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ANEMOMETER CALIBRATION PROCEDURES

UNITED STATES DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
TECHNICAL SUPPORT DIVISION

ANEMOMETER CALIBRATION PROCEDURE

December 2009

by

Staff, Ventilation Division

Originating Office

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INTRODUCTION

While calibration curves for various anemometers are indicative of the calibration curve for the type and manufacturer of the instrument, the individual curves vary due to slight differences in composition and wear of the inner components of each instrument. As a result, in order to obtain the most accurate velocity determinations possible, each anemometer must be calibrated.

The Mine Safety and Health Administration (MSHA) has established an anemometer calibration program which utilizes an open jet wind tunnel and various primary reference instruments calibrated by the National Institute of Standards and Technology (NIST). Current policy dictates that workbench standard anemometers and field anemometers must be calibrated on at least an annual basis. To ensure that calibration throughout MSHA is uniform and can be traced back to the NIST standard reference instruments, a standard calibration procedure must be followed by all responsible personnel.

The following step-by-step procedure is used by the Ventilation Division of the Pittsburgh Safety and Health Technology Center (PSHTC) to calibrate a workbench standard and should be followed to calibrate field anemometers.

TESTING PROCEDURE

1. The Airflow Dynamic Open Jet Wind Tunnel should be set up as described in the manufacturer's operating manual. Care should be taken to prevent air disturbances (open doors and windows) from interfering with airflow from the wind tunnel.

2. Set the anemometer test stand so that anemometers are exactly six inches away from the jet opening of the wind tunnel.

3. For the 4-inch rotating vane anemometer, normal calibration includes the determination of seven points along the calibration curve: 2000 fpm, 1500 fpm, 1000 fpm, 750 fpm, 500 fpm, 250 fpm and 100 fpm.

4. Start fan. Allow the fan to run 15-20 minutes prior to beginning calibration to allow the system to stabilize.

Note: Each anemometer should be checked to ensure that the vanes spin freely at an approximate velocity of 100 fpm before beginning the calibration process. This should be done so that time is not wasted calibrating an anemometer at the higher velocities only to discover it will not turn at the lower velocities. If an anemometer does not spin freely at an approximate velocity of 100 fpm, then the anemometer should be repaired or discarded.

5. Approximate velocities are set using the following table which provide the velocity versus the pressure drop across the orifice to select the orifice plate best suited for the calibration velocity being run:

Velocity (fpm)	Orifice Diameter (inches)	Pressure Drop Across Orifice (inches of water)
2000	6.450	0.29
1500	4.000	1.69
1000	4.000	0.76
750	4.000	0.42
500	4.000	0.19
250	2.842	0.18
100	1.268	0.77

Insert orifice into orifice plate clamp. Close the clamp.

Note: Actual velocities are determined with the reference instrument. It was decided not to use the orifice plate as a reference because calculations involving temperature and barometric pressure corrections on the pressure drop across the orifice would be as time-consuming as taking a velocity reading with the reference instrument.

6. Use the rheostat to set the pressure drop across the orifice on manometer to correspond to orifice pressure at the desired velocity.

   Note: It may be necessary to change orifice plate when changing from one test velocity to another.

7. Wait two minutes to assure the wind tunnel air velocity is stabilized.

8. Record the desired velocity, orifice size, and pressure drop across the orifice on a data sheet. (Figure 1)

9. Rotate the anemometer stand until reference NIST standard anemometer (workbench standard) is directly in front of jet opening.

   Note: Be sure that the anemometer is centered in and perpendicular to the airstream.

10. Take two readings at desired velocity of calibration on the workbench standard anemometer--record readings and anemometer serial number on data sheet. (Figure 2)

    Note: When calibrating an anemometer, set anemometer in airstream with dial on zero. Anemometer should be started simultaneously as stopwatch is started. When measuring velocities, dial should be allowed to record for 60.0 seconds--velocity is equal to dial reading.

11. Take two readings on each anemometer being calibrated at the same velocity without changing the pressure drop across the orifice--record readings and anemometer serial numbers on data sheet. (Figure 3)

    Note: A maximum of six test anemometers should be calibrated at one time.

12. Take two more readings on the workbench standard to ensure that the velocity did not change during the test period--record readings on data sheet. (Figure 4)

    Note: If velocity changes significantly (+ or - 1 percent from the initial NIST reading), use this NIST reading as initial NIST reading and repeat steps 11 and 12 above.

13. Rotate all anemometers out of the airstream. Reduce test velocity. Repeat steps 5 through 12 for each anemometer at each of the calibration velocities--record all information on data sheet. (Figure 5)

14. When calibrating a workbench standard anemometer repeat steps 5 through 13 two additional times. This procedure will give a 3-point data grouping at each test velocity for increased accuracy of calibration.

CALCULATIONS

1. When calibration is performed on a workbench standard anemometer by the Ventilation Division, PSHTC, a plot is constructed showing indicated velocity versus velocity correction factor. This curve is mailed out along with the calibrated instrument to responsible personnel. It must be used in conjunction with the reference instrument for subsequent calibration of field anemometers. (Figure 6)

2. The velocity correction from this curve should be added or subtracted from average indicated velocity readings on the NIST anemometer in columns 4 and 18 of the data sheet to obtain true velocities in columns 5 and 19. (Figure 7)

3. To obtain the velocity correction in Columns 7, 9, 11, 13, 15 and 17, subtract average indicated readings in columns 6, 8, 10, 12, 14 and 16 from the average true velocities. (Figure 8)

   Note: Calculate an average true velocity for each test with the following equation:

$$\frac{\text{Column } 5 + \text{Column } 19}{2}$$

4. Plot on a graph the velocity correction vs. indicated velocity for each instrument. Connect the points with a smooth curve. It is important to realize that velocity correction factors cannot be extrapolated. Therefore, the graphs can not be extended beyond the lowest and highest indicated velocities obtained during calibration. (Figures 9 - 12)

   Note: If the anemometer is a workbench standard, there will be three data points to be plotted at each test velocity. The points must be within + or - 1 percent of each other or the odd point must be run again.

5. Read the values from the graph and fill in the correction factor chart for each anemometer calibrated. Tape one copy of the chart to the instrument for quick reference and keep a copy of the charts on file. (Figure 13)

   Note: If the lowest indicated velocity obtained during calibration was 100 fpm, then the correction chart cannot be completed for indicated velocities less than 100 fpm.

Figure 1 - Sample Anemometer Calibration Data Sheet Completed for Step 8 of Testing Procedure

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read.	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
2000	6.450	0.29																
1500	4.000	1.69																
1000	4.000	0.76																
750	4.000	0.42																
500	4.000	0.19																
250	2.842	0.18																
100	1.268	0.77																

Figure 2 - Sample Anemometer Calibration Data Sheet Completed for Step 10 of Testing Procedure

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
Serial #			34677															
2000	6.450	0.29	2141 2142															
1500	4.000	1.69																
1000	4.000	0.76																
750	4.000	0.42																
500	4.000	0.19																
250	2.842	0.18																
100	1.268	0.77																

Figure 3 - Sample Anemometer Calibration Data Sheet Completed for Step 11 of Testing Procedure

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read.	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
Serial #			34677		22860		22881		24678		23001							
2000	6.450	0.29	2141 2142		2149 2147		2190 2188		2152 2154		2160 2165							
1500	4.000	1.69																
1000	4.000	0.76																
750	4.000	0.42																
500	4.000	0.19																
250	2.842	0.18																
100	1.268	0.77																

Figure 4 - Sample Anemometer Calibration Data Sheet Completed for Step 12 of Testing Procedure

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read.	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
Serial #			34677		22860		22881		24678		23001						34677	
2000	6.450	0.29	2141 2142		2149 2147		2190 2188		2152 2154		2160 2165						2140 2143	
1500	4.000	1.69																
1000	4.000	0.76																
750	4.000	0.42																
500	4.000	0.19																
250	2.842	0.18																
100	1.268	0.77																

Figure 5 - Sample Anemometer Calibration Data Sheet Completed for Step 13 of Testing Procedure

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read.	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
Serial #			34677		22860		22881		24678		23001						34677	
2000	6.450	0.29	2141 2142		2149 2147		2190 2188		2152 2154		2160 2165						2140 2143	
1500	4.000	1.69	1582 1584		1590 1590		1610 1611		1592 1595		1592 1594						1583 1581	
1000	4.000	0.76	1044 1047		1054 1056		1069 1070		1062 1064		1057 1058						1047 1049	
750	4.000	0.42	774 774		783 783		793 793		788 786		782 784						772 774	
500	4.000	0.19	522 526		536 535		542 542		537 538		528 232						525 528	
250	2.842	0.18	229 230		238 238		240 240		232 233		230 232						230 231	
100	1.268	0.77	78 78		82 82		87 87		87 87		76 78						78 78	

Figure 6 - Sample Calibration Curve for Low Speed Bench Standard Anemometer (Serial No. 34677)

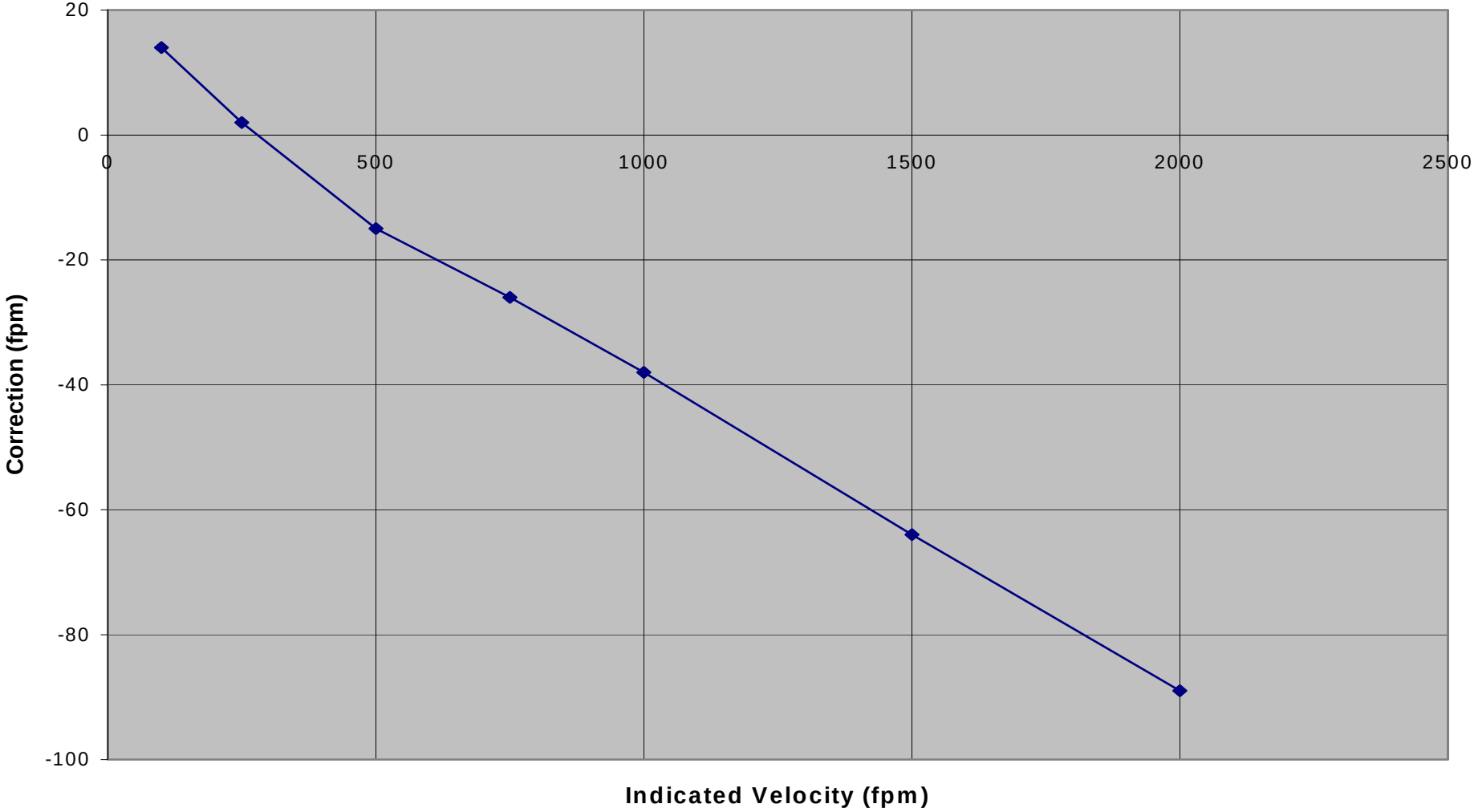

Figure 7 - Sample Anemometer Calibration Data Sheet Completed for Step 2 of Calculations

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read.	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
Serial #			34677		22860		22881		24678		23001						34677	
2000	6.450	0.29	2141 2142		2149 2147		2190 2188		2152 2154		2160 2165						2140 2143	
			2142	2053													2142	2053
1500	4.000	1.69	1582 1584		1590 1590		1610 1611		1592 1595		1592 1594						1583 1581	
			1583	1519													1582	1518
1000	4.000	0.76	1044 1047		1054 1056		1069 1070		1062 1064		1057 1058						1047 1049	
			1046	1008													1048	1010
750	4.000	0.42	774 774		783 783		793 793		788 786		782 784						772 774	
			774	748													773	747
500	4.000	0.19	522 526		536 535		542 542		537 538		528 232						525 528	
			524	509													527	512
250	2.842	0.18	229 230		238 238		240 240		232 233		230 232						230 231	
			230	232													231	233
100	1.268	0.77	78 78		82 82		87 87		87 87		76 78						78 78	
			78	92													78	92

Figure 8 - Sample Anemometer Calibration Data Sheet Completed for Step 3 of Calculations

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Desired Velocity	Orifice Size	♠ P	NIST Anem. Read.	True Vol.	Anem. Read. 1	Corr. Fact.	Anem. Read. 2	Corr. Fact.	Anem. Read. 3	Corr. Fact.	Anem. Read. 4	Corr. Fact.	Anem. Read. 5	Corr. Fact.	Anem. Read. 6	Corr. Fact.	NIST Anem. Read.	True Vol.
Serial #			34677		22860		22881		24678		23001						34677	
2000	6.450	0.29	2141 2142		2149 2147		2190 2188		2152 2154		2160 2165						2140 2143	
			2142	2053	2148	-95	2189	-136	2153	-100	2163	-110					2142	2053
1500	4.000	1.69	1582 1584		1590 1590		1610 1611		1592 1595		1592 1594						1583 1581	
			1583	1519	1519	-71	1611	-92	1594	-75	1593	-74					1582	1518
1000	4.000	0.76	1044 1047		1054 1056		1069 1070		1062 1064		1057 1058						1047 1049	
			1046	1008	1055	-47	1070	-62	1063	-55	1058	-50					1048	1010
750	4.000	0.42	774 774		783 783		793 793		788 786		782 784						772 774	
			774	748	783	-35	793	-45	787	-39	783	-35					773	747
500	4.000	0.19	522 526		536 535		542 542		537 538		528 232						525 528	
			524	509	536	-27	542	-18	538	-29	530	-21					527	512
250	2.842	0.18	229 230		238 238		240 240		232 233		230 232						230 231	
			230	232	238	-6	240	-8	233	-1	231	1					231	233
100	1.268	0.77	78 78		82 82		87 87		87 87		76 78						78 78	
			78	92	82	10	87	5	87	5	77	15					78	92

Figure 9 - Sample Calibration Curve for Low Speed Anemometer (Serial No. 22860)

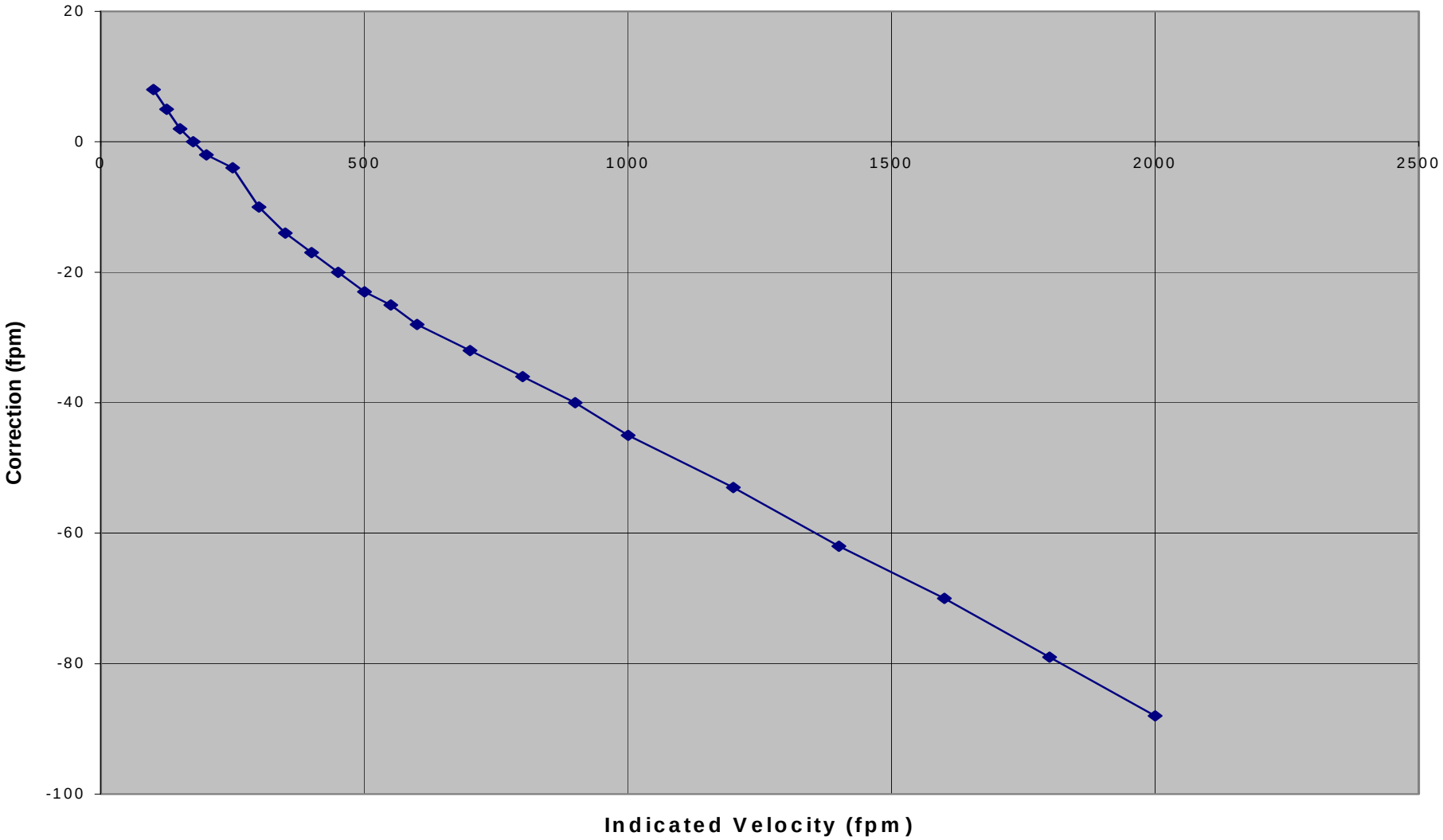

Figure 10 - Sample Calibration Curve for Low Speed Anemometer (Serial No. 22881)

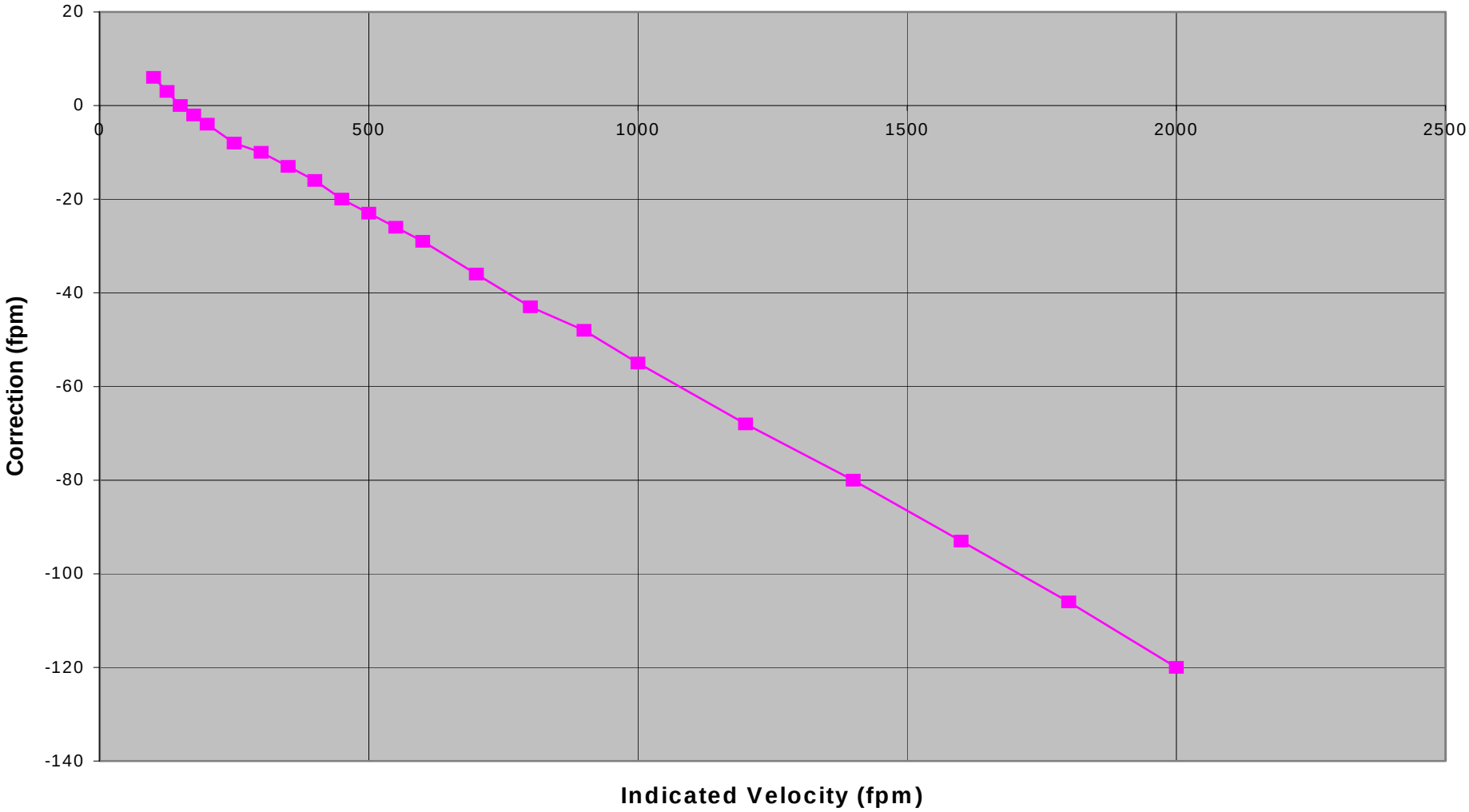

Figure 11 - Sample Calibration Curve for Low Speed Anemometer (Serial No. 24678)

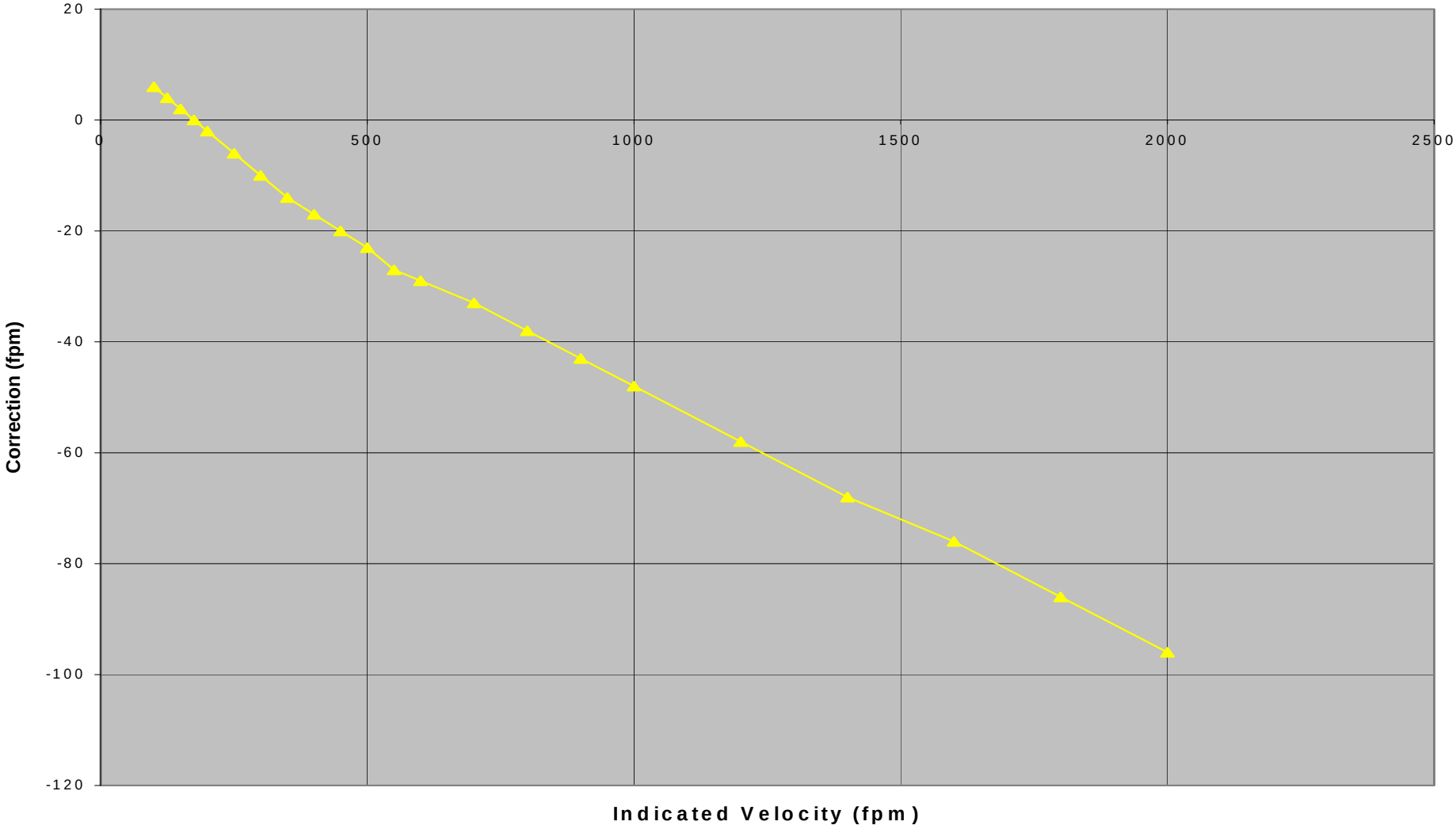

Figure 12 - Sample Calibration Curve for Low Speed Anemometer (Serial No. 23001)

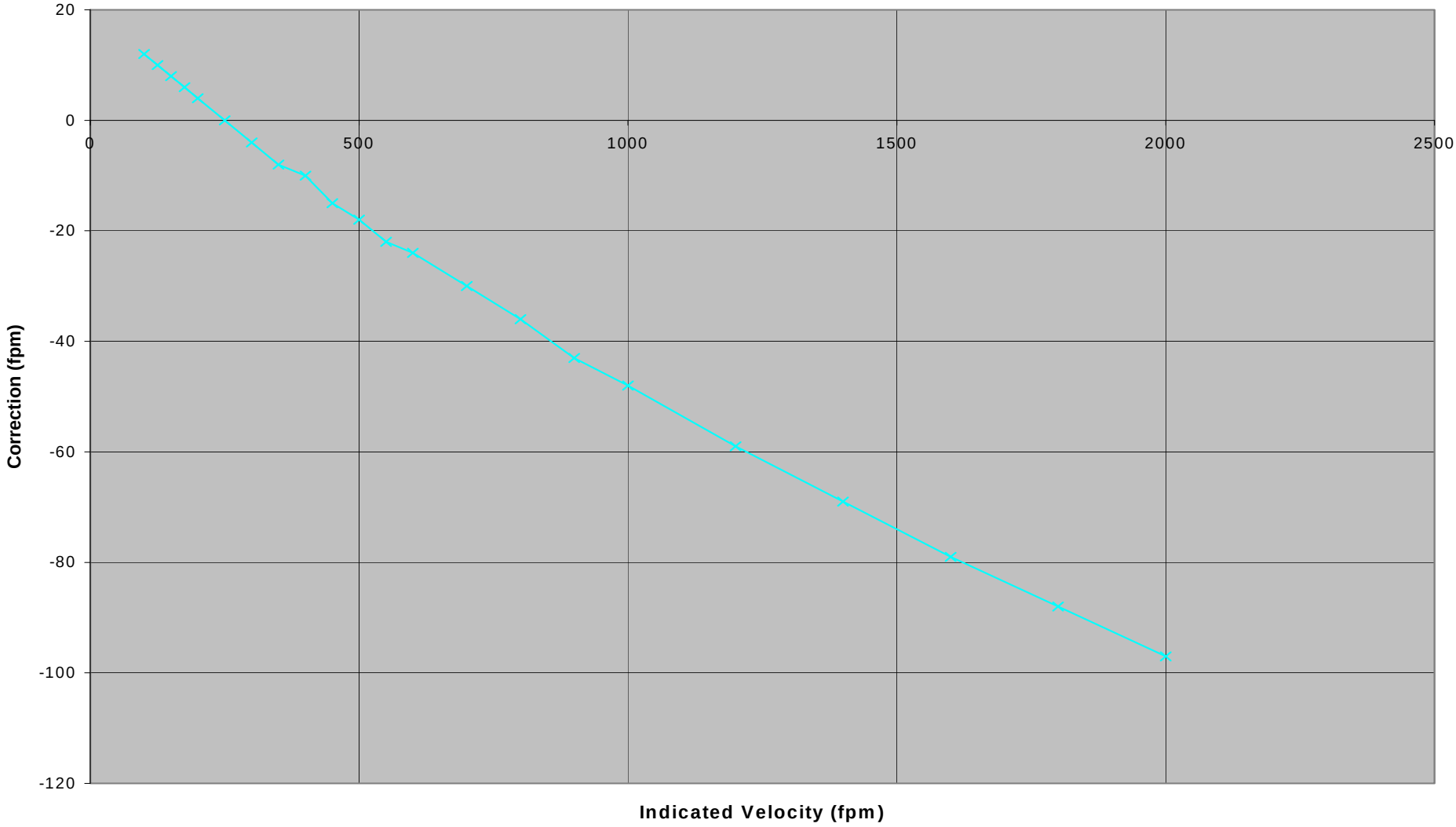

Figure 13 - Sample Correction Factor Charts for Calibrated Anemometers

Serial No. 22860 1/18/1989		Serial No. 22881 1/18/1989		Serial No. 24678 1/18/1989		Serial No. 23001 1/18/1989		Serial No. 34677 5/1988	
Ind. Vel.	Corr.	Ind. Vel.	Corr.	Ind. Vel.	Corr.	Ind. Vel.	Corr.	Ind. Vel.	Corr
100	8	100	6	100	6	100	12	100	14
125	5	125	3	125	4	125	10	250	2
150	2	150	0	150	2	150	8	500	-15
175	0	175	-2	175	0	175	6	750	-26
200	-2	200	-4	200	-2	200	4	1000	-38
250	-4	250	-8	250	-6	250	0	1500	-64
300	-10	300	-10	300	-10	300	-4	2000	-89
350	-14	350	-13	350	-14	350	-8		
400	-17	400	-16	400	-17	400	-10		
450	-20	450	-20	450	-20	450	-15		
500	-23	500	-23	500	-23	500	-18		
550	-25	550	-26	550	-27	550	-22		
600	-28	600	-29	600	-29	600	-24		
700	-32	700	-36	700	-33	700	-30		
800	-36	800	-43	800	-38	800	-36		
900	-40	900	-48	900	-43	900	-43		
1000	-45	1000	-55	1000	-48	1000	-48		
1200	-53	1200	-68	1200	-58	1200	-59		
1400	-62	1400	-80	1400	-68	1400	-69		
1600	-70	1600	-93	1600	-76	1600	-79		
1800	-79	1800	-106	1800	-86	1800	-88		
2000	-88	2000	-120	2000	-96	2000	-97		

Figure 14 - Combined Sample Calibration Curves for Low Speed Anemometers