



Thermal equilibration of Hyperion infrasound sensors

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An evaluation of several Hyperion 5313A infrasound sensors was performed in order to determine the length of time it takes for the sensors to thermally equilibrate under a variety of environmental conditions.

- The motivation for performing these tests was to aid in determining suitable procedures for station operators to follow when installing these sensors.
- Thermal equilibration occurs when the temperature of the component materials of a sensor are equalizing with its environment.
- This can occur when the sensor is exposed to an environment with a different ambient temperature or when the sensor is first powered on, both of which typically occur during the installation of a sensor.
- During the equilibration period, the measured noise on the sensor output can be considerably higher than when it has thermally stabilized.

Hyperion sensors were first installed at a U.S. IMS station (I53) in Fairbanks, AK in Fall 2019, after Type Approval completion.

- Installation at this and other U.S. IMS stations to follow encountered some challenges in which the sensors were not initially performing as expected.
 - Main issue seemed to be the measured in-field system noise was higher than expected, for some time after installation
- Desire to develop a set of recommendations to follow for future Hyperion deployments



Followed IMS process for revalidation:

- Sensor performance measured in WATC basement
- Sensitivity relative to IMS traveling reference (MB2005)
- Self-noise while sensors were capped
- Sensors passed checks before installation



System noise measured with sensors capped:

- In some cases, it took a long time for sensor self-noise to come down to expected levels.
- Working hypothesis was that it had something to do with the temperature change and possibly the sequencing of back-volume venting.

Tests were performed to answer a set of questions:

- How long does it take for the sensors to equilibrate when already thermally stabilized?
- How long does it take for sensors to re-equilibrate after a brief power cycle?
- How long does it take for sensors to equilibrate when they are not thermally stabilized?
- How long does it take for sensors to equilibrate when they are in a thermally dynamic environment?
- Is there any difference in equilibration time with or without the vent screw installed?

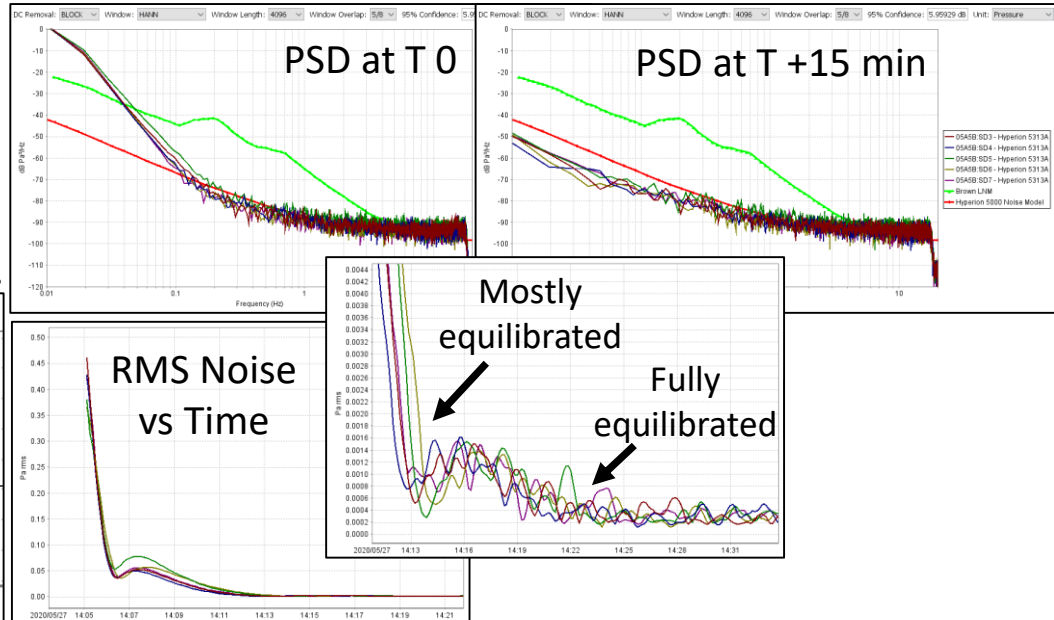
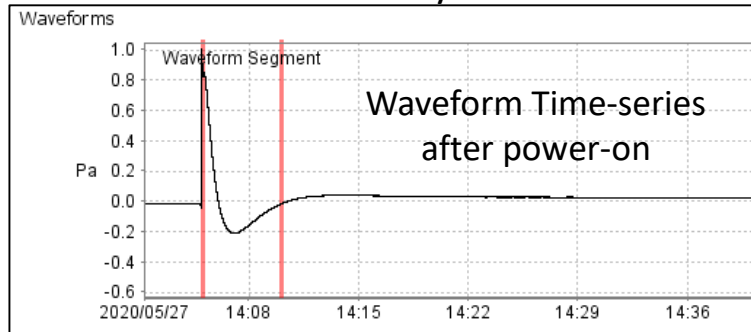


Sensors in infrasound isolation chamber

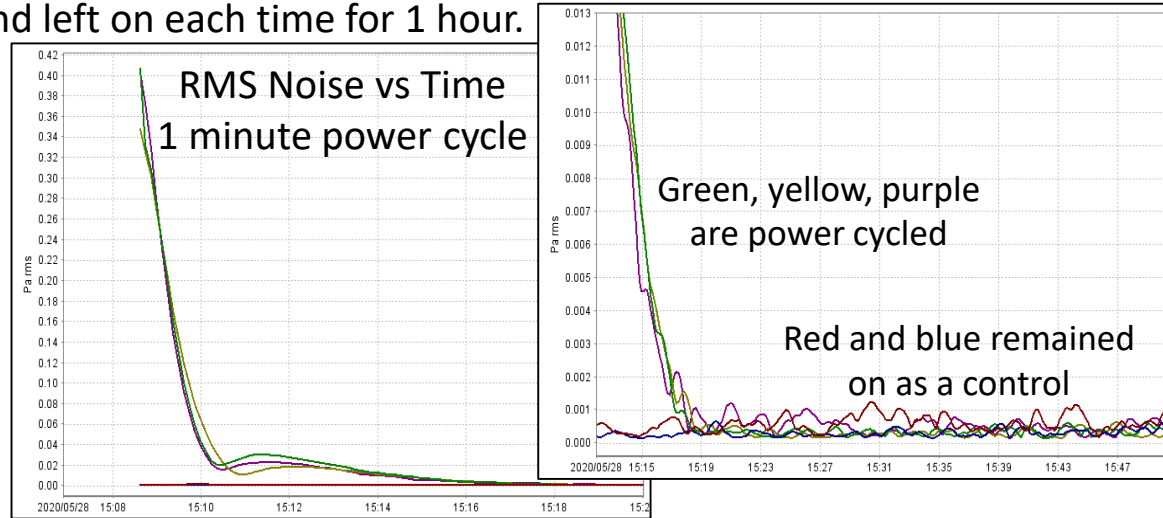
Sensors in thermal chamber
for temperature soak



- The sensors are capped and sealed inside of the infrasound isolation chamber at 23 C.
- The sensors equilibrate while powered off for a minimum of 12 hours.
- The sensors are then powered on and allowed to re-equilibrate for 12 hours.
- Elevated sensor output below 0.1 Hz
- Plotting RMS noise over:
0.001 Hz to 0.1 Hz passband
1-minute windows, step 7.5 second
- Sensors mostly equilibrated after 10 minutes and fully after 20 minutes.



- The sensors are capped and sealed inside of the infrasound isolation chamber at 23 C and powered on for 12 hours to equilibrate
- Two sensors remain powered on as a control.
- Three other sensors are power off for 1, 5, 15, 30, and 60 minutes and left on each time for 1 hour.



Power Off Duration	Equilibration Time
1 Minute	10 minutes
5 Minute	10 minutes
15 Minute	10 minutes
30 Minute	9 minutes
60 Minute	10 minutes

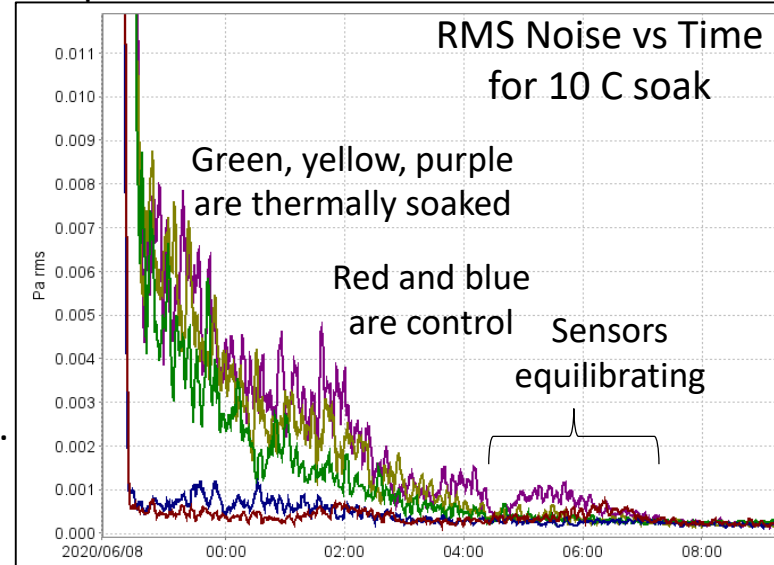
- For power cycles up to an hour, all sensors equilibrated within 10 minutes.

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- Two sensors are powered off in the isolation chamber at 23 C as a control.
- Three other sensors are power off and thermally soaked at -36 C, -10 C, 10 C, and 30 C in a temperature chamber for 3 hours before being reinstalled in isolation chamber at 23 C.
- The sensors are then powered on and allowed to equilibrate for 12 hours.

Temperature	Control Sensor Equilibration Duration	Temperature-Soaked Sensor Equilibration Duration
-36 C	8 minutes	7.5 hours – 3 days
-10 C	7 minutes	8.5 – 16.5 hours
10 C	8 minutes	6.5 - 9 hours
30 C	8 minutes	10 – 12.5 hours

- Stabilization from different temperatures can take a very long time and is highly variable.
- Very cold temperatures (-36 C) were difficult for equilibration.

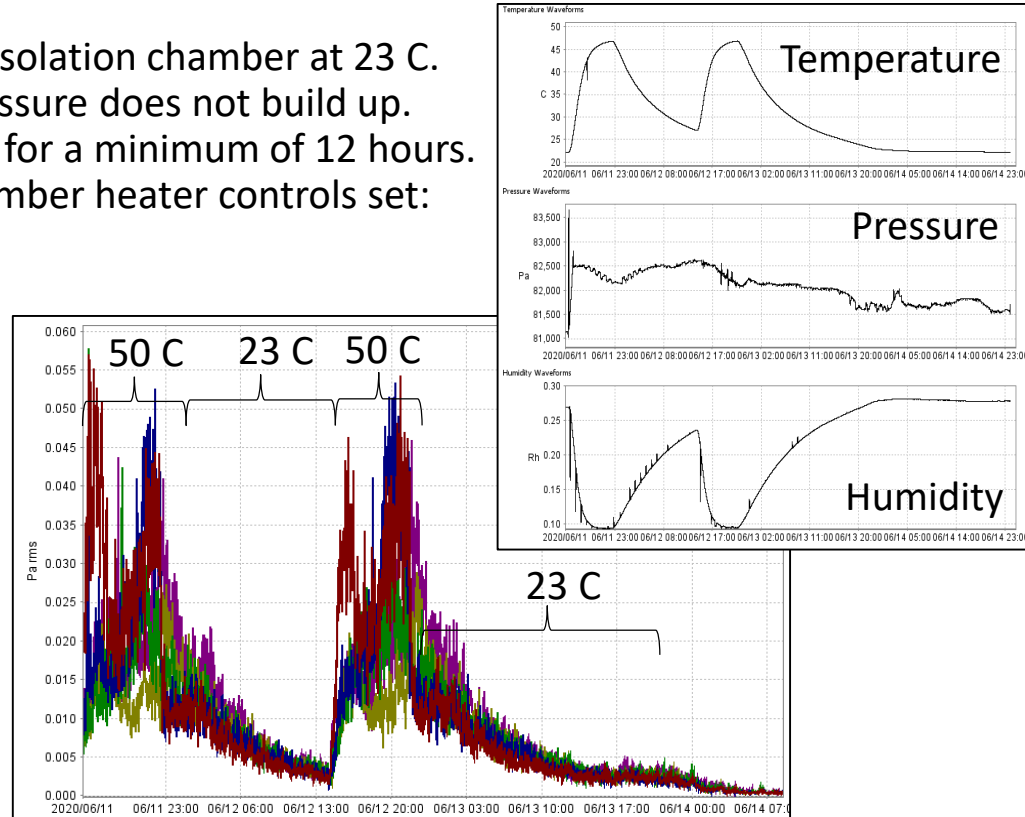


- The sensors are capped and sealed in the isolation chamber at 23 C.
- Chamber vented with a small valve, so pressure does not build up.
- The sensors equilibrate while powered off for a minimum of 12 hours.
- The sensors are then powered on and chamber heater controls set:

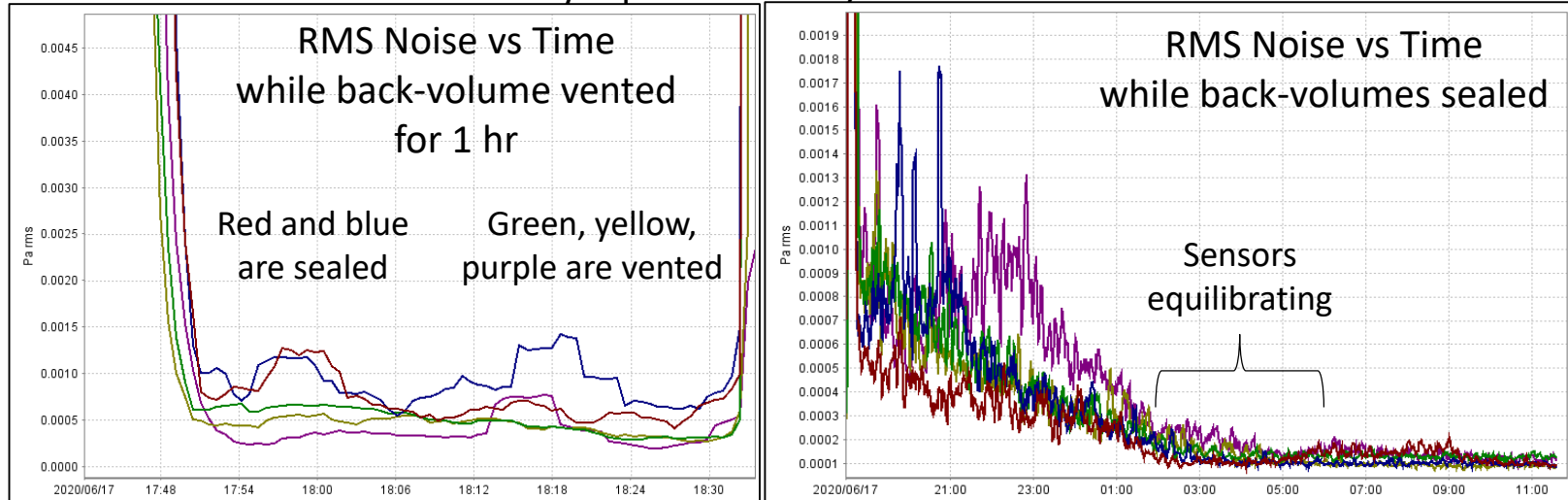
50 C for 8 hours
23 C for 16 hours
50 C for 8 hours
23 C for 16 hours

} 2 diurnal cycles

- Sensor noise never stabilized
- Noise correlated with temperature variations
- Best option to ensure sensors are isolated from temperature swings.
- Note: Noise is still well below the acoustic background and would not impact station operation, only measuring station system-noise.



- Tried multiple variations of removing the Hyperion inlet caps and back-volume vents to see if it could speed the equilibration of sensors thermally soaked at -10 C.
- In one example, some sensors had their back-volumes temporarily vented for 1 hour and then re-sealed to see if they equilibrated any faster.



- Results were inconsistent and did not indicate a clear improvement to equilibration time.

- When sensors are stabilized to ambient temperature, wait 10 minutes after power on to evaluate data.
- When sensors are powered off for as much as 1 hour in a temperature stable environment, wait 10 minutes after power on to evaluate data.
- Temperature stabilization takes a long time. It is best to introduce the sensor to the deployment environment 12 to 16 hours before operation.
- Sensors should be deployed in such a way as to minimize rapid temperature changes, such as insulated & air-sealed enclosures. Otherwise, temperature changes can elevate self-noise at low frequencies.
- It is unclear that removing the vent screw has any benefit to speed equilibration. However, it is still best practice to vent the back-volume after temperature stabilization to minimize static pressure differential across the transducer.