World's Largest
Fuse Measurements Report
01-2010

The measurements done, were made under the aspect of the influence of slow blow fuses on sonic behaviour of high-end audio gear.

Measurement of DC resistance;
measured at current of 3 Amp. DC (fuses with value below with lower currents)

Fuse, Type T 1,6 Amp. 6,3 x 32 mm.	DC R Direction1 mOhm	DC R Direction2 mOhm	DC R in Holder mOhm
HiFi-Tuning US-Ultimate³ (Silver Star)*	44,47	44,57	46,21
HiFi-Tuning US-Gold²	45,02	45,14	47,27
Iso Clean	155,8	155,9	158,0

Fuse, Type T 2 Amp. 5 x 20 mm.	DC R Direction1 mOhm	DC R Direction2 mOhm	DC R in Holder mOhm
HiFi-Tuning Ultimate² Cryo	24,077	24,115	26,257
HiFi-Tuning Ultimate²	24,586	24,611	25,723
HiFi-Tuning Ultimate³ Cryo	24,972	25,066	27,078
Iso Clean	27,610	27,643	29,228
SinnOxx	46,692	46,797	48,205
Super Cryo (LF)	54,432	54,527	55,048
AHP	586,43	585,69	588,28

Fuse, Type T 2 Amp. 6,3 x 32 mm.	DC R Direction1 mOhm	DC R Direction2 mOhm	DC R in Holder mOhm
HiFi-Tuning US-Gold² Cryo	31,314	31,340	33,081
Standard, Glass Fuse	112,54	117,74	114,38
Iso Clean	131,90	132,50	133,62

Fuse, Type T 3,15 Amp. 6,3 x 32 mm.	DC R Direction1 mOhm	DC R Direction2 mOhm	DC R in Holder mOhm
HiFi-Tuning US-Gold² Cryo	21,834	21,862	22.375
HiFi-Tuning US-Gold²	24,475	23,585	24,584
Infinity Power Evolution (3 Amp.) (rhodium)	49,578	49,769	50,267
Standard, Ceramic Fuse	55,043	54,465	56,402
Standard, Glass Fuse	58,041	55,934	67,053

Fuse, Type T 5 Amp. 6,3 x 32 mm.	DC R Direction1 mOhm	DC R Direction2 mOhm	DC R in Holder mOhm
HiFi-Tuning US-Gold² Cryo	12,750	12,782	13,086
Iso Clean	31,625	32,240	33,948
Standard Ceramic Fuse	40,491	40,923	41,543

Fuse, Type F 13 Amp. 6,3 x 25 mm. (UK-Plug Fuse)	DC R Direction1 mOhm	DC R Direction2 mOhm	DC R in Holder mOhm
HiFi-Tuning UK-Gold²	3,936	3,934	---
Iso Clean	4,463	4,465	---

*** = Worldpremiere 2010**

Fuse, Type	DC R Direction1	DC R Direction2	DC R in Holder

T 16 Amp. 5 x 20 mm.	**mOhm**	**mOhm**	**mOhm**
HiFi-Tuning Ultimate³ Cryo	2,4479	2,4435	4,0733
HiFi-Tuning Ultimate² Cryo	2,5135	2,5215	4,4667
Fuse, Type	**DC R Direction1**	**DC R Direction2**	**DC R in Holder**
T 16 Amp. 6,3 x 32 mm.	**mOhm**	**mOhm**	**mOhm**
HiFi-Tuning US-Gold² Cryo	3,0533	3,0631	3,9052

Fuse, Type	**DC R Direction1**	**DC R Direction2**	**DC R in Holder**
T 20 Amp. 5 x 20 mm.	**mOhm**	**mOhm**	**mOhm**
HiFi-Tuning Ultimate³ Cryo	1,7123	1,7139	3,9576
HiFi-Tuning Ultimate² Cryo	1,8194	1,8251	3,8136
Fuse, Type	**DC R Direction1**	**DC R Direction2**	**DC R in Holder**
T 20 Amp. 6,3 x 32 mm.	**mOhm**	**mOhm**	**mOhm**
HiFi-Tuning US-Gold² Cryo	2,1093	2,1210	3,9509

1. Measurement of Voltage drop over fuse at 1 Amp. AC 50 Hz

Fuse, Type	**Voltage drop at 1 A AC,50 Hz (or 90 % I at smaller Values) mV AC**
T 0,5 Amp. (500 mA.) 5 x 20 mm.	
HiFi-Tuning Ultimate² Cryo	76,611
HiFi-Tuning Ultimate³ Cryo	94,1954
AMR	251,188
Infinity Power Evolution (palladium)	264,997
Infinity Power Evolution (rhodium)	266,192
AHP	484,610
Super Cryo (LF)	522,403

T 1,6 Amp. 6,3 x 32 mm.	
HiFi-Tuning US-Ultimate³* (Worldpremiere)	51,005 (Silver Star)
HiFi-Tuning US-Gold² Cryo	54,838
Iso Clean	91,571

T 2 Amp. 5 x 20 mm.	
HiFi-Tuning Ultimate² Cryo	28,180
AMR	29,452
HiFi-Tuning Ultimate³ Cryo	29,730
Iso Clean	34,697
Solder Fuse	44,083
SinnOxx Germany	54,971
AHP	68,461
Super Cryo (LF)	99,635
Super Cryo (LF)	burns at 800mA!
T 2 Amp. 6,3 x 32 mm.	
HiFi-Tuning US-Gold² Cryo	37,022
Standard, Glass, Spiral	52,438
Iso Clean	142,058

T 3 Amp. 6,3 x 32 mm.	
HiFi-Tuning US-Gold² Cryo	25,469
Infinity Power Evolution 3 Amp. (rhodium)	52,477
Iso Clean	69,675

	Voltage drop at 1 A AC,50 Hz (or 90 % I at smaller Values) mV AC
F 10 Amp. 6,3 x 25 mm. (UK-Plug Fuse)	
HiFi-Tuning UK-Gold²	12,714
F 13 Amp. 6,3 x 25 mm.	
HiFi-Tuning UK-Gold²	11,225
Iso Clean	14,236

T 16 Amp. 5 x 20 mm.	
HiFi-Tuning Ultimate² Cryo	6,350
HiFi-Tuning Ultimate³ Cryo	6,591
T 16 Amp. 6,3 x 32 mm.	
HiFi-Tuning US-Gold² Cryo	7,542

T 20 Amp. 5 x 20 mm.	
HiFi-Tuning Ultimate² Cryo	6,223
HiFi-Tuning Ultimate³ Cryo	6,326
T 20 Amp. 6,3 x 32 mm.	
HiFi-Tuning US-Gold² Cryo	7,884

Evaluation of measurements :

1. DC- Resistance at 3 Amp. DC

First column is listed the DC resistance in milliohms in direction one.
Second column is listed the DC resistance in direction two.
Third column is listed the DC resistance with the fuse measured in a standard fuse holder.

Interpretation of measurements :

There is a measurable difference in directivity of fuses. Mostly that will be due to the way the melting wire is manufactured. The difference is in the range of 5 % . That is in the range of variations due to the factoring process, but the difference is measurable with all types of fuses.
The resistance of the fuse itself is dependent on the length and thickness of the melting wire. At pure DC- resistance measurements, of the commercial available fuses, the solder type with leads gives the best results. Worst results gives the fuse with a glass tube and spiral shaped melting wire.
The high end fuses all give better results in conductivity, the cryogenically treated fuses from HiFi-Tuning give the best results, while the rhodium coated fuse from Padis gives the highest DC- resistance..

For DC applications it´s recommended to use the solder type fuse or the cryogenically treated fuses from HiFi-Tuning Germany.
The drop in resistance up to the factor of 8 is clearly measurable and also could be detected in listening test.
Fuses with a glass tube and a spiral shaped melting wire are additionally by a factor of 20 more sensitive to micro phonic effects. Fuses with a glass tube and a straight wire still by a factor of 5.
An increasing nominal value of a fuse causes an increasing thickness of the melting wire and so a reduced DC-resistance. The conclusion to take a fuse with a higher nominal value

to decrease the DC-resistance should not be taken, cause acting that way is highly dangerous.

2. Voltage drop over the fuse with 1 Amp. AC at 50 Hz.

The set up for this measurement is: A calibrator is connected in the way that a current of 1 Amp. AC at 50 Hz is put through the fuse under test, The voltage drop over the fuse is measured. Is a line voltage of 230 V assumed, the unit fed by a current of 1 Amp. drags a power of 230 VA (earlier days rated watts). In that case a power of 0,113 VA is dissipated in the worst case (glass tubed fuse with spiral shaped melting wire) or of 0.060 VA (cryogenically treated fuse by HiFi-Tuning) by the fuse. That power is simply heat radiated from the fuse and does not reach the unit, that is running. This power loss of a maximum of 0,25 % is very small in comparison to typical variations in line voltage of average 3 %. When line voltage is 110 V Ac, the losses are even smaller by a number better than 2. (voltage drop is the same), but a higher rated fuse gives less voltage drop.
Power lost is U x I.
By a technical view, the cryogenically treated fuses of HiFi-Tuning give the best results, while standard glass tubed fuses with spiral shaped melting wire, give the worst results.

3. Vector Impedance measurements

A vector Impedance analyzer is a measurement unit, which measures the AC resistance of a DUT. The measurement is called vectorial, cause it takes in to account the complex resistance, including capacity and inductance. These components change the AC resistance depending on frequency applied.
In the 5 columns are given the measurement results for 50 Hz, 500 Hz, 1 kHz, 10 kHz and 100 kHz.

At higher frequencies the fuses having a smaller case have some advantage, cause that way the inductance and therefore the complex resistance is smaller.

This evaluation is done under the aspect of high end audio music reproduction, so you have to imagine, that music contains very much steep pulses. So all components direct or indirect in the signal pass, should be able to handle that pulses. Fuses with a rising AC-Resistance will limit that pulses to some degree. The high end fuses are technically a better solution than standard fuses under this aspect. Also with AC-Resistance measurements a directivity of fuses could be noted.

4. Measurements of noise induced in fuses.

The measurements done so far showed some measurable differences between fuse, but didn´t explain completely the sonic differences between fuses. One way to look at these phenomenon's is, that music, containing many pulses can be limited by the electronics being in the reproduction chain. Fuses with better contact material (e.g. no corrosion) and overall better make will limit these pulses less.
Another way to look at the problem is: like any wire or resistor fuses produce some thermal broadband noise. That noise depends mostly of the material used.
The thermal increase of noise was measured at a current of 0,1 Amp. DC and the increase is given in dB.
Also by the making of fuses from different metals, there can be thermal voltages develop by the choice of materials. These thermal voltages were measured with a nano-voltmeter.

In both noise measurements the fuses of HiFi-Tuning gave the best results.

Fuse, Type	Increase of Noise /0,1Amp. B		hermosp. µV
T 0,8 Amp. (800 mA.) 5 x 20 mm.			
HiFi-Tuning Ultimate³ Cryo	2,4		0,49
Standard Glass Spiral	2,7		0,62
AHP	3,2		0,68
Super Cryo Fuse (0,76 Amp.)	3,4		0,71
T 1 Amp. 6,3 x 32 mm.			
HiFi-Tuning US-Gold² Cryo	1,6		0,54
Standard Ceramic	1,9		0,82
Iso Clean	1,1		1,15
Infinity Power Evolution (rhodium)	2,3		1,15
T 1,6 Amp. 6,3 x 32 mm.			
HiFi-Tuning US-Ultimate³*(Silver Star)	1,0	WORLDPREMIERE	0,49
HiFi-Tuning US-Gold² Cryo	1,1		0,40
Iso Clean	1,0		2,03
T 3,15 Amp. 5X20mm.			
HiFi-Tuning Ultimate² Cryo	0,5		0,20
HiFi-Tuning Ultimate³ Cryo	0,5		0,22
Solder Type, round body	1,1		0,36
SinnOxx	1,0		0,55
Super Cryo (LF)	1,2		0,73
Padis Rhodium	0,9		1,16
AHP	1,3		1,16
T 3,15 Amp. 6,3x32mm.			
HiFi-Tuning US-Gold² Cryo	0,5		0,20
Standard, Ceramic Fuse	0,9		0,41
Standard, Glass, Spiral Fuse	1,0		0,45
T 3 Amp. 6,3x32mm.			
HiFi-Tuning US-Gold² Cryo	0,9		0,29
Infinity Evolution (rhodium)	1,0		0,36
T 5 Amp. 5X20mm.			
HiFi-Tuning Ultimate³ Cryo	0,7		0,15
Infinity Power Evolution (rhodium)	0,9		0,42
Standard, Glass, Spiral	0,8		0,43
HiFi-Tuning US-Gold² Cryo	0,7		0,51
AMR	0,6		0,61
SinnOxx	1,0		0,87
AHP	1,1		0,92
Iso Clean	0,6		2,64
UK-Plug Fuse 6,3x25mm.			
HiFi-Tuning UK-Gold²	0,4		0,13
Iso Clean	0,6		0,20

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2. Summary of measurements:

a. A smaller fuse has always a bigger resistance than a bigger fuse (as well value as size) which is dependent on physics laws. With smaller value fuses, also the current through the fuse decreases. So the total power loss stays more or less the same.
b. A fuse with smaller dimensions always gives better results, than same value fuse with bigger dimensions.
c. High Quality special High End fuses normally give better measurements results than standard fuses..
d. Fuses made in far east sometimes had worse results than standard fuses. Also manufacturing quality different more.
e. The Infinity Power Evolution 500 mA fuse (palladium) had a bad

manufacturing quality – coating rubbed off .
Here a microscopic photograph of the fuse cap

In comparison a fuse cap from HiFi-Tuning Ultimate³ Fuse

3. Tips for optimizing High End Audio gear:

a. Use the fuses with the smallest dimensions – for example: Exchange fuse holders for 6 x 32 mm type for 5 x 20 mm type.
b. Use highest quality fuses, like the ones from HiFi-Tuning.
c. Inside gear it could be a cost saving alternative, to use solder type fuse range.
d. Not all fuses inside equipment is necessary by law and safety regulations.

After studying the circuit it´s sometimes possible to avoid the fuse at all.

Things like that should only be done by trained technicians.

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www.HiFi-Tuning.com