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FINAL REPORT FOR

ICE-FREE WIND FIRMWARE 4.54 MODIFICATION TEST
2008

Version 3

SEPTEMBER 2008

PREPARED BY

From Science to Solutions

FOR

ASOS Product Improvement Program

National Weather Service W/OST/1

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **EXEC-1**

1.0 BACKGROUND 1

2.0 PURPOSE 1

3.0 TEST SETUP AND METHODOLOGY 1
- **3.1 Vaisala Diagnostics** 2
- **3.2 Wind Tunnel Testing** 2
- **3.3 Environmental Chamber Testing** 3
- **3.4 Sensor Description** 4
  - *3.4.1 Vaisala 425NWS IFW Sensor* 4

4.0 DATA ANALYSIS 5

5.0 RESULTS 5
- **5.1 IFWS Diagnostic Testing** 5
  - *5.1.1 Firmware 4.50 & 4.54 - SN0709 & SN0928* 5
- **5.2 ASOS Testing** 6
- **5.3 Wind Tunnel Testing** 7
- **5.4 Temperature Chamber Testing** 8

6.0 CONCLUSIONS 14

7.0 DATA REPORTING AND TEST SCHEDULE 15

8.0 RESPONSIBILITIES 16

APPENDIX A A-1

ACRONYMS AND ABBREVIATIONS

TERMS	DEFINITION
ASOS	Automated Surface Observing System
NWS	National Weather Service
IFWS	Ice Free Wind Sensor
FAA	Federal Aviation Administration
DAS	Data Acquisition System
FW	Firmware
PRT	Platinum Resistor Thermometer
kts	Knots (nautical miles per hour)

EXECUTIVE SUMMARY

The Belfort cup and vane wind system was the initial wind sensor deployed in the Automated Surface Observing System (ASOS). The sensor design consists of a vane and rotating cup anemometer. Previous testing has shown that during rime icing and freezing/frozen precipitation events, the sensor is susceptible to significant degradation in performance, ranging from substantial reductions in reported true wind speed to a complete lock-up of the cups and vane. This issue led to several phases of testing being conducted during the late 1990's to identify candidates for replacement of the current ASOS cup and vane wind system. At the conclusion of testing, an Ice Free Wind sensor (IFWS) manufactured by Vaisala (425NWS) was selected as the replacement for the current system.

In recent months, an issue related to the IFWS began appearing at a few ASOS sites around the country. The problem is that the analog switch on the thermistor that monitors the temperature of the transducer heaters can fail. When this happens the reported temperature is not within the bounds of the sensor specification therefore impeding the heater from activating. This can allow ice to build up on the transducer arms during freezing precipitation events. It is theorized that electrostatic discharge is causing the analog switch to fail.

The purpose of this test was to evaluate the Vaisala's new 425NWS IFWS Firmware (FW) version 4.54. This version of FW is supposed to set the overall status flag in the WA Command to "F" (failed) and report 999 for Wind Direction and 999.9 for Wind Speed when a failed analog switch on the thermistor is encountered. The new FW is also supposed to set the Thermistor Temperature status to "F" in the WT Command. The testing of this FW is to:

1. Ensure compliant operations of the sensor in the Wind Tunnel
2. Meet the sensor reporting accuracy in the Wind Tunnel
3. Check IFWS diagnostics to ensure compliant operations
4. Check the command strings used in ASOS (WA and WT) are reporting as expected
5. Ensure the proper heater functionality inside an environmental chamber

Diagnostic testing:

The two sensors with no known deficiencies (SN0054, SN0085) passed all diagnostic tests with the new firmware. All diagnostic parameters fell within the specifications for the IFWS.

The two sensors that have a known failure in the analog switch on the thermistor (SN0709, SN0928) reported as expected in most cases with the new firmware. There were a few questions in the outcome of the bench testing:

- It is unclear why SN0709 with FW4.54 passes the array heater resistance in the WS command, but fails the heater resistance in the WD command. It is assumed that this difference is due to a different failed component within the heater control and sensing circuitry of each of the test sensors.

- It is not known why SN0928 with FW4.54 pass the heater resistance test in the WD

command, while SN0709 fails on the same test. It is assumed that this difference is due to a different failed component within the heater control and sensing circuitry of each of the test sensors.

ASOS Testing

SN0928 with FW4.54 was connected to an ASOS system and the evaluation revealed the maintenance page showed an “F” in the thermistor temperature status. The OID screen, one-minute and 5-second page showed missing data for wind speed and direction. The average wind and peak time were set to 99. The SYSLOG also listed a 1775 message, which is a Thermistor Failure. These are expected outcomes for FW v4.54 with a sensor that has a failure in the analog switch on the thermistor.

SN0085 with FW4.54 was also tested on ASOS to ensure that a properly working sensor continued to report properly with the new firmware. This sensor reported wind speed and direction values and showed average wind and peak times were set to 5 and 3 seconds, respectively.

Wind Tunnel Testing

The two functioning sensors were tested with the old firmware, 4.50 and the new firmware, 4.54. SN0054 and SN0085 passed all specifications for wind speed and direction at all test speeds with FW4.50 and FW4.54.

Environmental Chamber Testing

The results for SN0085 and SN0054 show that the IFWS’s internal thermistor generally reflected the transducer arm temperature. It also shows that the heaters turn off when ambient temperatures exceeded 30 °C and that the heaters turned on to maintain transducer arm temperature at approximately 30 °C (or above) when the ambient temperature fell below approximately 30 °C. An additional examination of the WA and WT status flags indicated that SN0085 and SN0054 passed all internal diagnostic tests throughout the entire chamber test cycle. Wind speed and wind direction measurements contained in the WA data were consistent with the expected airflow inside the environmental chamber.

The results for SN0928 show that the IFWS’s internal thermistor generally reported transducer arm temperatures between 70 and 74 °C. However, when the ambient chamber temperature exceeded approximately 35 °C, the IFWS thermistor reported that the transducer arms were at 99 °C. None of these thermistor measurements had any validity because the PRT temperature sensor indicated that the heaters never turned on and that the transducer arms’ surface temperature were always roughly the same as the ambient chamber temperature. An examination of the status flag contained in the WA data showed that SN0928 failed (reported “F”) and the wind speed and wind direction measurements were reported as 999 throughout the entire chamber test cycle. An examination of the WT data status flags indicated that the instrument had a failed thermistor but that it did maintain a passing heater array resistance value (of between 4.9 and 5.2 ohms).

The results for SN0709 show that the internal thermistor reported transducer arm temperatures of -54 °C. This value never varied throughout the entire test. At the beginning of the test, the PRT temperature sensor measurements indicated that the transducer heaters were not turned on and that the transducer arms' surface temperature was roughly the same as the ambient chamber temperature.

At 10.25 hours into the test for SN0709, the PRT temperature measurements show that the transducer heaters had suddenly turned on and ran at full power for approximately 32 minutes. The temperature of the transducer arms rose to over 138 °C. At this point the heaters must have burned out because the temperature began to fall quickly and the heater array resistance flag (in the WT data string) went from "P" (a passing value of 4.9 ohms) to "F" (a failed value of 6.9 ohms). At this time, the data string in the WA command also changed from "F" (failed sensor) to "H" (heater failure) and the wind speed and direction changed from 999 to numerical measurement values. This change in status was due to the sensor determination that the new heater circuit failure would not impact sensor accuracy, which is in accordance with the operational design requirements set by the NWS for the sensor.

1.0 BACKGROUND

The Belfort cup and vane wind system was the initial wind sensor deployed in the Automated Surface Observing System (ASOS). The sensor design consists of a vane and rotating cup anemometer. Previous testing has shown that during rime icing and freezing/frozen precipitation events, the sensor is susceptible to significant degradation in performance, ranging from substantial reductions in reported true wind speed to a complete lock-up of the cups and vane.

Several phases of testing were conducted during the late 1990's to identify candidates for replacement of the current ASOS cup and vane wind system. At the conclusion of testing, an Ice Free Wind sensor (IFWS) manufactured by Vaisala (425NWS) was selected as the replacement for the current system. The IFWS is planned for installation at all 1001 ASOS locations nationwide. This includes 312 National Weather Service (NWS), 571 Federal Aviation Administration (FAA), 71 United States Navy, and 47 United States Air Force sponsored sites. Currently the IFWS is installed at approximately 770 sites, 704 of the 883 NWS and FAA sites, and 66 of the 118 Department of Defense sponsored sites.

In recent months, an issue related to the IFWS began appearing at a few ASOS sites around the country. The problem that is occurring is the analog switch on the thermistor that monitors the temperature of the transducer heaters can fail. When this happens the reported temperature is not within the bounds of the sensor specification therefore impeding the heater from activating. This can cause a build-up of ice in the winter season. It is theorized that electrostatic discharge is causing the analog switch to fail.

2.0 PURPOSE

The purpose of this test was to evaluate the Vaisala 425NWS IFWS Firmware (FW) v.4.54. This version of FW is supposed to set the overall status flag in the WA Command to “F” (failed) and report 999 for Wind Direction and 999.9 for Wind Speed when a failed analog switch on the thermistor is encountered. The new FW is also supposed to set the Thermistor Temperature status to “F” in the WT Command. The testing of this FW is to:

1. Ensure compliant operations of the sensor in the Wind Tunnel
2. Meet the sensor reporting accuracy in the Wind Tunnel
3. Check IFWS diagnostics to ensure compliant operations
4. Check the command strings used in ASOS (WA and WT) are reporting as expected
5. Ensure the proper heater functionality in the Temperature Chamber

3.0 TEST SETUP AND METHODOLOGY

The new firmware was tested on four IFWS at the NWS Sterling Field Support Center Wind Tunnel located in Sterling, Virginia. Two of these sensors (SN0709, SN0928) are units that were deemed to have a failure of the analog switch on the thermistor. The other two sensors (SN0054, SN0085) are working sensors with no known deficiencies.

A series of wind tunnel and bench tests were conducted on all four sensors with the old FW

(v.4.50) to determine a baseline for each sensor. The new FW was then installed on the sensors and the wind tunnel, bench testing, ASOS, and temperature Chamber testing was conducted.

The first phase of testing used the Vaisala Diagnostic tool to conduct bench tests with the old and new FW versions to ensure that they pass all internal diagnostics tests and show the proper expected outcome for the failed units.

Then the two working sensors were evaluated inside the Wind Tunnel for specification reporting accuracy testing. These wind tunnel tests were conducted at five wind speed intervals: 13, 22, 40, 70, and 125 knots. The tests were conducted with the old FW to establish a baseline and the new FW to ensure accuracy of the sensors.

Additional testing that were performed included connecting an IFWS to the ASOS to ensure proper status flags and SYSLOG messages were sent. Also, testing on the four sensors was conducted inside one of the Tenney Temperature Chambers to confirm that the transducer heaters are operating correctly.

3.1 Vaisala Diagnostics

The IFWS was mounted on the sensor pole and a wind tunnel verifier was placed on top of the sensor. The bench test shows:

1. The correct FW is installed
2. The Continuous Data is received to establish communications
3. The Zero Wind Test and WATE test to make sure all diagnostics pass
4. The correct information is sent on the WA, WD, WS and WT commands

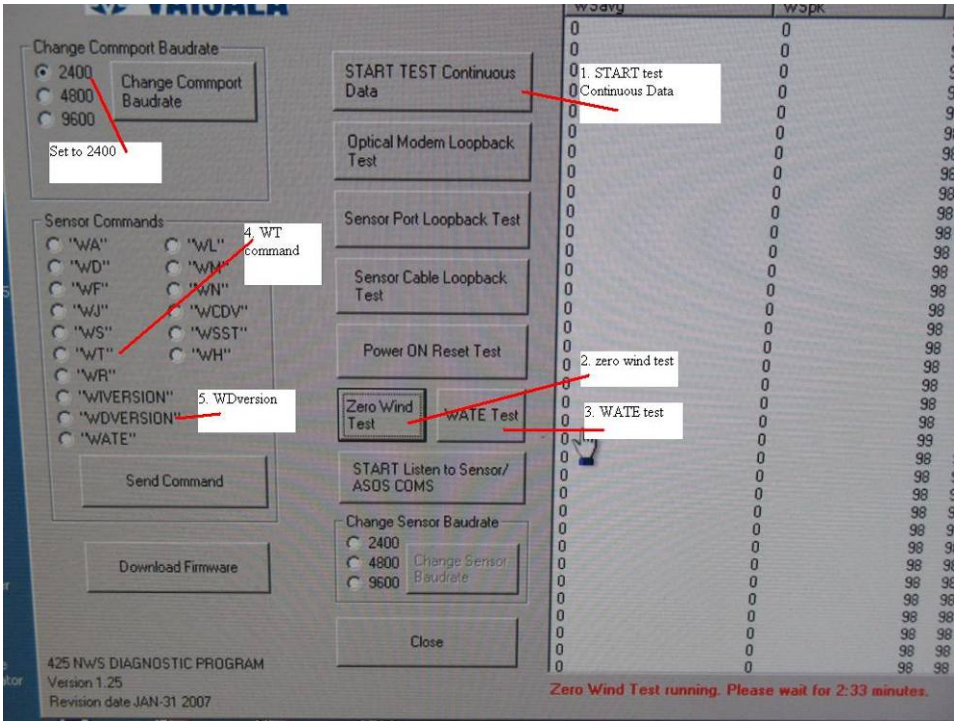

Figure 1 Wind Diagnostic Tool

3.2 Wind Tunnel Testing

The wind tunnel test section is 1.3 m x. 1.3 m x 2 m long. The maximum speed of the wind tunnel is 68 m/s. The reference wind tunnel air speed measurements are made with a pitot-static tube mounted in the test section. Ambient temperature, relative humidity, and barometric pressure measurements will be taken in the wind tunnel test section. These measurements are used to correct the air density in the wind tunnel test section to standard conditions of dry air at 15º C and 1013.25 hPa. This air density correction is then applied to the pitot-static tube pressure measurement. All wind tunnel parameters are sampled at a 6-hertz rate and recorded in 30-second intervals. The sensors were installed in the wind tunnel. The test was conducted at speeds of 13, 22, 40, 70, and 125 knots. At each constant test speed, the sonic anemometer was rotated in five-degree increments from 0 to 360 degrees to ensure that the IFWS passes the specification of ± 4º for wind direction and ± 2 knots (or ±3%, whichever is greater) for wind speed.

3.3 Environmental Chamber Testing

A pair of IFWS's (and their power supply enclosures) was installed on test stands inside a large environmental test chamber. Wooden panels covered with sound absorbing foam were installed around the IFWS to prevent interference caused by reflections from the chamber's wall and to prevent crosstalk between the sensors. To check the operation of the IFWS's heaters, a small platinum resistance thermometer (PRT) temperature sensor was attached to one of the transducer arms of each IFWS.

Figure 2 Surface mount PRT thermometers on IFWS transducer arm

The data output and PRT thermometers were connected to a pair of a data acquisition system (DAS) computers (and related data communications equipment) located outside the test chamber. One of these DAS computers was configured to record temperature measurements from the PRT's every 60 seconds. The other DAS was configured to poll both IFWS every 60 seconds, once with a "WT" data query followed by a "WA" query. The response to these data polls was recorded, along with a data time stamp, inside comma delimited ASCII data files.

At the beginning of the test, the chamber temperature was set to 20 °C and allowed to stabilize. The temperature was then slowly raised (at a rate of 10 °C per hour) up to 50 °C. The chamber was held at 50 °C for 90 minutes and then slowly lowered down to -10 °C. The chamber was held for 90 minutes at -10 °C and then raised back to 50 °C. This process was repeated for two cycles. This was to ensure that the heater for the IFWS would turn on at around 30 ºC and that the temperature of the transducers is maintained at that temperature.

3.4 Sensor Description

3.4.1 Vaisala 425NWS IFW Sensor

The IFW sensor has an array of three equally spaced sonic transducers in a horizontal plane. The sensor measures transit time, the time it takes the sound wave to travel from one transducer to another. The transit time is measured in both directions. Transit time depends on the wind velocity along the sonic path. For zero wind velocity, both the forward and reverse transit time are the same. If wind along the sound path occurs, the up-wind transit time increases and the down-wind transit time decreases. The micro controller's microprocessor computes the wind velocity in a direction parallel to each possible transducer pair from the transit times using a mathematical formula. The computed wind speeds are independent of altitude, temperature, and humidity. If a bad wind velocity reading is reported between two of the transducers, that reading will be eliminated and the wind speed and wind direction will be calculated from the best two vectors.

Figure 3 Vaisala 425NWS IFW Sensor

4.0 DATA ANALYSIS

The results of the sensor bench testing was analyzed and presented in section 5.1. The results of the ASOS testing are discussed in section 5.2. Any changes or discrepancies are discussed.

Data from the wind tunnel test was automatically converted into tabular and graphical format. These data were examined to determine if the sensor measurement accuracy was within ASOS specifications. The data from the baseline tests was compared to the tests run after the FW update to determine if there were any significant change in measurement accuracy. Analysis of this data is presented in section 5.3.

Data from the environmental chamber test was converted into tabular and graphical format. These data was examined to determine the temperature that the heaters activate and if the heaters can maintain the proper transducer temperature over the entire operating range. This data is presented in section 5.4.

5.0 RESULTS

5.1 IFWS Diagnostic Testing

Diagnostic testing was conducted on all four sensors using the Vaisala Diagnostic Program. The commands tested were: WATE, Zero Wind Test, WA, WS, WD, and WT.

- The purpose of the WATE command is to determine the sensor zero offset and verify that a sufficient signal-to-noise margin exists during high wind speeds.
- The purpose of the Zero Wind Test command is to determine the zero-point calibration and the signal quality index from the transducers.
- The sensor response to the WA command consists of the averaged wind speed and direction data, peak wind speed, and associated direction. This command is used in ASOS when the sensor is polled.
- The sensor response to the WS command consists of a textual run down of the results of all Built-in-tests (BIT).
- The sensor response to the WD command consists of a concise report on the pass/fail status of all BIT results.
- The sensor response to the WT command consists of an abbreviated version of the verbose BIT results and status command. This command is used in ASOS when the sensor is polled.

The two sensors with no known deficiencies (SN0054, SN0085) passed all diagnostic tests for both firmware versions (4.50 and 4.54). All diagnostic parameters fell within the specifications for the IFWS.

5.1.1 Firmware 4.50 and 4.54 – SN0709 and SN0928

These two sensors have a known failure in the analog switch on the thermistor. SN0709 reported a thermistor temperature of -54 ºC, while SN0928 reported a thermistor temperature of +73 ºC.

FW4.50 WATE Test/Zero-Wind Test
SN0709 and SN0928 reported wind speeds and passed all specifications.
FW4.54 WATE Test/Zero-Wind Test
SN0709 and SN0928 reported missing in the wind speed and failed overall. This is the expected output for sensors with a failure in the analog switch on the thermistor.

FW4.50 WA Command
SN0709 showed an 'H' flag and continued to report a Wind Speed and Wind Direction.
SN0928 showed a 'P' flag and also continued to report Wind Speed and Direction.
FW4.54 WA Command
SN0709 and SN0928 showed an 'F' flag and report missing for Wind Speed and Wind Direction. This is the expected output for sensors with a failure in the analog switch on the thermistor.

FW4.50 WS/WT Command
SN0709 pass all diagnostics except the thermistor temperature.
SN0928 pass all diagnostics.
FW4.54 WS/WT Command
SN0709 and SN0928 pass all diagnostics except the thermistor temperature.

FW4.50 WD Command
SN0709 pass all diagnostics except the heater resistance.
SN0928 pass all diagnostics.
FW4.54 WD Command
SN0709 pass all diagnostics except the heater resistance.
SN0928 pass all diagnostics.

Overall, diagnostic testing revealed that the sensors with the new firmware do report as expected in most cases. There are a few questions in the outcome of the bench testing:

- It is unclear why SN0709 with FW4.54 passes the array heater resistance in the WS command, but fails the heater resistance in the WD command. It is assumed that this difference is due to a different failed component within the heater control and sensing circuitry of each of the test sensors.

- It is not known why SN0928 with FW4.54 pass the heater resistance test in the WD command, while SN0709 fails on the same test, and what is the correct expected outcome. It is assumed that this difference is due to a different failed component within the heater control and sensing circuitry of each of the test sensors.

It is suspected that the heater in SN0709 is working on occasion, but is not functioning properly. More information on this can be found in the Temperature Chamber section 5.4 of results.

5.2 ASOS testing

In addition to diagnostic testing, SN0928 with FW4.54 was also connected to an ASOS system. The maintenance page was evaluated and showed an “F” (failed) in the thermistor temperature status. The OID screen, one-minute and 5-second page showed missing data for wind speed and direction. The average wind and peak time were set to 99. The SYSLOG also listed a 1775 message, which is a Thermistor Failure.

SN0085 with FW4.54 was also tested on ASOS to ensure that a properly working sensor continued to report properly with the new firmware. This sensor reported wind speed and direction values and showed average wind and peak times were set to 5 and 3 seconds, respectively.

5.3 Wind Tunnel Testing

The table below shows the results from the wind tunnel testing for the two sensors that have no known deficiencies.

Nominal Test Speed (kts)	**Results as Tested**									
	Max Wind Direction Difference(º)					**Max Wind Speed Difference(kts)**				
	SN0054		**SN0085**		**Spec**	**SN0054**		**SN0085**		**Spec**
	FW4.50	**FW4.54**	**FW4.50**	**FW4.54**		**FW4.50**	**FW4.54**	**FW4.50**	**FW4.54**	
13	1	1	1	1	±4	0.3	0.3	0.3	0.2	±2
22	1	1	1	1	±4	0.4	0.4	0.4	0.4	±2
40	1	1	1	2	±4	0.4	0.5	0.6	0.5	±2
70	1	1	1	2	±4	-1.1	-1.0	-1.1	-1.6	±2.1
125	1	1	1	1	±4	-2.5	-2.9	-2.5	-2.8	±3.75

Table 1 Wind Tunnel Results

The table shows the maximum wind speed and direction differences between the tunnel and the Unit Under Test. The specification for each test speed is also shown. The sensors were tested with the old firmware, 4.50 and the new firmware, 4.54. SN0054 and SN0085 passed all specifications for wind speed and direction at all test speeds with FW4.50 and FW4.54.

In addition to tabular, the results are also shown graphically. Below is a chart showing the wind speed and direction differences between SN0054 with version 4.54 and the calculated wind tunnel speed and direction.

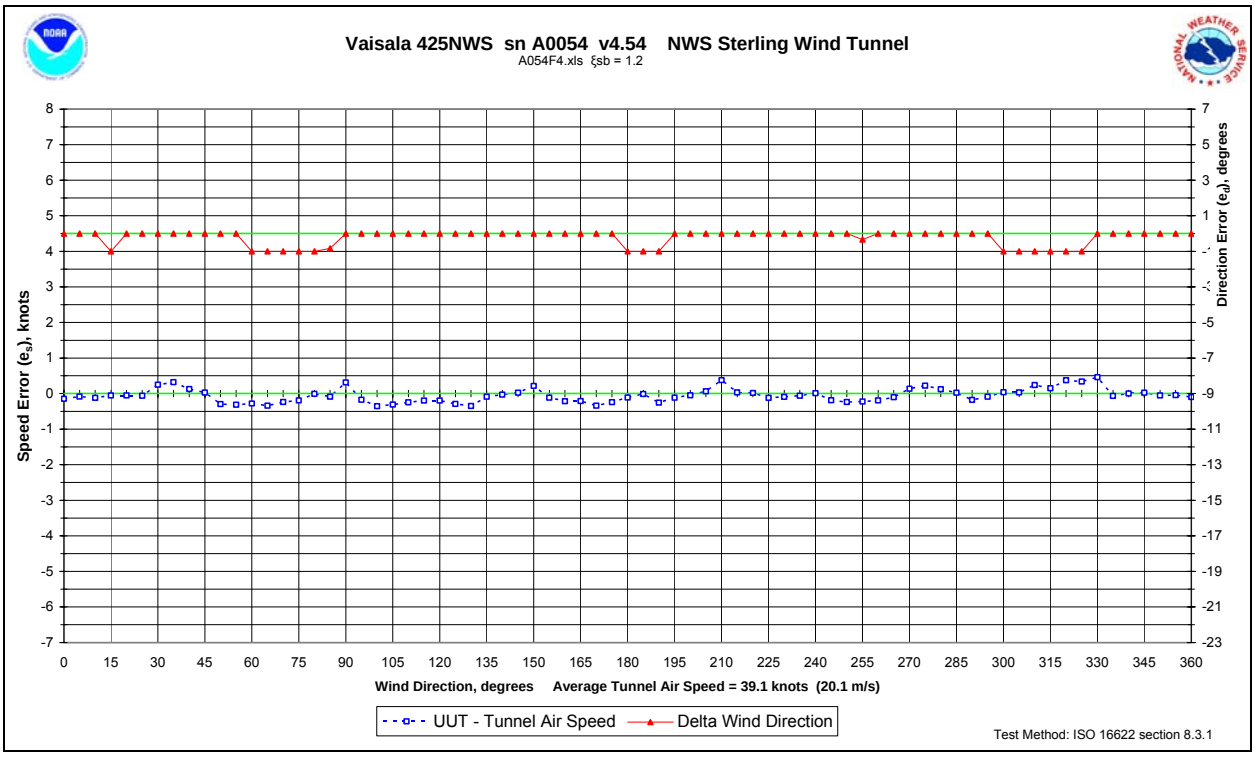

Figure 4 Wind Tunnel Results

The figure above depicts the outcome of wind tunnel testing at the 40 knot test speed. The differences between the wind tunnel speed and direction and the sensor are negligible. All information from the graphs was converted into table format and is shown in Table 1. Additional graphs are located in Appendix A.

5.4 Temperature Chamber Testing

Environmental chamber testing was conducted on all four sensors. The sensors were tested in pairs. IFWS SN0085 was tested with SN0928 and SN0709 was tested with SN0054. Each test ran for 36 hours. Sensors data was analyzed at the conclusion of each test run and graphed to compare the ambient chamber temperature with the IFWS's internal thermistors' temperature and the transducer arms' surface temperature. The IFWS's internal thermistor temperature was extracted from the WT command data. The transducer arm's surface temperature was recorded from the PRT attached to the arm. Additionally, the status of the diagnostic flags contained in the WT and WA data was examined to see if they changed during the test runs.

Figure 5 shows the results from the test run on an IFWS with no known defects, SN0085. The graph shows that the IFWS's internal thermistor generally reflected the transducer arm temperature. It also shows that the heaters turn off when ambient temperatures exceeded 30 °C and that the heaters turned on to maintain transducer arm temperature at approximately 30 °C (or above) when the ambient temperature fell below approximately 30 °C. An additional examination of the WA and WT status flags indicated that SN0085 passed all internal diagnostic tests throughout the entire chamber test cycle. Wind speed and wind direction measurements contained in the WA data were also consistent with the expected airflow inside the environmental chamber.

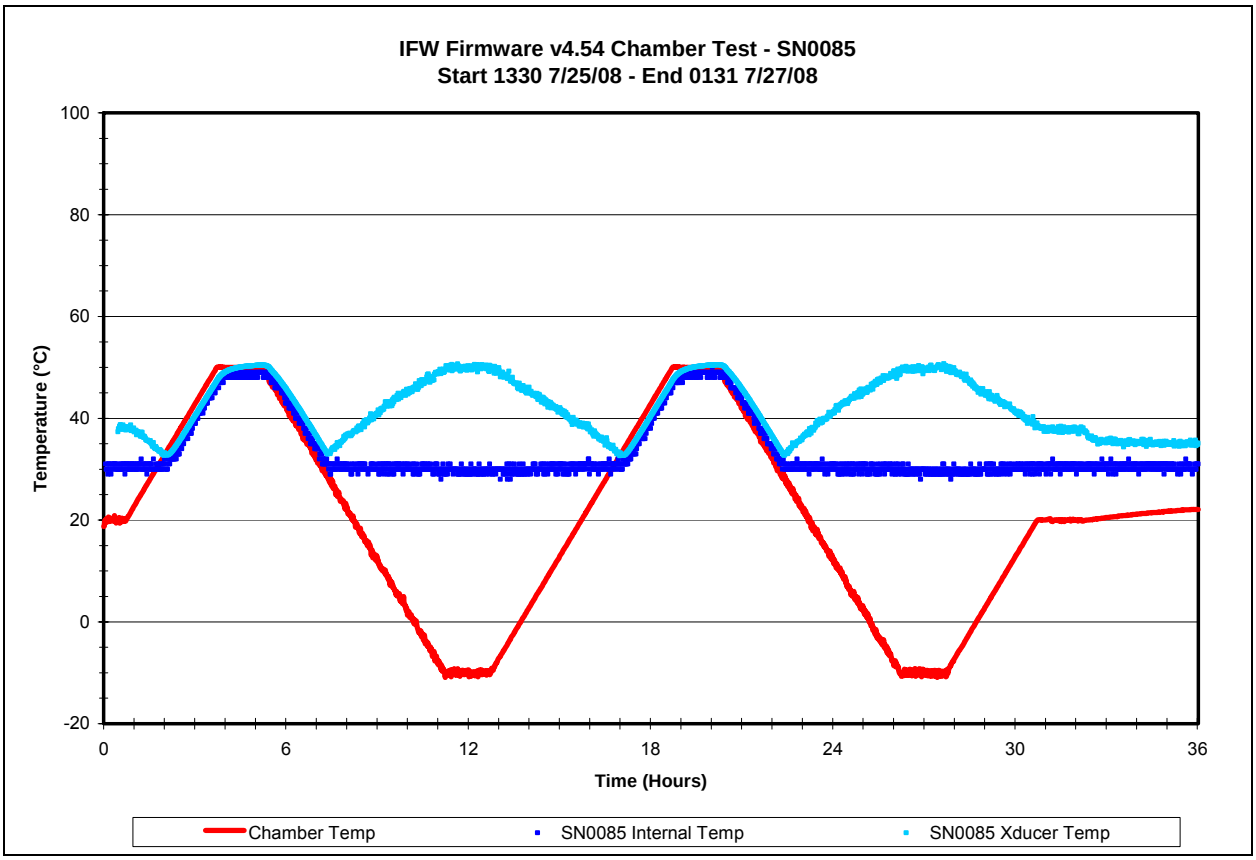

Figure 5 Environmental Chamber Test Results from SN0085

Figure 6 shows the results from the test run on IFWS SN0928. This sensor has a known thermistor measurement malfunction. The graph shows that the IFWS's internal thermistor generally reported transducer arm temperatures between 70 and 74 °C. However, when the ambient chamber temperature exceeded approximately 35 °C, the IFWS thermistor reported that the transducer arms were at 99 °C. None of these thermistor measurements had any validity because the PRT temperature sensor indicated that the heaters never turned on and that the transducer arms' surface temperature were always roughly the same as the ambient chamber temperature. An examination of the status flag contained in the WA data showed that SN0928 failed (reported "F") and the wind speed and wind direction measurements were reported as 999 throughout the entire chamber test cycle. An examination of the WT data status flags indicated that the instrument had a failed thermistor but that it did maintain a passing heater array resistance value (of between 4.9 and 5.2 ohms).

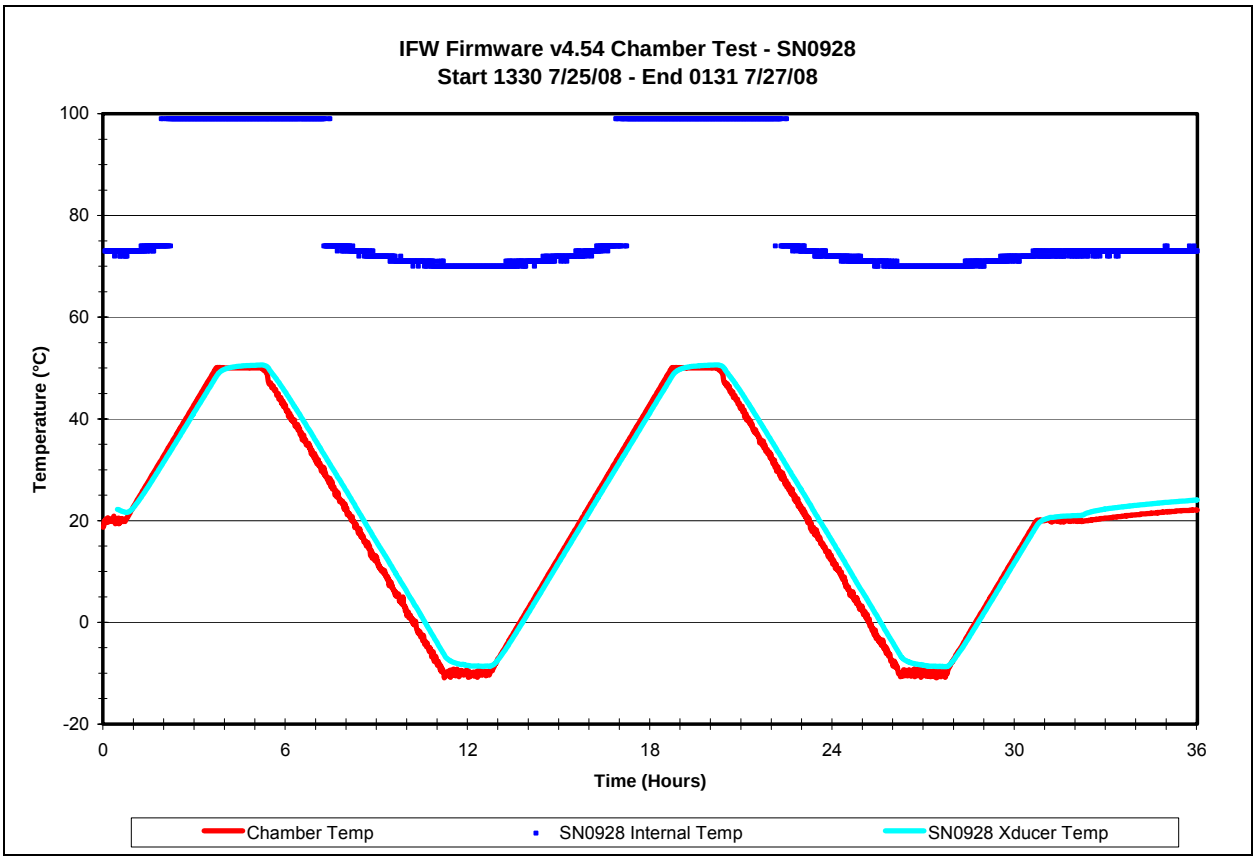

Figure 6 Environmental Chamber Test Results from SN0928

Figure 7 shows the results from the test run on IFWS SN0054. This sensor has no known defects. The results of this test were similar to the test run on SN0085. The heaters turned off when ambient temperatures exceeded 30 °C and then turned on when the ambient temperature fell below approximately 30 °C. Also, an examination of the WA and WT data indicated that SN0054 passed all internal diagnostic tests throughout the entire chamber test cycle. Wind speed/direction measurements were also consistent with the expected airflow inside the environmental chamber.

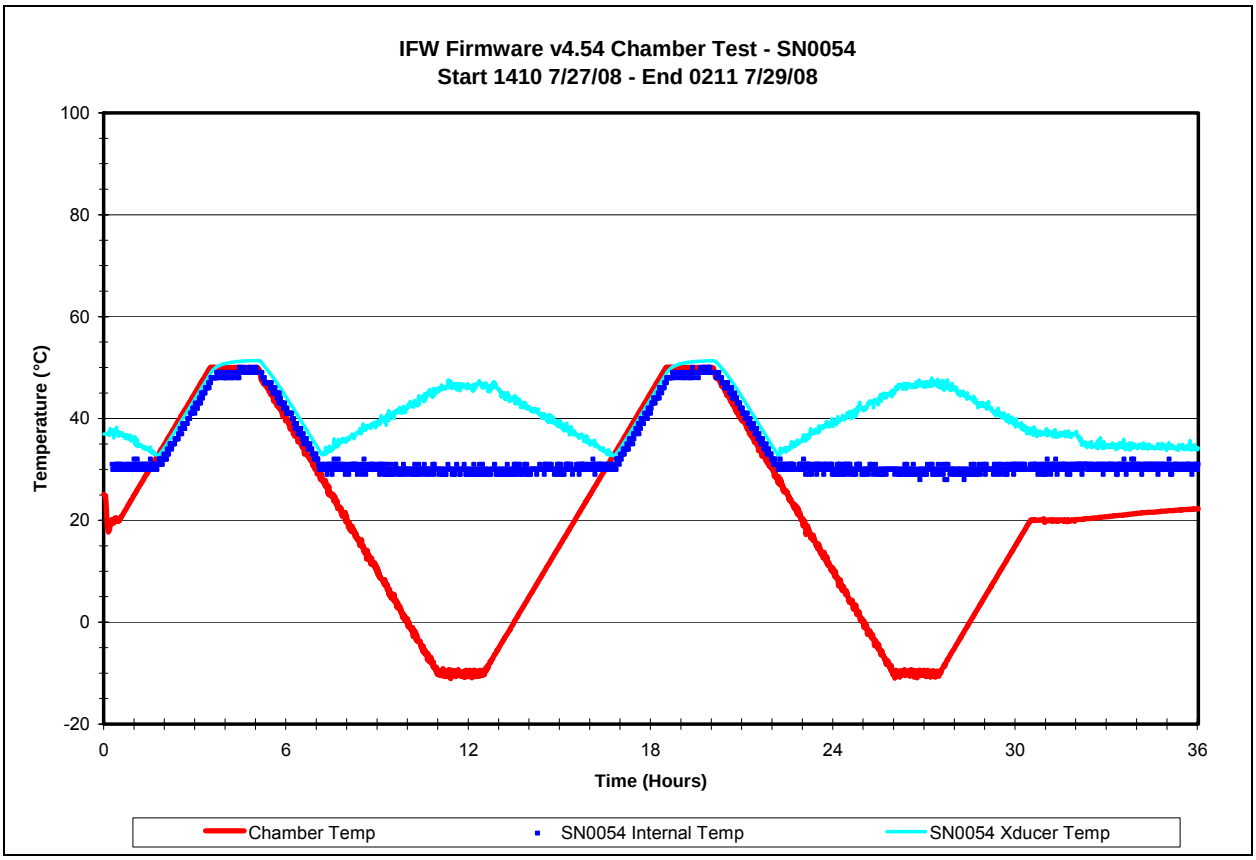

Figure 7 Environmental Chamber Test Results from SN0054

Figure 8 shows the results from the test run on IFWS SN0709. This sensor also has a known thermistor measurement malfunction. The graph shows that the IFWS's internal thermistor reported transducer arm temperatures of -54 °C. This value never varied throughout the entire test. At the beginning of the test, the PRT temperature sensor measurements indicated that the transducer heaters were not turned on and that the transducer arms' surface temperature was roughly the same as the ambient chamber temperature. An examination of the WA status flag during this period showed that SN0709 was reporting an "F" (failed sensor) and the wind speed/ direction measurements were reported as 999. Meanwhile the WT data status flags indicated that the instrument had a failed thermistor but that it was maintaining a passing heater array resistance value (of between 4.8 and 5.0 ohms).

An anomaly occurred 10.25 hours into the test. The PRT temperature measurements show that the transducer heaters had suddenly turned on and ran at full power for approximately 32 minutes. The temperature of the transducer arms rose to over 138 °C. The temperature was hot enough to partially melt the vinyl tape that held the PRT thermometer onto the transducer arm. At this point the heaters must have burned out because the temperature began to fall quickly and the heater array resistance flag (in the WT data string) went from "P" (a passing value of 4.9 ohms) to "F" (a failed value of 6.9 ohms).. After that the transducer arms quickly cooled down and returned to ambient temperature. By 11.50 hours (into the test), the temperature of the transducers were once again tracking along with the ambient chamber temperature and the heaters did not turn back on.

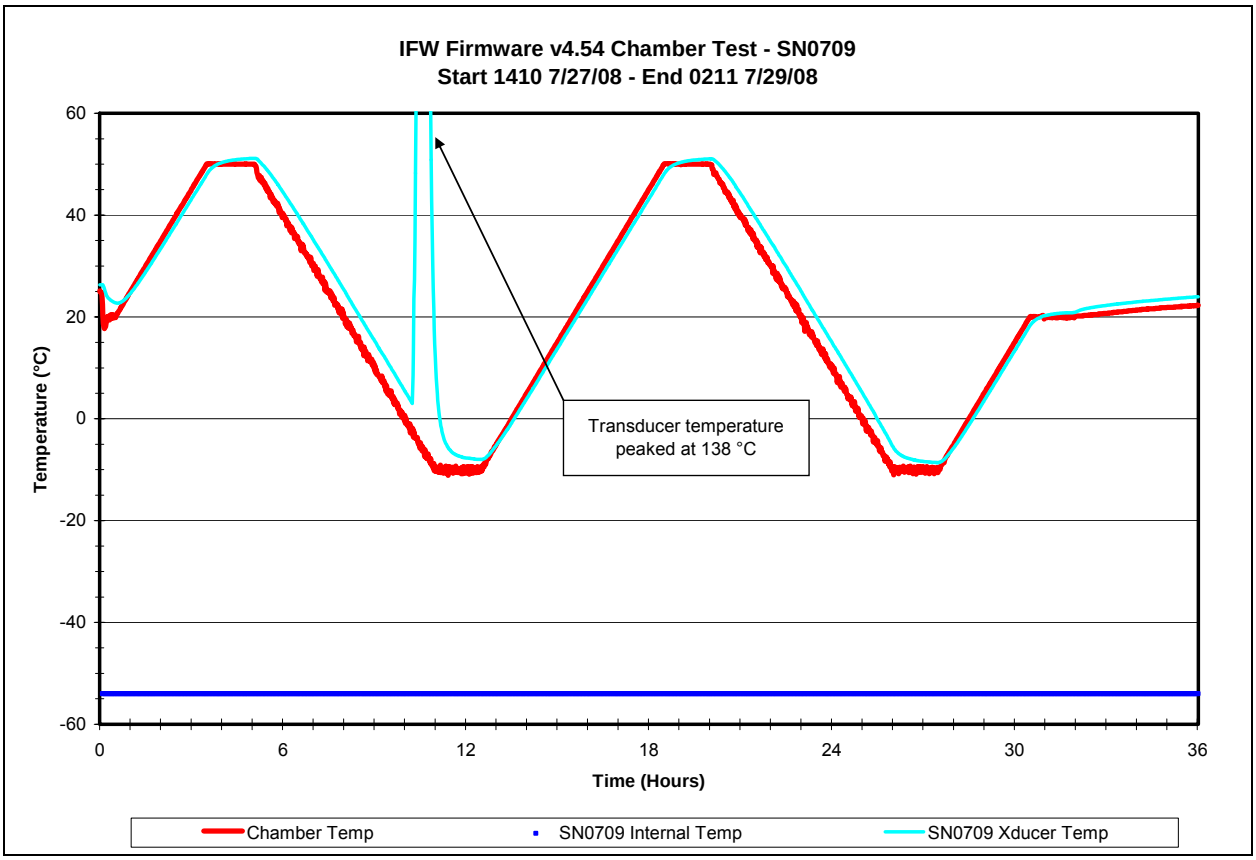

Figure 8 Environmental Chamber Test Results from SN0709

The cause of this behavior is not known. SN709's heaters came on just after midnight (at 00:25). The test equipment was unattended (and undisturbed) at that time and no known electrical disturbances occurred during this period. The other IFWS that was in the chamber at that time (SN0054) did not show any signs of aberrant behavior.

Another interesting thing that happened is right after SN0709's heaters failed, the status flag carried in the WA data string changed from "F" (failed sensor) to "H" (heater failure) and the wind speed and direction changed from 999 to numerical measurement values. This change in status was due to the sensor determination that the new heater circuit failure would not impact sensor accuracy, which is in accordance with the operational design requirements set by the NWS for the sensor. At that same time, the array heater resistance flag (in the WT data string) changed from a "P" with a value of 4.9 ohms to an "F" with a value of 6.9 ohms. The following tables shows selected data from before the heaters came on, while the heaters were running, and after the heaters failed.

Time	Responses from the WT and WA commands	Xducer Temp.
002300	┐WTP22.7P4.9P0.0F-54P12.0P5.04P10.1-00000P98P97P95P98P97P9940└ ┐WAF9999990503999.9999.9K99DD└	3.3
002400	┐WTP22.9P4.9P0.1F-54P12.0P4.99P10.1-00000P97P98P99P97P98P9853└ ┐WAF9999990503999.9999.9K99DD└	3.16
002500	┐WTP23.5P5.0P0.1F-54P11.9P5.02P10.1-00000P96P99P98P99P97P9942└ ┐WAF9999990503999.9999.9K99DD└	3.01
002600	┐WTP23.4P4.9P0.2F-54P12.0P4.99P10.1-00000P99P96P99P99P96P9850└ ┐WAF9999990503999.9999.9K99DD└	8.48
002700	┐WTP22.9P4.9P0.1F-54P12.0P5.05P10.1-00000P96P98P99P97P98P9947└ ┐WAF9999990503999.9999.9K99DD└	13.28
002800	┐WTP22.8P4.9P0.1F-54P11.9P5.07P10.1-00000P98P99P93P96P97P994B└ ┐WAF9999990503999.9999.9K99DD└	23.63

Table 2 Heaters come on at 00:25 and the transducer arms begin to heat up

005400	┐WTP23.4P4.9P0.1F-54P12.0P5.09P10.1-00000P85P90P98P83P93P852D└ ┐WAF9999990503999.9999.9K99DD└	138.44
005500	┐WTP23.0P5.0P0.1F-54P12.0P4.97P10.1-00000P88P95P86P89P85P8230└ ┐WAF9999990503999.9999.9K99DD└	138.52
005600	┐WTP23.1P4.9P0.1F-54P12.0P5.03P10.1-00000P86P92P75P86P91P8927└ ┐WAF9999990503999.9999.9K99DD└	138.73
005700	┐WTP24.4F6.9P0.1F-54P12.0P5.07P10.0-00000P82P82P83P81P92P9317└ ┐WAH1830650503001.9001.9K998C└	126.79
005800	┐WTP23.6F6.9P0.1F-54P12.0P4.98P10.1-00000P89P94P82P84P92P932E└ ┐WAH2822580503001.3001.9K998A└	106.37
005900	┐WTP24.3F6.9P0.0F-54P11.9P4.99P10.0-00000P86P92P89P90P93P9737└ ┐WAH3153150503001.3001.5K997D└	87.76
010000	┐WTP24.3F6.9P0.0F-54P12.0P5.06P10.1-00000P80P91P97P92P97P9622└ ┐WAH1831150503000.8000.9K9985└	72.88

Table 3 Transducer arms reach 138.73 °C and the heaters fail at 00:57

015700	┐WTP24.0F7.0P0.1F-54P11.7P5.06P10.1-00000P97P97P98P99P99P9737└- ┐WAH2362530503000.4000.5K997F└	-7.31
015800	┐WTP23.6F6.9P0.1F-54P12.0P5.01P10.1-00000P98P98P96P98P98P9939└- ┐WAH1571590503000.3000.4K9984└	-7.39
015900	┐WTP24.2F6.9P0.1F-54P12.0P5.08P10.1-00000P99P97P99P98P96P993E└- ┐WAH1941710503000.3000.4K997F└	-7.43

Table 4 Transducer arms finish cooling back down to ambient temperature

6.0 CONCLUSIONS

The new firmware v.4.54 was tested at the SFSC to:

1. Ensure compliant operations of the sensor in the Wind Tunnel
2. Meet the sensor reporting accuracy in the Wind Tunnel
3. Check IFWS diagnostics to ensure compliant operations
4. Check the command strings used in ASOS (WA and WT) are reporting as expected
5. Ensure the proper heater functionality in the environmental chamber

Diagnostic testing:

The two sensors with no known deficiencies (SN0054, SN0085) passed all diagnostic tests with the new firmware. All diagnostic parameters fell within the specifications for the IFWS.

The two sensors that have a known failure in the analog switch on the thermistor (SN0709, SN0928) reported as expected in most cases with the new firmware. There were a few questions in the outcome of the bench testing:

- It is unclear why SN0709 with FW4.54 passes the array heater resistance in the WS command, but fails the heater resistance in the WD command. It is assumed that this difference is due to a different failed component within the heater control and sensing circuitry of each of the test sensors.

- It is not known why SN0928 with FW4.54 pass the heater resistance test in the WD command, while SN0709 fails on the same test. It is assumed that this difference is due to a different failed component within the heater control and sensing circuitry of each of the test sensors.

ASOS Testing

SN0928 with FW4.54 was connected to an ASOS system and the evaluation revealed the maintenance page showed an “F” in the thermistor temperature status. The OID screen, one-minute and 5-second page showed missing data for wind speed and direction. The average wind and peak time were set to 99. The SYSLOG also listed a 1775 message, which is a Thermistor Failure. These are expected outcomes for FW v4.54 with a sensor that has a failure in the analog switch on the thermistor.

SN0085 with FW4.54 was also tested on ASOS to ensure that a properly working sensor continued to report properly with the new firmware. This sensor reported wind speed and direction values and showed average wind and peak times were set to 5 and 3 seconds, respectively.

Wind Tunnel Testing

The two functioning sensors were tested with the old firmware, 4.50 and the new firmware, 4.54. SN0054 and SN0085 passed all specifications for wind speed and direction at all test speeds with FW4.50 and FW4.54.

Environmental Chamber Testing

The results for SN0085 and SN0054 show that the IFWS's internal thermistor generally reflected the transducer arm temperature. It also shows that the heaters turn off when ambient temperatures exceeded 30 °C and that the heaters turned on to maintain transducer arm temperature at approximately 30 °C (or above) when the ambient temperature fell below approximately 30 °C. An additional examination of the WA and WT status flags indicated that SN0085 and SN0054 passed all internal diagnostic tests throughout the entire chamber test cycle. Wind speed and wind direction measurements contained in the WA data were consistent with the expected airflow inside the environmental chamber.

The results for SN0928 show that the IFWS's internal thermistor generally reported transducer arm temperatures between 70 and 74 °C. However, when the ambient chamber temperature exceeded approximately 35 °C, the IFWS thermistor reported that the transducer arms were at 99 °C. None of these thermistor measurements had any validity because the PRT temperature sensor indicated that the heaters never turned on and that the transducer arms' surface temperature were always roughly the same as the ambient chamber temperature. An examination of the status flag contained in the WA data showed that SN0928 failed (reported "F") and the wind speed and wind direction measurements were reported as 999 throughout the entire chamber test cycle. An examination of the WT data status flags indicated that the instrument had a failed thermistor but that it did maintain a passing heater array resistance value (between 4.9 and 5.2 ohms).

The results for SN0709 show that the internal thermistor reported transducer arm temperatures of -54 °C. This value never varied throughout the entire test. At the beginning of the test, the PRT temperature sensor measurements indicated that the transducer heaters were not turned on and that the transducer arms' surface temperature was roughly the same as the ambient chamber temperature.

At 10.25 hours into the test for SN0709, the PRT temperature measurements show that the transducer heaters suddenly came on and ran at full power for approximately 32 minutes. The temperature of the transducer arms rose to over 138 °C. At this point the heaters must have burned out because the temperature began to fall quickly and the heater array resistance flag (in the WT data string) went from pass (P 4.9 ohms) to fail (F 6.9 ohms). At this time, the data string in the WA command also changed from "F" (failed sensor) to "H" (heater failure) and the wind speed and direction changed from 999 to numerical measurement values. This change in status was due to the sensor determination that the new heater circuit failure would not impact sensor accuracy, which is in accordance with the operational design requirements set by the NWS for the sensor.

7.0 DATA REPORTING AND TEST SCHEDULE

A final report will be submitted no later than August 4, 2008. The final report will contain the results from the Wind Tunnel tests, the bench tests, and the environmental chamber tests.

EVENT	*START DATE*	*COMPLETION DATE*
Test Plan	June 16, 2008	June 19, 2008
Test Operational	June 23, 2008	July 21, 2008
Final Report	July 22, 2008	August 4, 2008

Table 5 Test Schedule

8.0 RESPONSIBILITIES

ASOS PI Manager	J. Monte W/OST
Program Manager	J. Vogel, SAIC
Test Director	J. Dover, SAIC
Lead Engineer	P.Oosterhout, SAIC

Table 6 Responsibilities

APPENDIX A

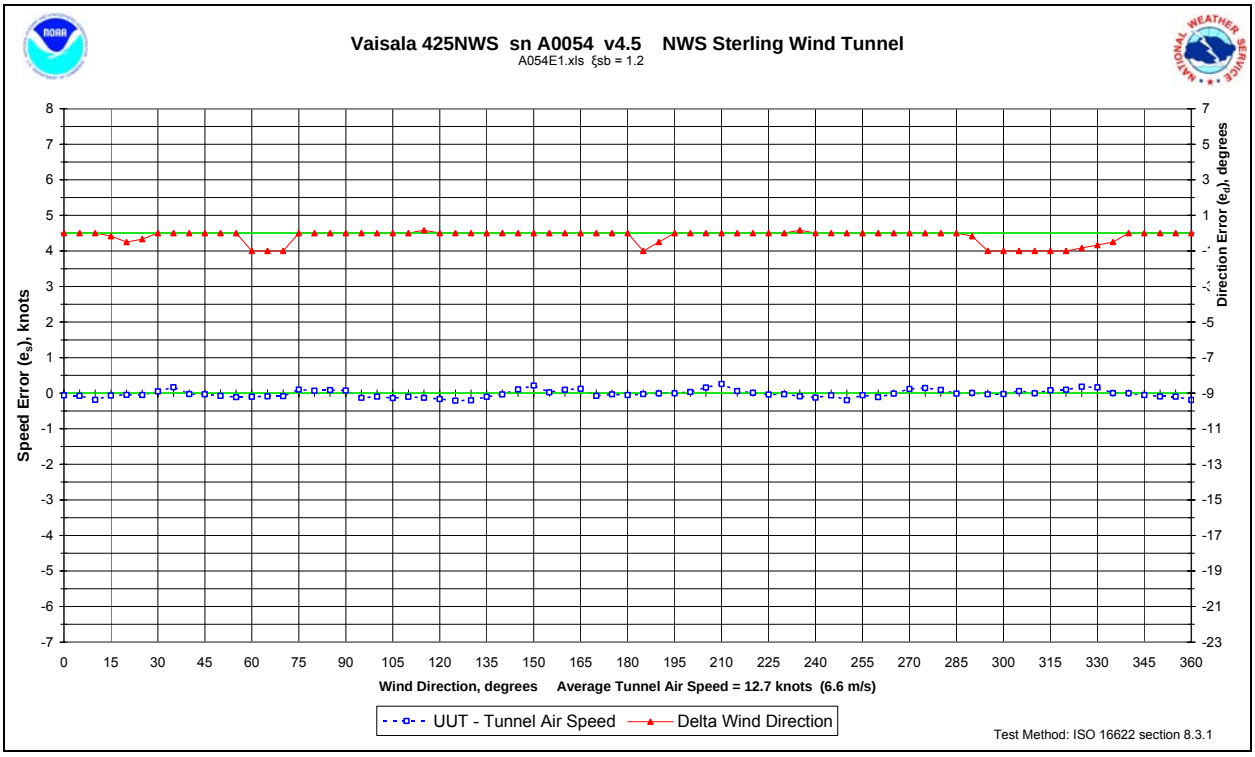

Figure 9 Wind Speed/Direction Differences SN0054, FW4.50, 13 knot test speed

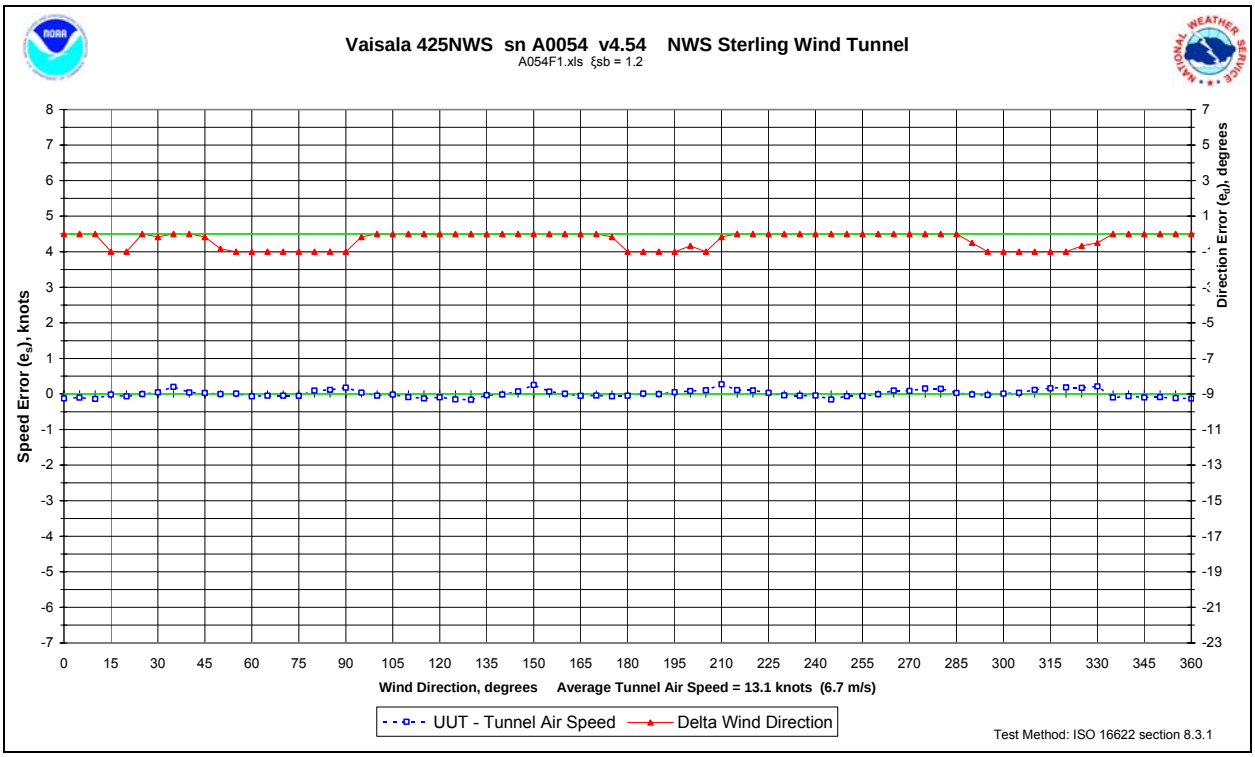

Figure 10 Wind Speed/Direction Differences SN0054, FW4.54, 13 knot test speed

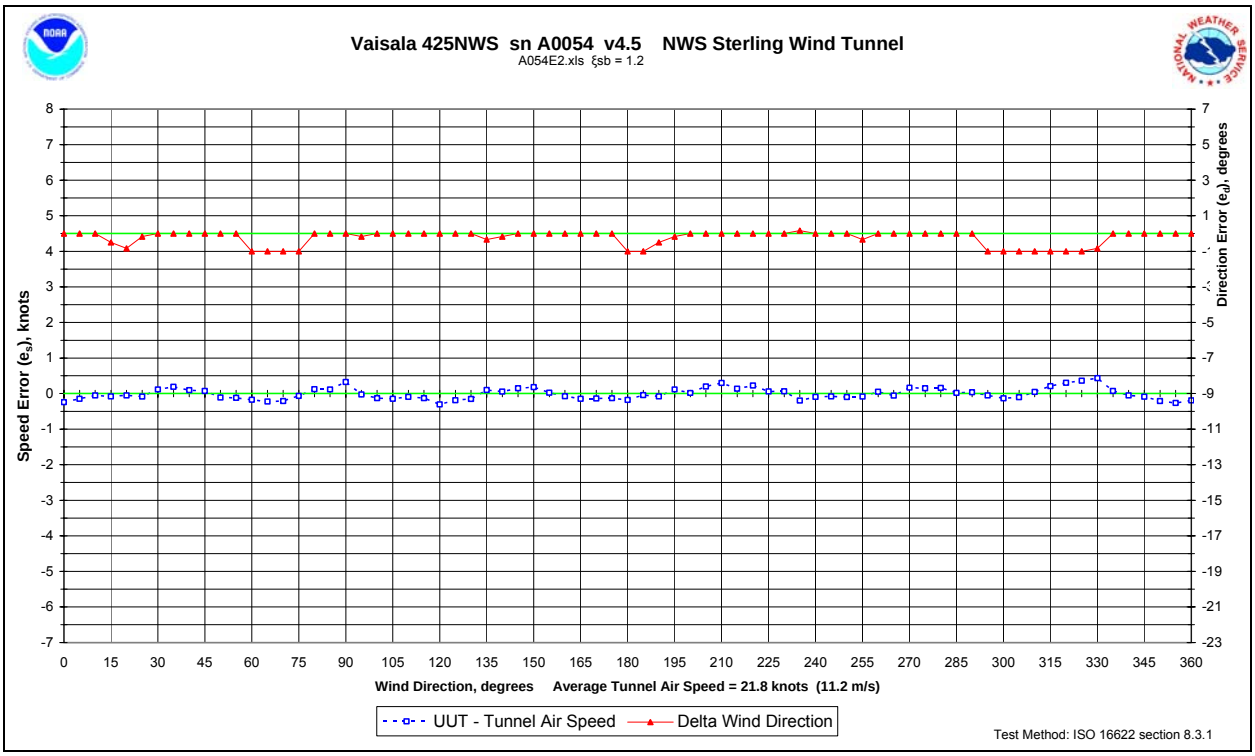

Figure 11 Wind Speed/Direction Differences SN0054, FW4.50, 22 knot test speed

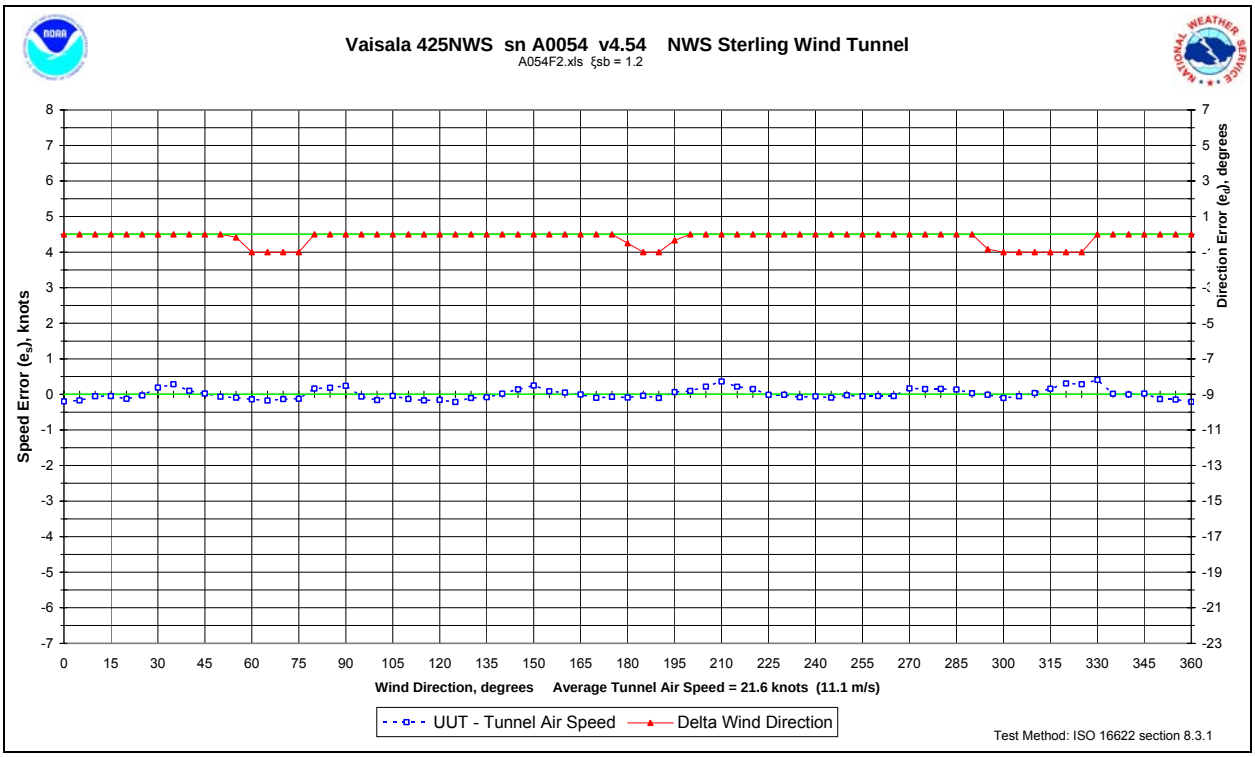

Figure 12 Wind Speed/Direction Differences SN0054, FW4.54, 22 knot test speed

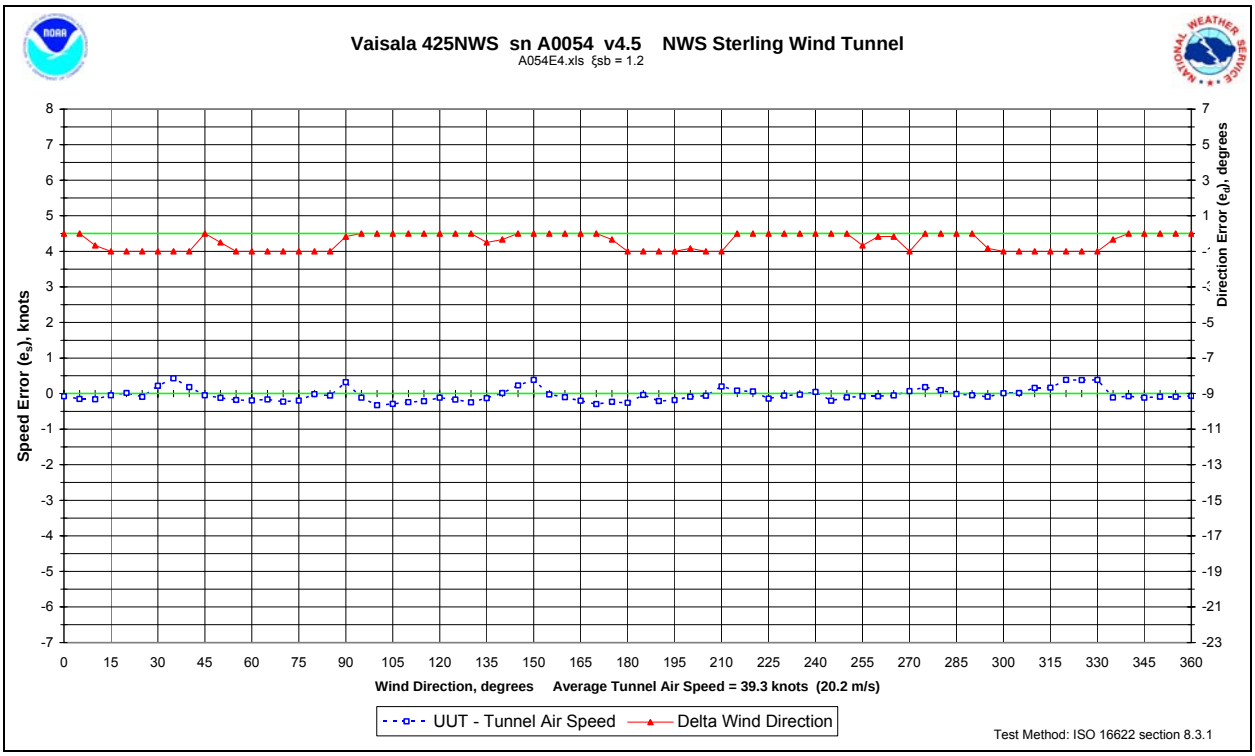

Figure 13 Wind Speed/Direction Differences SN0054, FW4.50, 40 knot test speed

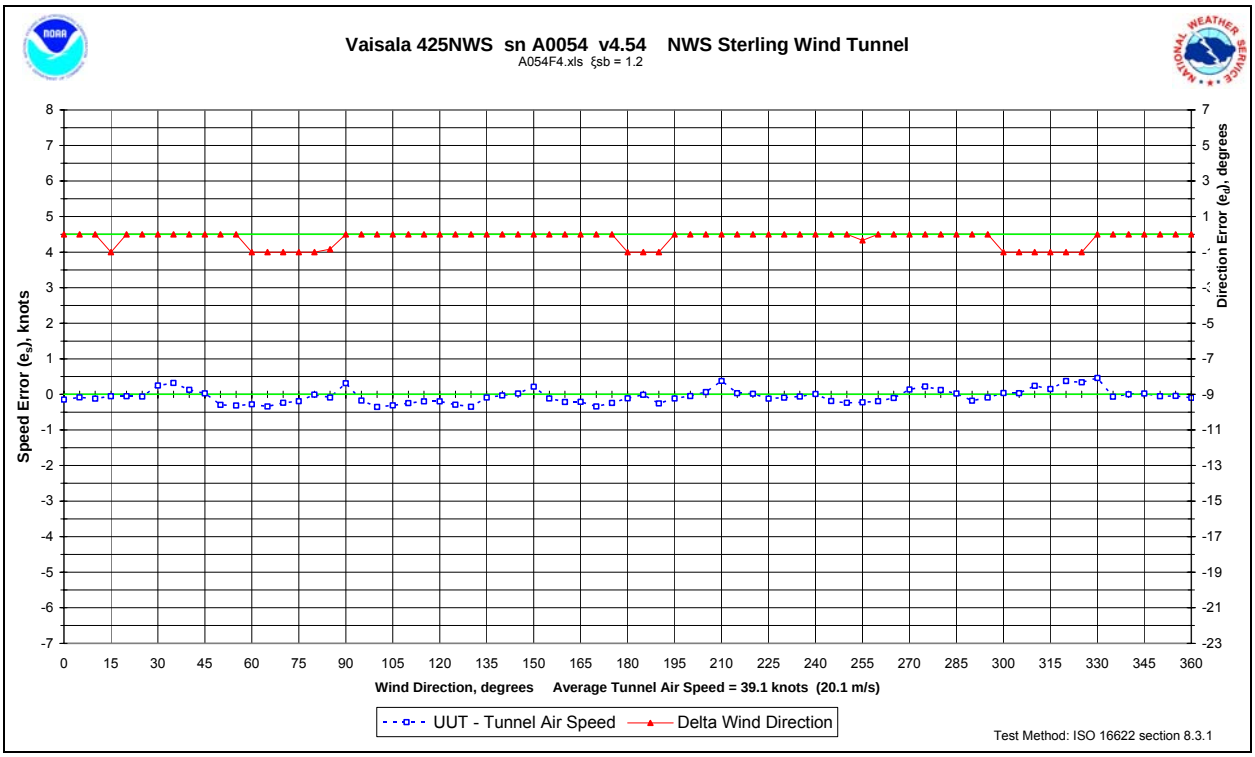

Figure 14 Wind Speed/Direction Differences SN0054, FW4.54, 40 knot test speed

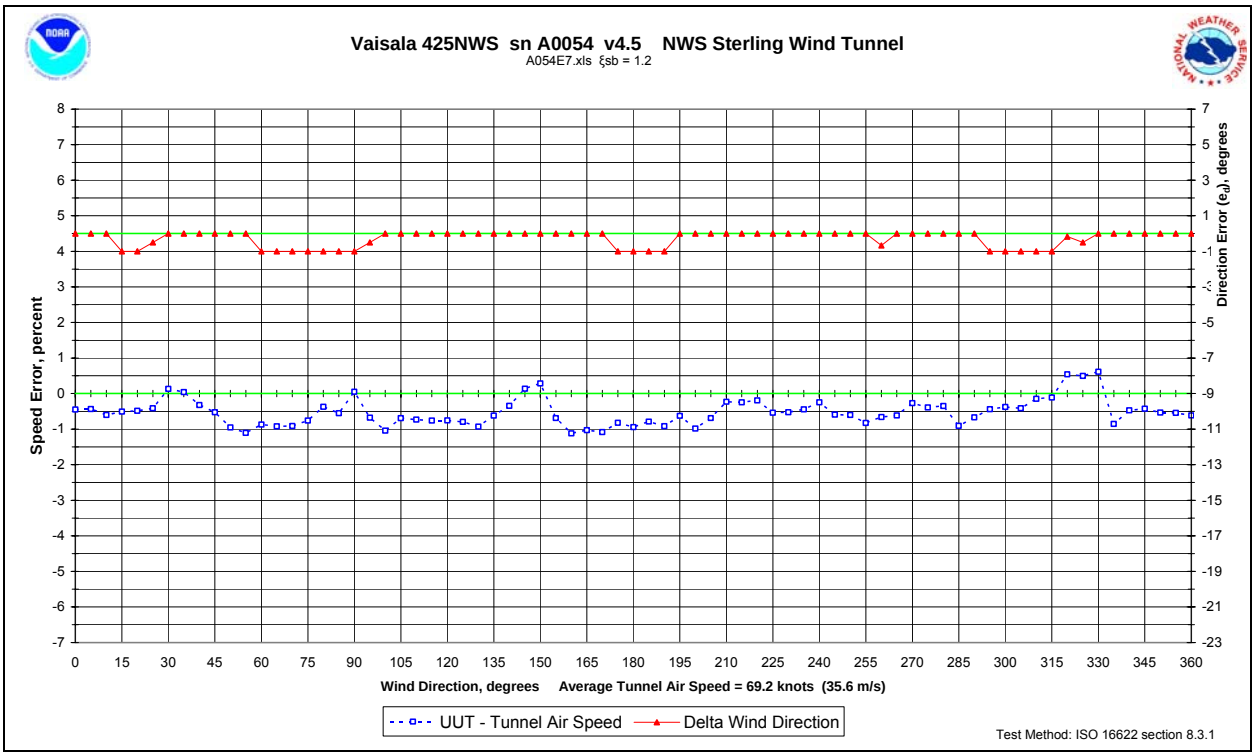

Figure 15 Wind Speed/Direction Differences SN0054, FW4.50, 70 knot test speed

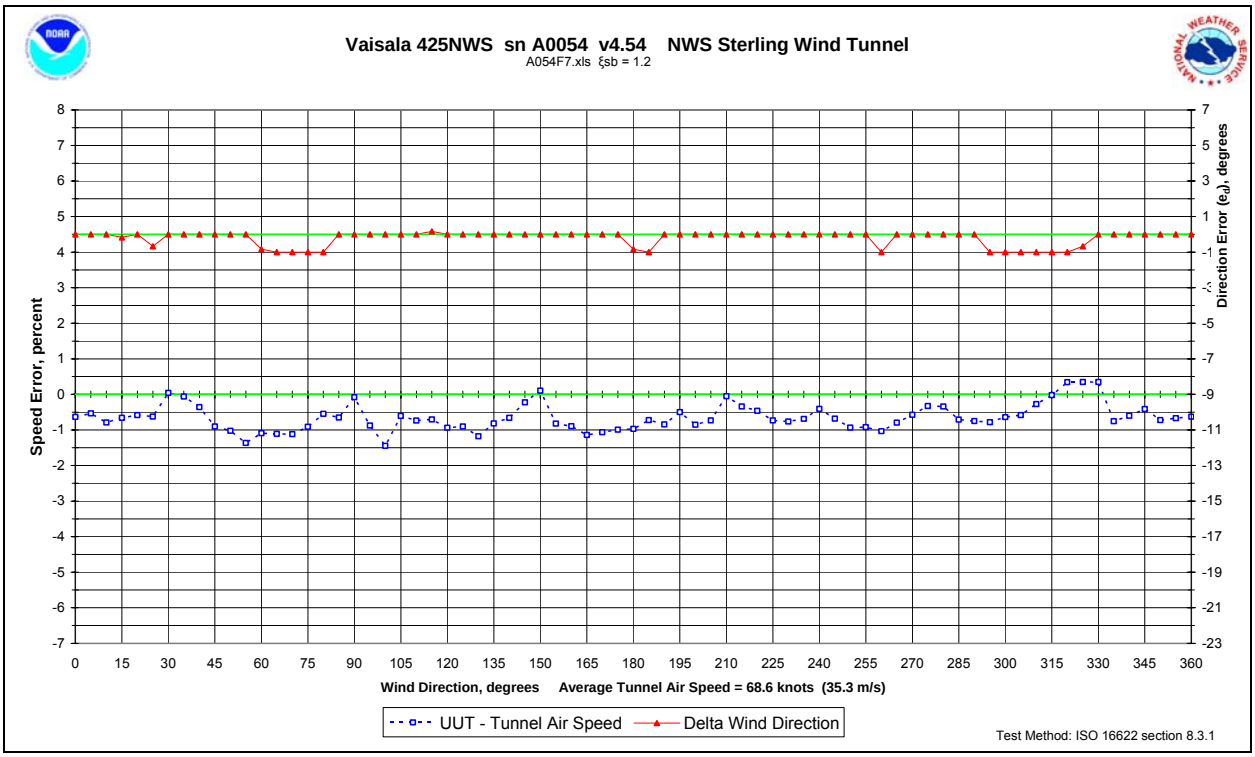

Figure 16 Wind Speed/Direction Differences SN0054, FW4.54, 70 knot test speed

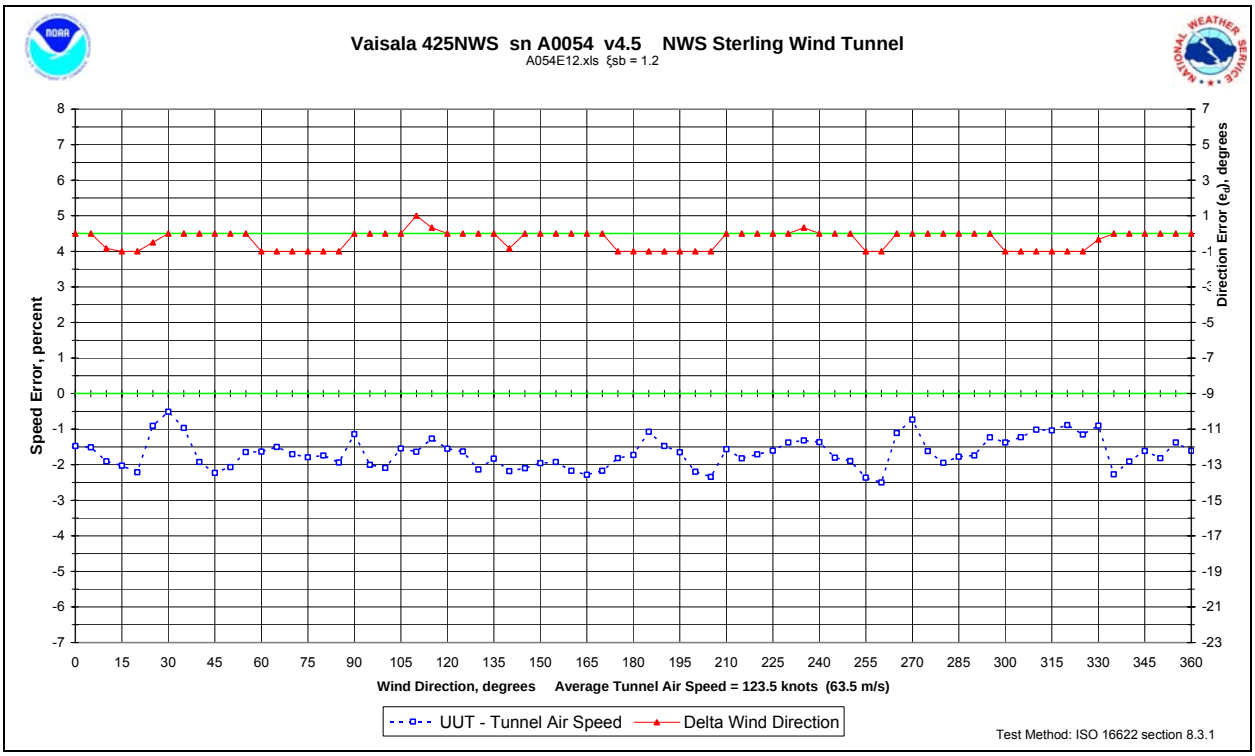

Figure 17 Wind Speed/Direction Differences SN0054, FW4.50, 125 knot test speed

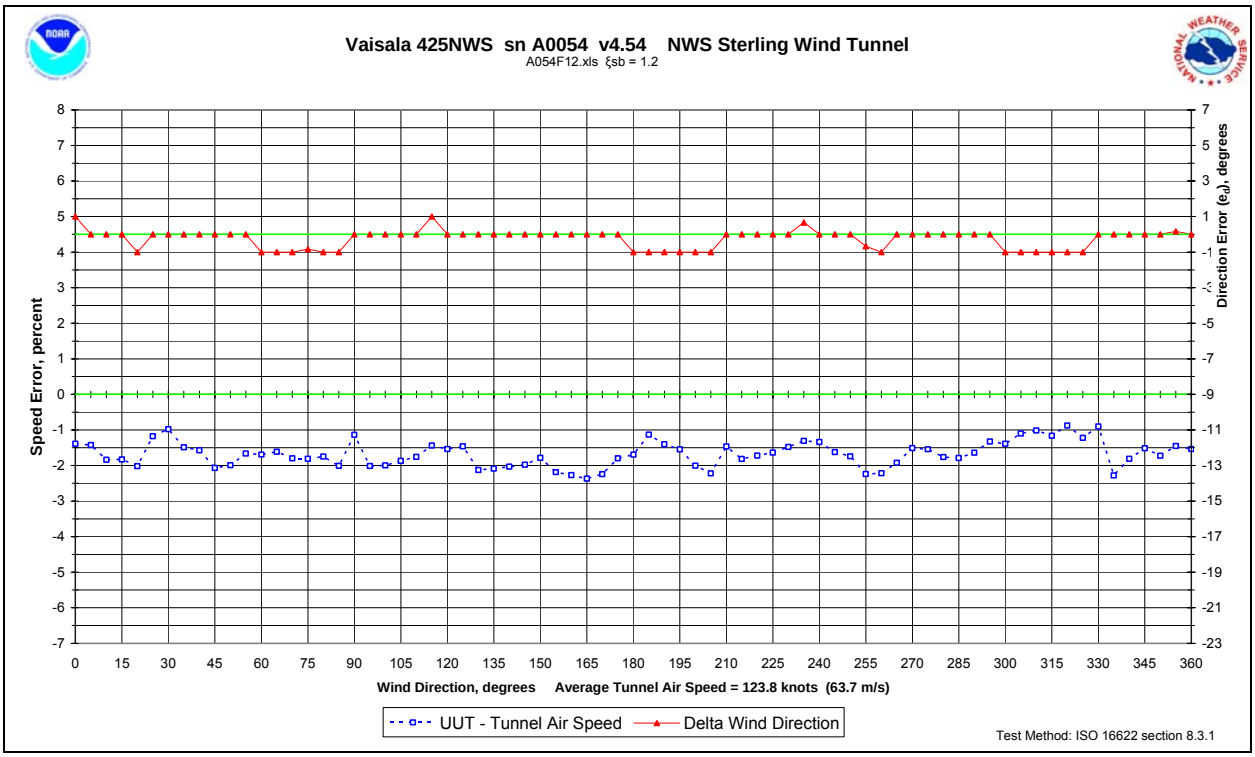

Figure 18 Wind Speed/Direction Differences SN0054, FW4.54, 125 knot test speed

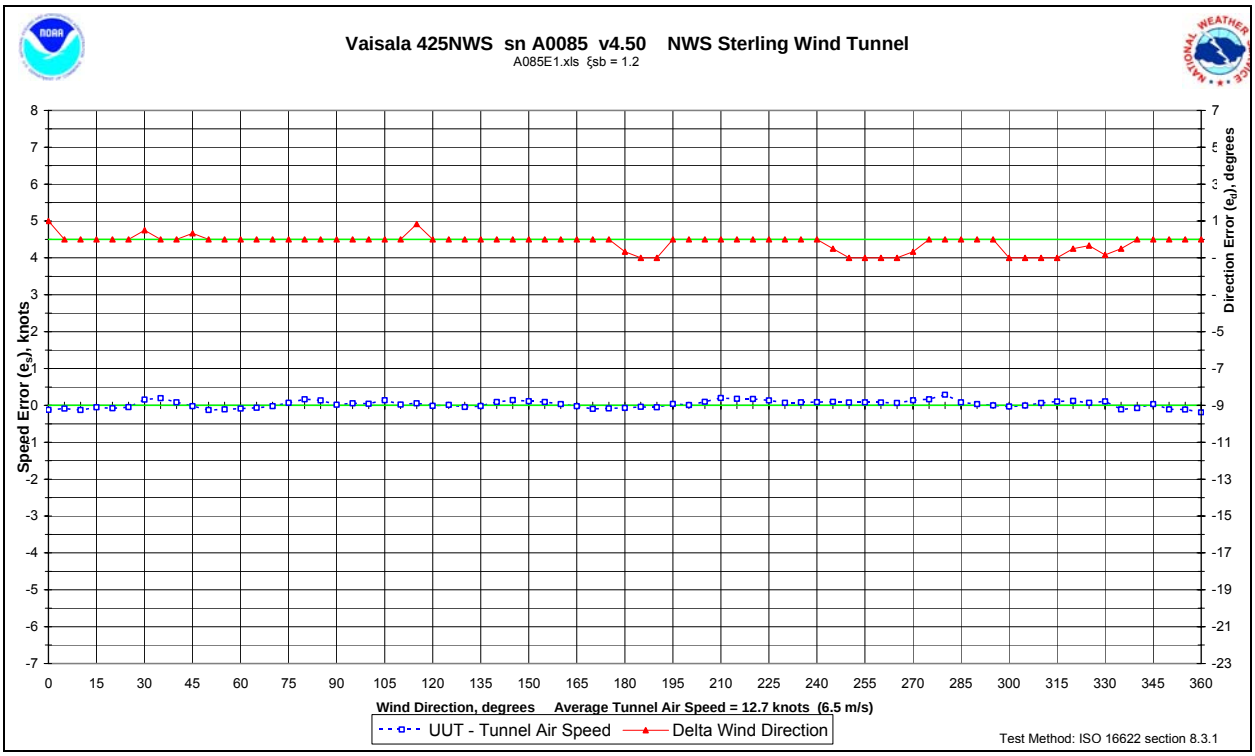

Figure 19 Wind Speed/Direction Differences SN0085, FW4.50, 13 knot test speed

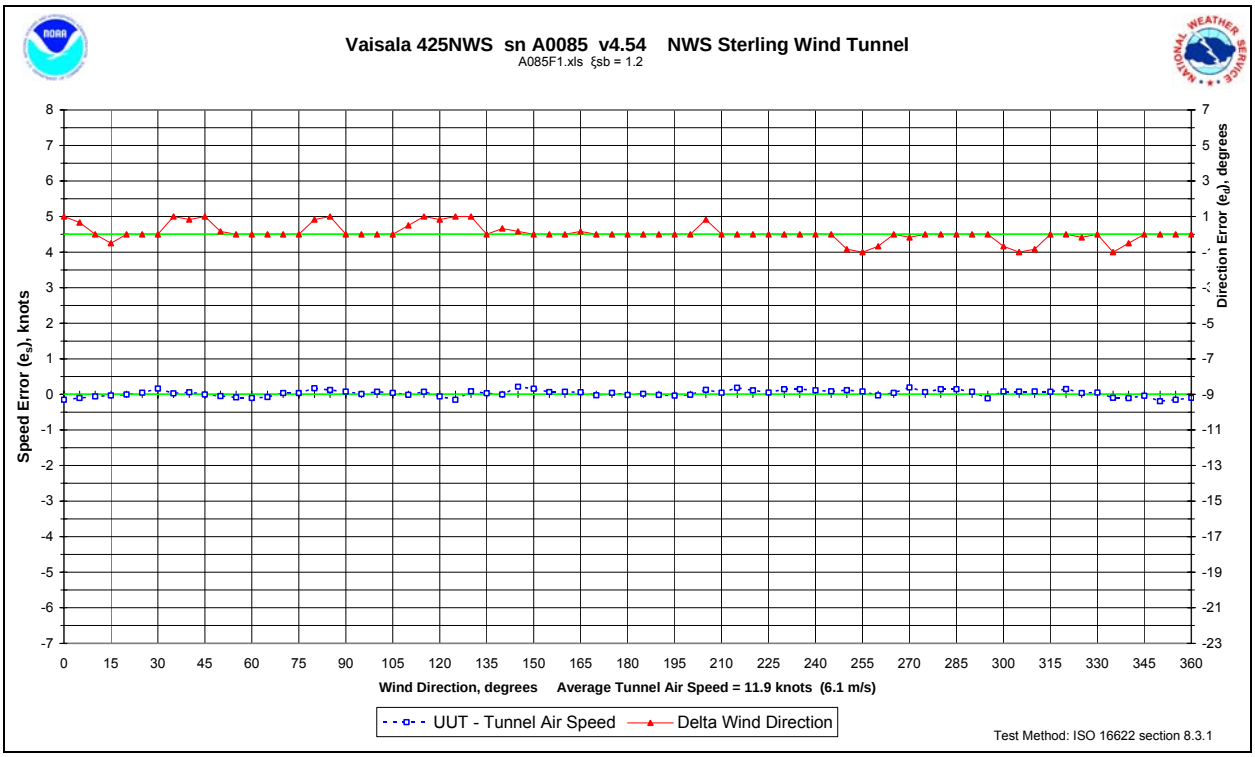

Figure 20 Wind Speed/Direction Differences SN0085, FW4.54, 13 knot test speed

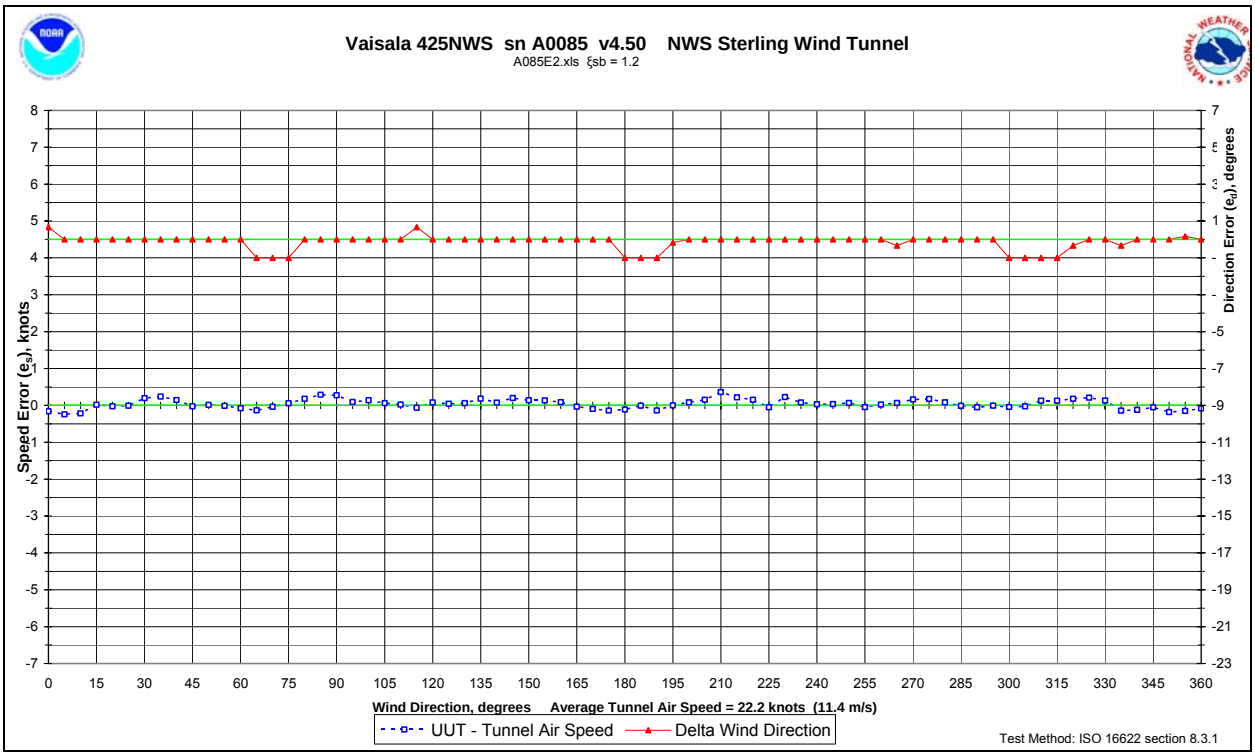

Figure 21 Wind Speed/Direction Differences SN0085, FW4.50, 22 knot test speed

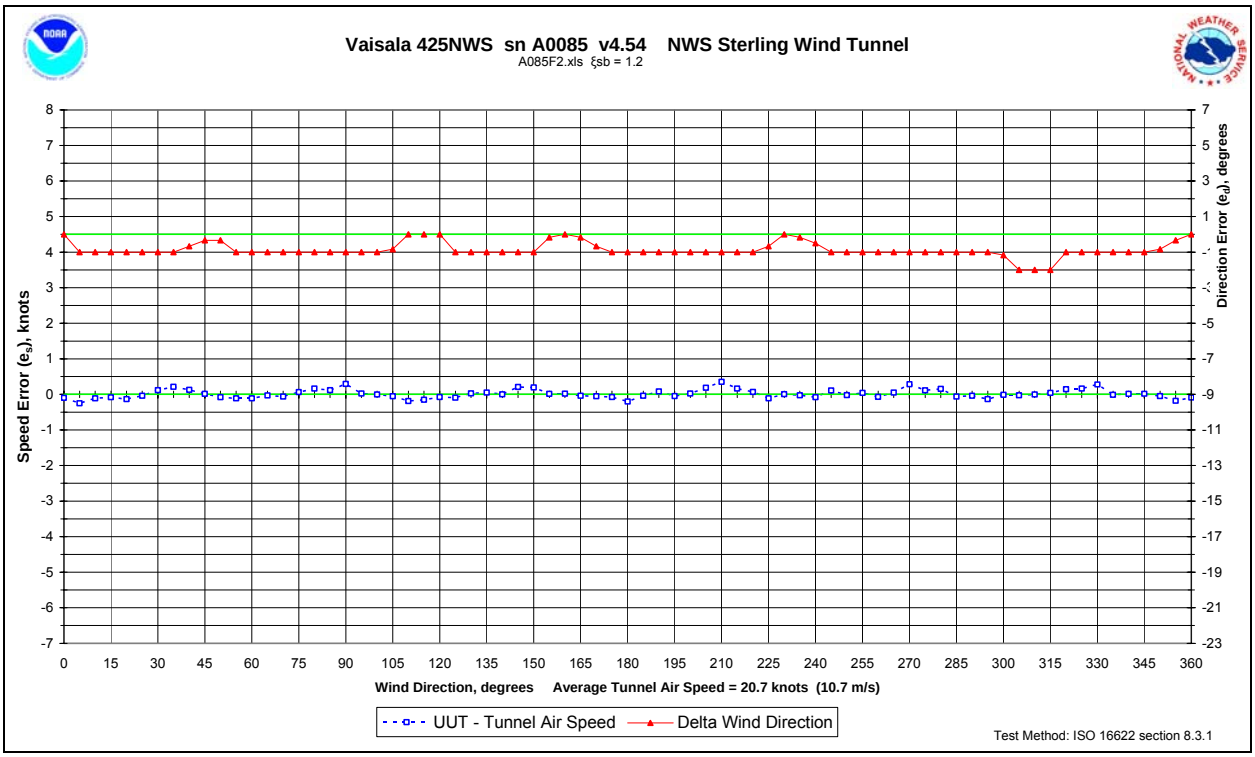

Figure 22 Wind Speed/Direction Differences SN0085, FW4.54, 22 knot test speed

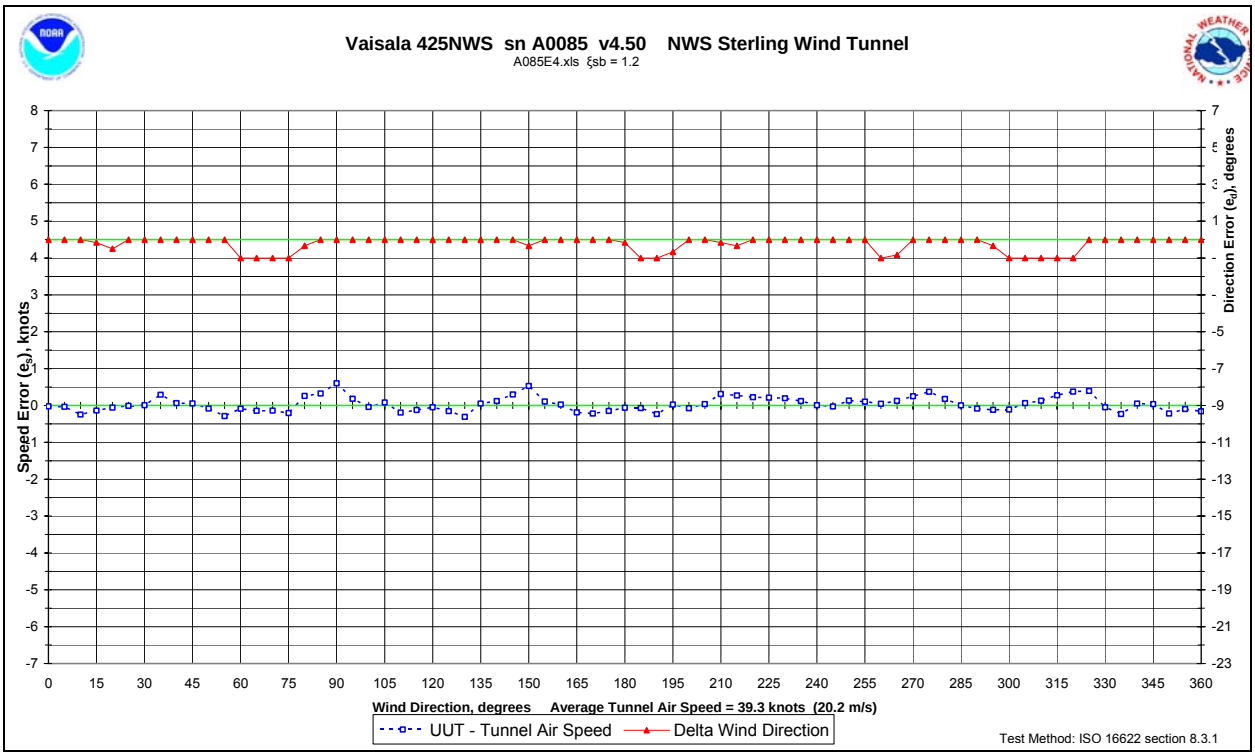

Figure 23 Wind Speed/Direction Differences SN0085, FW4.50, 40 knot test speed

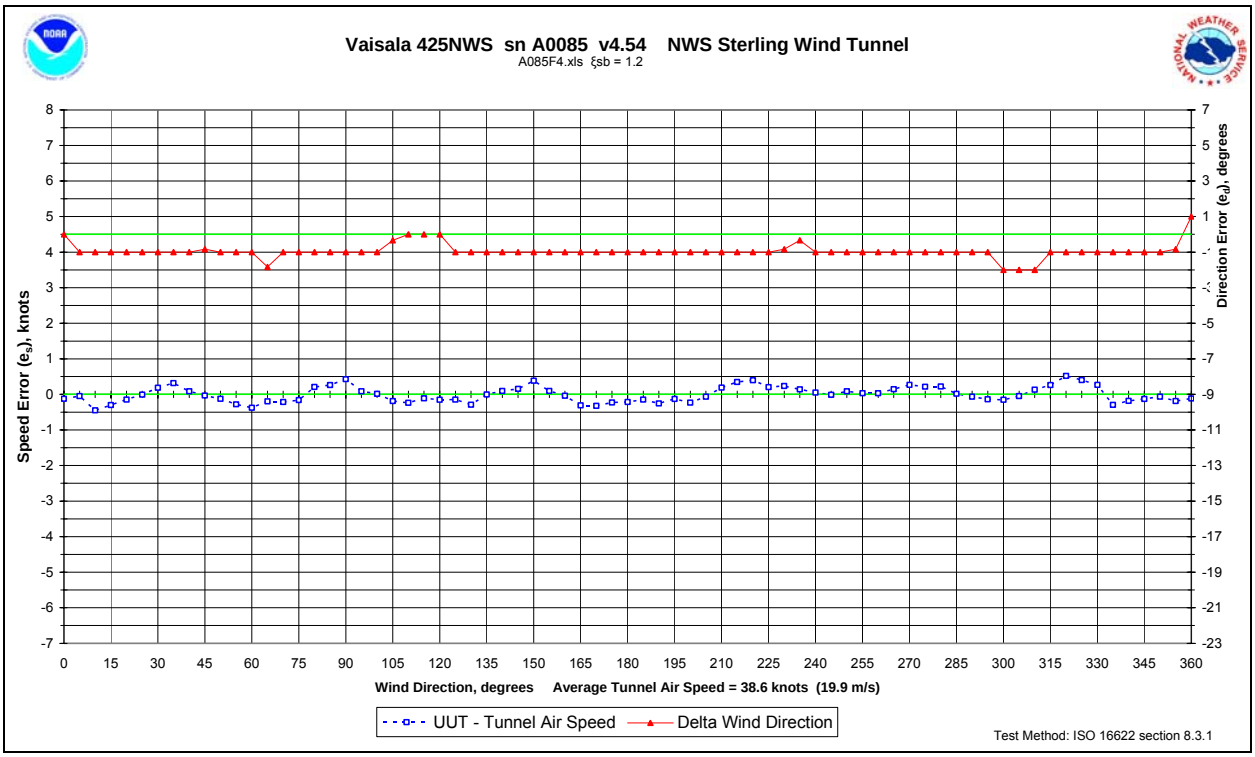

Figure 24 Wind Speed/Direction Differences SN0085, FW4.54, 40 knot test speed

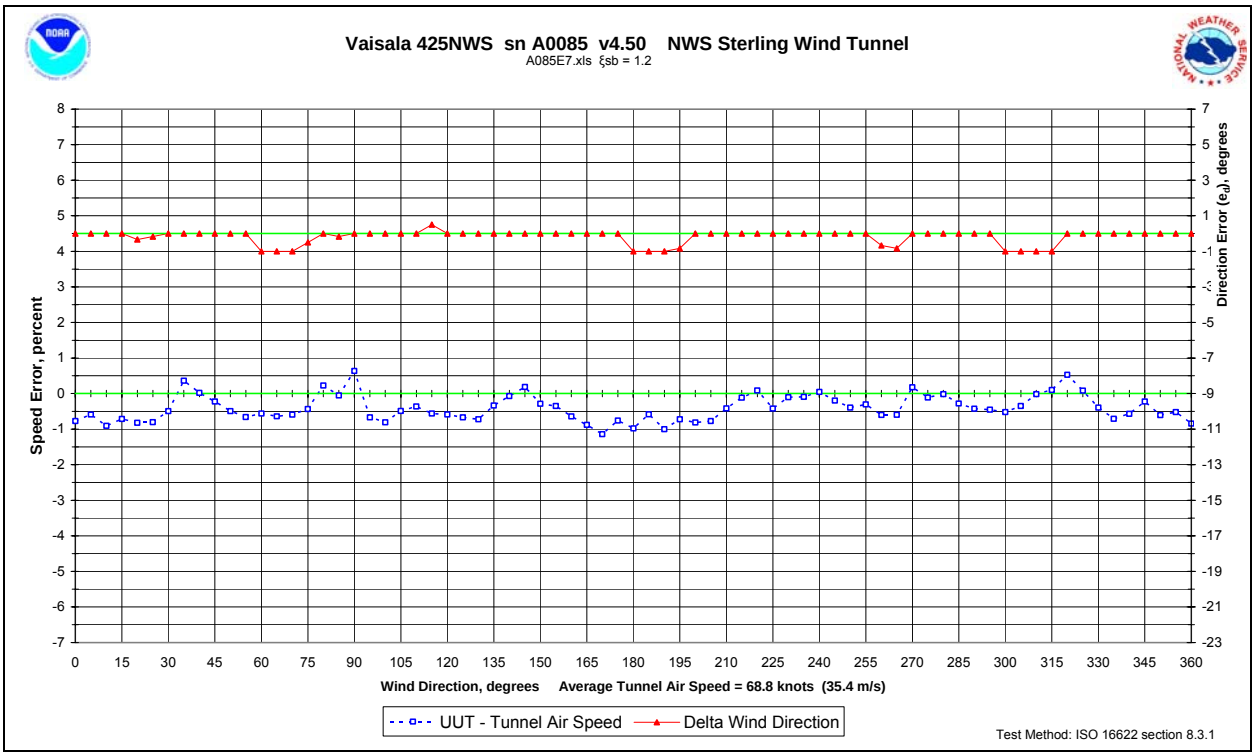

Figure 25 Wind Speed/Direction Differences SN0085, FW4.50, 70 knot test speed

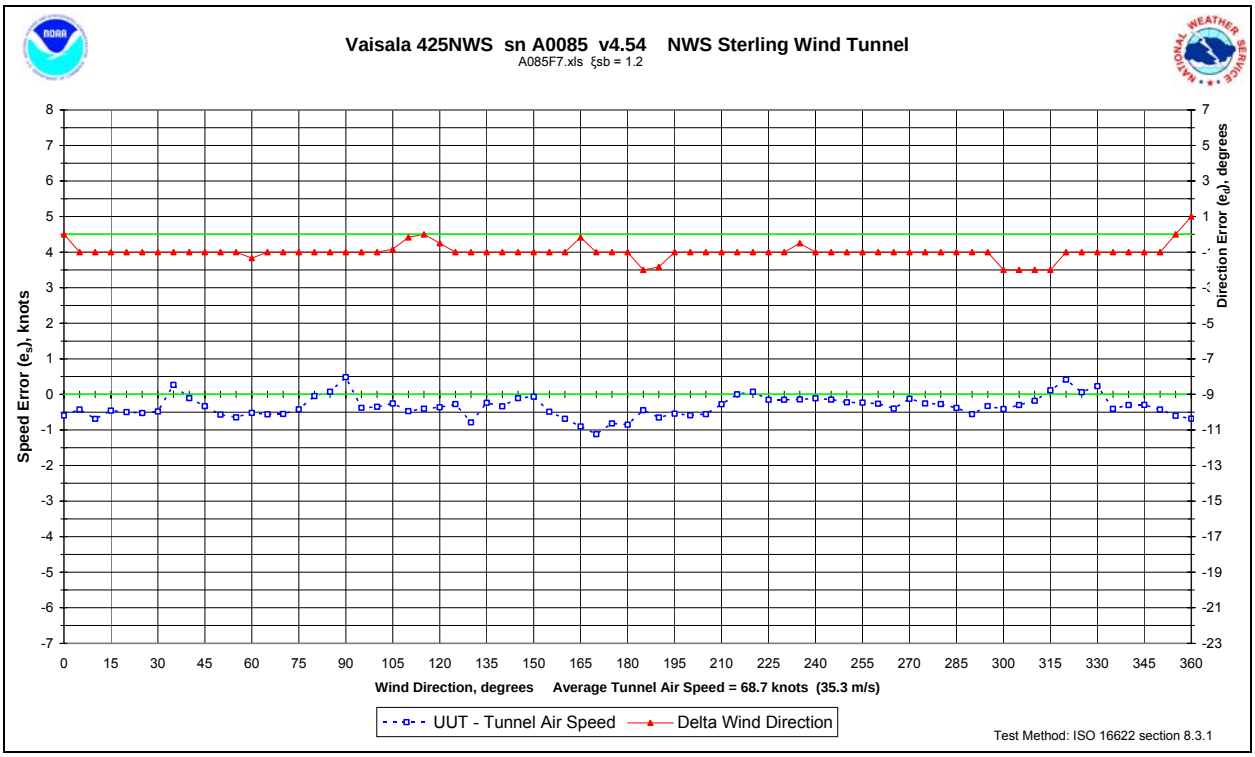

Figure 26 Wind Speed/Direction Differences SN0085, FW4.54, 70 knot test speed

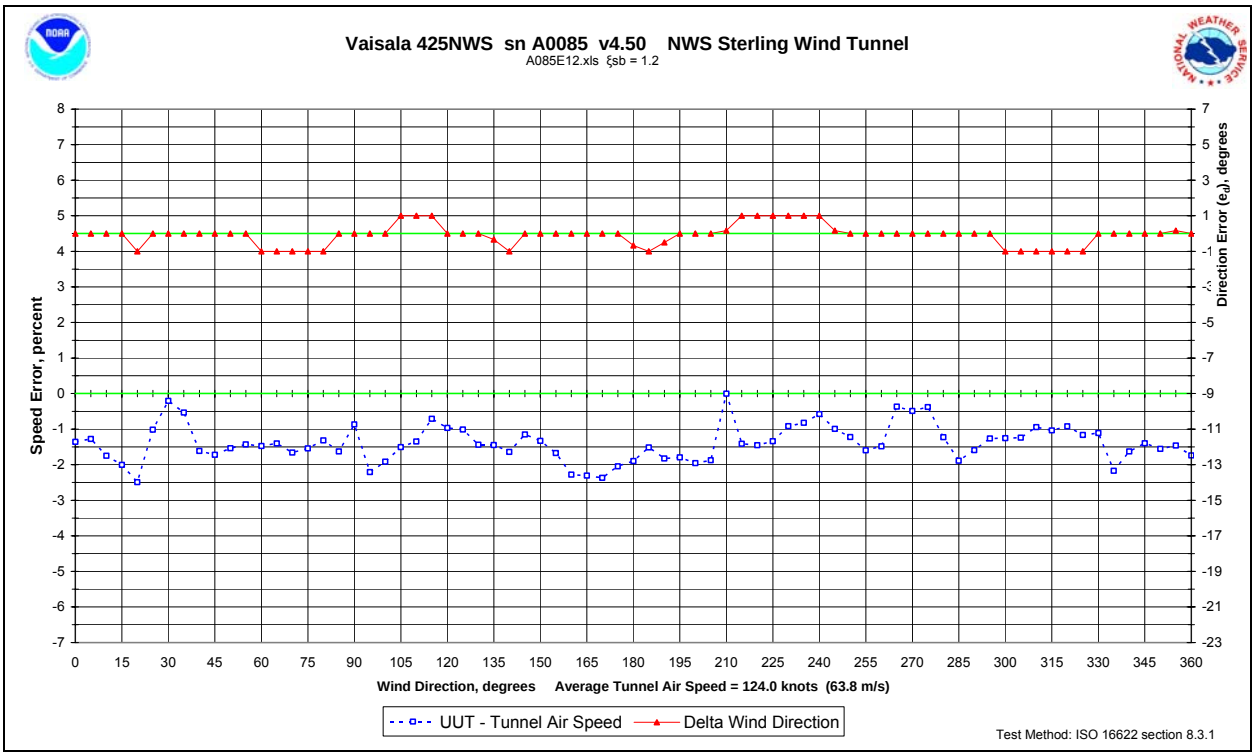

Figure 27 Wind Speed/Direction Differences SN0085, FW4.50, 125 knot test speed

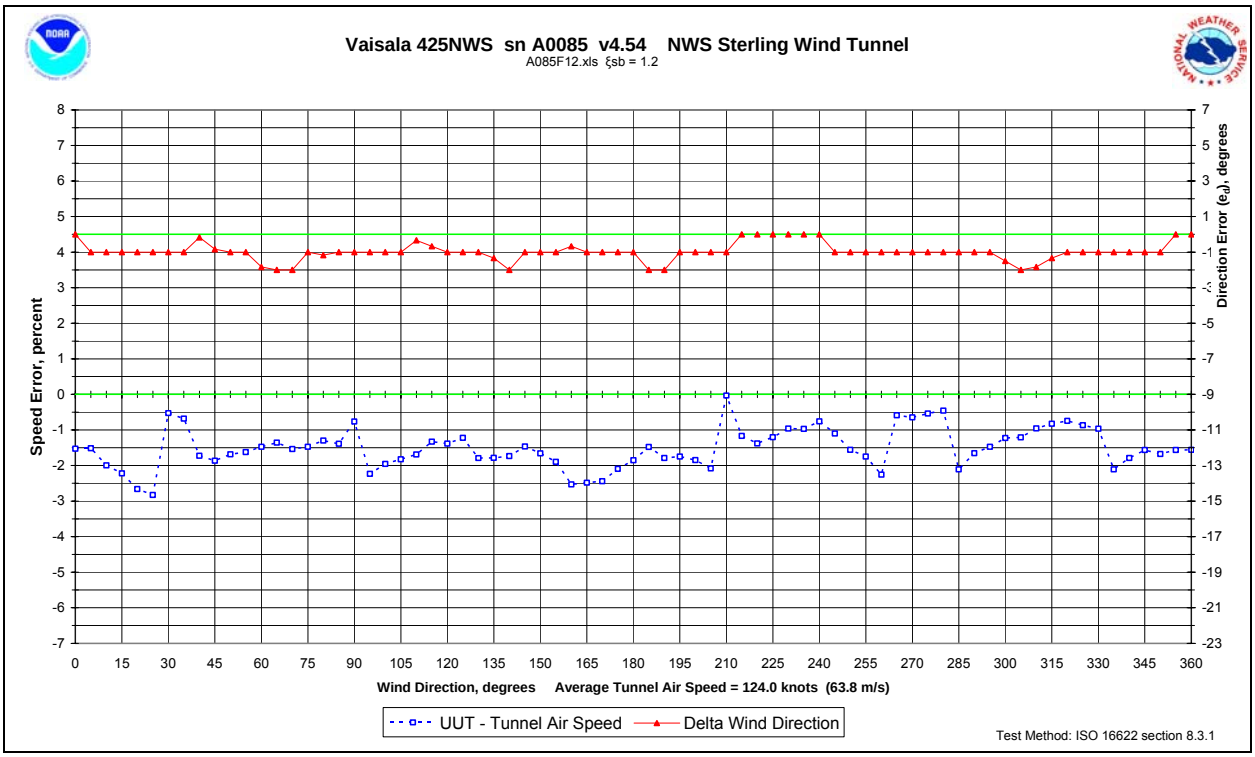

Figure 28 Wind Speed/Direction Differences SN0085, FW4.54, 125 knot test speed