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Ottawa, Canada
K1A 0R6

NRC · CNRC

March 8, 2018

Blake Medical Group Inc.
Attn.: Mr. Stephen Catapano
461 Cumberland Ave
Hamilton, Ontario
L8M 2A8

Subject: Report for Seat Cushions Vibration Testing, Post-Processed Data.
Reference: NRC report for seat cushions vibration testing dated 28th February 2018.

Dear Sir:

The National Research Council Canada has completed post-processing of vibration test data on four models of seat cushions provided by Blake Medical Group Inc. A total of six seat cushion setups were tested in February 2018. Specifically, four models labelled as Silver, Bronze, Platinum and Silver Low Profile (LP) and one seat cushion combination (LP and Original Bell-412 Non-Armored seat cushion) were tested and compared against the Original Bell-412 Non-Armored helicopter seat cushion. Note that all testing was performed in the vertical (Z) axis only. Four vibration test profiles were selected for this investigation and are identified below:

1) Helicopter - Sine-on-Random vibration test between 3 and 50 Hz with a vibration test severity level of 0.198 g_{rms}.
2) U.S. Highway Truck Vibration Exposures – Random vibration test between 5 and 500 Hz with a vibration test severity level of 1.08 g_{rms} as specified in MIL-STD-810F, Method 514.5, Figure 514.5C-1 and Table 514.5C-VII with the following modifications: profile is extended down to 5 Hz from 10 Hz with an amplitude of 0.015 g^2/Hz therefore increasing the test severity level from 1.04 to 1.08 g_{rms}.
3) Composite Two-Wheeled Trailer Vibration Exposures – Random vibration test between 5 and 500 Hz with a vibration test severity level of 3.66 g_{rms} as specified in MIL-STD-810F, Method 514.5, Figure 514.5C-2 and Table 514.5C-VII with the following modifications: amplitude was reduced between 5 and 13 Hz to 0.0253 g^2/Hz due to shaker displacement limitations therefore reducing the test severity level from 3.85 to 3.66 g_{rms}.
4) Composite Wheeled Vehicle Vibration Exposures - Random vibration test between 5 and 500 Hz with a vibration test severity level of 1.60 g_{rms} as specified in MIL-STD-810F, Method 514.5, Figure 514.5C-3 and Table 514.5C-VII with the following modifications: amplitude was reduced between 5 and 20 Hz to 0.0235 g^2/Hz due to shaker displacement limitations therefore reducing the test severity level from 2.18 to 1.60 g_{rms}.

These vibration tests were performed using NRC 10,000 lb(f) electrodynamic shaker. In the vibration test setup, a Bell-412 non-armoured helicopter pilot seat frame was bolted to the shaker table and excited in the vertical direction. A 50th percentile Hybrid III male mannequin was used as the test subject. The mannequin was seated on the seat and fastened using the safety belt. The LMS software controlled the specified vibration conditions accurately using one control accelerometer which was mounted on the fixture directly under the helicopter seat. Fourteen monitoring accelerometers were used. Details of the test conditions and preliminary results for each seat cushion were reported previously.

In accordance with ISO2631-1, the vibration test results measured at interfaces between the occupant and seat cushions, including the X, Y and Z directions at bottom seat cushion pad and the X direction of the back seat cushion pad, have been post-processed to determine the whole-body vibration exposure of a representative occupant on the test seat cushions when subjected to the four vibration test profiles, and are listed in Table-1, Table-2, Table-3 and Table-4, respectively. The filtered vibration plots of the tested seat cushions are also attached.

It is important to note that the vibration test profile for helicopter represented a typical floor vibration level on the NRC Bell-412 helicopter. The vibration test profiles for US Highway Truck, Composite Two-Wheeled Trailer and Composite Wheeled Vehicle represented the fatigue vibration input to accelerate testing time per MIL-STD-810F. Therefore, the vibration input levels may be higher than the actual vibration input levels experienced by the occupant in operations. However, there is no defined vibration input levels for these three road conditions. In this report, we used a 10% of the measured vibration response data as a reference to derive the likely occupant whole-body vibration exposure. The objective was to provide a qualitative assessment of the tested seat cushion to enable comparison of occupant whole-body vibration mitigation performance in the same test conditions.

Based on the post-processed whole-body vibration data of the 50% percentile Hybrid III mannequin on the tested seat cushions, the permitted exposure times for the Health Risk Caution Zone and Health Risk Likely Zone as defined in FIGURE 40: Health Guidance Zones for Limited Exposures of MIL-STD-1472G were also calculated, and listed in Table-5 for reference.

Should you have any questions, please contact me directly at 613-949-0924.

Yours sincerely,

Yong (Eric) Chen

Table 1: Mannequin whole-body vibration levels under sine-on-random vibration profile (0.198 grms)

Cushion Type	Non-weighted (m/s^2, rms)				ISO-weighted, (m/s^2, rms)			
	Bottom Cushion			Backrest	Bottom Cushion			Backrest
	X	Y	Z	X	X	Y	Z	X
Original	0.461	0.127	1.147	0.412	0.157	0.039	1.117	0.245
Silver	0.304	0.108	1.127	0.284	0.088	0.020	0.696	0.225
Bronze	0.294	0.108	1.137	0.372	0.088	0.010	0.902	0.333
Platinum	0.451	0.118	1.068	0.510	0.127	0.020	0.843	0.431
Silver Low Profile	0.549	0.147	1.166	0.470	0.186	0.039	0.941	0.461
Original+Silver Low Profile	0.598	0.108	0.980	0.608	0.196	0.020	0.960	0.539

Table 2: Mannequin whole-body vibration levels under US-highway vibration profile (1.08 grms)

Cushion Type	Non-weighted (m/s^2, rms)				ISO-weighted, (m/s^2, rms)			
	Bottom Cushion			Backrest	Bottom Cushion			Backrest
	X	Y	Z	X	X	Y	Z	X
Original	2.773	1.137	5.439	2.009	0.833	0.294	5.027	1.421
Silver	2.352	1.117	7.389	1.254	0.480	0.186	3.822	0.892
Bronze	2.832	0.951	7.144	1.940	0.706	0.108	5.018	1.588
Platinum	2.558	0.833	6.625	1.460	0.510	0.137	3.783	1.196
Silver Low Profile	2.871	1.225	5.909	2.058	0.500	0.167	4.283	1.754
Original+Silver Low Profile	1.960	0.490	5.410	1.637	0.588	0.069	4.292	1.441

Table 3: Mannequin whole-body vibration levels under composite two-wheeled trailer vehicle vibration profile (3.66 grms)

Cushion Type	Non-weighted (m/s^2, rms)				ISO-weighted, (m/s^2, rms)			
	Bottom Cushion			Backrest	Bottom Cushion			Backrest
	X	Y	Z	X	X	Y	Z	X
Original	1.980	1.029	6.762	1.686	0.500	0.186	4.675	0.657
Silver	3.665	1.960	13.338	1.842	0.676	0.372	5.292	1.225
Bronze	4.057	1.225	9.771	2.264	0.794	0.098	6.007	1.764
Platinum	3.420	1.294	10.633	1.999	0.676	0.167	5.557	1.666
Silver Low Profile	4.459	1.931	9.614	1.833	0.706	0.323	4.851	1.529
Original+Silver Low Profile	2.156	0.598	6.576	1.744	0.647	0.078	4.224	1.480

Table 4: Mannequin whole-body vibration levels under composite wheeled vehicle vibration profile (1.60 grms)

Cushion Type	Non-weighted vibration (m/s^2, rms)				ISO-weighted vibration (m/s^2, rms)			
	Bottom Cushion			Backrest	Bottom Cushion			Backrest
	X	Y	Z	X	X	Y	Z	X
Original	1.862	0.813	5.135	1.215	0.529	0.186	4.763	0.588
Silver	3.469	1.401	9.124	1.411	0.627	0.225	5.361	1.127
Bronze	3.303	1.078	7.487	2.274	0.853	0.108	6.135	1.970
Platinum	2.685	1.127	6.439	1.646	0.666	0.196	4.812	1.362
Silver Low Profile	3.430	1.842	6.047	1.578	0.588	0.235	4.273	1.284
Original+Silver Low Profile	2.342	0.666	5.243	1.862	0.745	0.098	4.733	1.656

Table 5: Exposure time limit of the mannequin under tested vibration profiles (Hours)

Vibration Profile	Sine-on-Random		US-Highway (Based on 10% response)		Composite Two-Wheeled Trailer (Based on 10% response)		Composite Wheeled Vehicle (Based on 10% response)	
Cushion Type	Caution Zone (Line B)	Health Risk Likely (Line A)	Caution Zone (Line B)	Health Risk Likely (Line A)	Caution Zone (Line B)	Health Risk Likely (Line A)	Caution Zone (Line B)	Health Risk Likely (Line A)
Bell-412 Original Cushion	0.40	4.81	6.28	23.74	7.27	27.46	7.00	26.45
Silver	2.65	12.39	10.87	41.07	5.67	21.42	5.52	20.88
Bronze	0.94	7.38	6.31	23.83	4.40	16.63	4.22	15.94
Platinum	1.23	8.45	11.09	41.93	5.14	19.43	6.86	25.91
Silver Low Profile	0.79	6.78	8.66	32.71	6.75	25.50	8.70	32.86
Original+Silver Low Profile	0.73	6.50	8.62	32.56	8.90	33.63	7.09	26.78

Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 16:40:41
Section Name:	SonR-Helicopter-V	Transducer S/N:	
Run Name:	SonR-Helicopter-V_1_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	200 Hz	LMS Channel No:	111
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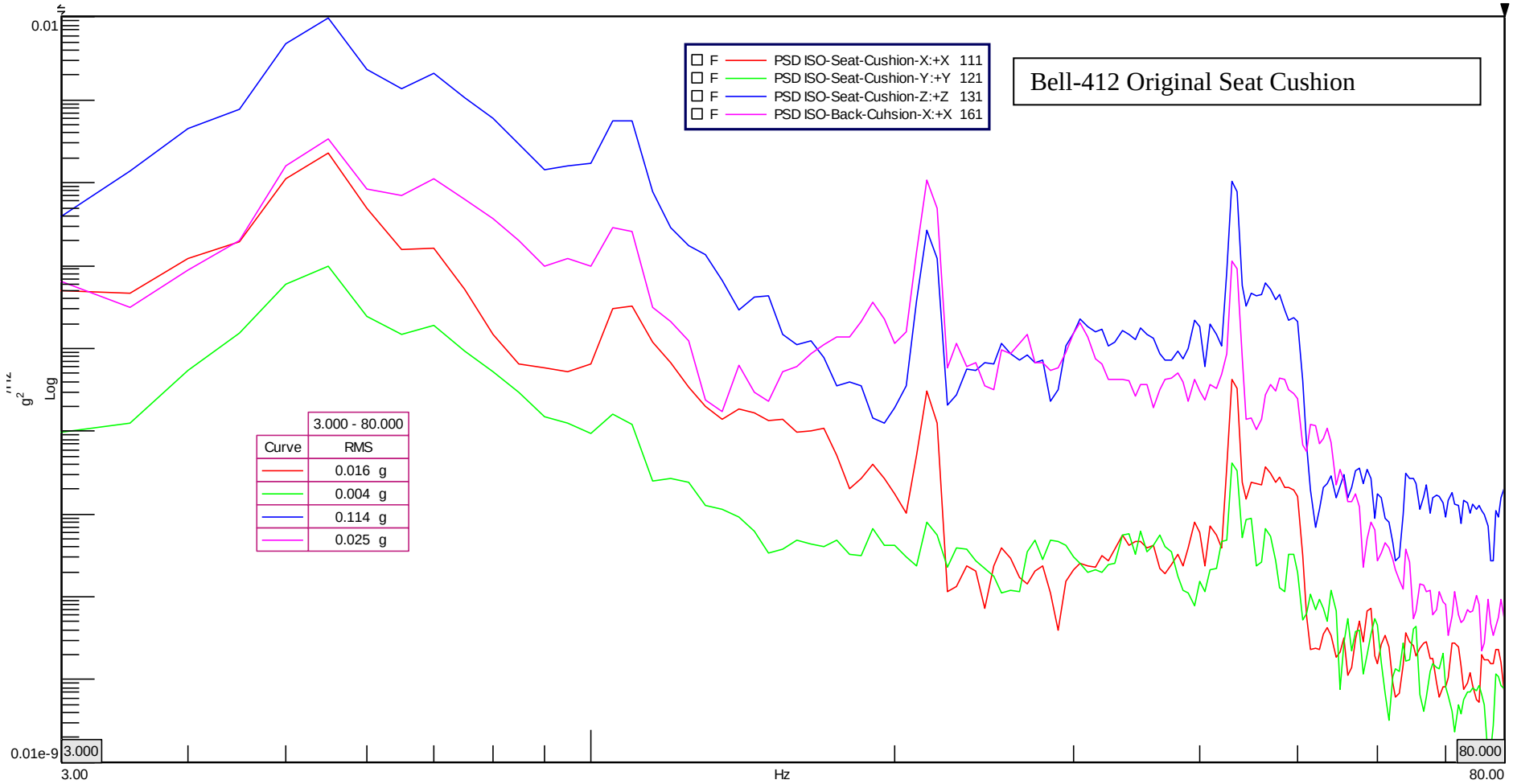
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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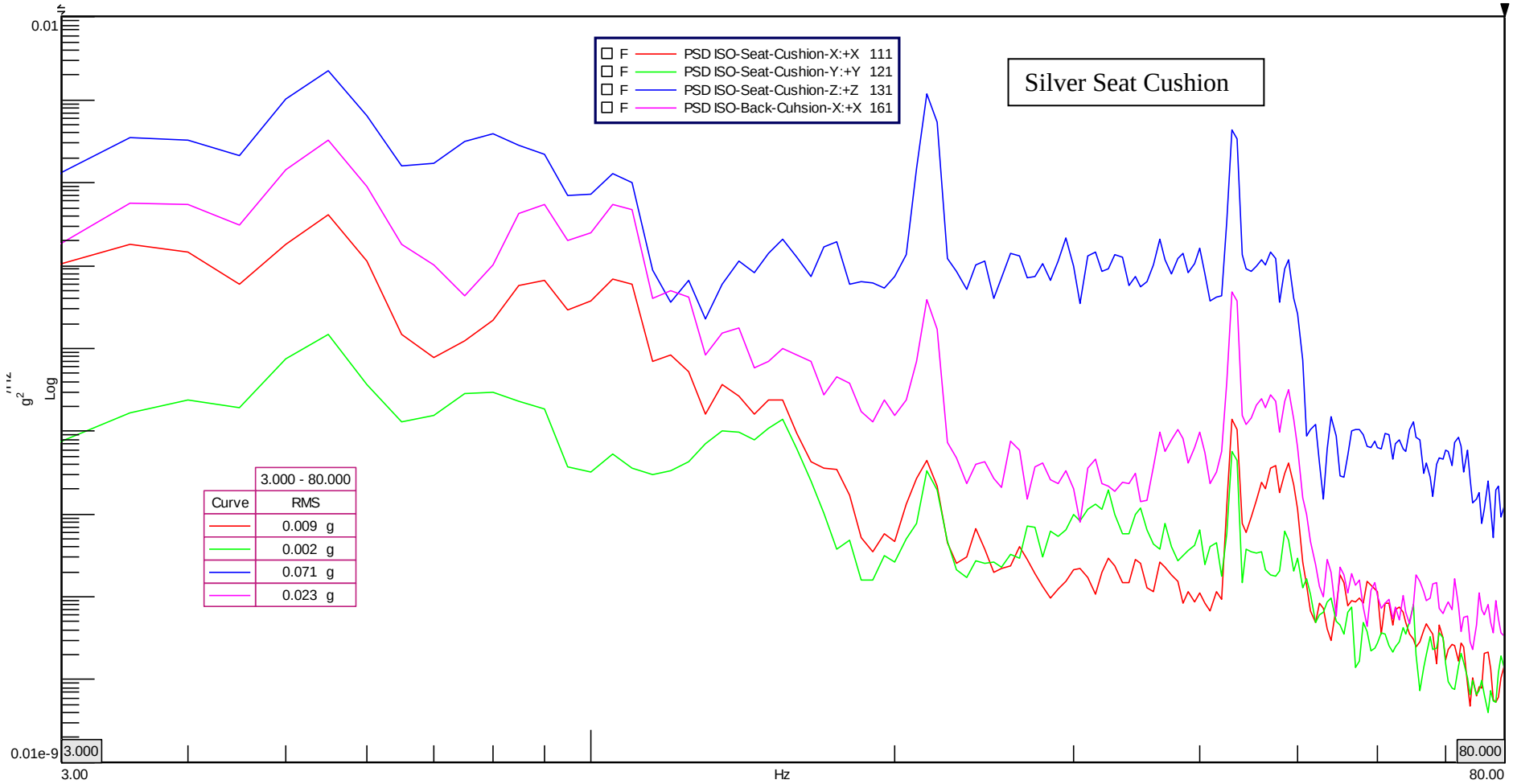
Section Name:	SonR-Helicopter-V	Transducer S/N:	
Run Name:	SonR-Helicopter-V_3_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	200 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



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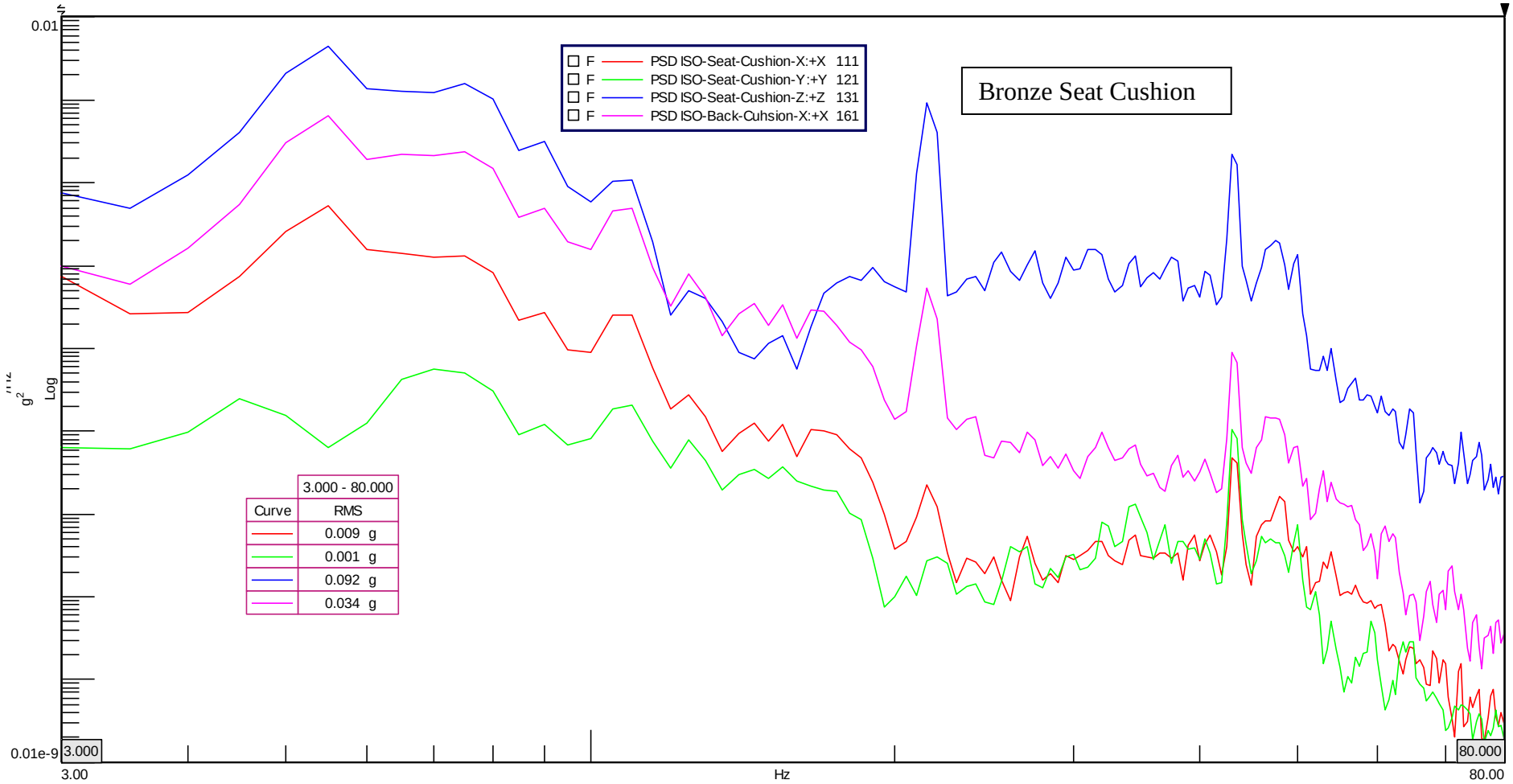
Section Name:	SonR-Helicopter-V	Transducer S/N:	
Run Name:	SonR-Helicopter-V_4_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	200 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



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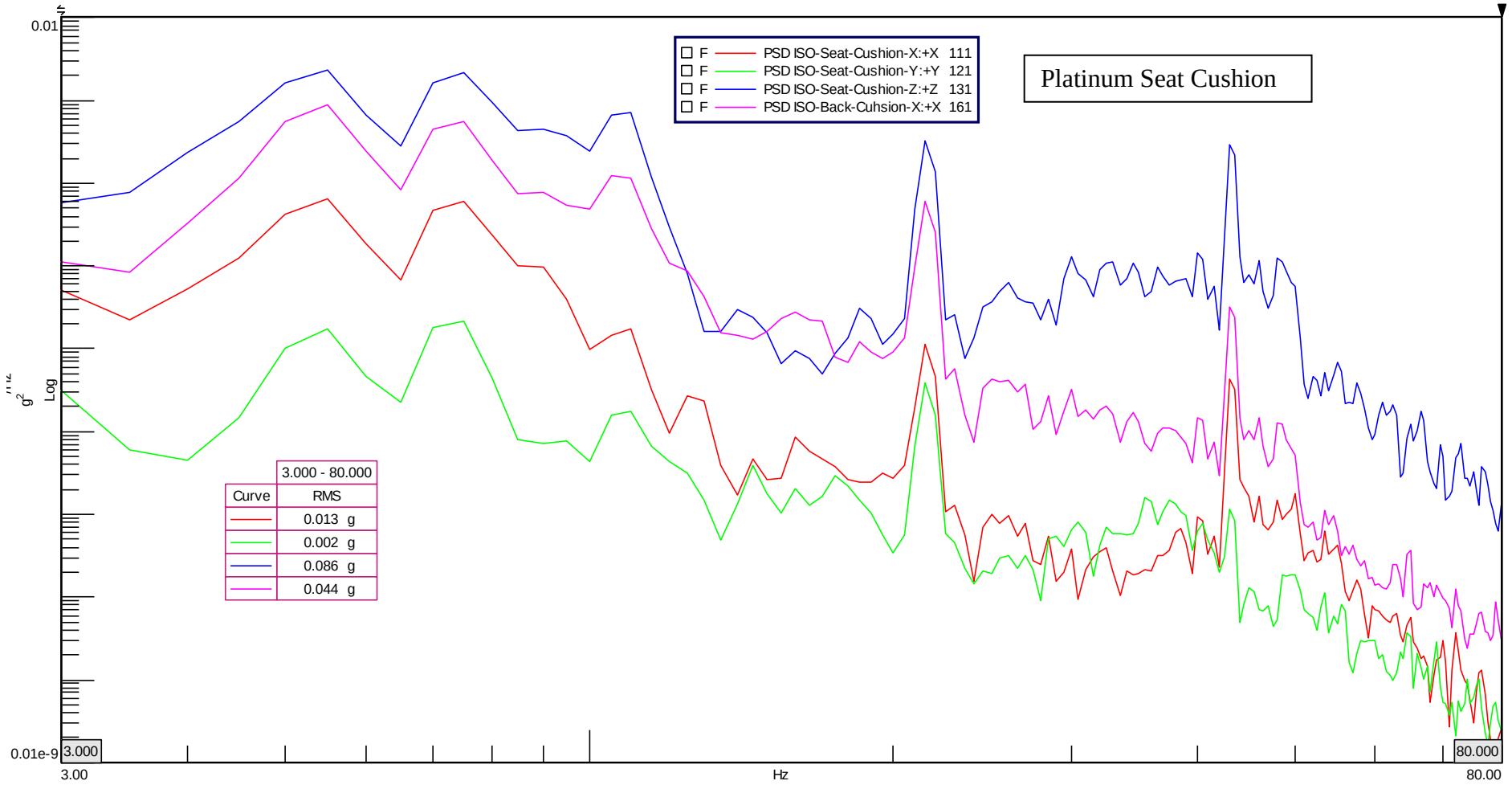
Run Name:	SonR-Helicopter-V_5_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	200 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



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Section Name:	SonR-Helicopter-V	Transducer S/N:	
Run Name:	SonR-Helicopter-V_6_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	200 Hz	LMS Channel No:	111
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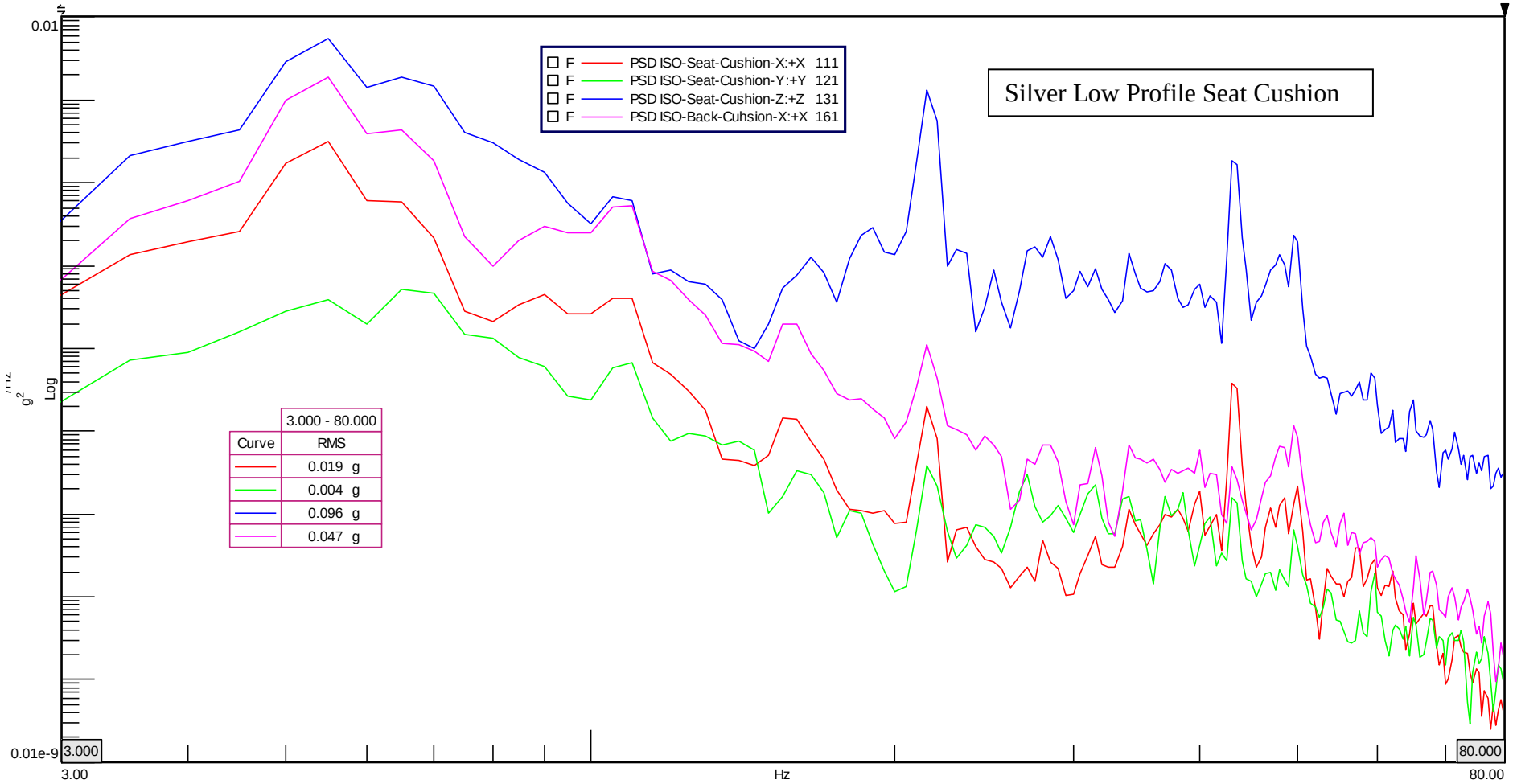
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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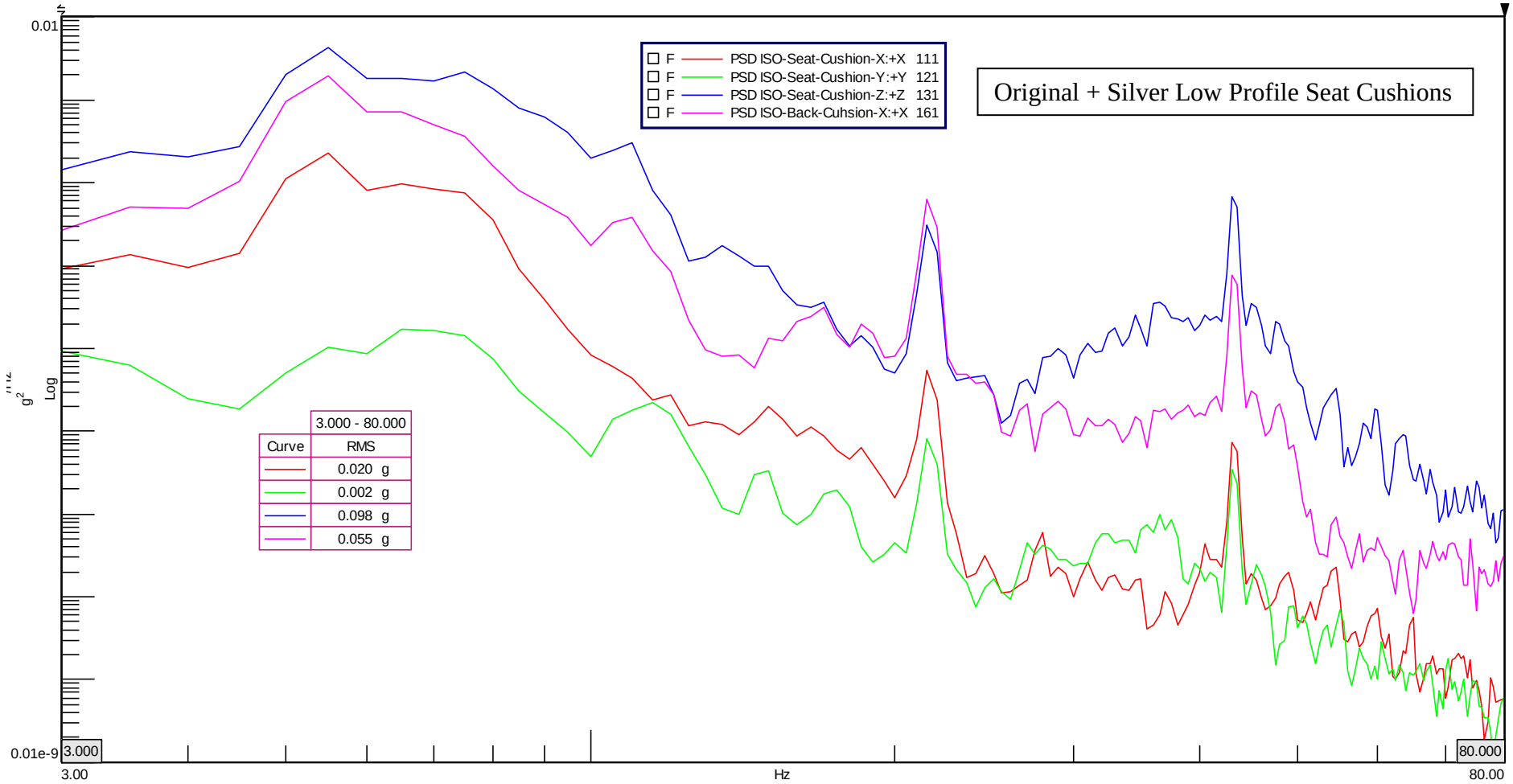
Section Name:	SonR-Helicopter-V	Transducer S/N:	
Run Name:	SonR-Helicopter-V_7_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	200 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



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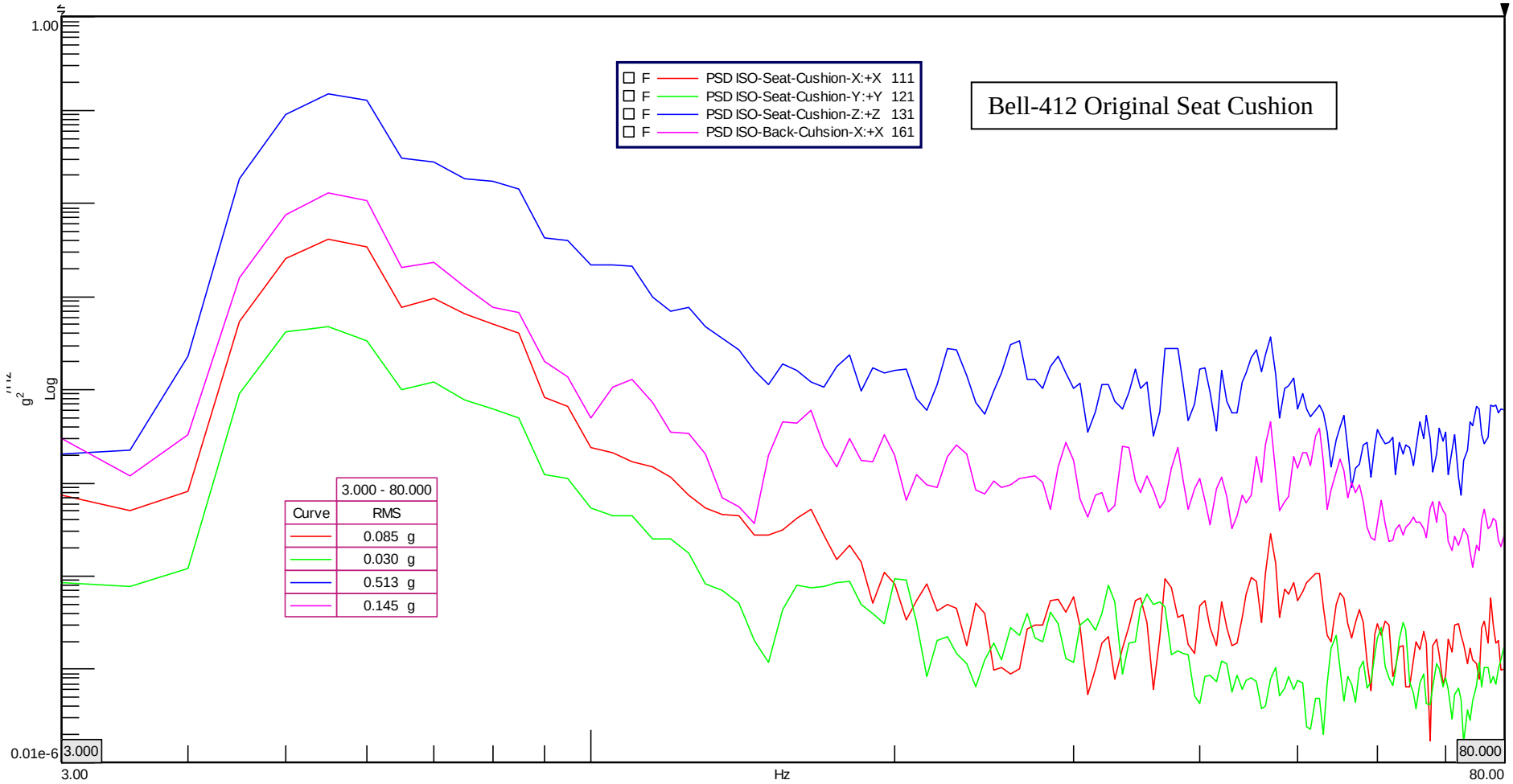
Section Name:	Rdm-US-Highway-Vertical	Transducer S/N:	
Run Name:	Rdm-US-Highway-V_3_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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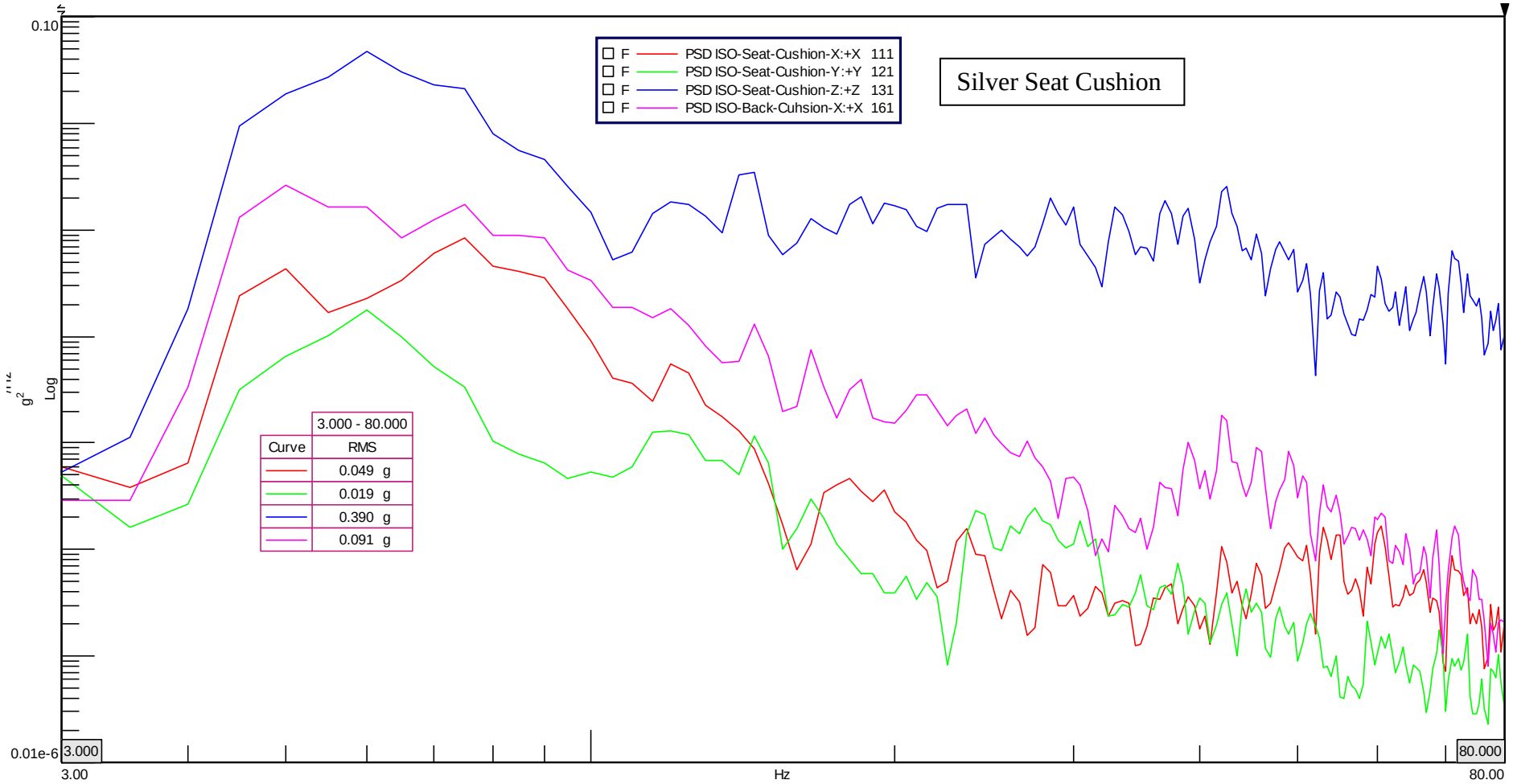
Section Name:	Rdm-US-Highway-Vertical	Transducer S/N:	
Run Name:	Rdm-US-Highway-V_5_HRV_PSD	Acquisition Mode:	Real-Time

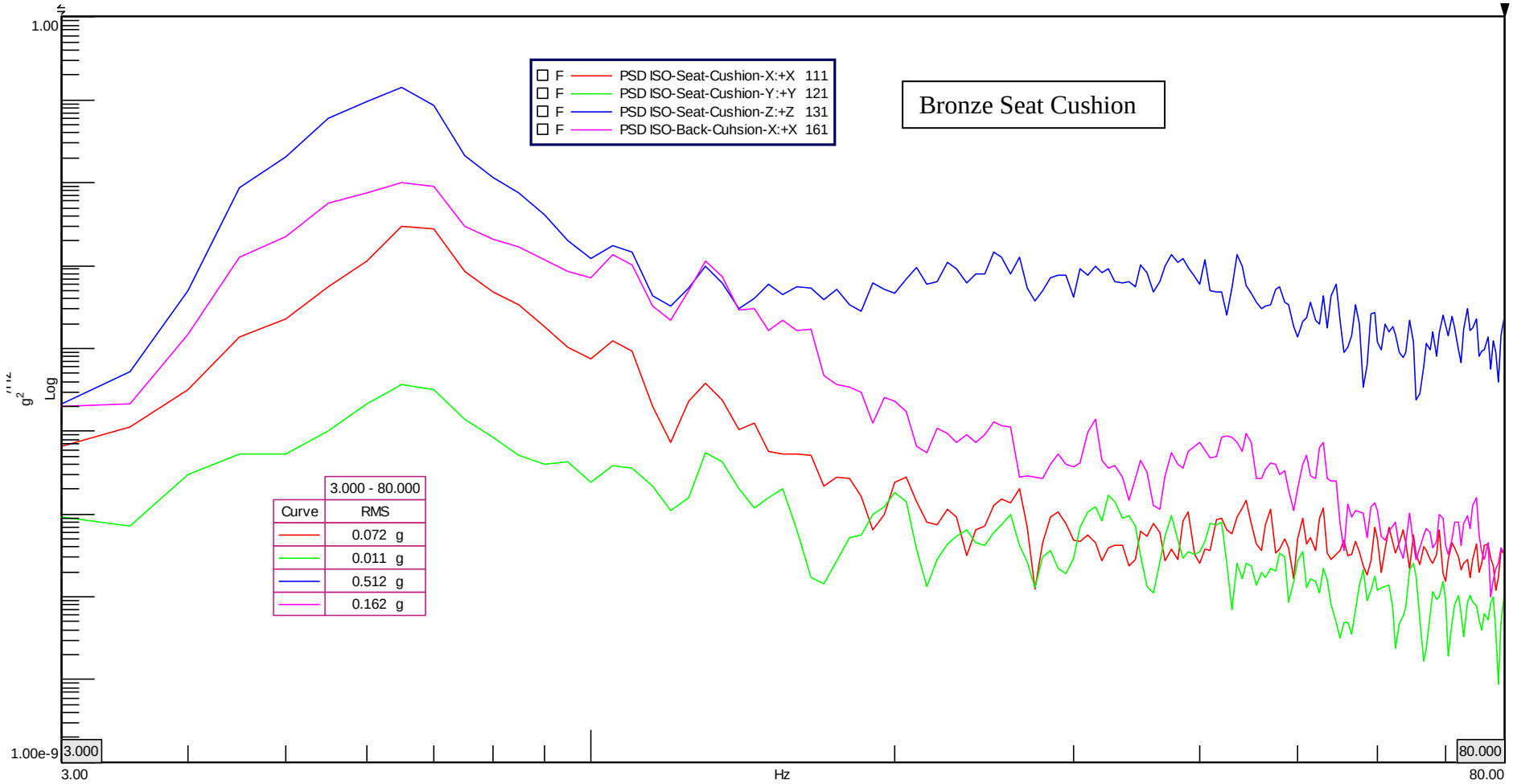
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:47:30
Section Name:	Rdm-US-Highway-Vertical	Transducer S/N:	
Run Name:	Rdm-US-Highway-V_6_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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Section Name:	Rdm-US-Highway-Vertical	Transducer S/N:	
Run Name:	Rdm-US-Highway-V_7_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
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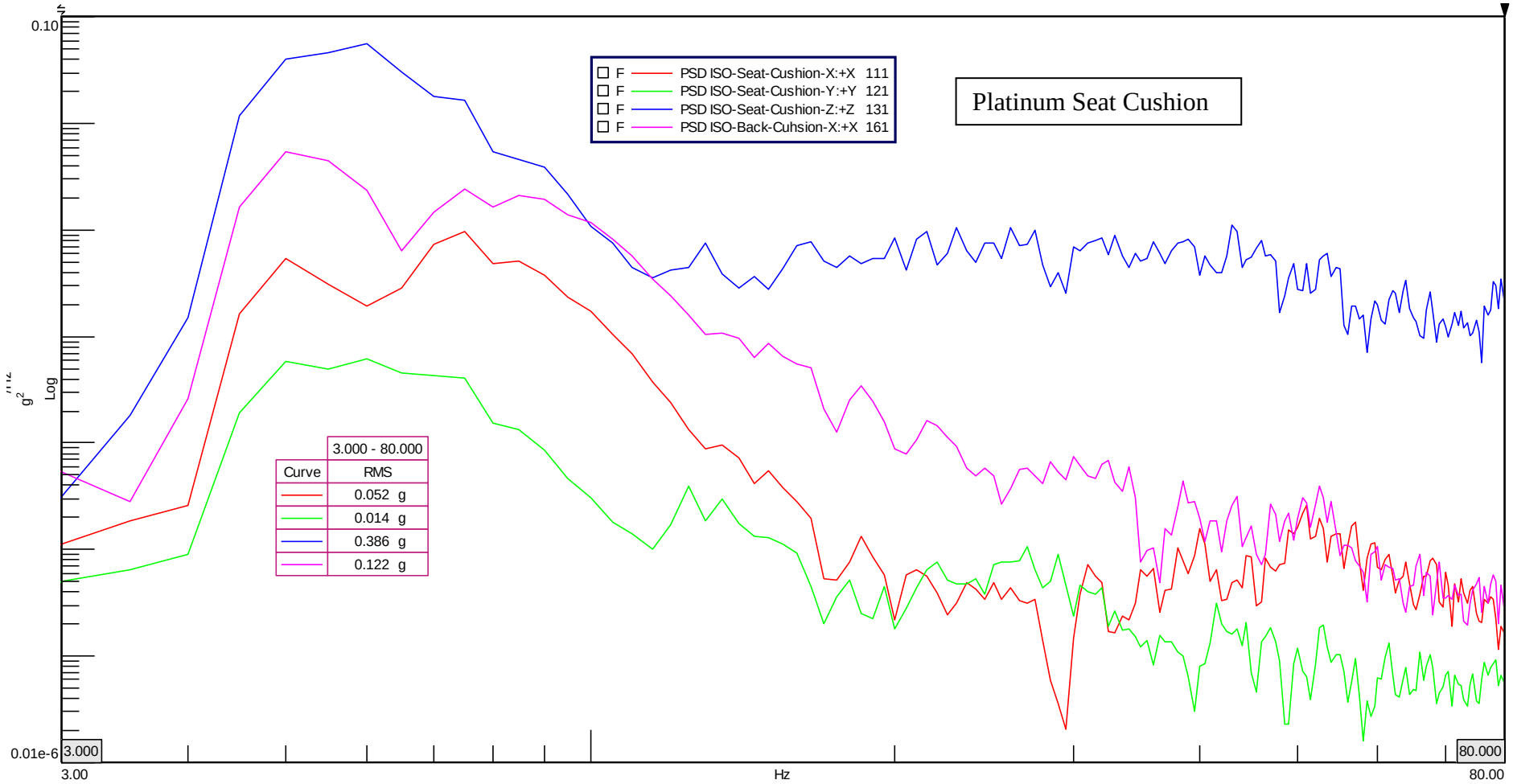
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



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Section Name:	Rdm-US-Highway-Vertical	Transducer S/N:	
Run Name:	Rdm-US-Highway-V_8_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
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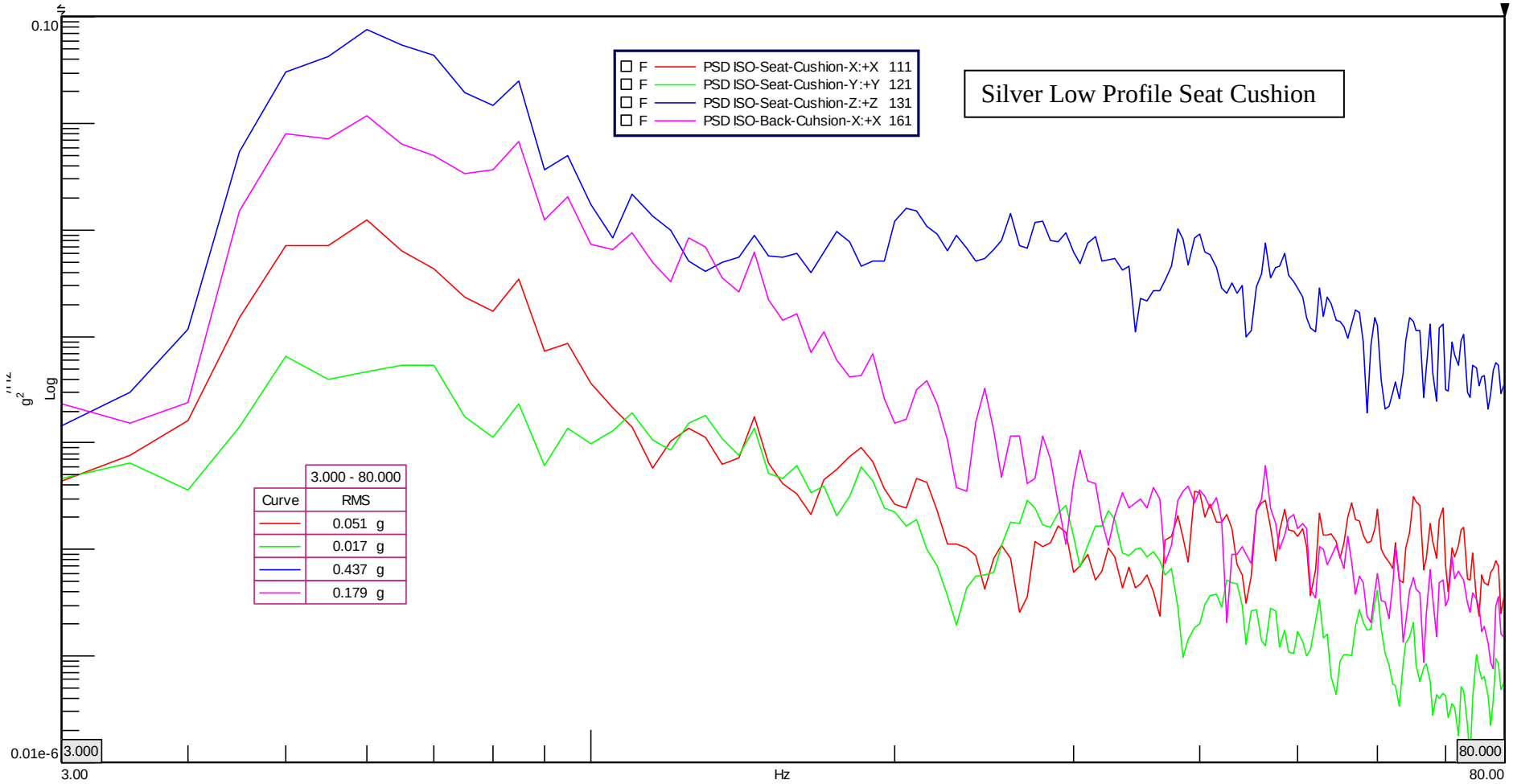
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



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Run Name:	Rdm-US-Highway-V_9_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
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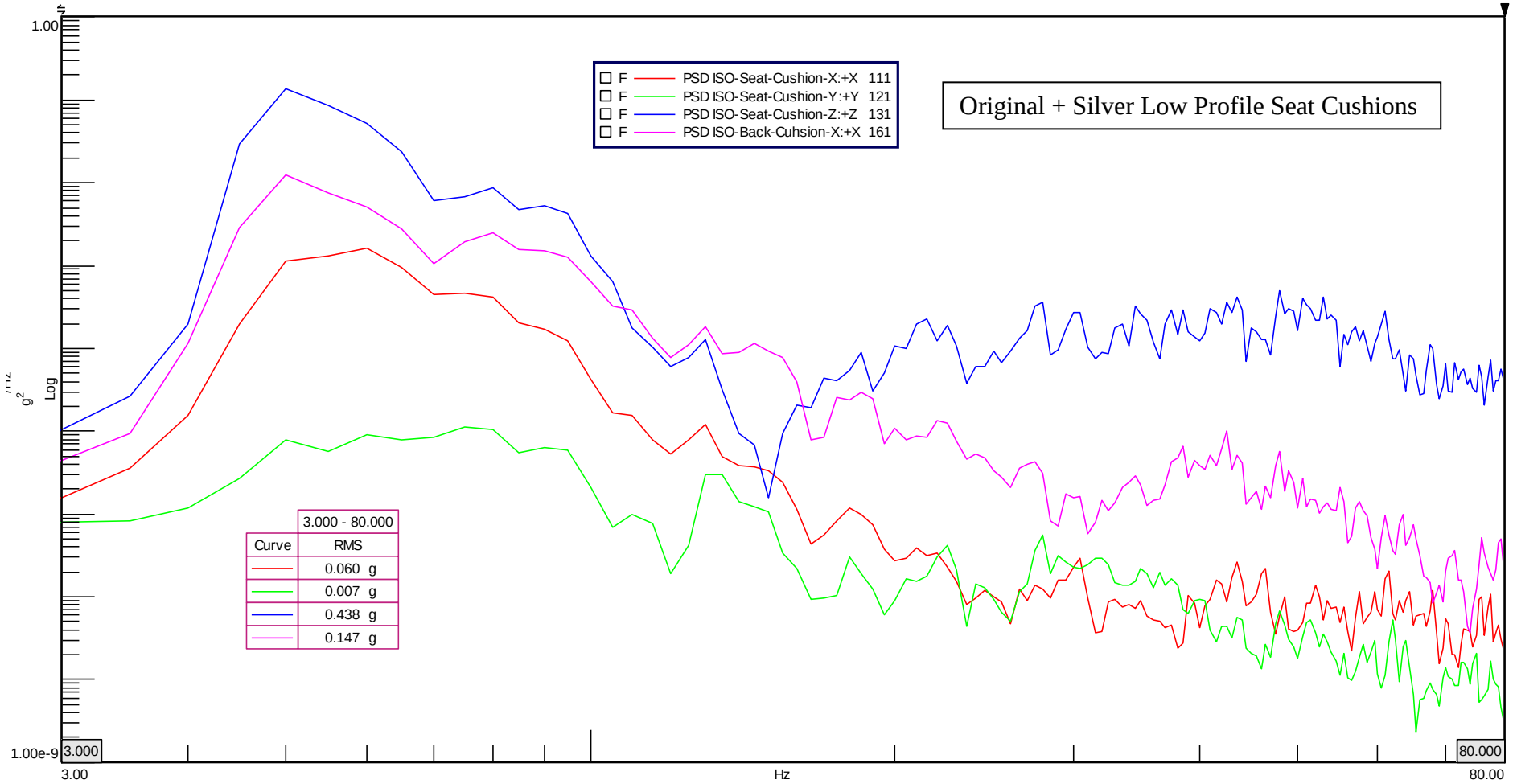
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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Section Name:	Rdm-2wheeled-V	Transducer S/N:	
Run Name:	Rdm-2wheeled-V_1_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
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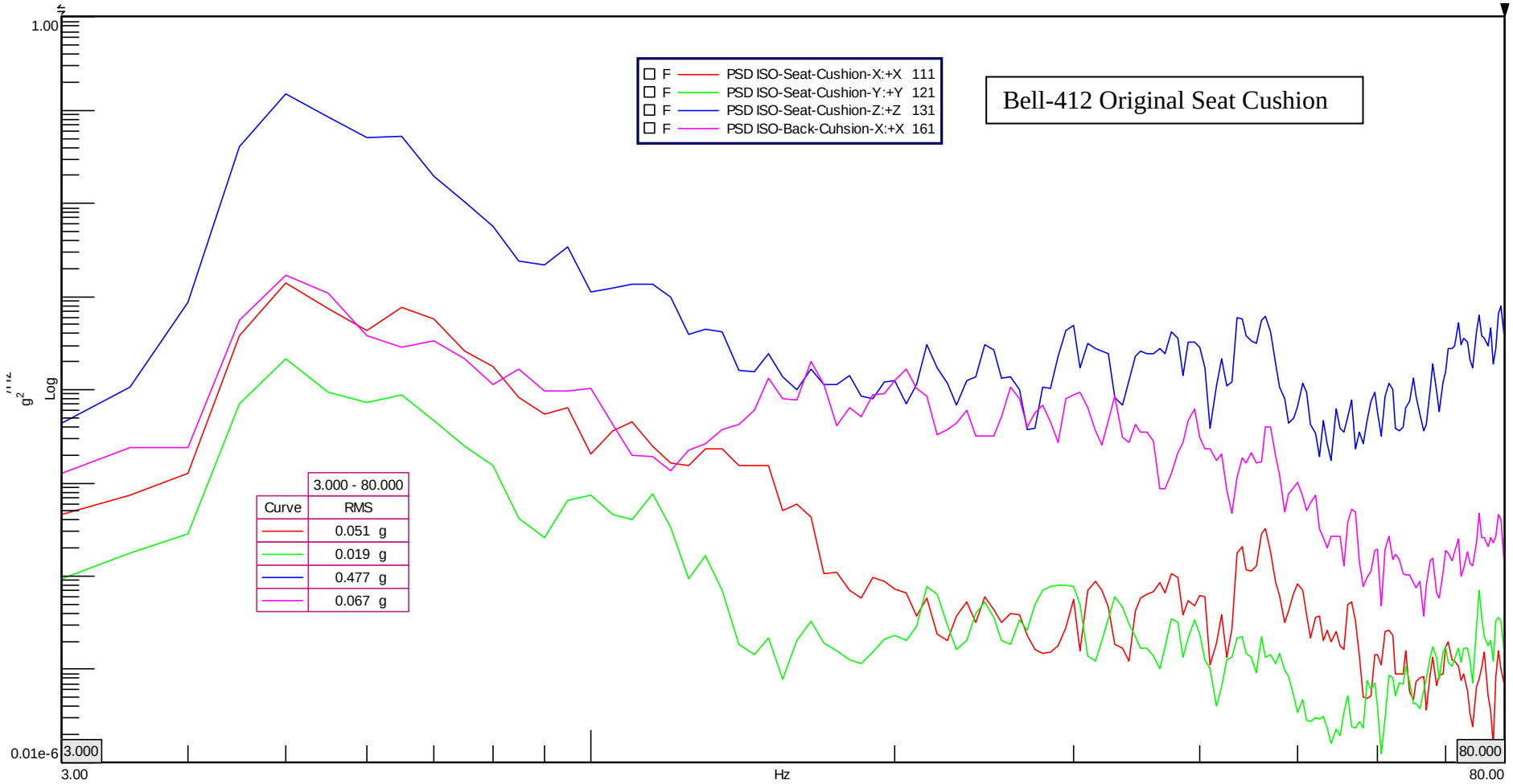

Blake Medical Seat Cushion Test

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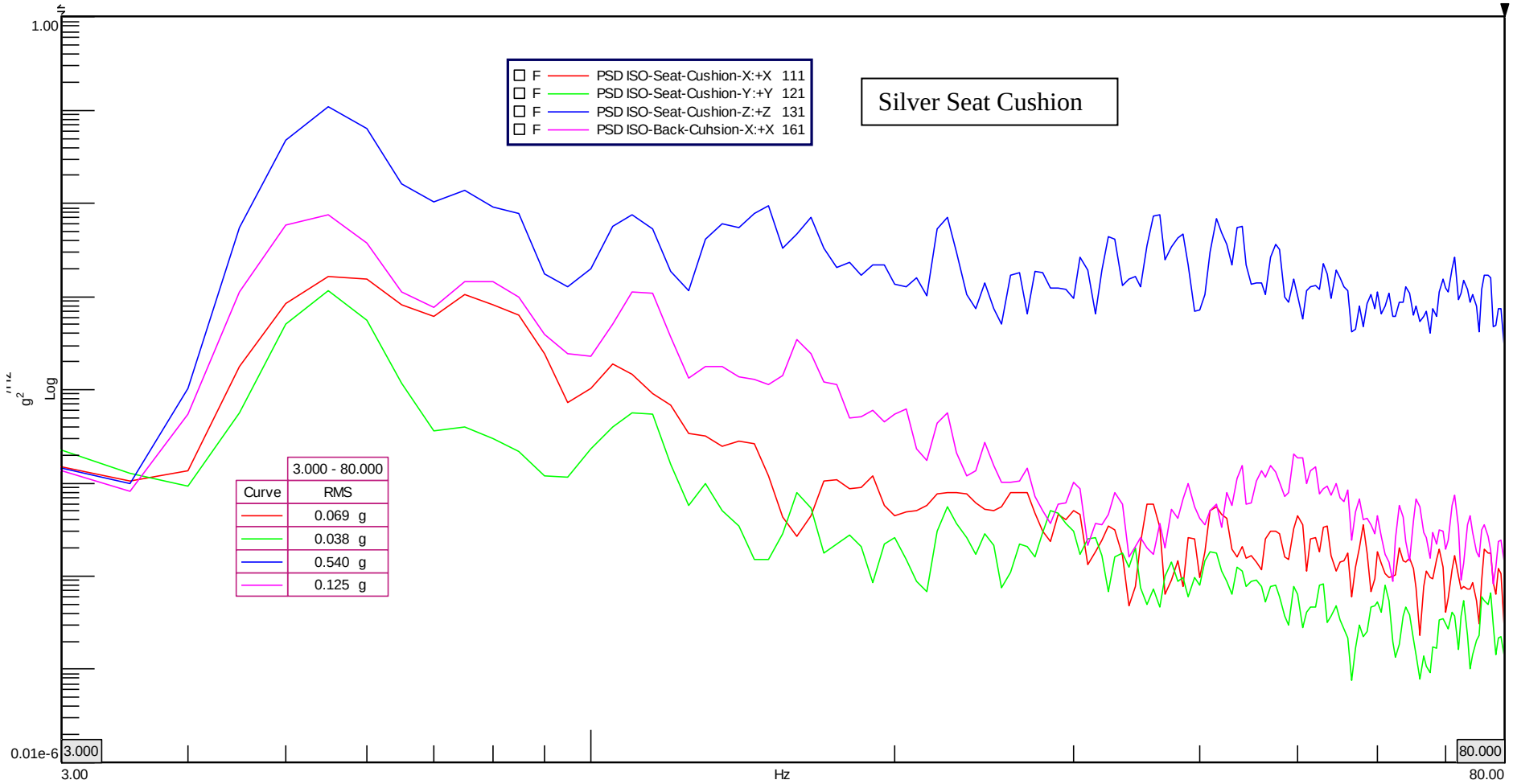
Section Name:	Rdm-2wheeled-V	Transducer S/N:	
Run Name:	Rdm-2wheeled-V_2_HRV_PSD	Acquisition Mode:	Real-Time

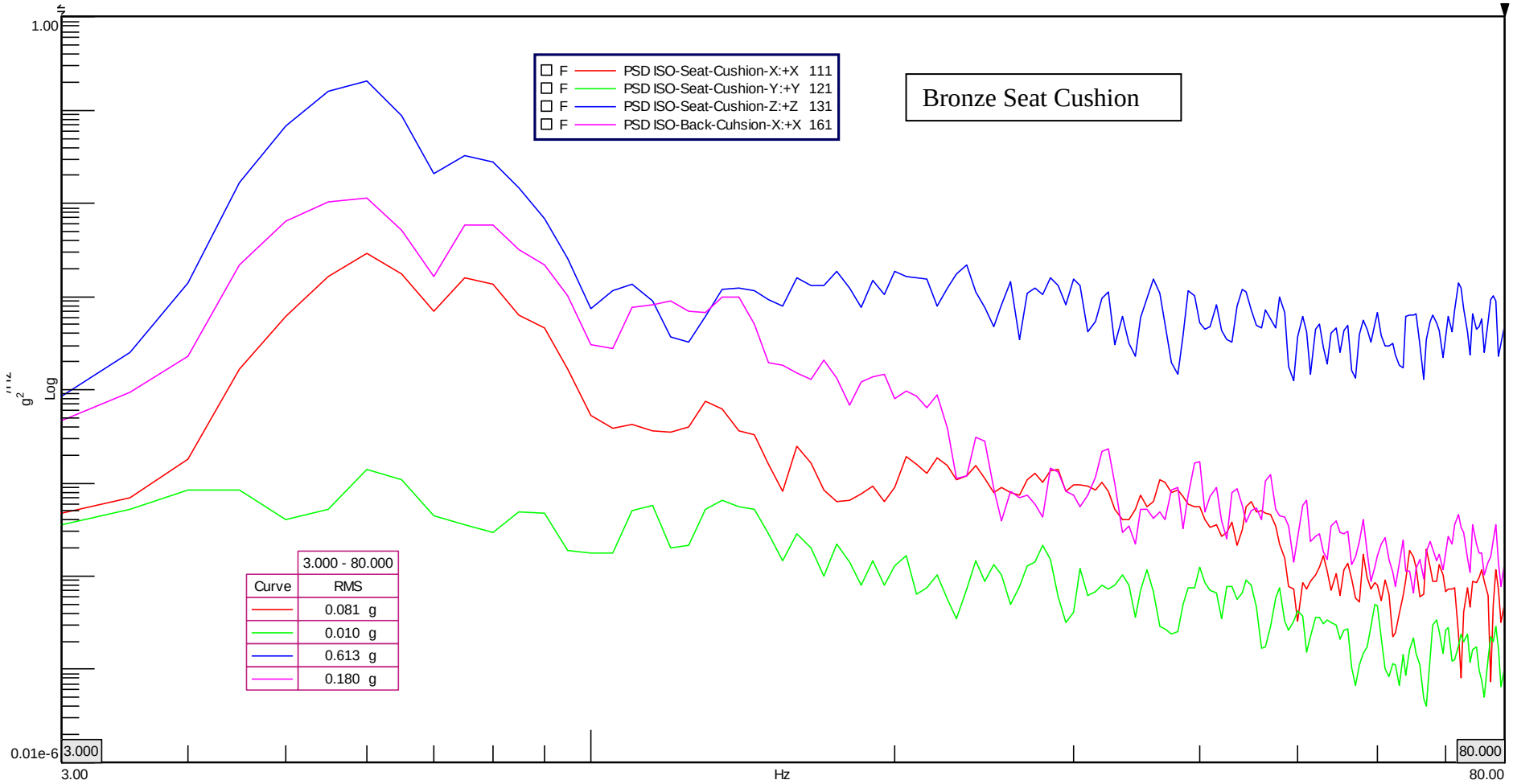
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:17:27
Section Name:	Rdm-2wheeled-V	Transducer S/N:	
Run Name:	Rdm-2wheeled-V_3_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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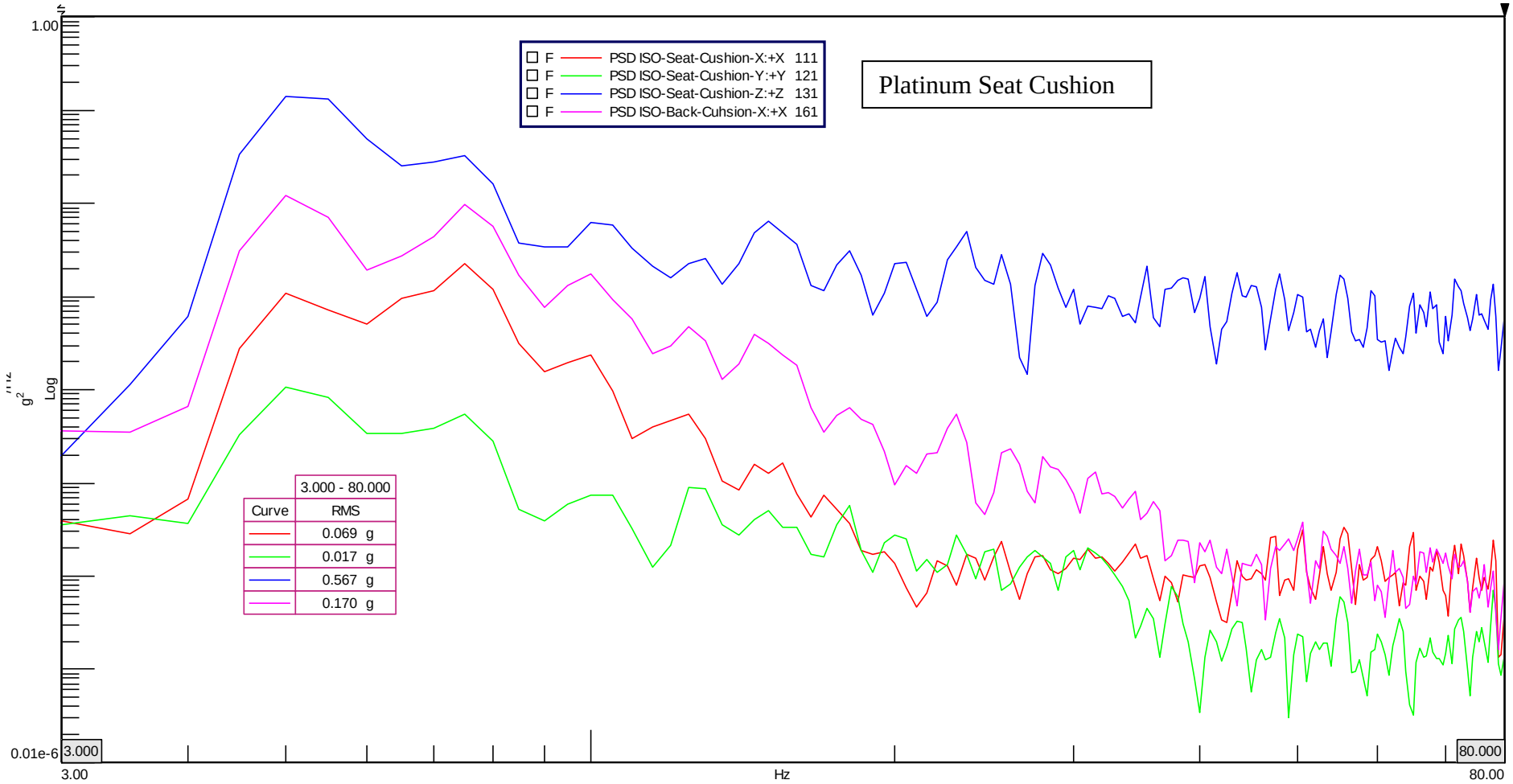
Section Name:	Rdm-2wheeled-V	Transducer S/N:	
Run Name:	Rdm-2wheeled-V_4_HRV_PSD	Acquisition Mode:	Real-Time

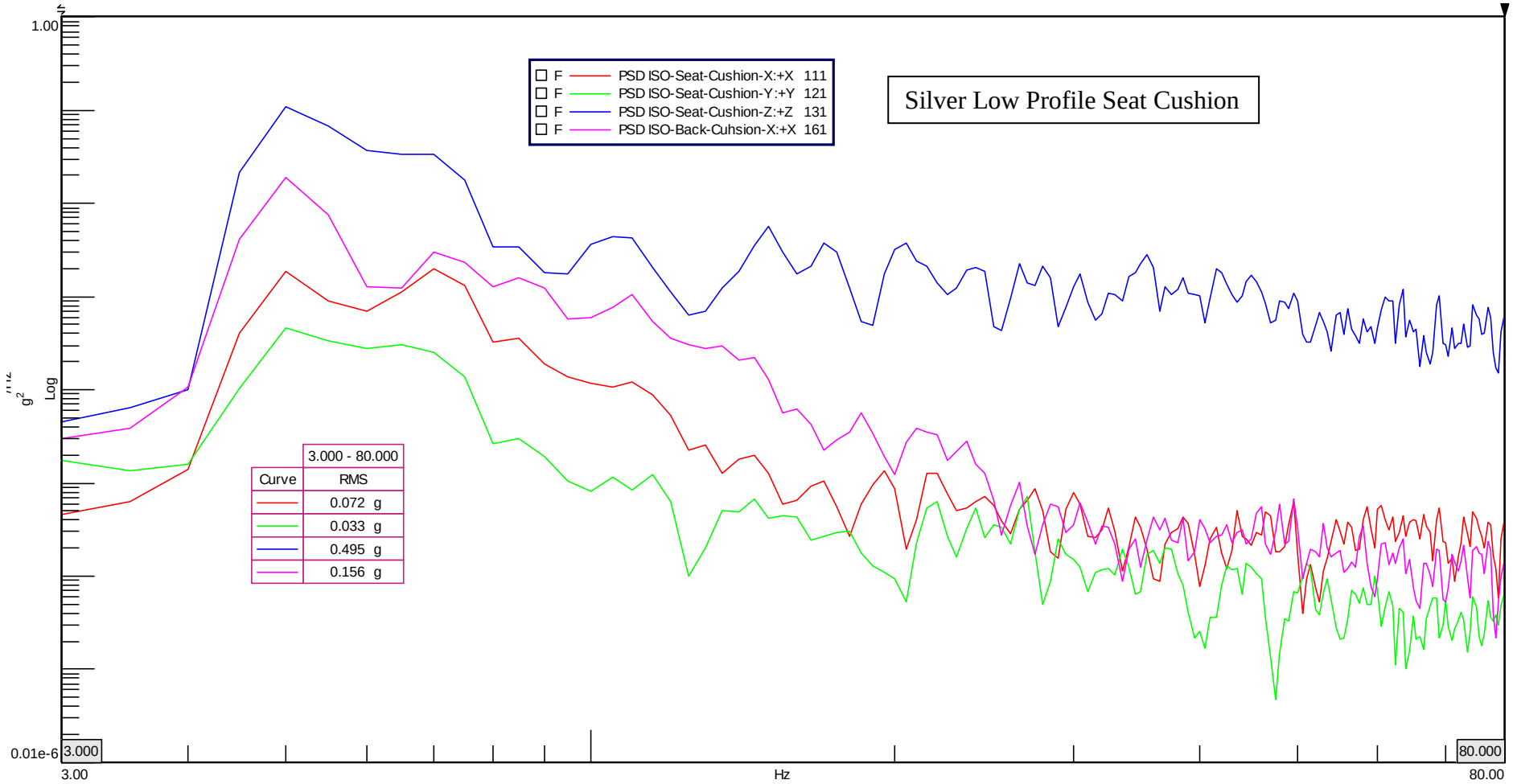
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:21:07
Section Name:	Rdm-2wheeled-V	Transducer S/N:	
Run Name:	Rdm-2wheeled-V_5_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

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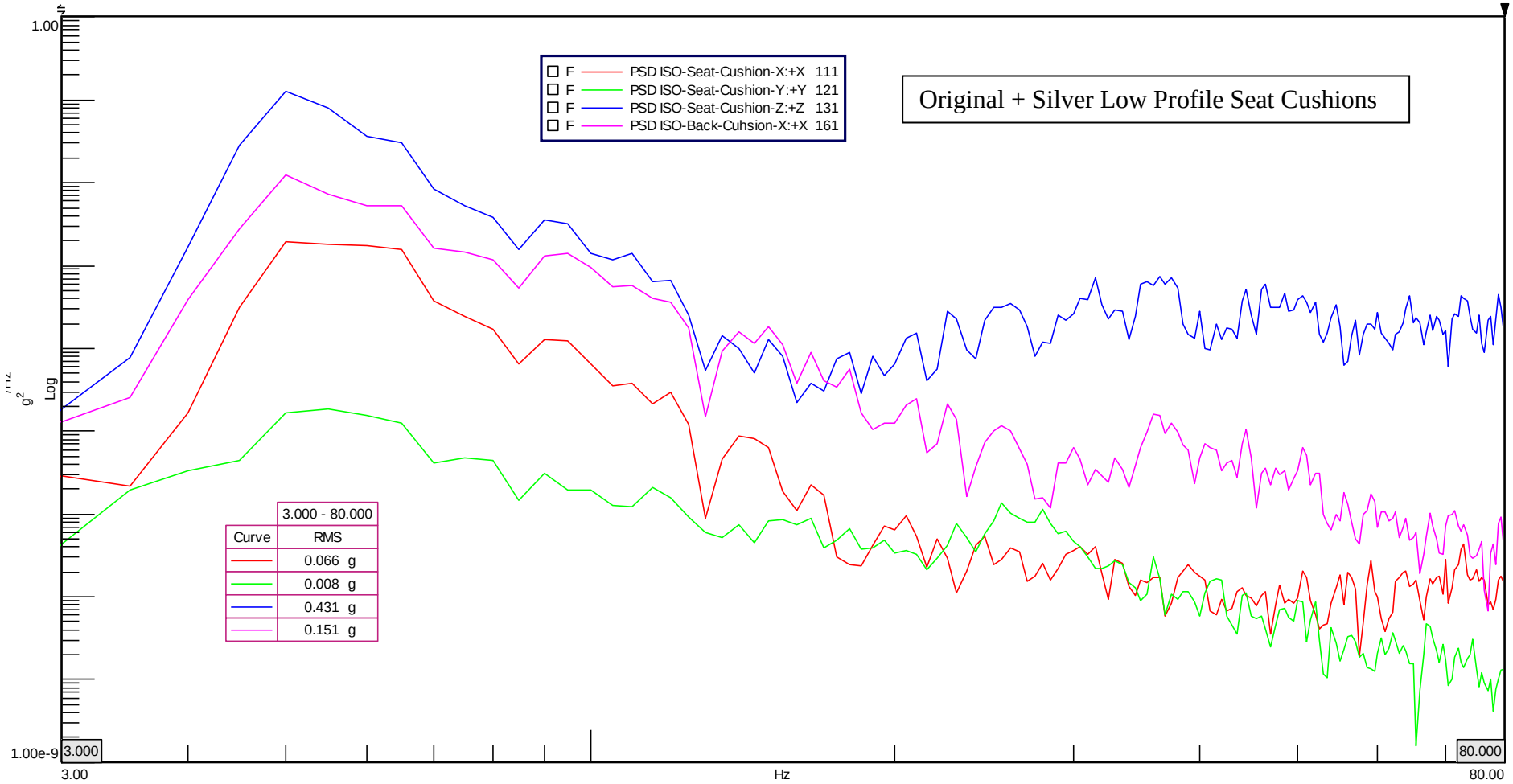
Section Name:	Rdm-2wheeled-V	Transducer S/N:	
Run Name:	Rdm-2wheeled-V_6_HRV_PSD	Acquisition Mode:	Real-Time

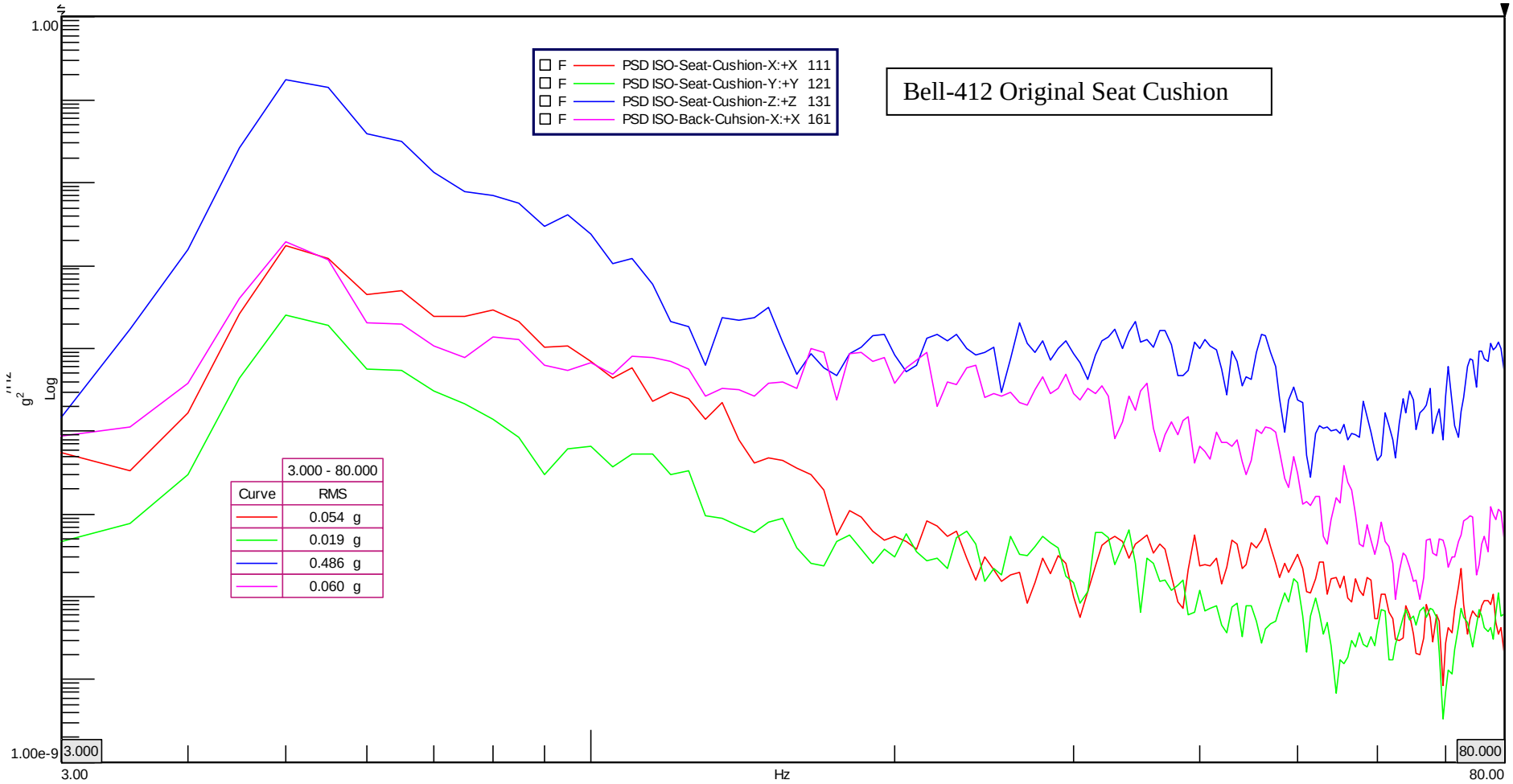
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:28:38
Section Name:	Rdm-Composite-V	Transducer S/N:	
Run Name:	Rdm-Composite-V_2_HRV_PSD	Acquisition Mode:	Real-Time

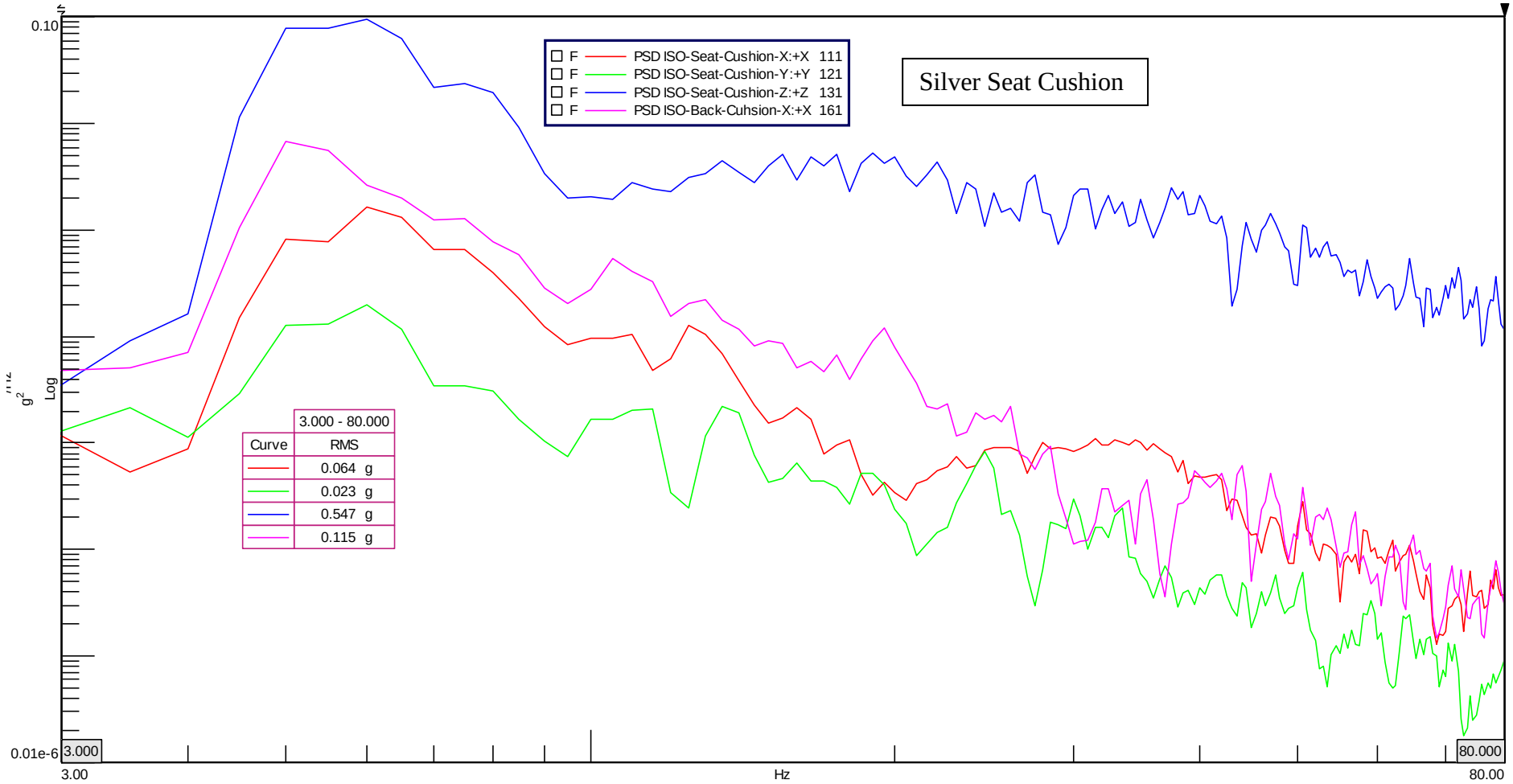
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:33:01
Section Name:	Rdm-Composite-V	Transducer S/N:	
Run Name:	Rdm-Composite-V_4_HRV_PSD	Acquisition Mode:	Real-Time

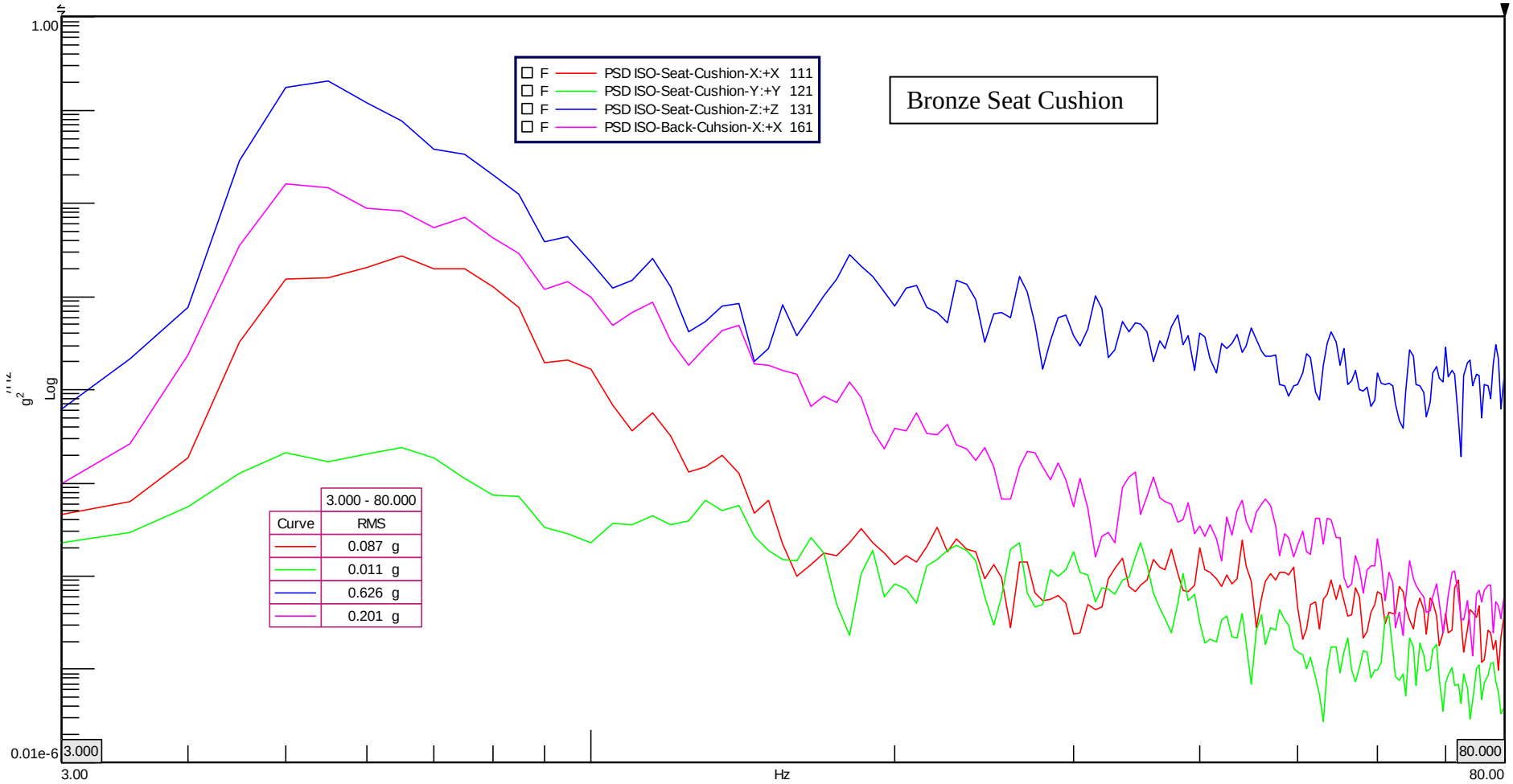
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:35:40
Section Name:	Rdm-Composite-V	Transducer S/N:	
Run Name:	Rdm-Composite-V_5_HRV_PSD	Acquisition Mode:	Real-Time

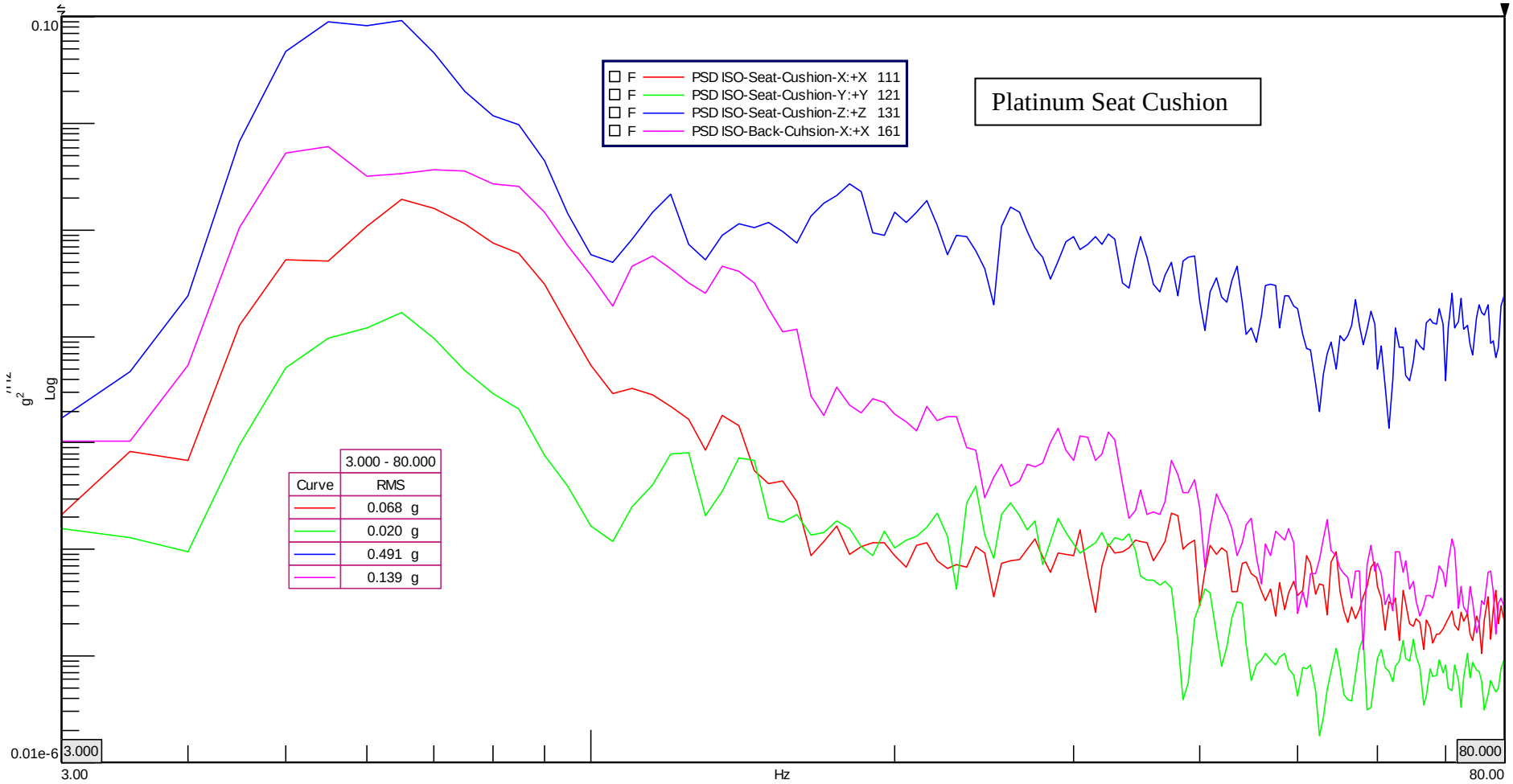
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:37:14
Section Name:	Rdm-Composite-V	Transducer S/N:	
Run Name:	Rdm-Composite-V_6_HRV_PSD	Acquisition Mode:	Real-Time

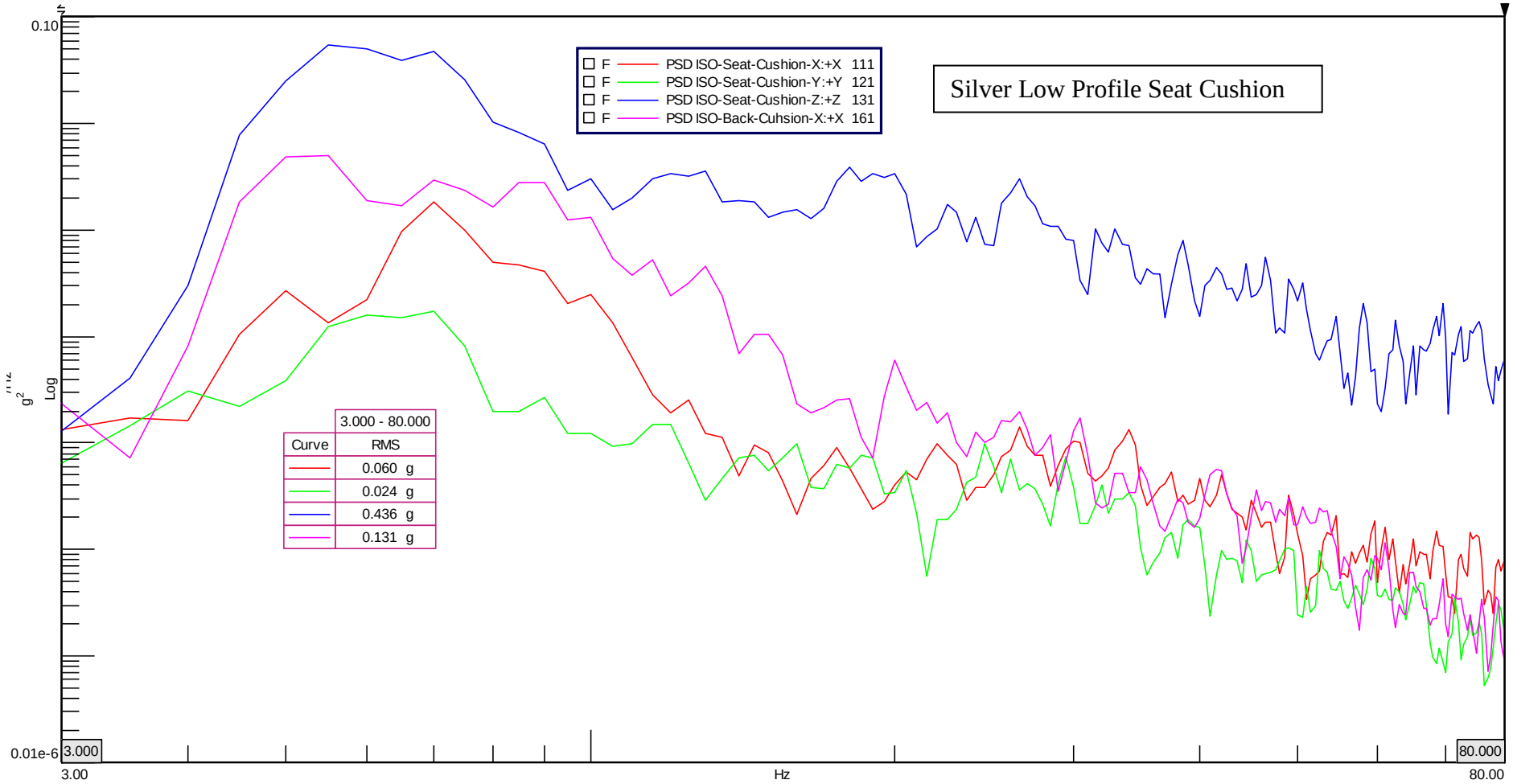
Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:38:29
Section Name:	Rdm-Composite-V	Transducer S/N:	
Run Name:	Rdm-Composite-V_7_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning



Blake Medical Seat Cushion Test

Project Name:	Blake-Medical-Updated	Date and Time:	Thu Mar 01 2018 17:39:34
Section Name:	Rdm-Composite-V	Transducer S/N:	
Run Name:	Rdm-Composite-V_8_HRV_PSD	Acquisition Mode:	Real-Time

Channel Name:	ISO-Seat-Cushion-X	Sampling Frequency:	1600 Hz	LMS Channel No:	111
Spectrum Format:	PSD	Averaging Type:	Energy average	Spectrum Scaling:	RMS
Frequency Resolution:	0.5 Hz	# of Averages:	5	Windowing Type:	Hanning