# Observer's Checklists
# for Test Methods 2F, 2G, and 2H

# Contents



The checklists that follow attempt to be comprehensive. Observers may not have time to perform all the checks. However, the intent is to equip observers with as complete a battery of checks as possible, leaving it to their discretion to implement those checks most suitable to the immediate circumstances. Any errors or omissions in this publication do not imply revisions or waivers of the provisions of Methods 2F, 2G, or 2H. Determination of compliance should be made by direct reference to the provisions of the applicable methods and to related guidance issued by EPA.

## General Information

| | | | |
|---|---|---|---|
| **Name of Source:** | | **Testing Contractor:** | |
| **ORISPL (if available):** | | **Address:** | |
| **Unit ID (if available):** | | | |
| **Location (town or city, state):** | | **Contact:** | |
| **Contact:** | | **Phone Number:** | |
| **Phone Number:** | | | |
| **Auditor/Observer:** | | **Date:** | |
| **Organization:** | | | |
| **Location:** | | | |
| **Phone #:** | | | |

## Notes, Terminology, and Mathematical Expressions

Notes

1. An electronic copy of this checklist is available in Corel WordPerfect 8.0. If data are entered in the electronic version of the Checklist, certain calculations have been programmed to be performed automatically by the WordPerfect software (e.g., calculation of $d_b$ and $d_{rem}$ in item 45c, *Adiff* in item 64d, *%Diff* in items 65d and 66d, and various statistics related to Method 2G calibrations in item 72). To automatically have WordPerfect calculate such values every time you change data, click in the table cell where the calculation is located, click "Table" on the toolbar. Select "Calculate" and place dot in "Calculate Table" option.

Terminology and Mathematical Expressions

$a \# x \# b$ means "x is greater than or equal to a and less than or equal to b"

$|x|$ means the absolute value of quantity *x*.

$|x| \# a$ is a shorthand equivalent of writing $\&a \# x \# a$. It is also an algebraic way of expressing that *x* is within ± *a* of 0. For example, the requirement that "pressures *R* and *C* shall agree to within ±3%" can be written algebraically as $|R\&C| \# 3\%$, which is equivalent to $\&3\% \# R\&C \# 3\%$

# Probe Checks

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Identification Number and Probe Type** | | | | | |
| 1a | ID number or code appearing on probe | _____ | Permanent unique ID number or code must appear on probe sheath | 6.1 | __ Pass__ Fail |
| 1b | Probe Type Used (Indicate probe type used.)<br>Method 2G<br>_____ Type S _____ DAT<br>_____ Spherical<br>Method 2F<br>_____ DAT _____ Spherical<br>If probe types other than those listed above were used, mark “Fail”. If not, mark “Pass.” | | | | |
| **Sheath** | | | | | |
| 2a | Shall be rigidly attached to probe assembly | | | 2F: 6.1.5<br>2G: 6.1.4 | __ Pass__ Fail |
| 2b | Shall enclose all pressure lines from probe head to farthest position away from the probe head where an angle measuring device may be attached in field | | | | __ Pass__ Fail |
| 2c | Shall provide surface for inscribing a permanent scribe line | | | | __ Pass__ Fail |
| 2d | Shall accommodate attachment of an angle-measuring device | | | | __ Pass__ Fail |
| 2e | Shall facilitate precise rotational movement of probe for determining yaw angles | | | | __ Pass__ Fail |
| **Length (manual probes only)** | | | | | |
| 3 | Effective length (L) from probe head to end of probe (including any probe extensions if necessary) | L = _____ feet | It is recommended that the effective length of the probe (coupled with a probe extension, if necessary) be at least 3 feet longer than the furthest traverse point marking on the probe shaft, i.e.,<br>$L \& D \$ 3 \; feet$ | 2F: 6.1.7.1<br>2G: 6.1.6.1 | Recommendation only |
| | Distance (D) from furthest traverse point mark on probe shaft to probe head | D = _____ feet | | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Scribe line (manual probes only)** | | | | | |
| 4 | Must be permanently inscribed on probe sheath.<br><br>(Note: The scribe line may be a single short line segment, e.g., 6 inches in length, multiple line segments placed at various locations along the length of the probe sheath, or a single continuous line extending along the full length of the probe sheath.) | | | 2F: 6.1.6.1<br><br>2G: 6.1.5.1 | __ Pass__ Fail |
| 5 | Width | _____ inches | Width # 1/16 inch | 2F: 6.1.6.1, 10.4<br><br>2G: 6.1.5.1 | __ Pass__ Fail |
| 6 | Maximum rotational angle ($è_{MAX}$) measured along scribe line<br><br>Minimum rotational angle ($è_{MIN}$) measured along scribe line | $è_{MAX}$ = __ degrees<br><br>$è_{MIN}$ = __ degrees | The rotational position of the scribe line shall not vary by more than 2°, i.e.,<br><br>$è_{MAX}$ & $è_{MIN}$ # 2° | 6.1.6.3<br>10.4.1 | __ Pass__ Fail |
| 7 | Rotational position of scribe line relative to the probe's impact pressure port. | _____ degrees | 90° or 180° from the probe's impact pressure port | 18.3 | Recommendation only |
| **Scribe Line Surrogate (automated probes only)** | | | | | |
| 8 | What physical feature is built into the automated probe design to serve as an indicator of the reference position of the probe head?<br>a ☐ Scribe line<br>b ☐ Flat<br>c ☐ Other: _____ | | If an automated probe does not have a reference scribe line, a "flat" (or comparable, clearly identifiable physical characteristic) must be provided on the probe casing or flange plate to ensure that the reference position of the probe assembly remains in a vertical or horizontal position.<br><br>If "a", "b", or "c" are not checked, mark "Fail." If "a", "b", or "c" is checked, mark "Pass." | 10.4.3 | __ Pass__ Fail |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Pressure tubings** | | | | | |
| 9 | Inside diameter ($D_{tube}$) of tubing | $D_{tube}$ = ____ inches | The tubing should have an inside diameter of at least 1/8 inch, i.e., $D_{tube}$ $ 1/8 inch | 2F: 6.1.8<br>2G: 6.17 | Recommendation only |
| **Type S Probes Critical Dimensions and Characteristics** | | | | | |
| 10 | External diameter ($D_t$) of pitot tubing | $D_t$ = _____ inches | $D_t$ $ 3/8 inch | 2G: 6.1.1 | __ Pass__ Fail |
| 11 | Mark on first leg | (Check off if present)<br>___ A ___ B | One leg of the tube must be marked A, and the other, B. | 2G: 10.2.1 | __ Pass__ Fail |
| | Mark on second leg | (Check off if present)<br>___ A ___ B | | | |
| 12 | Base-to-opening plane distance ($P_A$) on first leg | $P_A$ = _____ inches | $P_A$ and $P_B$ shall be equal. | 2G: 10.2.1 | __ Pass__ Fail |
| | Base-to-opening plane distance ($P_B$) on second leg | $P_B$ = _____ inches | | | |
| 13 | Distance (A) between opening planes of two legs | A = _____ inches | $2.10D_t$ # A #$3.00D_t$ | 2G: 10.2.1 | Recommendation only |
| | External diameter ($D_t$) of tubing | Same as item 10 | | | |
| 14a | Alignment parameters for opening plane of first leg | $á_1$ = ____ degrees<br>$â_1$ = ____ degrees | $\lvert á_1 \rvert$ # 2°<br>$\lvert â_1 \rvert$ # 2° | 2G: 6.1.1 & Table 2G-1 | __ Pass__ Fail |
| 14b | Alignment parameters for opening plane of second leg | $á_2$ = ____ degrees<br>$â_2$ = ____ degrees | $\lvert á_2 \rvert$ # 2°<br>$\lvert â_2 \rvert$ # 2° | 2G: 6.1.1 & Table 2G-1 | __ Pass__ Fail |
| 14c | Longitudinal separation distance (w) | w = ____ inches | w # 0.02 inch | 2G: 6.1.1 & Table 2G-1 | __ Pass__ Fail |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| 14d | Perpendicular separation distance (z) | z = ___ inches | z # 0.02 inch | 2G: 6.1.1 & Table 2G-1 | __ Pass__ Fail |
| 15 | Type S probe with sampling nozzle<br>Was a sampling nozzle coupled with the Type S probe? | | If so, then perform the checks specified below in item #69a-c. These include a check to ensure that a wind tunnel demonstration was performed which showed that the nozzle does not impair the probe's ability to yaw null. If all the provisions of these checks are satisfied, mark "Pass." If any provision in these checks is not met, mark "Fail." | 2F, 2G: 10.6<br>Method 2, Fig 2-6 and 2-8 | __ Pass__ Fail |
| **3-D Probes Critical Dimensions** | | | | | |
| 16 | Sensing head diameter ($D_{head}$) | $D_{head}$ = ___ inches | The minimum recommended diameter of the sensing head is 1 inch, i.e.,<br>$D_{head}$ $ 1 inch | 2F: 6.1 | Recommendation only |
| **Inspection of Probe Head** | | | | | |
| **Applicability:** All probes.<br>**Frequency:** (a) Before each field test and<br>(b) Before each calibration. | | | | | |
| 17a | Has the tester performed a careful examination of the physical condition of the probe head and have the required measurements and observations been noted on the forms and diagrams similar to those in Table 2G-1 (for Type S probes) or 2F-1 (for 3-D probes)? If so, continue with next step. If not, mark "Fail" and skip the remaining steps in this procedure. | | | 2F: 8.1.2, 10.2, Tbl. 2F-1<br>2G: 8.1.2, 8.1.3, 10.2 Tbl. 2G-1 | __ Pass __ Fail |
| 17b | Has the tester compared the results of the current inspection to those recorded in an earlier version of Table 2G-1 or 2F-1 that was required to be completed in conjunction with the most recent calibration? If not, mark "Fail" and skip the remaining steps in this procedure. | | | | |
| 17c | If there is visible damage to the probe head or if the face openings of a Type S probe are noticeably misaligned, has the probe been removed from service until necessary repairs are made, dimensional specifications verified, and the probe recalibrated? If not, mark "Fail" and skip the remaining steps in this procedure. | | | | |
| 17d | Does Table 2F-1 or 2G-1 for the current inspection include the probe's unique ID number and has the inspection form been signed and dated by the appropriate party? If not, mark "Fail." If the provisions in steps 17a through 17d have been successfully satisfied, mark "Pass." | | | | |
| **Thermocouple Inspection** | | | | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| **Applicability:** All probes.<br>**Frequency:** Before each field test. | | | | |
| 18a | Is the thermocouple attached to the probe so that the sensor tip does not touch any metal? | If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | 6.6 | __ Pass __ Fail |
| 18b | For 3-D probes, is the thermocouple located on the opposite side of the probe head from the pressure ports so as not to interfere with the gas flow around the probe head? | If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | |
| 18c | Is the position of the thermocouple relative to the probe's pressure port openings in the same configuration as used when the probe was calibrated in the wind tunnel?. | If not, mark "Fail." If so, mark "Pass." | | |
| **Horizontal Straightness Check** | | | | |
| **Applicability:** All probes used to perform horizontal traverses.<br>**Frequency:** (a) Before initial field use for probes constructed of a rigid steel material and consisting of a main probe without probe extensions unless a bend is visible.<br>(b) Before current field test for any probe consisting of probe extensions and, for probes not consisting of extensions, whenever a bend is observed during the mandatory pre-test visual inspection.<br>(c) This check must also be performed whenever the probe is recalibrated and whenever a change is made to the design or material of the probe assembly. | | | | |
| 19a | Will the probe be used to perform a horizontal traverse during this field test? | ___ Yes ___ No | If "yes" is checked, go to item 19b. If "no" is checked, mark "Not applicable" and skip the remaining steps in this procedure. | 8.2<br>Fig. 2F-9<br>Fig. 2G-6 | __ Pass __ Fail<br>__ Not applicable |
| 19b | Will the probe be used without probe extensions during this field test? | ___ Yes ___ No | If "yes" is always checked, mark "Pass" and skip the remaining steps in this procedure. If "no" is checked for any question, go to item 19c. | | |
| | Is the probe constructed of a rigid steel material? | ___ Yes ___ No | | | |
| | During the mandatory pre-test visual inspection of the probe, was the probe free from observable bends? | ___ Yes ___ No | | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | Was a successful horizontal straightness check performed before its initial field use and most recent calibration? | ___ Yes ___ No | | | |
| | Has the probe design and material remained unchanged since the last horizontal straightness test? | ___ Yes ___ No | | | |
| 19c | (i) Was the fully assembled probe properly secured? | ___ Yes ___ No | If "yes" is always checked, go to item 19d. If "no" is checked for any question, mark "Fail" and skip the remaining steps in this procedure. | | |
| | (ii) Was an angle-measuring device or trigonometry (see Figure 2F-9 or 2G-6) used to determine the sag angle. | ___ Yes ___ No | | | |
| | (iii) Was the probe rotated and the sag angle measured at several rotational positions? | ___ Yes ___ No | | | |
| 19d | Maximum sag ($S_{MAX}$) angle measured among all rotational positions. | $S_{MAX}$ =___ degrees | The sag angles at all rotational positions must not exceed 5 degrees, i.e., $S_{MAX} \# 5°$ | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| **Rotational Position Check** | | | | |
| **Applicability:** All manually operated probes except those in which the yaw angle measuring device is mounted directly on "reference scribe line."<br>**Frequency:** (a) Before start of each field test for probes not employing extension(s).<br>(b) First time a probe extension is added if the extension can be locked into mechanically fixed rotational position.<br>(c) Every time a probe extension is added if the extension cannot be locked into mechanically fixed rotational position.<br>(d) Before and after each field test if extensions remain in place throughout field test. | | | | |
| 20a | Will this probe be used without extensions and will the yaw angle-measuring device be mounted and aligned directly on the probe's permanent reference scribe line? If so, mark "Not applicable" and skip the remaining steps in this procedure. If not, mark "Applicable" and go to next step. | | 8.3, 8.3.5 | __ Applicable<br>__ Not applicable |
| 20b | Pre-test rotational position check<br>Look at the values of $R_{ADO}^{pre}$, the angle measuring device rotational offset, appearing in the last column of Table 2F-2 or 2G-2. Verify that they have been determined to within the pre-test specification (e.g., by having the tester repeat the rotational position check for one or more of the table entries). | Pre-test spec<br>$R_{ADO}$ shall be determined to within ±1° at each position where the angle-measuring device is mounted on the probe, i.e.,<br>$\lvert R_{ADO}^{pre} \rvert \# 1°$ | 8.3 | __ Pass__ Fail |
| 20c | Does the probe consist of extensions that will not be removed throughout the field test? If so, continue with this procedure. If not, skip the remaining step in this procedure. | | | |
| 20d | Post-test rotational position check<br>Compare the values of $R_{ADO}^{post}$ appearing in the last column of Table 2F-2 or 2G-2 for the post-test rotational position check with the corresponding values obtained in the pre-test check. Do they meet the post-test specification? | Post-test spec<br>$R_{ADO}$ obtained in the post-test check must be within ±2° of the corresponding value obtained in the pre-test check, i.e.,<br>$\lvert R_{ADO}^{post} \& R_{ADO}^{pre} \rvert \# 2°$ | 8.3.4 | __ Pass__ Fail |

# Other Equipment Checks

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Pressure-Measuring Devices — General** | | | | | |
| 21 | Indicate type of device used:<br>Type of Device: Fluid manometer — Purpose: Velocity Pressure **G**, Yaw Nulling **G**<br>Electronic manometer — Velocity Pressure **G**, Yaw Nulling **G**<br>Mechanical gauge (e.g., Magnehelic®) — Velocity Pressure **G**, Yaw Nulling **G** | | Under all conditions electronic manometers are recommended. Under low flow conditions, electronic manometers may be necessary to obtain acceptable measurements. | 6.4.1 | Recommendation only |
| 22a | For electronic manometers<br>Indicate the type of data display device used:<br>**G** Panel meter **G** Strip chart<br>**G** PC **G** Other: _____ | | Electronic manometers must include or be coupled with (i) a data display device that allows the tester to observe the measurements during testing, and (ii) a data recorder that has the ability to compute and retain the appropriate average value at each traverse point, identified by time and traverse point<br>If an electronic manometer is being used and these conditions are met, mark "Pass." If an electronic manometer is being used and these conditions are not met, mark "Fail." If an electronic manometer is not being used, mark "Not Applicable." | 6.5 | __ Pass __ Fail<br>__ Not Applicable |
| 22b | Indicate the type of data capture device used:<br>**G** Data logger **G** PC with data capture software<br>**G** Other: _____ | | | | |
| **Pressure-Measuring Devices — Readability** | | | | | |
| 23 | Upper limit (UL) of measurement range displayed on device | UL = ___ in. $H_2O$ | Differential pressure devices must have a readability of ±1 percent of full scale, i.e.,<br>R # 0.01 (UL)<br>For an inclined-vertical manometer, the specification shall be met separately on each scale. | 2F: 3.5, 3.13, 6.4.1<br>2G: 3.4, 3.13, 6.4.1 | __ Pass __ Fail |
| | Readability (R):<br>For Analog devices<br>½ smallest scale division<br>For digital devices<br>Decimal places displayed | R = ___ in. $H_2O$ | | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Pressure-Measuring Devices — Range Checks** | | | | | |
| 24a | Do the majority of pressure measurements fall between 10% and 90% of the device full-scale range? | | | 6.4.1 | Recommendation only |
| 24b | Is the device capable of measuring the maximum expected pressure differential? | | | 6.4.1 | __ Pass __ Fail |
| 24c | If the device is used for yaw nulling, is it bi-directional with a full scale range no greater than 1 in. $H_2O$, i.e., from -0.5 in. $H_2O$ to +0.5 in. $H_2O$? | | | 6.4.2 | __ Pass __ Fail |
| **Pressure-Measuring Devices — Zeroing** | | | | | |
| **Applicability:** All pressure measuring devices used in field or wind tunnel testing<br>**Frequency:** (a) Before and after each field test. Before each wind tunnel test.<br>(b) More frequently at the discretion of the tester. | | | | | |
| 25 | Zero reading (Z) | ___ inches $H_2O$ | Both conditions (a) and (b) must be met. If not, mark "Fail."<br>(a) <u>For fluid manometer and mechanical pressure gauges (e.g., Magnehelic® gauges)</u>: The zero reading shall not deviate from zero by more than ±0.03 inches $H_2O$ or one minor scale division, whichever is greater, i.e.,<br>$\lvert Z \rvert \# max\ of \left\{ \begin{array}{c} 0.03\ in.\ H_2O \\ or \\ 1\ minor\ scale\ division \end{array} \right\}$<br><u>For electronic manometers</u>: The zero reading shall not deviate from zero by more than ±0.01 inches $H_2O$ for full scales # 2.0 in. $H_2O$ or by more than ±0.03 inches $H_2O$ for full scales > 2.0 in. $H_2O$, i.e.,<br>$\lvert Z \rvert \# \left\{ \begin{array}{c} 0.01\ in.\ H_2O,\ if\ full\ scale\ \#\ 2.0\ in.\ H_2O \\ or \\ 0.03\ in.\ H_2O,\ if\ full\ scale\ >\ 2.0\ in.\ H_2O \end{array} \right.$<br>(b) For all devices except those used exclusively for yaw nulling, the zero reading shall not differ from zero by more than 5% of the average measured differential pressure at any distinct process condition or load level, i.e.,<br>$\lvert Z \rvert \# \left( 5\% \times ADP \right)$ | 8.5, 10.5.2,<br>2F: 10.6.7<br>2G: 10.6.4 | __ Pass __ Fail |
| | Average measured differential pressure (ADP) at a distinct process condition or load level. | ___ inches $H_2O$ | | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| **Pressure-Measuring Devices Used for Yaw-Nulling — Responsiveness Check** | | | | |
| 26 | Was the device checked for responsiveness to rotation of probe prior to each use? | If the check was not performed or if the device was not responsive to probe rotation, mark "Fail". If the check was performed and the device was responsive, mark "Pass." | 10.3.3.3 | __ Pass __ Fail |
| **Pressure-Measuring Devices — 3-point calibration** | | | | |
| **Applicability:** All pressure measuring devices used in field testing except those used exclusively for yaw nulling. All pressure devices used in wind tunnel testing, except precision manometers that meet the specifications for a reference device (as defined in section 6.4.3 of Methods 2F and 2G) and that are not used for field testing.<br>**Frequency:** (a) Before initial field use of pressure measuring device.<br>(b) No later than 90 days after the device's first field use following its most recent previous 3-point calibration.<br>(c) On each day that probe calibrations are performed. | | | | |
| 27a | Will this pressure measuring device be used exclusively for yaw nulling?<br>Is this device a precision manometer that meets the specifications for a reference device (as defined in 6.4.3 of Methods 2F and 2G) and that is not used for field testing? | If either of these apply, skip the remaining steps in this procedure. If not, continue with the following step. | 10.3.3.3, 10.8 | |
| 27b | Date ($D_0$) of most recent 3-point calibration of device.<br>Date ($D_1$) of first field test after date $D_0$.<br>Date ($D_C$) of current field test | ___/___/___<br>___/___/___<br>___/___/___ | If the following condition is not met, mark "Fail" and skip the remaining steps in this procedure. If the condition is met, continue with the following steps in this procedure.<br>$D_C - D_1 \geq 90$ days | 10.8 | __ Pass __ Fail |
| 27c | Is the reference device a precision manometer or NIST traceable pressure source? If not, mark "Fail" and skip the remaining steps in this procedure.<br>Is the reference device maintained under laboratory or similar conditions (e.g., climate-controlled trailer) and not used in field tests? If not, mark "Fail" and skip the remaining steps in this procedure.<br>If a precision manometer is used, are the following conditions met?<br>Scale gradations — Manufacturer's Documented Accuracy<br>0.01 in. $H_2O$ or less in 0 to 2 in. $H_2O$ range — At least 0.5% of full scale<br>0.1 in. $H_2O$ or less in 2 to 10 in. $H_2O$ range<br>If a precision manometer is used that does not meet these specifications, mark "Fail" and skip the remaining steps in this procedure. | | 6.4.3 | __ Pass __ Fail |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | If a NIST traceable pressure source is used, is the date of its most recent recertification within a year of the current 3-point calibration? If not, mark "Fail" and skip the remaining steps in this procedure. | | | | |
| 27d | Was any adjustment, other than adjustments to the zero setting, made to the device being calibrated since the its most recent 3-point calibration. If yes, mark "Fail"and skip the remaining steps in this procedure. | | | 10.8 | __ Pass __ Fail |
| 27e | Upper limit (UL) of measurement range of device being calibrated. | UL = ___ in. $H_2O$ | The pressures shall agree to within ±2% of the full scale of the device being calibrated or 0.02 in. $H_2O$, whichever is less restrictive, i.e., $\lvert R_{30} \ \& \ C_{30} \rvert \ \# \ max \ of \left\{ \begin{matrix} 2\% \times UL \\ or \\ 0.02 \ in. \ H_2 \end{matrix} \right\}$ | 10.3.3.1-10.3.3.2 | __ Pass __ Fail |
| | Readings of reference device ($R_{30}$, $R_{60}$, $R_{90}$) and calibrated device ($C_{30}$, $C_{60}$, $C_{90}$) at reference pressures of 30, 60, and 90% of UL. | $R_{30}$, $R_{60}$, $R_{90}$ = __, __, __ in. $H_2O$<br>$C_{30}$, $C_{60}$, $C_{90}$ = __, __, __ in. $H_2O$ | The specification must also be met for $\lvert R_{60} \ \& \ C_{60} \rvert$ and $\lvert R_{90} \ \& \ C_{90} \rvert$.<br>Note: For inclined-vertical manometers, separate checks must be performed on the inclined and vertical portions of the measurement scale. | | |
| **Pressure-Measuring Devices — 1-point calibration** | | | | | |
| **Applicability:** All pressure measuring devices used in field testing.<br>**Frequency:** (a) After completion of each field test.<br>(b) More frequently (e.g., after one or more field test runs) at the discretion of the tester. | | | | | |
| 28a | Was a 1-point calibration performed on the device before it was used for another field test? If not, mark "Fail" and skip the remaining steps in this procedure. | | | 10.8.1 | __ Pass __ Fail |
| 28b | Was the 1-point calibration performed before leaving the field test site? | | | | Recommendation Only |
| 28c | Reference device used to calibrate field device | | | | |
| | Is the reference device a precision manometer or NIST traceable pressure source meeting the requirements for performing a 3-point calibration? If so, mark "Pass" and skip to item 28d. If not, continue on next row of 28c. | | | 6.4.3, 6.4.4 | __ Pass __ Fail |
| | Is the reference device a pressure measuring device or pressure source with a documented calibration traceable to NIST, or an equivalent device that has been previously approved by the Administrator? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue on next row. | | | | |
| | If a pressure measuring device is used, does it have a readability equivalent to or greater than the tested device? If not, mark "Fail" and skip the remaining steps in this procedure. If so, mark "Pass" and skip to item 28d. | | | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | If a NIST traceable pressure source is used,<br>(a) Is the date of its most recent recertification within a year of the current 1-point calibration?<br>(b) Is the generated pressure known to within ±1% of the full scale of the device being calibrated?<br>If the answer to either of these questions is "No," mark "Fail" and skip the remaining steps in this procedure. | | | | |
| | Was any adjustment, other than adjustments to the zero setting, made to the device being calibrated since the its most recent 3-point calibration. If yes, mark "Fail" and skip the remaining steps in this procedure. | | | 10.8 | ___ Pass ___ Fail |
| 28d | Upper limit (UL) of measurement range of device being calibrated. | UL = ___ in. $H_2O$ | Both of the following conditions must be met. If not, mark "Fail." If both conditions are satisfied, mark "Pass."<br>(a) The reference pressure must be between 50 and 90% of the full scale range of the device being calibrated, i.e.,<br>$(50\% \times UL) \# R \# (90\% \times UL)$<br>(b) The pressures shall agree to within ±3% of the full scale of the device being calibrated or 0.03 in. $H_2O$, whichever is less restrictive, i.e.,<br>$\lvert R \ \& \ C \rvert \# \max of \left\{ \begin{array}{c} 3\% \times UL \\ or \\ 0.03 \ in. \ H_2O \end{array} \right\}$ | 6.4.4, 10.8.1, 10.8.2 | ___ Pass ___ Fail |
| | Readings of reference device (R) and calibrated device (C). | R = ____ in. $H_2O$<br>C = ____ in. $H_2O$ | | | |
| **Digital Inclinometers** | | | | | |
| **Applicability:** | For measuring the yaw angle of flow using a manual probe to perform a horizontal traverse of a stack or duct. At tester's discretion a protractor wheel and pointer device may be used instead of a digital inclinometer (see item #30 below). Analog and other yaw angle-measuring devices may only be used if approved by the Administrator (see item #31 below). | | | 8.9.1 | |
| 29a | <u>Readability</u>: What is smallest readable angular increment (R) displayed? | R = ___ degree(s) | Both of the following conditions must be met. If not, mark "Fail"and skip the remaining steps in this procedure. If so, continue with this procedure.<br>(a) Digital inclinometer must be capable of displaying the rotational position of the probe to within ±1 degree, i.e.,<br>R # 1°.<br>(b) Digital inclinometer must be capable of measuring angles to within ±1 degree, i.e.,<br>A # 1°. | | ___ Pass ___ Fail |
| | <u>Accuracy</u>: What is manufacturer's documented accuracy (A) of the device? | A = ___ degree(s) | | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| 29b | Has the digital inclinometer been calibrated according to the manufacturer's calibration procedures and according to section 10.3.4 of Method 2F or 2G? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | 10.3.4<br>Fig. 2F-12<br>Fig. 2G-9 | |
| | Calibration: Record angles of inclination ($R_1$ and $R_2$) measured on sides A and B of a triangular block with known angle è. | $R_1$ = ___ degree(s)<br>$R_2$ = ___ degree(s)<br>è = ___ degree(s) | The difference between the sum of the two readings from 180° shall be within ±2° of the known angle è, i.e.,<br>$\lvert 180° \ \& \ R_1 \ \& \ R_2 \ \& \ è \rvert \ \# \ 2°$<br>If this condition is satisfied, mark "Pass". If not, mark "Fail". | | |
| **Protractor Wheel and Pointer Device** | | | | | |
| **Applicability:** | (a) For measuring yaw angle of flow when using a manual probe to perform a vertical traverse of a horizontal duct (i.e., a when measuring from on top or into the bottom of a horizontal duct). See section 8.9.1 of Methods 2F and 2G.<br>(b) As an alternative to using a digital inclinometer to measure the yaw angle of flow. | | | | |
| 30a | Diameter (D) of measurement ring on face of protractor wheel. | D = ___ inches | Both of the following conditions must be met. If not, mark "Fail"and skip the remaining steps in this procedure. If so, continue with this procedure.<br>(a) The measurement ring on the face of the protractor wheel must be no less than 7 inches in diameter, i.e.,<br>D $ 7 inches<br>(b) The measurement ring on the protractor wheel must indicate angles to a resolution of 1°, i.e.,<br>$R_W$ # 1° | 6.2.2.1 | ___ Pass ___ Fail |
| | Readability: What is smallest readable angular increment ($R_W$) displayed on the protractor wheel? | $R_W$ = ___ degree(s) | | | |
| 30b | Does the collar of the pointer assembly have a scribe line that corresponds to the position of the pointer needle and that can be aligned with the scribe line on the probe sheath? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | 6.2.2.2 | |
| | Is the pointer needle of sufficient length, rigidity and sharpness to meet the following readability specification: | | | | |
| | Readability: What is smallest angular increment ($R_N$) that can be determined using the pointer? | $R_N$ = ___ degree(s) | The pointer must allow the tester to determine the probe's angular position to within 1° from the markings on the protractor wheel, i.e.,<br>$R_N$ # 1°<br>If not, mark "Fail" and skip the remaining steps. | | |
| 30c | After measurements are taken at the last traverse point accessed from each test port, did the tester perform a verification that the rotational orientation of the protractor wheel had not changed during the traverse? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with either items (i) or (ii) below. | | | 18.2.8 | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | (i) <u>For ports on vertical stacks or ducts and ports on the side of horizontal ducts</u>: Was a digital inclinometer used for the verification? If not, mark "Fail." If so, continue with this procedure. | | | | |
| | Angle (á) reading of inclinometer when aligned with 0° mark on protractor wheel. | á = ___ degree(s) | If the observed angle at any port exceeds ±2° of 0°, mark "Fail." If the observed angles at all ports are within ±2° of 0°, mark "Pass," i.e., $\lvert á \rvert \# 2°$ | | |
| | (ii) <u>For ports on the top or bottom of horizontal ducts</u>: Was a permanent mark placed on the duct before the start of the traverse, and, was a visual inspection performed after the completion of the traverse to confirm that the 0° mark on the protractor was in proper alignment with the permanent 0° mark on the duct? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | | |
| | Reading on protractor (R) wheel corresponding to 0° mark on the duct. | R = ___ degree(s) | If the observed angle at any port exceeds ±2° of 0°, mark "Fail." If the observed angles at all ports are within ±2° of 0°, mark "Pass," i.e., $\lvert R \rvert \# 2°$ | | |
| **Other Yaw Angle-Measuring Devices** | | | | | |
| 31 | Was device approved for use by the EPA Administrator? | Yes / No | Other yaw angle-measuring devices may only be used if (i) approved by the Administrator, and (ii) they have a manufacturer's specified precision of 1° or better.<br><br>If an alternative yaw angle-measuring device is being used and both of these conditions are met, mark "Pass." If either condition is not met, mark "Fail." If an alternative yaw angle-measuring device is not being used, mark "Not Applicable." | 6.2.3 | __ Pass __ Fail<br>__ Not applicable |
| | Enter manufacturer's specified precision. | degrees | | | |
| **Temperature Gauges** | | | | | |
| 32a | Is the gauge capable of measuring temperatures within ±5°F of the stack or duct temperature? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | 6.6 | __ Pass __ Fail |
| 32b | Was the gauge calibrated no more than 30 days prior to the start of the current field test or the series of field tests that include the current field test? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | Methods 2F, 2G: 10.9<br><br>Method 2: 4.3 | |
| | Will the gauge be recalibrated no more than 30 days after completion of the current field test or the series of field tests that include the current field test? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | | |
| | Were the following specifications met when the calibration was performed? | | | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | Absolute temperature ($T_G$) from gauge being calibrated | $T_G$ = ___ °F + 460° | The absolute temperature measured by the gauge being calibrated and the reference gauge must agree within 1.5%, i.e., $\frac{\lvert T_G \& T_R \rvert}{T_R} \times 100\% \# 1.5\%$ | | |
| | Absolute temperature ($T_R$) from reference gauge or standard | $T_R$ = ___ °F + 460 | | | |
| **Barometer** | | | | | |
| 33a | Was the barometric pressure gauge capable of measuring atmospheric pressure to within 0.1 inch Hg? If not, mark "Fail" and skip remaining steps in this procedure. If so, continue with procedure. | | | Methods 2F, 2G: 6.8, 10.10<br><br>Method 2: 2.5, 4.4 | ___ Pass ___ Fail |
| 33b | If a barometric pressure reading was obtained from a nearby National Weather Service station, was an adjustment made for elevation differences between the weather station and the sampling point? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | | | |
| | Elevation ($E_S$) at sampling point | $E_S$ = ___feet above sea level | If there was an elevation difference between the weather station and the sampling point the following relationship should hold: $\frac{\lvert E_W \& E_S \rvert}{A} \leq 1{,}000$ If there is an elevation difference and this condition is not met, mark "Fail." If this condition is satisfied or if there is no elevation difference between the weather station and sampling point, mark "Pass." | | |
| | Elevation ($E_W$) at weather station | $E_W$ = ___feet above sea level | | | |
| | Adjustment (A) made to NWS barometric pressure reading | A = ___ in. Hg | | | |
| 33c | If a mercury, aneroid, or other barometer was used at the sampling location, was it calibrated against a mercury barometer no more than 30 days prior to the start of the current field test or the series of field tests that include the current field test? If not, mark "Fail." If so, mark "Pass" | | | | |

# Field Test Performance

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| **Traverse Point Verification** | | | | |
| **Applicability:** All probes.<br>**Frequency:** Before each field test. | | | | |
| 34a | Was the stack diameter obtained by physically measuring the stack or duct dimensions or by using a calibrated laser measuring device, rather than from engineering drawings. If not, mark "Fail" and skip the remaining steps in this procedure. If so, record the stack diameter and continue with this procedure. (Diameter = _____ inches) | | 8.6 | ___ Pass ___ Fail |

At each stack port, were the probe lengths necessary to reach each traverse point calculated and recorded, taking into account the dimensions of any exterior port flange and interior port nipple? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure.

If a manual probe is used, are the probe lengths needed to reach each traverse point marked directly on the probe sheath? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure.

Prior to the start of testing are out-of-stack measurements made of the markings on a manual probe or the flange-to-impact-port distances for an automated probe to verify the accuracy of traverse point positions for the probe. If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure.

34b

Enter the values indicated below. If any value in column (vi) is greater than 1/4 inch, mark "Fail." If all values in column (vi) do not exceed 1/4 inch, mark "Pass".

| Port/Traverse Point ID (e.g., A1, A2) | Traverse Point Locations from Test Method 1 | Adjustments due to port flange and nipples | Resulting Calculated Probe Lengths | Measured probe lengths | Calculated vs. Measured probe lengths \| col (v)-col(iv)\| |
|---|---|---|---|---|---|
| (i) | (ii) | (iii) | (iv) | (v) | (vi) |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| • • • | • • • | • • • | • • • | • • • | • • • |

| | | | | | |
|---|---|---|---|---|---|
| **Gas density and moisture determination** | | | | | |
| 35a | Enter ID number of EPA test method used to determine the dry molecular weight of the stack gas. | Method _____ | Method 3 or 3A shall be used to determine the dry molecular weight of the stack gas. Method 4 shall be used for moisture content determination and computation of wet molecular weight. Other methods may be used only if approved by the Administrator.<br><br>If these requirements are met, mark "Pass." If not, mark "Fail." | 6.9 | __ Pass __ Fail |
| 35b | Enter ID number of EPA test method used to determine the wet molecular weight and moisture of the stack gas. | Method _____ | | | |
| **Leak Checks** | | | | | |
| **Applicability:** All probes and pressure measuring devices used in field or wind tunnel testing<br>**Frequency:** (a) Before and after each field and wind tunnel test.<br>(b) More frequently at the discretion of the tester. | | | | | |
| 36 | Upper limit (UL) of pressure measurement device. | UL = ___ in. $H_2O$ | All of the following conditions must be met. If not, mark "Fail."<br>(a) The initial pressure must be at least 3 in. of $H_2O$ or a pressuring corresponding to approximately 75% of the pressure-measuring device's measurement scale, whichever is less, i.e.,<br>$IP \geq min\ of \left\{ \begin{array}{c} 3\ in.\ H_2O \\ or \\ Approximately\ 75\% \times UL \end{array} \right\}$<br>(b) The pressure shall remain stable to within ±0.10 inches $H_2O$, i.e.,<br>$\lvert FP - IP \rvert \leq 0.10\ in.\ H_2O$<br>(c) The leak check shall be performed for at least 15 seconds, i.e.,<br>$T \geq 15\ seconds$ | 8.4, 10.3.2 | __ Pass __ Fail |
| | Initial pressure (IP) during leak check.. | IP = ___ inches $H_2O$ | | | |
| | Final pressure (FP) reading during leak check.. | FP = ___ inches $H_2O$ | | | |
| | Elapsed time (T) between initial and final pressure reading. | T = ___ seconds | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Zeroing Pressure-Measuring Devices** | | | | | |
| **Applicability:** All pressure measuring devices used in field or wind tunnel testing, including devices used for yaw nulling<br>**Frequency:** (a) Before and after each field test. Before each wind tunnel test.<br>(b) More frequently at the discretion of the tester. | | | | | |
| 37 | Zero reading (Z) | Z = ___ inches $H_2O$ | Both conditions (a) and (b) must be met. If not, mark "Fail."<br><br>(a) <u>For fluid manometer and mechanical pressure gauges (e.g., Magnehelic® gauges)</u>: The zero reading shall not deviate from zero by more than ±0.03 inches $H_2O$ or one minor scale division, whichever is greater, i.e.,<br>$\lvert Z \rvert \# max\ of \left\{ \begin{array}{c} 0.03\ in.\ H_2O \\ or \\ 1\ minor\ scale\ division \end{array} \right\}$<br><u>Electronic manometers</u>: The zero reading shall not deviate from zero by more than ±0.01 inches $H_2O$ for full scales # 2.0 in $H_2O$ or by more than ±0.03 inches $H_2O$ for full scales > 2.0 in. $H_2O$, i.e.,<br>$\lvert Z \rvert \# \left\{ \begin{array}{c} 0.01\ in.\ H_2O,\ if\ full\ scale \# 2.0\ in.\ H_2O \\ or \\ 0.03\ in.\ H_2O,\ if\ full\ scale > 2.0\ in.\ H_2O \end{array} \right.$<br>(b) For all devices except those used exclusively for yaw nulling, the zero reading shall not differ from zero by more than 5% of the average measured differential pressure at any distinct process condition or load level, i.e.,<br>$\lvert Z \rvert \# \left( 5\% \times \Delta P_{AVG} \right)$ | 2F, 2G: 8.5, 10.5.2,<br><br>2F:10.6.7<br><br>2G:10.6.4 | ___ Pass ___ Fail |
| | Average measured differential pressure ($\Delta P_{AVG}$) at a distinct process condition or load level. | $\Delta P_{AVG}$ = ___ inches $H_2O$ | | | |
| **System Response Time** | | | | | |
| 38a | Was system response time determined for a "cold" probe before the start of the field test? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with the next step. | | | | |
| 38b | Enter the time interval between measurements used to determine the response time. | seconds | Differential pressure (ΔP) and temperature measurements must be recorded every 15 seconds. If this was not done, mark "Fail" and skip the remaining steps in this procedure. | 8.8, 8.9.2 | ___ Pass ___ Fail |

| | | | | | |
|---|---|---|---|---|---|
| 38c | Enter the elapsed time ($ET_p$) required to reach stable differential pressure (ΔP) reading | seconds | The response time is the longer of the times required to reach a stable differential pressure (ΔP) or temperature reading, i.e., $RT = \max \begin{Bmatrix} ET_p \\ or \\ ET_t \end{Bmatrix}$ If this condition does not hold, mark "Fail" and skip the remaining steps in this procedure. If this condition is met, continue with the next step. | | |
| | Enter the elapsed time ($ET_t$) required to reach stable temperature reading | seconds | | | |
| | Enter response time (RT) recorded by the tester. | seconds | | | |
| 38d | Enter minimum time (MinT) elapsed at first point traversed in any port | seconds | At the start of testing in each port and any time a probe is removed from the flue gas stream, the tester must allow at least the response time to elapse before taking measurements at the first traverse point accessed from the port, i.e., $MinT \geq RT$ If condition met, mark "Pass." If not, mark "Fail." | | |
| **Sampling** | | | | | |
| | Alignment check for manually operated probes | | | | |
| | At each traverse point was the alignment of the yaw angle-measuring device checked after taking measurements at that traverse point? | | If not, mark "Fail," and skip the remaining steps in this procedure. If so, continue with this procedure. | | |
| 39a | Did the alignment check at every traverse point show that the yaw angle-measuring device maintained proper alignment with the reference scribe line or with the rotation offset position established in the rotational position check? | | If so, mark "Pass" and skip the remaining step in this procedure. If the yaw angle-measuring device was not maintained in proper alignment at any traverse point, continue with the next step in this procedure. | 8.9.6 | __ Pass __ Fail |
| | At any traverse point, where the angle-measuring device was not in proper alignment, was the device brought back into proper alignment and the differential pressure measurements at the traverse point repeated? | | If so, mark "Pass." If not, mark "Fail." | | |
| | Probe orientation check for Type S probes used with Method 2G | | | | |
| 39b | Was the calibrated leg facing into the flow when pressure measurements were taken? | | If so, mark "Pass." If not, mark "Fail." | 8.9.3.1, 8.9.5, 10.6.10 | __ Pass __ Fail |
| 39c | If a horizontal traverse was performed with probes longer than 10 feet, was the probe secured in a horizontal position (e.g., by use of probe stands, monorails, or bushing sleeve)? If not, mark "Fail." | | | 6.3 | __ Pass __ Fail |

| | | | | | |
|---|---|---|---|---|---|
| 39d | Was a visual check made of the probe's horizontal stability prior to each reading? Was the probe's horizontal stability verified periodically using a carpenter's level or angle-measuring device? | | | 9.1.2 | Recommendation Only |
| **Velocity Calibration Usability Check** | | | | | |
| **Applicability:** Any time a field test is performed using Method 2F and 2G, pre-test checks should be made to verify that the calibration is valid and current. A post-test check must be made to confirm that the calibrations coefficient(s) and/or curves were derived at wind tunnel velocities that are compatible with the velocity encountered in the field<br>**Frequency:** Items 40a and 40b should be performed prior to the start of each field test and item 40c at the completion of a field test. | | | | | |
| 40a | Were the probe's calibration coefficient(s) and/or curves obtained through a wind tunnel test performed in accordance with section 10 of Method 2F or 2G? (Default coefficients may not be used.) | | | 6.1.1 | __ Pass __ Fail |
| 40b | Time (T) elapsed since first field use of probe after most recent calibration | T = ____ months | If BOTH of the following conditions are true, mark "Fail". The calibration is no longer valid. If either condition is not met, mark "Pass."<br><br>T > 12 months<br>N > 10 field tests | 10.7 | __ Pass __ Fail |
| | Number (N) of field tests performed since most recent calibration | N = _____ | | | |

<table>
<tr><td rowspan="4">40c</td><td colspan="5">Verification that the probe calibration was performed at wind tunnel velocity settings appropriate for the velocity encountered in the field test</td></tr>
<tr><td>Average axial velocity ($v_{a(avg)}$) obtained using equation Eq. 2F-9 or Eq. 2G-8.</td><td>$v_{a(avg)}$ = ___ ft/sec</td><td rowspan="3">Method 2F<br><u>Case 1</u>: If $v_{a(avg)}$ < 20 ft/sec, Method 2F may not be used.<br><br>If $v_{a(avg)}$ $ 20 ft/sec:<br><u>Case 2a</u>:The calibrations are usable for any value of $v_{a(avg)}$, if both of the following conditions are true:<br>55 ft/sec # L # 65 ft/sec<br>85 ft/sec# H# 95 ft/sec<br><br><u>Case 2b</u>: If the conditions in Case 2a are not satisfied, the calibrations are only usable if $v_{a(avg)}$, # H.</td><td rowspan="3">Method 2G<br>The calibration is usable if either of the following apply.<br><br><u>Case 1</u>:<br>L – 5 # $v_{a(avg)}$, # H +5<br><br><u>Case 2</u>: $v_{a(avg)}$ $ 30 ft/sec and both of the following conditions are true:<br>55 ft/sec # L # 65 ft/sec<br>85 ft/sec # H # 95 ft/sec</td><td rowspan="3">12.4</td><td rowspan="3">__ Pass __ Fail</td></tr>
<tr><td>Lower wind tunnel velocity setting (L) used when calibrating probe</td><td>L = ___ ft/sec</td></tr>
<tr><td>Higher wind tunnel velocity setting (H) used when calibrating probe</td><td>H = ___ ft/sec</td></tr>
<tr><td colspan="6">Yaw Angle Calibration Usability Check (Method 2G only)</td></tr>
<tr><td colspan="6">Applicability: (1) Only applies to Method 2G<br>(1) Only applies when using a detachable probe head which is coupled to the probe sheath.<br>Frequency: Should be checked prior to the start of each field test and observed throughout a field test.</td></tr>
<tr><td>41</td><td colspan="2">Was the probe head uncoupled or re-oriented since the most recent yaw angle calibration in the wind tunnel?</td><td colspan="2">Once the detachable probe head is uncoupled or re-oriented, the yaw angle calibration of the probe is no longer valid.<br><br>If the probe head has been uncoupled or re-oriented, mark “Fail.” If not, mark “Pass.”</td><td>6.1.8</td><td>__ Pass __ Fail</td></tr>
</table>

# Wall Effects (Method 2H) Checks

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Site Prerequisites** | | | | | |
| 42 | Where will measurements be made? | ___ Vertical Stack<br>___ Horizontal Duct<br>___ Vertical Duct<br>___ Other: _____ | Method 2H is only applicable to circular stacks or ducts.<br><br>If "circle" is selected, go to next item. If any other option is chosen, mark "Fail" and stop. Method 2H cannot be used. | 1.1 | ___ Pass ___ Fail |
| | What is the geometrical shape of the stack or duct at the measurement plane? | ___ Circle<br>___ Ellipse<br>___ Rectangle or square<br>___ Other: _____ | | | |
| | What is diameter (D) of the stack or duct? | D = ___ feet | Method 2H is applicable to stacks and ducts whose diameter is greater than or equal to 3.3 feet, i.e.,<br><br>D $ 3.3 feet<br><br>If this condition is met, go to next item. If not, mark "Fail" and stop. Method 2H may not be used. | 1.3 | |
| **Default Wall Effects Adjustment Factor (WAF)** | | | | | |
| 43a | Was a default wall effects adjustment factor (DWAF) used? | ___ Yes ___ No | If "yes" continue. If "no," skip the remaining steps in this procedure. | | |
| 43b | What value was used for DWAF? | DWAF =<br>___ 0.9900<br>___ 0.9950<br>___ Other: _____ | If DWAF = "Other," mark "Fail" and skip the remaining steps in this procedure. If DWAF = 0.9900 or 0.9950, go on to next step. | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| 43c | Out of what material is the inside surface (SURF) of the stack or duct constructed? | SURF =<br>___ Bricks and mortar<br>___ Other: _____ | A default wall effects adjustment factor of 0.9900 for brick and mortar stacks and ducts or 0.9950 for all other types of stacks and ducts may be used without taking wall effects measurements, i.e.,<br>(i) If SURF = "Bricks and mortar," then DWAF = 0.9900.<br>(ii) If SURF = "Other," then DWAF = 0.9950<br>If either of these conditions is met, mark "Pass." If neither is met, mark "Fail." | 2.2.2, 8.1, Table 2H-2 | __ Pass __ Fail |
| Note: If the default WAF was used, no further checks need to be performed. The following checks apply only when wall effects measurements are taken and the Method 2H calculational approach is used. | | | | | |
| **Particulate Build-up in Horizontal ducts** | | | | | |
| | If testing is not being performed in a horizontal duct, skip the following procedure. If testing is being performed in a horizontal duct, continue with the following procedure. | | | | |
| 44 | Is there a build-up of particulate matter or other material in the bottom of the duct? | ___ Yes<br>___ No | The calculational procedure based on velocity measurements shall not be used for horizontal ducts where there is build up of particulate matter or other material in the bottom of the duct.<br>If "yes" is selected, mark "Fail" and do not continue. Only a default wall effects adjustment factor may be used. If "no" is selected, continue with next procedure. | 2.2.1, 9.1 | __ Pass __ Fail |
| **Traverse Point Determination** | | | | | |
| The following checks verify key determinants ($d_{last}$, $d_b$, and $d_{rem}$) used to locate wall effects traverse points. | | | | | |
| 45a | Enter the number of traverse points (M1TP) in original Method 1 traverse | M1TP = | | | |
| 45b | Enter the diameter of stack or duct (D) in inches. | D = | | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| 45c | Enter the values in columns (ii)-(iv) as indicated in the table below. If no measurement was taken at a designated location, enter "NM" (i.e., no measurement). | | | |

| | Distance from wall where measurements were taken | | | Values used to check col. iii and (iv) | |
|---|---|---|---|---|---|
| | 1-in. incremented wall effects traverse points | | | | |
| Port ID | Closest Point to Wall | Furthest Point from Wall ($d_{last}$) | $d_{rem}$ | Enter $d_b$ below from Eq. 2H-4 | Enter $d_{rem}$ below from Eq. 2H-1 |
| (i) | (ii) | (iii) | (iv) | (v) | (vi) |
| A | _____ inches | inches | inches | | |
| | | | | | |
| | | | | | |
| | | | | | |

| | | | | |
|---|---|---|---|---|
| 45d | Did the Method 1 traverse have a sufficient number of traverse points? | Method 2H must be performed in conjunction with a Method 1 traverse consisting of 16 or more points, i.e.,<br>M1TP $ 16<br>If the value in item 45a satisfies this condition, continue with the next step in this procedure. If not, mark "Fail" and stop. The calculational procedure under Method 2H cannot be used. | 2.2.1, 8.2.1 | __ Pass __ Fail |
| 45e | Was any wall effects traverse point too close to the center of the stack or duct? | $d_{last}$ must not be closer to the center of the stack or duct than the distance of the interior boundary ($d_b$) of the Method 1 equal area sector closest to the wall, i.e.,<br>$d_{last} \# d_b$<br>If any of the values in column (iii) is greater than the corresponding value in column (v), mark "Fail." If not, continue with the next step in this procedure. | 8.2.2.3 | |
| 45f | Was the value of $d_{rem}$ correctly calculated?<br>(Note: $d_{rem}$ must be calculated using Eq. 2H-2 for a 16-point Method 1 traverse or Eq. 2H-1 for Method 1 traverse with more than 16 points. ) | If each value in column (iv) is within 0.25 in. of the corresponding value in column (vi), mark "Pass" and continue with the next step in this procedure. If not, mark "Fail," i.e.,<br>$\lvert(col.\ iv)\ \&\ (col.\ vi)\rvert \# 0.25\ inch$ | 8.2.2.2 | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| 45g | Did "NM" appear anywhere in column (ii)? | At a minimum, measurements must be taken in all four Method 1 exterior equal area sectors at 1 in. from the wall or at the 1-in. incremented wall effects traverse point closest to the wall where the probe can be positioned and velocity pressure can be detected.<br><br>If "NM" appears anywhere in column (ii), mark "Fail." If not, continue with the next step in this procedure. | 8.2.2 | |
| 45h | If "NM" appeared in column (iv), was the value in column (vi) within ½ inch of the value in column (iii)? | At a minimum, measurements must be taken in all four Method 1 exterior equal area sectors either (a) at position $d_{rem}$ or (b) at $d_{last}$, if $d_{rem}$ is within ½ inch of $d_{last}$.<br><br>Mark "Fail" if "NM" appeared in column (iv), and the value in column (vi) was not within ½ inch of the value in column (iii), i.e., if<br><br>$\lvert(col.\ iii)\ \&\ (col.\ vi)\rvert > 1/2\ inch$<br><br>If this condition does not apply or if no "NM" appeared in column (iv), mark "Pass." | 8.2.2, 8.2.4.2 | |
| **Traverse Point Verification** | | | | |
| The following Method 2H checks supplement those typically performed under Methods 2F and 2G. The Method 2F and 2G traverse point checks should be performed in conjunction with the following checks, but their description is not repeated here. (See item 34 above.) | | | | |
| 46a | If a manual probe is used, are the probe lengths needed to reach each Method 1 and wall effects traverse point marked directly on the probe sheath? If not, mark "Fail" and skip the remaining steps in this procedure. If so, continue with this procedure. | | 9.2.1 | __ Pass __ Fail |
| 46b | Were different color marks used to distinguish Method 1 and wall effects traverse points? | | | Recommendation Only |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| 46c | Spot check selected wall effects traverse point markings by entering the values indicated below for the selected traverse points. Include at least one of traverse point located at $d_{rem}$ and $d_{last}$. If all values in column (vi) do not exceed 1/4 inch, mark "Pass" and skip the remaining step in this procedure . If any value in column (vi) is greater than 1/4 inch, perform the procedures in step 46d. | | | __ Pass __ Fail |

| Port/Traverse Point ID (e.g., A1w, A2w) | Traverse Point Distance from Wall Calculated as Specified in 2H, section 8.2 | Adjustments due to port flange and nipples | Resulting Calculated Probe Lengths | Measured probe lengths | Calculated vs. Measured probe lengths \| col (v)-col(iv)\| |
|---|---|---|---|---|---|
| (i) | (ii) | (iii) | (iv) | (v) | (vi) |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| _____ | _____ inches | _____ inches | _____ inches | _____ inches | _____ inches |
| • • • | • • • | • • • | • • • | • • • | • • • |

| | | | | | |
|---|---|---|---|---|---|
| 46d | For every point that does not meet the ¼ -inch specification in item 46c, the following check is performed to see if the point meets the special provision of being within ½ inch of a Method 1 traverse point. | | | | |
| | For every value in column (vi) greater than ¼ inch, perform the following check: | | | When the distance between a wall effects traverse point (column ii) and a Method 1 traverse point is less than ½ inch, i.e., $\lvert d_w \& d_{M1} \rvert$ # 0.5 *inch*, measurements may be taken at the point that is farther from the wall, and the resulting velocity value used for both points<br><br>If $\lvert d_w \& d_{M1} \rvert$ > 0.5 *inch* for any point checked, mark "Fail." That point did not meet the condition in item 46c or the special provision of being within ½ inch of a method 1 traverse point.<br><br>If $\lvert d_w \& d_{M1} \rvert$ # 0.5 *inch* for every point checked in this step, mark "Pass." The special provision was satisfied. | 8.2.4.1 | |
| | Enter calculated distance from wall ($d_w$) shown in column (ii) for this point | | inches | | |
| | Enter distance from wall ($d_{M1}$) of Method 1 traverse point closest to wall | | inches | | |
| | Find the absolute value of the difference between the preceding two values, i.e., $\lvert d_w \& d_{M1} \rvert$ | | inches | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| **Sampling** | | | | |
| The following Method 2H checks supplement those performed on Methods 2, 2F and 2G. The checks of system response time and sampling procedures (items 38 and 39 above), performed on Methods 2, 2F, and 2G, must also be performed when Method 2H is used, but their description is not repeated here. | | | | |
| 47a | Was system response time determined before the start of the field test by placing the "cold" probe at a Method 1 traverse point, not a wall effects traverse point? If so, mark "Pass." If not, mark "Fail." | | 8.4.1 | __ Pass __ Fail |
| 47b | Were temperature measurements for Method 2H obtained in one of the following two ways:<br>(i) Taking measurements at each wall effects traverse point, or<br>(ii) Taking measurements at the Method 1 traverse point closest to the wall at each port.<br>If one of these two options was used, mark "Pass." If not, mark "Fail." | | 8.4.2 | __ Pass __ Fail |
| 47c | Were the Method 1 and wall effects traverse points accessed from the same port sampled without interruption? If so, mark "Pass." If not, mark "Fail." | | 8.3.2.1 | __ Pass __ Fail |
| 47d | Was the Method 1 traverse point closest to the wall sampled in sequence between the adjacent wall effects traverse points? | | 8.3.3 | Recommendation Only |
| 47e | Was the same type of probe (e.g., the spherical probe) used to take measurements at all Method 1 and wall effects traverse points? If so, mark "Pass." If not, mark "Fail."<br><br>(Note: Different copies of the same type of probe may be used ( e.g., copy 1 and 2 of a spherical probe) but not different types of probes (e.g., a spherical and a Type S). | | 8.3.4 | __ Pass __ Fail |
| 47f | Was the ID number of the probe used at each traverse point recorded? | | 8.3.4 | __ Pass __ Fail |
| 47g | Were adequate measures taken to seal the stack port during testing to prevent flue gas in- and out-leakages that could jeopardize measurements at traverse points close to the stack or duct wall? | | 9.3 | Recommendation Only |
| **Partial or Complete Traverse Check** | | | | |
| The following check is used to determine whether a partial or complete wall effects traverse was performed. This is important because a lower (i.e., more beneficial) WAF can be claimed when a complete traverse is performed than when a partial traverse is performed. | | | | |
| 48a | Is any value in col (ii) of the table in item 45c greater than 4 inches? | For a complete traverse, a measurement must be taken at the 1-inch incremented wall effects point that is as close to the wall as the probe can be positioned and velocity detected, but no further than 4 inches from the wall<br><br>If any value in col (ii) is greater than 4 inches, mark "Partial" and skip the remaining step in this procedure. If not, continue with this procedure. | 8.2.3 | __ Partial<br>__ Complete |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| 48b | Were measurements taken in 1-inch increments starting at the wall effects point closest to the wall and proceeding out to the lower of the following<br>(a) 12 inches from the wall or<br>(b) the value shown in column (v) of the table in item 45c? | For a complete traverse, measurements must be taken in 1-inch increments starting at a point no further from the wall than 4 inches and proceeding out to the interior edge of the Method 1 equal area sector or to 12 inches from the wall, whichever comes first.<br><br>If sufficient measurements were not taken, mark "Partial." If sufficient measurements were taken, mark "Complete." | | |

# Wind Tunnel Checks

## General Wind Tunnel Information

| | | | |
|---|---|---|---|
| **Wind Tunnel Name:** | | **Auditor/Observer:** | |
| **Address:** | | **Organization:** | |
| **Address:** | | **Location (City, State):** | |
| **Contact:** | | **Phone #:** | |
| **Phone Number:** | | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| **Ports** | | | | |
| 49 | Indicate ports found in the wind tunnel:<br>a ☐ Port for Tested Probe<br>b ☐ Port for Verification of Axial Flow (located 90° from tested probe port)<br>c ☐ Port for Calibration Pitot | The wind tunnel must have a port for tested probe.<br><br>A separate port for the calibration pitot is optional. The calibration pitot may either be inserted in a separate port or the port used for the tested probe.<br><br>If box “a” is not checked, mark “Fail” and skip the remaining step in this procedure. If box “a” is checked, continue with the following step. | 6.11.4 | __ Pass__ Fail |
| | Indicate type of probe used for the axial flow verification:<br>d ☐ Calibrated 3-D probe<br>e ☐ Uncalibrated prism-shaped 3D probe (e.g., DAT, DA)<br>f ☐ Uncalibrated wedge probe | A separate port for verification of axial flow is required if the axial flow verification is performed with an uncalibrated prism-shaped 3-D probe or wedge probe. It is not required if the axial flow verification is performed with a calibrated 3-D probe.<br><br>If box “e” or “f” is checked and box “b” is not checked, mark “Fail.” If neither box “e” nor “f” is checked, mark ”Pass.” | 10.1.2 | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| **Dimensions of "Test Section"** | | | | | |
| 50a | **G** Circular Duct Diameter (D) | W = _____ inches | D $ 12 inches | 6.11.1 | __ Pass__ Fail |
| 50b | **G** Rectangular Duct Length (L):<br><br>Width (W): | L = _____ inches<br><br>W = _____ inches | The shorter side should be no less than 12 inches, i.e.,<br>$min\ of \left\{ \begin{matrix} Length(L) \\ or \\ Width(W) \end{matrix} \right\} \geq 12\ inches$ | | |
| **Distance of Calibration Location from Wall** | | | | | |
| 51 | Closest distance from wall of any point in calibration location | _____ inches | <u>Circular Duct</u><br>Distance $ 4 inches or 25% of tunnel diameter (whichever is greater)<br><u>Rectangular or Elliptical Duct</u><br>Distance $ 4 inches or 25% of cross-sectional axis (whichever is greater) | 3.20 | __ Pass__ Fail |
| **Blockage** | | | | | |
| 52a | Projected area (P) of probe head, shaft, and attached devices inside wind tunnel | P = _____ square inches | The blockage by the probe head, shaft, and attached devices shall not exceed 4% of the cross-sectional area of the wind tunnel, i.e.,<br>$\left(\frac{P}{A}\right) \times 100\% \leq 4\%$<br>If this condition is met, mark "Pass." If not, mark "Fail." | 6.11.1 | __ Pass__ Fail |
| 52b | Cross-sectional area (A) of wind tunnel at calibration location<br><br><u>Circular ducts</u>:<br>A = ð × (diameter/2)$^2$<br><br><u>Rectangular ducts</u>:<br>A = length × width | A = _____ square inches | | | |
| **Velocity Range** | | | | | |
| 53a | Lowest velocity (L) tunnel is capable of maintaining. | L = _____ ft/sec | Wind tunnel should be capable of maintaining velocities between 20 and 100 ft/sec, i.e.,<br>$L \leq 20\ ft/sec, \qquad H \geq 100\ ft/sec$ | 6.11.2 | Recommendation only |
| 53b | Highest velocity (H) tunnel is capable of maintaining. | H = _____ ft/sec | | | |
| **Velocity Pressure Cross-Check** | | | | | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| 54a | Was this procedure performed using a calibration pitot tube which satisfied the checks described in item # 57 below? | If not, mark “Fail” and skip the remaining steps in this procedure. If so, go on to next step. | | |
| 54b | Were pressure measurements taken at all the test points specified in the method? | Pressure measurements must be taken at<br>(i) the fixed calibration pitot tube location and<br>(ii) 1-in. or smaller intervals across the full length, width and depth (if applicable) of the wind tunnel calibration location.<br><br>If measurements were not taken at all of the specified test points, mark “Fail” and skip the remaining steps in this procedure. If measurements were taken at all the specified, points go to next step. | 3.20<br>10.1.1 | __ Pass__ Fail |
| | At each test point were three differential pressure measurements taken at each wind tunnel velocity setting? | If so, go to the next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |
| | Were each of the three measurements at a point in the wind tunnel calibration location alternated with the three measurements at the calibration pitot tube location? | If so, go to the next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |
| | Was the procedure repeated at the lowest and highest velocity setting at which probes will be calibrated? | If so, go to the next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |
| | Were the pressure measurement values recorded in a table similar to Table 2F-4 or 2G-4? | If so, go to the next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| 54c | For each test point in the wind tunnel calibration location, were the following values calculated and were the specifications on these values achieved? | | The average velocity pressure at each tested point in the calibration location must be within ±2% (Case 1) or 0.01 inches $H_2O$ (Case 2) , whichever is less restrictive of the average velocity pressure at the fixed calibration pitot tube location, i.e.<br>Case 1<br>$\left\| \frac{\Delta P_{STD} \ \& \ \Delta P_{CAL}}{\Delta P_{STD}} \times 100\% \right\| \ \# \ 2\%$<br>Case 2<br>$\left\| \Delta P_{STD} \ \& \ \Delta P_{CAL} \right\| \ \# \ 0.01 \ in. \ H_2O$<br>One of these two conditions must be met at every tested point and every tested velocity shown in Table 2F-4 or 2G-4. If this occurs, mark “Pass.” If not, mark “Fail.” | | |
| | Average of three velocity pressure readings ($\Delta P_{CAL}$) at a point in the Calibration Location | $\Delta P_{CAL}$=___ in. $H_2O$ | | | |
| | Average of three corresponding velocity pressure readings ($\Delta P_{STD}$) at calibration pitot tube location | $\Delta P_{STD}$=___ in. $H_2O$ | | | |
| **Axial Flow Verification** | | | | | |
| 55a | Was the axial flow verification performed with a calibrated 3-D probe? | | If so, skip to item 55b. If not, continue with this procedure. | 3.20<br>10.1.2 | __ Pass__ Fail |
| | Was the axial flow verification performed with an uncalibrated prism-shaped 3-D probe (e.g., DA or DAT) or uncalibrated wedge probe? | | If not, mark “Fail” and skip the remaining steps in this procedure. If so, continue with this procedure. | | |
| | Were angle measurements at each test point taken from two ports: the tested probe port and a second port 90° from the tested probe port? | | If not, mark “Fail.” If so, continue with this procedure. | | |
| 55b | Were yaw and pitch angle measurements taken at all the test points used in Velocity Pressure Cross-check? (See item 54b above.) | | If so, go on to next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |
| | At each test point were yaw and pitch angle measurements taken at the lowest and highest velocity setting at which probes will be calibrated? | | If so, go on to next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |
| | Were the yaw and pitch angle measurements recorded in a table similar to Table 2F-5 or 2G-5? | | If so, go to the next step. If not, mark “Fail” and skip the remaining steps in this procedure. | | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| 55c | Did every measured yaw ($è_y$) and pitch ($è_p$) angle meet the required performance specifications? | | At every test point and velocity setting each measured yaw and pitch angle (recorded in a table similar to Table 2F-5 or 2G-5) must be within ±3° of 0°, i.e.,<br>$\lvert è_y \rvert \# 3°$ *and* $\lvert è_p \rvert \# 3°$<br>If these conditions are met by every measured yaw and pitch angle, mark "Pass." If not, mark "Fail." | | |
| **Pitch Angle Protractor Plate (Method 2F only)** | | | | | |
| 56a | Enter angles shown on pitch plate ($á_{PLATE}$) | _____ degrees | At a minimum, the protractor plate shall indicate angles in 5° increments from -15° to +15°. Additional angle settings must be symmetric around 0°( i.e., if -20° and -25° are shown, +20° and +25° must also be shown) and must exceed the largest pitch angle expected in the field by 5°.<br>If all these conditions are met, mark "Pass." If not, mark "Fail." | 10.6.11 | __ Pass__ Fail |
| | Enter largest pitch angle expected in field. | _____ degrees | | | |
| | Are the angles shown in increments of 5°? | | | | |
| | Are the 5° increments symmetric around 0°? | | | | |
| | Do they extend at least from -15° to +15°? | | | | |
| | Do they exceed by 5° the largest pitch angle expected in the field? | | | | |
| 56b | Angles measured by inspector ($á_{INSP}$) | _____ degrees | The protractor plate shall indicate angles to a resolution of ±2° at every pitch angle setting, i.e.,<br>$\lvert á_{PLATE} \ \& \ á_{INSP} \rvert \# 2°$<br>If this condition is met at every angle setting, mark "Pass." If not, mark "Fail." | 6.11.5 | __ Pass__ Fail |

# Calibration Performance Checks

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| **Calibration Pitot Tube** | | | | | | |
| Was a qualifying standard pitot used as the reference for the calibration? | | | | | | |
| 57a | Did it have a calibration coefficient obtained from the National Institute of Standards and Technology (NIST) or traceable to NIST? | | | A standard pitot that meets one of the following conditions may be used:<br>Condition #1: Known calibration coefficient obtained directly from NIST.<br>Condition #2: Known calibration coefficient obtained by calibration against another standard pitot with a NIST-traceable calibration coefficient.<br><br>If either of these conditions is met, mark “Pass” and skip the remaining steps in this procedure. If neither is met, continue with the following steps. | 6.10 Method 2, 2.7, Fig 2-4 | ___ Pass ___ Fail |
| 57b | Was it designed according to the specifications defined below? | | | | | |
| | Does it have a hemispherical (shown in Method 2 Fig. 2-4), ellipsoidal, or conical tip? | | | Pitots meeting all of the following conditions may be used as a reference:<br><br>(i) Must have a hemispherical, ellipsoidal, or conical tip.<br><br>(ii) $d_T$ $ 6$D$<br><br>(iii) $d_B$ $ 8$D$<br><br>(iv) Static pressure holes<br>(a) Of equal size,<br>(b) $D_H$ . 0.1$D$,<br>(c) Equally spaced in piezometer ring configuration.<br><br>(v) è$_B$ ' 90° with curved or mitered junction<br><br>(vi) $C_{p(std)}$ ' 0.99 ± 0.01<br><br>If all of the above conditions are met, mark “Pass.” If all are not met, mark “Fail.” | | |
| | Enter the external diameter (D) of the pitot tubing | | in. | | | |
| | Enter the straight-run distance ($d_T$) from the tip to the static pressure holes | | .in | | | |
| | Enter the straight-run distance ($d_B$) from the static pressure holes to the centerline of the external tube following the 90° bend | | .in | | | |
| | Enter diameter ($D_H$) of static pressure holes | | .in | | | |
| | Enter the angle of the bend (è$_B$) in tube | | ° | | | |

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| | Enter standard pitot calibration coefficient ($C_{p(std)}$) | | | | | |
| **Preparatory Checks** | | | | | | |
| 58 | Did the probe have a permanent scribe line (manual probes) or scribe line surrogate (automated probes) and meet all the relevant requirements specified above in items 4-8? | | | | 2F:6.1.5.1<br>2G:6.1.6.1<br>10.4.3 | __ Pass __ Fail |
| 59 | Immediately prior to calibrating a probe, did the tester perform and satisfy all provisions of the probe head inspection (item 17 above), horizontal straightness check (item 19), and leak check (item 36)? If so, mark "Pass." If not, mark "Fail." | | | | 10.3 | __ Pass __ Fail |
| 60 | Immediately prior to calibrating a probe, were tests performed to ensure that all provisions applying to pressure measurement devices (items 21-27 and 37), digital inclinometers (item 29), protractor wheel and pointer devices (item 30), temperature gauges, and barometers were met? If so, mark "Pass." If not, mark "Fail." | | | | 10.3 | __ Pass __ Fail |
| 61 | Were the entry ports surrounding the calibration pitot tube and the tested probe properly sealed throughout the yaw angle and velocity calibrations? If so, mark "Pass." If not, mark "Fail." | | | | 10.6.3,<br>10.6.5 | __ Pass __ Fail |
| **Yaw Angle Calibration** | | | | | | |
| **Applicability:** All probes used to measure yaw angles (under Method 2F or 2G) must perform this procedure to determine the reference scribe line rotational offset, $R_{SLO}$, if any. Automated probes without reference scribe lines should determine the rotational offset of the flat (or comparable, clearly identifiable physical characteristic) which is used to establish the reference position of the automated probe assembly.<br>**Frequency:** (a) Whenever a velocity calibration of a probe is performed.<br>(b) Whenever a detachable probe head is uncoupled or reoriented. | | | | | | |
| 62a | Was the yaw angle calibration procedure performed on the main probe and all devices (excluding probe shaft extensions) that will be attached to the probe in the field? | | | If so, go to next step. If not, mark "Fail." | 10.5 | __ Pass __ Fail |
| 62b | Was a carpenter's level used to ensure the probe was in a horizontal position during the procedure? | | | If so, go to next step. If not, mark "Fail." | 10.5.4 | |
| 62c | Enter first velocity setting where this procedure was performed. | | ft/sec | If number of repetitions at each velocity setting is greater than or equal to 2, go to next step. If not, mark "Fail." | 10.5.7 | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | Enter number of repetitions of this procedure at first velocity setting. | reps | | | |
| | Enter second velocity setting where this procedure was performed. | ft/sec | | | |
| | Enter number of repetitions of this procedure at second velocity setting. | reps | | | |
| 62d | How was the yaw angle determined?<br>a ☐ Yaw nulling procedure<br>b ☐ Curve fitting procedure | | If "a" is checked, go on to next numbered item. If "b" is checked, continue with this item. | 8.9.1.3 | |
| | Was a wind tunnel demonstration performed to show that the curve fitting procedure was able to determine the yaw angle of flow to within ±1°? | | If so, proceed to next item. If not, mark "Fail" and skip remaining steps in this procedure. | | |
| 62e | What procedures were used to determine the reference scribe line rotational offset, $R_{SLO}$?<br>a ☐ Annex D (Section 18.4 of Methods 2F and 2G)<br>b ☐ Other: _____ | | If "a" is checked, go on to next numbered item. If "b" is checked, continue with this item. | 10.5.6 | |
| | Was the alternative procedure able to determine $R_{SLO}$ to within 1°? | | If not, mark "Fail" and skip to next procedure. If so, continue in this item. | | |
| | Is the alternative procedure explained in detail in the field test report? | | If not, mark "Fail." | | |
| 62f | Were values of $R_{SLO}$ calculated and recorded for each repetition at each velocity setting? | | If so, go to next step. If not, mark "Fail." | 10.5.7 | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| | Were the individual values of $R_{SLO}$ correctly averaged and the result documented as the reference scribe line rotational offset for the probe? | | If so, go to next step. If not, mark "Fail." | 10.5.8 | |
| | Was the resulting average $R_{SLO}$ used when yaw angles were determined in the field? | | If so, mark "Pass" and go to next step. If not, mark "Fail." | 10.5.9, 8.9.4 | |
| **Calibration of 3-D Probes (Method 2F)** | | | | | |
| **Applicability:** All probes used under Method 2F.<br>**Frequency:** (a) Before first field test.<br>(b) Within 12 months of first field use after its most recent calibration or after 10 field tests, whichever occurs later.<br>(c) Whenever there is visible damage to the probe head | | | | | |
| 63 | Was the calibration procedure performed at two wind tunnel velocity settings? | | If the answer to each question is "yes," go to next step. If the answer to any question is "no," mark "Fail" and skip the remaining steps in this procedure. | 10.6.1, 10.6.11, 10.6.12 | __ Pass __ Fail |
| | At each velocity setting, were pressure readings taken in 5° increments over a pitch range symmetric around zero and extending at least from -15° to +15°? | | | | |
| | Did the pitch range exceed the largest pitch angle expected in the field by 5°? | | | | |
| | Was the testing across all pitch angles repeated at least twice at each velocity setting? | | | | |
| Velocity Drift Check | | | | | |
| 64a | Were paired calibration pitot tube and tested probe measurements taken at each pitch setting? | ___ Yes ___ No | If paired calibration pitot tube and tested probe measurements are not taken at each pitch setting, a velocity drift check must be performed.<br><br>If the answer is "Yes," skip the remaining steps in this procedure. If the answer is "No," continue with this procedure. | 10.6.15 | __ Pass __ Fail |

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| 64b | Enter pressure measurement ($\Delta P_t$) by calibration pitot tube at point in time *t*. | $\Delta P_t$ = (in. $H_2O$) | | At each velocity setting consecutive measurements by the calibration pitot tube must not differ by more than 2% or 0.01 in. $H_2O$, whichever is less restrictive, i.e.,<br>$ADiff = \lvert \Delta P_t - \Delta P_{t+1} \rvert \leq max\ of \left\{ \begin{matrix} 0.01\ in.\ H_2O \\ or \\ 2\% \times \Delta P_t \end{matrix} \right\}$<br>If this condition is met for all consecutive pressure readings at all velocity settings, mark "Pass." If not, mark "Fail." | | |
| 64c | Enter pressure measurement ($\Delta P_{t+1}$) by calibration pitot tube at next consecutive point in time *t+1* | $\Delta P_{t+1}$ = (in. $H_2O$) | | | | |
| 64d | Calculate the absolute value of difference (*ADiff*) of the two consecutive pressure measurements | Adiff = (in. $H_2O$) | | | | |
| Spot check that sufficient repetitions were performed by recording the following values at a selected pitch/velocity setting: | | | | | | |
| 65a | Enter the pitch angle and velocity setting used in the spot check | Pitch Setting =___°<br>Velocity = ___ ft/sec | | If one of the following conditions is satisfied mark, "Pass." If not, mark "Fail."<br>%Diff ≤ 2% No additional reps needed at this pitch/velocity setting<br>2% < %Diff ≤ 5% One more rep (for a total of 3 reps) must be performed at this pitch/velocity setting<br>%Diff > 5% Four more reps (for a total of 6) must be performed at this pitch/velocity setting | 10.6.12, 10.6.13 | ___ Pass ___ Fail |
| 65b | Enter velocity pressure ($F_2$) reading from first repetition at this setting. | | in. $H_2O$ | | | |
| 65c | Enter velocity pressure ($F_2$) reading from second repetition at this setting. | | in. $H_2O$ | | | |
| 65d | Label the larger of the two values $F_2^{max}$, the smaller $F_2^{min}$, and compute the percent difference (%Diff): $\frac{F_2^{max} - F_2^{min}}{F_2^{min}} \times 100\%$ | %Diff = | | | | |
| Select a pitch angle setting and perform a spot check to determine whether the percent difference between the average velocity calibration coefficients ($F_2$) obtained at the first and second velocity settings is within the limits prescribed in the test method. | | | | | | |

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| 66a | Enter the pitch angle setting (P) and the two velocity settings ($V_{LOW}$ and $V_{HIGH}$ used in the spot check | P =___°<br><br>$V_{LOW}$ = ___ ft/sec<br>$V_{HIGH}$ = ___ ft/sec | | If the one of the following conditions is satisfied mark, "Pass." If not, mark "Fail."<br><br>%Diff # 3.0% for &15° # *P* # 15°<br><br>%Diff # 5.0% for *P* < &15° or *P* > 15° | 10.6.16 | __ Pass __ Fail |
| 66b | Average velocity pressure ($F_2$) coefficient at first velocity setting. | | in. $H_2O$ | | | |
| 66c | Average velocity pressure ($F_2$) coefficient at second velocity setting. | | in. $H_2O$ | | | |
| 66d | Label the larger of the two values $F_2^{max}$, the smaller $F_2^{min}$, and compute the percent difference (%Diff): $\frac{F_2^{max} - F_2^{min}}{F_2^{min}} \times 100\%$ | %Diff = | | | | |
| **Calibration of 2-D Probes (Method 2G)** | | | | | | |
| **Applicability:** All Type S probes used under Method 2G.<br>**Frequency:** (a) Before first field test.<br>(b) Within 12 months of first field use after its most recent calibration or after 10 field tests, whichever occurs later.<br>(c) Whenever there is visible damage to the probe head. | | | | | | |
| 67 | Is a 3-D probe (e.g., a DAT or spherical probe) being calibrated for use under Method 2G in yaw determination mode only? | | | If so, do not continue with this procedure. Follow the 3-D probe calibration procedures in items 63-66 to obtain the velocity calibration coefficient $F_2$ at the 0° pitch setting only.<br><br>If a 2-D Type S probe is being calibrated for use under Method 2G, continue with the following steps. | 10.6 | |
| 68 | Was the calibration performed on the main probe and all devices (excluding probe shaft extensions) that will be attached to the probe in the field? | | | If so, go to next step. If not, mark "Fail." | 10.6 | |

| ID | Parameters | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|
| 69a | Was a sampling probe and/or nozzle part of the probe assembly? | | If so, continue with this procedure. If not, skip remaining steps in this procedure. | 10.6 | |
| | Separation distance ($D_x$) between Type S tube and sampling nozzle tube | in. | For Type S pitot tubes with outside diameters between 3/16 and 3/8 inch and sampling nozzles with an outside diameter of ½ inch, the separation distance should be greater than or equal to 3/4 inch, i.e., $D_x \geq 3/4$<br><br>If this condition is met, go to next step. If this condition is not met, mark "Fail" and skip the remaining steps in this procedure. | Method 2: Fig. 2-6a | |
| 69b | Is the impact pressure opening plane of the Type S pitot above the entry plane of the sampling nozzle? | | The impact pressure opening plane of the Type S pitot shall be even with or above the nozzle entry plane.<br><br>If this requirement is met, go to next step. If not, mark "Fail" and skip the remaining steps in this procedure. | Method 2: Fig. 2-6b | ___ Pass ___ Fail |
| | Enter the separation distance (Y) from the end of the sample probe to the center of the Type S pitot's impact port. | in. | To prevent interference, the distance from the end of the sample probe to the center of the Type S pitot's impact port must be greater than or equal to 3 inches, i.e. $Y \geq 3$ inches<br><br>If this condition is not satisfied, mark "Fail." If this condition is met, mark "Pass." | Method 2: Fig. 2-8 | |
| 69c | Was a wind tunnel demonstration performed that shows that the probe's ability to yaw null is not impaired when the nozzle is drawing a sample? | | A demonstration must be performed to show that the probe's ability to yaw null is not impaired when the nozzle is drawing a sample<br><br>If the demonstration was performed successfully," mark "Pass." If not, mark "Fail." | 10.6 | |

| ID | Parameters | Specifications | Cite | Outcome |
|---|---|---|---|---|
| 70 | Was the calibration procedure performed at two wind tunnel velocity settings? | If the answer to each question is "yes," go to next step. If the answer to any question is "no," mark "Fail" and skip the remaining steps in this procedure. | 10.6.1, | __ Pass __ Fail |
| | Was the tested probe secured at the 0° pitch position? | | 10.6.5, | |
| | Were at least three pairs of ΔP measurements obtained from the calibration pitot tube and tested probe at each velocity setting? | | 10.6.9 | |
| | Was the tested probe yaw nulled and then rotated back 90° before taking each pressure reading? | | 10.6.7 | |
| 71 | Will only one leg (e.g., Side A), not the other leg, always be used as the impact pressure port, i.e., oriented into the direction of flow, to obtain velocity pressure measurements during field testing? | The calibration procedure must be repeated on both A-side and B-side of a Type S pitot tube unless it is always used in the same orientation.<br><br>If the probe will always be used in the same orientation, mark "Pass" and skip the remaining step in this procedure. If not, continue with this procedure. | 10.6.10 | __ Pass __ Fail |
| | Was the calibration procedure repeated on both the A- and B-sides of the tested probe? | If so, mark "Pass." If not, mark "Fail." | | |

Check to determine whether the calibration coefficients meet the conditions specified in Methods 2G.

| | | | |
|---|---|---|---|
| Enter the low ($V_{LOW}$) and high ($V_{HIGH}$) wind tunnel velocities at which the calibration was performed. | $V_{LOW}$ = (ft/sec) | | 10.6.12 |
| | $V_{HIGH}$ = (ft/sec) | | |

Low Velocity Checks

| Side A | | | Side B (if performed) | | |
|---|---|---|---|---|---|
| Enter the values of $C_p$ obtained at $V_{LOW}$ for Side A in the 1st, 2nd, and 3rd repetition of the calibration | $C_p^{LOW1(A)}$, | | Enter the values of $C_p$ obtained at $V_{LOW}$ for Side B in the 1st, 2nd, and 3rd repetition of the calibration | $C_p^{LOW1(B)}$, | |
| | $C_p^{LOW2(A)}$, | | | $C_p^{LOW2(B)}$, | |
| | $C_p^{LOW3(A)}$, | | | $C_p^{LOW3(B)}$, | |
| Calculate $\bar{C}_p^{LOW(A)}$, the average of the three Side A calibration coefficients at $V_{LOW}$ | $\bar{C}_p^{LOW(A)}$, | | Calculate $\bar{C}_p^{LOW(B)}$, the average of the three Side B calibration coefficients at $V_{LOW}$ | $\bar{C}_p^{LOW(B)}$, | |

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| 72a | Average deviation ($ó^{(A)}_{LOW}$) of individual $C_p$'s from average $\bar{C}_p$ at $V_{LOW}$ from Eq.2-4 Method 2 | $ó^{(A)}_{LOW}$ , | | At each velocity setting, the average deviation (ó) of the three individual $C_p$ values from the average $C_p$ values must be less than or equal to 0.01, i.e.,<br>$ó^{(A)}_{LOW} \# 0.01$<br>$ó^{(B)}_{LOW} \# 0.01$<br>If both of these conditions are not met, mark "Fail" and skip the remaining steps in this procedure. If both conditions are met, continue with this procedure. | 2G: 10.6.12.4,<br>Method 2, 4.1.4.4, 4.1.4.5 | ___ Pass ___ Fail |
| | Average deviation ($ó^{(B)}_{LOW}$) of individual $C_p$'s from average $\bar{C}_p$ at $V_{LOW}$ from Eq.2-4 Method 2 | $ó^{(B)}_{LOW}$ , | | | | |
| 72b | If only A-side calibration coefficients are calculated, mark "Pass" and skip the remaining steps in this procedure. If both A- and B-side calibration coefficients are calculated, perform the following check. | | | | | |
| | Absolute value of difference between A-side and B-side average $\bar{C}_p$ at $V_{LOW}$ | | | The absolute value of the difference between the average $C_p$'s must not exceed 0.01, i.e.,<br>$\lvert \bar{C}_p^{LOW(A)} \& \bar{C}_p^{LOW(B)} \rvert \# 0.01$<br>If this condition is met, mark "Pass." If not, mark "Fail." | | |

High Velocity Checks

| Side A | | | Side B (if performed) | | |
|---|---|---|---|---|---|
| Enter the values of $C_p$ obtained at $V_{HIGH}$ for Side A in the 1st, 2nd, and 3rd repetition of the calibration | $C_p^{HIGH1(A)}$ , | | Enter the values of $C_p$ obtained at $V_{HIGH}$ for Side B in the 1st, 2nd, and 3rd repetition of the calibration | $C_p^{HIGH1(B)}$ , | |
| | $C_p^{HIGH2(A)}$ , | | | $C_p^{HIGH2(B)}$ , | |
| | $C_p^{HIGH3(A)}$ , | | | $C_p^{HIGH3(B)}$ , | |
| Calculate $\bar{C}_p^{HIGH(A)}$ , the average of the three Side A calibration coefficients at $V_{HIGH}$ | $\bar{C}_p^{HIGH(A)}$ , | | Calculate $\bar{C}_p^{HIGH(B)}$ , the average of the three Side B calibration coefficients at $V_{HIGH}$ | $\bar{C}_p^{HIGH(B)}$ , | |

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| 72c | Average deviation ($ó^{(A)}_{HIGH}$) of individual $C_p$'s from average $\bar{C}_p$ at $V_{HIGH}$ from Eq.2-4 Method 2 | $ó^{(A)}_{HIGH}$ = | | At each velocity setting, the average deviation (ó) of the three individual $C_p$ values from the average $C_p$ values must be less than or equal to 0.01, i.e.,<br>$ó^{(A)}_{HIGH} \# 0.01$<br>$ó^{(B)}_{HIGH} \# 0.01$<br>If both of these conditions are not met, mark "Fail" and skip the remaining steps in this procedure. If both conditions are met, continue with this procedure. | 2G: 10.6.12.4,<br>Method 2, 4.1.4.4, 4.1.4.5 | ___ Pass ___ Fail |
| | Average deviation ($ó^{(B)}_{HIGH}$) of individual $C_p$'s from average $\bar{C}_p$ at $V_{HIGH}$ from Eq.2-4 Method 2 | $ó^{(B)}_{HIGH}$ = | | | | |
| | If only the A-side calibration coefficient is calculated, mark "Pass" and skip the remaining steps in this procedure. If both A- and B-side calibration coefficients are calculated, perform the following check. | | | | | |
| 72d | Absolute value of difference between A-side and B-side average $\bar{C}_p$ at $V_{HIGH}$ | | | The absolute value of the difference between the average $C_p$'s must not exceed 0.01, i.e.,<br>$\lvert \bar{C}_p^{HIGH(A)} \& \bar{C}_p^{HIGH(B)} \rvert \# 0.01$<br>If this condition is met, mark "Pass." If not, mark "Fail." | | |
| 72e | Percent difference (%Diff) between the average $\bar{C}_p$ obtained at $V_{HIGH}$ and $V_{LOW}$ for Side A.<br>(See Equation in "Specifications" column.) | %Diff$^{(A)}$ = | | The percent difference between the average $C_p$ obtained at high and low velocity settings must not exceed 3%, i.e.,<br>$\%DIFF = \frac{\lvert \bar{C}_p^{HIGH(A)} \& \bar{C}_p^{LOW(A)} \rvert}{\bar{C}_p^{LOW(A)}} \times 100\% \# 3\%$<br>If this condition is not met, mark "Fail" and skip the remaining step in this procedure. If only the A-side calibration coefficient is calculated and this condition is met, mark "Pass." If both the A-side and B-side calibrations were performed, continue with the following step. | 10.6.14 | ___ Pass ___ Fail |

| ID | Parameters | | | Specifications | Cite | Outcome |
|---|---|---|---|---|---|---|
| 72f | Percent difference (%Diff) between the average $\bar{C}_p$ obtained at $V_{HIGH}$ and $V_{LOW}$ for Side B.<br><br>(See Equation in "Specifications" column.) | $\%Diff^{(B)}$ = | | If the calibration coefficient is calculated for the B-side, the same condition must be met, i.e.,<br>$\%DIFF = \frac{\lvert \bar{C}_p^{HIGH(B)} - \bar{C}_p^{LOW(B)} \rvert}{\bar{C}_p^{LOW(B)}} \times 100\% \leq 3\%$<br>If this condition is not met, mark "Fail." If this condition is met, mark "Pass." | | |
| 73 | Comparison of tester's and observer's final calibration coefficients (Side A) | | | | | |
| | Enter the value $\bar{C}_p^{LOW(A)}$ used above | $\bar{C}_p^{LOW(A)}$ = | | If the testers and observer's final $C_p$ values differ by more than 0.01, i.e.,<br>$\lvert Obs\&\bar{C}_p^{(A)} - Tst\&\bar{C}_p^{(A)} \rvert > 0.01$<br>it is advisable to review the tester's calculations. | 10.6.14 | Recommendation Only |
| | Enter the value $\bar{C}_p^{HIGH(A)}$ used above. | $\bar{C}_p^{HIGH(A)}$ = | | | | |
| | Average the two preceding values to obtain the observer's Side A calibration coefficient ($Obs\&\bar{C}_p^{(A)}$) | $Obs\&\bar{C}_p^{(A)}$ = | | | | |
| | Enter tester's final Side A calibration coefficient ($Tst\&\bar{C}_p^{(A)}$) | $Tst\&\bar{C}_p^{(A)}$ = | | | | |
| 74 | Comparison of tester's and observer's final calibration coefficients (Side B) (If Side B of the probe was calibrated, perform the following check.) | | | | | |
| | Enter the value $\bar{C}_p^{LOW(B)}$ used above | $\bar{C}_p^{LOW(B)}$ = | | If the testers and observer's final $C_p$ values differ by more than 0.01, i.e.,<br>$\lvert Obs\&\bar{C}_p^{(B)} - Tst\&\bar{C}_p^{(B)} \rvert > 0.01$<br>it is advisable to review the tester's calculations. | 10.6.14 | Recommendation Only |
| | Enter the value $\bar{C}_p^{HIGH(B)}$ used above. | $\bar{C}_p^{HIGH(B)}$ = | | | | |
| | Average the two preceding values to obtain the observer's Side B calibration coefficient ($Obs\&\bar{C}_p^{(B)}$) | $Obs\&\bar{C}_p^{(B)}$ = | | | | |
| | Enter tester's final Side B calibration coefficient ($Tst\&\bar{C}_p^{(B)}$) | $Tst\&\bar{C}_p^{(B)}$ = | | | | |