

Understanding Headphone Power Requirements

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INTRODUCTION

Much confusion abounds regarding headphone power requirements. This Rane Note is intended to dispense some of the mist surrounding headphone specifications and hopefully give you a clearer understanding of how much power is really needed for your application.

HEADPHONE SENSITIVITY

Headphone manufacturers specify a “sensitivity” rating for their products that is very similar to loudspeaker sensitivity ratings. For loudspeakers, the standard is to apply 1 watt and then measure the sound pressure level (SPL) at a distance of 1 meter. For headphones, the standard is to apply 1 milliwatt ($1 \text{ mW} = 1/1000$ of a watt) and then measure the sound pressure level at the earpiece (using a dummy head with built-in microphones). Sensitivity is then stated as the number of dB of actual sound level (SPL) produced by the headphones with 1 mW of input; headphone specifications commonly refer to this by the misleading term “dB/mW.” What they really mean is dB SPL for 1 mW input.

Think about these sensitivity definitions a moment: headphone sensitivity is rated using $1/1000$ of a watt; loudspeaker sensitivity is rated using 1 watt. So a quick rule-of-thumb is that you are going to need about $1/1000$ as much power to drive your headphones as to drive your loudspeakers since both of their sensitivity ratings are similar (around 90-110 dB SPL). For example, if your hi-fi amp is rated at 65 watts, then you would need only 65 mW to drive comparable headphones. (Actually you need less than 65 mW since most people don’t listen to their loudspeakers at 1 meter.) And this is exactly what you find in hi-fi receivers—their headphone jacks typically provide only 10-20 mW of output power.

Take another moment and think about all those portable tape players. They sound great, and loud. Why, you can even hear them ten feet away as the teenage skateboarder that ran over your foot escapes.

Power output? About 12 mW.

THE LIST

As an aid in finding out how much power is available from either the HC 6 or HC 4 Headphone Consoles, we have compiled a listing of popular headphones. Included is a column giving the maximum SPL obtainable using the HC 6 or HC 4 and any particular headphone—ultimately, it all gets down to actual SPL. The power rating really doesn’t matter at all—either it’s loud enough or it isn’t (of course it has to be clean power, not clipped and distorted). The SPL numbers shown are for maximum *continuous* SPL; for momentary peak SPL add 3 dB.

Note that the maximum achievable SPL varies widely for different models and manufacturers, ranging from a low of 107 dB to a harmful 146 dB! The table also shows there is very little relationship between headphone impedance and sensitivity, and that power output *alone* means nothing, since in one case 80 mW produces a maximum SPL of 107 dB, yet in another case the same 80 mW yields an SPL of 124 dB!

Sensitivity (dB) is the measured sound pressure level with 1 mW of power. The **Max Power (mW)** columns are typical continuous average (rms) power, 20 Hz-20 kHz, with THD less than 0.1%.

If headphones are not yet owned, or replacements are desired, use this listing as a guide for selecting headphones with sufficient sensitivity for the maximum desired SPL.

Note: headphones with an impedance of less than 32 ohms are not recommended for use with the HC 6 or the HC 4.

Manufacturer	Model	Impedance (ohms)	Sensitivity (dB)	HC 4 Max Power (mW)	HC 4 Max SPL (dB)	HC 6 Max Power (mW)	HC 6 Max SPL (dB)
AKG	K141M	600	98	89	117	80	117
	K240M, K240DF	600	88	89	107	80	107
	K270S	75	92	239	115	380	118
	K301	100	94	225	118	285	119
	K401, K501	120	94	220	117	290	119
Audio-Technica	ATH-COM1, ATH-COM2, ATH-908	40	90	220	113	440	116
	ATH-910	40	92	220	115	440	118
	ATH-P5	40	100	220	123	440	126
	ATH-M40	60	100	238	123	400	126
	ATH-D40	66	102	235	126	295	127
Beyerdynamic	ATH-M2X, ATH-M3X	45	100	230	123	435	126
	DT150	250	97	160	119	175	119
	DT211, DT311	40	98	220	121	440	124
	DT250	80	98	240	121	360	123
	DT411	250	102	160	124	175	124
	DT 531	250	95	160	116	175	116
	DT431, DT331	40	86	220	109	440	112
	DT770PRO, DT990PRO	600	96	89	115	80	115
	DT801, DT811, DT511	250	94	160	116	175	116
	DT901, DT911	250	98	160	120	175	120
Fostex	T-5	44	96	225	119	435	122
	T-7	70	98	240	121	385	124
	T-20	50	96	233	120	425	122
	T-40	50	98	233	122	425	124
Grado	SR 325	40	96	220	119	440	122
Hosa	HDS-701	40	91	220	114	440	117
Koss	A/250, A/200, A/130, TD/80	60	98	238	123	320	125
	R/200	60	84	238	108	400	110
	R/100, R/45	60	85	238	109	400	111
	R/90, HD/2, SB/15	60	100	238	123	400	126
	R/80, R/35S, R/20, Porta Pros	60	101	238	124	400	127
	R/70B, R/55B, SB/50, SB/35	60	101	238	124	400	127
	R/40	60	90	238	114	400	116
	R/30S	60	106	238	130	400	132
	R/10	60	103	238	127	400	129
	TD/75	60	95	238	119	400	121
	TD/65	90	101	235	124	340	126
	TD/61	38	93	212	116	440	119
MB Quart	QP 805	300	98	145	120	80	117
Sennheiser	HD 400, 433, 435, 470	32	94	200	117	450	121
	HD25	70	120	240	144	380	146
	HD445	52	97	235	121	390	123
	HD25SP	85	100	235	123	350	125
	HD265, 525, 535, 545, 565	150	94	207	117	190	117
	HD455, 475	60	94	238	118	400	120
	HD465	100	94	225	118	285	119
	HD 570	120	95	220	110	290	120
Sony	HD580, 600	300	97	145	118	80	116
	MDR-V100MK2	32	98	200	121	450	125
	MDR-85	40	102	220	125	440	128
	MDR-V600, MDR-D77	45	106	230	129	435	132
	MDR-CD10	32	96	200	119	450	123
	MDR-CD550, CD750	45	100	230	123	435	126
	MDR-CD6	45	110	230	133	435	136
	MDR-CD850, CD950	32	102	200	125	450	129
	MDR-CD1000, CD3000	32	104	200	127	450	131
	MDR-D33, MDR-D55, MDR-7504	45	104	230	127	435	130
	MDR-7506	63	106	240	129	400	132
	MDR-7502	45	102	230	125	435	128
Stanton	ST PRO, DJ PRO 1000	32	100	200	123	450	127
Telex	PH-6	600	105	89	124	80	124
Yamaha	RH5MA	32	98	200	121	450	125
	RH1	32	90	200	113	450	116
	RH2	32	95	200	118	450	122
	RH3	60	95	238	119	400	121
	RH10M	40	102	220	125	440	128
	RH40M	32	103	200	126	450	130

Sound Pressure Level Equivalents

SPL-dB	Common Example	SPL-dB	Common Example
140	Irreparable damage	60	Normal conversation
130	Jet aircraft taking off	50	Elevator music
120	Threshold of pain / Thunder	40	Normal home background (kids asleep)
110	Threshold of discomfort	30	Studio background
100	Dirt bike / Riveter	20	Rustling of leaves / Quiet whisper
90	Start of unsafe levels	10	Butterfly swoop
80	Average factory	0	Threshold of hearing
70	Kids at play		

Permissible Noise Exposures

Extracted from the U.S. Department of Labor Noise Regulations

Duration Per Day, Hour	Sound Level (dB), A-Weighting
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115