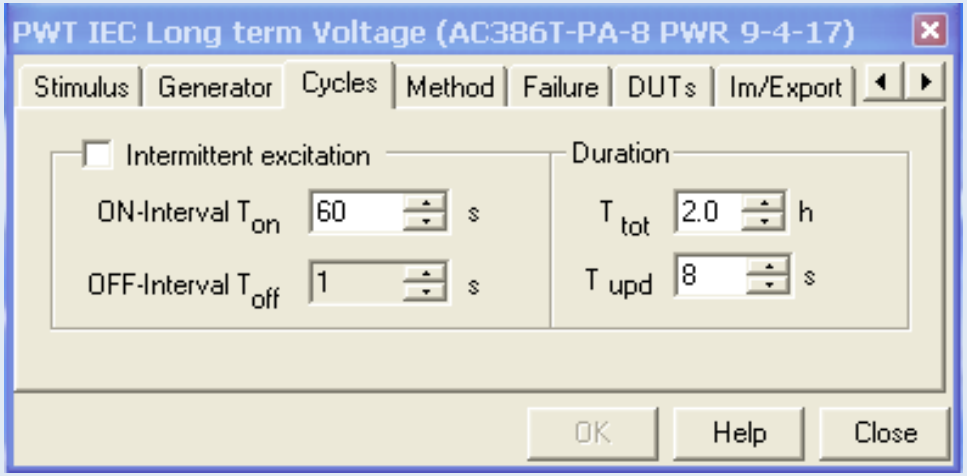


Delema - What starting frequency should we use as Xpk =4.2?
I chose 60Hz

AES 1984 test on AC386T-PA-8 Using Klippel







AC386T-PA-8

2.5” Voicecoil /Ht = 14mm

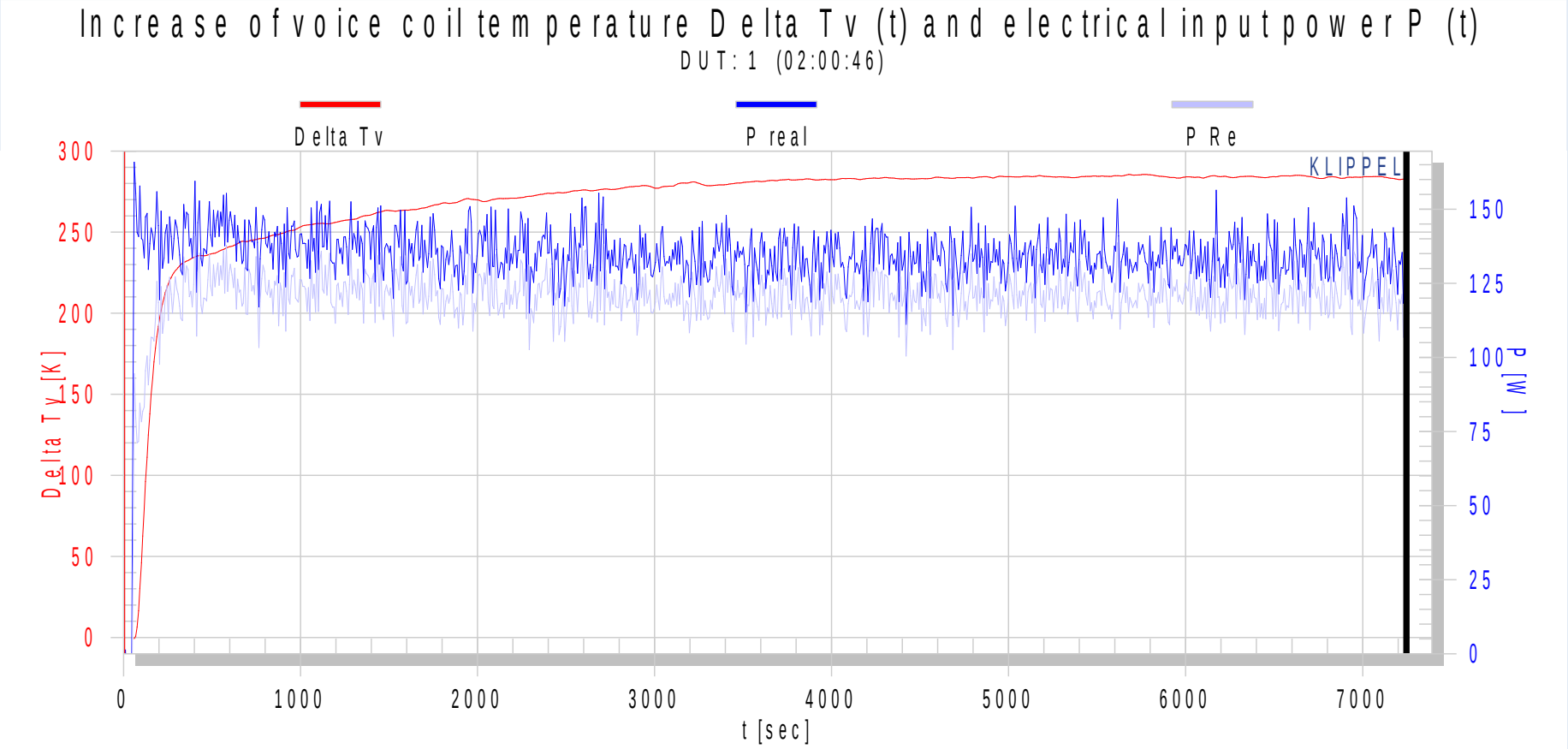
AES rating =250W = 44.7V

Program rating =500W = 63.2V

Describe the 15” speaker

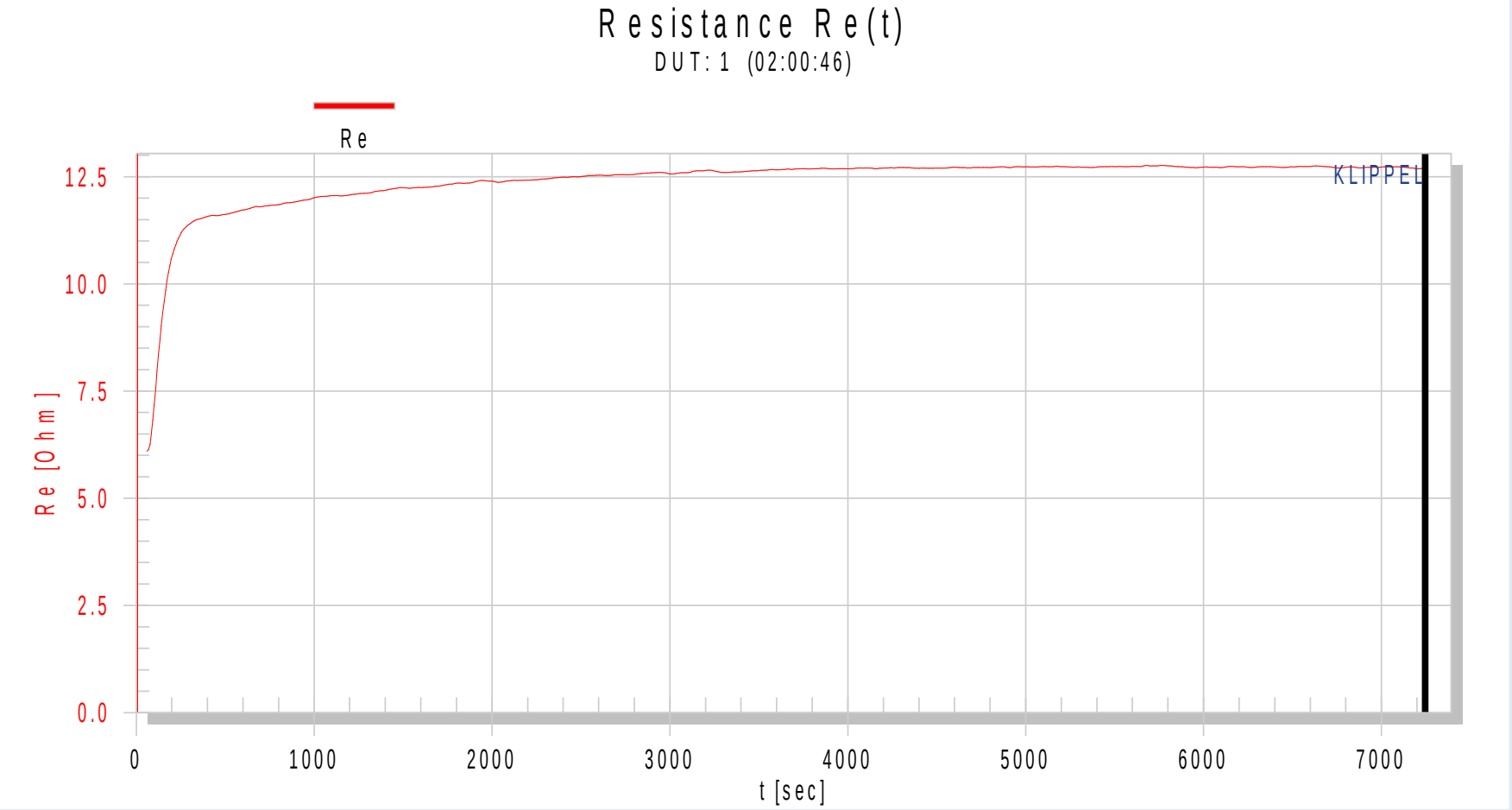
Lets see what happens?

2Hr Cont. Pink Noise



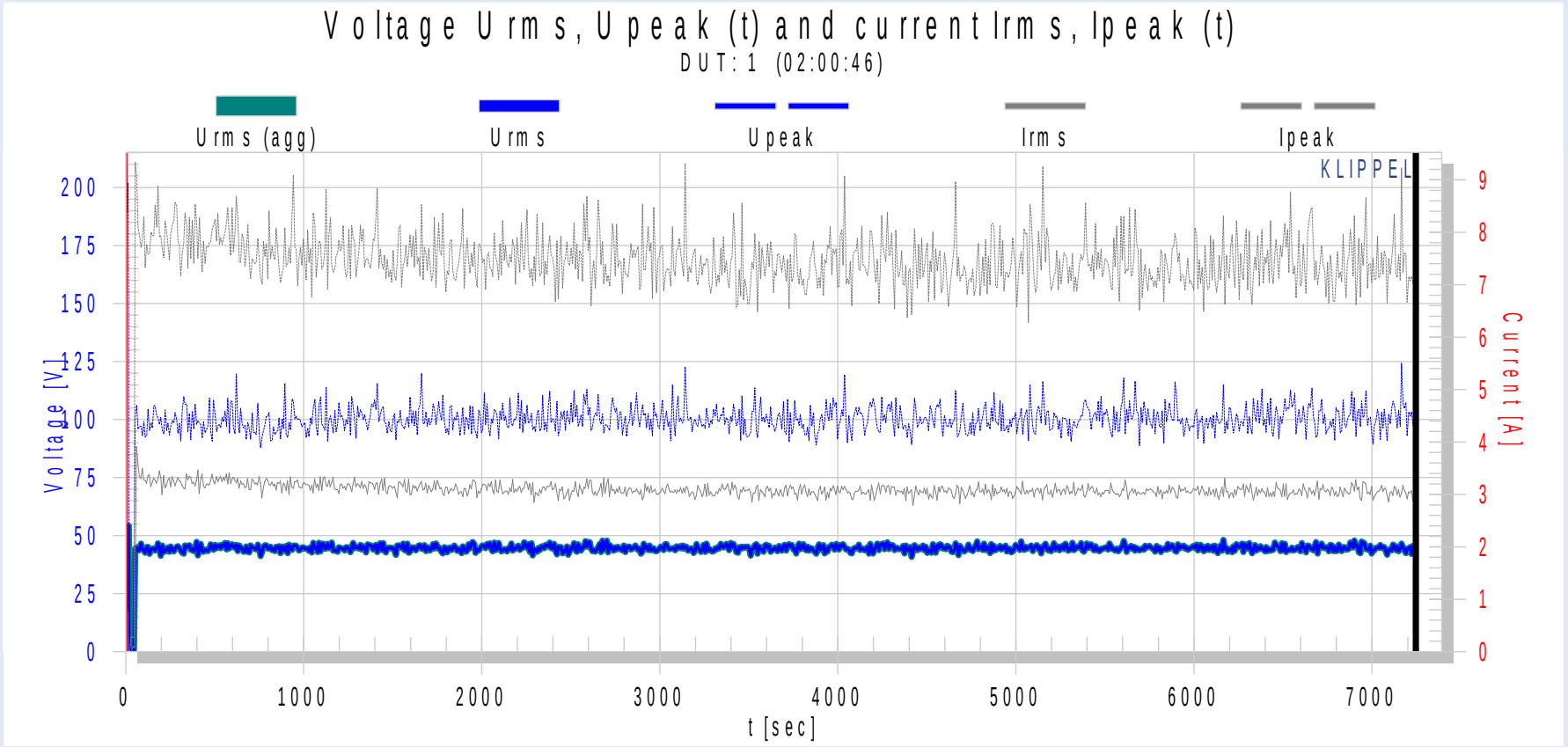
We need class H materials at this working temperature
AES Nominal 250W = 118W dissipated in V/coil & 130W total dissipation.

2Hr Cont. Pink Noise

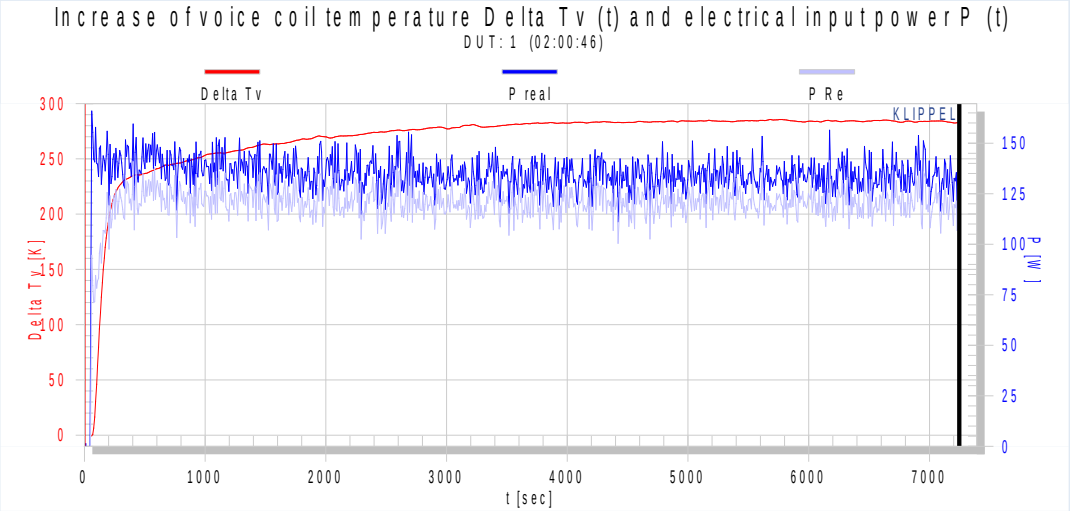


Re has more than doubled and we now have thermal compression of 6.36 dB.
6.0 ohm at start and 12.5 ohm at 2Hrs

Klippel records every 8 seconds

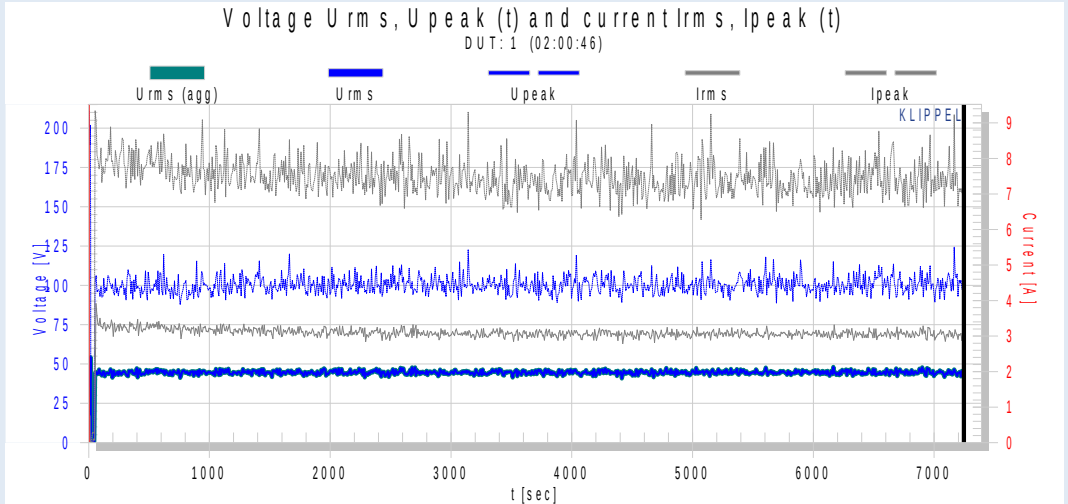


Vrms setting 44.7V and peak voltage should be 2*44.7 = 89.4Vpk =1000Wpk
Note the maximum peak voltage recorded was 125V = 1953Wpk



Date	2017-04-12	
Time	18:29:53	
Serial number	429	
Mode	PWT interval on	
Record	916/916	
t	02:00:46	h:min:s
	measurement time	
DUT 1	alive	
Selected DUT	1	

Delta Tv	283.9	K	increase of voice coil temperature
P	130.887628	W	real electrical input power
Pn		W	IMPORT Zn at Driver page to see nominal electrical input power
P Re	118.647565	W	Power heating voice coil
Irms	3.053	A	rms value of the electrical input current
Urms	43.862	V	rms value of the electrical voltage at the transducer terminals
Ipeak	6.965	A	peak value of the electrical input current
Upeak	95.409	V	peak value of the electrical voltage at the transducer terminals
PC	6.36	dB	thermal power compression factor
freq_pilot	1	Hz	Frequency of pilot tone for temperature measurement (automatic)



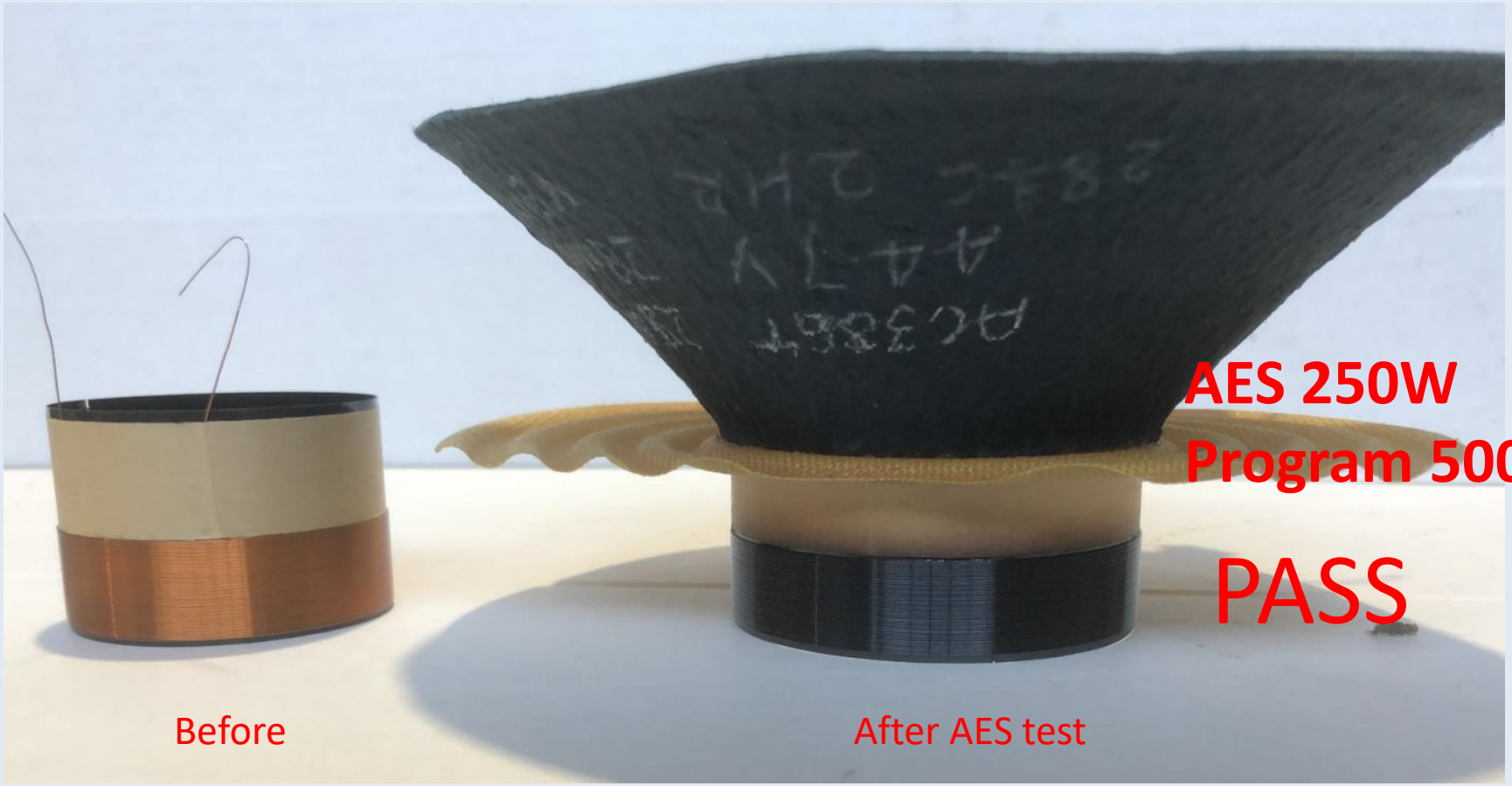
V set at 44.7V = 250W nominal

Peak voltage = 89.4 V=1000Wpk

6dB Crest factor

COMPRESSION = 6.36dB

Coil condition after AES Power Test for Lorantz AC386T-PA-8 500W Spk.



Beyma 12MC500 equiped with 2.5” V/C and Malt Cross air deflector runs 110C cooler And can handle 600W.

PASS

No Scrape marks on the coil

AES rating is the MAXIMUM POWER the loudspeaker can endure for 2 HRS

Issues performing AES test

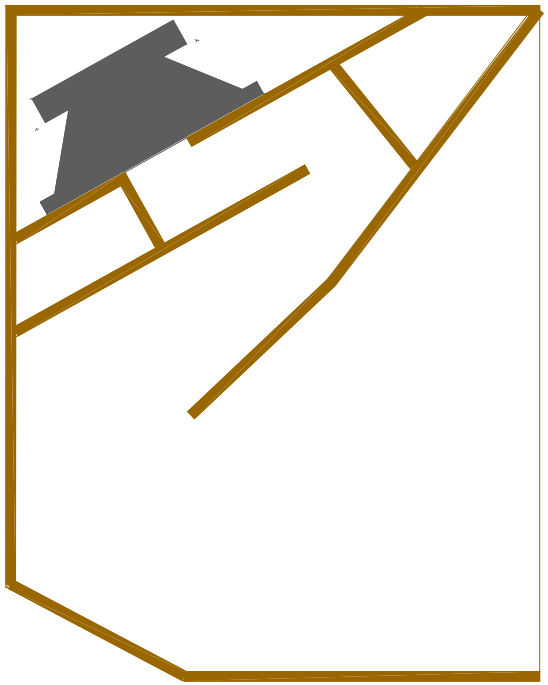
- Noise - need dedicated test room
- Ambient conditions
- Expense (3 amplifiers destroyed)
- How many speakers should we test?
- Time (5 days is too long but required for fatigue)
- We only know the average voice coil temperature.

What the AES does not tell us!

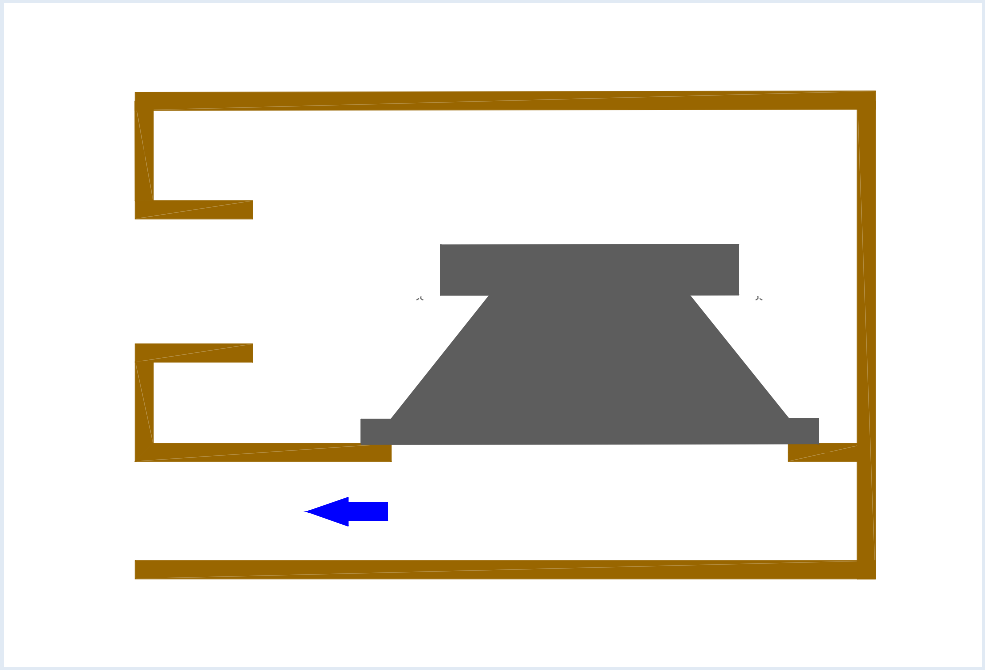
- Distortion level
- Stress fatigue not performed
- Test performed with no acoustic load
- No consideration of the end user
- No consideration of the end use HIFI vs. Professional use.
- No safety consideration
- Can the driver handle feedback at 2*rated?

Customer wants an 18” sub-woofer to handle 1000W amplifier
How does the AES rating help me?

Derate high Stress situations



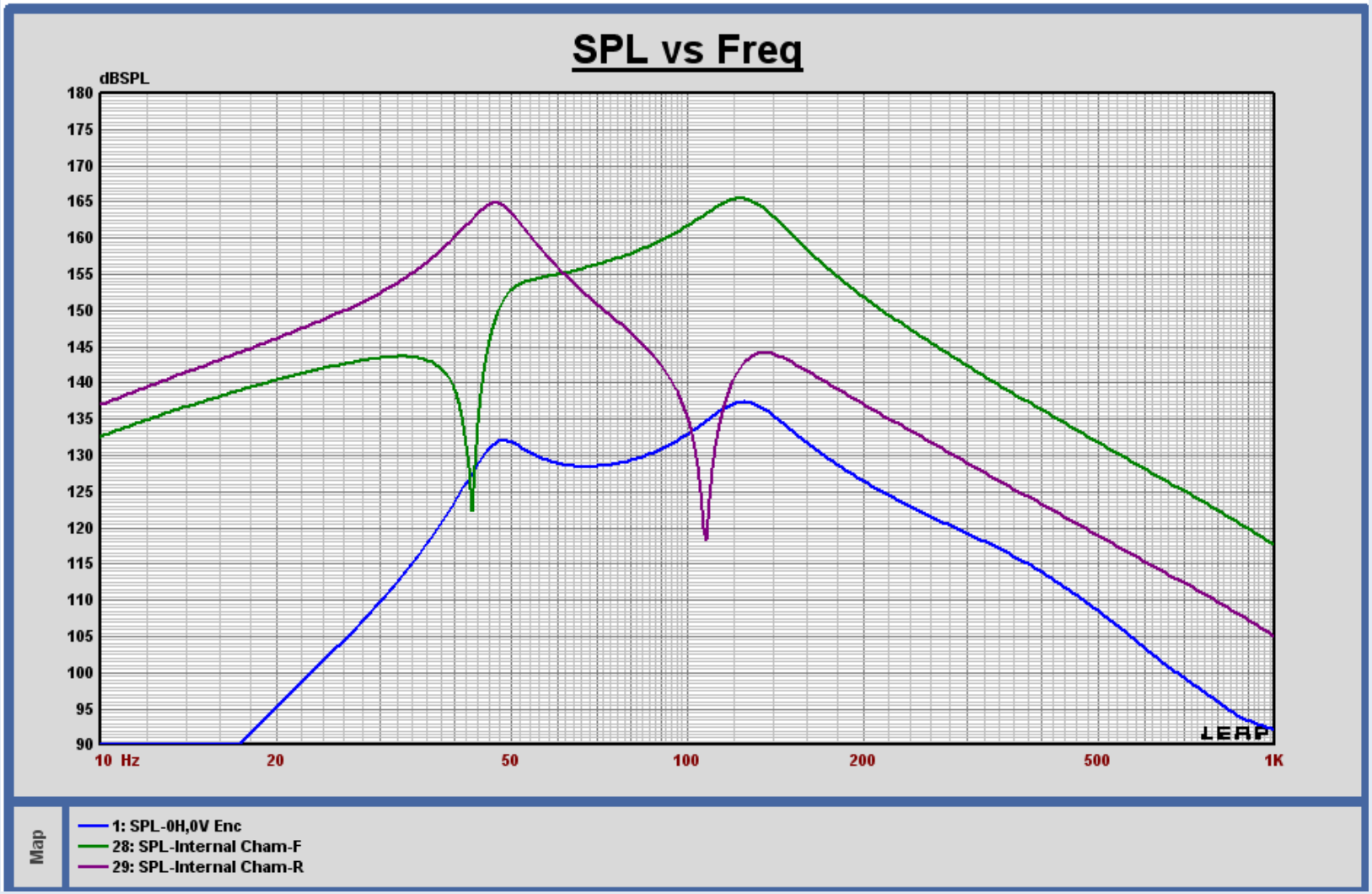
High Stress
No Ventilation
Hot day ambient 45C



Non Symmetric acoustic load

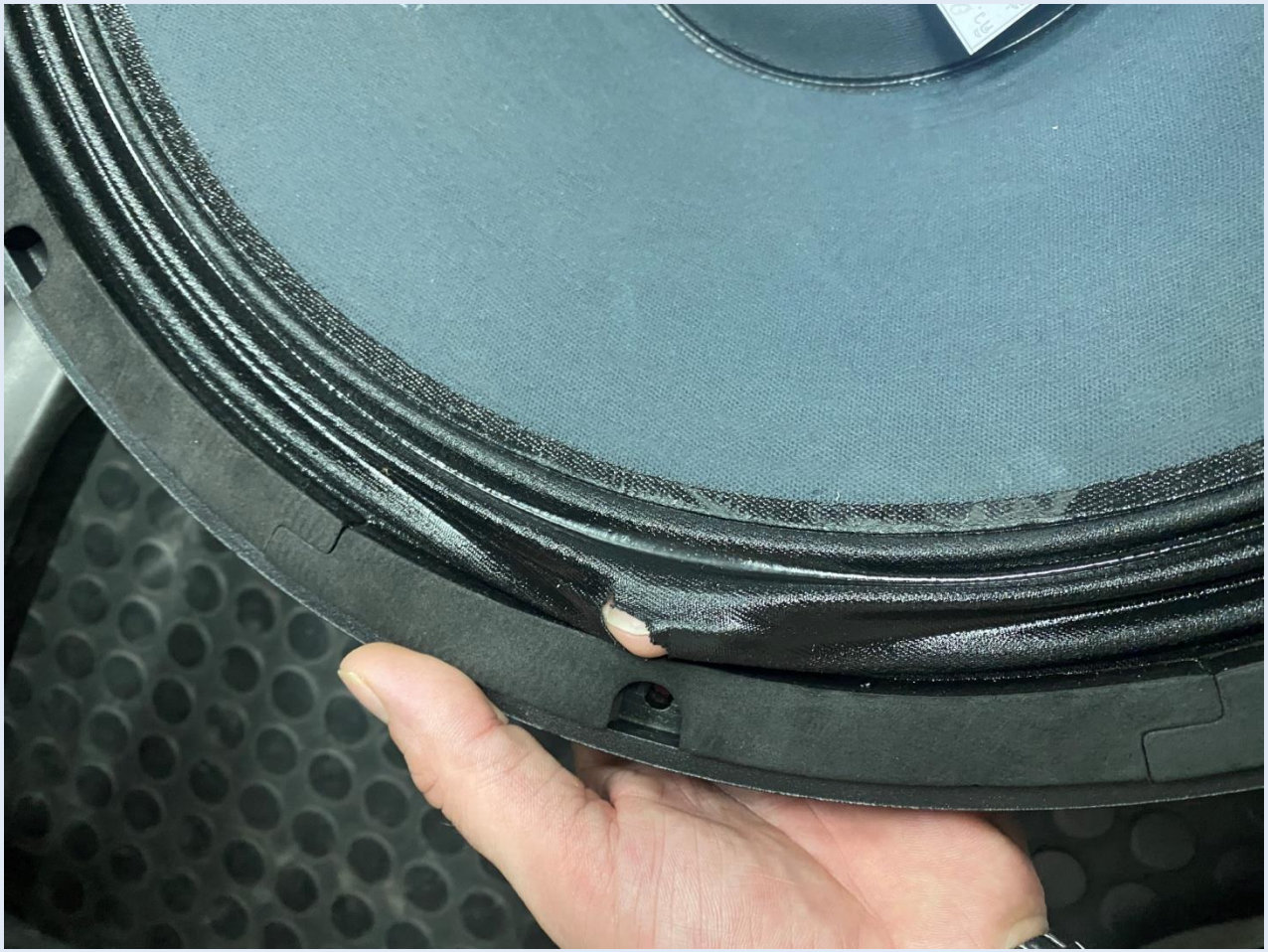
Derate Power Handling in these applications

Bandpass Stress failure



SPL response and internal pressure levels.

Bandpass Surround Stress Fracture

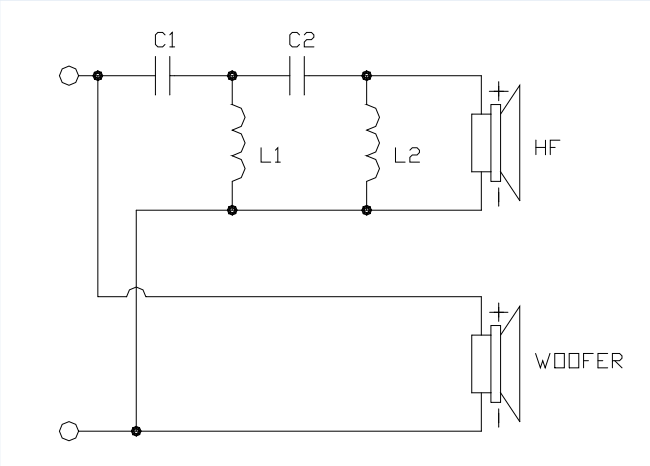


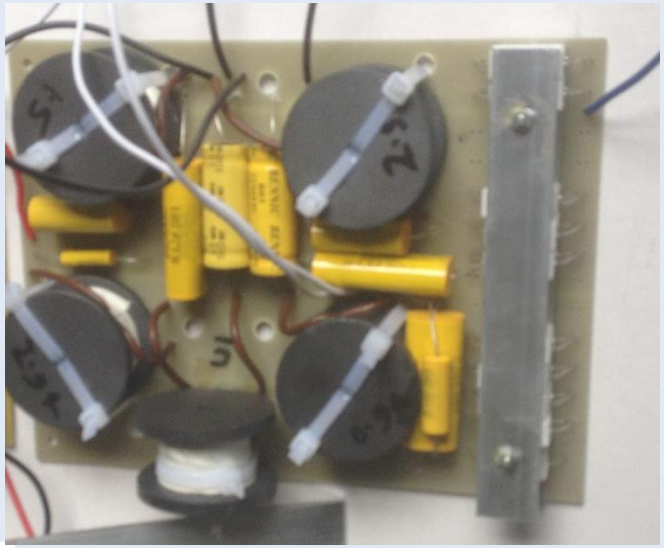
Cone body stress failure

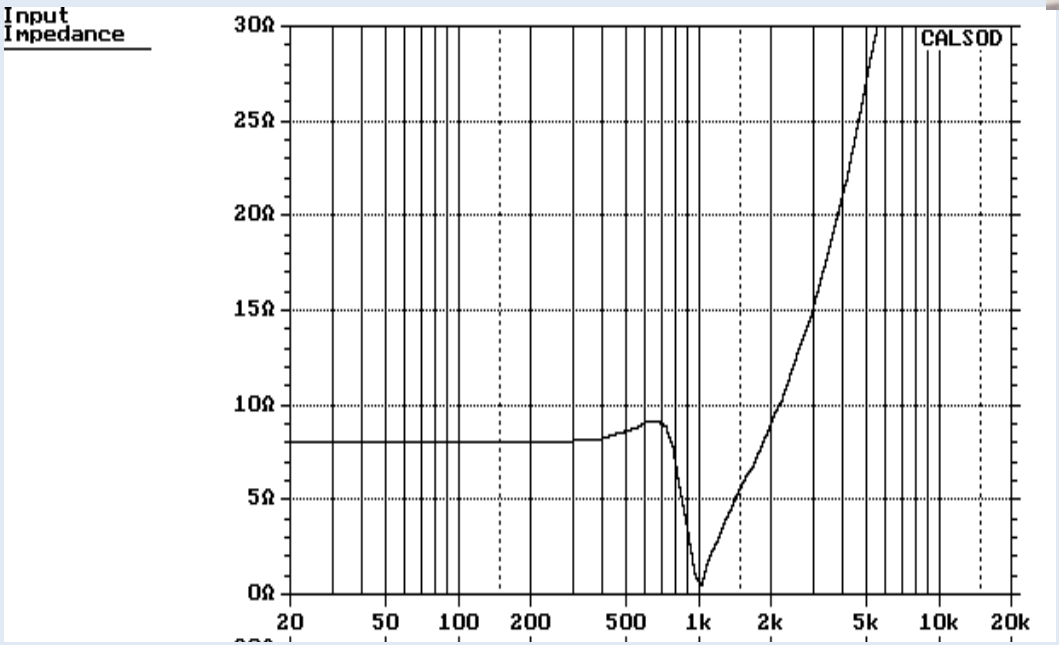
Possible causes:

(a) Wrong choice of cone shape
(b) Surround limiting excursion
(c) High acoustic load
(d) Abuse

Protection -Passive Xover Issues







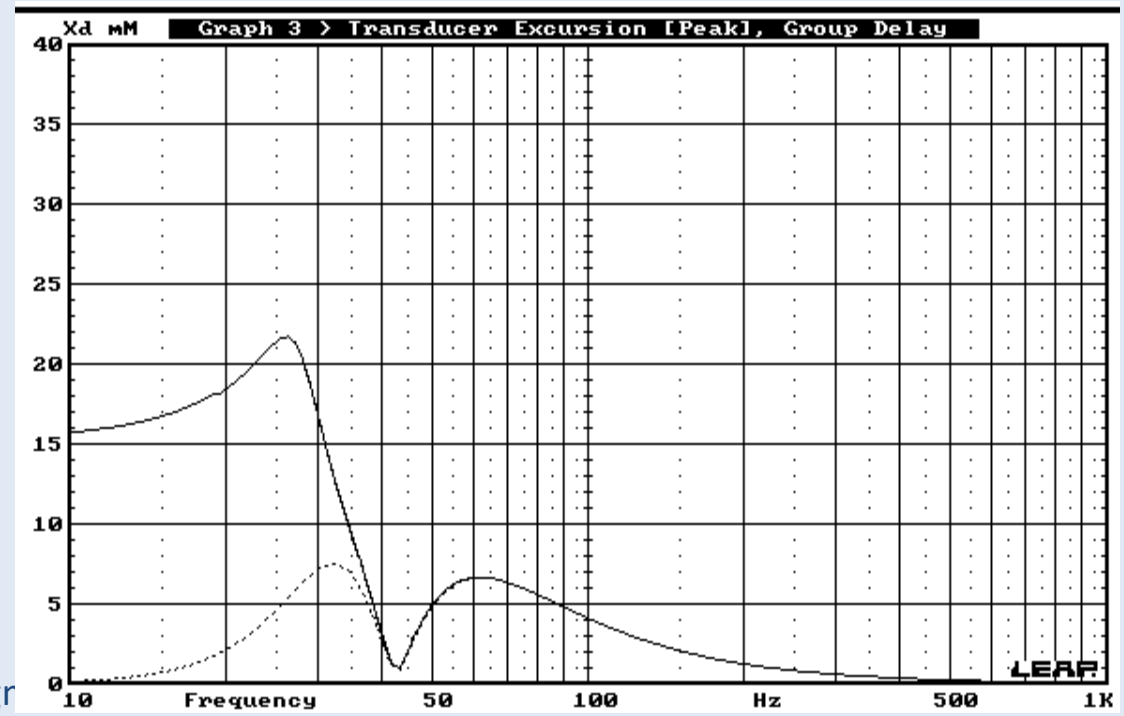
Also consider the effect of thermal and positional changes to the xover load impedance and the effect they have.

Protection

- Lamp in series with driver
- PolySwitch PTC resistor in series with driver
- Metal oxide Varistor
- Fuse or Thermal circuit breaker
- Back to back Zener diodes
- Ferro Fluid
- Eminence Speaker's D-fend is a programmable stand alone unit.
- Cannot leave passive xover open circuit

Protecting 12”Vented System

VB Diaphragm Excursion



Solid line diaphragr

Dash line diaphragm excursion with electronic B4, 35Hz hi-pass filter.

Diaphragm excursion is enclosure dependent

HI-PASS FILTER IS ESSENTAIL

Excursion Protection DSP

- Low frequency bandwidth extension and loudspeaker driver protection is achieved with a dynamic high-pass filter where the Q and high-pass frequency is signal dependent.

- Patent US 8,019,088 Tom Holman

Active heat protection system

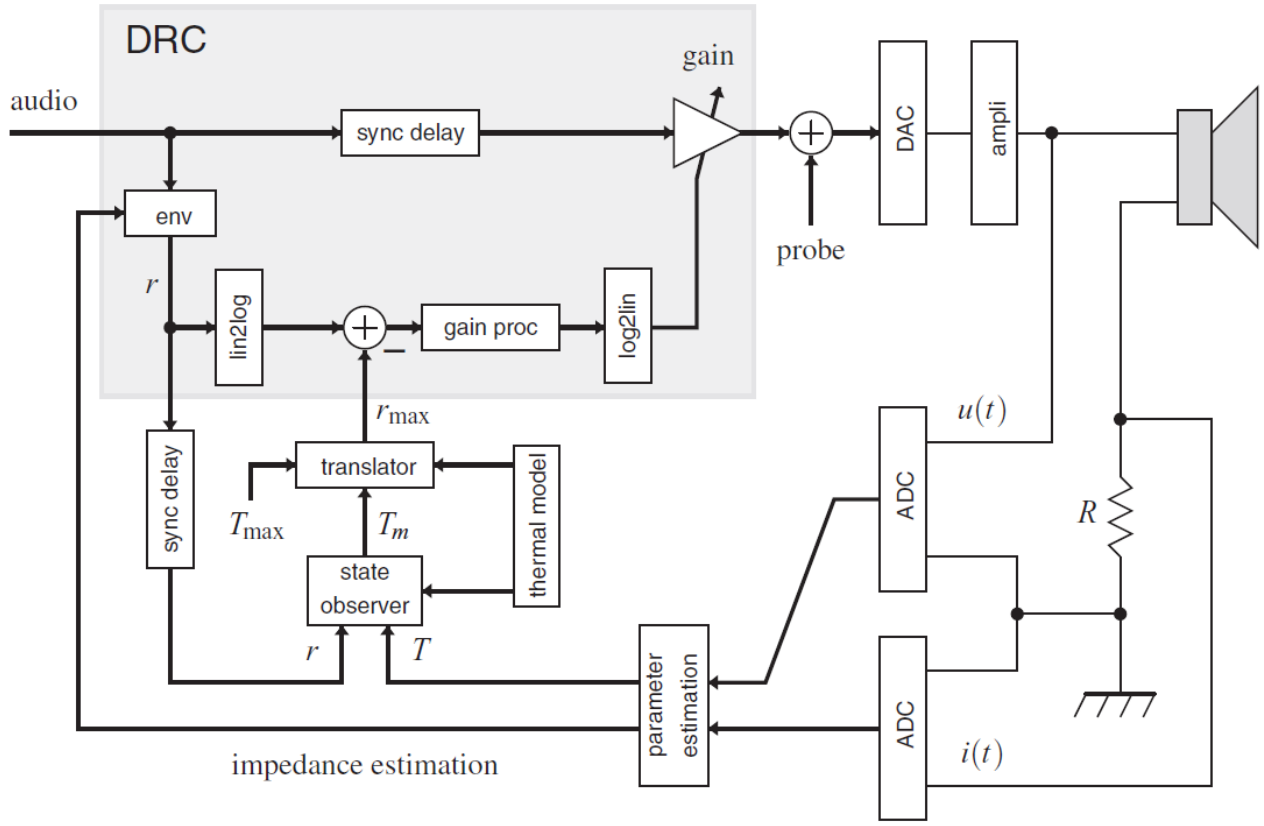


Fig. 2. Active heat protection system for the loudspeaker.

Active Loudspeaker Heat Protection JAES_V62_11_PG767.pdf

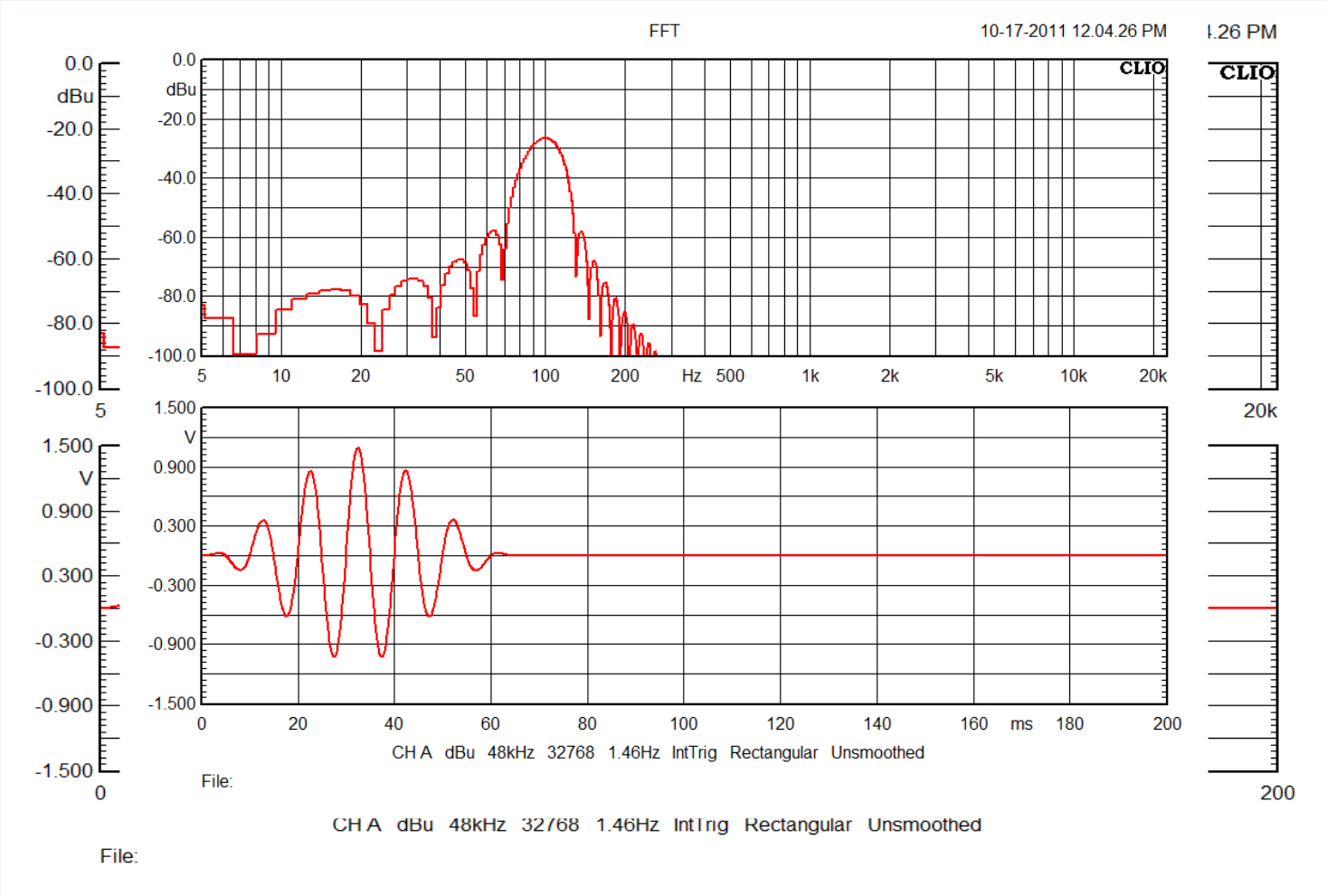
Measuring maximum subwoofer output ANSI/CEA-2010 Standard

The Consumer Electronics Association (CEA), in 2006, has released a *"standard Method of Measurement for Powered Subwoofers"* [1].

This standard aims to create a reliable testing method and a rating procedure to let manufacturers and customers compare powered subwoofers in an simple way.

The CEA standard is built upon a tone burst sequence performed at various frequencies and levels, until a certain distortion threshold is reached. While the test is intended for powered subwoofers, the same burst test can be applied to a broad case of electro-acoustic devices such as non-powered subwoofers drivers, tweeter drivers and compression drivers.

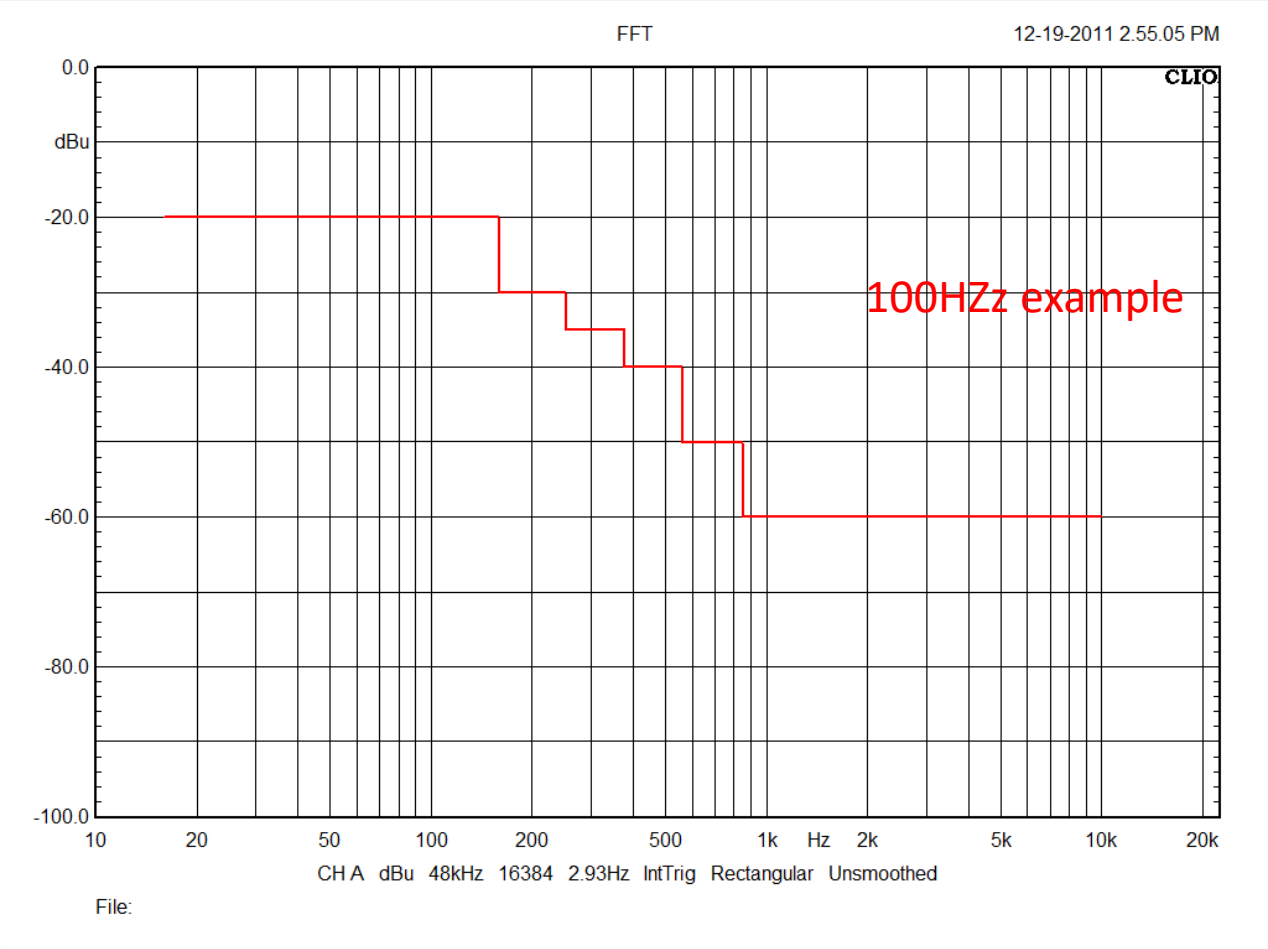
ANSI/CEA-2010



Test signal is a 6.5 cycles hann-burst signal.

The bandwidth of the test signal is exactly one third of an octave

ANSI/CEA-2010 Standard



Raise the test signal till one of the harmonics exceeds the allowed limits

Conclusion

- The AES power test is a demanding test testing the speaker's build integrity and thermal capabilities.
- However the end use, customer safety and fidelity acceptance also need to be consider.
- 12" example – expand
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Questions