REPORT OF SPECIAL TEST

Of

Optical Flow Sensor (OFS)

At

National Institute of Standards and Technology (NIST)

April 2001

Optical Scientific, Inc.
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Optical Scientific Inc. submitted an Optical Flow Sensor (OFS) to National Institute of Standards and Technology (NIST) for wind tunnel test and calibration during April 19 – 24, 2001. The test and calibration of the OFS (SN 0900002) was performed in the 1.5-m by 2.1-m rectangular test section NIST Dual Test Section Wind Tunnel. In this tunnel, the air speed is measured by NIST Standard (laboratory standard Pitot-static tube).

The test was conducted at a location 7-m downstream from the entrance area of the wind tunnel test section. During the test, the air stagnation temperature, stagnation pressure and the relative humidity were measured in the tunnel settling-chamber. The air temperature, barometric pressure, and relative humidity were measured at the location where the NIST standard was positioned.

To determine the reproducibility of the OFS under test, two calibration cycles were done separated by a tunnel shutdown. During each calibration cycle, each air speed was measured five times to ascertain the repeatability of the anemometer under test.

Figure 1. Images of the Optical Scientific, Inc., Optical Flow Sensor System – top view of the receiving optics as installed in the NIST Dual Test Section Wind Tunnel.

As shown in Figure 1, the OFS was placed outside the tunnel. The light beam is perpendicular to the flow and roughly 4-m apart from transmitter to receiver. Figure 1 also indicated that OFS has been put upside down for the convenience of cable arrangement. However, it will not effect the performance of the OFS. The width of the tunnel at this location is 2.1-m. The transmitter emitted a visible beam of light which entered the Dual Test-section Wind Tunnel through one of its Plexiglas windows. The NIST standard was placed in the tunnel at a position 0.13-m below the sensing area of the OFS under test, at a position and 0.38-m away from the tunnel wall. Temperature and humidity sensors were placed in the area where the NIST standard made its measurements. These parameters were used to calculate the air velocity at this position.

The OFS uses optical scintillation to measure the flow rate by temporal correlation – the time-difference between optical scintillation signals detected by the two detectors aligned parallel to the flow direction. The method is non-intrusive and measures the average flow across an optical path. The OFS is designed to make measurements in turbulent flows. Hot-air guns were installed in the test-section at a position 2-m upstream from the sensing area. The hot-air guns introduced heat into the tunnel perpendicular to the flow direction. The OFS measured flow rate is independent of the temperature, pressure, and the relative humidity of the flowing media. Therefore, no correction is needed to the measurements of OFS.

During the test, the raw signals detected by the two optical receivers are recorded on VHS tapes (on stereo audio format) for different wind tunnel air velocities. This tape will be used as the reference of laboratory OFS calibration standard. A summary of the OFS wind tunnel test results at NIST is as follows. (A detailed test report provided by NIST is available upon request.)

Table 1 shows that the reproducibility uncertainty of OFS is around the display resolution of 0.1 m/s up to air speed of 25 m/s. Throughout the range from 2.5 m/s to 40 m/s, the standard deviation of the reproducibility uncertainty is 1.05%. Because a less reproducibility uncertainty indicates a better repeatability of the sensor, the results clearly indicate that OFS is a reliable sensor. It should also be noted that the reproducibility uncertainty included not only the uncertainty of the OFS measurements but also the uncertainty of the NIST standards! (See details in NIST Test Report.) Each value of air speed represents the average of 10 readings. The standard deviation of the accuracy of OFS (after calibration) is 2.35% of that of the NIST standard. A scattered diagram of the air speed measured by NIST standard and that of the OFS is shown in Figure 2.

Table 1 OFS Test Results at NIST Wind Tunnel (April 23, 2001)

NIST Air Speed, m/s	OFS Output, m/s	OFS Accuracy m/s (%)	Reproducibility Uncertainty m/s (%)
1.59	1.58	-0.01 (-0.56%)	0.12 (7.73%)
2.58	2.67	0.09 (3.39%)	0.10 (3.86%)
4.94	4.90	-0.04 (-0.84%)	0.14 (2.84%)
7.59	7.69	0.10 (1.35%)	0.07 (0.96%)
9.75	9.41	-0.34 (-3.50%)	0.07 (0.72%)
14.80	15.23	0.43 (2.90%)	0.17 (1.16%)
19.70	20.37	0.67 (3.40%)	0.15 (0.80%)
24.50	23.86	-0.64 (-2.60%)	0.12 (0.51%)
29.00	28.42	-0.58 (-2.00%)	0.22 (0.77%)
35.00	34.53	-0.47 (-1.34%)	0.63 (1.80%)
40.00	40.35	0.35 (0.88%)	0.33 (0.82%)

The Standard Deviation of the OFS Accuracy is **2.35%**.
The Standard Deviation of the Reproducibility Uncertainty is **1.05%** (from 2.5 m/s to 40 m/s).
Less Reproducibility Uncertainty indicates better Repeatability of the instrument.

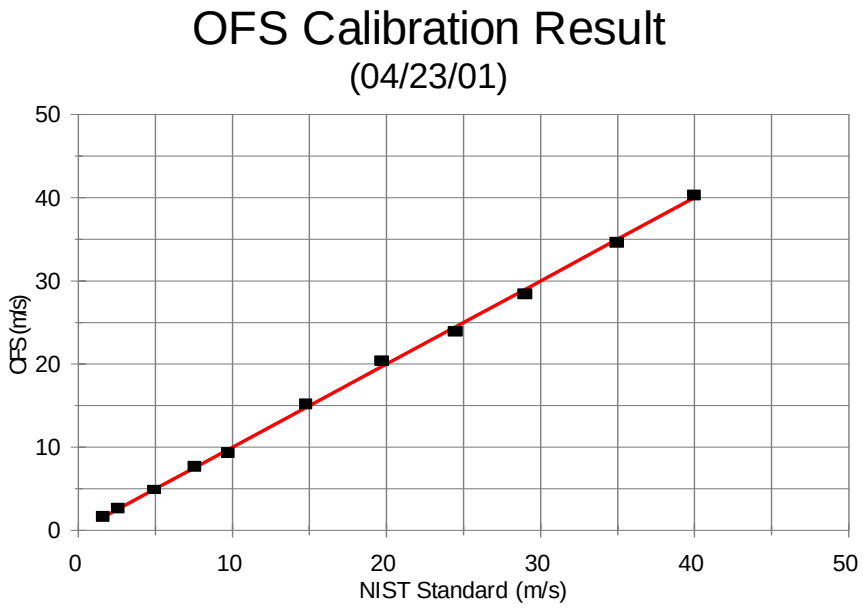

Figure 2 OFS measured Air Speed vs NIST Standard at NIST Wind Tunnel.