Thermal Dispersion Airflow Measurement

Model HP1/SP1

Technical Manual

Hybrid/Silver Series Thermal Dispersion Airflow Measurement Technology

Advantage by Ebtron

Hybrid/Silver Series

Installation, Operation and Maintenance Technical Manual

HP1/SP1

Duct and Plenum Probes

For use with Hybrid and Silver Series Transmitters

Includes Analog output models: HTA104-P STA102-P

Includes RS-485 output models: HTN104-P

Document Name: TM_HP1_SP1_R5A

HYBRID SERIES *TECHNICAL MANUAL*

SILVER SERIES *TECHNICAL MANUAL*

TM_HP1_SP1_R5A

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LIST OF EFFECTIVE AND CHANGED PAGES

Insert latest changed pages (in bold text); remove and dispose of superseded pages.
Total number of pages in this manual is 26.

Page No	Revision *	Description of Change	Date
1	**R5A**	**Updated Revision to R5A**	**01/12/2012**
2	**R5A**	**Updated List of Effective Pages**	**01/12/2012**
21, 22	**R5A**	**Revised note and statement on standoff mount probe sizes**	**01/12/2012**
3-26	**R5A**	**Replaced all references to 'x' density to 'C' density and re-issued document as R5A.**	**01/12/2012**
14, 15	R4A	Added Minimum placement Guidelines for Filter and Filter Media Bank Applications	03/07/2011
2-24	R4A	Added sensor density selections for Hybrid Series; Removed references to STx104 products; Updated Figure references , page numbers and reissued all other pages as R4A	03/07/2011
2-24	R3A	Clarified sensor density and placement data text; Accumulated all prior changes; Reissued as R3A	09/09/2010
23	R2E	Correction to Table for 18x18 - 'C' equivalent	11/23/2009
6	R2D	Updated duct sizes to reflect minimum internal probe size change - from 8 inches to 12 inches	08/13/2009
7 through 16	R2D	Updated insertion mounting instructions to reflect no terminal end bracket plate on round/oval applications.	08/13/2009
17	R2D	Updated internal probe detail mechanical dimensions - changed minimum size from 8 inches to 12 inches	08/13/2009
19, 20	R2D	Updated standoff probe detail mechanical dimensions; modified text to clarify supplied standoff probe length	08/13/2009
1	R2C	Added part number; updated Revision to R2C	03/19/2009
5	R2B	Updated Footnote	12/16/2008
21	R2B	Updated Footnote	12/16/2008
1 through 24	R2A	Initial Document Release	11/06/2008

* R5A indicates an original page.

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Figure 1. HP1/SP1 Duct and Plenum Sensor Probes

OVERVIEW

EBTRON's HP1/SP1 Hybrid/Silver Series airflow sensor probes (Figure 1) are ideal for the direct measurement of outside air intakes as well as precise airflow measurement in ducts and plenums. HP1/SP1 probes, with up to 4 individual sensing points per probe and flexible mounting options, provide accurate airflow measurement and ease of installation in locations where most traditional technologies cannot be applied. HP1/SP1 sensor probes are available in three sensor densities and in mounting configurations to meet virtually any application. Options are available for general analog or network output for all standard BAS communication protocols. HP1/SP1 probes feature outstanding airflow measurement accuracy, repeatability and quality using *EBTRON*'s advanced thermal dispersion airflow measurement technology.

HP1/SP1 probes are ideal for dilution ventilation control of outside air intake flow rates for ASHRAE® 62.1-2007 compliance, and are paramount in the acquisition of LEED® points. In addition, this airflow measurement technology is essential for the control of the pressurization flow and building and space pressurization, a prerequisite for moisture and contaminant control for indoor air quality (IAQ), healthcare and process applications. Sensor probes can be installed directly in outside air intakes, supply and return ducts, exhaust ducts and air handler cabinets to accurately measure airflow rates.

Unlike pitot arrays, *EBTRON* advanced thermal dispersion uses heat transfer rather than differential pressure to determine airflow rate. Accuracy is percent of reading, rather than percent of full scale and sensitivity increases as the flow rate decreases. Individual sensors, rather than a single averaging pressure manifold, ensure true average airflow measurement in the extreme velocity profiles typical of HVAC applications. Pitot arrays have significant averaging errors in extreme velocity profiles since only a single sensor (the pressure transducer) is used to convert the average velocity pressure to airflow.

EBTRON uses only precision "bead-in-glass" thermistor probes. These extremely stable and reliable thermistors were developed for use in the space program, and are also used in precision milli-degree laboratories where precise temperature control is required with negligible long-term drift. Competitors' devices typically employ inexpensive "chip" style thermistors that do not have the same long-term performance and reliability, and are subject to drift and mechanical failure over time. *EBTRON* sensing probes and transmitters are designed for years of trouble free operation. Periodic field calibration and maintenance are not recommended or required in most environments[1].

ADVANCED TECHNOLOGY

- *EBTRON* Advanced Thermal Dispersion (TD) airflow measurement technology ensures accurate, repeatable measurement from zero flow (still air).
- Each sensor factory calibrated to NIST-traceable standards.
- Sensor density options permit matching instrument performance to application measurement accuracy requirements.
- *EBTRON* sensor design allows placement in locations typically not possible with other sensing technologies.
- True average, multi-point, independent sensors.
- Highest quality and stability hermetically sealed "bead-in-glass" thermistors.
- Exclusive "Plug and Play" SMART sensor design with provision for up to 4 airflow/temperature sensors.
- Versatile mounting options for placement in the most challenging field locations.
- Standard 6063 aluminum sensor tube construction; Type 316 polished stainless steel sensor tube construction optional.

APPLICATIONS

- OA measurement for dilution control and ASHRAE® 62.1 2007 compliance.
- Ideal for attainment of LEED® EQc1 - Outdoor Air Delivery Monitoring and contributes towards attainment of other LEED® EA and EQ Credits.
- Building, floor or room pressurization and volumetric tracking.
- Direct measurement of outside air intake flow rates.
- Constant volume air change monitoring, control and validation.
- Process control.
- Continuous commissioning.

[1] In certain applications where a large amount of airborne particulate is present, especially fibrous material such as lint, pre-filtering of the return air may be required to ensure optimum instrument performance. If no pre-filtering is provided, it may be necessary to periodically inspect and clean sensors using compressed air or a small brush. Factory performance returns immediately after cleaning. Recalibration is NOT required. Periodic inspection of the sensors is always advised, and accessibility must be considered in these applications.

SPECIFICATIONS

Sensor Probe Configurations

- HTx104 (available in 'C', 'B' and 'A' densities)
  Type A (probes x sensors): 1x4 (independent sensors)
  Type B (probes x sensors): 2x2

  STx102 (available in limited 'A' densities)
  Type A (probes x sensors): 1x2 (independent sensors)

Sensor Accuracy

- Airflow: ± 2% of reading, ±0.25% repeatability
- Temp: ± 0.15°F (± 0.08° C)

Sensor Ranges

- 0 to +5,000 fpm[1]
  (0 to +25.4 m/s)
- Temperature: -20°F to 160°F
  (-28.9°C to 71.1°C)
- Humidity: 0 to 99% RH, non-condensing

Sensor Distribution

- Equal area (std.) or
  Log-Tchebycheff

Sensor Assembly (each sensing point)

- Heated element: One bead-in-glass, hermetically sealed, thermistor probe
- Temperature sensor: One bead-in-glass, hermetically sealed, thermistor probe
- Sensor housing: Glass-filled polypropylene
- Sensor potting material: Marine grade, waterproof epoxy
- Internal wiring: Kynar® coated copper

Duct Sizes

- Standard Insertion and Standoff Mounts:
  8 in to 120 in (203.2 mm to 3048 mm)
  Standard Internal Mount:
  12 in to 120 in (304.8 mm to 3048 mm)
- Custom: (may not meet sensor density requirements)
  120 in to 192 in (3048 mm to 4876.84 mm)
  [sensor quantity may be limited]

Tube Construction

- Standard: 6063 aluminum alloy
  Stainless steel option: Type 316 polished stainless steel
- Nominal Tube Diameter:
  Aluminum: 1.1 inches (*27.94 mm*)
- Mounting Brackets: Type 304 stainless steel
- Mounting Styles: Insertion, Internal or Standoff

Cable Assembly

- Type: UL® Plenum Rated, with extended temperature range FEP jacket
- Length: 10 feet std. (*3.048 m*), 50 feet (*15.24 m*) max.
- Termination: 0.625 inches (*15.88 mm*) plug [transmitter end]

"Plug and Play" Sensor Probes

- Probes do not require matching to transmitter

Compatible Transmitters

- HTA104, HTN104, STA102

Listings

- UL® 873 Airflow & Temperature Indicating Devices
  (Hybrid pending)
- CE (European Union shipments only)
  (Hybrid pending)

Warranty

- 36 months from shipment

[1] Transmitter can be configured for output higher than calibrated range.

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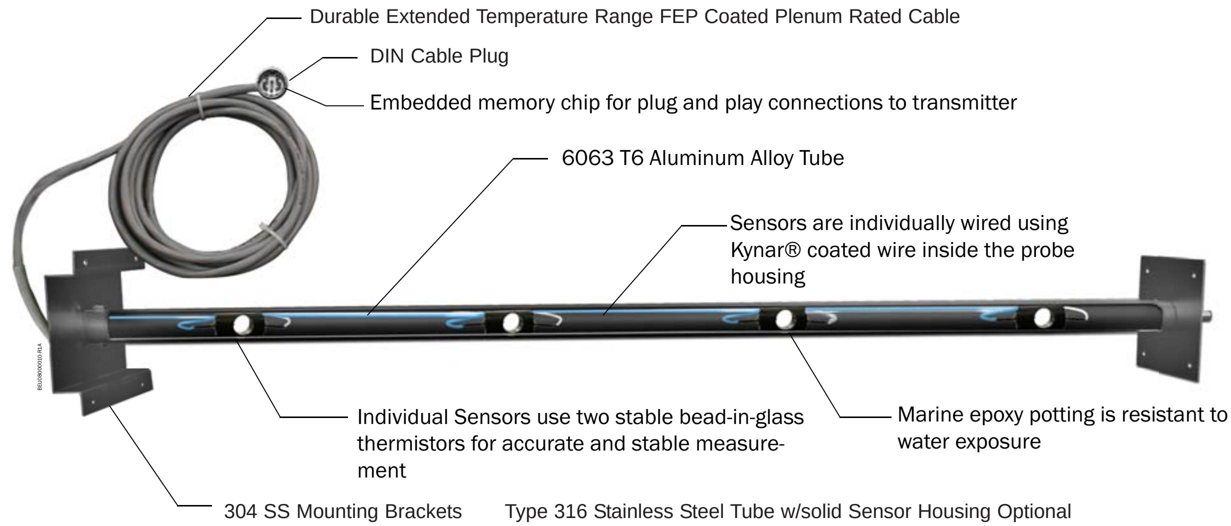

Figure 2. HP1/SP1 Sensor Probe Features

HP1/SP1 FEATURES

<u>Advanced Thermal Dispersion Technology</u>

EBTRON advanced thermal dispersion technology relates the velocity of the air to the power dissipation and rise in temperature of a heated element in a moving air stream. ***EBTRON*** uses extremely stable and reliable bead-in-glass, self-heated thermistors as the heated element and ambient air temperature sensor. Multiple sensing points are used to produce an average velocity for true volumetric airflow (cfm). Each probe is factory calibrated at 16 points to NIST-traceable airflow standards. The sensitivity to airflow increases as the flow rate decreases, and accuracy is percent of reading. Greater sensitivity results in better accuracy, especially with turn-down, compared to differential pressure-based devices. As a result, ***EBTRON*** advanced thermal dispersion technology is ideal for the measurement of relatively low airflow rates typically found in most HVAC applications. Long term stability is ensured by the selection of high quality thermistors and signal processing components. Unlike pressure-based devices that frequently require field calibration and auto-zeroing, ***EBTRON*** does not recommend periodic calibration of its airflow measuring devices. In fact, there is no auto-zero function in ***EBTRON*** flow measuring device. It simply is not required.

<u>Display and User Interface</u>

Sensor probes are available in precision ('C') density, general ('B') density and economy ('A') density for use with the Hybrid Series Transmitter model **HTx104-P.** The Hybrid airflow station includes a standard 16-character alpha-numeric display for local indication of airflow rate and temperature, and a convenient pushbutton user interface for simple user selection of units of measure, display units, output scaling, dampening filter, diagnostics and instrument status.

Economy 'A' density sensor probes are available with the Hybrid Series (**HTx104-P**) and the Silver Series Transmitter (**STx102-P**). The economical Silver Series instruments feature a dip-switch user interface for simple selection of units of measure and instrument scaling for applications where an LCD display is not required.

<u>HP1/SP1 Sensor Density Options</u>

Hybrid precision 'C' sensor density probes are optimized to provide accuracy of ±3% of reading and the closest distance between duct disturbances as shown in the 'C' recommended minimum placement guidelines in Figure 3 . Appendix I details the configuration of 'C' density probes. Sensor probes are also available in general 'B' and economy 'A' sensor densities to provide accuracy of ±3% of reading when more distance is available between duct disturbances as shown in the 'B' and 'A' recommended minimum placement guidelines of Figure 3. Appendix II details the configuration of general 'B' and economy 'A' density probes. As indicated in Figure 3, Hybrid precision 'C' density probes require the least distance between duct disturbances and therefore provide the most flexibility in placement. Lower density 'B' and 'A' probes are suitable for those applications where progressively more distance is available between duct disturbances, and yield a cost effective alternative to less accurate pressure based type instrumentation.

Refer to the SENSOR DENSITY SELECTION OPTIONS, and the LOCATING PROBES sections of this document or consult your local ***EBTRON*** sales representative or the ***EBTRON*** application engineering team for other available sensor densities and applications.

HP1/SP1 APPLICATIONS

Dilution Ventilation (Outside Airflow Measurement)

- ASHRAE® 62 Compliance
  ASHRAE 62 is a rate-based standard. Outside airflow rates should be monitored and controlled to compensate for wind and stack pressure variations on the intake system. This is especially important on VAV systems that have the additional challenge of changes in mixed air plenum pressure resulting from changes in the supply airflow rate. Direct measurement of outside airflow rates can save energy by ensuring that only the required amount of outside air is provided while improving IAQ.

- USGBC LEED New Construction & Major Renovation v3
  LEED EQ Credit 1 *Outdoor Air Delivery Monitoring* requires that a permanent direct outside airflow measuring device be installed on all mechanical systems providing air to spaces with an occupant density of less than 25 people per 1,000 square feet. HP1/SP1 sensors are ideal for this application, combining the benefits of ***EBTRON*** outdoor air intake monitoring in a single high performance package. Additional LEED® points can be realized by using ***EBTRON*** airflow measurement to improve system control, energy conservation and long-term building performance.

Compartmentalized Pressure Control

Building, floor or room pressure is maintained by producing either a positive, negative or neutral pressurization flow across adjacent pressure zones. The pressurization flow results in a measurable pressure drop across pressure zone boundaries. However, it is the pressurization flow, rather than boundary pressure drop that should be controlled to ensure that net pressurization is maintained. This is best accomplished by controlling the differential airflow rate between supply and return (or exhaust) flow rates to the pressure zone. Pressure control is achieved by compartmentalizing the building into unique pressure zones. In some cases, the pressure zone will require that the supply and return flow rates at the air handler are maintained (volumetric flow tracking), while other cases may require that the supply and return differentials are maintained at either the floor level or individual zone level. Pressurization control has direct influence on the following:

Moisture Control

- Envelope moisture
  - -Pressure-driven water as vapor
  - -Pressure-driven water as liquid
- Space humidity
- Space temperature

Contaminant Control

- Dirt/debris
- Bio-contaminants
- Infection control
- Chemical contaminants

OVERVIEW OF HYBRID AND SILVER SERIES PROBES

HP1/SP1 probes are available in selectable sensor densities permitting tailoring of instrument performance and cost to the specific application. HP1 precision 'C' density probes ensure typical installed accuracy of ±3% of reading with the most flexible minimum placement guidelines (detailed in the following section of this manual). HP1 /SP1 probes are also available in lower density 'B' and 'A' versions for placement in less critical economy applications.

Hybrid Series transmitters include an LCD display, Field Calibration Wizard and additional features not included in the economical Silver Series product line.

Silver Series transmitters are an economical alternative for those applications where only basic airflow monitoring is necessary and local display and advanced transmitter features are not required.

Appendix I details HP1 precision 'C' density probe and sensor configurations for various duct sizes. Appendix II details 'B' and 'A' density probe configurations and probe sizes available for various ducts sizes within these two sensor densities. To ensure accuracy, sensor probes must be installed within the recommended minimum placement guidelines as shown in Figure 3. For outside air (OA) applications, refer to the OUTSIDE AIR (OA) INTAKE APPLICATIONS section of this document.

Note: When placement guidelines cannot be met, the installed accuracy compared to field verification results may be improved, regardless of sensor density, by using the Field Calibration Wizard on the Hybrid Series, or the offset and gain controls on the Silver Series. Field verification results will typically yield measurement uncertainties of 5% to 10% of reading depending upon the equipment used, measurement technique, and the expertise of the verification technician.

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MINIMUM PLACEMENT GUIDES AND SENSOR DENSITIES

Minimum Placement Guides

Extensive research in ***EBTRON***'s airflow measurement test laboratories has resulted in the development of optimum placement and sensor densities required for HP1/SP1 probes under a wide variety of installation conditions normally encountered in typical HVAC applications. This is reflected in the Minimum Placement Guides of Figure 3 for duct and plenum, Figure 6 for outside air intake plenum/dampers and Figure 7 for air filter and filter media bank applications. Common installation scenarios and duct disturbances are shown, as well as recommended minimum installation distances between them. Minimum placement guidelines are provided for precision 'C', general 'B' and economy 'A' density probes.

Sensor Densities

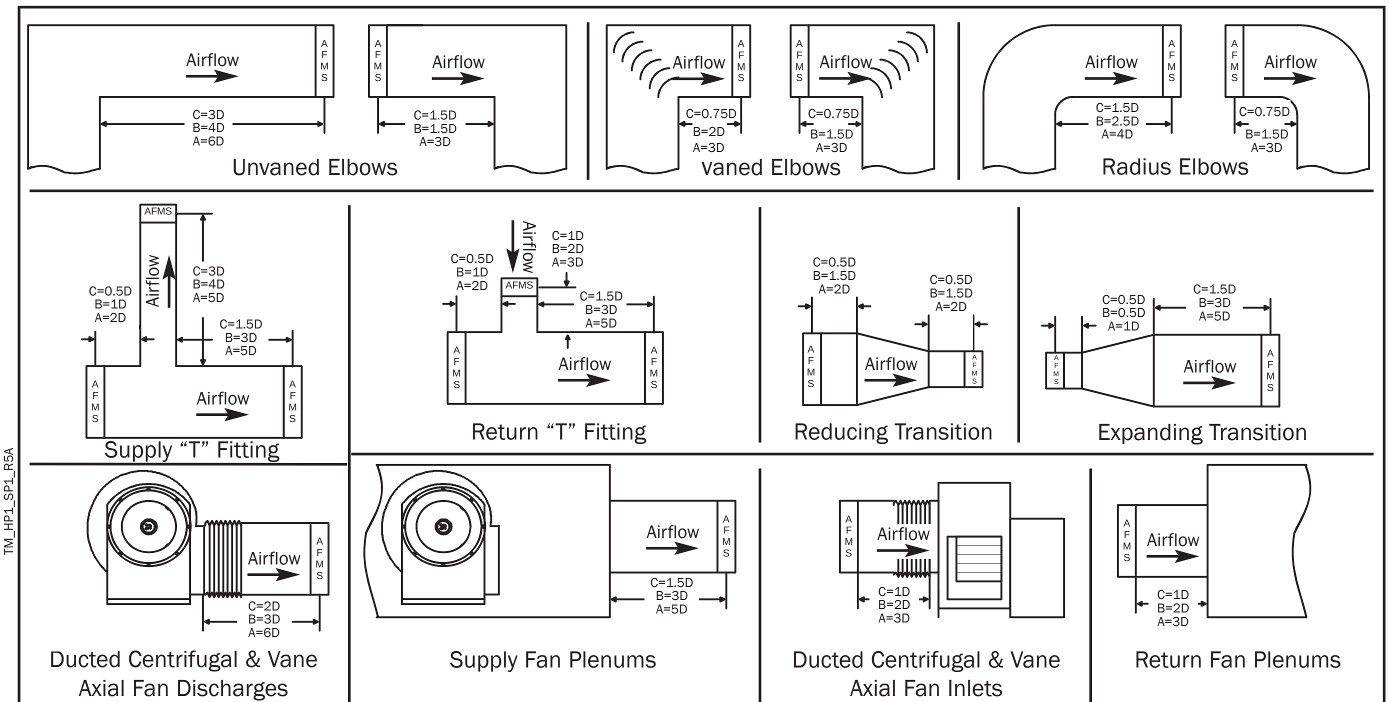
EBTRON's probes are optimized with a specific number of sensing points in each size to ensure installed accuracy at the specified minimum placement locations for each density. The sensor density tables of Appendices I and II indicate the number of probes and discrete sensing points provided for each density and application/probe size. Figure 3 details minimum placement dimensions for each probe density. Figures 6 and 7 detail placement guidelines for Outside Air and for Filter and Filter Media Bank applications respectively.

Precision 'C' Density Probes

Precision 'C' density sensor probes are performance optimized for the Hybrid Transmitter to ensure accurate performance when placed in accordance with Figure 3. For duct sizes where sensor density is not indicated, contact the ***EBTRON*** application engineering team at ***800-2EBTRON*** (*800-232-8766*). For OA intake damper and louver applications, refer to the OA INTAKE APPLICATIONS section of this document. For applications adjacent to filter/media bank applications, refer to the MINIMUM PLACEMENT GUIDELINES FOR AIR FILTER AND FILTER MEDIA BANK APPLICATIONS.

General 'B' and Economy 'A' Density Probes

Sensor probes are also available in either general 'B' density (for installation at the 'B' placement locations of Figure 3), or in economy 'A' density (for installation at the 'A' placement locations of Figure 3). Appendix II shows the 'B' and 'A' sensor densities available for various duct sizes. For duct sizes where sensor density is not indicated, contact the ***EBTRON*** application engineering team at ***800-2EBTRON*** (*800-232-8766*). For OA intake damper and louver applications, refer to the OA INTAKE APPLICATIONS section of this document. For applications adjacent to filter/media bank applications, refer to the MINIMUM PLACEMENT GUIDELINES FOR AIR FILTER AND FILTER MEDIA BANK APPLICATIONS.



NOTES: 1. 'D' is Simple Equivalent Diameter = (duct width + duct height)/2
2. Probe Minimum Placement is expressed in terms of 'D'

Figure 3. HP1/SP1 Minimum Placement Guide for Duct and Plenum Applications

LOCATING PROBES

EBTRON has developed the *EBTRON* **Auto-Select Tool** software solution for Reps and Sales Engineers for optimizing the placement of airflow measuring probes in ducts, plenums and outside air intake dampers and plenums. The selection tool uses a Microsoft® Excel® spreadsheet to create a schedule for printing or e-mailing to *EBTRON*. Contact your local *EBTRON* Sales Rep to ensure optimum placement using the *EBTRON* **Auto-Select Tool**. Alternatively, optimum probe placement can be manually calculated using the appropriate DUCT/PLENUM PROBE PLACEMENT PROCEDURE, the OUTSIDE AIR INTAKE PROBE PLACEMENT PROCEDURE and the FILTER/FILTER MEDIA PROBE PLACEMENT PROCEDURE outlined in the following paragraphs. Ensure that the Minimum Placement Guide dimensions for the selected probes can be met before performing the manual calculations.

EBTRON's Hybrid precision 'C' sensor density probes are optimized for precise measurement of air flow and the most flexible duct placement options. When 'C' density probes are installed within the minimum designated 'C' locations as shown in the Minimum Placement Guides (Figures 3 and 6), the installed accuracy will typically be equal to or better than ±3% of reading.

Sensor probes are also available in general 'B' and economy 'A' sensor densities. The general 'B' sensor density is ideal for less demanding installations and provides installed accuracy equivalent to 'C' density probes when installed within the designated 'B' locations of the minimum placement guides. Similarly, the economy 'A' sensor density is an economical alternative to less accurate pressure based devices. The 'A' density probes provide installed accuracy equivalent to 'C' density probes when installed within the designated 'A' locations of the minimum placement guidelines. In general, sensor probe accuracy improves as the distance between disturbances is increased. Table 1 contains placement tips that can be used in all applications.

Factors shown to improve performance of 'B' and 'A' density devices in the 'C' location
Coils (avoid water carry-over)
Filters
Honeycomb
Turning vanes (supply and return)

Factors shown to lessen performance of 'B' and 'A' density devices in the 'C' location
Absence of turning vanes (supply and return)
Dampers
Fan discharges
Louvers
Sound attenuators (unless installed in attenuator)

Table 1. Probe Placement Application Tips

DUCT/PLENUM APPLICATIONS

The following paragraphs provide information for optimizing sensor placement in typical duct and plenum applications. For information on optimizing probe placement in outside air intake damper/louver applications or for filter/filter media bank applications, refer to the individual separate sections of this manual.

EBTRON has conducted extensive research in its airflow measurement test laboratories to optimize the number of advanced thermal dispersion sensors required to provide typical accuracy of ±3% of reading in duct and plenum applications using 'C' placement criteria. Similarly, for the 'B' and 'A' sensor density probes, *EBTRON* developed 'B' and 'A' sensor density tables and minimum placement guidelines to permit selection of more economical devices yielding equivalent accuracy in less demanding placement applications.

The result of that research is reflected in the *EBTRON* Sensor Density Tables of Appendices I and II, and the Minimum Placement Guidelines of Figures 3, 6 and 7.

Contact your *EBTRON* Sales Representative who can guide your design using the ***EBTRON Auto-Select Tool*** to determine the optimum location of probes. To determine the location manually, use the following placement procedure; however, be certain that the Minimum Placement Guide dimensions for the selected probes can be met before performing the manual calculation.

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Duct/Plenum Optimum Probe Placement Procedure

1. Identify the immediate up and downstream disturbances.
2. Locate the diagram that most closely matches the application within Figure 3, and determine the minimum distances required upstream and downstream of each disturbance for the selected probe sensor density. For precision 'C' density probes, use the equivalent 'C' sensor density location placements indicated in Figure 3.
   The minimum distance requirements indicated in Figure 3 are expressed in multiples of **'D',** which are ***simple equivalent duct diameters***, determined as follows: **'D' = Duct Width + Duct Height / 2**

   *For example a 30 x 18 inch duct has a simple equivalent duct diameter **'D'** of {(30 + 18) divided by 2}, or **24 inches**.*
3. Using the illustration in Figure 3 that best matches the application, and the calculated **'D"** value from step 2, calculate the minimum probe placement to the upstream disturbance as **'X'**. Then, calculate the minimum probe placement from the downstream disturbance as **'Y'**.
4. In the duct, measure and record the actual distance between disturbances as 'Z'. Ensure that all measurement units are common (inches or *mm*).
5. Calculate the optimum placement of the probe(s) from the upstream disturbance as follows:

Optimum probe placement from upstream disturbance = [X/(X+Y)]*Z

Observe the following precautions in all installations:

CAUTIONS/WARNINGS

Contact *EBTRON* for assistance if minimum guidelines cannot be achieved.

If other devices are used to verify performance, ensure that the minimum placement and flow requirements of the verification device measurements are met (pitot tubes require greater distances between duct disturbances).

Avoid locating the airflow measurement station immediately downstream of a modulating or partially closed damper. Contact *EBTRON* for assistance if a modulating damper is upstream of the flow station, regardless of the distance.

Do not locate the airflow measurement station where it will be exposed to rain or condensate from a humidifier or coil. Consult humidifier or coil manufacturer for absorption distance recommendations.

Example:
*Figure 4 shows an application where airflow measurement is required between two vaned elbows. Determine optimum 'C' density probe placement for a 30 x 18 inch duct, located upstream and downstream of vaned elbows, with 80 inches between the two elbows (**Z**). According to the minimum placement 'C' guidelines (Figure 3), 'C' density probes must be located a minimum of 0.75D (simple equivalent diameters) downstream of the elbow (**X**) and 0.75D upstream of the elbow (**Y**). '**D**', the simple equivalent duct diameter, is equal to one half of the sum of duct height + duct width. For a 30 x 18 duct, '**D**' is equal to (30+18)/2; which is 24 inches. 0.75D is therefore 18 inches. This is the minimum distance required (for both **X** and **Y** in this example). To determine the optimum location, use the equation in step 5 above, and calculate [**18/(18+18)]x80** = **40** inches. The flow station should therefore be installed **40** inches downstream of the elbow for optimum performance.*

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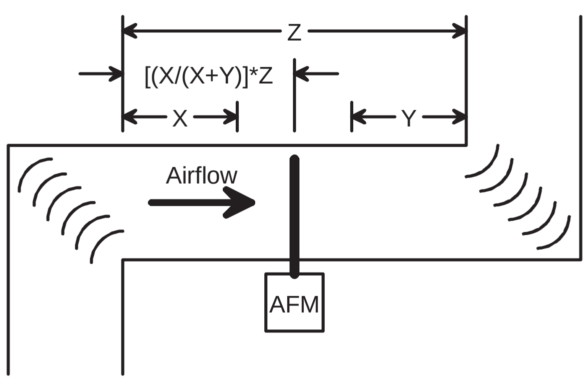

Figure 4. Typical Example for Calculating HP1/SP1 Duct and Plenum Optimum Probe Placement

SILVER SERIES TECHNICAL MANUAL HYBRID SERIES TECHNICAL MANUAL

OUTSIDE AIR (OA) INTAKE APPLICATIONS

EBTRON thermal dispersion devices are well suited for outside air intakes that generally have flow rates less than 500 fpm *(2.54 m/s)*. Unlike other technologies, ***EBTRON*** sensors do not require a developed velocity profile to accurately measure airflow rates and are not subject to fouling in most outside air environments. Each sensor is independent and accurately averages a variable velocity profile without additional straight duct or flow straighteners.

Figure 5. Typical HP1/SP1 Outside Air Damper Installation

OA Intake Probe Placement Procedure

To ensure optimized placement of airflow measuring probes in outside air intakes, ***EBTRON*** has developed the ***EBTRON*** **Auto-Select Tool** for trained Reps and Sales Engineers. Contact your local ***EBTRON*** Sales Rep for optimum placement using this simple, innovative application. Alternatively, calculations for OA Intake probe location and placement can be manually performed as follows:

1. Locate the airflow measuring device upstream of the outside air damper (between the louver and the damper). Determine the minimum airflow rate, **fpm(*min*)** at the desired installation location as follows:

   fpm(*min*) = cfm(minimum)/Duct Cross Sectional Area (sq ft).

   If the airflow measuring device is located within 10 feet of an intake louver or hood and the airflow rate is less than 200 fpm *(1.02 m/s),* consider relocating the airflow measuring device, resizing the opening, or adding a separate damper for the minimum outside air intake. Although installations that do not meet this guideline have been successfully installed and operated, ***EBTRON*** can only recommend and approve installations meeting this guideline. This guideline is based upon laboratory tests, and the following field experience:

   a. Systems designed with outside air dampers sized for 200 fpm *(1.02 m/s)* or less may not provide adequate control to maintain desired minimum airflow setpoint.

   b. Transient wind gusts often result in airflow of 100 fpm *(0.51 m/s)* or more In outside air intakes, even when the intake damper is fully closed. These seemingly 'false" airflow readings are actually the result of true air movement induced by winds on outside air intakes. A "low-limit" cutoff filter option, available on the Hybrid HTx104 transmitters, can force the output to zero '0' when airflow is below a specified value. However, **DO NOT ENABLE THE OUTPUT SIGNAL OFFSET ADJUSTMENT TO COMPENSATE FOR THIS EFFECT**. All ***EBTRON*** airflow measuring devices indicate 0 fpm (0 m/s) when no airflow is across the sensors. Adding a filter or moisture eliminator upstream of the airflow measuring device may reduce the wind effect on some installations.

2. Within Figure 6, find the diagram that best matches your application. Ensure that the minimum placement distances can be achieved to ensure proper performance. Minimum distance requirements may necessitate relocating dampers or adding an extension "sleeve". A standoff probe mounting option is available for applications where ductwork is unavailable. Follow the optimum placement procedure described in LOCATING PROBES when the distance exceeds minimum requirements.

3. The OA placement diagrams of Figure 6 were developed to achieve the specified installed accuracy for each type of probe at less than or equal to the louver manufacturer's maximum free area velocity (i.e. the louver is applied properly).

Probe Density	Accuracy
'C' Density at Placement C	±3%
'B' Density at Placement B	±10%
'A' Density at Placement A	Contact EBTRON or your local representative

4. Select a mounting style, insertion, internal or standoff, that best suits the specific application installation. Mounting style does not need to be specified until the product is ordered.

5. For best results, use one of ***EBTRON****'s* sequencing control strategies, described in the APPLICATIONS section of the ***EBTRON*** CATALOG.

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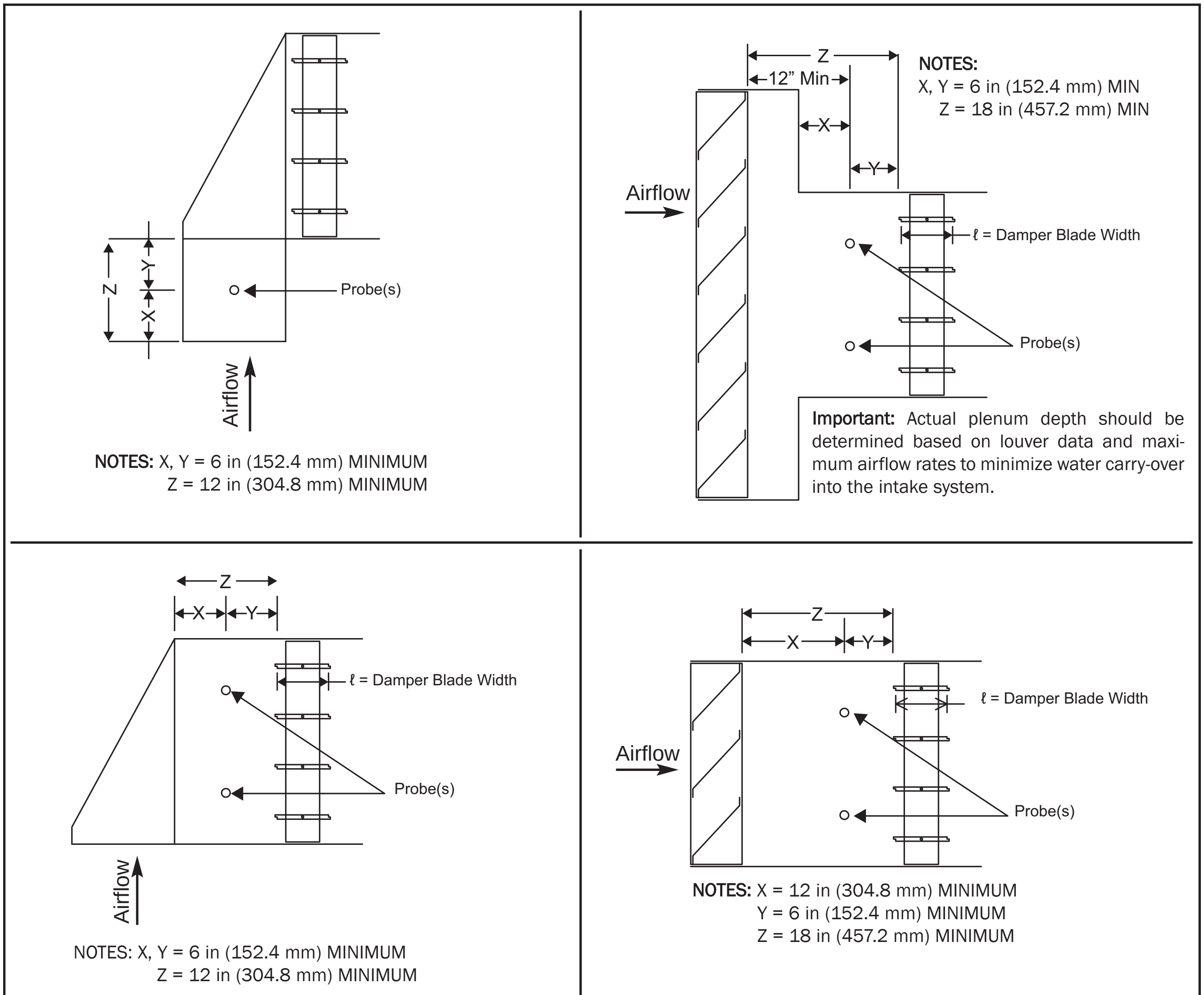
OUTSIDE AIR INTAKE DAMPER/PLENUM APPLICATION EXAMPLES SHOWING MINIMUM DISTANCE REQUIREMENTS



KEY:
X = Distance to upstream disturbance
Y = Distance to downstream disturbance
Z = Distance between disturbances
ℓ = Damper blade width

Consult your ***EBTRON*** Sales Rep for assistance with probe placement in critical Outside Air and Damper applications.

Figure 6. HP1/SP1 Minimum Placement Guide for Outside Air Applications

Outside Air Intake Stand-off mounting may result in greater measurement uncertainty since the effective area may be larger than the area used to determine the volumetric flow rate. Therefore, the use of the Field Calibration Wizard (Hybrid) or the digital gain and offset feature (Hybrid/Silver) in the menus may be required for acceptable accuracy performance.

When placement guidelines cannot be met, the installed accuracy of the EBTRON instrument, compared to field verification results, may be improved in all sensor densities by using the field airflow offset and gain controls in conjunction with the field verification results obtained. However, it is important to note that field verification results typically yield measurement uncertainties of 5% to 10% of reading, depending upon the equipment used, the measurement technique, and the expertise of the verification technician.

MINIMUM PLACEMENT GUIDELINES FOR AIR FILTER AND FILTER MEDIA BANK APPLICATIONS

Laboratory tests conducted in wind tunnels at the *EBTRON* Loris, SC engineering facility have resulted in the development of additional minimum recommended airflow sensor probe placement guidelines for applications where pleated air filters or filter media banks are located directly upstream of airflow sensor probes. When these additional minimum placement guidelines can be met, *EBTRON* airflow stations will operate normally, and all other standard guidelines apply. Non uniform velocity profiles develop downstream (within 18 to 24 inches) of pleated filter media installed in ducts and plenums in "push through" and "pull-through" airflow measurement applications as shown in Figure 7. Placement of *EBTRON* airflow measurement sensor probes in these applications must be in accordance with the following guidelines to ensure optimum performance of the airflow stations.

"Push-through" Filter Applications

In "push-through" filter applications where airflow is pushed through the media (Figure 7 upper detail), *EBTRON* recommends that airflow sensor probes be placed a minimum of 24 inches downstream of pleated filters. For CFM readings in these recommended applications, free area is defined by the simple duct dimensions.

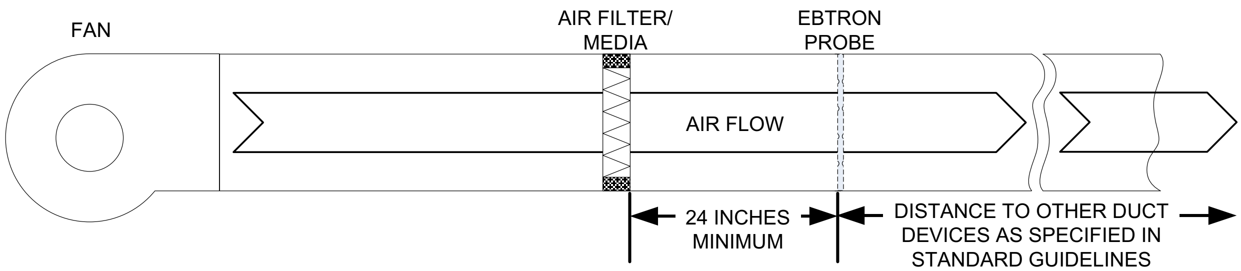
"Pull-through" Filter Applications

In "pull-through" filter applications where airflow is pulled through the media (Figure 7 center detail), *EBTRON* recommends that airflow sensor probes be placed a minimum of 18 inches downstream of pleated filters. For CFM readings in these recommended applications, free area is defined by the simple duct dimensions.

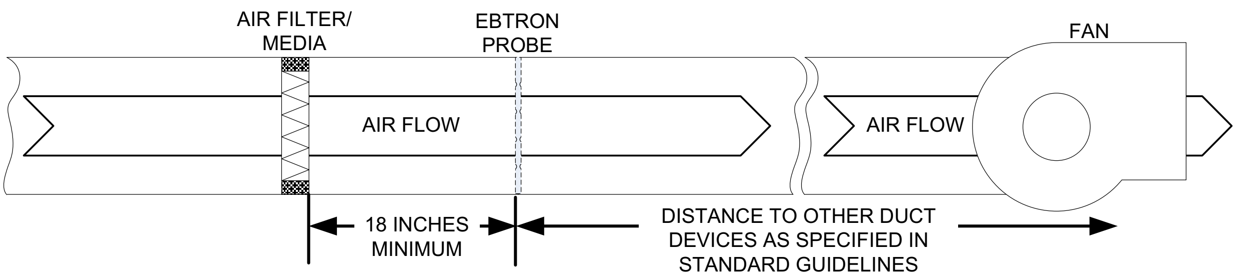
Probe Placement at Less than Minimum Recommended "Push-through" and "Pull-through" Distances

When probe to filter "push-through" or "pull-through" distances are less than the recommended minimums, airflow readings will be higher than actual flow. In these applications, the airflow station shall be adjusted to reliable test and balance values, AND the actual free area of the filter (or frame – whichever is less) shall be entered into the airflow station to determine CFM. Figure 7 (lower detail) illustrates the filter free area measurement for filter applications at less than the minimum recommended placement.

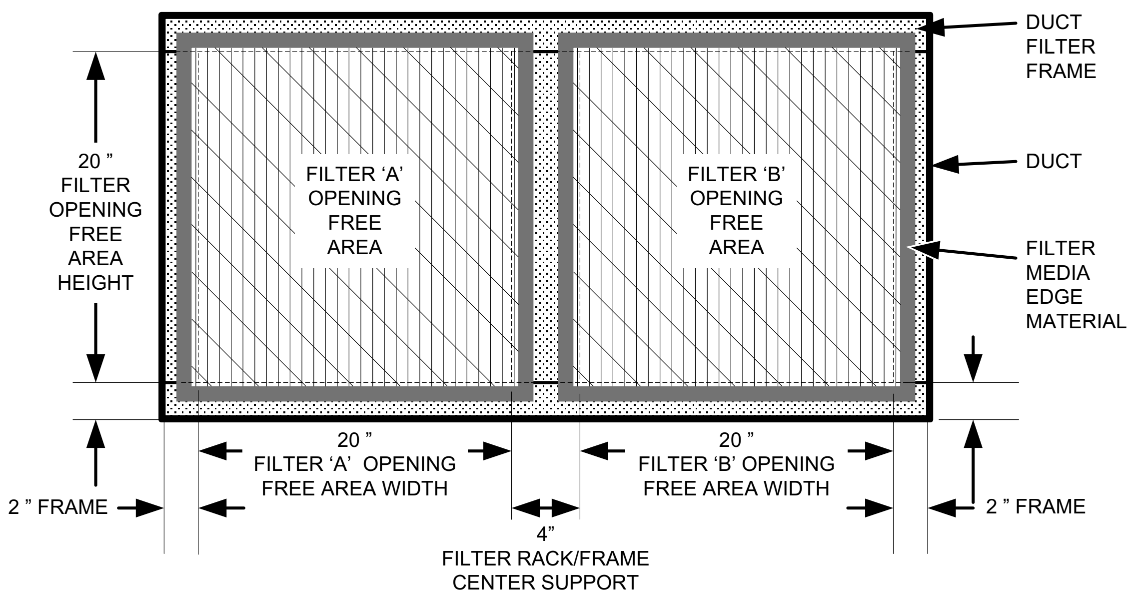
TM_HP1_SP1_R5A



Push-Through Filter Airflow Applications



Pull-Through Filter Airflow Applications



NOTE!
FOR APPLICATIONS WHERE MINIMUM FILTER TO PROBE DISTANCES CANNOT BE ACHIEVED, THE AIRFLOW STATION SHOULD BE ADJUSTED TO RELIABLE TEST AND BALANCE VALUES, AND FILTER FREE AREA AS SHOWN ABOVE MUST BE ENTERED INTO THE FLOW STATION TO DETERMINE CFM.

TOTAL FREE AREA = (FILTER 'A' OPEN AREA) + (FILTER 'B' OPEN AREA)
= **(20 X 20) + (20 X 20)**
= **(400) + (400)**
= **800** SQUARE INCHES

Calculation of Free Filter Area for Applications at Less Than Minimum Recommended Probe to Filter Distances

Figure 7. Minimum Placement Guidelines for Air Filter/Filter Media Bank Applications

SENSOR PROBE INSTALLATION OPTIONS

Sensor probes are available in 3 mounting styles:

- Insertion Mount - through a hole(s) in the duct/plenum wall(s)
- Internal Mount - mounted inside of the duct or plenum
- Standoff Mount - mounted on standoff brackets, typically for damper applications

Refer to the appropriate installation section that follows for installation of each mounting style, and observe the following precautions:

CAUTIONS/WARNINGS

⚠ Location of the sensor probes is critical for proper performance of the airflow station. Refer to Minimum Placement Guidelines section of this document for recommended probe placement.

⚠ Ensure that adequate clearance exists at the installation site to permit installation of the probe.

⚠ If traverse data is desired, place the lowest numbered probe at the top of the duct for horizontal mounting. For vertical mounting, place the lowest numbered probe on the left side of duct when viewed from the upstream side of the mounting location.

⚠ Install probe(s) in accordance with Appendix III (recommended Probe Mounting Spacing and Configuration).

⚠ Insulation that interferes with mounting should be temporarily removed prior to installation.

⚠ In vertical probe installations (particularly on OA applications), probes should be placed with the cable exit on the higher side to prevent any potential moisture from accumulating on the heated sensor.

INSERTION MOUNT INSTALLATION

Figures 8 and 9 show a typical Insertion Mount Sensor Probe and the required installation dimensions. Insertion mounting is the most common style for installation through one side of the duct. Probes less than 18 inches (*457.2 mm*) overall do not require an end stud (or terminal bracket), and are fabricated 0.25 inches (*6.3 mm*) less than the overall duct size. Insertion mounting requires a 1.25 inches (*31.7 mm*) hole on the insertion side of the duct. Probes of 18 inches or greater include a terminal stud (and for rectangular ducts, a terminal bracket plate) for additional support at the far end of the probe. On these longer probes, an additional hole is required on the other side of the duct (opposite the insertion side) for this terminal stud. Install each probe as follows:

1. Each sensor probe package is factory labeled with the specific location and duct size for which it was designed. Orders for locations having more than one probe will generally have individually packaged probes banded together. Determine the specific duct location for the sensor probe as indicated on the engineer's plans showing where the airflow measuring station probe is to be located. Refer to the illustrations of Appendix III to determine the proper probe spacing and orientation.
2. Carefully open the package and inspect for damage. Proceed to the specific instructions in this section for rectangular (step 3), round (step 6) and flat oval duct applications (step 9).

For Rectangular Ducts

3. The first dimension of the probe size indicates the length of the probe. The second dimension indicates the specific duct insertion side dimension 'X'. Mark a point at the center of the insertion side of the duct at ‘X’. Draw a line on the insertion side of the duct at this point that is perpendicular to the edge of the duct. This line will be used to locate the position of the hole(s) to be drilled for probe insertion. Refer to probe installation and orientation shown in Appendix III.
4. Using Figure 9 and Appendix III, locate and mark the location(s) on the insertion side of the duct (where the probes will be inserted through) at the line drawn in step 3.
5. For rectangular ducts greater than 18 inches (*457.2 mm*), probes are supplied with a terminal end bracket and stud opposite the insertion side bracket. For these probes, mark the corresponding terminal end bracket installation location(s) for each probe on the opposite side of the duct. **Probes under 18 inches(*457.2 mm*) do not have the terminal end bracket and stud and do not require marking or drilling holes on the opposite side of the duct.** Prepare a 1.25 inch insertion hole at each of the points marked for the probes. Proceed to step 12, For All Ducts.

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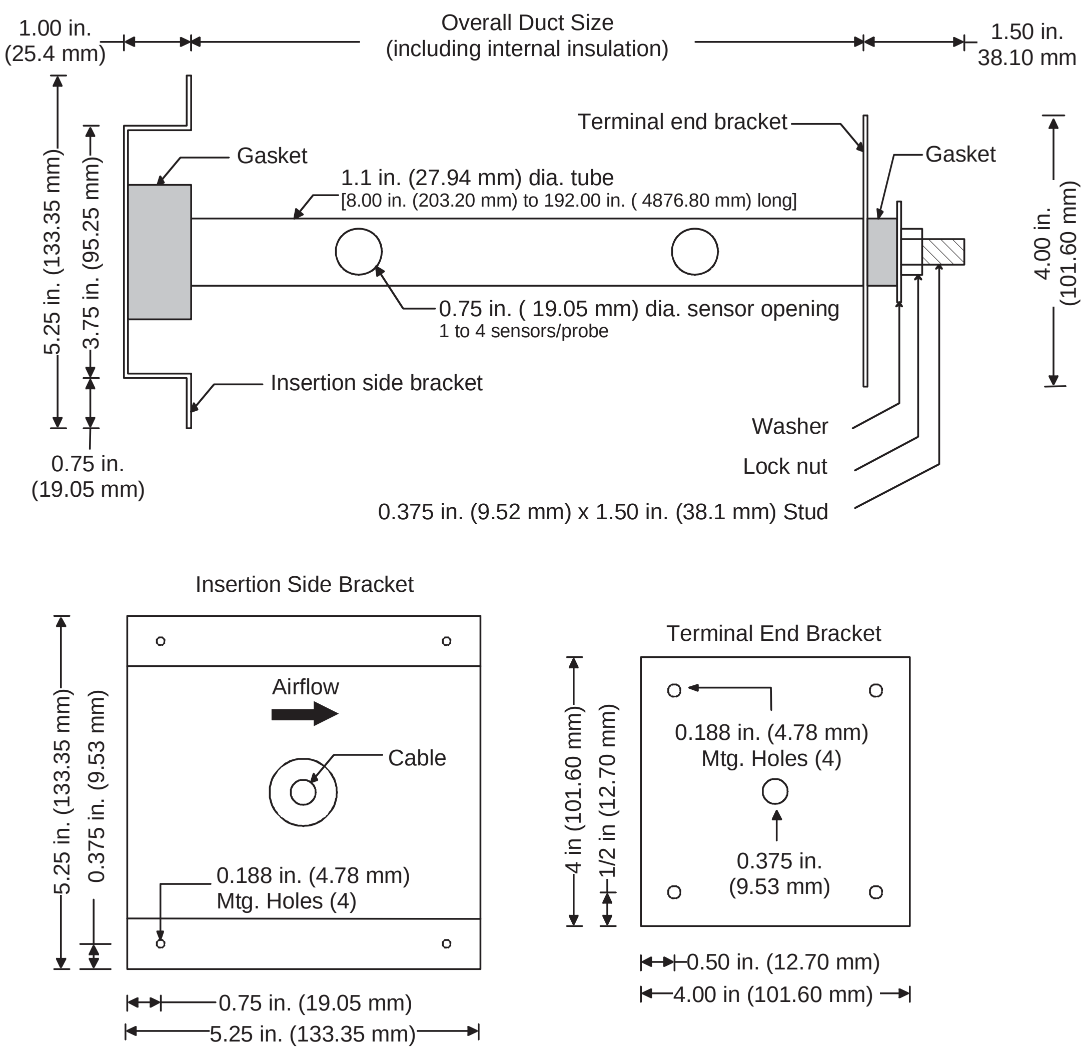
Figure 8. HP1/SP1 Insertion Mount Probe Style



NOTE: Probes under 18 inches(457.2 mm) are not equipped with the terminal end bracket, and therefore do not require a mounting hole on the opposite side of the duct.

Figure 9. HP1/SP1 Insertion Mount Probe Mechanical Dimensions

TM_HP1_SP1_R5A

For Round Ducts

6. Mark and draw a line around the circumference of the duct at the point where the probes are to be installed. The number of probes for this specific measurement site determines the probe installation locations and orientation as shown in Appendix III. **Multiple probes must be staggered 1.5 to 2 inches (*38.1 to 50.8 mm*) from each other to avoid intersecting at the center of the duct.**
7. Using Figure 9 and Appendix III, locate and mark the probe installation location(s) on the circumference line drawn in step 6 where each of the probe(s) will be inserted.
8. Probes 18 inches (457.2 mm) and longer are supplied with a terminal stud located at the probe end opposite the insertion side bracket. For these probes, mark the corresponding stud location(s) for each probe on the opposite side of the duct. **Probes under 18 inches (*457.2 mm*) do not have a terminal stud and do not require marking or drilling on the opposite side of the duct.** Prepare a 1.25 inch insertion hole on the side of the duct where the probe will be inserted. For probes 18 inches or longer, also prepare a 0.5 inch hole for the terminal stud on the opposite side of the duct for each probe location marked. Proceed to step 12, For All Ducts.

For Flat Oval Ducts

9. Mark and draw a line around the circumference of the duct at the point where the probes are to be installed. Probes supplied for flat oval duct applications are marked with a configuration suffix, letters ‘a’ to ‘c’ for installation and orientation as shown in Appendix III. **Configuration ‘b’ probes must be staggered 1.5 to 2 inches (*38.1 to 50.8 mm*) from each other to avoid intersecting at the center of the duct.**
10. Using Figure 9 and Appendix III, locate and mark the probe installation location(s) on the circumference line drawn in step 9 where each of the probe(s) will be inserted.
11. Probes 18 inches (457.2 mm) and longer are supplied with a terminal stud located at the probe end opposite the insertion side bracket. For these probes, mark the corresponding terminal stud location(s) for each probe on the opposite side of the duct. **Probes under 18 inches (*457.2 mm*) do not have a terminal stud and do not require marking or drilling on the opposite side of the duct.** Prepare a 1.25 inch insertion hole on the side of the duct where the probe will be inserted. For probes 18 inches or longer, also prepare a 0.5 inch hole for the terminal stud at the opposite side of the duct for each probe location marked. Proceed to step 12, For All Ducts.

For All Ducts

12. Carefully place each probe assembly through the insertion side mounting hole, making sure that the larger insertion side gasket is firmly seated against the insertion side bracket. On probes with terminal studs, make sure that the terminal stud passes through the hole prepared for it on the opposite side of the duct. Fasten the insertion side mounting plate to the duct at four places with appropriate sheet metal screws, making sure that the edge of the plate, which mounts to the duct, is parallel to the edge of the duct and that the printed airflow arrow points in the direction of duct air flow. On probes under 18 inches without terminal studs, proceed to step 16.
13. **For rectangular duct applications of 18 inches or greater,** use the terminal stud and a terminal end bracket plate. Place the terminal end bracket plate onto the terminal stud that is protruding through the opposite side of the duct. Fasten the terminal end bracket plate to the duct at four corners using appropriate sheet metal screws, while keeping the terminal stud as close as possible to the center of the drilled hole.
14. **For round and oval duct applications of 18 inches or greater,** use the terminal stud only (without the terminal end bracket).
15. Place the smaller foam shock absorber/gasket over the terminal mounting stud, then place the large flat washer against the shock absorber/gasket. Tighten the lock nut onto the terminal mounting bolt until snug. A tight fit is not required. This will limit probe movement and air leakage when the duct is pressurized.
16. Connect sensor probes to the transmitter. Refer to the applicable Hybrid Series (HTx) or Silver Series (STx) Transmitter Installation, Operation and Maintenance Technical Manual (under separate cover) for set up instructions.

TM_HP1_SP1_R5A

HP1/SP1 INTERNAL MOUNT INSTALLATION

Internal mount probes are ideal for applications where access through the outside of the duct is not available. This mounting style is also well suited for installation in air handling units and plenums. Figure 10 shows a typical internal mount probe.

Probes are installed inside of the duct or plenum. Internal insulation that interferes with mounting should be removed prior to installation. There is approximately ± 0.75 inches *(19 mm)* of adjustment from the nominal probe length ordered.

Figure 11 shows the installation dimensions for the internal mount probe. Install probes as outlined in the following steps:

Figure 10. HP1/SP1 Internal Mount Probe Style

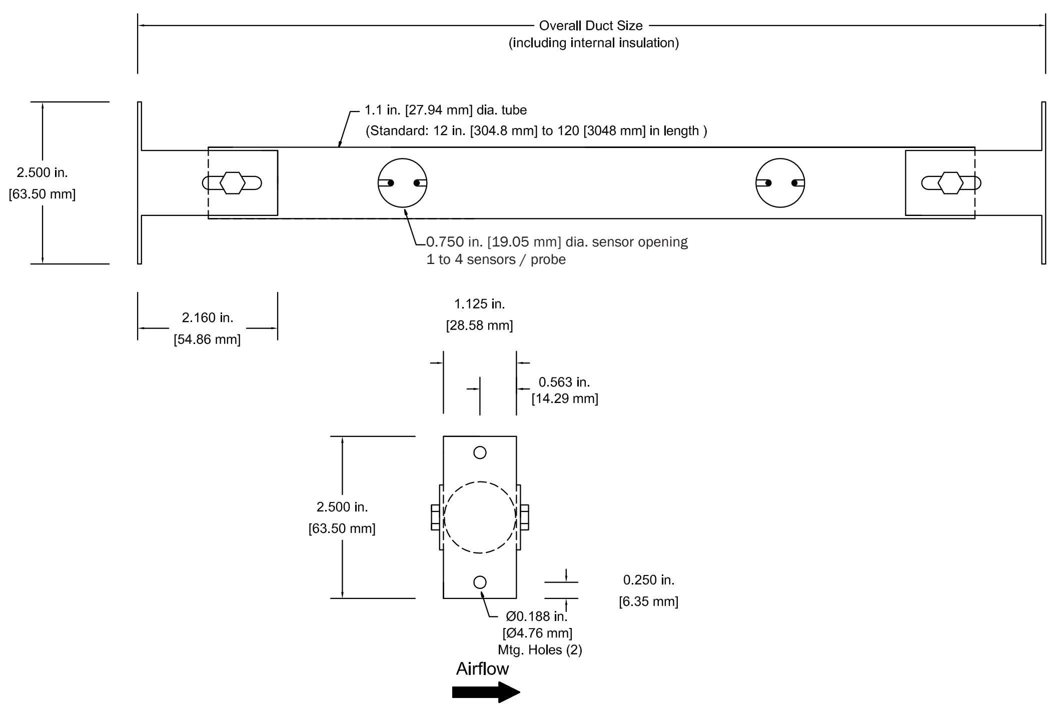


Figure 11. HP1/SP1 Internal Mount Probe Mechanical Dimensions

TM_HP1_SP1_R5A

1. Each sensor probe package is factory labeled for the specific location and duct size it is designed for. Orders for locations having more than one probe will generally have individually packaged probes banded together. Determine the specific duct location for the sensor probe as indicated on the engineer's plans showing where the airflow measuring station probe is to be located. Refer to illustrations of Figure 11 and Appendix III to determine the proper probe spacing and orientation.
2. Carefully open the package and inspect for damage. Proceed to the specific instructions in this section for rectangular, round or flat oval ducts.

For Rectangular Ducts

3. The first dimension of the probe size indicates the length of the probe. The second dimension indicates the specific duct internal mounting inside dimension 'X' (including internal insulation). On ducts with internal insulation that cannot be removed, adjust 'X' to equal the internal mounting inside dimension, minus two times the thickness of the insulation. Mark a point on the center of the inside of the duct at 'X'. Draw a line on the inside of the duct at this point that is perpendicular to the edge of the duct. This line will be used to locate the position of the hole(s) to be drilled for probe installation. The number of probes for the specific measurement site determines the probe installation locations as shown in Appendix III.
4. Using Figure 11 and Appendix III, locate and mark the individual probe installation location(s) on the line drawn in step 3, where each of the probe(s) will be installed.
5. Mark the corresponding end bracket installation location(s) for each probe on the opposite side of the duct. Proceed to step 12, For All Ducts.

For Round Ducts

6. Mark and draw a line around the inside circumference of the duct at the point where the probes are to be installed. The number of probes for this specific measurement site determines the probe installation locations and orientation as shown in Appendix III. **Multiple probes must be staggered 1-1/2 to 2 inches (*38.1 to 50.8 mm*) from each other to avoid intersecting at the center of the duct.**
7. Using Figure 11 and Appendix III, locate and mark the probe installation location(s) on the circumference line drawn in step 6 where each of the probe(s) will be installed.
8. Mark the corresponding end bracket installation location(s) for each probe on the opposite side of the duct. Proceed to step 12, For All Ducts.

For Flat Oval Ducts

9. The number of probes for the specific measurement site determines the probe installation locations and orientation as shown in Appendix III. Mark and draw a line around the inside circumference of the duct at the point where the probes are to be installed. **Configuration 'b' probes must be staggered 1-1/2 to 2 inches (*38.1 to 50.8 mm*) from each other to avoid intersecting at the center of the duct.**
10. Using Figure 11 and Appendix III, locate and mark the probe installation location(s) on the circumference line drawn in step 9 where each of the probe(s) will be installed.
11. Mark the corresponding end bracket installation location(s) for each probe on the opposite side of the duct. Proceed to step 12, For All Ducts.

For All Ducts

12. Carefully remove any internal insulation where the probe will be mounted. The insulation should be reinstalled after the probe is mounted.
13 Fasten each of the probe brackets to the duct with suitable hardware. Ensure that the sensors are oriented properly as shown in Appendix III, and installed in the direction of duct airflow as indicated by the airflow arrow on the probe.
14. Route the connecting cables from each probe out of the duct and seal with suitable hardware and/or gasketing material.
15. Connect sensor probes to transmitter. Refer to the applicable Hybrid Series (HTx) or Silver Series (STx) Transmitter Installation, Operation and Maintenance Technical Manual (under separate cover) for set up instructions.

TM_HP1_SP1_R5A

HP1/SP1 STANDOFF MOUNT INSTALLATION

The standoff mounting option is designed for applications where duct extension sleeves cannot be added before outside air intake dampers. Unducted standoff mounting can add additional uncertainty to the system installed accuracy. The uncertainty decreases as the damper size increases.

Install directly in an outside air intake plenum or on the intake damper frame. The sensor probe should be mounted 2 inches *(50.8 mm)* away from the full open blade position.

Figure 12 shows a typical Standoff Mount HP1/SP1 Probe. Figure 13 shows dimensions for the HP1/SP1 Standoff Mount probe. Note that for standoff mounting, probes supplied include an additional 2 in. [50.8 mm] of tube length (which is 2 in. longer than the specified opening size) to allow for bracket installation and damper blade clearance.

Figure 12. HP1/SP1 Standoff Mount Probe Style

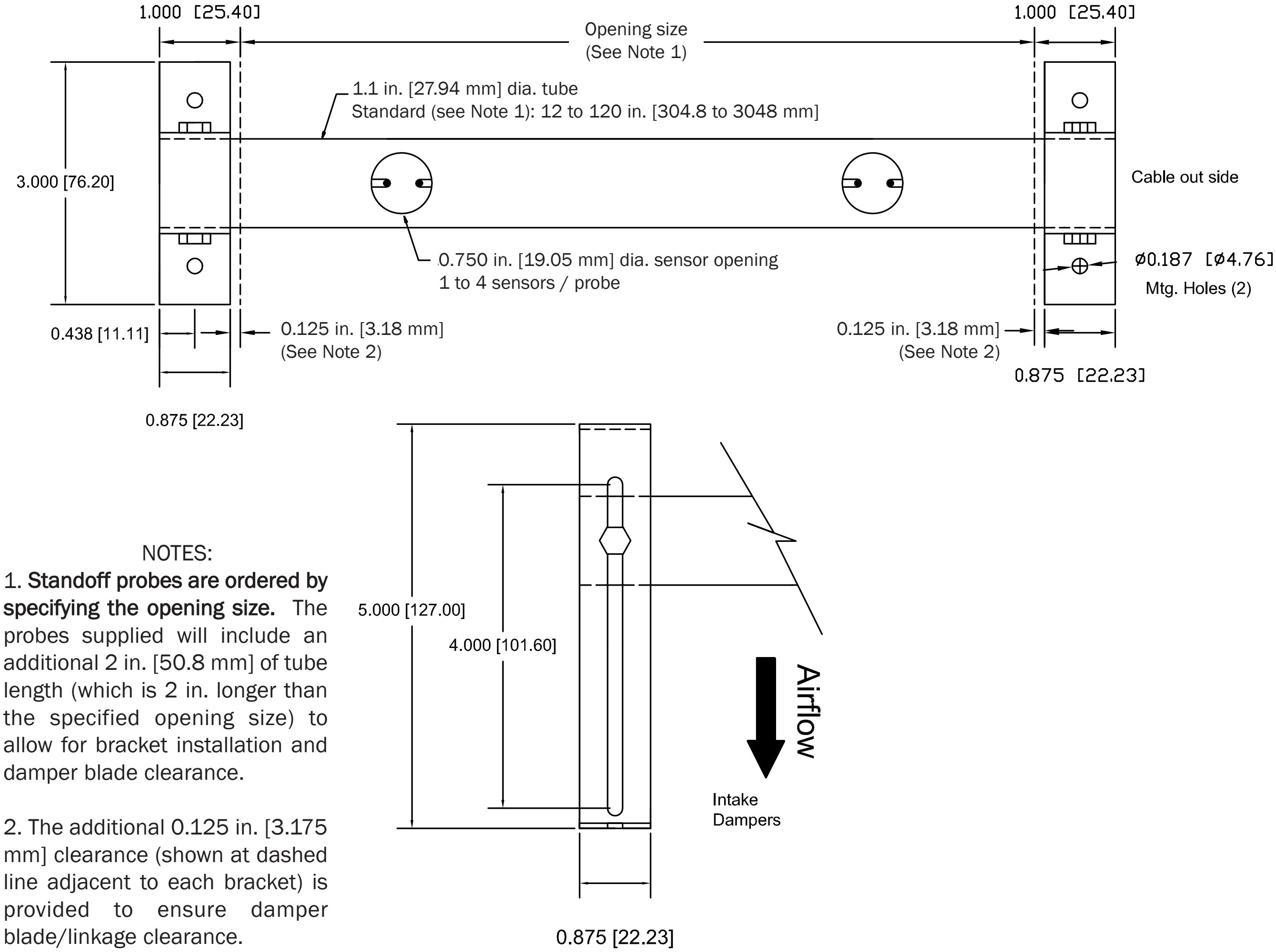
Figure 14 shows a typical outside air intake damper frame installation using the standoff mount option. Observe the following precautions when using the standoff mount installation:

CAUTIONS/WARNINGS

- ⚠ Location of the sensor probes is critical for proper performance of the airflow station. Refer to Minimum Placement Guidelines section of this document for recommended probe placement.
- ⚠ Ensure that adequate clearance exists at the installation site to permit installation of the probe.
- ⚠ For applications where multiple probes are necessary at a single measurement location, install probes in accordance with Appendix III (Recommended Probe Mounting, Spacing and Configuration).
- ⚠ Insulation that interferes with mounting should be temporarily removed prior to installation.
- ⚠ In vertical probe installations (particularly on OA applications), probes should be placed with the cable exit on the higher side to prevent any potential moisture from accumulating on the heated sensor.
- ⚠ Standoff mounting may yield additional measurement uncertainty compared to duct mounted configuration and should only be used when additional duct sleeves cannot be added to the intake damper.

1. Each HP1/SP1 sensor probe package is factory labeled with the specific location and duct size it is designed for. Orders for locations having more than one probe will generally have individually packaged probes banded together. Locate the position on the plenum or damper frame indicated by the engineer's plans where the airflow measuring station is to be located and refer to Appendix III to determine the proper spacing and orientation of the probes.
2. Carefully open the package and inspect for damage.
3. The first dimension of the probe size for standoff mount models corresponds to the damper opening, and the probes supplied will be 2" longer in length to permit installation of the mounting brackets, and provide for damper blade clearance - see Figures 13 and 14). The second dimension indicates the mounting bracket side dimension 'X'.
4. Install directly into an outside air intake plenum or directly on the upstream side of an unducted intake damper as shown in Figure 14. Ensure that adequate mounting surface exists for the brackets when installing them on the damper. The brackets are 0.875 in (22.23 mm) wide, and an additional clearance of 0.125 in (3.175 mm) is provided between each inside bracket edge and the outside frame opening edge for mechanical clearance of damper blades/linkages, etc. The sensor probe should be mounted 2 in (50.8 mm) from the full open blade position. Unducted standoff mounting can add additional uncertainty to the system installed accuracy.
5. Refer to Figure 13 and Appendix III to determine the location of the mounting brackets from the edge of the plenum or damper opening.
6. Fasten the mounting brackets to the opening with appropriate sheet metal screws, and ensure that the edge of the bracket is parallel to the edge of the opening, and that the printed airflow arrow is in the same direction as airflow.
7. For multiple probes repeat Step 6.
8. Connect sensor probes to transmitter. Refer to the applicable Hybrid Series (HTx) or Silver Series (STx) Transmitter Installation, Operation and Maintenance Technical Manual (under separate cover) for set up instructions.

TM_HP1_SP1_R5A

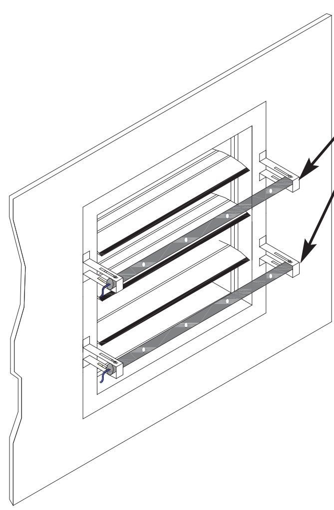


NOTES:

1. **Standoff probes are ordered by specifying the opening size.** The probes supplied will include an additional 2 in. [50.8 mm] of tube length (which is 2 in. longer than the specified opening size) to allow for bracket installation and damper blade clearance.

2. The additional 0.125 in. [3.175 mm] clearance (shown at dashed line adjacent to each bracket) is provided to ensure damper blade/linkage clearance.

Figure 13. HP1/SP1 Standoff Mount Probe Mechanical Dimensions



Probes supplied are 2 in. [50.8 mm] longer than the specified opening size to allow for bracket installation and damper blade clearance.

Install probes upstream of the outside air intake damper when extension sleeves cannot be added.

TM_HP1_SP1_R5A

Figure 14. HP1/SP1 Standoff Mount Upstream Outside Air Intake Damper Detail

HP1/SP1 POWER AND SIGNAL WIRING NOTES

Power Requirements

Sensor probes are powered by the Hybrid Series (HTx) or Silver Series (STx) Transmitters. The STx102 transmitter requires 24VAC at 8VA maximum, and the HTx104 transmitter requires 24VAC at 11VA maximum (depending on the number of sensors). An isolated 24VAC power source is NOT required on analog output transmitters to ensure a "floating" output signal to the host controls, since the analog outputs are isolated.

Interfacing to the Host Control System:

- HTA104-P, STA102-P Analog Output: The output signal is field selectable for either voltage or current independently for the airflow and temperature. Analog output signal scaling has factory default settings or can be configured by the user in the field.
- HTN104-P RS-485 Output: The RS-485 output can be configured for **BACnet® MS/TP Master, Modbus® RTU or Johnson Controls® N-2 bus®networks**.

Refer to the applicable transmitter Installation, Operation and Maintenance Technical Manual, under separate cover, for additional information on options and setting up the airflow measurement station.

HP1/SP1 MAINTENANCE

In most HVAC environments, periodic maintenance and calibration is not required or recommended[1].

[1] In certain applications where a large amount of airborne particulate is present, especially fibrous material such as lint, pre-filtering of the return air may be required to ensure optimum instrument performance. If no pre-filtering is provided, it may be necessary to periodically inspect and clean sensors using compressed air or a small brush. Factory performance returns immediately after cleaning. Recalibration is NOT required. Periodic inspection of the sensors is always advised, and accessibility must be considered in these applications.

HP1/SP1 STANDARD LIMITED PARTS WARRANTY

If any ***EBTRON*** product fails within 36 months from shipment, ***EBTRON*** will repair/replace the device free of charge as described in the company's warranty contained in ***EBTRON***'s Terms and Conditions of Sale. Defective equipment shall be shipped back to ***EBTRON***, freight pre-paid, for analysis.

APPENDIX I
HP1 Precision 'C' Sensor Density Table

Precision 'C' Sensor Density Table

HP1 Rectangular, Round-Oval Probe Sensor Density (# Probes / # Sensors per probe)

HTx104-PC

ADJACENT SIDE LENGTH / DUCT HEIGHT	PROBE LENGTH / DUCT WIDTH														
	12	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**	**66**	**72**	**84**	**96**	**108**	**120**
12	1/2	2/2	1/4	1/4	1/4	1/4									
18	2/2	2/2	2/2	2/2											
24	2/2	2/2													
30	2/2	2/2													
36	2/2														
42	2/2														
48															
54															
60															
66															
72															
84															
96															
108															
120															
144															
168															
192															

Hybrid Precision 'C' Density Table

Consult factory for application of sizes not shown, or consider our Gold Series product line.

TM_HP1_SP1_R5A

APPENDIX II

HP1/SP1 - 'B' and 'A' Sensor Density Tables

HP1B/SP1B - General 'B' Sensor Density Table

HP1/SP1 Rectangular, Round-Oval Probe Sensor Density (# Probes / # Sensors per probe)

HTx104-PB

ADJACENT SIDE LENGTH / DUCT HEIGHT	PROBE LENGTH / DUCT WIDTH														
	12	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**	**66**	**72**	**84**	**96**	**108**	**120**
12	1/2	1/2	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4			
18	2/1	2/2	2/2	2/2	1/4	1/4	1/4	1/4	1/4						
24	2/2	2/2	2/2	2/2	2/2	2/2									
30	2/2	2/2	2/2	2/2	2/2										
36	2/2	2/2	2/2	2/2											
42	2/2	2/2	2/2												
48	2/2	2/2													
54	2/2	2/2													
60	2/2	2/2													
66	2/2														
72	2/2														
84	2/2														
96															
108															
120															
144															
168															
192															

Hybrid General 'B' Density Table

Consult factory for application of sizes not shown, or consider our Gold Series product line.

HP1A/SP1A - Economy 'A' Sensor Density Table

HP1/SP1 Rectangular, Round-Oval Probe Sensor Density (# Probes / # Sensors per probe)

HTx104-PA

ADJACENT SIDE LENGTH / DUCT HEIGHT	PROBE LENGTH / DUCT WIDTH														
	12	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**	**66**	**72**	**84**	**96**	**108**	**120**
12	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/3	1/3	1/3
18	2/1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/3	1/3	1/3	1/4	1/4	1/4
24	2/1	2/1	1/2	1/2	1/2	1/2	1/3	1/3	1/3	1/3	1/4	1/4			
30	2/1	2/1	2/1	1/2	1/2	1/3	1/3	1/3	1/4	1/4	1/4				
36	2/1	2/1	2/1	2/1	2/2	2/2	2/2	2/2	2/2						
42	2/1	2/1	2/1	2/2	2/2	2/2	2/2	2/2							
48	2/1	2/1	2/2	2/2	2/2	2/2									
54	2/1	2/1	2/2	2/2	2/2	2/2									
60	2/1	2/1	2/2	2/2	2/2										
66	2/1	2/2	2/2	2/2											
72	2/1	2/2	2/2	2/2											
84	2/1	2/2	2/2												
96	2/2	2/2													
108	2/2	2/2													
120	2/2	2/2													
144	2/2														
168	2/2														
192															

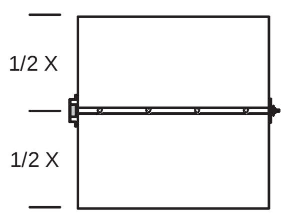
Hybrid Economy 'A' Density Table

Consult factory for application of sizes not shown, or consider Gold Series product line.

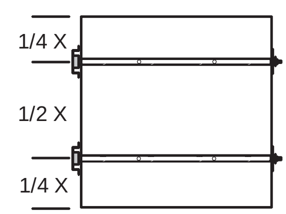
APPENDIX III
HP1/SP1 Probe Mounting, Spacing and Configuration

RECTANGULAR DUCT PROBE SPACING

☐ One Probe

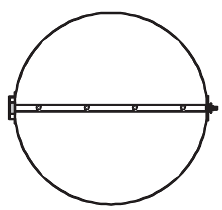


☐ Two Probes

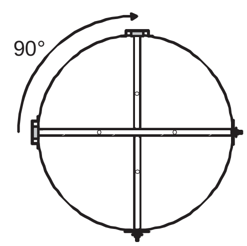


ROUND DUCT PROBE SPACING

☐ One Probe

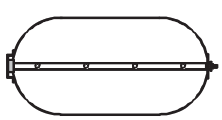


☐ Two Probes

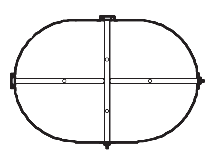


OVAL DUCT PROBE SPACING

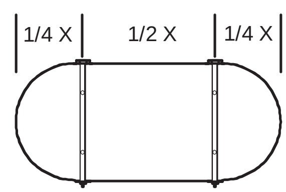
☐ One Probe (configuration ‘a’)



☐ Two Probes (configuration ‘b’)

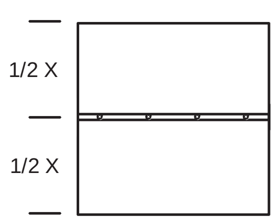


☐ Two Probes (configuration ‘c’)

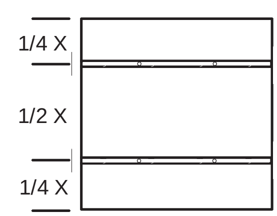


STANDOFF MOUNT RECTANGULAR OPENING PROBE SPACING

☐ One Probe



☐ Two Probes



TM_HP1_SP1_R5A