**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 08 01.00 20

TESTING INDUSTRIAL VENTILATION SYSTEMS

**04/06**

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|---|---|
| **USACE / NAVFAC / AFCEC / NASA** | **UFGS-23 08 01.00 20 (April 2006)** |
| | **----------** |
| **Preparing Activity: NAVFAC** | **Replacing without change UFGS-15951N (September 1999)** |

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**

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SECTION 23 08 01.00 20

TESTING INDUSTRIAL VENTILATION SYSTEMS
**04/06**

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**NOTE: This guide specification covers the requirements for air flow testing of industrial ventilation systems.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**

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**NOTE: An industrial ventilation system is the mechanical equipment that provides the simultaneous exhaust and replacement of air to control contaminants generated from industrial operations. Test the following industrial ventilation system applications according to this specification:**

**1. Systems installed to control employee exposure to:**

**a. Hazardous airborne materials with a Permissible Exposure Limit (PEL) or Threshold Limit Value (TLV) of 0.1 milligram per cubic meter or the equivalent value in parts per million.**

**b. Isocyanate paints.**

**c. Lead.**

**d. Beryllium.**

**e. Otto Fuel II.**

**2. Permanently installed asbestos delagging facilities.**

**3. Metal cleaning or electroplating shops.**

**4. Foundries.**

**5. Fiberglass layup and sprayup operations.**

**6. Abrasive blasting operations.**

**7. Carpentry shops.**

**8. Advanced composite operations (e.g., graphite).**

**9. Indoor Firing Ranges.**

**Include this specification with the construction project and require the Contractor to hire an independent subcontractor. This specification encourages the use of the Commissioning Process. Modify this specification for an acceptance or performance test contract for any industrial ventilation system.**

**********

PART 1 GENERAL

1.1 REFERENCES

**********

**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**

**********

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, INC. (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 Pascals (Pa) 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 21.1 degrees Celsius and 101.3 kilopascals 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 Pa 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 meter per second (m/s) 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 Pa inches of wg.

## 1.3 SUBMITTALS

**********

**NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

**Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.**

**********

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] 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] [Contracting Officer] 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] [10] years of experience as an agency in testing industrial ventilation systems or current member of either AABC or NEBB.

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**NOTE: There are two major certifying organizations for agencies testing, adjusting and balancing heating, cooling and ventilating equipment. The main difference between the two organizations, NEBB and AABC, is their affiliation. AABC certified agencies must be independent of any Contractor or equipment manufacturer. Many NEBB certified agencies are affiliated with a mechanical or sheet metal contractor, but many are independent. Other differences are listed below:**

| | AABC | NEBB |
|---|---|---|
| 1. Minimum number of years: | | |
| a. Agency in business | 3 | 1 |
| b. Individual: experience | 10 | 8-10 |
| c. Individual: test experience | 5 | |
| 2. Licensed P.E. as Manager | no | no |
| 3. Agency possesses own instruments | yes | yes |
| 4. Job references required | 10 | 5 |
| 5. Written exam required | yes | yes |
| 6. Continuing education requirements | 2/cycle | annual |
| 7. Recertification cycle in years | 1 | 2 |

**********

b. References from five [Contracting Officers] [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

**********
**NOTE: This guide specification is not intended to give guidance on testing air pollution control devices. Refer to guide specifications specific to the air pollution device.**
**********

**********
**NOTE: This guide specification does not address testing the heating and cooling equipment in the industrial ventilation system. Refer to Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC, to test heating and cooling equipment. Coordinate the testing requirements with the following guide specifications, when used:**

**Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS**

**Section 23 30 00 HVAC AIR DISTRIBUTION**

**Section 23 35 19.00 20 INDUSTRIAL VENTILATION AND EXHAUST**
**********

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**Note: This guide specification does not address noise and vibration testing. See Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL, NEBB publication, "Procedural Standards for the Calibration and Measurement of Sound and Vibration," and American Society of Heating Refrigerating and Air-Conditioning Engineers publication, "Handbook HVAC Systems and Applications," for noise and vibration testing details.**
**********

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 meters per second (cms) and meter per second (m/s) 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] [converted] 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] [converted] 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

**********
**NOTE: Estimate the amount of time necessary for the Contractor to make corrections and for the test engineer to retest the system in the event that the system fails to pass the initial test.**
**********

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 150 mm 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 (m/s) (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: | | | | | | | | | | | |
| | | | | | | | | | | | |
| _____m/s / _____ = _____ m/s x _____ SQ. METER = _____ CMS _____FPM / _____ = _____ FPM x _____ SQ. FEET = _____ ACFM<br>* 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 | 0-150 mm | 150-1219 mm | | >1219 mm 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 [_____] m/s / [_____] = [_____] m/s x [_____] SQ. METER = [_____] CMS | | | | | |
| REMARKS | | | | | |

| 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 | [_____] | [_____] |

| Pitot Traverse Matrix | | | | | |
|---|---|---|---|---|---|
| 8 | [_____] | [_____] | 28 | [_____] | [_____] |
| 9 | [_____] | [_____] | 29 | [_____] | [_____] |
| 10 | [_____] | [_____] | 30 | [_____] | [_____] |
| 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 | [_____] | [_____] | |

| EXHAUST AIR SYSTEM TEST DATA | | | |
|---|---|---|---|
| [_____] | [_____] | [_____] | 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 |

| 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. | |

| EXHAUST AIR SYSTEM TEST DATA | | | |
|---|---|---|---|
| elbow | [_____] | [_____] | |
| 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 Meter per Second) 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 (PA) (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 Meter per Second) 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

**********

**NOTE: Facilities requiring industrial ventilation often contain offices, restrooms, locker rooms with showers and mechanical rooms. These rooms are affected by the industrial ventilation system for the facility. Contaminants from the work area must be prevented from migrating into these rooms. This is accomplished by providing a slightly negative pressure in the work area.**

**********

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

**********

**NOTE: Straight duct prior to the test point is essential to obtain a realistic average duct velocity. The velocity profile becomes distorted after disturbances such as elbows, contractions, expansions, branch entries in the exhaust system and heating coils in the replacement air system. Look at the drawings and determine if there is enough straight duct to obtain 7.5 duct diameters of straight airflow before the test points. If not, specify the exact test points more explicitly, e.g., 3 meters 10 feet from the positive pressure side of the fan, or between the fan and the scrubber. Do not use the terms upstream or downstream. In exhaust systems the total volume flow rate test point may be located before or after the fan or pollution control device. In replacement air systems the test point is placed after the fan.**

**********

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 3 m/s 600 fpm; and

[e. Slot velocities.]

3.2.2.4 Static Pressure Readings

**********

**NOTE: Static pressures are always required. If the system has no pollution control device, static pressure measurements are only required at the fan**

**inlet and outlet. This is also true for the replacement air fans. To properly evaluate the system, differential pressures are needed across the fan and each air pollution control device. Look at each system and determine the appropriate test points.**

**********

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."

## 3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurements commonly agreed on by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

| Products | Inch-Pound | Metric |
|---|---|---|
| a. [_____] | [_____] | [_____] |

-- End of Section --