

# IS THERE A RELATIONSHIP BETWEEN CAPACITOR VOLTAGE RATING AND SONIC PERFORMANCE IN LOUDSPEAKERS?

By Carl Richard (Feb./2010)

## **Background**

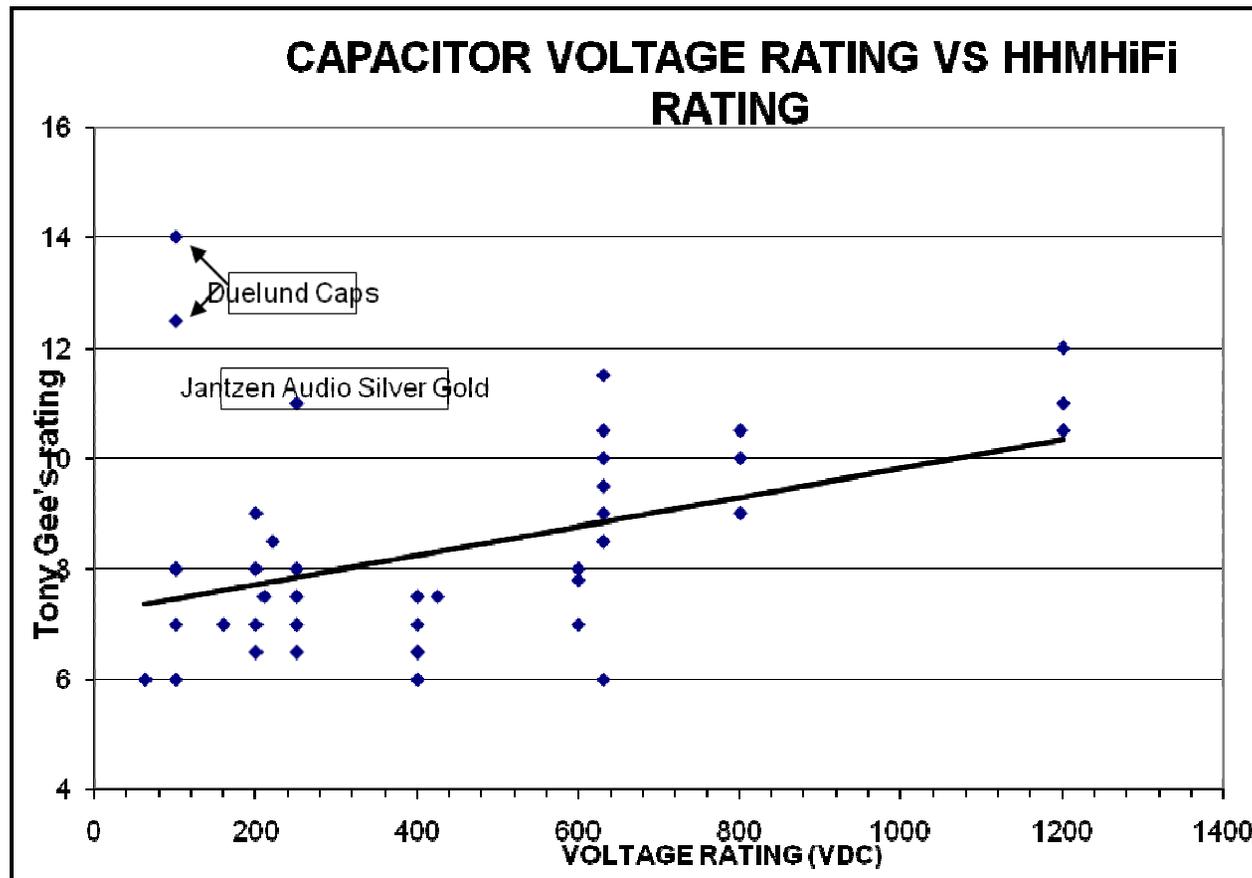
The intent of this document is to present some information I pulled together regarding the relationship between crossover capacitors and their impact on what we hear from a loudspeaker. Much of what follows involves anecdotal responses and quantitative ratings by a sole reviewer (Tony Gee) to listening tests performed with a wide variety of capacitor brands used in actual passive loudspeaker crossovers. Those responses and ratings are his alone. I felt that despite the subjective nature of his and other's evaluations also presented, there might be some merit in investigating further, their findings; particularly if the general trends seen by independent reviewers follow similar paths. However, it must be understood that these types of evaluations which were conducted whilst having full knowledge of what is being rated can carry a bias and thus be subjected to severe skepticism from the scientific community. On the objective side, progress is being made in the scientific measurement of capacitor's operating characteristics and loudspeaker's sonic output under highly controlled conditions. However, even the existing science isn't [perfect](#) and is also subject to much [debate](#) on which measurements matter and how they correlate with human's likes and dislikes. So, with that backdrop, I offer the following for your consideration.

## **THE FINDING**

Last summer, I was browsing Tony's web site, [www.humblehomemadehifi.com](http://www.humblehomemadehifi.com). As I read down through his list of capacitor reviews and ratings<sup>1</sup>, it became apparent his rating scores seemed to be higher with caps that had relatively higher voltage (VDC) specifications. I decided to make a listing of the VDC ratings and Tony's subjective evaluation ratings of all the caps on his list. This was done on an Excel spreadsheet. In all, 48 data sets were listed. In cases where Tony gave a +, I added 0.5. Where he gave a -, I subtracted 0.5. For example, a rating of 6+ would be listed in the data set as a 6.5. Next, I plotted the data and ran a simple linear regression (see pg. 2). The best fit regression line showed there might be some reasonable correlation between VDC and Tony's ratings. This was somewhat of a surprise to me because of the great divide between a capacitor's inherent voltage rating and its subsequent use in such a complex device as a passive loudspeaker crossover and ultimately impacting on the visceral sonic impressions of one's human ears. Obviously, the whole process is fraught with a multitude of variables. As such, I thought that even a mild correlation warranted further investigation in spite of my initial skepticism stemming from a suspicion of bias on Tony's part, albeit unintended IMO.

## THE ANALYSIS

The scatterplot below shows the fit of a linear regression line to the data. However, there are 3 obvious outliers – the 100 VDC Dueland caps which rated very high and the 250 VDC Jantzen Silver/Gold cap. With these outliers in the mix, the  $R^2$  coefficient is 0.171 – not significant. With the Dueland's out of the mix (unique construction sets them apart),  $R^2$  rose dramatically to a statistically significant 0.386 and with the Jantzen S/G out,  $R^2$  rose further to a highly significant 0.400 at 45 degrees of freedom (see the Pearson's Critical Value correlation table<sup>2</sup>) thus suggesting the relationship between VDC and Tony Gee's rating are somehow correlated. But first, read Tony Gee's comments posted recently under his Mundorf M-Cap MKP 630 VDC which he rated a 7+. With this mix of brands, uF levels and types, it was self evident that a special evaluation was needed to isolate some key variables that could possibly answer the question as to whether or not VDC makes a significant difference. Also worthy of note is the wide spread in ratings at the 630 VDC level.



The three 1200 volt caps are all Mundorf Supreme types

## THE CHALLENGE

At my request late last summer, Tony agreed to conduct an evaluation of 3 caps of the same uF value but with 3 different levels of voltage rating, all made by one manufacturer. I thought that this test might help isolate some of the variables a bit since Tony's 48 listings included for the most part, two uF values (4.7uF and 10uF), and broad list of manufacturers. Tony picked a 10 uF M-Cap in 250, 400 and 630 VDC made by Mundorf. Over the course of the past 7 months he used them in different speakers for break in and eventual critical listening evaluations. His final ratings were the 250 unit received a 7-, the 400 unit a 7, and the 630 unit a 7+. Thus, the outcome followed an upward trend in rating – similar to the initial finding. Since Tony's evaluation methodology incorporates a non-scientific conscious switching of caps in and out of speakers – all the while knowing what it is he is evaluating, I asked that the 3 special evaluations be done blind under this challenge so as to not interject any bias into the results. Most unfortunately, that was not done. So, was there bias? Perhaps. However, [Tony explains his impressions following this trial under 'sound' in his Mundorf 630 VDC MKP evaluation.](#) IMO, it's not hard to imagine the presence of an unintended bias resulting from knowing that higher VDC translates to both larger physical size caps and higher cost, and I'm as guilty as anyone of the 'more = better' syndrome.

My impression from Tony's site is he definitely is not your average DIY'r. A close look at his home page reveals a large assortment of his own designs, each of which he provides all the details to construct – including capacitor recommendations. Other than Zaphaudio.com and troelsgravesen.dk, I know of no other 'professional' DIY'r on the net who is willing to share in such large volume the type of information that many others sell. My impression is he spends quite a bit of time with loudspeakers and has accumulated a very large amount of experience listening to different combinations of capacitors and drivers over a number of years. Thus, I feel he should be given the some benefit of the doubt. Tony uses subjective expressions like “deeper the image size and there is also an increase in the amount of fine detail.” How can those audible attributes be measured?

## THE DEBATE & AT LEAST ONE POSSIBLE ANSWER

There are many threads spread across the WWW debating the significance of capacitor's abilities to affect the sound quality of a loudspeaker<sup>3</sup>. There are hundreds of posts and many thousands of views made by inquisitive visitors who seek information and help with their decision to simply replace and or upgrade their capacitors. In many cases, arguments boil down to the subjectivists (i.e. the listeners – mostly believers) vs. the objectivists (the measurers, who are mostly skeptics). A paper was given at the 124<sup>th</sup> AES convention ([Paper #7314 "Audio Capacitors. Myth or reality?"](#)) that takes up the subject of capacitor evaluation. It was written by a UK researcher from the University of Salford and two engineers under the employ of ICW Ltd<sup>4</sup>. (the company that makes Clarity caps). The paper describes in some detail what the researchers went thru before settling on a rigorous test panel methodology which helped to clearly differentiate between test samples. Initially, 32 panelists were able to easily differentiate a NPE cap from film caps but had trouble differentiating between film caps. ICW had developed the MR series capacitor designed and constructed to reduce resonance effects the researchers found were detrimental to performance. The improvement was a subtle effect which required a special 'golden ear' panel and enhanced listener panel training under ITU-R BS.1116-1 test standard. Eventually, 60-70% of the 16 final panelists found the MR caps preferred when evaluating clarity and spatial information.

## **OTHER, SIMILAR EVALUATIONS ON THE WWW**

Tony is not the only person doing cap evaluations. Below are some links to other sites where capacitor comparisons have been done. He also seems to have a significant group of believers [here](#)

<http://www.hificritic.com/downloads/APassiveRole.pdf> Distinguished audio writer, Martin Colloms measures and rates caps in this dated study ("Passive Role?" & "Capacity to Change", HIFI News&Record Review, 10&12/85). Caps used in his studies were used as coupling caps and not in loudspeakers. In his conclusion, he states the degree of the sonic effects is partly dependent on the dielectric stress, and this may be reduced by **choosing higher voltage ratings than are strictly required.** Additionally, Mr. Colloms measured electro-mechanical resonance. This appears to have been picked up by researchers at Clarity Cap who published a white paper on the subject

[http://wduk.worldomain.net/pdf/ClarityCap\\_Technical\\_Report.pdf](http://wduk.worldomain.net/pdf/ClarityCap_Technical_Report.pdf) which appears to be a blatant ad for their MR Range high-end caps. Colloms' study include some blind and double-blind tests wherein 2/3 of the time each of three test subjects were able to 'reliably detect to some extent the subjective difference between two plastic film capacitors under test.' Theoretically, if the blind test had failed to differentiate between the caps, the test panelists would have averaged about ½ guesses correctly.

<http://www.head-fi.org/forums/f21/orgy-capacitors-cap-thread-284863/> A large number of caps evaluated in coupling amp applications with some loudspeaker application as well. No ratings – just anecdotal comments on sonics.

<http://www.laventure.net/tourist/caps.htm> A fair number of cap evaluations in a variety of applications included loudspeakers. An alphabetical tiered rating system is used to classify quality.

[http://www.10audio.com/sonicap\\_oimp\\_multicap.htm](http://www.10audio.com/sonicap_oimp_multicap.htm) Four caps evaluated in a Magnapan speaker. Author liked Mundorf Silver/Oil the best, but thought Sonicaps were a 'best buy'.

<http://www.vhaudio.com/21capacitorshootout.pdf> A Chinese review (translated into English for the most part) of 21 caps. They were used as coupling caps in high-end audio chain.

<http://www.ecp.cc/cap-notes.html> This study included quantitative ratings. However, it was done with caps being used as coupling caps upstream of loudspeakers. The 20 data points in the results table show a slightly upward trending correlation line. However, the R<sup>2</sup> coefficient was not statistically significant.

In most of the above evaluations, I found similarities in brands and types the authors favored.

**DID ALL THESE PEOPLE IMAGINE THEY HEARD A DIFFERENCE?**

## MY OWN IMPRESSIONS & RANDOM THOUGHTS

It's my opinion that higher VDC caps may improve the sonics of hi-end speakers in a very subtle way. Those who opt for these more expensive caps may or may not notice any improvement or, convince themselves they notice. The extent of the improvement isn't large, but audiophiles seeking that last bit of sonic nirvana are going to pay the extra \$\$\$ for these typically more pricey caps. The better the speaker they have, the higher the likelihood they will be able to hear a difference. Or, the higher the likelihood they will imagine a difference?

There are many terms used by subjectivists to describe what they hear. Below is a partial list developed by Robert Harley (Stereophile, July 1994) Tonal Balance, Overall Perspective, Soundstaging, Dynamics, Pace, Rhythm, Timing, Coherence and Musicality. How many, if any, of these descriptive audio attributes can be measured? Certainly, some can be characterized with known tests like IM Dist., impulse response, soundfields, etc.. But how do quantitative characterizations correlate with these terms? Toole and Olive have done the most, perhaps, in this area but much more needs to be done.

I think there is a catch 22 with ABX testing. For example, if a test subject can't tell the difference between two caps with quick switching back and forth between them, if the subject asks for more time to listen, the objectivists will begin to suspect the subject may eventually imagine something that isn't real (e.g. [psychoacoustic masking](#)). It's clear from the Clarity Cap MR study AES paper that simple ABX blind listening tests with just any group of listeners isn't a satisfactory methodology for discriminating very subtle sonic differences. This raises the following question in my mind: Does such a small measurable improvement in performance justify a roughly 10X increase in price over their own SA series cap in the standard value 4.7 uF value (ref. Madisound 2009 cat.)? I suspect [Audiophiles](#) will continue to pay the price as evidenced by all the high end caps available in the marketplace.

If a cap company had a clear and decisively superior cap, I'm sure they would be quoting theirs or other's blind test results in ads. I haven't seen evidence of this to any significant extent. The MR Clarity cap ads appear to currently be the first to venture into this area. However, it must be kept in mind they struggled to find a test methodology they could use that shed a favorable light on their new product. That struggle isn't evident in their white paper. Only in their AES paper. Certainly it would be great if a controlled blind test were conducted wholly by a non-commercial entity with the resources and manpower.

Currently, I'm on the fence concerning the objective vs. subjective debate. In my work, I do both measurements and listening tests. Both are needed to make a complete assessment. A while back, I made a somewhat feeble attempt at an objective study of capacitors<sup>5</sup> using borrowed waveform analysis software from Cornell University Bioacoustics Program. I concluded there wasn't any significant difference in the data between a \$1 NPE cap and a much pricier Hoveland Musicap of the same uF value. I'd like to repeat the study again in the future with a better test mic which I now own. There may be better software available currently as well. By no means is this paper the final word on the subject. I'm just an outsider for the most part looking in. Perhaps it might become the impetus for a researcher to explore the topic further. I hope so.

Did I answer the initial question? Nope, but the journey was worth it. In retrospect, it looks like I raised more questions than I answered.

Of course, in the end, if an audio consumer is happy with their recapping results; regardless of the price paid, isn't that all that matters?

**After all, it is all about the music!**

## References:

- 1) <http://www.humblehomemadehifi.com/Cap.html>
- 2) <http://www.gifted.uconn.edu/siegle/research/correlation/corrchrt.htm>
- 3) <http://www.audiokarma.org/forums/showthread.php?t=7897>  
<http://www.classicspeakerpages.net/IP.Board/index.php?showtopic=1431&hl=capacitor+myth>  
<http://www.classicspeakerpages.net/IP.Board/index.php?showtopic=3859&hl=capacitors>  
<http://forum.audiogon.com/cgi-bin/fr.pl?cspkr&1211428524>  
<http://www.ecp.cc/cap-notes.html>  
<http://techtalk.parts-express.com/showthread.php?t=207799>
- 4) <http://www.icwltd.co.uk/audio/image.htm>
- 5) <http://www.classicspeakerpages.net/IP.Board/index.php?showtopic=2252&pid=64027&st=0&#entry64027> (post #2 link)

## Further reading & viewing:

<http://www.reliablecapacitors.com/pickcap.htm> - Jung and Marsh's 1980 Article in Audio mag.  
[http://www.kenkantor.com/publications/audio\\_fetishes/fetish\\_part\\_02.pdf](http://www.kenkantor.com/publications/audio_fetishes/fetish_part_02.pdf) - The objectivist's view  
<http://www.youtube.com/watch?v=BYTIN6wjcvQ&feature=related>  
<http://sound.westhost.com/articles/capacitors.htm#ref>  
<http://www.ivorcatt.com/2603.htm>

ITU-R BS 1116-1: Methods for the subjective assessment of small impairments in audio systems including multichannel sound systems. 1997