SAND2013-8398C

Evaluation of the Sandia Portable Infrasound Testbed: Based on Observations from Infrasound Sensors testing at I56US, I57Us and FACT site Infrasound Testbed

Infrasound Technology Workshop

Vienna, Austria

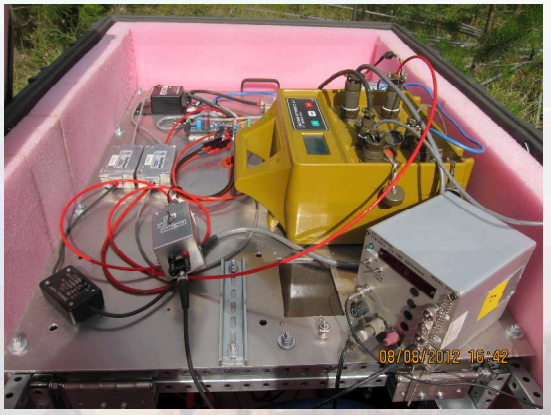
October 7-11, 2013

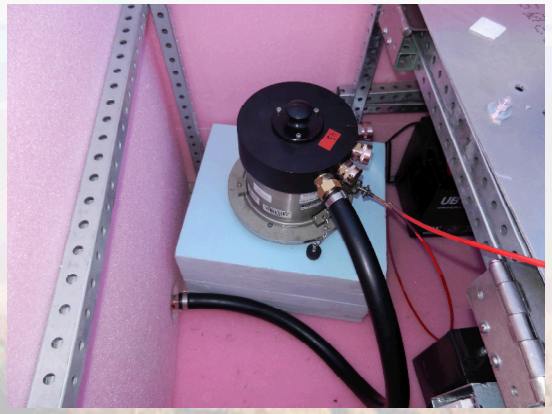
Outline:

- I56US Upgrade and Component Evaluation Results
- I57US Infrasound Sensor Evaluation
- FACT site Evaluation of Portable Infrasound Calibrator

I56US Upgrade

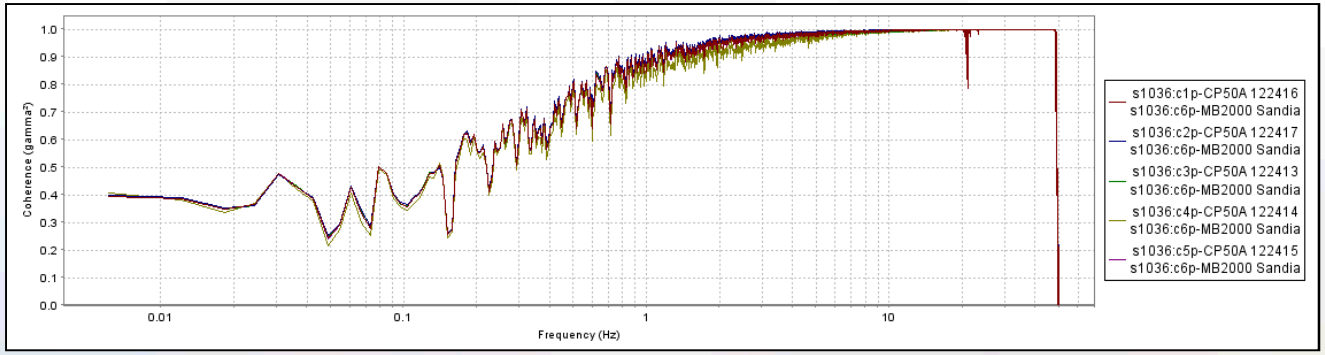
- Sensor upgrade from Martec MB2000 to Chaparral Physics 50A
- Digitizer upgrade from Geotech DR24 to Geotech Smart24
- Enclosures





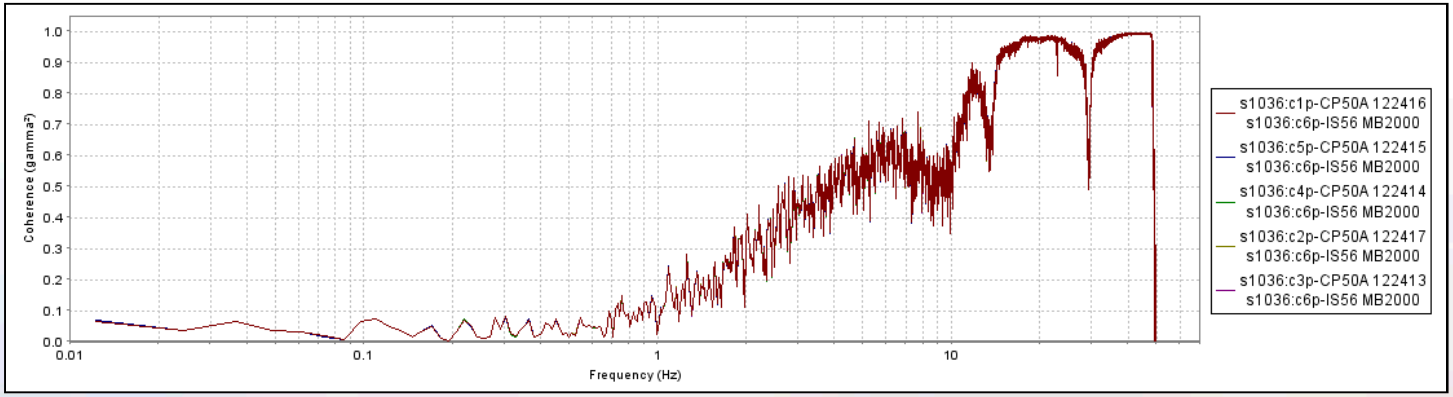
Motivation: I56US Newport, Washington On-Site Component Testing

During on-site testing of the Chaparral Physics 50A, reduced coherence was observed between the Sandia reference sensor and the sensors to be installed.



Coherence plot between Sandia MB2005 and CP50A. Note the dramatic reduction in coherence at low frequencies.

The MB2000 from I56US H1 was swapped into the Sandia infrasound testbed and the test re-run.

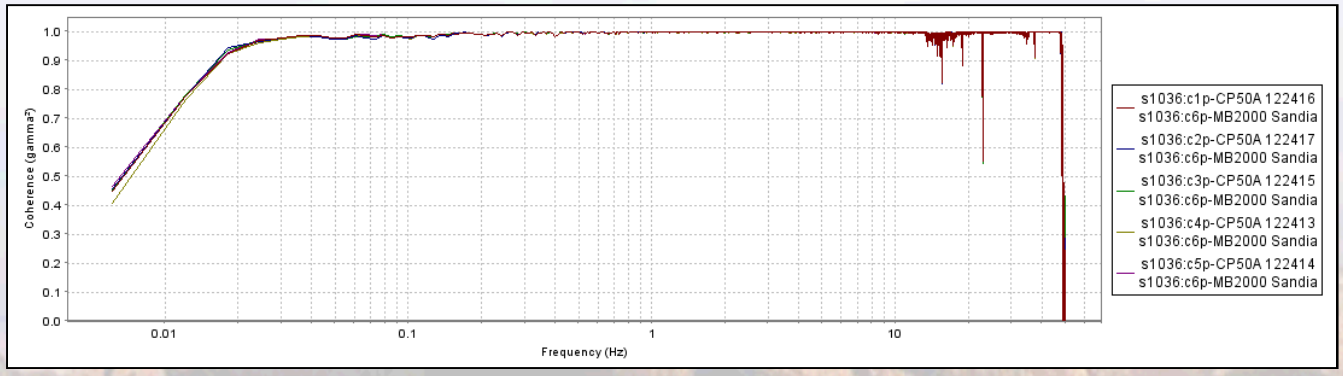


Coherence plot between Sandia MB2005 and CP50A. Note the dramatic reduction in coherence at low frequencies.

These test results lead us to believe the LVDT of the Sandia MB2005 was damaged in shipment or loose, and needed adjustment before testing could proceed.

The MB2005 set screw was found to be loose, and therefore the LVDT was re-centered.

The MB2005 was reattached to test manifold and new test data collected. The new coherence plot showing the expected broadband coherence between reference and sensors under test.



Concern:

Could loose LVDT set screws effect MB2000/MB2005 sensor performance? A complete review of components from the I56US upgrade should allow us to make a determination and identify any other oddities in the hardware components.

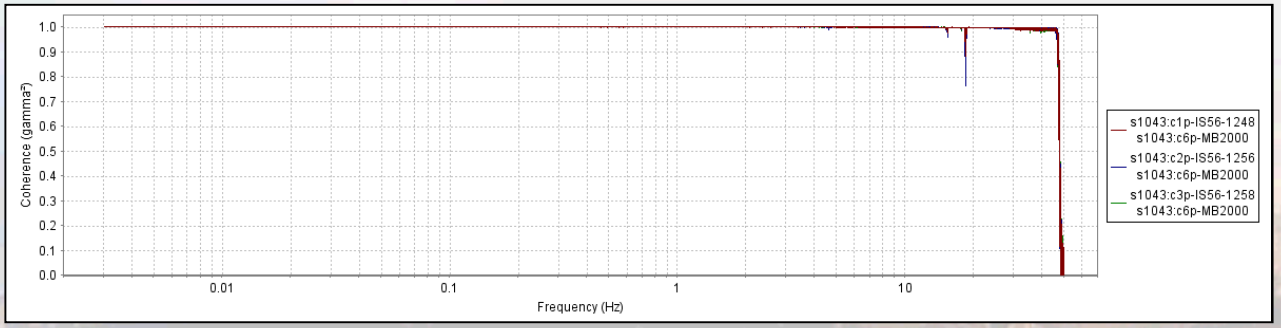
Sensors were shipped from I56US to UAF and then back to the Sandia FACT site.

Sensor ID	PT9 OUTPUT (V) Before Centering	PT9 OUTPUT (V) After Centering
1380 (Sandia)	0.13	0.13
1248	11.06	-0.035
1251	12.39	-0.035
1254	13.87	0.050
1256	12.98	0.010
1258	13.98	0.020

Sandia National Laboratories

Tests conducted on Infrasound Sensors: Piston-Phone Linearity @ six amplitudes (66 mPa to 2 Pa), and Response Verification

Infrasound Sensor SN	Measured Sensitivity (mV/Pa)	% difference from Nominal (20mV/Pa)	Signal-to-Noise (dB)	SRN Standard Deviation (dB)	Phase (deg)	Phase Standard Deviation (deg)
1248	19.801	1.00	45.8	7.1	-0.112	0.269
1251	19.857	0.72	45.5	6.8	0.058	0.124
1254	19.843	0.79	46.2	5.877	-0.092	0.225
1256	19.878	0.61	45.7	6.1	-0.144	0.336
1258	19.854	0.73	46.3	5.5	-0.070	0.121



Coherence plot between Sandia MB2000 and three I56US MB2000 after LVDT reset. High degree of similarity over passband.

Sandia National Laboratories

Digitizer Testing at Sandia National Laboratory

Tests to be conducted on Digitizers: DC-Accuracy at 0.1, 1 and 10 Volts, Input Terminated Noise @ 100 Ω, Time-Tag Accuracy, Time-Tag Statistics, and Time-Tag Drift (on unit 1226).

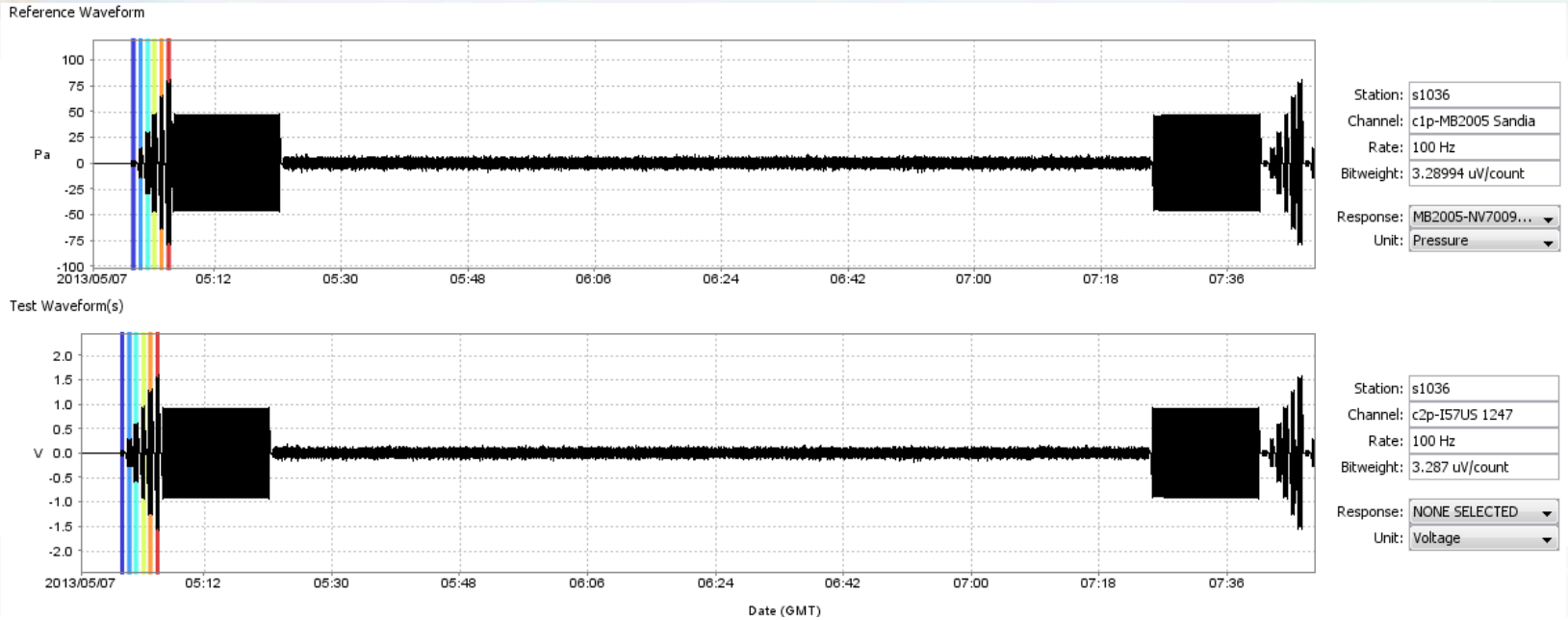
DR24 ID	DR24 Gain Resistor (Ω)	Bit-Weight (µV/count) for 0.1 V Input	Bit-Weight (µV/count) for 1 V Input	Bit-Weight (µV/count) for 10 V Input	Time-Tag Accuracy (µSec)	RMS Noise (µV) for 0.02 – 4 Hz Passband
1225	35.98	2.01502	2.01491	2.01487	70.8	1.1172
1226	32.85	1.91818	1.91821	1.91816	70.8	1.0627
1227	35.90	2.01320	2.01311	2.01310	69.6	1.0719
1229	35.82	2.01076	2.01071	2.01068	68.2	1.1772
1231	35.91	2.01432	2.01432	2.01428	70.6	1.2308

Summary I56US Infrasound System Evaluation

I56US Array Element	MB2000	DR24	IDC MB2000 Sensitivity (mv/Pa)	IDC DR24 Bit-weight (counts/V)	IDC calib (Pa/count)	Sandia calib (mPa/count)	Percent change in calib
H1	1254	1227	19.995	496803	0.000100669	0.101671633	-0.992
H2	1256	1225	20	496310	0.000100743	0.101476557	-0.722
H3	1248	1229	20.003	497437	0.000100500	0.101333468	-0.827
H4	1251	1231	19.992	496463	0.000100753	0.101334138	-0.577
Spare	1258	1226	19.998	521380	0.000095909	0.096614284	-0.737

I57US On-Site Sensor Evaluation

- Test all eight infrasound sensors at I57US
  - Performed tests in groups of three due to limitations in the sensors cables
- Piston-Phone Linearity @ six amplitudes (2.6 Pa to 77 Pa), 15 minute single frequency (1.4 Hz) constant amplitude (46 Pa) tone, Response Verification and Self-Noise
- Verified PT9 Output range and set barometric pressure output (not reported on)



Waveform	0.1 V	0.5 V	1 V	1.5 V	2 V	2.5 V
Observed Reference	2.6 Pa	13.7 Pa	29.2 Pa	45.9Pa	62.7 Pa	77.3 Pa
s1036:c2p-I57US 1247	19.76139 mV/Pa	19.76011 mV/Pa	19.75975 mV/Pa	19.75944 mV/Pa	19.75944 mV/Pa	19.75951 mV/Pa

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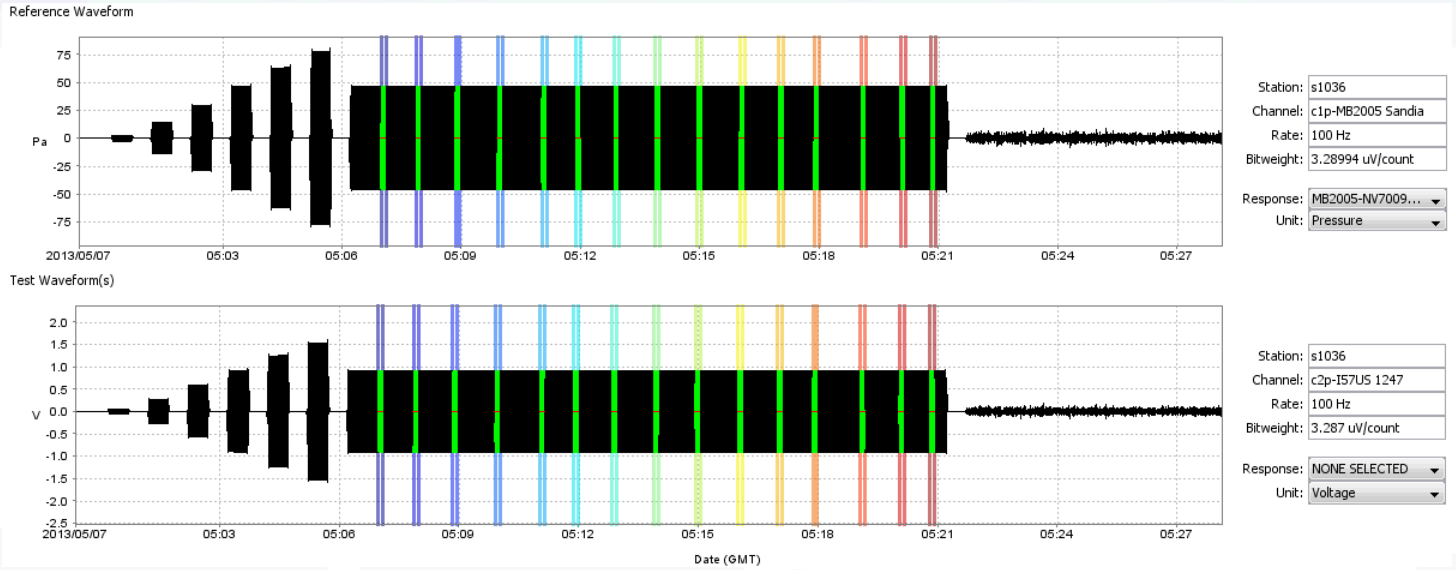
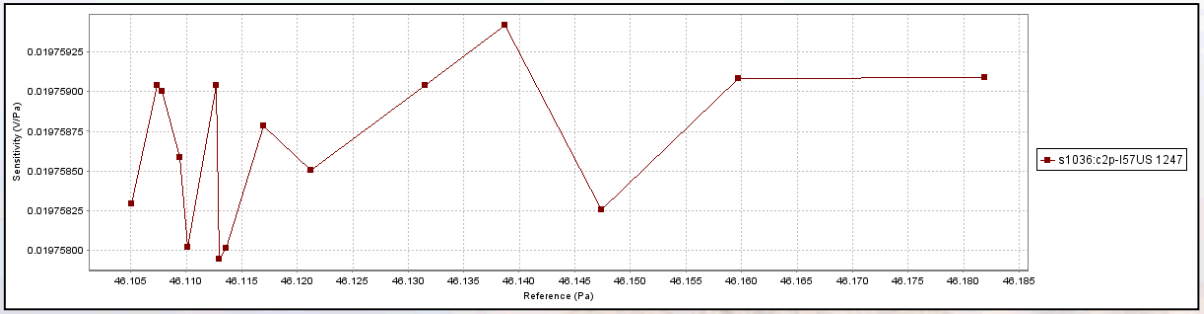




Observed Reference	46.125 Pa	0.0226
s1036:c2p-I57US 1247	19.759 mV/Pa	0.000475

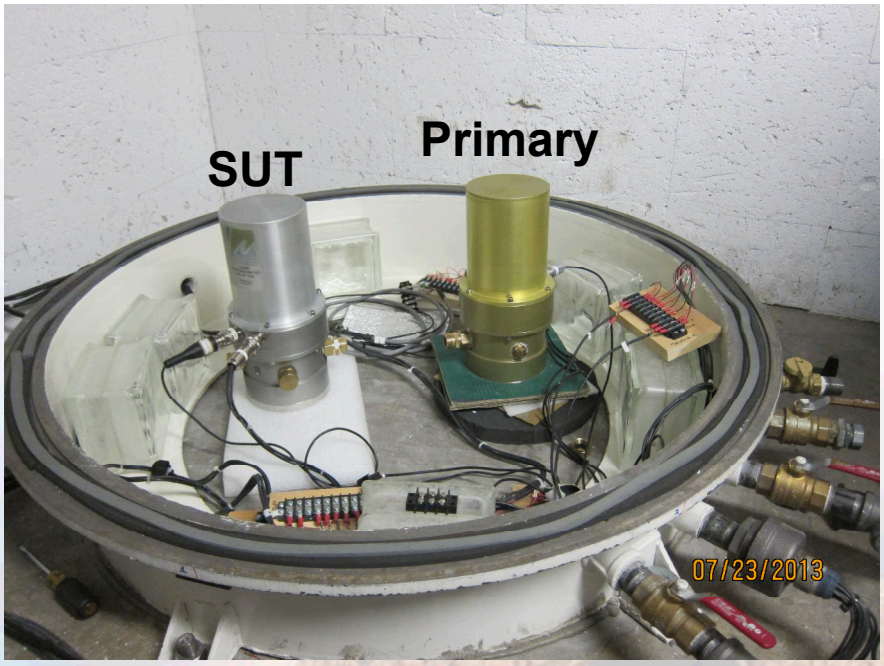
	Mean (Pa or mV/Pa)	Standard Deviation	% Difference from SCM*	Sensitivity (mV/Pa) from SCM*
Observed Reference	**46.02**	**0.1139**		
s1036:c2p-I57US 1247	19.762	0.003181	1.141	19.99
s1036:c4p-I57US 1255	19.808	0.002124	0.936	19.995
s1036:c5p-I57US 1245	19.71	0.002993	1.215	20.004
Observed Reference	**45.42**	**0.02071**		
s1036:c2p-I57US 1253	19.832	0.004369	0.811	19.994
s1036:c4p-I57US 1250	19.871	0.003801	0.634	19.998
s1036:c5p-I57US 1257	19.845	0.002307	0.802	20.005
Observed Reference	**45.25**	**0.03591**		
s1036:c2p-I57US 1252	19.832	0.001793	0.824	19.997
s1036:c4p-I57US 1246	19.836	0.000911	0.847	19.995
s1036:c5p-I57US 1249	19.844	0.001132	0.807	20.005

***Station Certification Manual**

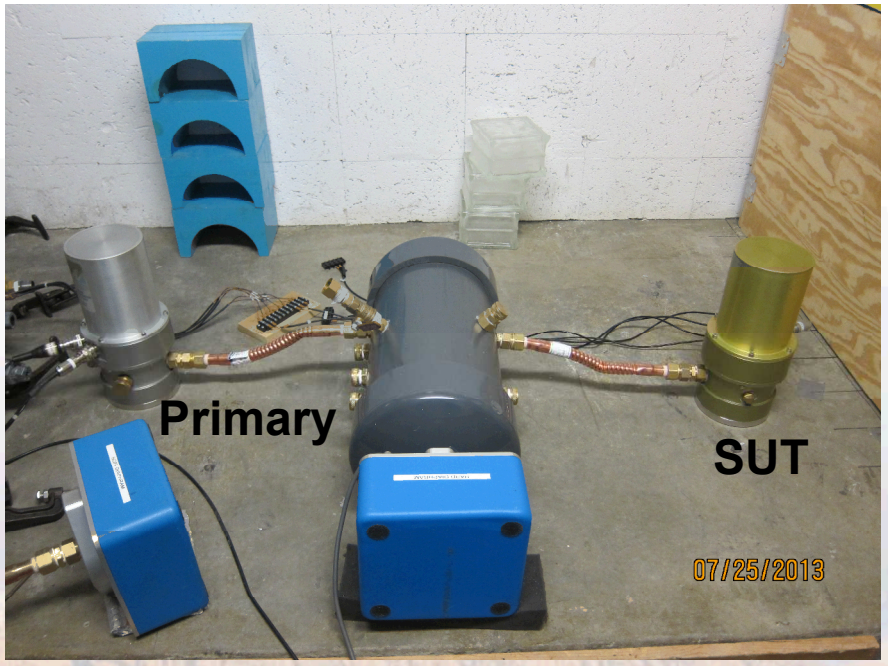
Comparison of Sandia Portable Calibrator with Sandia's Primary Infrasound Evaluation System

- Verify portable system calibration capability of primary standard

Sandia's Primary Infrasound Evaluation System



Sandia Portable Calibrator



SUT - Sensor Under Test

Martec MB2000 Primary Reference

Martec MB2005 Secondary Reference

Power: MB2000 = 4 watts and MB2005 = 1.6 watts @ 12V

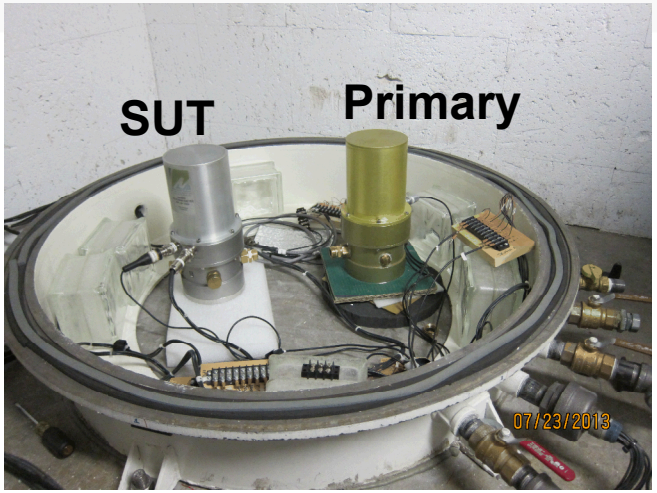
Sensitivity: MB2000 ***100 mV/Pa*** and MB2005 ***97.6 mV/Pa***

Noise: -64 dB rel 1 Pa^2/Hz ~ 0.7 mPa rms (0.5-2 Hz)

Full-scale Pressure: 107 Pa (zero to peak)

Dynamic Range: 104 dB

Passband:0.01 – 30 Hz (-3dB roll-off of response model)



Waveform	0.1 V	0.5 V	1 V	1.5 V	2 V	2.5 V
Observed Reference	0.11793 Pa	0.62571 Pa	1.32576 Pa	2.08972 Pa	2.87716 Pa	3.6133 Pa
s1043:c3p -MB2005 Sandia	97.91215 mV/Pa	97.58412 mV/Pa	97.49698 mV/Pa	97.53092 mV/Pa	97.51218 mV/Pa	97.53907 mV/Pa

Mean = 97.596 mV/Pa +/- 0.158 mV/Pa

Waveform	0.1 V	0.5 V	1 V	1.5 V	2 V	2.5 V
Observed Reference	0.29636 Pa	1.49236 Pa	3.02162 Pa	4.59278 Pa	6.19898 Pa	7.83151 Pa
s1043:c6p -MB2000 Sandia	0.10005 V/Pa	0.10016 V/Pa	0.10018 V/Pa	0.10017 V/Pa	0.10017 V/Pa	0.10017 V/Pa

Mean = 100.15 mV/Pa +/- 0.049 mV/Pa

LANL – Infrasound Chamber Uncertainty Determination (2007)

Component	Uncertainty (1σ)
Piston Area	4.1%
Piston Travel	0.3%
Chamber Empty Volume	0.4%
Sensor Volume Displacement	0.2%
Heat Conduction Correction	0.1 at 1 Hz; 2% at 0.02 Hz
Wall Stiffness	0.1%
Non-Ideal Gas Correction	0.2%
Humidity Correction	0.1%
Noise in the Signal	0.1%
Ambient Pressure	<0.1%
Digitizer Calibration	<0.1%
Chamber Leaks	<0.1%
MB2005 Sensitivity Drift	1%*
Digitizer Calibration – Sandia	<0.1%
Sandia Chamber – Noise in Signal	<0.1%
Total Standard Uncertainty	5.2 – 5.7% SNL (4.2-4.7% LANL)

Thank You