Comparison of Air Velocity Measurement Techniques

By:

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Introduction

SRK compared measurement techniques and compared results for:

Medium to high velocity:

1. Detailed grid survey using hot wire anemometer
2. Mechanical and digital anemometer measurements

Low velocity:

1. Grid survey with smoke tube
2. Traditional smoke tube survey

Instruments

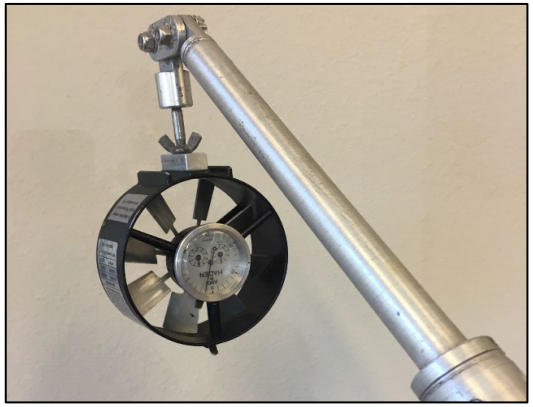
TSI Alnor model 9535 hot wire anemometer

A hot wire anemometer measures the air velocity by measuring heat transfer from a small wire or film immersed in the air. The rate of which heat is removed from the sensor is directly related to the velocity of the fluid flowing over the sensor.

Instruments

TSI Alnor model RVA 501 digital anemometer and Davis medium speed mechanical anemometer

Alnor digital anemometer



Davis mechanical anemometer

A vane anemometer works on the principle that the freely turning turbine will rotate at a speed directly proportional to the wind speed. Readings may need to be adjusted per calibration certificate.

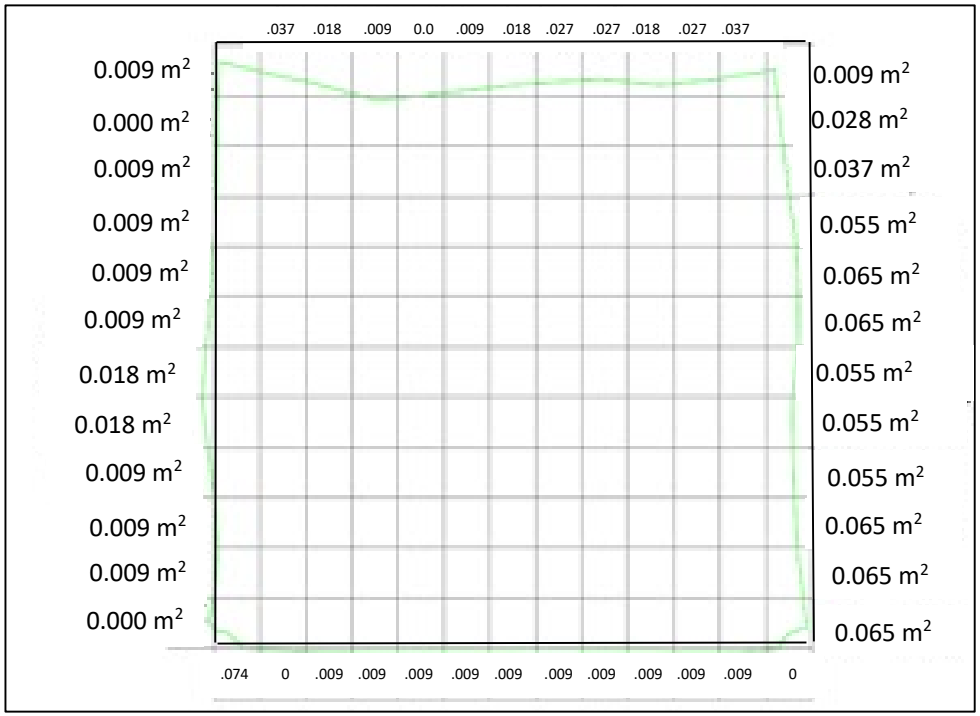
Instruments

Smoke tubes - Draeger tube with aspirator

Smoke tubes works on the principle the smoke will be timed over a known distance giving a velocity. Correction factors are applied to this technique.

High Velocity Measurements

A detailed grid was measured for an entry as follows:



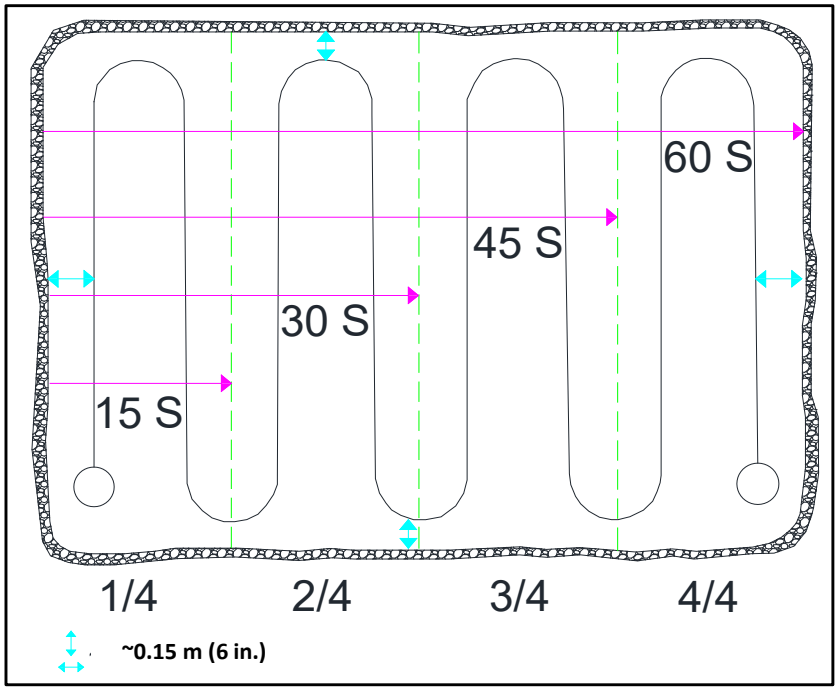
Areas around perimeter are added or subtracted from the perimeter grids to accurately account of measurement area

Grid Measurements

- Grid was established with horizontal string and the hot wire anemometer was positioned in the center of each grid.
- The hot wire was set at one second intervals over a 10 second time average. In this way, each grid location would be an average of 10 readings.
- The method to take data was to position the probe at the measurement location ensuring the sensor alignment is correct and wait until the instrument appeared to give stable results.

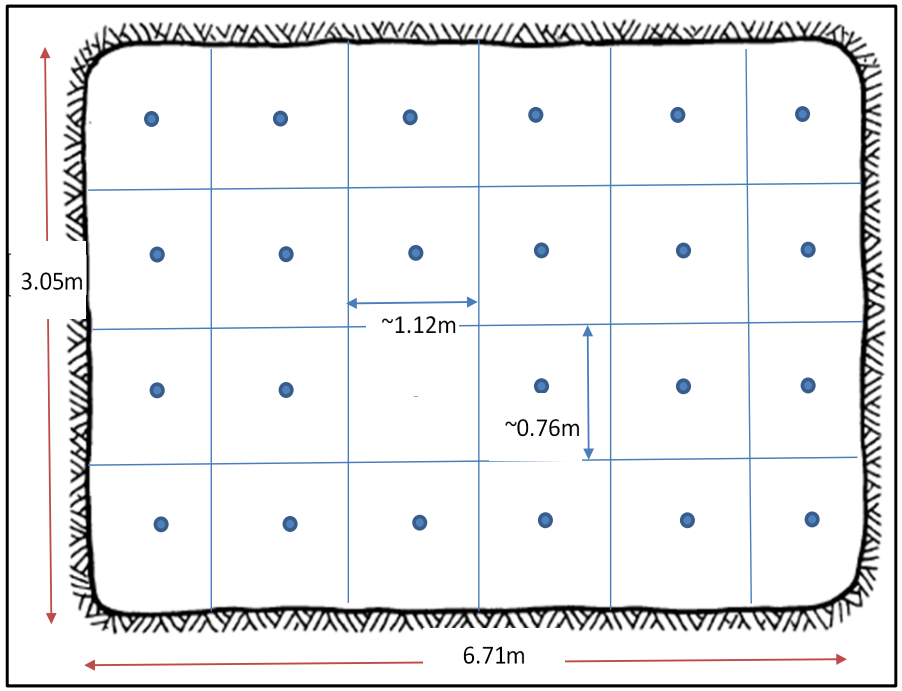
Anemometer Measurements

- A traverse was performed for both the digital and mechanical anemometers based on the traverse method below



Low Velocity Measurements

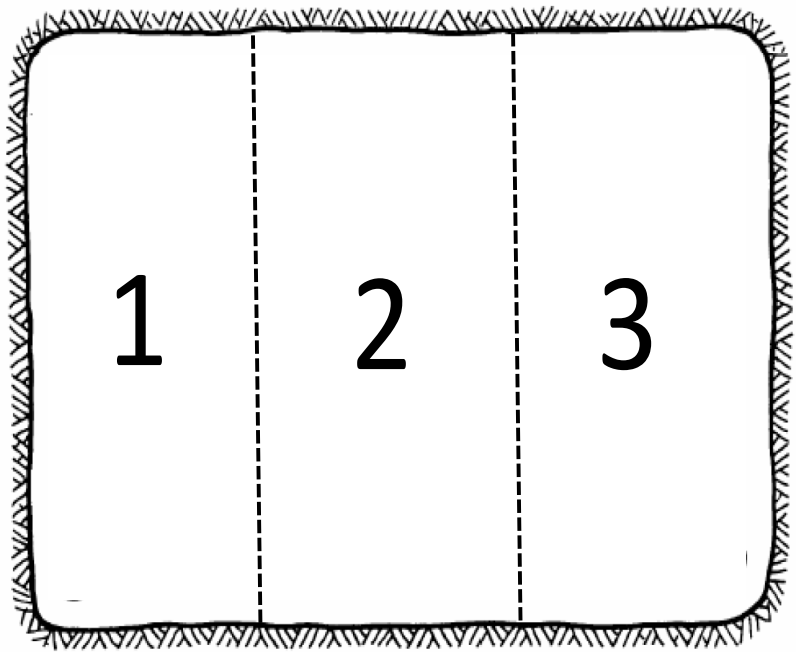
A 24-point grid was measured for a low velocity entry as follows:



- A smoke tube is used to determine flow direction in each grid.
- The hot wire anemometer is used to measure the center point in each grid.

Low Velocity Measurements

The grid survey was compared to a traditional smoke tube survey where the airway is divided into thirds:



- A smoke tube is used to determine flow direction in each third.
- The average smoke speed is recorded in each section and averaged (at least two measurements).
- A correction value of 0.8 was applied to each smoke reading.

Comparison of Measurement Techniques

- Detailed grid against anemometer readings
- Less detailed grid against anemometer readings
- 24-point smoke tube/grid survey against traditional smoke tube survey.

Grid Survey Results (m/s)

2.29	2.11	2.19	2.49	2.04	1.78	2.05	2.26	2.35	2.48	2.38	2.23	Not Read
2.44	2.31	2.51	2.83	2.62	2.56	2.60	2.77	2.82	2.67	2.50	2.54	1.61
2.55	3.08	2.98	3.20	3.01	2.97	3.04	3.24	3.25	3.07	3.11	2.57	2.03
2.68	3.29	3.35	3.23	3.25	2.96	3.18	3.30	3.15	3.23	2.82	2.44	2.01
2.59	2.91	3.49	3.48	3.54	3.29	3.58	3.51	3.60	3.25	3.12	2.55	2.04
2.36	2.88	3.20	3.29	3.20	3.31	3.37	3.35	3.36	2.90	2.89	2.58	2.11
1.79	2.27	2.78	3.14	2.95	2.98	3.01	3.01	2.86	2.72	2.41	2.14	1.74
2.16	2.59	2.70	3.16	3.11	3.13	2.94	2.79	2.60	2.60	2.39	2.24	1.62
1.80	2.55	3.24	3.37	3.42	3.45	3.32	3.27	3.10	3.00	2.70	2.24	1.51
1.94	2.68	3.05	3.29	3.38	3.37	3.48	3.07	3.08	3.20	2.85	2.58	1.84
1.51	2.67	2.87	2.90	2.95	3.04	2.93	2.76	2.64	2.67	2.51	2.26	1.95

Grid Survey Results (m^3/s)

0.32	0.27	0.24	0.23	0.19	0.18	0.23	0.27	0.28	0.28	0.29	0.29	Not Read
0.23	0.21	0.23	0.26	0.24	0.24	0.24	0.26	0.26	0.25	0.23	0.24	0.06
0.26	0.29	0.28	0.30	0.28	0.28	0.28	0.30	0.30	0.29	0.29	0.24	0.11
0.27	0.31	0.31	0.30	0.30	0.27	0.30	0.31	0.29	0.30	0.26	0.23	0.13
0.26	0.27	0.32	0.32	0.33	0.31	0.33	0.33	0.33	0.30	0.29	0.24	0.13
0.24	0.27	0.30	0.31	0.30	0.31	0.31	0.31	0.31	0.27	0.27	0.24	0.12
0.18	0.21	0.26	0.29	0.27	0.28	0.28	0.28	0.27	0.25	0.22	0.20	0.10
0.24	0.24	0.25	0.29	0.29	0.29	0.27	0.26	0.24	0.24	0.22	0.21	0.09
0.20	0.24	0.30	0.31	0.32	0.32	0.31	0.30	0.29	0.28	0.25	0.21	0.10
0.18	0.25	0.28	0.31	0.31	0.31	0.32	0.29	0.29	0.30	0.26	0.24	0.12
0.11	0.25	0.27	0.30	0.33	0.31	0.30	0.28	0.27	0.27	0.26	0.23	0.13

Grid Survey Results

- Summing the flows for each grid equaled a flow of 36.86 m^3/s (78,100 cfm)

- Multiple digital and mechanical anemometer traverses resulted in flows of:
  - Digital anemometer: 40.66 m^3/s (86,170 cfm)
  - Mechanical Anemometer: 41.86 m^3/s (88,700 cfm)

High velocity with only a 24-point grid

- SRK compared the detailed grid pattern to a simplified 24-point grid pattern in the higher velocity airway. The results (in m^3/s):

2.82	3.66	2.51	3.29	2.71	2.02
3.66	3.21	3.98	3.45	2.46	2.80
3.66	3.33	3.75	3.86	3.21	2.58
2.82	2.29	3.40	2.99	3.24	2.56

Results showed a flow of 40.66 m^3/s (86,170 cfm)

Low Velocity Measurements (grid against traditional)

Grid Survey with hot wire anemomter

0.03	0.05	0.08	0.05	0.06	0.07
0.08	0.14	0.14	0.12	0.10	0.12
0.08	0.16	0.16	0.15	0.14	0.11
0.04	0.13	0.14	0.13	0.08	0.12

Average of all 24 Readings: 0.10 m/s 22.0 m^2 (surveyed)

Airflow **2.26** m^3/s

Smoke tube survey (multiple smoke measurements at each segment)

0.16	0.16	0.14

Average of all Smoke Readings: 0.15 m/s

Correction 0.8 Estimated

Airflow **2.71** m^3/s

Low Velocity Measurements (grid against traditional)

Grid Survey with hot wire anemomter

0.18	0.16	0.16	0.17	0.16	0.17
0.16	0.12	0.06	0.14	0.14	0.17
0.09	0.05	0.04	0.02	0.04	0.15
0.05	0.02	0.02	0.03	0.02	0.02

Average of all 24 Readings: 0.10 m/s 12.7 m^2 (surveyed)

Airflow **1.23** m^3/s

Smoke tube survey (multiple smoke measurements at each segment)

0.15	0.10	0.16

Average of all Smoke Readings: 0.14 m/s 12.7 m^2 (surveyed)

Correction 0.8 Estimated

Airflow **1.41** m^3/s

Low Velocity Measurements (grid against traditional)

Grid Survey with hot wire anemomter

-0.07	0.00	0.00	-0.04	-0.05	-0.03
0.00	0.06	0.00	0.04	0.05	0.03
0.07	0.07	0.00	0.00	0.04	0.03
0.07	0.08	0.07	0.05	0.00	0.06

Average of all 24 Readings: 0.02 m/s 21.7 m^2 (surveyed)

Airflow **0.45** m^3/s

Smoke tube survey (multiple smoke measurements at each segment)

0.10	0.03	0.00

Average of all Smoke Readings: 0.04 m/s 21.7 m^2 (surveyed)

Correction 0.8 Estimated

Airflow **0.73** m^3/s

Summary of Results

- Anemometer traverse was consistently higher than the detailed grid survey by between 8 to 15%.
- A less detailed grid survey gave higher airflows than the detailed grid survey.
- Data suggests that the detailed grid survey better defines the velocity at edges of airway.
  - Anemometer survey techniques should attempt to better capture the edge velocities.
  - Greater time may be needed for anemometer surveys.

Discussion

- The measurements presented are for a rectangular airway.
- For arched and irregular airways, the methodology and conclusions are still valid
  - Anemometer traverses need to be uniform across the area
  - Traverse needs to capture low velocities at perimeter.

Discussion

- For arched and irregular airways, the methodology and conclusions are still valid
  - Hot wire and smoke tube method will provide more consistent low velocity measurements.
  - Grid should be established based on rough equal areas for each measurement point.
  - Number of grid points will need to be determined based on airway geometry.

Summary of Results

- A 24-point smoke tube/hot wire method for low velocities gave more consistent values than traditional smoke tube methods (particularly for different observers taking the measurements).
- Correction factors on traditional smoke methods can very widely.
- There was no correlated finding comparing traditional smoke measurements versus 24-point survey techniques. The variability between the two methods was -25 to +100%.
- Inaccurate low volume measurements may not be of any significant importance to a model or overall ventilation system description for most operations.