Project Report

FIELD INVESTIGATION OF VALVED SOFFIT VENTS IN POUCH COVE NL:

IN SITU HOUSEHOLD VSV PERFORMANCE

APRIL-JULY 2006

Submitted to:

Stormfirma Inc.
c/o R. E. Platts, P.Eng
Ottawa, Ontario

Submitted by:

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CONTENTS

1.0 Background

Typical vulnerabilities of houses constructed prior to modern standards in the tropics include insufficient anchorage of the roof sheathing and trusses and an inadequate soffit barrier to wind-driven rain. Stormfirma Inc of Ottawa Ontario is developing products to mitigate hurricane wind and rain damage to these houses. Of particular import, Stormfirma's valved soffit vent product, or VSV, is in the latter stages of development and requires some measure of full-scale performance evaluation in an existing house prior to field trials in a hurricane-prone region later in 2006.

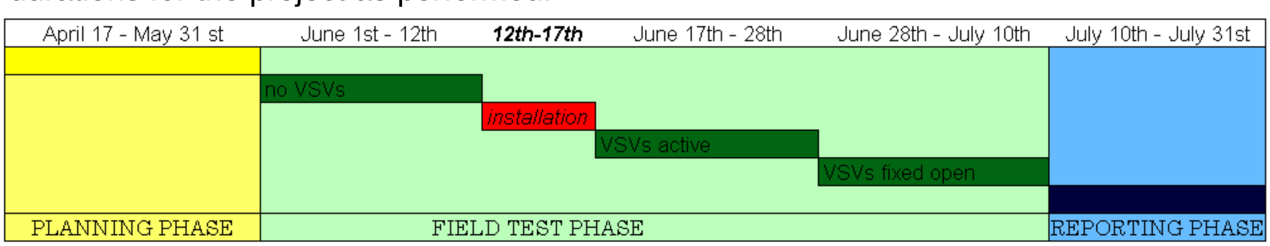
Prior experience of the client led to their search for a suitable test site in Newfoundland and in March 2006, a test house in Pouch Cove, near St. John's was secured. Industry contacts further directed Bob Platts of Stormfirma to contact Memorial University's Industrial Outreach Group (IOG) for the express purpose of carrying out the proposed field trials in a timely manner. A contract between Memorial's IOG and Stormfirma was finalized in April 2006 with the work to begin immediately. This document outlines the execution and results of these field trials as performed by The Industrial Outreach Group of Memorial's Faculty of Engineering for Stormfirma Inc.

2.0 Project Execution

<u>Scope and Plan</u>

The client's introductory work scope was drafted prior to the commencement of the program and is presented in Appendix A "Draft Work Plan". This plan was used as a basis for the development of a work scope developed by IOG and formally presented in the project proposal and contract document. The work scope for the contract is thus presented in Appendix B. In broad terms the program involved three phases: planning, field work and synthesis/reporting. For each phase, subtasks were identified and described and a 10-week schedule was developed as presented in Appendix C.

Though the project followed the proposed schedule in principle, deviation from the schedule dates occurred in three instances: during the planning phase where longer delivery time for a DA board pushed dates ahead by 3 weeks, in the testing phase where longer testing and VSV installations pushed the schedule ahead by an additional two weeks, and, in the analysis phase where longer and more time-consuming data processing pushed the schedule by an additional week. In total, five extra weeks were required to complete the work. The timeline below illustrates the activities and durations for the project as performed:



PROJECT TIMELINE

Data acquisition equipment was sourced, tested and installed through May with on-site operations beginning June 1^{st}. Weather data were recorded continuously beginning June 1^{st} through to the conclusion of tests July 10^{th}. Pressure data from six transducers was collected from June 2^{nd} to July 10^{th} with the exception of the week of June 12^{th} to June 17^{th} during which time the client installed the VSV units. During the field trials data were recorded for three household venting conditions:

1. Somewhat-normally (and poorly) vented condition prior to VSV installation
2. Venting via active VSV operation.
3. Venting with VSVs fixed in the open position

<u>Data Acquisition Equipment</u>

The data acquisition equipment was comprised of two semi-independent systems, the first being the ***meteorological station*** with associated display and recording unit, and the second, a computer-based ***pressure data acquisition system***.

1- Meteorological Station:

The met station utilized for the study was a DAVIS Vantage Pro 2 System – a high-end private-use kit often used for low-end commercial applications. It was an inexpensive in-stock item that had a high degree of flexibility and reliability in non-extreme weather environments like that expected at the Pouch Cove test site during summer months. The unit shown below is essentially comprised of two parts: an indoor display and recording unit, and an array of instruments and sensors for placement outdoors.

Meteorological Station Components
Left = Weather Instruments
Above = Data Display and Logging Unit

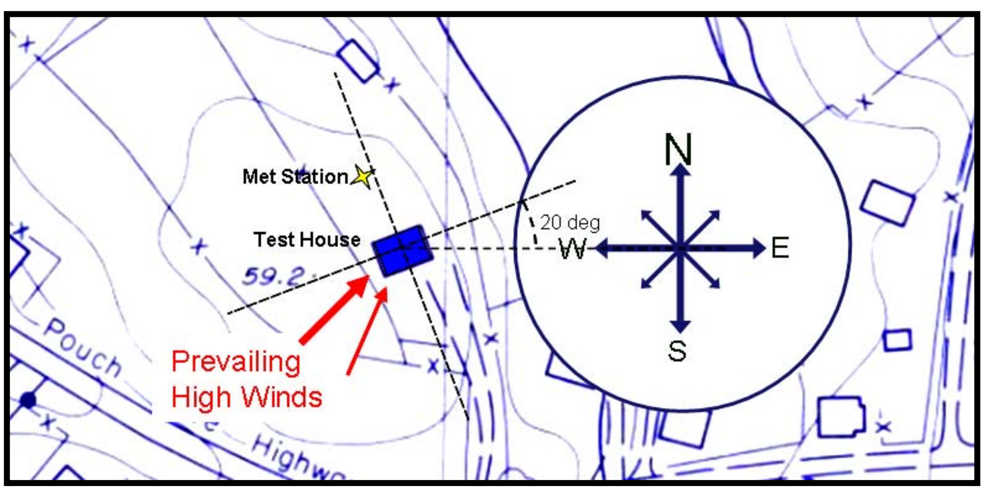
The sensors and instruments of the met station measured wind speed, direction, duration, temperature, humidity, barometric pressure, solar radiation and precipitation. The Davis logging unit communicated with the instruments via wireless radio transmission and displays instantaneous conditions while recording peaks and averages on a 10 minute interval basis.

This unit was also linked to a dedicated laptop computer for periodic downloads. Downloads were required occasionally during the field test program due to the limited memory storage on the dedicated DAVIS logger. Although the DAVIS logger is designed to operate either independently, or, as part of a computer-based display/logging system, the simultaneous computer-based operation of the DAVIS unit and the pressure data acquisition system resulted in corrupted operations. Thus best efforts were made to sync the clocks on both units and then the met station was allowed to run independently for the test duration. The field station was positioned 25 meters NNW of the house in a clear open field setting on top of a rigid, 3 meter support structure (anemometer was 3m above ground level).

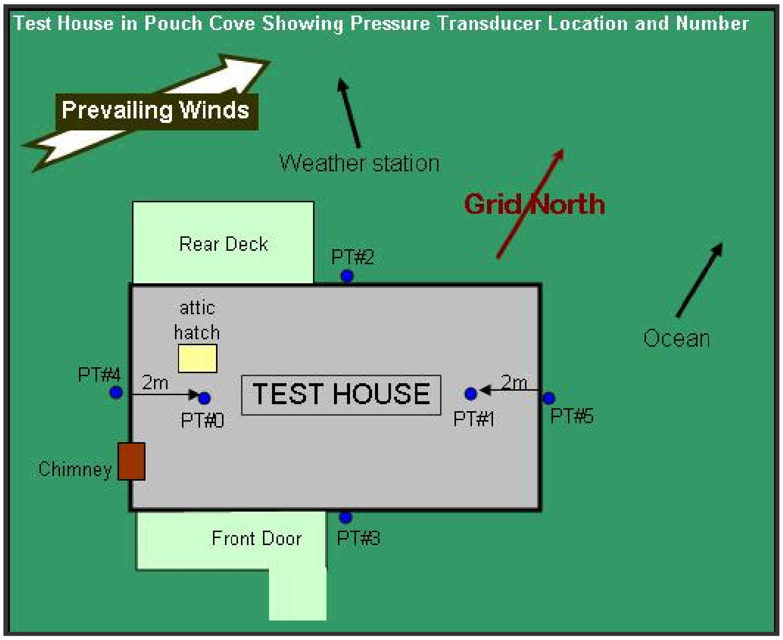
2- Pressure Transducers and Data logging Equipment

To expedite mobilization and to minimize costs, pressure data were acquired using equipment sourced in the retail market. This was comprised of a 16 channel, USB connected, external DA board purchased from US suppliers in-stock. Transducers were simple differential measuring devices (Setra Corp Model 265s - Appendix D) that had a range of plus-minus 5 inches of water pressure at 24 VDC excitation with 0-5VDC output. Six units were purchased to provide for two internal (attic space) pressure measurements and four external (outside) measurements at the soffit level, midway along each of the four sides of the rectangular house.

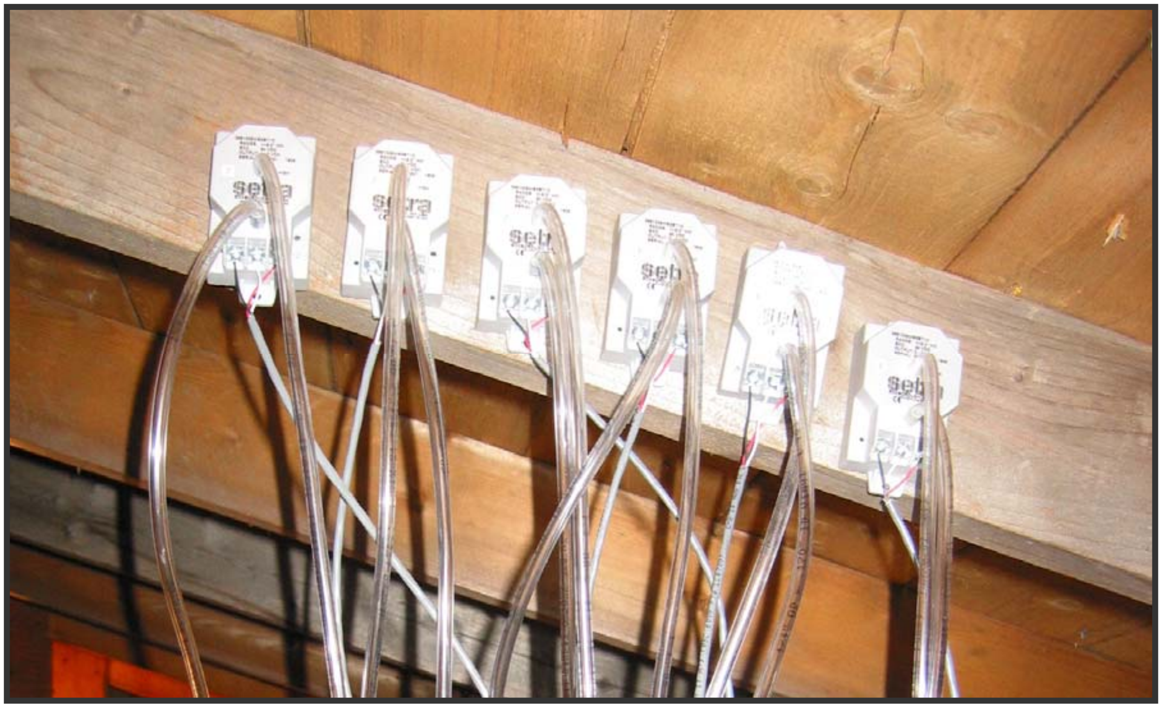
The sketch below indicates the position of the house, met station and prevailing winds:



The positions of the pressure measurement locations within and around the house are identified below:



The six transducer units have electronic terminals for power supply and output, plus a high and low pressure pneumatic connector. From each connector 3/16" vinyl tubing is run to the desired measurement location (high) and to pressure datum (low), respectively. The manufacturer stated that tubes extending less than 50 feet would in no way adversely affect readings thus allowing the installation of all transducers at a convenient central location with tubes radiating outwards towards the desired pressure points. The photo below shows the bank of transducers as-installed in the attic space:



The low pressure datum where all six tubes terminated inside the house was in an open bedroom/closet space isolated from the attic and open to the main and lower levels of the bungalow. The transducers were electronically connected to the external USB DA board (Data Foundry, 16 ch. unit) via cables running through the main level ceiling and floor into the basement of the test house where the terminal was stored.

<u>Local Weather</u>

A detailed discussion of the wind environment at the nearby International Airport is Provided in Appendix E. During the six week window of operation wind strengths were equal to, or above, seasonal in persistence and magnitude, direction was as expected.

Source: Dept of Geography, Memorial University of Newfoundland

Though winds were weak in the first days of testing, conditions changed to the point where peak winds exceeding 50 kph were experienced for over half of the 40 days of recording. In addition, strong summer breezes over 60 kph occurred bi-weekly allowing for the thorough testing of all three venting arrangements in a six week window.

Records and Files

Weather data were stored on the DAVIS logger and downloaded weekly onto the laptop hard drive in both **DAVIS** proprietary, and, ASCII data file formats. Likewise pressure data were recorded and stored on the laptop hard drive in both **Measure Foundry** proprietary and ASCII formats. The **Measure Foundry** software was permanently fixed at 50 Hz sampling rate and thus required a manual download/store operation every seven hours of active record taking. This also required a resetting of the acquisition software. Home owner and project assistant Cyril Snook diligently carried out this procedure on a regular basis during the six week period resulting in 84 record sessions averaging 7 hours each with complete coverage of key events. The figure below is indicative of the file listing on the accompanying data DVD.

pressure_4-21-47 PM.txt	19,573 KB	Text Document	6/2/2006 11:06 AM
pressure_11-30-02 AM.txt	21,215 KB	Text Document	6/2/2006 8:28 PM
pressure_8-29-06 PM.txt	17,206 KB	Text Document	6/3/2006 9:04 AM
pressure_9-04-37 AM.txt	19,429 KB	Text Document	6/3/2006 7:23 PM
pressure_7-23-32 PM.txt	19,637 KB	Text Document	6/4/2006 4:41 AM
pressure_4-41-33 AM.txt	19,900 KB	Text Document	6/4/2006 12:20 PM
pressure_12-22-41 PM.txt	18,387 KB	Text Document	6/4/2006 7:25 PM
pressure_7-26-35 PM.txt	14,227 KB	Text Document	6/5/2006 12:49 AM
pressure_12-49-42 AM.txt	19,769 KB	Text Document	6/5/2006 8:22 AM
pressure_8-24-08 AM.txt	20,893 KB	Text Document	6/5/2006 4:16 PM
pressure_4-17-35 PM.txt	19,754 KB	Text Document	6/6/2006 12:26 AM
pressure_12-27-11 AM.txt	19,357 KB	Text Document	6/6/2006 8:12 AM
pressure_8-13-45 AM.txt	19,932 KB	Text Document	6/6/2006 4:17 PM
pressure_4-18-40 PM.txt	20,634 KB	Text Document	6/7/2006 12:16 AM
pressure_12-17-34 AM.txt	19,322 KB	Text Document	6/7/2006 8:13 AM
pressure_8-14-54 AM.txt	19,465 KB	Text Document	6/7/2006 5:34 PM
pressure_5-35-43 PM.txt	18,627 KB	Text Document	6/8/2006 12:43 AM
pressure_12-44-35 AM.txt	20,194 KB	Text Document	6/8/2006 8:30 AM
pressure_8-30-56 AM.txt	19,652 KB	Text Document	6/8/2006 4:15 PM
pressure_4-16-50 PM.txt	20,122 KB	Text Document	6/9/2006 12:57 AM
pressure_12-58-21 AM.txt	19,242 KB	Text Document	6/9/2006 8:19 AM
pressure_8-20-43 AM.txt	18,883 KB	Text Document	6/9/2006 5:58 PM
pressure_5-59-17 PM.txt	19,346 KB	Text Document	6/10/2006 1:14 AM
pressure_1-14-49 AM.txt	18,770 KB	Text Document	6/10/2006 8:22 AM
pressure_8-23-59 AM.txt	13,713 KB	Text Document	6/10/2006 1:31 PM
pressure_1-32-45 PM.txt	20,017 KB	Text Document	6/10/2006 9:06 PM
pressure_9-07-02 PM.txt	10,158 KB	Text Document	6/11/2006 12:55 AM
pressure_12-56-22 AM.txt	20,973 KB	Text Document	6/11/2006 12:09 PM
pressure_12-10-01 PM.txt	13,093 KB	Text Document	6/11/2006 5:05 PM
pressure_6-56-51 AM.txt	18,277 KB	Text Document	6/19/2006 3:43 PM
pressure_3-48-05 PM.txt	20,181 KB	Text Document	6/20/2006 12:30 AM
pressure_12-31-48 AM.txt	19,564 KB	Text Document	6/20/2006 8:21 AM
pressure_8-23-54 AM.txt	19,699 KB	Text Document	6/20/2006 6:39 PM
pressure_6-40-09 PM.txt	14,784 KB	Text Document	6/21/2006 12:21 AM
pressure_12-22-08 AM.txt	18,290 KB	Text Document	6/21/2006 7:26 AM
pressure_7-27-50 AM.txt	18,288 KB	Text Document	6/21/2006 4:36 PM
pressure_4-37-29 PM.txt	18,284 KB	Text Document	6/22/2006 2:01 AM
pressure_2-02-03 AM.txt	19,948 KB	Text Document	6/22/2006 9:45 AM
pressure_9-57-04 AM.txt	18,859 KB	Text Document	6/22/2006 5:19 PM
pressure_5-20-30 PM.txt	18,432 KB	Text Document	6/23/2006 12:29 AM
pressure_12-29-53 AM.txt	17,917 KB	Text Document	6/23/2006 8:19 AM
pressure_12-29-53 AM.txt	17,917 KB	Text Document	6/23/2006 8:19 AM
pressure_8-20-11 AM.txt	18,721 KB	Text Document	6/23/2006 7:35 PM
pressure_7-36-19 PM.txt	11,010 KB	Text Document	6/23/2006 11:50 PM
pressure_11-51-18 PM.txt	19,113 KB	Text Document	6/24/2006 7:21 AM
pressure_7-24-40 AM.txt	19,252 KB	Text Document	6/24/2006 4:08 PM
pressure_4-09-31 PM.txt	18,250 KB	Text Document	6/24/2006 11:16 PM
pressure_11-17-17 PM.txt	19,036 KB	Text Document	6/25/2006 6:49 AM
pressure_6-50-59 AM.txt	18,558 KB	Text Document	6/25/2006 3:50 PM
pressure_3-50-46 PM.txt	18,784 KB	Text Document	6/25/2006 11:13 PM
pressure_11-14-01 PM.txt	18,172 KB	Text Document	6/26/2006 8:10 AM
pressure_8-11-31 AM.txt	18,926 KB	Text Document	6/26/2006 5:42 PM
pressure_6-09-21 PM.txt	14,250 KB	Text Document	6/26/2006 11:37 PM
pressure_11-42-49 PM.txt	19,138 KB	Text Document	6/27/2006 7:54 AM
pressure_7-55-51 AM.txt	13,551 KB	Text Document	6/27/2006 1:04 PM
pressure_1-43-24 PM.txt	17,837 KB	Text Document	6/27/2006 8:50 PM
pressure_8-51-50 PM.txt	5,783 KB	Text Document	6/27/2006 11:08 PM
pressure_11-08-42 PM.txt	19,123 KB	Text Document	6/28/2006 8:04 AM
pressure_8-05-23 AM.txt	10,944 KB	Text Document	6/28/2006 12:14 PM
pressure_12-14-36 PM.txt	17,732 KB	Text Document	7/3/2006 3:17 PM
pressure_3-19-25 PM.txt	19,480 KB	Text Document	7/3/2006 10:56 PM
pressure_10-57-21 PM.txt	18,664 KB	Text Document	7/4/2006 7:08 AM
pressure_7-10-00 AM.txt	11,314 KB	Text Document	7/4/2006 11:25 AM
pressure_11-26-32 AM.txt	18,341 KB	Text Document	7/4/2006 6:30 PM
pressure_6-31-37 PM.txt	15,793 KB	Text Document	7/5/2006 12:38 AM
pressure_12-39-06 AM.txt	19,016 KB	Text Document	7/5/2006 8:18 AM
pressure_8-23-49 AM.txt	18,490 KB	Text Document	7/5/2006 3:33 PM
pressure_3-34-31 PM.txt	19,237 KB	Text Document	7/5/2006 11:02 PM
pressure_11-02-57 PM.txt	18,200 KB	Text Document	7/6/2006 8:04 AM
pressure_8-05-05 AM.txt	19,153 KB	Text Document	7/6/2006 3:55 PM
pressure 3-56-08 PM.txt	18.847 KB	Text Document	7/6/2006 11:36 PM
pressure_3-56-08 PM.txt	18,847 KB	Text Document	7/6/2006 11:36 PM
pressure_11-37-27 PM.txt	19,043 KB	Text Document	7/7/2006 7:28 AM
pressure_7-29-12 AM.txt	8,563 KB	Text Document	7/7/2006 10:42 AM
pressure_10-43-19 AM.txt	19,257 KB	Text Document	7/8/2006 11:41 AM
pressure_1-25-11 PM.txt	18,854 KB	Text Document	7/8/2006 9:35 PM
pressure_9-35-40 PM.txt	8,939 KB	Text Document	7/9/2006 1:02 AM
pressure_1-03-12 AM.txt	18,528 KB	Text Document	7/9/2006 9:06 AM
pressure_9-09-02 AM.txt	18,008 KB	Text Document	7/9/2006 8:55 PM
pressure_8-56-24 PM.txt	11,580 KB	Text Document	7/10/2006 1:22 AM
pressure_1-23-32 AM.txt	19,960 KB	Text Document	7/10/2006 9:35 AM
pressure_9-36-34 AM.txt	5,688 KB	Text Document	7/10/2006 11:47 AM

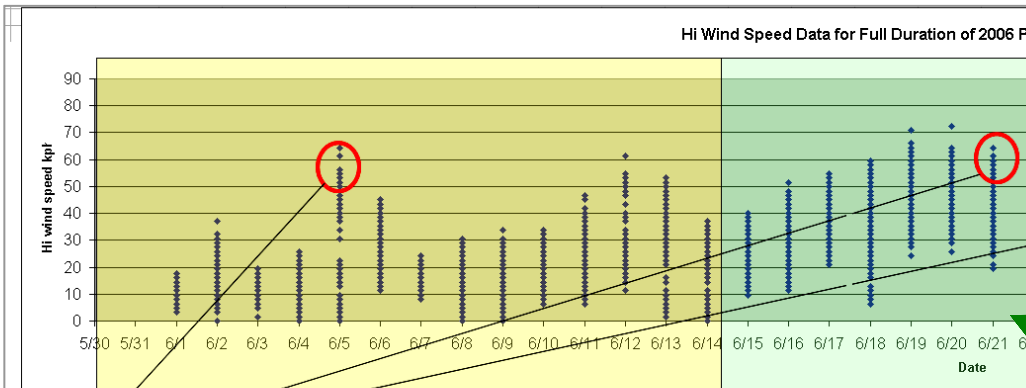
Demobilization

Once it was judged that significant wind events had been experienced for all three house venting conditions the equipment was demobilized. The met station, and data logging equipment were removed from the house/property and brought to the University for data uploading and processing on July 10th.

Data Reduction

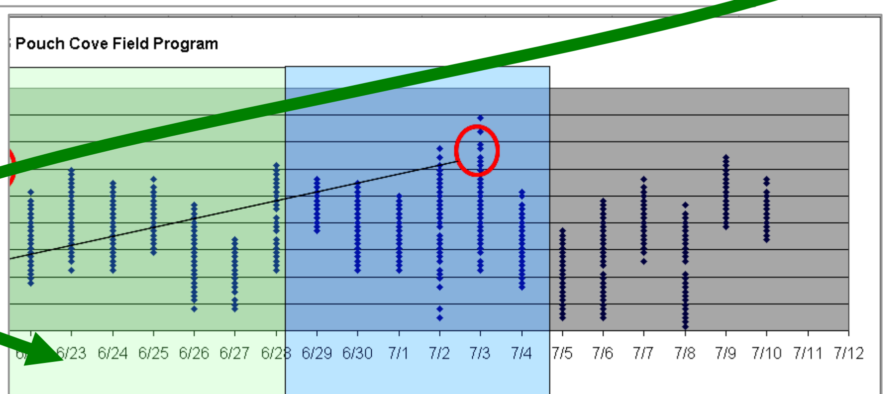
Raw ASCII data files have been used for all analysis carried out in this report. Future work may chose to use proprietary software or other means for additional analysis but this was not required for first-order synthesis. Calibrated meteorological data for peak and sustained wind speeds were plotted for the six week program so that significant wind events could be identified within the three test scenarios.

After scrutinizing the data sets it was found that three independent but similar wind events occurred for each house venting condition. These occurred on June 5th, June 21st and July 3rd - in all three instances sustained winds of 37 kph and peak winds of 61 kph from the SW quadrant were recorded over a ten minute interval.



Date	Time	Temp Out	Hi Temp	Low Temp	Out Hum	Dew Pt.	Wind Speed	Wind Dir	Wind Run	Hi Speed	Hi Dir	Wind Chill	Heat Index	THW Index	Bar
6/5/2006	17:10	17.1	17.4	17.1	94	16.1	37	SW	6.17	61.2	SW	13.2	17.6	13.7	1006
6/21/2006	1:10	15.6	15.6	15.5	96	15	37	WSW	6.17	61.2	SW	11.5	15.8	11.7	1010
7/3/2006	17:50	17.4	17.6	17.4	96	16.7	37	SW	6.17	61.2	SW	13.6	17.9	14.1	10(

Plot and Table split for legibility in report



	Rain	Rain Rate	Heat D-D	Cool D-D	In Temp	In Hum	In Dew	In Heat	Wind Samp	Wind Tx	ISS Recept	Arc. Int.
006.7	0	0	0.008	0	24.7	52	14.2	24.7	227	1	99.6	10
010.9	0	0	0.019	0	24.9	48	13.1	24.7	230	1	100	10
1002	0	0	0.007	0	24.6	58	15.8	24.9	229	1	100	10

The pressure data files for these periods were sourced and truncated so that uploading into Excel could be accommodated. Once uploaded, the data sets were zeroed based on initial no-load tests run June 1st (@ baro=1013.4 or 4.068 inches of water) prior to the installation of pressure tubes, and then, the files were calibrated using the factory-provided unit factors as shown below. Subsequently, the three data sets, each with six transducer outputs were plotted on same-scale axes for review. Below is a sample view of the calibration file used for data processing

Pressure Transducer Zeroing Tests

#1	2.491023	2.511343	2.520981	2.497484	2.502751	2.477654
#2	0.036399	2.511452	2.519798	2.496138	2.501776	2.472612
#3	0.040497	2.510712	2.51889	2.495941	2.502258	2.471436
avg(avg)	2.491023	2.511169	2.51989	2.496521	2.502261	2.473901

Pressure Transducer Calibration Factor:

plus and minus five inches of water

for zero to 5 volts DC at 24 VDC excitation (internal)

inches water per volt	pascals
2	498.1778

Data File #1

Pressure_2-33-49PM.txt
Calibration File
For zeroing the pressure transducers prior to upper tube install

Time	Clock	Ch. 0	Ch. 1	Ch. 2	Ch. 3	Ch. 4	Ch. 5
6/1/06 2:33 PM	38869.61	2.495117	2.504883	2.519531	2.504883	2.495117	2.480469
6/1/06 2:33 PM	38869.61	2.495117	2.514648	2.524414	2.485352	2.504883	2.475586
6/1/06 2:33 PM	38869.61	2.490234	2.509766	2.524414	2.485352	2.5	2.485352
6/1/06 2:33 PM	38869.61	2.490234	2.519531	2.519531	2.490234	2.5	2.480469
6/1/06 2:33 PM	38869.61	2.5	2.509766	2.514648	2.5	2.5	2.480469
6/1/06 2:33 PM	38869.61	2.485352	2.504883	2.519531	2.5	2.5	2.475586
6/1/06 2:33 PM	38869.61	2.485352	2.504883	2.529297	2.504883	2.5	2.480469
6/1/06 2:33 PM	38869.61	2.495117	2.514648	2.514648	2.490234	2.504883	2.480469
6/1/06 2:33 PM	38869.61	2.490234	2.519531	2.519531	2.5	2.514648	2.475586
6/1/06 2:33 PM	38869.61	2.490234	2.519531	2.524414	2.495117	2.504883	2.470703
6/1/06 2:33 PM	38869.61	2.485352	2.509766	2.524414	2.509766	2.509766	2.475586
6/1/06 2:33 PM	38869.61	2.485352	2.519531	2.524414	2.490234	2.504883	2.480469
6/1/06 2:33 PM	38869.61	2.490234	2.519531	2.524414	2.495117	2.5	2.480469
6/1/06 2:33 PM	38869.61	2.490234	2.514648	2.524414	2.490234	2.504883	2.475586
6/1/06 2:33 PM	38869.61	2.490234	2.509766	2.519531	2.495117	2.504883	2.480469
6/1/06 2:33 PM	38869.61	2.480469	2.519531	2.519531	2.5	2.504883	2.475586
6/1/06 2:33 PM	38869.61	2.485352	2.504883	2.524414	2.504883	2.504883	2.475586
6/1/06 2:33 PM	38869.61	2.490234	2.514648	2.519531	2.495117	2.5	2.480469

Data File #2

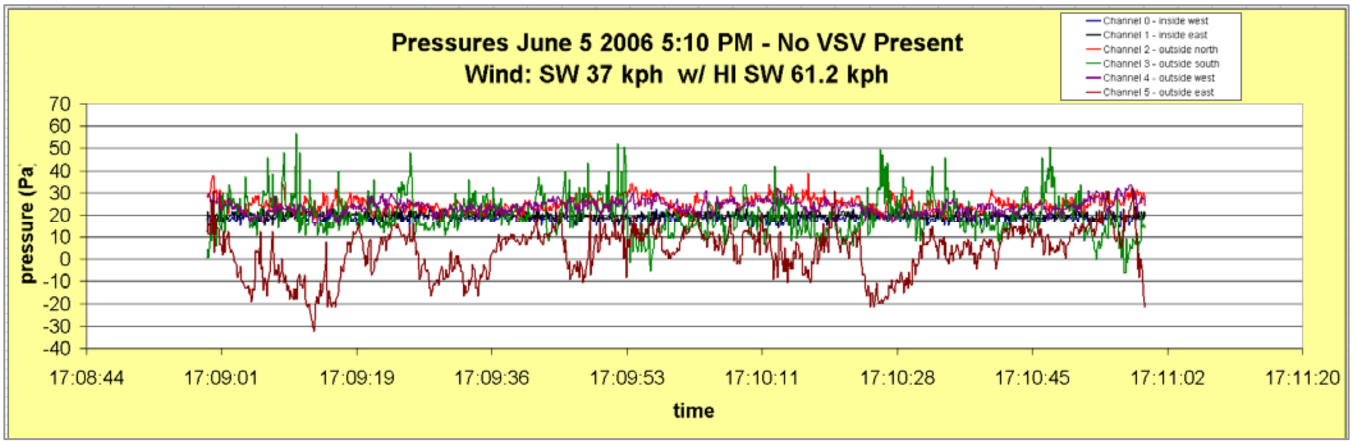
Pressure_2-34-36PM.txt
Calibration File
For zeroing the pressure transducers prior to upper

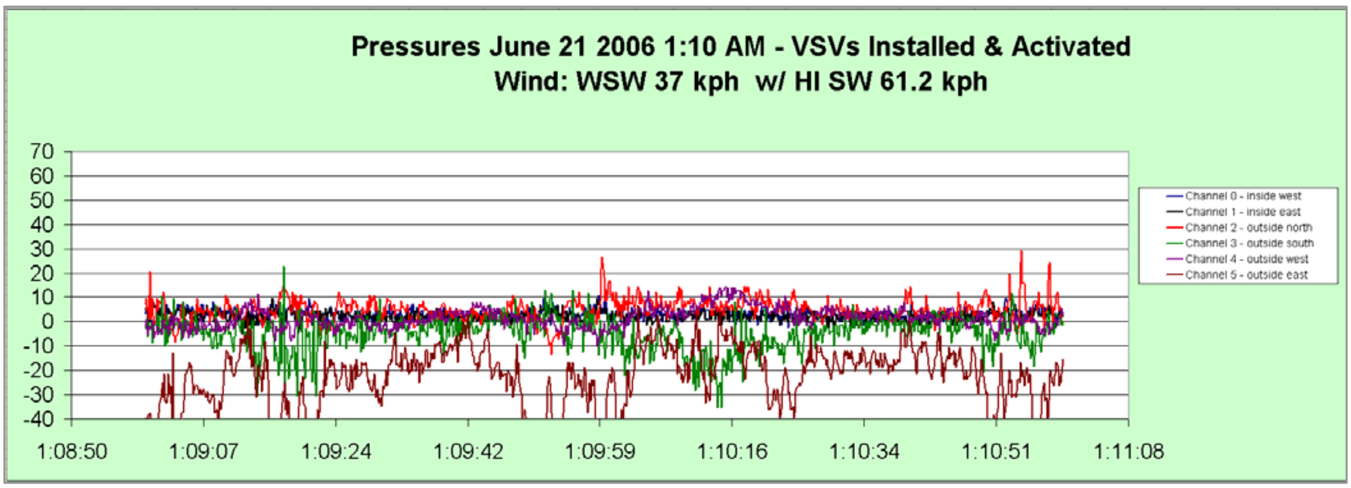
Time	Clock	Ch. 0	Ch. 1	Ch. 2	Ch. 3
6/1/06 3:34 PM	38869.65	0.03418	2.509766	2.524414	2.4951
6/1/06 3:34 PM	38869.65	0.039063	2.514648	2.519531	2.4951
6/1/06 3:34 PM	38869.65	0.039063	2.514648	2.514648	
6/1/06 3:34 PM	38869.65	0.03418	2.514648	2.524414	2.4951
6/1/06 3:34 PM	38869.65	0.03418	2.509766	2.509766	2.4902
6/1/06 3:34 PM	38869.65	0.039063	2.514648	2.524414	
6/1/06 3:34 PM	38869.65	0.029297	2.514648	2.524414	2.4853
6/1/06 3:34 PM	38869.65	0.039063	2.509766	2.519531	2.4951
6/1/06 3:34 PM	38869.65	0.03418	2.504883	2.514648	2.4902
6/1/06 3:34 PM	38869.65	0.03418	2.509766	2.514648	2.4902
6/1/06 3:34 PM	38869.65	0.03418	2.504883	2.519531	2.4951
6/1/06 3:34 PM	38869.65	0.029297	2.514648	2.524414	2.4951
6/1/06 3:34 PM	38869.65	0.03418	2.514648	2.519531	
6/1/06 3:34 PM	38869.65	0.039063	2.514648	2.524414	
6/1/06 3:34 PM	38869.65	0.03418	2.514648	2.514648	2.4951
6/1/06 3:34 PM	38869.65	0.039063	2.509766	2.519531	2.5097
6/1/06 3:34 PM	38869.65	0.03418	2.509766	2.519531	2.4853
6/1/06 3:34 PM	38869.65	0.03418	2.514648	2.514648	2.4902

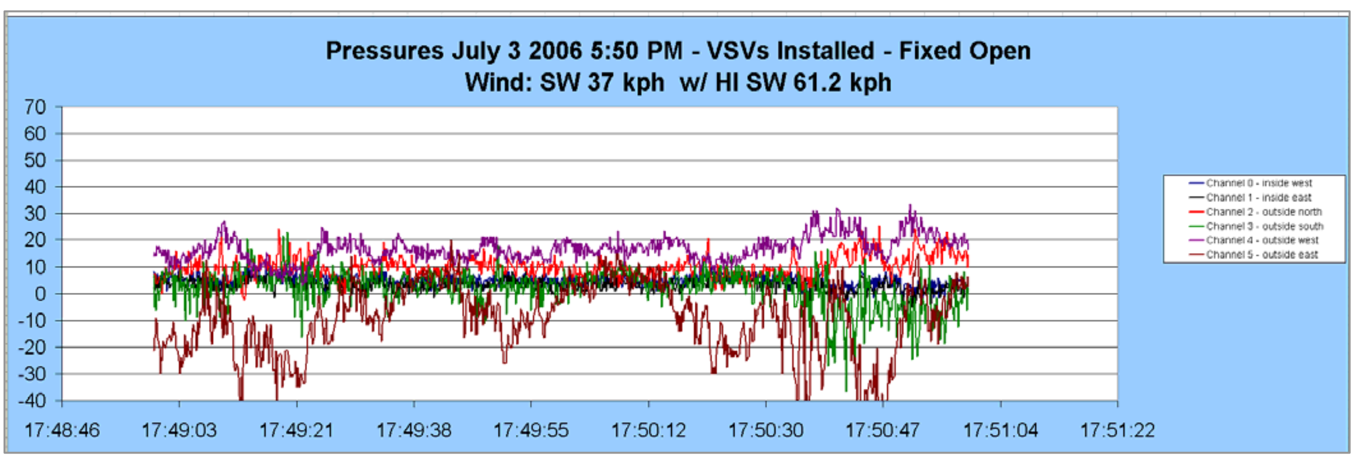
3.0 Results and Analysis

A thorough analysis of VSV performance was not within the scope of this project. A quantitative assessment would require some form of power spectral density investigation in which the differential between inside and outside pressures was assessed. In addition this work would be required for various wind approaches to the structure. A sensitivity analysis may also reveal correlations between differential pressure measurements and factors other than soffit venting. These and other analysis techniques may be the focus of future work, however, for this study analysis was limited to a qualitative look at the pressures recorded during three similar weather events . Below are the plots representing these events:

Note that the data sets were zeroed on the basis of no-wind readings on June 1st.







Observations:

The following observations have been made from these plots:

1. The pressure state inside the attic (relatively flat black and blue lines in plot background) appears to be further displaced to the positive side from the pressures outside at the soffits in the active VSV state than in either the no-VSV or the fixed open VSV conditions.
2. A higher pressure flux is observed in the attic when VSVs are fixed open than in either of the other two conditions.
3. Attic space pressures at opposing ends of the structure do not vary or differ significantly.
4. Though wind events were similar, subtle changes in direction must occur over short time intervals giving rise to significantly different surface pressure readings around the house perimeter – demonstrated by varying dominant pressures on the positive side. Negative pressures on the lea side (Eastern) gable end were greatest in magnitude in all test cases.

The complete dataset provides for analysis opportunities for other wind directions and magnitudes, the choice for that above having been somewhat arbitrary. Results may vary according to these factors and therefore should be considered for follow on work. Video clips of VSVs in operation during high wind conditions record the following: VSVs flap open and shut during operation in windy conditions. The noise and vibration caused by this action requires the attention of the designers to mitigate homeowner/ client discomfort.

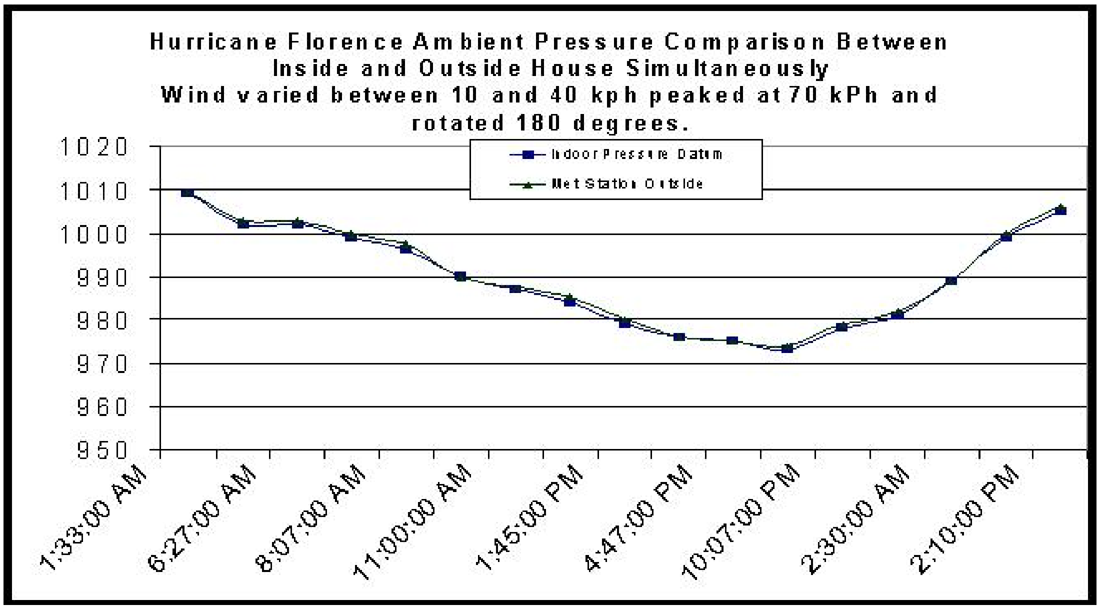
Uncertainty Analysis and Mitigation

Many factors affect household venting and not all are understood nor were they carefully controlled during these tests. From the glimpse provided by the three intervals plotted above it cannot be concluded that the VSVs in operation had a remarkable impact on attic space venting. However, it is quite likely that subtle changes in the wind direction and turbulence intensity affect pressure distribution around the house in a significant way. Therefore, no conclusive statement can or should be made about VSV operations until a thorough analysis of the full dataset is performed using power spectral density analyses procedures.

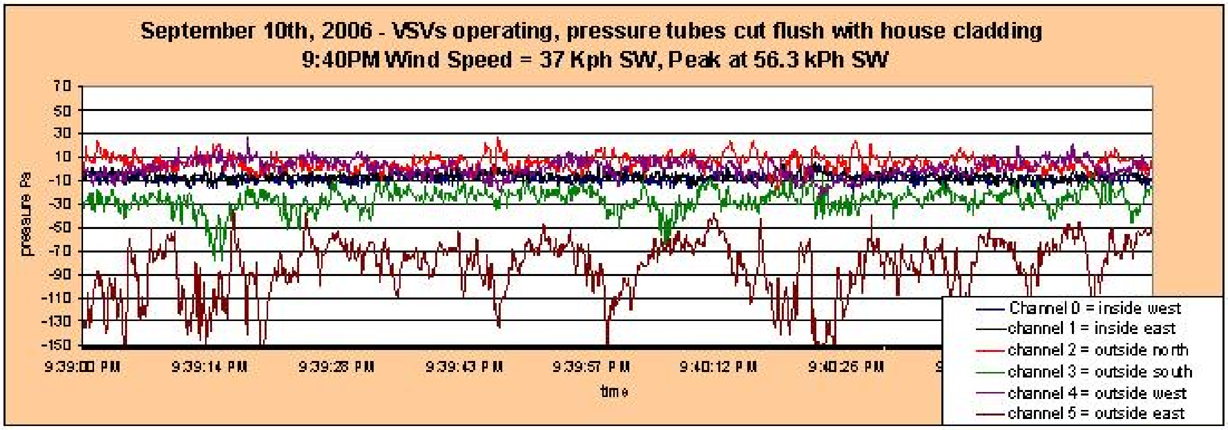
Two concerns were expressed by the client after the initial results were presented: the adverse affects of the pressure high-side tube terminations and in-house depressurization where low-side tubes were terminated. Pressure tube (high side, outside) terminations projected 10cm from each soffit and wall surface with the open tube end pointed downwards for rain avoidance. It was suggested that this was causing significant flapping and trailing leading to lower than normal pressures due to suction. The pressure datum for all six transducers was the ambient pressure inside the living space of the house – where all six tubes (low side) were bundled and terminated in an open, well-vented room. The status of household windows, chimney and doors were not recorded and it was a concern that gross depressurization within the house may have diminished the value of the data qualitatively and quantitatively.

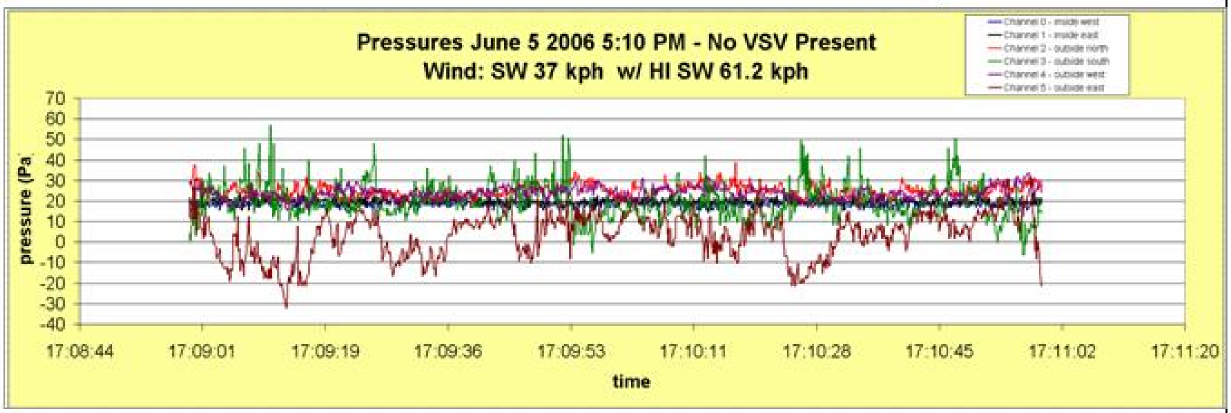
To alleviate these concerns an additional set of tests were performed with two modifications. High-side pressure tube terminations outside were clipped and carefully flush-mounted to avoid any projection into the air space. A second digital barometric pressure gauge was installed inside the house beside the low-side transducer tube terminations. This indoor gauge was previously calibrated side-by-side against the outside gauge.

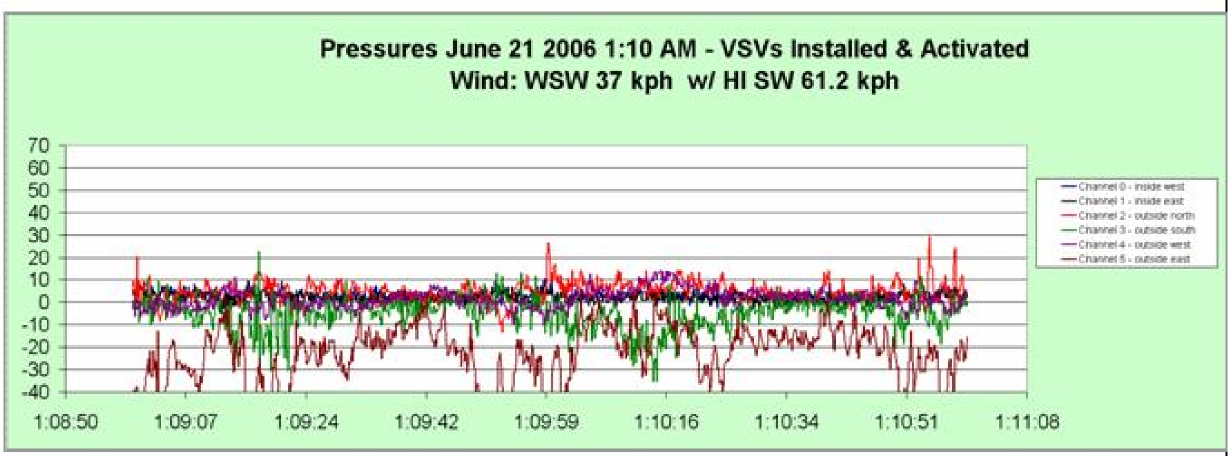
Data were recorded over a one-month period during which two post-hurricane tropical depressions passed with 60 nautical miles of the house. The figure below shows that the ambient pressure measured inside the house at the datum for the transducers was equal to the pressure measured outside the house at the met station – at all times. There was no significant or apparent de-pressurization of the home interior during any time interval measured.

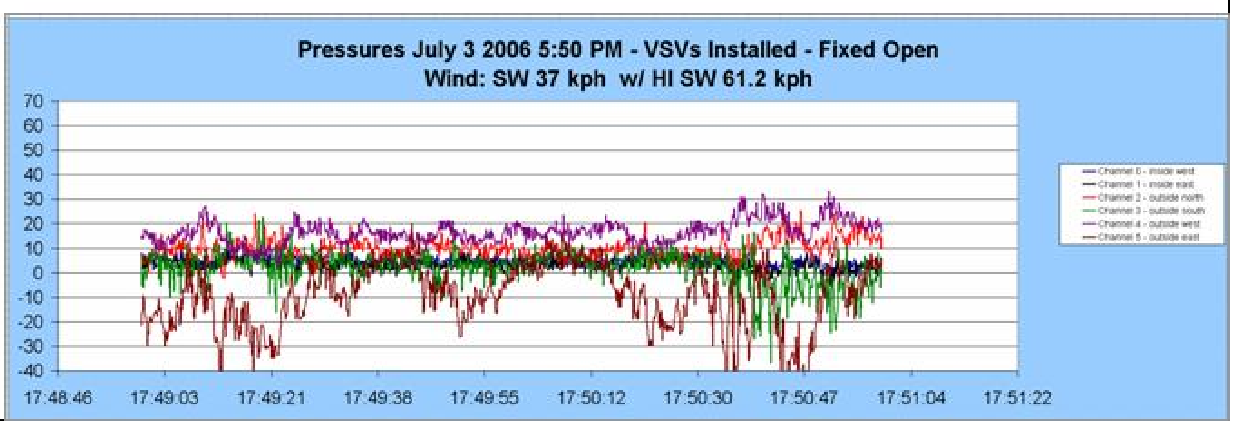


To analyze the effect of tube terminations a wind event with the same characteristics as the three previously analyzed events - was identified. An identical analysis procedure was undertaken and the results plotted (below with others). The similarity of this plot with the others indicates that the degree of rapid pressure flux, the relative variation between sensors and the significant negative displacement of the lee-side pressure is a real and robust phenomenon and not an artifact of the experimental procedure or equipment. This result further suggests that the previous body of data for which these changes were not affected - is valid and representative. In summary, definitive and conclusive statements of VSV performance cannot be made given the first-order analysis presented.


September 10th, 2006 - VSVs operating, pressure tubes cut flush with house cladding
9:40PM Wind Speed = 37 Kph SW, Peak at 56.3 kPh SW
pressure Pa
time
Channel 0 = inside west
channel 1 = inside east
channel 2 = outside north
channel 3 = outside south
channel 4 = outside west
channel 5 = outside east


Pressures June 5 2006 5:10 PM - No VSV Present
Wind: SW 37 kph w/ HI SW 61.2 kph
pressure (Pa)
time


Pressures June 21 2006 1:10 AM - VSVs Installed & Activated
Wind: WSW 37 kph w/ HI SW 61.2 kph


Pressures July 3 2006 5:50 PM - VSVs Installed - Fixed Open
Wind: SW 37 kph w/ HI SW 61.2 kph

4.0 Project Contacts

The Client:	Bob Platts, P.Eng, of Stormfirma Inc. Ottawa bobplatts@yahoo.com>
Project Manager:	Steve Bruneau, PhD, P.Eng of Memorial University in St. John's Newfoundland, 709 737 2119 sbruneau@engr.mun.ca
Contract Manager:	Andy Fisher, PhD, P.Eng Memorial University of Newfoundland, 709 737-6180 adfisher@mun.ca
Technical Support:	Karl Tuff, C-CORE, St. John's Newfoundland 709 737-8367 karl.tuff@c-core.ca
House Location host:	Cyril Snook, MUN Physics, cyril@physics.mun.ca

5.0 Deliverables

Deliverable included with this final report are:

(a) Meteorological and Pressure Transducer Data

Time sequenced data series on DVD format with index of file names and ID information.

(b) Written Report

3 hard copies, 1 digital of final report.

6.0 Commitment

It should be understood that the nature of research work in the field is complex and it is difficult to predict the exact nature of a given result until the process has been completed. Within the context of this uncertainty, the Industrial Outreach Group has done its best to execute the proposed work and to provide a clear summary of the results and observations.

For more information please contact Steve Bruneau at 709 737-2119.

APPENDIX A

Stormfirma Inc. Draft work Plan and Instrumentation Proposals

Stormfirma Inc.
R.E. Platts, P.Eng.
bobplatts@yahoo.com
Ottawa, 3rd April 2006

WORK PLAN – draft –
for the project TESTING THE PERFORMANCE OF VALVED SOFFIT VENTS IN DEPRESSURIZING ROOF SPACES DURING WINDSTORMS

The Job: To determine the effect of Valved Soffit Vents in reducing uplift on roof sheathing, equip the test house with Valved Soffit Vents and monitor its roof space pressures vs. wind speeds and directions during strong windstorms, alternating between normal soffit venting and VSV venting, and varying the roof space-to-indoor air-leakiness as well.

Tasks: (Tasks 1-4 begin now and proceed in parallel)

1. Refine the Project Design: Review the 'Instrumentation Options' document, suggest any improvements and recommend the minimum level of set-up and testing, all to ensure this job can be accomplished fully.
   - **Primarily MUN**, by April 15th approx $2000
2. Describe the test house and site: House type, configuration, external dimensions, features/obtrusions, roof type and slopes, roof framing and spacing, overhangs, soffits, roof space-soffit space continuity... Site sketch, house orientation, elevation (above sea level), 'wind fetch' from house looking NSEW – photos.
   - Primarily CS (separate budget) by April 15th
3. Select, source and install instrumentation
   - **Primarily MUN**, by April 30-May 15th, approx $5000 (Stormfirma buys instrumentation or leases from MUN, internal funding)
4. Prepare and install VSVs: Fabricate prototypical VSVs specifically for these field tests, using lightweight plastic valves –so that VSV performance can be demonstrated even in winds of less than gale force. Devise and install "de-activators" on each VSV for these tests, to allow on-off "control" runs (see 5). Valve or seal off any other vents such as gable vents. Air seal the ceiling and soffits. Install an operable opening in the attic hatch to allow determination of air leakage effects on VSV performance. "Road test" all in strong winds, and report.
   - Primarily Stormfirma (internal funds) with MUN,
   - with air seal specialist (up to $4000)
   - and CS (sep. budget), by April 30th-May 15th
5. Monitor VSV performance during windstorms: Switch on instrumentation as gales come in, and run alternating on-off cycles of the VSVs through the worst hours. Open the defined 'air leak' during certain cycles. From the outside, video-record the valve action of windward and leeward VSVs concurrently with wind and pressure recordings, during gales from for at least two cardinal directions.
   - Primarily CS (sep. budget),
   - **with MUN**/Stormfirma $2000 by May 15th-30th
6. Analyze and Report in full: Determine the efficacy of VSVs in depressurizing the roof space with winds/gusts from various directions; the effect of normal venting likewise, in pressurizing as well as depressurizing; the effects of air leakage, roughly; the calculated reductions/increases in uplift forces on the sheathing.
   - **Primarily MUN**, up to $7000, by May 30th-June 15th

Stormfirma Inc.
R. E. Platts, P.Eng.
bobplatts@yahoo.com

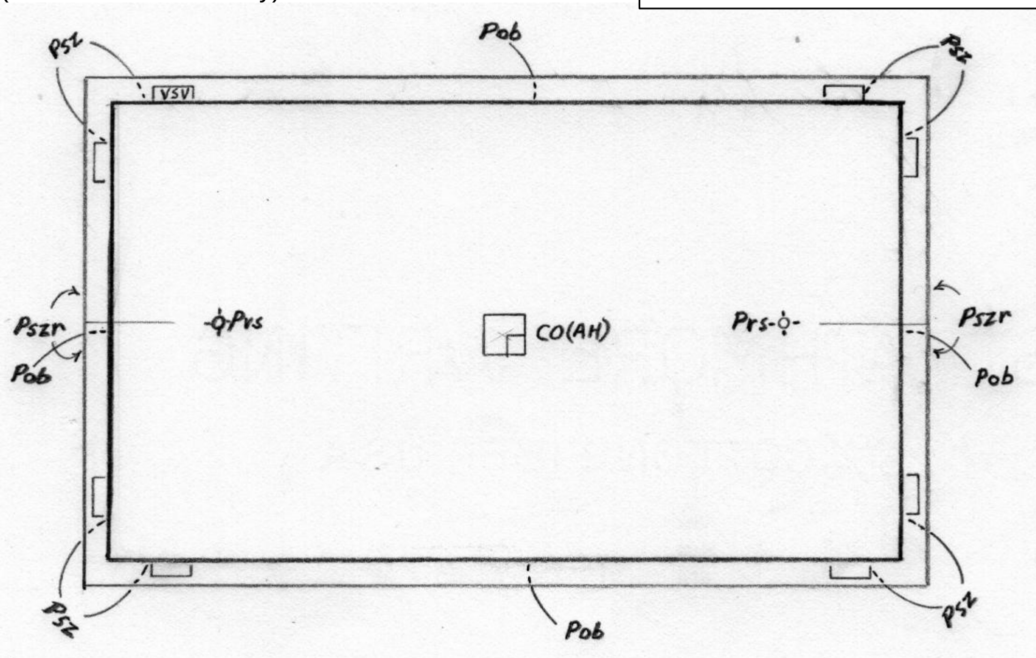
Field testing VSVs in high winds:

Instrumentation Options for Test House

(Assuming: simple rectangular plan, with soffited overhangs all 'round –either hip roof or gable roof with rake overhangs; VSVs in separation zones only, as shown; alternating test runs during windstorms with vents normal vs. runs with vents valved.)
Datalogger indoors below ceiling; connections through DO(AH)?

Prs –pressure tap in roof space
Pob –press outside building under soffit, middle of wall length
Psz –press separation zone under soffit
Pszr – press sep zone <u>over</u> roof
DO(AH) –defined opening (e.g. in attic hatch; variable?)
MS –meteorological station
WS –on-site wind station

PLAN VIEW OF ROOF & SOFFIT SPACE
(roof removed for clarity):



Level 1 setup (usable minimum package; 2 press. taps)
Prs+MS
Level 2 setup (defensible minimum; 6 press. taps)
Prs+Pob+MS+DO(AH)
Level 3 setup (preferred minimum; 6 press. taps)
Prs+Pob+MS+WS+DO(AH)
Level 4 setup (desirable research package; 14 press. taps)
Prs+Pob+Psz+MS+WS+DO(AH)
Level 5 setup (definitive research package; 18 press taps)
Prs+Pob+Psz+Pszr+MS+WS+DO(AH)

<u>Favoured for first field trial: Level 3;</u> Level 2 okay. Does MUN prefer 4 or 5 for better research?

REP, 15 Mar 06
revised 31 Mar 06

APPENDIX B

Proposal Work Scope and Sub Tasks

Work Scope and Sub Tasks:

Task A - PLAN

1. Develop understanding of project request and the purpose of the proposed device, review and refine client ***draft work plan (Appendix A)***.
2. Establish and manage the project schedule and budget, incl. communications between all stakeholders
3. Evaluate the characteristics and configuration of the proposed test house in Pouch Cove (Cyril Snook, homeowner, directly contracted to client).
4. Design an instrumentation and data acquisition system to meet the technical and scheduling needs of the client.
5. Source the DA equipment, configure it for the test program and perform lab test.

Task B - FIELD

6. Mobilize kit into the field by setting up the met station and installing pressure transducers while minimizing household disturbances with the positioning of the tubing, wires, and D.A. test base station.
7. Perform brief field trial for troubleshooting.
8. Begin monitoring
9. VSV installation and house HVDC modifications performed by others on an ASAP basis either before or after system monitoring begins.
10. Check ongoing system performance and perform routine data downloads.
11. Host a client site visit and accommodate specific performance tests over a few day period for a few hours each day.
12. Perform pressure measurement tests with, and without, the VSV's in operational mode during gusty conditions.
13. End data acquisition program after approximately 4-6 weeks of operation. Demobilize the equipment back to Memorial University.

Task C - REPORT

14. Download, backup, calibrate, label and package digital data in DVD format.
15. Perform first order review of pressure activity during one or more key meteorological events and provide plotted results.
16. Write a report that provides an overview of the test program, describes the data acquisition, lists the data, provides brief analysis of key event(s) and lists salient observations of, and recommendations for, the tested VSV product.
17. Courier digital and three hard copies of the draft final report and data DVD(s) to the client on or before June 15th, 2006.
18. Receive and consider the draft report review by client and incorporate into final report issue.

APPENDIX C

Proposal Schedule

SCHEDULE WINDOW FOR EACH TASK													
			Schedule	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
TASK A - PLAN			Start date	16-Apr-06	23-Apr-06	30-Apr-06	7-May-06	14-May-06	21-May-06	28-May-06	4-Jun-06	11-Jun-06	18-Jun-06
	1	Review and refine project parameters	17-Apr	■	■								
	2	Develop budget, schedule, project team			■								
	3	Evaluate Pouch Cove house			■	■							
	4	Design D.A. System			■	■							
	5	Source D.A. and perform Lab tests				■	■						
TASK B - FIELD													
	6	Mobilization of equipment					■	■					
	7	Field trial troubleshooting					■	■					
	8	Commence monitoring						■					
	9	VSV installation, HVAC mods.					■	■	■				
	10	Routine maintenance data downloads						■	■	■	■	■	
	11	Client site visit						■	■				
	12	Perform control tests						■	■	■	■	■	
	13	Demobilization										■	
TASK C - REPORT													
	14	Data storage and handling										■	
	15	First-order analysis										■	
	16	Write report										■	■
	17	Send draft report										■	■
	18	Finalize report											■

APPENDIX D

Pressure Transducer Specifications

6.0 RETURNING PRODUCTS FOR REPAIR

Please contact a Setra application engineer (800-257-3872, 978-263-1400) before returning unit for repair to review information relative to your application. Many times only minor field adjustments may be necessary. When returning a product to Setra, the material should be carefully packaged and shipped prepaid to:

Setra Systems, Inc.
159 Swanson Road
Boxborough, MA 01719-1304
Attn: Repair Department

To assure prompt handling, please supply the following information and include it inside the package or returned material:

1. Name and phone number of person to contact.
2. Shipping and billing instructions.
3. Full description of the malfunction.
4. Identify any hazardous material used with product.

Notes: Please remove any pressure fittings and plumbing that you have installed and enclose any required mating electrical connectors and wiring diagrams.

Allow approximately 3 weeks after receipt at Setra for the repair and return of the unit. Non-warranty repairs will not be made without customer approval and a purchase order to cover repair charges.

Calibration Services

Setra maintains a complete calibration facility that is traceable to the National Institute of Standards & Technology (NIST). If you would like to recalibrate or recertify your Setra pressure transducers or transmitters, please call our Repair Department at 800-257-3872 (978-263-1400) for scheduling.

7.0 WARRANTY AND LIMITATION OF LIABILITY

SETRA warrants its Model 265 Transducer products to the original consumer purchaser against defects for a period of one year from the date of sale by SETRA, as shown in its shipping documents.
Without charge, SETRA will repair or replace products found to have manufacturing defects within the warranty period.
The serial number or date code must not have been removed, defaced or otherwise changed.
SETRA must be notified in advance of any returns; any products returned to SETRA must be transportation prepaid.
The foregoing warranty is in lieu of all warranties, express, implied or statutory, including but not limited to, any implied warranty of merchantability for a particular purpose.
SETRA's liability for breach of warranty is limited to repair or replacement, or if the goods cannot be repaired or replaced, to a refund of the purchase price. SETRA's liability for all other breaches is limited to a refund of the purchase price. In no instance shall SETRA be liable for incidental or consequential damages arising from a breach of warranty, or from the use or installation of its products.
No representative or person is authorized to give any warranty other than as set out above or to assume for SETRA any other liability in connection with the sale of its products.

159 Swanson Road, Boxborough, MA 01719-1304
Tel: 800-257-3872/978-263-1400

SS2009 Rev.F 08/08/01

Installation Guide

Setra Systems Model 265
Differential Pressure Transducer

1.0 GENERAL INFORMATION

Every Model 265 has been tested and calibrated before shipment. Specific performance specifications are shown on page 3 of this Guide.

Setra Systems 265 pressure transducers sense differential or gage (static) pressure and convert this pressure difference to a proportional high level analog output for both unidirectional and bidirectional pressure ranges. The Model 265 is available in the following excitation and output versions:

Excitation	Output
9-30 VDC	0-5 VDC
9-30 VAC	0-5 VDC
12-30 VAC	0-10 VDC
9-30 VDC (measured between the + and - terminals)	4-20 mA

Check the label on the unit to confirm the excitation and ouput.

2.0 MECHANICAL INSTALLATION

2.1 Media Compatibility

Model 265 transducers are designed to be used with air or nonconducting gases. **Use with liquids or corrosive gases will damage the unit.**

2.2 Environment

The operating and compensated temperature limits of the 265 are 0℉ to +150℉ (-18℃ to +65℃).

2.3 Pressure Fittings

The Model 265 is supplied with two factory installed 1/4" O.D. pressure fittings for the pressure signal connection and typically installed with 1/4" push-on tubing. Both the positive (high) pressure port and the reference (low) pressure port are located on the front of the unit, labeled "HIGH" and "LOW" respectively. For best results (shortest response times), 3/16" I.D. tubing is suggested for tubing lengths up to 100 feet long, 1/4" I.D. for tubing lengths up to 300 feet, and 3/8" I.D. for tubing lengths up to 900 feet.

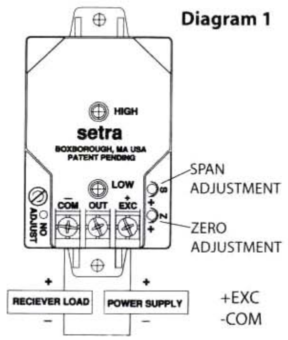
3.0 ELECTRICAL INSTALLATION

If the Model 265 is supplied with the optional Conduit Enclosure, access the electrical terminations by removing the cover.

3.1 Voltage Output Units

The Model 265 voltage output is a 3-wire circuit, with three terminals available for wiring. These terminals have the designation COM, OUT and EXC (see Diagram 1). [Note: The - designation above COM and the + designation above EXC are designations for the current output terminals.] The -Excitation and -Output are commoned on the circuit (see Diagram 2). The 265 voltage output can operate from 9-30 VDC or 9-30 VAC excitation with 0-5 VDC output, or 12-30 VAC excitation with 0-10 VDC output.

Diagram 1



Voltage Circuit Diagram

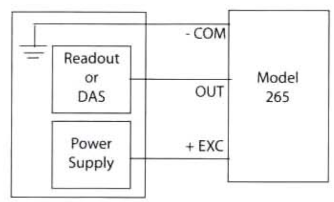


Diagram 2

+EXC	Connected to positive terminal of DC/AC power supply
-COM	Connect as the reference for power supply and output signal
OUT	Connect to positive terminal of control or pressure monitor

3.2 Current Output Units

The Model 265 is a two-wire loop-powered 4 to 20mA current output unit (see Diagram 3). The current flows into + terminal and returns back to the power supply through the - terminal (see Diagram 3). The power supply must be a DC voltage source with a voltage range between 9 and 30 measured between terminal + and - terminals. The unit is calibrated at the factory with a 24 VDC loop supply voltage and a 250 ohm load.

CurrentCircuit Diagram

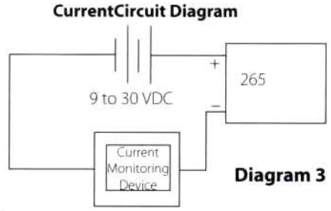


Diagram 3

4.0. CALIBRATION

The 265 transducer is factory calibrated and should require no field adjustment. Generally, the mounting position will have a zero shift effect on ranges below 1"WC. Whenever possible, any zero and/or span offsets should be corrected by software adjustment in the user's control system. However, both zero and span adjustments are accessible either on the front of the unit or by removing the optional conduit enclosure. The 265 transducer is calibrated in the vertical position at the factory.

4.1 Voltage Output Zero Adjustment

While monitoring the voltage between the positive output (OUT) and common (COM), and with both pressure ports open to atmosphere, the zero may be adjusted by turning the zero adjustment screw. (See Diagram 1 for

2

location of zero adjustment.) For 0-5 VDC output units, the factory settings are 0.0VDC (±50mV) for unidirectional pressure ranges and 2.5VDC (±50mV) for bidirectional pressure ranges. Optional outputs are set at the same ±1% factory setting.

4.2 Voltage Output Span Adjustment (Complete the zero adjustment before setting span.)

Span or full scale output adjustments should only be performed by using an accurate pressure standard (electronic manometer, digital pressure gage, etc.), with at least comparable accuracy to the 265 transducer (<±1% FS). With full range pressure applied to the high pressure port (reference port open to atmosphere), the span may be adjusted by turning the SPAN adjustment screw. (See Diagram 1 for location of the SPAN adjustment.) For 0-5 VDC output units, the factory settings are 5.0 VDC (±50mV) for unidirectional and bidirectional ranges. Optional outputs are set at the same ±1% factory setting.

4.3 Current Output Zero Adjustment

While monitoring the current output between +EXC and OUT, and with both pressure ports open to atmosphere, the zero may be adjusted by turning the zero adjustment screw. (See Diagram 1 for location of zero adjustment.) The factory settings are 4mA (0.16mA) for unidirectional pressure ranges and 12mA (0.16mA) for bidirectional ranges.

4.4 Current Output Span Adjustment

Span or full scale output adjustments should only be performed by using an accurate pressure standard (electronic manometer, digital pressure gage, etc.) with at least comparable accuracy to the 265 transducer (<±1% FS). With full range pressure applied to the high pressure port (reference port open to atmosphere), the span may be adjusted by turning the SPAN adjustment screw. (See Diagram 1 for location of SPAN adjustment.) The factory settings are 20mA (0.16mA) for unidirectional and bidirectional pressure ranges.

5.0 MODEL 265 PERFORMANCE SPECIFICATIONS

Accuracy RSS*	±1.0% FS	Thermal Effects	
(at constant temperature.)		Compensated Range °F(°C)	0 to +150 (-18 to +65)
Non-Linearity, BFSL	±0.98% FS	Zero/Span Shift %FS/°F(°C)	0.033 (0.06)
Hysteresis	0.1% FS	Maximum Line Pressure	10 psi
Non-Repeatability	0.05% FS	Overpressure	10 psi in positive or negative direction
*RSS of Non-Linearity, Non-Repeatability and Hysteresis.		Warm-up Shift	±0.1% FS total
Position Effects			
(Unit is factory calibrated at 0g effect in the vertical position)			
Range	Zero Offset (%FS/G)		
0 to 1" WC	.22		
0 to 5" WC	.14		
0 to 30" WC	.06		

3

APPENDIX E

Torbay International Airport Wind Environment

St. John's Meteorology

St. John's Airport is located in the northeast corner of the Avalon Peninsula and is in close proximity to water in almost every direction. The elevation of the Airport is about 450 feet and the terrain slopes steadily downward towards Torbay, reaching sea level. To the east, cliffs rise to over 500 feet at the ocean edge. Marshland, at an elevation of 200 or 300 feet, lies beyond these cliffs.

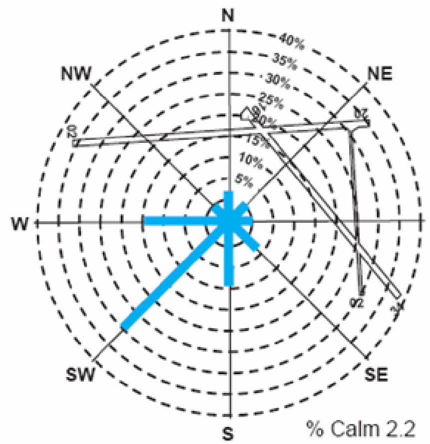
The winds at St. John's are, for the most part, determined by large-scale weather systems. The prevailing wind direction is from the western quadrant but does vary slightly from season to season. Winds during the winter are predominantly from the west, whereas summer winds exhibit a shift to a more southwesterly direction due to the strengthening of the Bermuda High over the Atlantic Ocean. The stronger winds generally occur in the winter and are always associated with storms moving northeastward near Newfoundland. Gusts of up to 35 knots occur frequently at St. John's and often persist for prolonged periods of time. Winds with gusts to 35 knots or more occur most frequently from the southwest. Very strong winds with gusts to 60 knots or more occur mostly with very deep, low pressure systems that pass to the west of the Avalon Peninsula. Calm winds, on the other hand, only occur about 2% of the time.

Although sea breeze activity does occur at St. John's, its overall effect on the prevailing wind direction is small. Even if the water temperatures are favourable for the development of sea breezes, the prevailing wind speed and direction are often such that any sea breeze formation will be suppressed. When they do develop, sea breezes at St. John's tend to be between 120 and 150 degrees or between 40 and 60 degrees.

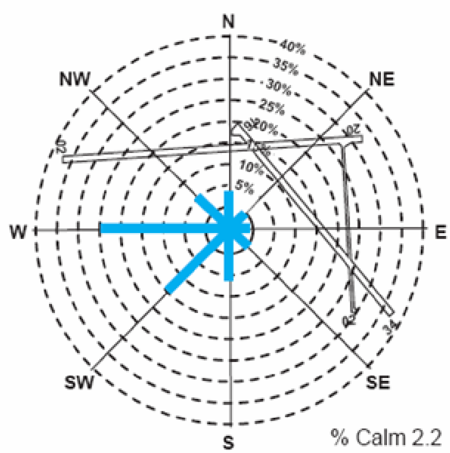
St. John's Airport has a reputation for being one of the foggiest airports in Canada. The worst cases by far occur during the spring. Low ceilings and visibility are extremely common when winds are from the northeast to southeast. This is due to the upslope nature of the terrain and the air's prolonged exposure to the ocean when winds are from these directions. As seen from the winter diagram, when IFR conditions are present, there is very little diurnal variation. In the summer time, sea fog may move inland at night, however, it often burns off during the day accounting for the more pronounced improvement after about 1000 UTC on the summer diagram.

The fall is more stable at St. John's in that IFR conditions are generally less frequent during this time than during all other seasons. Although very low conditions sometimes exist in mild flow, particularly if fog blankets the water south of the Avalon Peninsula, operational ceilings usually exist in the winter especially when winds are from the western quadrant. IFR conditions in this season are often due to snow and blowing now and can be quite variable. A particular hazard to aviation that develops frequently at St. John's is freezing precipitation, which occurs an average of 175 hours each year.

St John's (Torbay)
Wind Frequency by Direction
Summer



St John's (Torbay)
Wind Frequency by Direction
Winter



Source: NavCanada at: www.navcanada.ca/ContentDefinitionFiles/publications/lak/atlantic/5-AE34.PDF

REVISIONS		DATE
A		
B		
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D		
E		
F		
G		

Memorial University of Newfoundland

Faculty of Engineering & Applied Science

PROJECT TITLE
WIND ENGINEERING RESEARCH LABORATORY

DRAWING TITLE
ST. JOHN'S METEOR. DATA

CHECKS

PROJECT NO.	DRAWING NO.
WERL06-P1	P1-SITE-01
DATE FEB., 2006	DRAWN BY SEB