SECTION 23 08 01.00 20

TESTING INDUSTRIAL VENTILATION SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH-2092S	(2004) Industrial Ventilation: A Manual of Recommended Practice

1.2 DEFINITIONS

a. Capture velocity: Air velocity at any point in front of the hood or at the hood opening necessary to overcome opposing air currents and to capture contaminated air at that point to cause it to flow into the hood.

b. Capture zone: Controlled space around an industrial process that provides a safe and healthy workspace.

c. Equilibrium performance point: The operating condition after sufficient start-up time that an air pollution control device reaches optimum efficiency. The manufacturer recommends the minimum start-up time for each device.

d. Facility: A building or portion of a building in which contaminated air is controlled by the industrial ventilation system. This includes the shop space, equipment room, offices, restrooms and locker rooms affected by the industrial process.

e. Full load condition: Condition in the facility where exhaust and replacement air systems operate simultaneously, as installed by the Contractor according to the design plans and specifications.

f. Heating and cooling equipment: Equipment used to temper air in the facility. Equipment includes, but is not limited to: condensers, chillers, pumps, heat exchangers, heating and cooling coils, heat pumps, cooling towers, and duct heaters.

g. Hood static pressure: Static pressure, in inches of water gage (wg), taken at 3 duct diameters from a flanged or plain hood or 1 duct diameter from a tapered hood.

h. Manometer: An instrument for measuring pressure. Electronic or U-tube manometers with water or light oil are acceptable.

i. Replacement air system: The mechanical system supplying air to a facility to replace exhausted air.

j. Standard Temperature and Pressure: Air at standard conditions of 70 degrees Fahrenheit and 1 atmosphere.

k. Static Pressure: The potential pressure exerted in all directions by a fluid at rest. For a fluid in motion, it is measured in a direction normal to the direction of flow. Usually expressed in inches of wg.

l. System Effect: The estimated loss in fan performance from non-uniform air flow at the fan's inlet or outlet.

m. Test agency: A first tier subcontractor who is independent from the Contractor and the mechanical Sub-contractor except by the affiliation established by this contract.

n. Transport velocity: Minimum air velocity, in feet per minute (fpm), required to prevent contaminants from settling, condensing, or pocketing in the ductwork.

o. Velocity pressure: The kinetic pressure in the direction of flow necessary to cause a fluid at rest to flow at a given velocity. Usually expressed in inches of wg.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Preliminary review report; G

Smoke tests report; G

Fan operating points report; G

Static pressure report; G

Volume and velocity flow rates report; G

Pitot traverse report; G

Submit 6 copies of an organized report bound in a durable, 3-ring water-resistant binder. The report shall contain a table of contents, an executive summary, an introduction, a results section and a discussion of the results. Include the reports specified in paragraphs entitled "Preliminary Review Report," "Smoke Test Reports,""Fan Operating Points Reports," "Static Pressure Report," "Volume and Velocity Flow Rates Report," and"Pitot Traverse Report" as appendices.

Submit field data and report forms in appendices separated by the fan system tested. Use the sample forms, "Replacement Air

System Test Data" and "Exhaust Air System Test Data," to summarize the tests for the appropriate fan. Forms other than those listed may be used; however, include all information required by these forms.

Document deficiencies and unmet design requirements identified during testing. Notify the Prime Contractor in writing, no later than 5 calendar days after encountering deficiency, describe the nature of the deficiency and a recommended course of action for resolution. Report daily temperature, humidity and barometric pressure readings. Note extreme weather and barometric pressure changes during the day.

SD-07 Certificates

Test agency Qualifications; G

Record of Document Submittal to Testing Agency; G

Work plan; G

List of test instruments; G

1.4 QUALITY ASSURANCE

1.4.1 Modification of References

Test the industrial ventilation system according to the referenced publications listed in paragraph entitled "References" and as modified by this section. Consider the advisory or recommended provisions, of the referred references, as mandatory.

1.4.2 Certification

1.4.2.1 Test Agency Qualifications

Submit, no later than 15 calendar days after contract award, information certifying that the test agency is not affiliated with any other company participating in work on this contract. The work of the test agency shall be limited to testing and making minor adjustments to the industrial ventilation system.

Use the sample form, "Test Agency Qualifications Sheet," to submit the following information:

a. Verification of 5] years of experience as an agency in testing industrial ventilation systems or current member of either AABC or NEBB.

b. References from five facility managers of facilities with industrial ventilation systems that the agency has tested. A minimum of one facility shall have processes and contaminants similar to those generated by the facility in this project.

c. Registration for Professional Engineer (PE) license or Certification for an Industrial Hygienist (CIH) or Test and Balance (TAB) Engineer for the lead test engineer. Submit PE license, CIH registration number, or TAB certification number. Include the discipline, date of issue, and expiration date. Engineers shall include the state of

issue.

d. Confirmation of 5 years of industrial ventilation test experience for the lead test engineer. References from five [Contracting Officers] [facility managers] for facilities where the lead engineer has supervised industrial ventilation systems tests in the last 5 years.

e. Verification of length of time lead engineer has been employed by a test and balance agency.

1.4.2.2 Record of Document Submittal to Testing Agency

Submit not later than 30 calendar days prior to the work plan submittal due date, a record of transmittal of the following documents to the approved independent testing agency. Information is required to develop a testing work plan and prepare for field testing.

a. Copy of working as-built project drawings and specifications, including marked design changes. Changes current as of the date of transmission.

b. Copies of all project submittals relating to the industrial ventilation system. Transmit copies of final record submittals including approval sheets.

1.4.2.3 Work Plan

Submit not later than 120 calendar days after contract award, but before start of work, steps to be taken by the lead engineer to accomplish the required testing. Submit the following:

a. Memorandum of test procedure.

(1) Proposed dates for the preliminary review and test.

(2) Plan view showing proposed test locations (i.e. static pressure locations).

(3) Proposed pitot traverse reading locations.

b. Test equipment to be used.

c. Scaffolding and other Contractor's support equipment required to perform test.

d. Factory representatives and other Contractor's support personnel who will be on site for testing.

1.4.2.4 List of Test Instruments

Submit a signed and dated list of test instruments, their application, manufacturer, model, serial number, range of operation, accuracy and date of calibration.

1.4.3 Test Requirements

The Contractor shall adjust and balance the industrial ventilation system according to Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. An independent test agency shall test the industrial ventilation system

according to ACGIH-2092S and this section under full load conditions. For tempered supply air repeat the industrial ventilation systems test for the following conditions: [plus or minus 20 percent minimum outdoor temperature design condition,] [plus or minus 10 percent maximum outdoor temperature design condition,] [[_____] percent loads on a variable air volume system,] [and] [_____].

1.4.4 Test Engineer

1.4.4.1 Field Work

The lead test engineer shall be present at the project site while testing is performed and shall be responsible for conducting, supervising, and managing of test work. Management includes health and safety of test agency employees.

1.4.4.2 Reporting Work

The lead test engineer shall prepare, sign, and date the test agenda, equipment list, and certified report.

1.4.5 Test Report

1.4.5.1 Preliminary Review Report

Submit a preliminary review report, see paragraph entitled "Preliminary Review" 15 calendar days prior to beginning the test.

1.4.5.2 Smoke Tests Report

Describe turbulent air flow and dead air spaces in and around the hood capture zone. Describe air flow exiting from the replacement air distribution device and the effect of room air currents on smoke capture. Report leaks in the ductwork, access door, and duct connectors to fan. Report smoke behavior as it exits from the exhaust stack and describe entrainment around the tested facility, nearby structures and any geographical features.

1.4.5.3 Fan Operating Points Report

Determine the difference between measured and design volume flow rate. Compare measured fan static pressure to manufacturer's performance data. Show the design and measured operating point for each fan on the corresponding fan curve. Report fans that cannot operate at speeds 25 percent faster than the measured speed while remaining within the boundaries of the fan curve and fan class. Identify fan motors that are operating at or near full load amperage.

1.4.5.4 Static Pressure Report

Include the following:

a. Hood static pressures. Use tables to summarize test results by system.

b. Fan static pressure, as defined by ACGIH-2092S, for replacement and exhaust air systems.

c. Room static pressure, as compared to [atmosphere] [adjacent rooms], for each room in the facility.

d. Static pressures that are inconsistent and the probable reason. For example:

(1) Inconsistent static pressure drop or increase in one or a series of hoods on the same branch;

(2) Different static pressures for similar systems in the facility; and

(3) Decreasing static pressures as the hoods get closer to the exhaust fan inlet.

[e. Differential pressure across air pollution control devices.]

1.4.5.5 Volume and Velocity Flow Rates Report

Report volume flow rates and velocities in standard cubic feet per minute (cfm) and feet per minute (fpm), respectively, on the "Exhaust Air System Test Data" sample form or comparable form.

[Convert measured volume flow rates to standard volume flow rates for locations with operating conditions other than standard temperature and pressure. The conversion may be ignored if the volume flow rate changes less than plus or minus one percent. Show both the actual and standard value for test points. Show a sample conversion equation.]

Compare measured] volume flow rates with the design value for each hood, the total exhaust air system, each replacement air distribution point and the total replacement air system. List the measured and design values in tabular form. Report the transport velocity for each branch [submain] and main duct in the exhaust air system.

Indicate if the test value is adequate or inadequate. Adequate hood volume flow rates and duct velocities are those with [measured] [converted] values within plus or minus 10 percent of design values. Adequate total system volume flow rates are those with [measured] [converted] values within plus or minus 10 percent of the design values.

1.4.5.6 Pitot Traverse Report

Use the "Pitot Traverse Data" sample form or comparable form to record pitot traverse readings. Submit the following data, as a minimum, for each test location:

a. Velocity pressure and their corresponding velocities;

b. Average velocity;

c. Duct dimensions and area;

d. Total measured volume flow rate; and

e. Static pressure reading.

1.4.5.7 Deadline

Provide a simplified pass/fail report within [3] [_____] days after completion of testing. Provide a complete test report [15] [30] [_____]

days after completion of testing. [The only exception is for the last seasonal work session which shall be completed by [_____].]

1.5 SAMPLE FORMS

1.5.1 Test Agency Qualification Sheet

TEST AGENCY QUALIFICATION SHEET	
DATE:	COMPLETED BY:
A. Agency Qualifications	
Agency Name:	
Address:	
Telephone Number:	
Years of experience testing industrial ventilation systems:	
Industrial facilities tested (5 required). Include the following:	
Facility Name, Address, Point of contact with telephone number;	
Dates of test;	
Type of operation tested;	
List of Contaminants;	
Number of fans;	
Type of exhaust hoods;	
Air cleaning devices; and	
Personnel performing the test.	
Attach letters of recommendation for tests performed at these facilities. Three facilities shall be of the type of operation to be tested.	
B. Lead Test Engineer Qualifications	

TEST AGENCY QUALIFICATION SHEET
Name:
Length of time lead engineer has worked with Agency:
Years of experience testing industrial ventilation systems:
Professional Engineering Information:
discipline:
license number:
issue date:
recertification date:
state of registration:
Industrial facilities tested (5 required). Include the following:
Facility Name, Address, Point of contact with telephone number;
Dates of Test;
Type of Operation;
List of Contaminants;
Number of Fans;
Type of Exhaust Hoods; and
Air Cleaning Devices.

1.5.2 Pitot Traverse Data - Rectangular Duct

PITOT TRAVERSE DATA - Rectangular Duct		
Test Date:		
Readings By:		Traverse By:
Static Pressure:		
Room:		Air Temperature:
Traverse Location:		Inside/Outside Duct Width:
Distance to Resistance Component:	Causing Component Distance:	Inside/Outside Duct Height:
		Inside Duct Area:
before:	before:	Required Velocity:
after:	after:	Required Actual Volume Flow Rate:
Velocity Pressure Reported as [_____] Units		

Pitot Traverse Matrix											
Velocity | Pressure Readings (minimum center distance is 6 inches											
Point Position	1	2	3	4	5	6	7	8	9	10	Confirm
A	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
B	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
C	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
D	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
E	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
F	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
G	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
H	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
I	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
J	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	

Pitot Traverse Matrix											
Pressure Readings Converted to Velocity (FPM)											
Velocity Point Position	1	2	3	4	5	6	7	8	9	10	
A	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
B	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
C	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
D	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
E	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
F	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
G	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
H	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
I	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
J	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	
Subtotal:											
Total Velocity/# Readings = Avg. Velocity x Duct Area = Actual Volume Flow Rate:											
_____FPM / _____ = _____ FPM x _____ SQ. FEET = _____ ACFM * ACFM - actual cubic feet per minute											
REMARKS											

1.5.3 Pitot Traverse Data - Round Duct

PITOT TRAVERSE DATA - Round Duct		
Test Date:		
Readings By:		Traverse By:
Static Pressure:		
Room Number:		Air Temperature:
System/Unit:		Barometric Pressure:
Traverse Location:		Inside/Outside Duct DIA:
Distance to Resistance Component:	Causing Component Distance:	Inside Duct Area:
before:	before:	Required Velocity:
after:	after:	Required Actual Volume Flow Rate:
Velocity Pressure Reported as [_____] Units		

Pitot Traverse Matrix					
Duct Diameter	0-6 in.	6-48 in.		>48 in. or unstable velocity	
Readings	12 (6/traverse)	20 (10/traverse)		40 (20/traverse)	
TEST POINT	Velocity Pressure	Velocity	TEST POINT	Velocity Pressure	Velocity
1	[_____]	[_____]	21	[_____]	[_____]
2	[_____]	[_____]	22	[_____]	[_____]
2	[_____]	[_____]	22	[_____]	[_____]
3	[_____]	[_____]	23	[_____]	[_____]
4	[_____]	[_____]	24	[_____]	[_____]
5	[_____]	[_____]	25	[_____]	[_____]
6	[_____]	[_____]	26	[_____]	[_____]
7	[_____]	[_____]	27	[_____]	[_____]
8	[_____]	[_____]	28	[_____]	[_____]
9	[_____]	[_____]	29	[_____]	[_____]
10	[_____]	[_____]	30	[_____]	[_____]

Pitot Traverse Matrix					
11	[_____]	[_____]	31	[_____]	[_____]
12	[_____]	[_____]	32	[_____]	[_____]
13	[_____]	[_____]	33	[_____]	[_____]
14	[_____]	[_____]	34	[_____]	[_____]
15	[_____]	[_____]	35	[_____]	[_____]
16	[_____]	[_____]	36	[_____]	[_____]
17	[_____]	[_____]	37	[_____]	[_____]
18	[_____]	[_____]	38	[_____]	[_____]
19	[_____]	[_____]	39	[_____]	[_____]
20	[_____]	[_____]	40	[_____]	[_____]
Confirm 1:			Confirm 1:		
Confirm 2:			Confirm 2:		
Velocity Sum:					
(Without Confirm Value)					
Velocity Sum/# Readings = Average Velocity x Duct Area = Actual Volume Flow					
Rate [_____] FPM / [_____] = [_____] FPM x [_____] SQ. Feet = [_____] ACFM					
REMARKS					

1.5.4 Exhaust Air System Test Data

EXHAUST AIR SYSTEM TEST DATA			
Test Dates:			
Readings By:			
Unit Number:		Pressures (Pa)	
Unit Location:		Fan Inlet Static:	
Make Model:		Fan Outlet Static:	
Model:		Fan Inlet Velocity:	
Serial Number:		Fan Static:	
		Fan Total:	
Damper Positions			
Hoods:		Differential Pressure across air cleaning device	
Submains:		Device	Delta P (Pa)
Total Volume Test Location		[_____]	[_____]
Duct dia. before fan	[_____]	[_____]	[_____]
Duct dia. after fan	[_____]		
		Fan Speed (RPM or RPS) [_____]	
		Motor Speed (RPM or RPS) [_____]	
Resistance Causing Elements			

Type	Relationship to Fan		Pulley - Center to Center Distance
	before/after	# Duct dia.	
elbow	[_____]	[_____]	
damper	[_____]	[_____]	
expansion	[_____]	[_____]	Amperage - T1, T2, T3 [_____]
contraction	[_____]	[_____]	Voltage - T1-2, T2-3,T3-1 [_____]
plenum	[_____]	[_____]	
[_____]	[_____]	[_____]	Temperature (W.B./D.B.)

EXHAUST AIR SYSTEM TEST DATA			
[_____]	[_____]	[_____]	Outside Air [_____]
[_____]	[_____]	[_____]	Replacement Air [_____]
* RPM - revolutions per minute			W.B. - wet bulb
RPS - radians per second			D.B. - dry bulb

EXHAUST AIR SYSTEM TEST DATA			
Test Dates:			
Readings By:			
Unit Number:		Pressures (inches of wg)	
Unit Location:		Fan Inlet Static:	
Make Model:		Fan Outlet Static:	
Model:		Fan Inlet Velocity:	
Serial Number:		Fan Static:	
		Fan Total:	
Damper Positions			
Hoods:		Differential Pressure across air cleaning device	
Submains:		Device	Delta P (in. wg)
Total Volume Test Location		[_____]	[_____]
Duct dia. before fan	[_____]	[_____]	[_____]
Duct dia. after fan	[_____]		
		Fan Speed (RPM or RPS) [_____]	
		Motor Speed (RPM or RPS) [_____]	
Resistance Causing Elements			
Type	Relationship to Fan		Pulley - Center to Center Distance
	before/after	# Duct dia.	
elbow	[_____]	[_____]	

EXHAUST AIR SYSTEM TEST DATA			
damper	[_____]	[_____]	
expansion	[_____]	[_____]	Amperage - T1, T2, T3 [_____]
contraction	[_____]	[_____]	Voltage - T1-2, T2-3,T3-1 [_____]
plenum	[_____]	[_____]	
[_____]	[_____]	[_____]	Temperature (W.B./D.B.)
[_____]	[_____]	[_____]	Outside Air [_____]
[_____]	[_____]	[_____]	Replacement Air [_____]
* RPM - revolutions per minute			W.B. - wet bulb
RPS - radians per second			D.B. - dry bulb

VOLUME FLOW RATES (Standard Cubic Feet per Minute)				
SYSTEM	ACTUAL	DESIGN	ADEQUATE	INADEQUATE
Total Volume	[_____]	[_____]	[_____]	[_____]
SUBMAIN				
Submain name	[_____]	[_____]	[_____]	[_____]
Submain name	[_____]	[_____]	[_____]	[_____]
Submain name	[_____]	[_____]	[_____]	[_____]
HOODS				
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]
Hood name	[_____]	[_____]	[_____]	[_____]

1.5.5 Replacement Air System Test Data

REPLACEMENT AIR SYSTEM TEST DATA			
Test Dates:			
Readings By:			
Unit Number: [_____]		Pressures (inches of wg)	
Unit Location:		Fan Inlet Static:	
Make Model:		Fan Outlet Static:	
Model:		Fan Inlet Velocity:	
Serial Number:		Fan Static:	
		Fan Total:	
Damper Positions			
		Differential Pressure	
Terminals:		across Filters [_____]	
Submains:		across Reheat Coil[_____]	
across Cooling Coil [_____]			
across Preheat Coil [_____]			
Total Volume Test Location			[_____]
Total Volume Test Location			
Duct dia. before fan	[_____]	Fan Speed (RPM or RPS) [_____]	
Duct dia. after fan	[_____]	Motor Speed (RPM or RPS) [_____]	
Resistance Causing Elements			
Type	Relationship to Fan		Pulley - Center to Center Distance
	before/after	# Duct dia.	
elbow	[_____]	[_____]	
damper	[_____]	[_____]	
expansion	[_____]	[_____]	Amperage - T1, T2, T3 [_____]

REPLACEMENT AIR SYSTEM TEST DATA			
contraction	[_____]	[_____]	Voltage - T1-2, T2-3,T3-1 [_____]
plenum	[_____]	[_____]	
[_____]	[_____]	[_____]	Temperature (W.B./D.B.)
[_____]	[_____]	[_____]	Outside Air [_____]
[_____]	[_____]	[_____]	Replacement Air [_____]
[_____]	[_____]	[_____]	Mixed Air [_____]
* RPM - revolutions per minute			W.B. - wet bulb
RPS - radians per second			D.B. - dry bulb

VOLUME FLOW RATES (Standard Cubic Feet per Minute)				
SYSTEM	ACTUAL	DESIGN	ADEQUATE	INADEQUATE
Total Volume	[_____]	[_____]	[_____]	[_____]
Outside Air Volume	[_____]	[_____]	[_____]	[_____]
Return Air	[_____]	[_____]	[_____]	[_____]
Ratio: Outside/Return	[_____]	[_____]	[_____]	[_____]
BRANCH				
Branch name	[_____]	[_____]	[_____]	[_____]
Branch name	[_____]	[_____]	[_____]	[_____]
Branch name	[_____]	[_____]	[_____]	[_____]
Branch name	[_____]	[_____]	[_____]	[_____]
Branch name	[_____]	[_____]	[_____]	[_____]
Branch name	[_____]	[_____]	[_____]	[_____]
Branch name	[_____]	[_____]	[_____]	[_____]

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 TEST PROCEDURE

Determine the static pressure of the work area relative to [the outdoors and] the following rooms: [_____]. Report the results.

3.1.1 Preliminary Review

Conduct a preliminary review of the facility [45] [_____] calendar days prior to beginning the test. Perform the following tasks and report the results of each task in the Preliminary Review Report.

a. Locate industrial ventilation system components including hoods, hood transitions, ductwork, branch to main duct entries, elbows, expansions and contractions, fans, air pollution control devices, exhaust stacks, weather protection, replacement air plenums, and distribution devices. Show components on a single line drawing for each fan system.

b. Review design drawings, specifications, and shop drawings to verify that testing can be performed on the system. Record, on the single line drawings, locations of planned pitot traverses of mains and branches and design velocities. Report potential test problems, such as inadequate space, to the Contracting Officer.

c. Identify on the single line drawings the location of system fire protection components that may alter air flow, such as fire dampers.

d. Identify on the single line drawings the location of emergency and spill sensors.

e. Identify on the single line drawings the location of [pressure differential sensors] [static pressure sensors].

f. Use AMCA 201 to identify system effects that occur at the inlet and outlet of each replacement and exhaust air fan.

g. Verify that ductwork sizes, elbows and fittings, exhaust stacks and weather protection meet the design plans and specifications for both replacement and exhaust air systems.

h. Verify that fans are rotating in the proper direction.

i. Identify equipment such as fans, air pollution devices, heating coils, and controls, that do not meet the design plans and specifications.

j. Obtain fan performance data.

k. Verify that replacement air terminals including [diffusers] [louvers] [grilles] [perforated plate] [perforated ductwork] are installed according to design plans and specifications.

l. Obtain the differential pressure data and maximum operating pressures for air filtration devices including [dirty and clean replacement air filters] [high efficiency particulate air filters] [dust collectors]

[mist eliminators] [wet scrubbers] [cyclone separators] [electrostatic precipitators] [_____].

m. Obtain the temperature and pressure control diagrams for the supply [and exhaust] industrial ventilation system.

n. Record the nameplate data from each fan, motor, [air cleaning device] [vacuum system] and [_____].

o. Record motor starter sizes and the type of thermal overload protection devices.

p. Verify the following requirements unless otherwise specified in the individual section:

(1) Fan bearings have a minimum rated average life of 200,000 hours.

(2) Fan bases are level.

(3) Fan wheels are balanced and clear the housing.

(4) Fan shafts are of uniform diameter [and there are no step down cuts at the bearings].

(5) Access to fan grease fittings and other routine maintenance equipment.

(6) Bearings are greased and the tube is full upon installation.

(7) Safety equipment, such as fan belt guards, are in place.

[(8) Drive alignment and belt tension are correct for each fan.]

3.2 FIELD TESTS

3.2.1 Preliminary Procedures

Provide instruments and consumable equipment required to test the industrial ventilation system.

Before beginning the test:

a. Close all windows and doors in the facility.

b. Ensure that exhaust and replacement air ductwork and air intake sources are free from debris and dirt, through a visual inspection.

c. Load the replacement air prefilters to the manufacturer's recommended maximum load condition.

d. Run the exhaust air systems, containing air pollution control devices, for a sufficient time to obtain the manufacturer's recommended equilibrium performance point.

[e. Ensure that a duct leakage test is complete and accepted by the Contracting Officer.]

3.2.2 Test Method

Test the ventilation under full load conditions according to ACGIH-2092S, Chapter 9 and this section. Record quantitative readings on sample forms, "Pitot Traverse Data, [Rectangular Duct] [Round Duct]," "Exhaust Air System Test Data," and "Replacement Air System Test Data."

The test engineer is authorized to readjust and rebalance the system if minor adjustments will bring the system into compliance with the design. Minor adjustments include [adjusting the fan sheave] [correcting fan rotation] [resetting dampers] [adjusting blast gates] [_____].

3.2.2.1 Smoke Test

Test each hood with smoke generators to verify contaminant control in the capture zone, prior to performing quantitative tests on the industrial ventilation system. Smoke simulates the contaminant. [Videotape the air movement pattern at the worker's breathing zone for the [hoods] [booths] [indoor firing range] [_____] [and air currents].] Comply with restrictions on the use of incendiary devices. Inform the fire department or other responsible parties when large quantities of smoke are expected [or the ventilation system has internal smoke alarms].

3.2.2.2 Air Quantity Readings

Use a pitot tube and manometer to measure the velocity pressures for the exhaust and replacement air systems. Determine the number and location of velocity pressure readings required for round and rectangular ducts according to ACGIH-2092S. Drill traverse access holes. [Round ducts require two traverse access holes positioned 90 degrees apart.] [Rectangular ducts may require several traverse access holes.]

Take pitot traverses away from air disturbing devices (i.e. elbows, branch entries, duct expansions, and hood transitions). Minimum distances are:

a. Five (5) duct diameter of straight duct after the fan outlet; and

b. Seven and one-half (7.5) duct diameters of straight duct after an air disturbing device.

When these distances of straight duct are not available, use a schematic drawing to note the disturbance producing device, and distance between the pitot traverse and the device.

Confirm one velocity pressure reading for each access hole after completing a traverse. Accept traverse data when the difference between the original and confirmation measurement is plus or minus 10 percent; otherwise repeat the traverse. Plug holes with cap plugs immediately after each traverse.

Convert velocity pressure readings to velocity before averaging the duct velocity. Calculate average velocity from velocity pressure readings and volume flow rates for the following locations:

a. Replacement air fan outlet;

b. Replacement air duct branch;

c. Exhaust air duct branch, including hoods [and submains];

d. Exhaust fan inlet or outlet;

[e. Air pollution control device inlet; and]

[f. Outside and return air ducts in recirculating replacement air system.]

3.2.2.3 Air Velocity Meter Readings

A flow hood may be used for measuring office and restroom replacement air quantities. Do not substitute air velocity meter readings for manometer and pitot tube readings. Use air velocity meters to estimate the following:

a. Velocity exiting from replacement air systems without ductwork;

b. Crossdrafts in a room;

c. Hood capture velocity;

d. Duct velocities less than 600 fpm; and

[e. Slot velocities.]

3.2.2.4 Static Pressure Readings

Take static pressure readings using a pitot tube and manometer. The following readings are required:

a. Hood static pressure. Take readings at a distance of one duct diameter from tapered hoods, and 3 diameters from plain or flanged hoods;

b. Replacement and exhaust fan inlet and outlet static pressure;

c. Room static pressure as compared to [outdoors] [outside the area controlled by industrial ventilation];

[d. Air cleaning device inlet and outlet static pressure; and]

[e. Branch static pressure in the replacement and exhaust air system submain ductwork.]

Verify test instrument readings correspond with attached static pressure gages

3.2.2.5 Control System Check-Out

Test warning system controls for the industrial ventilation system including the following:

a. Above and below range alarms for room static pressure.

b. Fan motor operating lights.

[c. Dampers operated by the control motor.]

[d. Hood static pressure.]

[e. Dislodged or ripped filtration equipment.]

[f. Overloaded air cleaning device.]

3.2.2.6 Other Readings

Take the following readings on each day testing is performed:

a. Temperature readings after the system has stabilized and has been running for at least 4 hours:

(1) Wet bulb and dry bulb temperature of ancillary rooms, workspaces, replacement air, outside air, [return air,] [and] [mixed air].

(2) External temperature for fan and motor bearings on ventilation equipment.

b. Record barometric pressure and altitude.

3.2.3 System Markings

Mark the settings and test ports to re-evaluate the industrial ventilation system during follow-up tests. Label test points before submitting the report. Use spray paint or another acceptable practice, i.e. permanent marker, to mark the airflow adjusting devices [such as valves, splitters, dampers, and blast gates], so the devices can be returned to their original position if an unauthorized adjustment is made.

3.2.4 Test Verification

Notify Contracting Officer [30] [_____] calendar days prior to conducting the Test Verification. In the presence of the Contracting Officer, the test engineer shall repeat at least [10] [20] [_____] percent of the test for each replacement and exhaust air system to verify the results. As a minimum, re-test the following readings:

a. Total volume flow for each fan;

b. Inlet and outlet static pressure for each fan;

c. Volume flow and hood static pressure for the hood with the longest duct run from the exhaust fan; [and]

d. Hood volume flow rates and total system volume flow rates which disagree with the design value; [and]

[e. Differential pressure across each air pollution control device].

3.2.4.1 Test Result Disagreements

Static and velocity pressure test readings shall be within plus or minus [10] [_____] percent of the verification readings. When the difference between test and verification readings are greater than these acceptable values, the test engineer shall:

a. Recalculate the test and verification results.

b. Recalibrate test equipment.

c. Retest the entire system.

d. Verify the results.

3.2.5 Test Engineers Out-Brief

Provide a verbal summary for the Contracting Officer describing the condition of the industrial ventilation system. Report test data that does not meet the design criteria as defined in paragraph entitled "Field Test Reports."

-- End of Section --