KURZ

INSTRUMENTS INC.

EVA 4000
Electronic Velocity Array
User's Guide

May1989

Unit Description Sheet

Complete Model Number: ____

Serial Number: ____

Kurz Order Number: ____

Customer P. O. Number: ____

Purchasing Specification:

____Flow Rate/Velocity: ________________________

____Stack/Duct Size: ___________________________

____Wall Thickness: ___________________________

____Nominal Pressure: __________________________

____Nominal Temperature: _______________________

Input Power:

____Standard 115 VAC - 60 Hz

____Optional 230 VAC - 50 Hz

Signal Output:

____Standard 0-5 Vdc Linear

____Optional Non-Isolated 4-20 mA (131 or 131RM)

____Optional Isolated 4-20 mA (132 or 132RM)

____Optional Isolated 0-5 Vdc (133 or 133RM)

____ Average Velocity: ________________________

____ Total Flow Rate Output: ____________________

____Optional 0-5 Vdc (134 or 134RM)

____ Scaled to Engineering Units: _______________

____Other (specify): ___________________________

Probe Assembly:

____KBAR 12; Length: _________________________

____KBAR 24; Length: _________________________

Probe Construction:

____Aluminum

____316 Stainless Steel

____Hastelloy

____PVC

Sensor Type:

____Dual-Sting MetalClad

____Triple-Sting Integral Temperature Sensor

Sensor Construction:

____316 Stainless Steel (Standard)

____HHT

____Titanium

____Hastelloy

____Tefzel Sensor Cable

____Other: ________________________________

Mounting Configuration:

____TASE (Transmitter Attached, Single-Ended)

____TSSE (Transmitter Separate, Single-Ended)

____TADE (Transmitter Attached, Double-Ended)

____TSDE (Transmitter Separate, Double-Ended)

____Other: ________________________________

Mounting Hardware:

____FMA

____CFMS

____DESC

____FMS

____DESF

____Other: ________________________________

Series 195 Current-Transmitter Enclosure:

____195-080604-N4

____195-201608-N4

____195-221310-FWT-N4

____Other: ________________________________

Series 193 System Electronics Enclosure:

____193-141208

____193-201608

____193-201608-N4

____193-302412-N4

____193RC-302412-FWT-N4

____193RC-482212-FWT-N4

____193RC-722532-FWT

____193RC-402422

____193RC-702422

____Other: ________________________________

Current-Transmitter Board:

____Series 465, Model: ________________________

____Other: ________________________________

Power Supply:

____191-2.4 (2.4 Amp)

____191RM-2.4 (2.4 Amp, Rack-Module)

____191-4.8 (4.8 Amp)

____191RM-4.8 (4.8 Amp, Rack-Module)

____191-12 (12 Amp)

____191RM-12 (12 Amp, Rack-Module)

____Other: ________________________________

Series 151 Signal Conditioner/Linearizer Model: ______________________

Standard Options:

____Digital Display

____131 Non-Isolated 4-20 mA Output Module

____131RM Non-Isolated 4-20 mA Output Rack Module

____132 Isolated 4-20 mA Output Module

____132RM Isolated 4-20 mA Output Rack Module

____133 Isolated 0-5 Vdc Output Module

____133RM Isolated 0-5 Vdc Output Rack Module

____134 Non-Isolated 0-5 Vdc Output Module

____134RM Non-Isolated 0-5 Vdc Output Rack Module

____161RM Temperature Module with 0-5 Vdc Output

____ Temperature Range:________________________

____161RMD Temperature Module with Digital Display

____ Temperature Range:________________________

____101RM Non-Resettable Flow Totalizer

____101SRM Resettable Flow Totalizer

____111RM Dual Alarm Module

____101S/111RM Resettable Flow Totalizer/Dual Alarm Module

____KRZ2015 19" Rack Chassis

____Model 40 Field Calibrator

Other Options:

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____

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____

2411 Garden Road
Monterey, CA 93940
(408) 646-5911
(800) 424-7356

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Because the EVA systems are modular, each system and installation is unique. Kurz attempts to provide reasonable documentation generic in nature and covering typical systems and installations. No guarantee is made that an EVA system was built accoding to standard procedures. Extensive typical drawings are available for use in field installations. Customers who desire as-built drawings should contact the factory for price quotations.

Equipment sold by Kurz Instruments, Inc. is not intended for use in connection with any nuclear facility or activity unless covered by a specific quotation where the conditions of such usage will be detailed. If the equipment is used in a nuclear facility or activity without supporting quotation, Kurz disclaims all liability for any damage, injury, or contamination, and the buyer shall indemnify and hold Kurz, its officers, agents, employees, successors, assigns, and customers, whether direct or indirect, harmless from and against any and all losses, damages, or expenses of whatever form or nature (including attorney's fees and other costs of defending any action) which they, or any of them, may sustain or incur, whether as a result of breach of contract, warranty, tort (including negligence), strict liability or other theories of law, by reason of such use.

Warranty Statement

The Kurz EVA 4000 Electronic Velocity Array is warranted to be free from defects in material or workmanship for one year from the date of shipment from the factory. Kurz's obligation is limited to repairing, or at its option, replacing products and components that, on verification, prove to be defective. Warranty work will be performed at the factory in Monterey, California. Kurz shall not be liable for installation charges, for expenses of buyer for repairs or replacement, for damages from delay or loss of use, or other indirect or consequential damages of any kind. Kurz extends this warranty only upon proper use and/or installation of the product in the application for which it is intended and does not cover products that have been serviced or modified by any person or entity other than Kurz Instruments Incorporated and its authorized service technicians. This warranty does not cover damaged sensors, units that have been subjected to unusual physical or electrical stress, or upon which the original identifications marks have been removed or altered.

Transportation charges for material shipped to the factory for warranty repair are to be paid for by the shipper. Kurz will return items repaired or replaced under warranty prepaid. No items shall be returned for warranty repair without prior authorization from Kurz. Call Kurz Instruments service department at (408) 646-5911 to obtain a return authorization number.

This warranty contains the entire obligation of Kurz Instruments Incorporated. No other warranties, expressed, implied, or statutory are given.

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Figures

Tables

About This Book

This book contains five sections and five appendixes, each of which is briefly described below. The book is not designed to be read cover to cover; rather, it is designed to present information to the EVA 4000 user in as accessible a manner as possible.

Organization

Section 1: Product Overview

This section introduces you to the purpose, specifications, as well as the unique features and advantages of the EVA 4000 system. You can safely skip this section if you are already familiar with that information.

Section 2: System Components and Functions

Section 2 describes the functions performed by the basic components of the EVA 4000 system: The Kurz MetalClad sensor, the KBAR probe, the current-transmitter board housed in the current-transmitter enclosure, as well as as the signal conditioner/linearizer board and system power supply housed in the system electronics enclosure.

Section 3: Installation

Section 3 explains, in necessarily general terms, how to install your 435DC. This section explains how to determine the correct location for installation, as well as how to perform the physical installation in pipes and flat or round ductwork. You should read thoroughly the parts of this section that apply to your installation before you install the EVA system.

Section 4: Operation and Routine Maintenance

This section explains how to start using the EVA system and how to do a quick check to determine if the system is operating properly. It also describes how to perform routine maintenance such as cleaning the sensor, verifying the output signal, and checking the power supplies.

Section 5: Options

This section lists and explains most of the options available for expanding the capability of your EVA 4000 system. Contact Kurz Instruments for a complete, up-to-date list of available options.

Appendix A: Engineering Drawings - For Installation

Appendix A contains three types of drawings: (1) Field Interconnection Wiring Diagrams, (2) 195 Transmitter Enclosure Assembly Layouts, and (3) 193 System Electronics Enclosure Assembly Layouts. These drawings are helpful during installation because they illustrate the interconnections between components of the EVA system. Other drawings, required for trouble-shooting an EVA system, are included in Appendix E.

Appendix B: Sensor Placement Examples

The EPA and ANSI both provide standards for monitoring gas velocities in ducts and stacks. In common use are EPA methods 1 and 2 and ANSI method N13.1-1969. Each is described briefly in this appendix.

Appendix C: Kurz Equipment Storage Requirements

The Kurz specification for equipment storage requirements provides general storage criteria and specifies the minimum storage and maintenance requirements for the supplied equipment for periods up to five years at the manufacturer's facilities, the plant sites, or other storage facilities.

Appendix D: Sales Literature on the EVA System

This appendix contains the latest sales information on the EVA systems.

Appendix E: Additional Engineering Drawings

Appendix E contains drawings that will be helpful for trouble-shooting your EVA system. This appendix contains five types of drawings: (1) 195 Tranmitter Enclosure Internal Wiring Diagrams, (2) 193 System Electronics Enclosure Internal Wiring Diagrams, (3) Model 143 Signal Conditioner Internal Wiring Diagrams, (4) Model 143 Electronic Components - Schematics and Component Layouts, and (5) Optional Electronic Components - Schematics and Component Layouts.

About the Art in This Book

The computer-generated art in the main sections of this book is intended to illustrate particular points under discussion. It includes only as much detail as is relevant to the discussion at hand. No attempt has been made to accurately scale these drawings or to include details not under discussion in the text that precedes and follows each drawing. If you need more detailed and precise visual information, refer to the appropriate engineering drawings.

Section 1: Product Overview

EVA Electronic Velocity Arrays revolutionize the way the world measures airflow in ducts and stacks of all sizes. The EVA system allows you to measure and control airflow with a precision and reliability never before possible.

Our EVA 4000 uses the MetalClad™ 316 stainless-steel-clad thermal sensor. Multiple sensors are combined on one or more probes to create a multi-point array, electronically averaging each independent sensor to produce a total duct or stack flow rate. Because EVA sensors automatically correct for temperature and barometric pressure variations, no extra transducers are necessary. And because the EVA sensors directly measure mass flow, systems can be ranged in units of lbs/hr, Standard Cubic Feet per Minute (SCFM), or other engineering units of your choice.

The rugged stainless-steel-sheathed Kurz MetalClad sensor addresses applications previously impossible with pitot-tube arrays. EVA is very clog resistant, works well even when it's dirty, and excels at low velocity measurements (down to 20 SFPM).

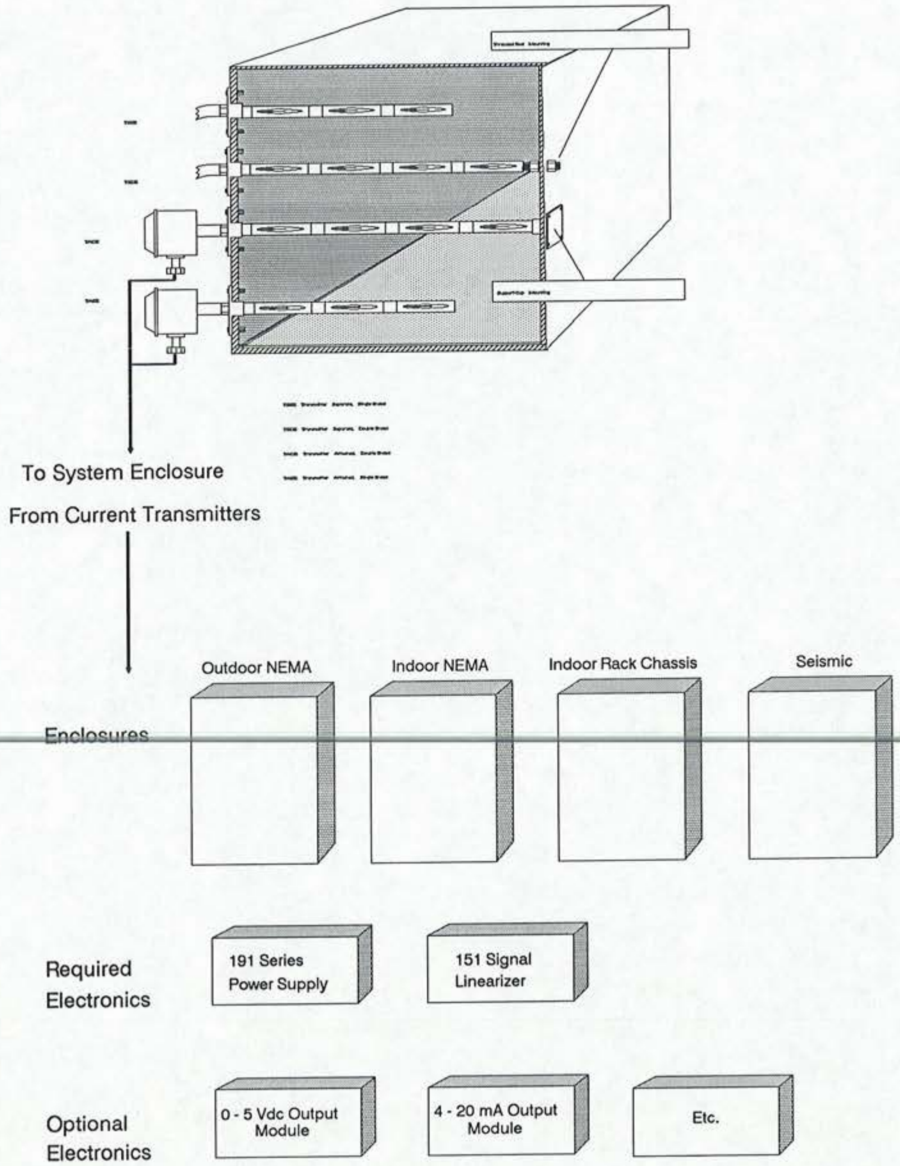
With the MetalClad sensor, the EVA 4000 is designed to tackle the toughest industrial applications – anywhere the airflow is hot, dirty, or corrosive. EVA is an all-electronic technology that is virtually maintenance free. The MetalClad sensor runs clean and is substantially unaffected by dirt and particulate build-up. EVA offers a significant advantage over all other velocity measurement methods.

Applications include particulate-laden combustion air, smelter exhaust flows, flue gases, power-plant effluent release, isokinetic radiation monitoring, and many others.

1.1 System Components

The basic components of the EVA 4000, illustrated in Figure 1-1, are the MetalClad sensor, the KBAR probe, the current transmitter enclosure containing 1 current-transmittter board per sensor, and the system electronics enclosure containing the signal conditioner/linearizer modules, power supply, and optional components.

Figure 1-1. *EVA 4000 System Components*



1.2 Specifications

The specifications of the EVA 4000 are given in Table 1-1.

Table 1-1. *Specifications*

Sensor Construction:	Each sensor is constructed of reference-grade 385 platinum RTD-type windings around a high-purity ceramic core, sheathed in 316 stainless steel.
Wetted Surfaces:	The only sensor material exposed to the working fluid is 316 stainless steel.
Accuracy:	Each independent sensor is accurate to 3% of full scale (linearized output) over the temperature range of 0° to +125° C.
Minimum Air Velocity Sensitivity:	Each sensor can accurately measure air velocities down to 50 feet per minute.
Temperature Compensation:	+ 2% degradation of accuracy at temperatures from +125° to 250° C; +3% degradation of accuracy at temperatures from +250° to 500° C
Repeatability:	Each sensor repeats a reading or output within 1% ten consecutive times when flow is cycled from 100% flow to 50% flow over a one minute period
Response Time:	Each sensor responds within 5 seconds within the accuracy specification to changes in air velocity from 100% to 50% of the calibrated range, and from zero (no flow) to 50% of the calibrated range.

Specifications (continued)

Calibration:	Each sensor is factory calibrated in NBS-traceable wind tunnel for air at 25° C (77° F) and 760 mm (29.92") Hg. A Calibration Certificate showing output voltage vs air velocity is included.
Sensor Operating Temperature Range:	0° C to +250° C standard HHT rated sensor optionally available for temperatures from 0° C to +500° C **NOTE:** The current-transmitter board is rated only to 125° F. Specify a remote-mounted enclosure for the electronics or longer probe if the portion of the probe **outside** the pipe or duct to be monitored will be exposed to temperatures higher than 125° F.
Pressure Compensation:	Each sensor compensates for variations in pressure of the working fluid between 0 psia and 1000 psia.
Sensor Integrity Verification:	The integrity and electrical continuity of each sensor is quickly verified by two ohmage measurements.
Sensor Electrical Terminations:	Each sensor's electrical wiring is terminated by spade lugs.
Probe Construction:	Standard EVA probes are constructed of aluminum. The standard aluminum probe is sufficient for non-nuclear applications, up to a temperature of 250° C. For nuclear applications or or service in temperatures up to 500° C, probe construction of 316 stainless steel should be specified.

Specifications (continued)

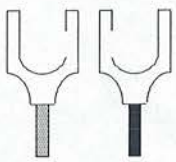
Probe Construction (cont.):	Hastelloy™ is available for temperatures to 500° C and for very corrosive environments. PVC probe construction is also available. Sensor windows and supporting pipe nipples are constructed of PVC; the MetalClad sensor itself remains sheathed in stainless steel. MetalClad sensors are mounted by screwing in protective windows, which in turn connect together by a screw fitting. All threads are NPT standard. Sensors are easily replaceable with hand tools. No welding or cutting on probe structures is required to exchange any of the sensors.
Probe Mounting:	Each probe structure can be mounted via an attached 4-bolt pattern ASA flange.
Output:	Linear 0-5 Vdc outputs are standard, nonisolated 4-20 mA outputs are optionally available.
Averaging Methodology:	Each sensor in an EVA 4000 system functions independently to produce a linear output signal

1.3 Advantages of EVA Technology

Relative to other velocity-profiling technology, the technology employed in the EVA line enjoys the following advantages:

- **Mass Velocity Measurement:** Kurz EVA systems measure the mass velocity rate expressed as SCFM/ft^2. Therefore, no corrections are needed for temperature or pressure. Humidity has a very slight effect, which – at the levels encountered in most applications – is negligible.

- **Large Turn-Down Ratio:** The EVA system has a tremendous turn-down ratio. Air flow as low as 20 SFPM can be measured.



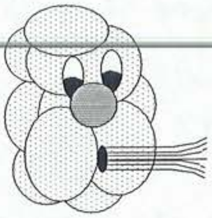
- **Simple Interface to Recorder or Control Systems:** EVA system output is a linear 0-5 volt (or optional 4-20 mA) isolated DC output proportional to the average velocity and the total flow rate. No corrections for temperature or pressure are required.

- **Easy Installation:** Each EVA 4000 Air Velocity Array is light weight (less than 75 pounds), and can easily be mounted in the existing duct structure in a short time. Special handling equipment is not required. Kurz supplies all fittings (mating flanges) and accessories needed to complete the system installation. The electrical connections are straightforward. Large field-wiring terminals are provided in NEMA type enclosures. Terminals are also provided on the rear of rack modules. Because EVA systems are installed, in most cases, after plant construction is complete, EVA installation does not entail construction delays.

- **No Duct Section Required:** EVA systems do not require a duct section. This means that the EVA velocity-sensor arrays can be inserted into a standard section of duct **after** all other systems are built. The arrays can also be inserted into **existing** systems. This saves time and money and eliminates the requirement that extra duct sections be purchased. Because EVA systems do not require a duct section and the accompanying honeycomb flow-straightening and profiler sections, the possibility of particulate collection on the large surface areas of the honeycomb sections is eliminated.

- **Insensitivity to Dirt:** The EVA MetalClad velocity sensors use a flow-through design that does not plug or clog with particulate build-up. Kurz has had excellent experience in extremely dirty environments such as copper smelters and cement plants. We have found the EVA equipment to be highly insensitive to dirt. With the EVA system, the operation of each sensor can be verified at any time through the use of the velocity profiler feature.

  Pitot-tube sensors, on the other hand, are based on the deceleration of the air stream to develop a pressure output. Thus, the pitot tube is a nearly perfect particulate impactor, and collects a large percentage of any particulate carried in the flow streamline striking the pitot-tube sensor. This large amount of dirt negatively affects maintenance cost and data quality assurance. If one of the pitot-tube sensors becomes clogged, the fact that it has ceased to operate is not apparent from the output data, which are then no longer valid.



- **No Purge System Required:** Because of the MetalClad sensor's insensitivity to dirt, the EVA system does not require a high-pressure purge system in its controls.

- **Calibration Verification:** Several special features are possible with the EVA 4000 system:
    - Because even zero velocity requires electrical energy to heat the sensors, zero velocity is a calibration point. Thus, a calibration check of the system can be made even with the system at zero velocity.
    - The Model 142 Velocity Profiler feature allows the user to measure the output of each sensor separately. This allows verification of the zero calibration point and verification that the sensor is functioning. It also allows the output of an individual sensor to be compared with the reading obtained during an in-situ velocity measurement, as explained below.
    - Ports can be machined into EVA mounting flanges to allow the insertion of the Kurz Model 4440 Digital Portable Air Velocity Meter. If purchased with a sufficiently long probe, the 4440 can be used to obtain a velocity profile of the duct and to check the calibration of each sensor in the EVA array.
    - Kurz also manufactures a portable wind tunnel, the Model 400CP Air Velocity Calibrator, which can be used to calibrate and verify calibration of each sensor before installation or whenever the EVA 4000 probes are withdrawn from the duct.
    - Finally, Kurz offers the Model 40 Field Calibrator, described in more detail in Section 5.

End of Section 1

Section 2: System Components and Functions

The basic components of the EVA 4000, as illustrated in Figure 1-1 on page 1-2, are the MetalClad sensor, the KBAR probe, the current transmitter enclosure containing 1 current-transmittter board per sensor, and the system electronics enclosure containing a signal conditioner/linearizer board for each sensor, a system power supply, and optional components.

The features and functions of each of these components will be described further in this section.

2.1. The MetalClad Sensor

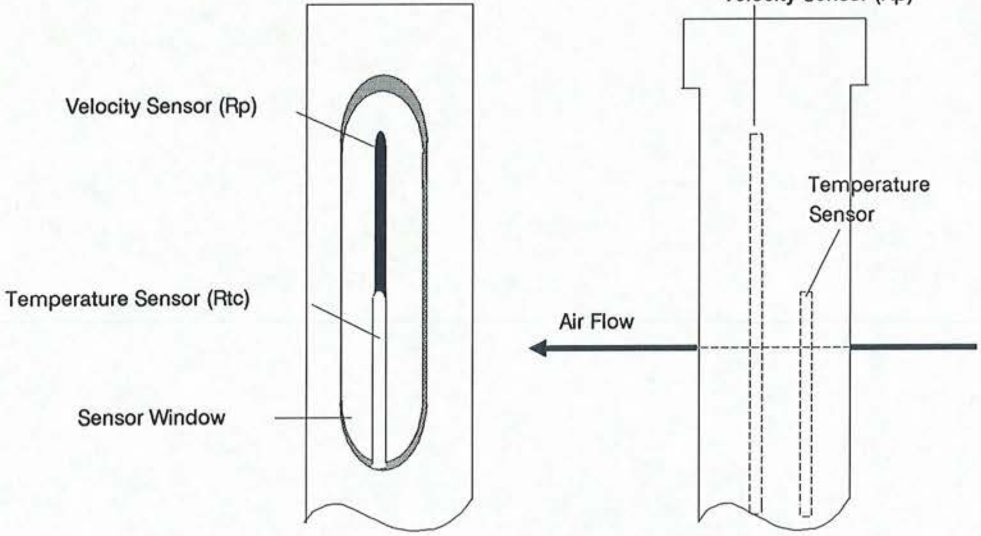
The MetalClad sensor measures the airflow in a duct or stack. It can be constructed of stainless steel, Titanium, or Hastelloy, depending on the environment in which the sensor will be used. Refer to Section 5 for information on sensor construction options and other options that can be added to you EVA system.

2.1.1 How the Sensor Works

The EVA MetalClad sensor is in fact two sensors in one: a temperature sensor and a velocity sensor. Both sensors consist of reference-grade platinum windings wound around a ceramic mandrel and enclosed in a stainless steel sheath. The temperature sensor (R_{tc}) is the shorter of the MetalClad's two sensor elements. The velocity sensor (R_p) is the longer of the two elements. Figure 2-1 shows a close-up view of the MetalClad sensor within its protective sensor window.

The temperature sensor senses the ambient temperature of the air flow. The velocity sensor is then heated to approximately 75°to 100° F **above** the ambient temperature and is maintained at the same level of temperature differential (overheat) above the ambient temperature regardless of changes in ambient temperature.

Figure 2-1. *The MetalClad Sensor: Two Views*

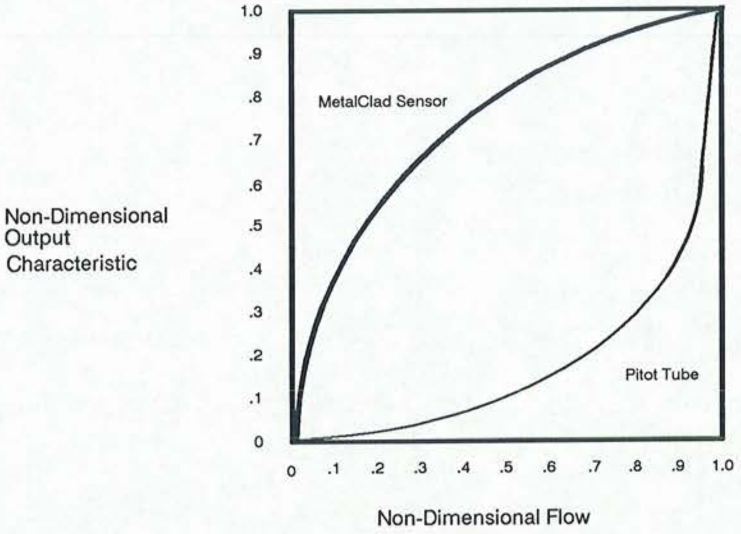


The temperature and velocity sensors form two legs of a balanced Wheatstone bridge. The bridge circuitry itself is contained on the current-transmitter board in the transmitter enclosure. The temperature sensor leg (R_{tc}) is input to the positive side of an operational amplifier as a reference. The bridge is activated through an offset differential of the two legs. The sensor is heated with current through the R_p winding. Resistance increases until it balances with the minus input of the operational amplifier, which drives a power transistor to provide bridge current.

With the temperature sensor compensating for fluctuations in ambient temperature, the amount of electrical power needed to maintain the velocity sensor's overheat is affected only by the flow of air or other gases over the sensor: The greater the velocity of the flow, the greater its cooling effect on the sensor and the greater the electrical power needed to maintain the sensor's overheat. It is this power or current draw that is measured by the EVA system.

The signal received from each sensor is nonlinear in that the amount of power needed to maintain the velocity sensor's overheat is not directly proportionate to the velocity of the airflow. Instead, the power-consumption curve is fairly steep at low flow rates and relatively flatter at higher rates of flow. Figure 2-2 shows the MetalClad sensor's output curve as flow increases. It also shows the corresponding curve for a pitot-tube type sensor. Note the greatly superior sensitivity of the MetalClad sensor at low flow rates.

Figure 2-2. *Sensor Output vs Flow*

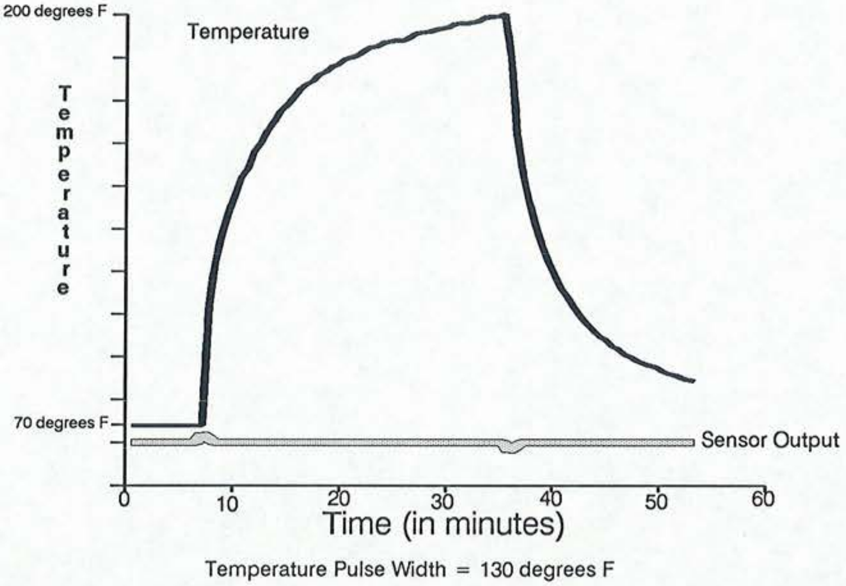


The sensor is directly measuring mass flow (i.e., the number of molecules carrying heat away from the velocity sensor), and is calibrated in standard units, which are referenced to a temperature of 25° C and atmospheric pressure of 760 mm Hg. In other words, air at 25° C and 760 mm Hg, flowing at 100 cubic feet per minute (CFM) will produce a reading of 100 standard cubic feet per minute (SCFM). A 100 CFM flow at a different temperature or pressure produces a reading in SCFM that accurately compensates for the temperature or pressure differential.

2.1.2 Temperature Compensation

All heat transfer results from a **difference** in temperature between the heated winding and the gas stream. Since we maintain that difference **constant** by using a carefully set up Wheatstone bridge circuit, the sensor, especially with the R_{tc} isolated at the end of its own thermowell, ought to compensate for changes in ambient temperature well. The graph shown in Figure 2-3 demonstrates that it does.

Figure 2-3. *Temperature Change vs Signal Fluctuation*



Note that the onset of sudden increases and decreases in temperature cause only a small (about 20 millivolts) and short-lived (about two-minute) fluctuation in the sensor's signal. The 20 millivolts, over the 0-1 Vdc current-sense voltage span, represents one part in 50, or an error of +/- 2%.

2.1.3 Pressure Compensation

The Kurz thermal sensor, because it responds to the amount of heat being carried away, and because heat is carried away by molecules, inherently and automatically compensates for variations in density or pressure (more pressure means more molecules, which means more mass flow). Table 2-1 shows the performance of a single sensor operating over turndowns of approximately 40 to 1 over both velocity and pressure.

Table 2-1. *Effects of Pressure on Non-Linear Output*

Pressure	15*	29.92*	15	30	45	75	100	175	300	500	600	800	1000
SFPM	Non-Linear Bridge Voltages												
0	3.59	3.55	3.623	3.71	3.77	3.89	3.97	4.2	4.54	4.80	4.97	5.20	5.42
250	5.05	5.04	5.04	5.04	5.05	5.05	5.06	5.06	5.08	5.15	5.36	5.54	5.76
500	5.60	5.60	5.59	5.60	5.61	5.61	5.62	5.62	5.64	5.73	5.84	5.89	6.00
750	5.87	5.868	5.868	5.87	5.87	5.87	5.88	5.88	5.93	5.99	6.10	6.15	6.23
1000	6.11	6.111	6.08	6.09	6.09	6.09	6.11	6.11	6.15	6.25	6.35	6.38	6.41
2000	6.77	6.79	6.79	6.78	6.78	6.79	6.80	6.80	6.82	6.89	6.90	6.93	7.00
3000	7.29	7.285	7.28	7.28	7.27	7.28	7.28	7.26	7.26	7.32	7.35	7.35	7.40
4000	7.67	7.67	7.67	7.65	7.65	7.67	7.67	7.64	7.64	7.65	7.65	7.69	7.75
5000	7.97	7.97	7.97	7.95	7.95	7.95	7.95	7.95	7.95	7.96	7.96	7.98	8.00
6000	8.24	8.238	8.24	8.22	8.23	8.23	8.23	8.23	8.23	8.23	8.23	8.24	8.24
7000	8.52	8.51	8.52	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.49
8000	8.80	8.80	8.80	8.72	8.74	8.72	8.72	8.72	8.72	8.72	8.72	8.72	8.73
9000	9.03	9.03	9.04	8.95	8.96	8.96	8.95	8.95	8.95	8.95	8.95	8.95	8.96
10,000	9.27	9.27	9.28	9.15	9.16	9.15	9.15	9.15	9.15	9.15	9.16	9.16	9.17
11,000	9.46	9.46	9.47	9.35	9.36	9.35	9.35	9.35	9.35	9.35	9.35	9.36	9.37
12,000	9.65	9.65	9.69	9.50	9.49	9.49	9.49	9.50	9.50	9.51	9.51	9.52	9.53

* These pressures are in inches of mercury. All other pressures are given in PSIG.
All readings are for air at 25 degrees C.

The data in Table 2-1 characterize sensor performance at 13 different pressures ranging from 15 inches of mercury to 1,000 psi and at 16 flow rates ranging from 0 to 12,000 SFPM. These data demonstrate that pressure is a significant issue only at very low rates of flow.

At 0 SFPM, for example, output voltages range from 3.59 volts at 15 inches of mercury to 5.42 volts at 1,000 psi, a differential of approximately 50%. To create a live zero, to know the zero at high pressure and low flows, the sensor must be calibrated in the pressure.

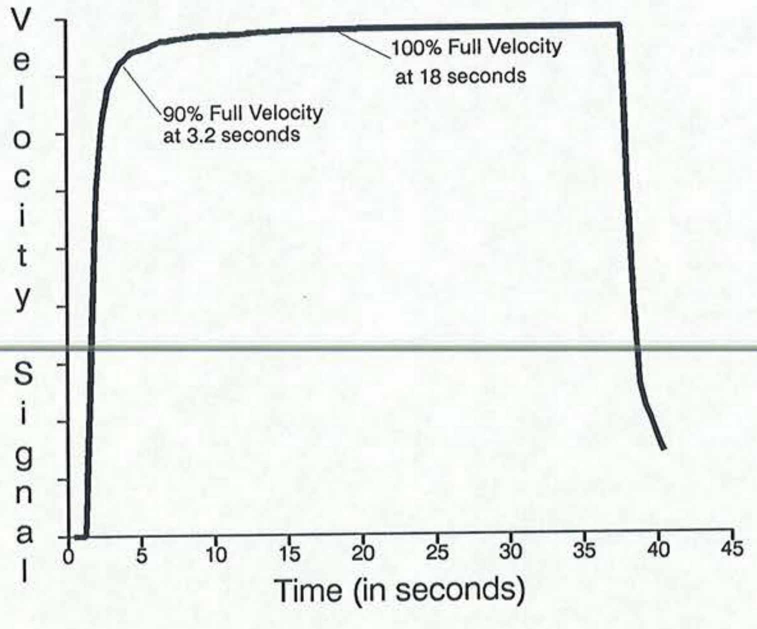
Once flow begins at 1,000 SFPM, for instance, output voltages range from 6.11 volts to 6.41 volts over the same range of pressures. This represents a 30 millivolt error, or one part in 165, considering the 5 volt output span of the sensor, an inaccuracy potential of 6/10 of 1%.

At healthier flows (e.g., 5,000 SFPM), output voltages range from 7.97 volts to 8.00 volts – pressure compensation is textbook perfect.

2.1.4 Time Response

Because the surface temperature is maintained constant by a very simple and thus very fast electronic circuit, and because the ceramic mandrel upon which the platinum wire is wound and the metal cladding are **already at the same temperature as the winding**, the sensor has a much faster response to changes in flow than one would normally expect. As shown in Figure 2-4, when flow over the metalclad sensor is instantaneously boosted from 0 to 6,000 SFPM, the sensor's output is 90% of actual flow within 3.2 seconds. Within 18 seconds, sensor output is at 100% of actual flow.

Figure 2-4. *Time Response of MetalClad Sensor*



2.1.5 Repeatability

Repeatability is one of the strongest features of a thermal anemometer with platinum construction. Excellent repeatability on the order of 1/4% or better is due to the inherent stability and minimal change in resistance over temperature of platinum. All grades of platinum share this stability, but the reference grade 385 platinum used in Kurz sensors and in NBS temperature standards is particularly stable..

2.1.6 Signal

With thermal sensors and accompanying Wheatstone bridge, the circuit develops a raw output signal from the bridge of typically 3 Vdc to 8Vdc. This healthy amount of DC voltage output means there is plenty of sensitivity in our sensors to detect velocity differences of only a few feet-per-minute.

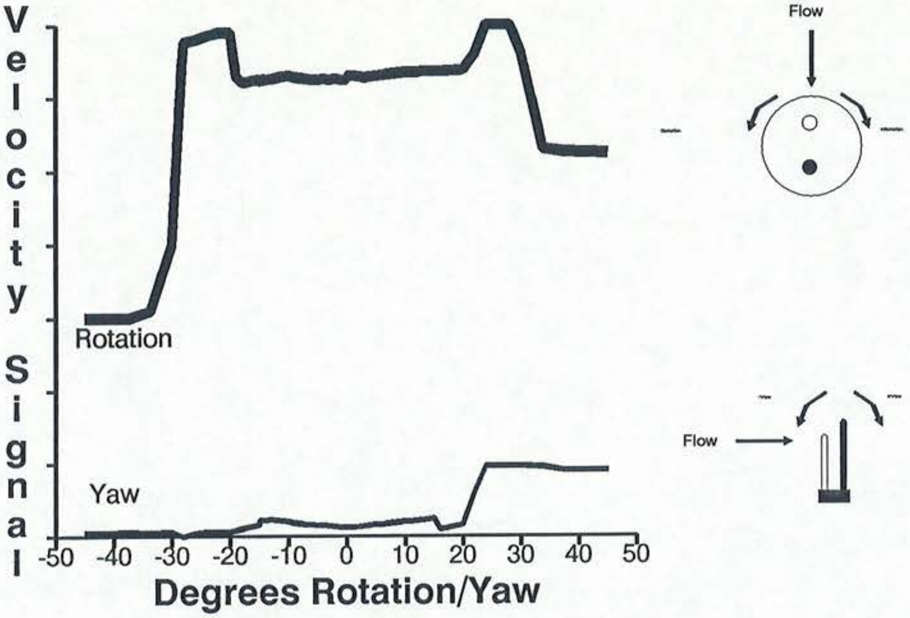
2.1.7 Sensor Orientation: Rotation and Yaw

As you would expect, the thermal sensors are calibrated with the probe positioned into the flow perpendicularly; that is, the two sensor elements are aligned parallel to the flow, with the shorter temperature-compensation winding upstream of the longer velocity winding. Ideally, the sensor's orientation during actual use should be the same as its orientation during calibration. The metalclad sensor can, however, tolerate significant deviations from the ideal orientation as to both rotation and yaw. Rotation refers to deviations from parallel in the alignment of the sensor elements with the gas flow. Yaw refers to deviations in the angle of the sensor's insertion into the flow.

As shown in Figure 2-5, rotational deviations of +/- 10 degrees result in a measurement error of only 1%. Yaw of +/- 10 degrees results in a measurement error of only 2.7%.

Lastly, if so calibrated, these sensors work just as well when flow strikes them end-on first.

Figure 2-5. *Measurement Error: Rotation and Yaw (Data taken at 6000 SFPM)*



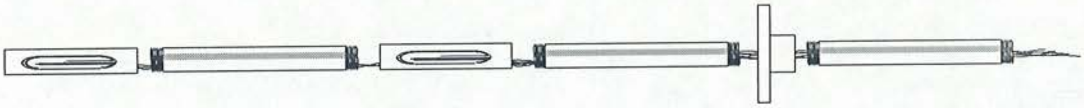
2.2 The KBAR Probes (KBAR 12 and KBAR 24)

KBAR probes consist of one or more MetalClad sensors housed within protective windows and joined together by pipe-nipple sections to provide spacing and structural support. The sensor windows of the KBAR probes provide some degree of flow straightening. Depending on their length, probes can be supported on both ends (double-ended) or supported on one end only (single-ended).

Standard EVA probes are constructed of aluminum. The standard aluminum probe is sufficient for non-nuclear applications, up to a temperature of 250° C. For nuclear applications or for service in temperatures up to 500° C, probe construction of 316 stainless steel should be specified. Hastelloy is available for temperatures to 500° C and for very corrosive environments. PVC probes are also available.

The wiring of each sensor passes through the pipe sections and sensor windows between that sensor and the outside end of the probe. An exploded view of a typical KBAR probe is shown in Figure 2-6.

Figure 2-6. *KBAR Probe: Exploded View*



2.2.1 KB12 Systems

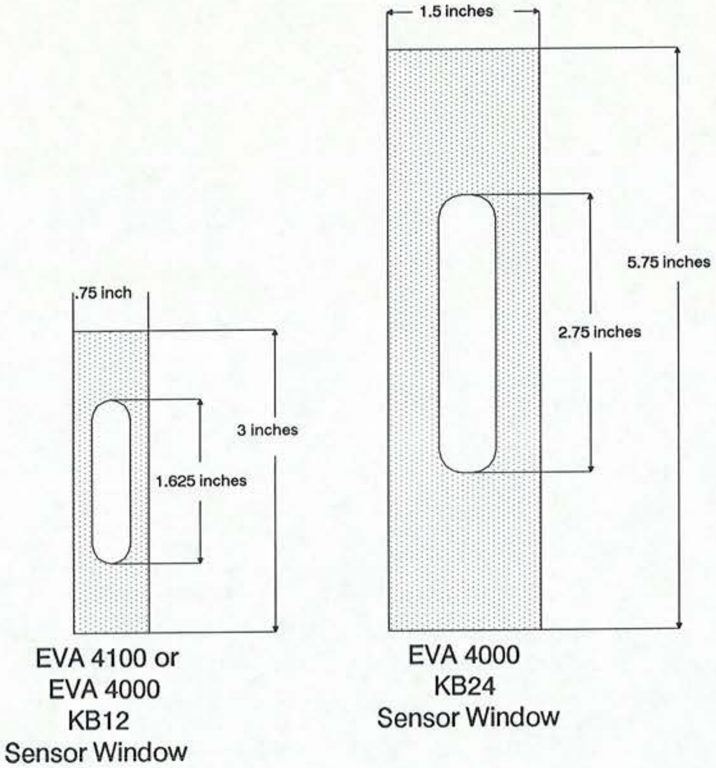
The KB12 is a multipoint system for smaller, low temperature industrial ducts. The KBAR 12 probe has an outside diameter of 3/4" (12/16") and now uses the new Mini MetalClad dual-prong sensor with improved temperature compensation to the KB12's small sensor windows. Each KBAR 12 probe can include a maximum of five Mini MetalClad sensors. KBAR 12 probes are generally single-ended up to a maximum length of 60 inches and double ended above that length.

2.2.2 KB24 Systems

The KB24 is a multipoint system for large industrial ducts or stacks operated at ambient or higher stack temperatures. Each KBAR 24 probe has an outside diameter of 1 1/2" (24/16") and can include up to seven dual-prong MetalClad sensors. KBAR 24 probes are generally single ended up to a maximum length of 96 inches and double ended above that length.

Figure 2-7 shows the sensor windows of the various EVA products drawn to scale.

Figure 2-7. *EVA Sensor Windows Drawn to Scale*



2.3 The Current-Transmitter Boards and Enclosures

Each sensor is connected to a separate 465 current-transmitter board. The current-transmitter boards are housed in a steel enclosure, which may be mounted on the end of the probe (transmitter attached) or remote from the probe (transmitter separate), depending on the number of sensors and the temperature at the end of the probe.

2.3.1 The 465 Current-Transmitter Board

The 465 Current-Transmitter Board is connected to the sensor through a 4-conductor cable. The current-transmitter board contains the wheatstone bridge circuit formed by the inputs from the temperature and velocity sensors. The 191 Series Power Supply provides the 24 Vdc signal required for the circuitry on the board.

As flow increases, the bridge circuit draws more current to stay balanced. Due to heat transfer properties, the amount of power needed to maintain the velocity sensor's overheat is not directly proportionate to the velocity of the airflow. Instead, the power-consumption curve is fairly steep at low flow rates and relatively flatter at higher rates of flow. (See Figure 2-2.)

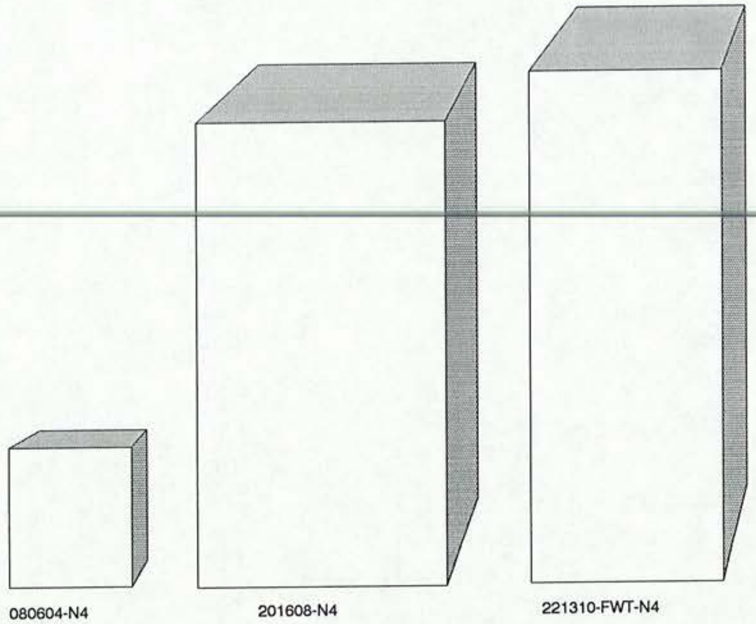
The current-transmitter board transmits the 100-600 mA return signal from the bridge circuit to a 151 signal conditioner/linearizer module contained in the system electronics enclosure.

2.3.2 The Series 195 Current-Transmitter Enclosures

Kurz Instruments offers a selection of three standard enclosures for the EVA systems, each available in painted steel or 304 stainless steel. The current-transmitter enclosure is either mounted at the end (transmitter attached) or mounted separate from the probe (transmitter separate). The enclosure should be mounted separate from the probe if there are more than 4 sensors on the probe or the ambient is greater than 65° C.

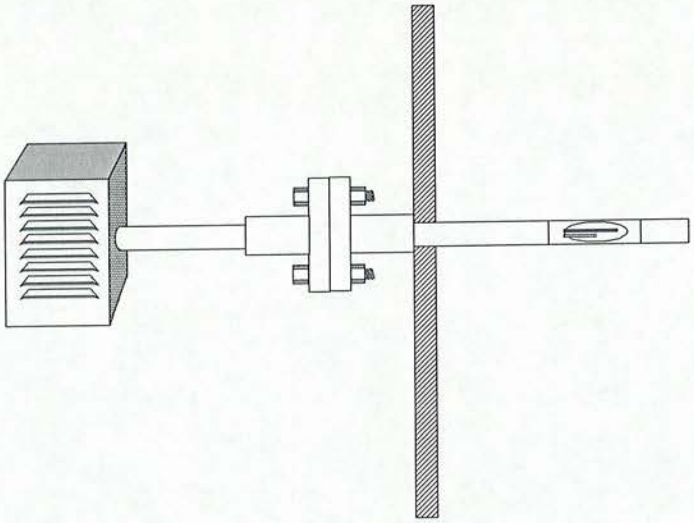
The relative sizes of the transmitter enclosures are shown in Figure 2-8.

Figure 2-8. *Series 195 Tranmitter Enclosures: Relative Sizes*



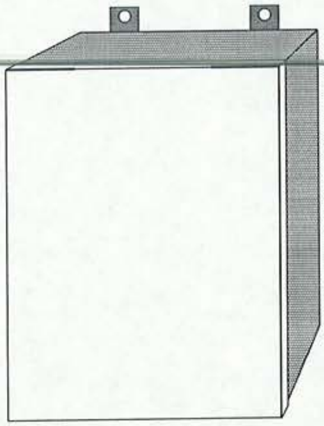
The 195-080604-N4 is a NEMA 4 enclosure that can be mounted at the end of the KBAR 24 probe, as shown in Figure 2-9, or mounted separate from the KBAR 24 probe. This enclosure measures 8 X 6 X 4 inches and houses up to four current-transmitter boards.

Figure 2-9. *195-080604-N4 Enclosure Mounted on End of Probe*



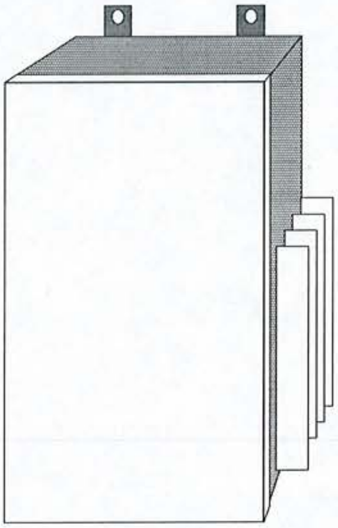
The 195-201608-N4, illustrated in Figure 2-10, is a NEMA 4 enclosure that is designed to be mounted separate from a KBAR 12 or KBAR 24 single-ended or double-ended probe. The enclosure measures 20 x 16 x 8 inches and can house up to eight current-transmitter boards.

Figure 2-10. *The 195-201608-N4 Current-Transmitter Enclosure*



The 195-221310-FWT-N4, illustrated in Figure 2-11, is a NEMA 4 seismically-qualified enclosure that is designed to be mounted separate from a KBAR 12 or KBAR 24 single-ended or double-ended probe. The enclosure measures 21.75 x 12.5 x 10 inches and can house up to nine current-transmitter boards.

Figure 2-11. *The 195-221310-FWT-N4 Seismically Qualified Enclosure*

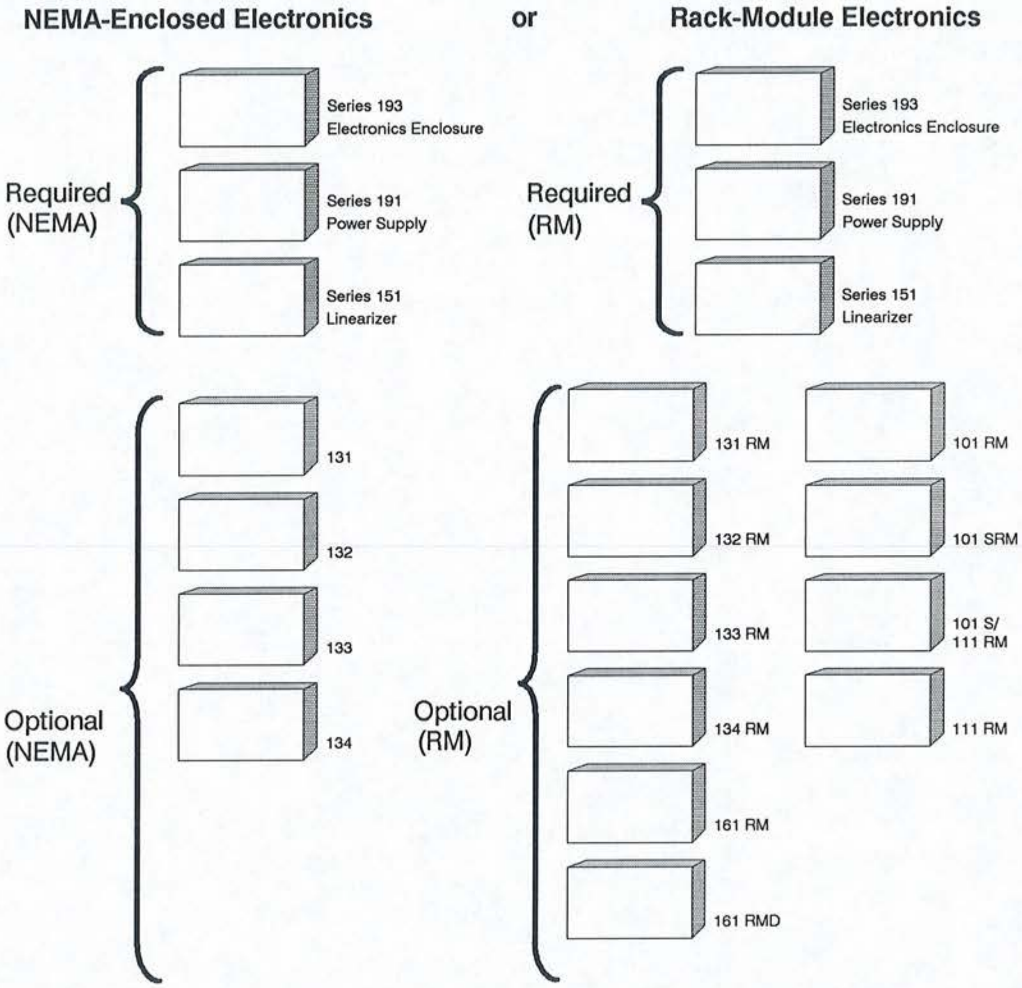


2.4 EVA System Electronics and Series 193 Enclosures

The Series 193 System Electronics Enclosures house the main electronics of the EVA system, pictured diagramatically in Figure 2-12. System electronics are typically installed remote from the EVA probes themselves in a control room or instrument shed.

As shown is Figure 2-12, the 193 electronics enclosure contains the Series 151 Signal Conditioner and Linearizer, the Series 191 Power Supply, and may include other system options described in Section 5.

Figure 2-12. *Required and Optional EVA System Electronics*



2.4.1 193 Series System Electronics Enclosures

Figure 2-13. *The 193-141208 Fan-Cooled Electronics Enclosure*

For Indoor Use Only (in clean air)
Dimensions: 14"H x 12"W x 8"D
Construction: Painted Steel
Max. No. of EVA Systems: 1, Non-Rack
Max. No. of Sensors: 8
Power Supply: Model 191-2.4 or 4.8

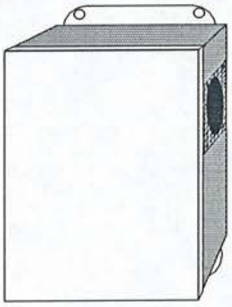


Figure 2-14. *The 193-201608 Fan-Cooled Electronics Enclosure*

Dimensions: 20"H x 16"W x 8"D
Construction: Painted Steel
Max. No. of EVA Systems: 1, Non-Rack
Max. No. of Sensors: 9-16
Power Supply: Any Series 191

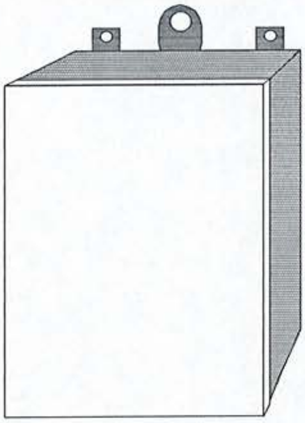


Figure 2-15. *The 193-201608-N4 NEMA 4 Electronics Enclosure*

NEMA 4 Rated
Dimensions: 20"H x 16"W x 8"D
Construction: Painted Steel
Max. No. of EVA Systems: 1, Non-Rack
Max. No. of Sensors: 8
Power Supply: Model 191-2.4 or 4.8

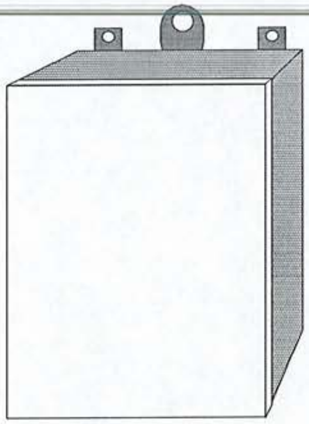


Figure 2-16. *The 193-302412-N4 NEMA 4 Electronics Enclosure*

NEMA 4 Rated
Dimensions: 30"H x 24"W x 12"D
Construction: Painted Steel
Max. No. of EVA Systems: 1, Non-Rack
Max. No. of Sensors: 9-16
Power Supply: Any Series 191

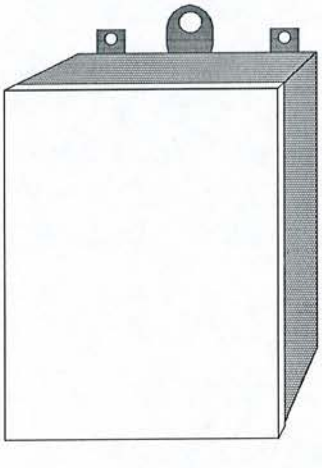


Figure 2-17. *The 193RC-302412-FWT-N4 Rack Chassis Enclosure*

Rack Cabinent, Wall-Mount
NEMA 4 Rated
Dimensions: 30"H x 24"W x 12"D
Construction: Painted Steel
Max. No. of EVA Systems: 4, Rack-Based
Max. No. of Sensors: 16
Power Supply: Any Series 191
Includes: Mounting rails for one KRZ 2015 19" Rack Chassis (included) with 16.8" of rack module space, field wiring terminals

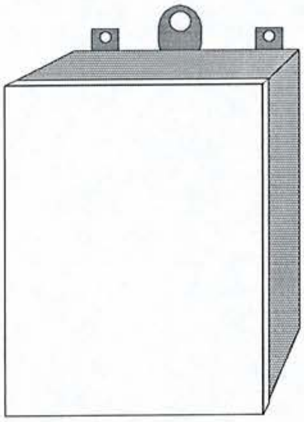


Figure 2-18. *The 193RC-482212-FWT-N4 Rack Chassis Enclosure*

Rack Cabinent, Wall-Mount
NEMA 4 and Seismically Rated
Dimensions: 48"H x 22"W x 12"D
Construction: Painted Steel
Max. No. of EVA Systems: 8, Rack-Based
Max. No. of Sensors: 26
Power Supply: Any Series 191
Includes: Mounting rails for one or two KRZ 2015 19" Rack Chassis (included) with up to 33.6" of rack module space, field wiring terminals

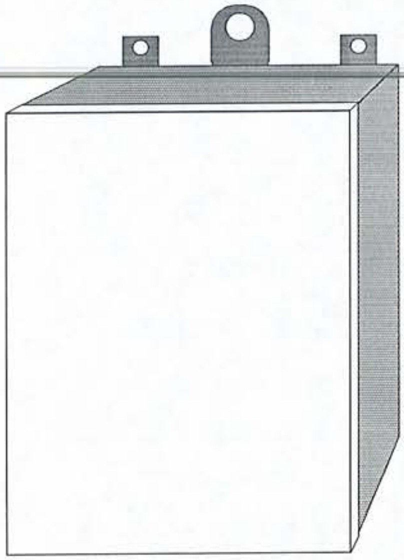
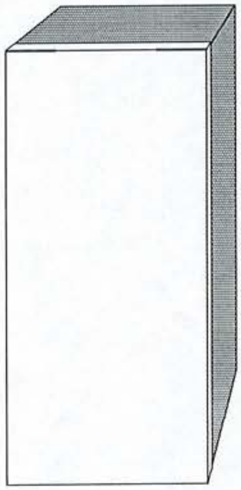
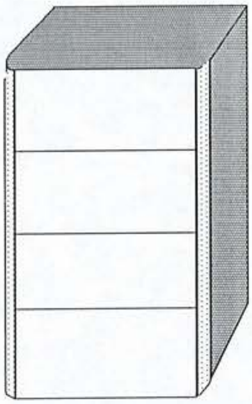


Figure 2-19. *The 193RC-722532-FWT Free-Standing Electronics Enclosure*



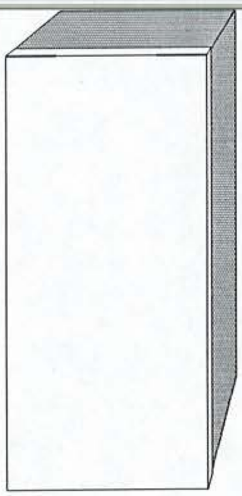
Rack Cabinent, Floor-Mount
NEMA 4 and Seismically Rated
Dimensions: 72"H x 25"W x 32"D
Construction: Painted Steel
Max. No. of EVA Systems: Rack-Based
Max. No. of Sensors:
Power Supply: Any Series 191
Includes: Mounting rails for KRZ 2015
    19" Rack Chassis (included as needed),
    field wiring terminals

Figure 2-20. *The 193RC-402422 Light-Duty Electronics Enclosure*



For Indoor Use Only
Rack Cabinent, Free-Standing
Dimensions: 40"H x 24"W x 22"D
Construction: Painted Steel
Max. No. of EVA Systems: Rack-Based
Max. No. of Sensors:
Power Supply: Any Series 191
Includes: Mounting rails for KRZ 2015
    19" Rack Chassis (included as needed),
    louvered rear door for easy access
    to the terminals

Figure 2-21. *The 193RC-702422 Light-Duty Electronics Enclosure*



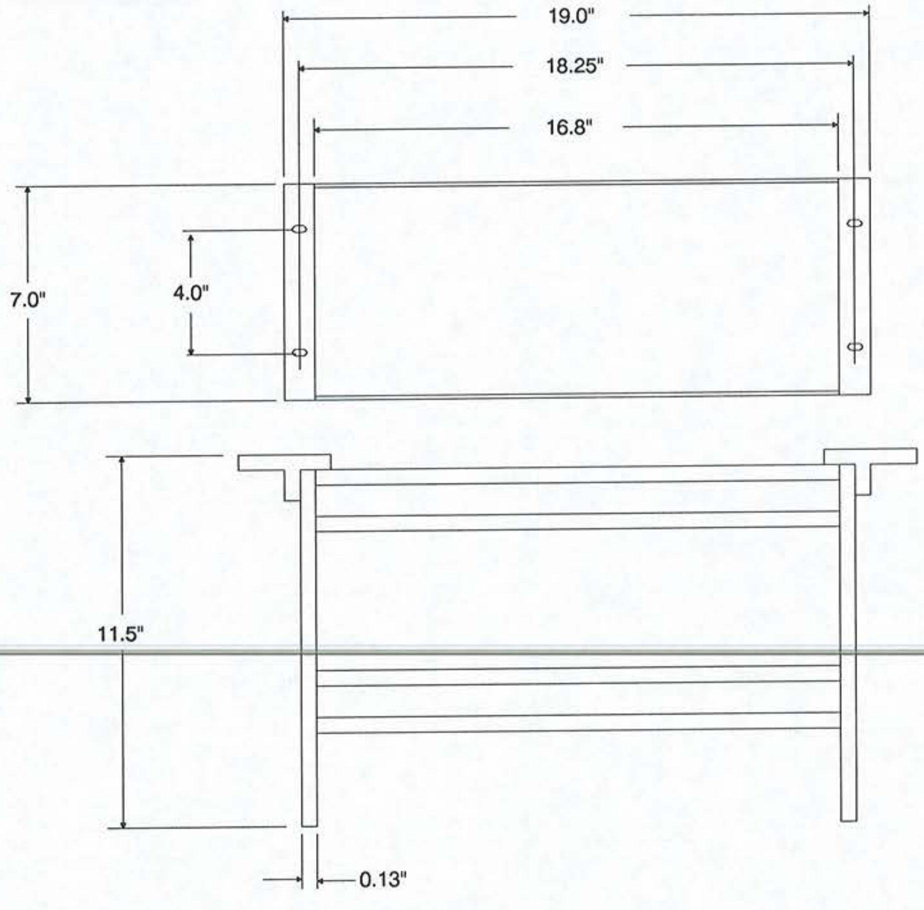
For Indoor Use Only
Rack Cabinent, Free-Standing
Dimensions: 70"H x 24"W x 22"D
Construction: Painted Steel
Max. No. of EVA Systems: Rack-Based
Max. No. of Sensors:
Power Supply: Any Series 191
Includes: Mounting rails for KRZ 2015
    19" Rack Chassis (included as needed),
    louvered rear door for easy access
    to the terminals

2.4.2 Using the KRZ 2015 19" Rack Chassis for the System Electronics

If the system electronics for the EVA system is installed in a clean environment such as a control room you can mount the various rack modules of your EVA system in your own 19" wide rack chassis, or you can order the Kurz Model KRZ 2015 19" Rack Chassis. Our 19" rack provides 16.8" of rack module space.

Overhead and front views of the KRZ 2015 are shown in Figure 2-22.

Figure 2-22. *KRZ 2015 19" Rack Chassis: Overhead and Front Views*

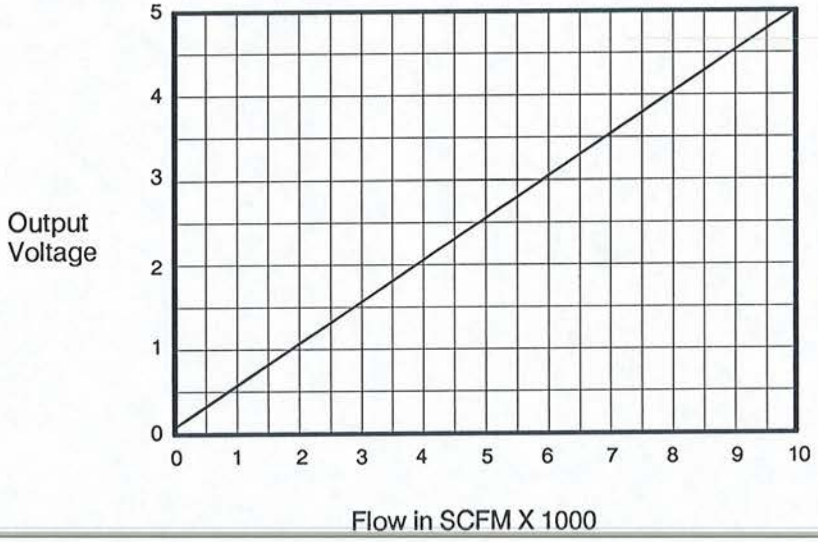


2.4.3 151 Series Signal Conditioner and Linearizer

Each 151 module is housed in the system electronics enclosure and includes a linearization and signal conditioning board for each velocity sensor, up to a maximum of eight. The signal conditioner/linearizer individually linearizes the signal from each sensor's current-transmitter board. The 100-600 mA return signal from the current-transmitter board is drawn across a resistor on the linearization and signal conditioning board, resulting in 0.3 to 2 Vdc signal.

This voltage is then converted to a linear 0-5 Vdc signal that is directly proportionate to the flow velocity; 0 Vdc indicated no flow, 5 Vdc indicates maximum flow, and 2.5 Vdc indicates a flow exactly half of the maximum measurable flow, as shown in Figure 2-23.

Figure 2-23. *Linearized Output*



The linearized voltages are then summed and divided to produce an average duct flow. The multiposition profiler switches also allow you to look at the velocity of each sensor individually. This is especially useful for troubleshooting. An LCD digital panel meter is a standard feature on the EVA 4000. This allows you to read the output, calibrated in the engineering units of your choice, directly from the signal conditioner/linearizer.

If your EVA 4000 system has more than eight sensors, you will have one or more Auxiliary Modules to be used in conjunction with the 151 Master Module. Each Auxiliary Module mounts a linearization and signal conditioning board for any additional velocity sensors, up to a maximum of eight. The output of the linearization and signal conditioning boards in the Auxiliary Module(s) is summed with the Master Module.

The 151 can accommodate up to three Auxiliary Modules (A, B, and C). Thus, the 151 Signal Conditioner and Linearizer can, in fact, be used for up to 32 velocity sensors. The Master Module is for sensors 1 through 8, Auxiliary Module A is for sensors 9 through 16, Auxiliary Module B for sensors 17 through 24, and Auxiliary Module C for sensors 25 through 32.

If you wish to display the output of a sensor whose linearization and signal conditioning board is in an Auxiliary Module—velocity sensor 12, for example—you must first turn the knob on the Master to "AUX.A." Then turn the knob on the face plate of Auxiliary Module A to "12."

The knob on the face plate of the 151 unit is locked out based on the number of velocity sensors in the system. In other words, if your EVA system has five sensors, the knob will not turn past position 5.

The 151 Signal Conditioner and Linearizer is housed in the NEMA system electronics enclosure or supplied in a 4.2" (1/4th) rack module (Master Module) or a 2.8" (1/6th) rack module (Auxiliary Modules).

2.4.4 191 Series Power Supply

The Series 191 Power Supplies provide a regulated +24 Vdc supply to the electronics circuitry in the EVA systems. Since it is a regulated supply, the voltage remains constant.

Table 2-2 shows the proper power supply selection for the number of sensors used in the EVA system.

Table 2-2. Power Supply Selection

Number of Sensors	Power Supply
1-4	191-2.4 or 191RM-2.4
5-8	191-4.8 or 191RM-4.8
9-20	191-12 or 191RM-12

The 191 power supply is most often installed in the 193 Series System Electronics Enclosure but can be installed almost anywhere. The only requirements are these:

- Standard 110-volt AC power must be available. (220-volt AC units are optionally available.)
- The total resistance in the two-wire current-transmitter loop must not exceed 4 ohms.

The second requirement is worth looking at a little more closely. Loop resistance is primarily a function of wire size: The larger the diameter of the wire, the lower its resistance per foot. You can therefore position the 191 Power Supply quite a distance from the probe and current-transmitter junction box if you use sufficiently heavy wire. If the wire supplied with your EVA 4000 system doesn't suit your needs, consult Table 2-3 to determine the wire gauge required for the run you have in mind.

In consulting the table, there are two things you should bear in mind:

- The table applies to stranded copper wire at 65° F. Resistance in other kinds of wire, or in stranded copper wire at different temperatures, will vary.
- American Wire Gauge (AWG) numbers are inversely proportionate to the size of the wire they apply to. That is, the smallest AWG number specifies the **largest** wire and vice versa.

Table 2-3. *Approximate Loop Resistance in Current-Transmitter Wire*

AWG#	Ohms/Ft	Maximum Loop (Ft)	Maximum Run (Ft)
4	.0003	13,333	6,667
8	.0005	8,000	4,000
10	.0008	5,000	2,500
12	.002	2,000	1,000
14	.003	1,333	667
16	.005	800	400
18	.008	500	250
20	.012	333	167
22	.019	211	105
24	.03	133	67
28	.077	52	26

End of Section 2

Section 3: Installing the EVA System

3.1 Installing EVA Systems - An Overview

A representative of Kurz Instruments should inspect the proposed site of installation if existing, or review appropriate drawings for new installations not yet constructed. Upon equipment installation, our representative will inspect and verify that the installation is in accordance with our specifications and recommendations, prior to applying power to the system. Further, our representative shall assist in verifying that all wiring is correct prior to applying power to the system. We will then provide written certification, upon request, that all equipment has been installed correctly and that power-up is authorized.

There are a number of steps to be taken during installation of EVA systems. Note that some steps require that planning be done, decisions be made, and necessary supplies be ordered prior to beginning the installation procedure. Generally, installation steps are as follows:

1. Evaluate installation requirements.
2. Install the EVA probes in the plant vent, duct, or stack.
3. Decide where the current-transmitter electronics enclosure (Series 195) for the EVA system is to be mounted.
4. Decide where to locate the system-electronics enclosure.
5. Install system interconnection wiring between the electronics and components.
6. Before you supply power to the system, make sure that interconnection wiring is installed properly.
7. Supply power to the system.

3.2 Evaluate Installation Requirements

If you have already evaluated your requirements and you are ready to proceed with the installation, please skip to Section 3.3.

3.2.1 Flow Straighteners

As a general policy, Kurz Instruments recommends that in situations where you would normally use flow straighteners, it is preferable to use several more EVA sensors instead. However, in situations where profiles are particularly bad, Kurz can supply flow-straightening equipment. Such a situation might arise, for example, if the only place to gain access to a particular pipe were immediately upstream or downstream from a sharp bend.

Even in applications with 90-degree elbows just upstream, EVA systems with more than 4 sensors have been found to provide a total duct flow measurement very close to the total flow determined in duct traverse studies. These results would argue against the necessity of flow straighteners in most situations.

Kurz EVA systems can incorporate "build-in-place" flow conditioning sections in order to ensure straightened flow to allow accurate duct flow rate sensing over the wide range of flow conditions to be encountered in a particular application. Each flow straightener can be constructed of several separate pieces, which can be easily carried through access doors on the existing duct work and securely bolted to attachment fixtures welded to the inside of the duct.

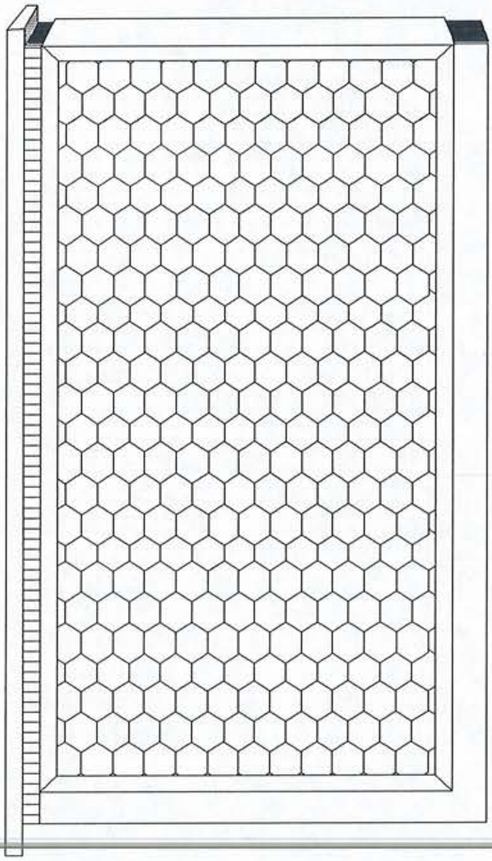
The flow conditioning elements are constructed of stainless steel or aluminum honeycomb having a hexagonal pattern with dimensions of 1/2" on a side. Generally, the length is 4" in the direction of the flow. The honeycomb material is framed and securely welded to form an exceedingly strong structure.

EVA systems with flow straighteners have been installed at nuclear plants and have demonstrated seismic and environmental qualification. Flow straighteners have also been installed on boiler air inlet pipe sections.

The Kurz engineering department provides quote drawings showing typical construction and necessary installation information. Contact your Kurz sales representative with these requests.

A typical rectangular flow straightener section built recently at Kurz is illustrated in Figure 3-1.

Figure 3-1. *Honeycomb Flow Straightener*



3.2.2 Determining the Number of Sensors Required

The EVA Electronic Velocity Array products can best be specified component by component. An EVA can consist of a bare minimum of a single sensor on a single probe with an accompanying power supply and linearizer. At the other extreme, an EVA can consist of an array of many probes, each with multiple sensors, combined with a rack full of system electronics.

The number of sensors required depends on the cross-sectional area of the duct or stack, upstream and downstream geometries, and type of flow: turbulent or laminar? Only a best approximation can be made, and in general Kurz follows rules of thumb laid down in ANSI Standard N13.1-1969. To paraphrase: In circular ducts with laminar flows, the flow profile is a parabolic distribution of velocities. The maximum velocity occurs along the centerline or axis of the duct, and the average velocity is approximately 1/2 the centerline flow. Generally, the average velocity may be found at 0.7 distance along the radius from the centerline to the wall.

For square and rectangular ducts, a velocity profile study is recommended in every case. The Kurz 4440 Series Portable Air Velocity Meters are recommended for this. The general steps for performing such a study, and for determining an appropriate number of sensors based on the results of the study, are given below.

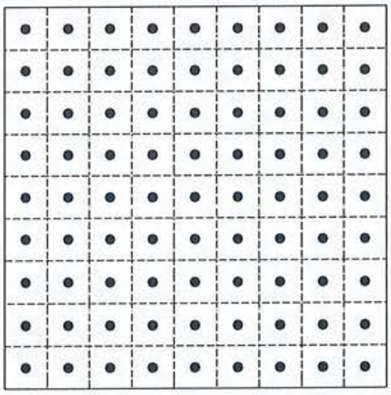
1. Draw a cross section of the duct and divide it into a number of squares of equal area. This will become your velocity profile. There are no hard-and-fast rules for determining the number of squares to use, even though this determination is crucial to everything that follows.

   Using a larger number of smaller squares increases the level of confidence you can have in your final decision regarding the number of sensors to use and their placement. On the other hand, a smaller number of larger squares minimizes the number of holes that will have to be drilled in the duct to perform the velocity profile study.

A good rule of thumb to follow is this: Squares should range from 6" x 6" (1/4 ft^2) to 2' x 2' (4 ft^2). Smaller squares than 6" x 6" are almost never cost effective. Larger squares than 2' x 2' are likely to result in such a gross measurement as to defeat the purpose of performing the study at all.

Figure 3-2 shows a square duct of unspecified dimensions divided into 81 equal areas. In the center of each area is the point at which velocity readings will be taken during the study.

Figure 3-2. *Square Duct Divided Into 81 Equal Areas*



2. Take a velocity reading at the center point of each of the equal areas established at step 1, and enter those readings on the velocity profile.

   The readings should of course be taken under realistic conditions. If, during normal operations, flow rates in the duct are known or suspected to fluctuate considerably, several sets of readings should be taken under different flow conditions, and several velocity profiles prepared. If that isn't practical (and, generally, it won't be), take the readings while flow in the duct is at its maximum, as high flow rates are likely to yield the most detailed velocity profiles. If you base decisions about the number and placement of sensors on a high-flow velocity profile, those decisions are likely to be reasonably appropriate for lower-flow velocity profiles.

3. Determine the least significant velocity increments appropriate to the application. That is, is your application sensitive to 50-SFPM velocity fluctuations, or is a change in velocity of 500 SFPM the smallest significant fluctuation? This step is crucially important, because it determines the visible shape of the velocity profile that will be produced. A velocity profile accurate to the nearest 20 SFPM is difficult to create, and even more difficult to base decisions upon; such a fine-grained profile is unnecessary for most applications. On the other hand, a velocity profile accurate only to the nearest 1000 SFPM is unlikely to yield sensor-number and location information sufficiently accurate for an application in which process-control decisions are based on velocity fluctuations of +/- 50 SFPM.

4. Group the readings obtained at Step 2 into ranges, according to the units selected at Step 3. Suppose, for example, that (1) the lowest readings is 35 SFPM, (2) the highest reading is 175 SFPM, and (3) the least significant velocity increment is 50 SFPM (Actually, 50 SFPM increments make for a very fine-grained profile – increments of 100 SFPM or higher are sufficient for most applications.) Based on those facts, you would group the readings into 4 ranges, as shown in Table 3-1.

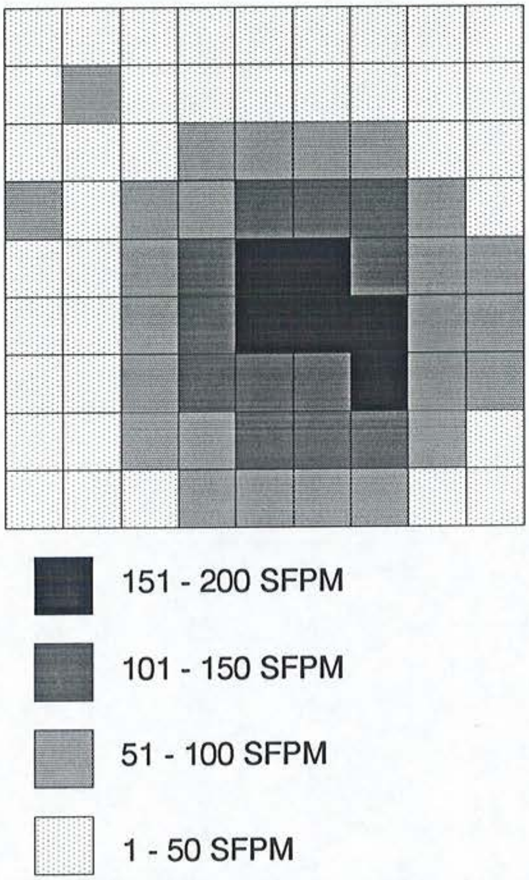
Table 3-1. *Sample Velocity Ranges*

Range No.	Lower Limit	Upper Limit
1	**1 SFPM**	**50 SFPM**
2	**51 SFPM**	**100 SFPM**
3	**101 SFPM**	**150 SFPM**
4	**151 SFPM**	**200 SFPM**

5. Use cross-hatching, color-coding, or some similar visual device to represent each range, and fill in the velocity profile accordingly.

   Figure 3-3 shows one possible velocity profile for the duct shown in Figure 3-2.

Figure 3-3. *Sample Velocity Profile*



6. Decide on the number and placement of sensors necessary to adequately monitor flow in the duct, given the established velocity profile.

   This last step can be approached in a variety of different ways, only some of which are discussed here.

In general, the more sensors you use, the more confident you can be that the averaged readings you receive from those sensors represent the actual average velocity in the duct. The number of wires that can be passed through the window section of the sensor closest to the outside end of the probe effectively limits the number of sensors that can be mounted on a single probe. For K-Bar 12 probes, the limit is five sensors. For K-Bar 24 probes, the limit is seven sensors.

Given average accuracy requirements, budgetary constraints, and velocity profile, Kurz generally recommends the following sensor specifications:

- 2 ft. x 2 ft. Duct: 4 Sensors, 2 Each on 2 Single-Ended Probes
- 3 ft. x 3 ft. Duct: 4 Sensors, 2 Each on 2 Single-Ended Probes
- 6 ft. x 6 ft. Duct: 6 Sensors, 3 Each on 2 Double-Ended Probes
- 6 ft. x 8 ft. Duct: 8 Sensors, 4 Each on 2 Double-Ended Probes

3.2.3 Sensor Placement - Evenly Spaced Sensor Placement

The easiest and by far the most common method of determining sensor placement is to space sensors at equal intervals on probes and probes at equal intervals within ducts. Again, the number of probes and sensors is essentially a cost-benefit decision.

Having a velocity profile is important, even though the sensors will be evenly spaced. You can consider different placement schemes, calculating the effectiveness of each by plotting it on the velocity profile and comparing the results it would yield with the actual average velocity shown by the profile. See Appendix B for example of different sensor placement schemes, given the velocity profile shown in Figure 3-2.

3.2.4 Sensor Placement - Equally Weighted Area Placement

This method is discussed at some length in Appendix B. That discussion illustrates some of the difficulties of establishing a really accurate velocity average in a large duct. This method **potentially** allows for very accurate measurements with a relatively small number of sensors. In general, however, it is probably more trouble than it is worth.

In general, the idea is to place sensors asymmetrically such that the flow each sensor "sees" is proportionate to the total flow in the line, not necessarily to the total cross sectional area of the line. That is, if the flow profile is skewed, like the one shown in Figure 3-2, sensor placement would be similarly skewed to account for that profile. See Appendix B for detailed examples.

3.2.5 Additional Sensor Placement Methods

EPA and ANSI both provide standards for monitoring gas velocities in ducts and stacks. In common use are EPA methods 1 and 2 and ANSI method N13.1-1969. Each is described briefly in Appendix B. Contact your Kurz factory regional sales manager for copies of the full documents. Note that each of these additional methods was designed to apply to obtaining a one-time velocity profile; they were not designed with permanently mounted monitoring installations in mind. You may nevertheless wish to consider them as guides to the placement of EVA sensors.

3.3 Install and Secure the EVA Probes

There are two phases to installing a probe in a vent, duct, or stack:

1. Prepare the vent, duct, or stack for sensor installation.

2. Install and secure the EVA probe(s) in the prepared vent, duct, or stack with mounting hardware (i.e. flange, bolts, screws, etc.).

3.3.1 Prepare the Vent, Duct, or Stack for sensor Installation.

Each vent, duct, or stack should be prepared for the EVA probe per Kurz installation drawings provided with the system. These drawings provide the suggested layout, duct modifications, and installation drawings.

Typically, duct preparation consists of the following:

A. Cutting an access hole for the EVA probes and support structure.

B. Modifying the duct to include mounting provisions such as spool piece or flange to which the EVA probes mount.

C. Weld or bolt the double-ended support fitting, if used, to the opposite duct wall.

Kurz provides a cup-like fitting for installation by the customer with double-ended systems. The double-ended fitting or “cup” provides a more rigid system mounting. It should be installed along the center line of the EVA probe on the opposite duct wall.

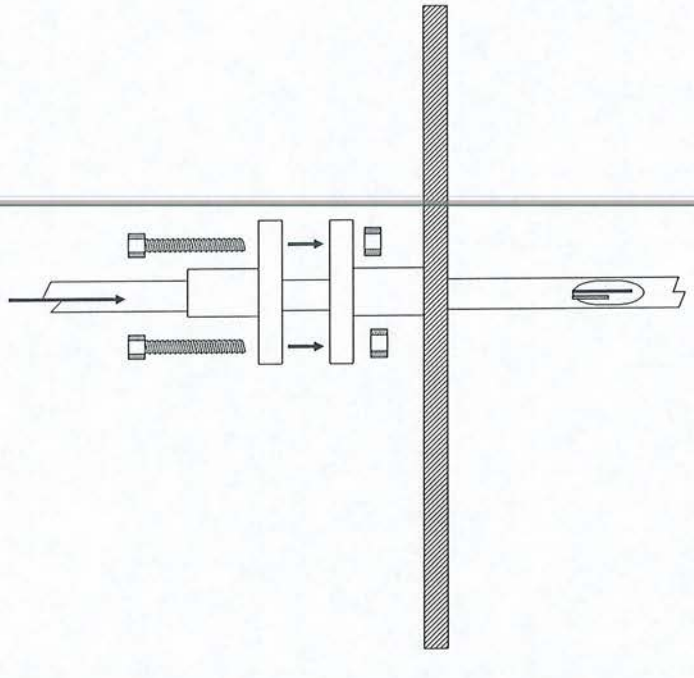
A clearance hole, with the approximate inside diameter of the cup should be drilled prior to cup installation.

3.3.2 Install and Secure the EVA Probes

Depending on their length, probes can be supported on both ends or on one end only. Probes supported on only one end are termed *single-ended*; probes supported on both ends are termed *double-ended.*

Single-ended probes are mounted to the duct or stack using a single flange bolted or welded to the outside of the duct or stack. This flange is usually supplied by the customer, but the necessary parts can be ordered from Kurz. A matching flange (supplied) is threaded onto the probe itself, between the first pipe section that will be inside the duct or stack and the pipe section, if any, that will stay outside the duct or stack. The probe is then passed through the flange on the duct or stack until the two flanges meet.

Figure 3-4. *Flange Mounting*



The flanges of a K-Bar 12 probe are secured with either 2 1/2" stud bolts or with 2 1/4" machine bolts. Each flange has four bolt holes, each of which is .62 inches in diameter.

The flanges of a K-Bar 24 probe are secured with either 3" stud bolts or 2 1/2" machine bolts. Each flange has four bolt holes, each of which is .62 inches in diameter.

K-BAR 12 probes are generally single ended up to a maximum length of 60 inches and double ended above that length. K-BAR 24 probes are generally single ended up to a maximum length of 96 inches and double ended above that length. Each installation should be considered individually, however. Particularly turbulent, high-velocity flow might justify going to a double-ended probe at a shorter length, for example.

Installation hardware for a double-ended EVA probe is identical to that for a single-ended probe, except that it includes a support cup that is bolted or welded to the **inside** of the duct or stack opposite the hole through which the probe is to be inserted. The cup accepts and supports the end of the probe.

The various types of flanges available are described on the following pages. Bolts and gaskets are supplied by the customer.

3.3.3 Mounting Hardware for the KBAR 12 Probes

Figure 3-5. *FMA12 Flange Mounting Adapter*

The FMA12 Flange Mounting Adapter is a 3/4" thick flange with a 4" long stub suitable for welding to a duct or stack. This adapter can be used in both single-ended and double-ended applications.

Figure 3-6. *FMS12 Flange Mounting Spool Piece*

The FMS12 Flange Mounting Spool Piece is similar to the FMA12, except that it comes with a flat plate that can be either welded or bolted to rectangular ducts or stacks.

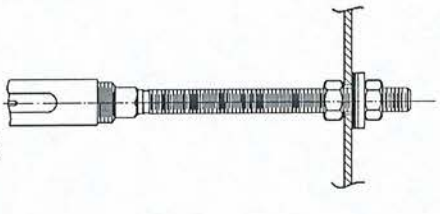
Figure 3-7. *CFMS12 Flange Mounting Spool Piece*

The CFMS12 Curved Flange Mounting Spool Piece is designed to be welded or bolted to round ducts or stacks. The diameter of the duct or stack to which the CFMS12 is to be mounted must be specified when this fitting is ordered.

Figure 3-8. *DESC12 Double-Ended Support Cup*

The DESC12 Double-Ended Support Cup supports the end of a double-ended probe. It is welded to the opposite wall of the duct or stack, on the inside.

Figure 3-9. *DESF12 Double-Ended Support Fitting*



The DESF12 Double-Ended Support Fitting provides an alternative method for supporting the end of a double-ended probe. The DESF12 consists of a threaded rod that screws into the last EVA sensor on the probe and extends through the wall of the duct or stack. It is secured on both sides of the wall with a washer and nut set.

3.3.4 Mounting Hardware for the KBAR 24 Probes

Figure 3-10. *FMA24 Flange Mounting Adapter*

The FMA24 Flange Mounting Adapter is a 1.5" thick flange with a 4.0" long stub suitable for welding to the outside of a duct or stack. This adapter can be used in both single-ended and double-ended applications.

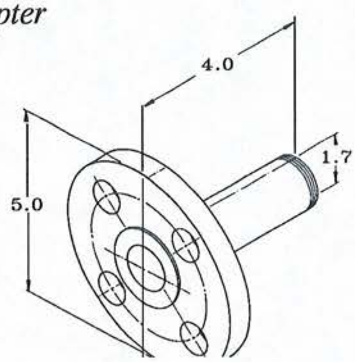


Figure 3-11. *FMS24 Double-Ended Support Cup*

The FMS24 Flange Mounting Spool Piece is similar to the FMA24, except that it includes a flat plate that can be either welded or bolted to a rectangular duct or stack.

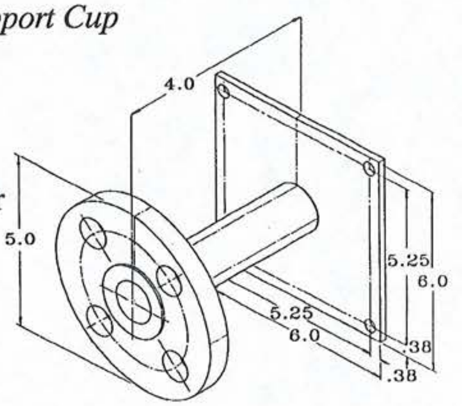


Figure 3-12. *CFMS24 Curved Flange Mounting Spool Piece*

The CFMS24 Curved Flange Mounting Spool Piece is designed to be bolted or welded to round ducts or stacks. The diameter of the duct or stack must be specified when this fitting is ordered.

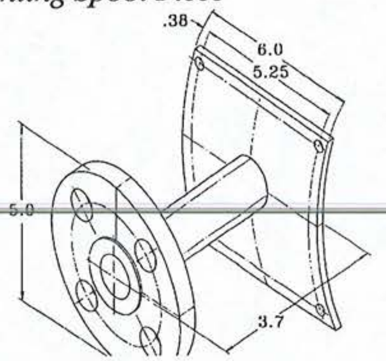
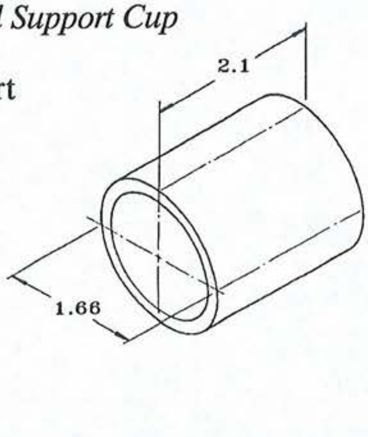


Figure 3-13. *DESC24 Double-Ended Support Cup*

The DESC24 Double-Ended Support Cup supports the end of the probe. It is welded to the opposite side of a duct or stack, on the inside.



3.4 Install the Current-Transmitter Electronics Enclosure

The Series 195 current-transmitter enclosure can be mounted on the end of the probe that remains outside the duct or stack, or can be remotely mounted up to 25 feet away.

Most Series 195 enclosures are mounted using either 3/8" or 5/16" bolts, and the appropriate size lockwashers and flatwashers. Using this hardware and fastening all four ears results in adequate support for the enclosure. High-quality bolts, lockwashers, flatwashers, and other hardware must be used to assure proper enclosure support.

The 195 enclosure houses the current-transmitter boards (one per sensor) and customer field-wiring terminals. It should be located as near as possible to the vent or stack in which the EVA sensors are located, the location being limited by the EVA sensor cable length (typically 25 feet). Electrical power is not required for this enclosure, since the board power comes from the main system electronics enclosure. Each is connected to one EVA sensor. Wiring should be done as shown in the system drawings provided by Kurz for the installation.

Enclosure door clearance for general system operation and troubleshooting should be provided (as with the main electronics enclosure).

3.4.1 Mounting the 195 Enclosure on End of the Probe

Mounting the enclosure on the end of the probe is the preferred method under the following conditions:

- There are no more than four sensors on the probe.
- The temperature at the end of the probe where the enclosure will be mounted does not exceed 125° F.

When the current-transmitter enclosure is mounted on the end of the probe, the probe threads directly into the back of the enclosure, and the sensor wires pass through the end of the probe into the enclosure. The length of probe that remains outside the duct or stack and separates the current-transmitter enclosure from the duct or stack can be varied to distance the enclosure from a hot duct or stack.

The two-wire hookup to the system-electronics enclosure passes out of the current-transmitter enclosure through a coupling in the side of the enclosure and into a conduit supplied by the customer.

3.4.2 Mounting the 195 Series Enclosure Separate from the Probe

If, because of the number of sensors on the probe or the temperature at the outside end of the probe, the current-transmitter enclosure cannot be mounted on the end of the probe, it can be wall mounted anywhere within 25 feet of the probe.

NOTE: Sensor cable is integral to the calibration of the EVA system; if the length of the cable is changed, the entire system must be recalibrated. Enough cable to separate the probe and the current-transmitter enclosure by 25 feet is provided standard with every HHT or transmitter-separate EVA system. Somewhat longer cable runs are possible, but they must be special ordered, and the system must be specifically calibrated for the cable length actually used. **In no event should you change the sensor cable length without having the system recalibrated.** When the current-transmitter enclosure is wall mounted, it is equipped with two conduit couplers, one on each side of the box. One conduit runs from the outside end of the probe to the current-transmitter enclosure and carries the wiring from the sensors. The other conduit carries the two-wire, twisted-pair hookup for each sensor from the current-transmitter enclosure to the system-electronics enclosure.

3.5 Install the System-Electronics Enclosure.

System enclosures include the display and operator controls, so they should be located somewhere convenient to the user. The Series 193 Electronics Enclosure houses the Series 191 power supply, the Series 151 Linearizer, and any optional electronics modules, such as 4-20 mA output or a totalizer board.

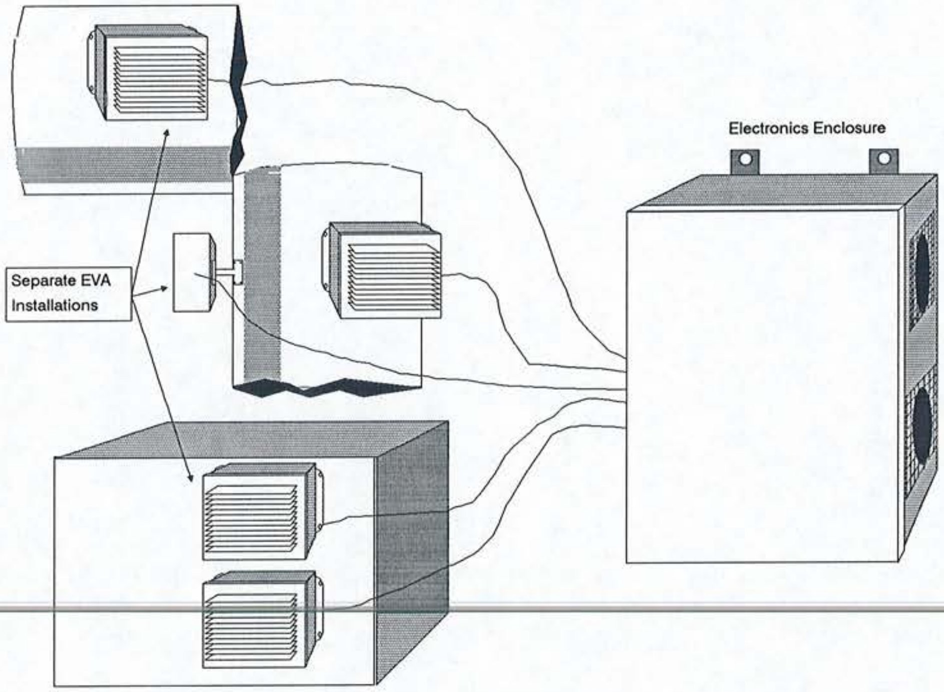
Depending on the type of enclosure chosen, the enclosure can be outdoor mounted, instrument-shed mounted, or control-room mounted. Electrical power must be available.

When wall-mounting the Series 193 enclosures, Kurz recommends using premium quality bolts with locking type nuts. Cautious users may want to use castle nuts and "safe-wire" the nuts. All four mounting ears should be used.

Floor mounting the larger 193C enclosure is less critical, unless seismic concerns apply. Again, Kurz recommends using the highest quality fasteners in an installation configuration offering generous safety factors.

The system electronics for two or more separate probe installations can be housed in a single large 193 enclosure, as shown in Figure 3-14.

Figure 3-14. *Large 193 Enclosure for Multiple Installations*



For control room installations, you can dispense with the NEMA housing. System electronics can then be mounted in standard 19" relay racks, such as the inexpensive Kurz Model KRZ 2015 19" rack.

3.6 Install System Interconnection Wiring Between the Electronics and Components.

Interconnection wiring should be done as shown in the Kurz system drawings provided with your system. Interconnection terminals, along with field spare terminals, are provided in the upper portion of the system main electronics enclosure and current-transmitter electronics enclosure.

Four major types of electrical connections are required to complete the system interconnection. These are illustrated in Figure 3-15:

1. Individual sensor wires from velocity sensors on the EVA probe to the current transmitter board located in the Series 195 transmitter enclosure.

2. Signal inputs to the main electronics enclosure.

   Source: Series 4000 or 4100 EVA Sensors.

   Type: Current signals from current-transmitter enclosure.

   Destination: System-Electronics Enclosure.

3. Power input to the main electronics enclosure: 110Vac/60Hz.

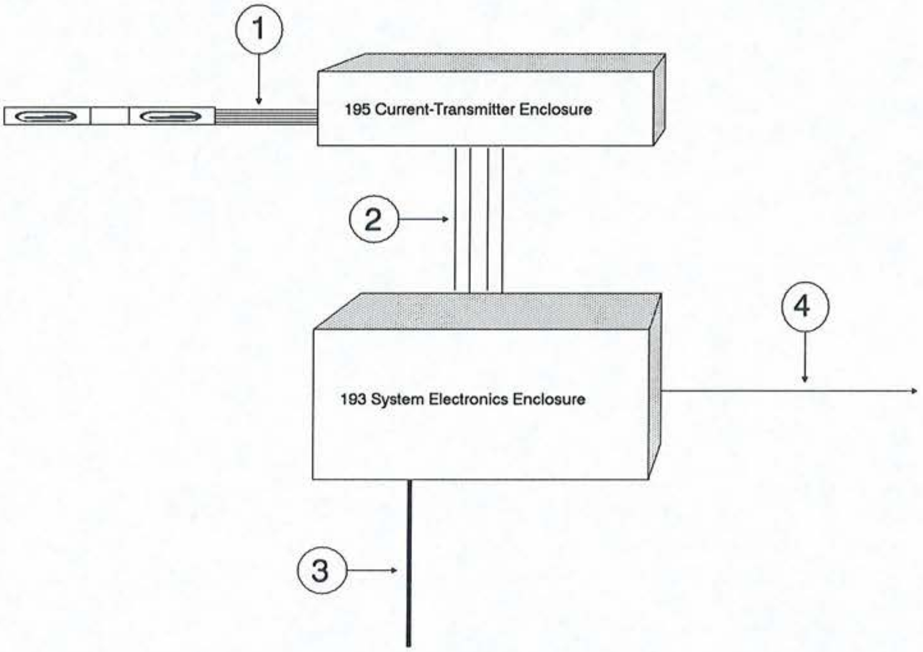
4. Output Signals from the main electronics enclosure:

   A. EVA Sensor linear output signal representing average duct or stack velocity.

   B. Velocity profiler output signal for individual velocity sensor output reading.

   C. Any 4-20 mA outputs for retransmission of above signals.

Figure 3-15. *Wiring Interconnections: Conceptual View*



Electrical connections for the above listed functions are provided on the terminals as shown in the engineering drawings shipped with EVA systems. Recommended wire size, signal level, terminal-board location and additional comments are provided. Field-wiring connections should be verified by testing prior to the initiation of system power to minimize the possibility of damage to the Kurz electronics due to wiring errors.

3.6.1 Sensor Connections to Current-Transmitter Board

Four wires run from each MetalClad sensor through the KBAR probe to the current-transmitter board, with two of these wires grounded to a single terminal. The EVA system uses a floating ground. Normally, the wire from the temperature sensor (R_{tc}) is white, the wire from the velocity sensor (R_p) is red, and the two ground wires are red and white. The color of the wires may vary, however, depending upon the type of wire used. Each wire is labeled by Kurz Instruments before it is shipped to you. Refer to the Drawings section at the back of this manual for a drawing of the wiring connections for your system.

NOTE: Sensor cable is integral to the calibration of the EVA sensors; if the length of the cable is changed, the affected sensors must be recalibrated. Enough cable to separate the probe and the current-transmitter enclosure by 25 feet is provided standard with every HHT or transmitter-separate EVA system. Somewhat longer cable runs are possible, but they must be special ordered, and the system must be specifically calibrated for the cable length actually used. In no event should you change the sensor cable length without having the sensors recalibrated.

3.6.2 Connections from the Current-Transmitter Enclosure to the System Electronics Enclosure

The return signals from each of the current-transmitter boards are run to the 151 Signal Conditioner/Linearizer Module through the two-wire hook-up from each sensor's current-transmitter board. The other wire in the two-wire twisted pair is used to provide +24 Vdc to the current-transmitter board. (Some systems may use one larger wire to provide +24 Vdc to multiple current-transmitter boards, rather than use a second wire for each current-transmitter board). The wires exit the current-transmitter enclosure through a coupling in the side of the enclosure and into a conduit supplied by you.

Each 151 module can contain up to 8 signal conditioner/linearizer boards, each connected to the return signal from the current-transmitter enclosure. Three auxiliary modules can be used to support up to 32 EVA sensors.

Refer to the Drawings section at the back of this manual for a drawing of the wiring connections for your system.

3.7 Before You Supply Power to the System, Make Sure that Interconnection Wiring is Installed Properly.

Perform point-to-point tests to ensure that signal cables, power cables, ground wires and other system connections are complete. This will minimize any equipment failures caused by improper wiring.

Check system wiring against the Kurz system drawings provided with your equipment **and** against the architect/engineer or OEM equipment vendor drawing to ensure that terminations have not been changed or altered during the design process or during installation.

Make sure that any other equipment interfacing with the EVA System has been installed, with interconnections properly made (i.e., Kurz Bypass Flow Controller System or customer radiation monitoring equipment).

NOTE: Do not supply power to the system until this check-out procedure is satisfactorily completed.

NOTE: Do not supply power to the system without sensors connected to the Series 195 current-transmitter enclosure. Damage to board components from overheating could result.

3.8 Supply Power to the System

Supply power to the Kurz equipment. Confirm power level to enclosure (i.e., 110 Vac +/- 10%).

Within the system enclosure, turn the key power switches (if so equipped) to the **ON** position. Also, turn on any module power switches. Make sure that all fuses and/or other circuit protection equipment is functioning properly.

End of Section 3

Section 4: Operation and Routine Maintenance

4.1 Operation

After the completion of system installation and interconnection, the following steps will allow the operator to initialize the EVA system operation.

1. Turn key lock power switches to the "on" or vertical position.
2. Turn power supply on/off switch to the "on" or vertical position.
3. If installed, turn Model 151RM master panel power switch to the "on" or vertical position. If 151 auxiliary modules are installed, turn each of the power switches on the modules to the "on" position as well.

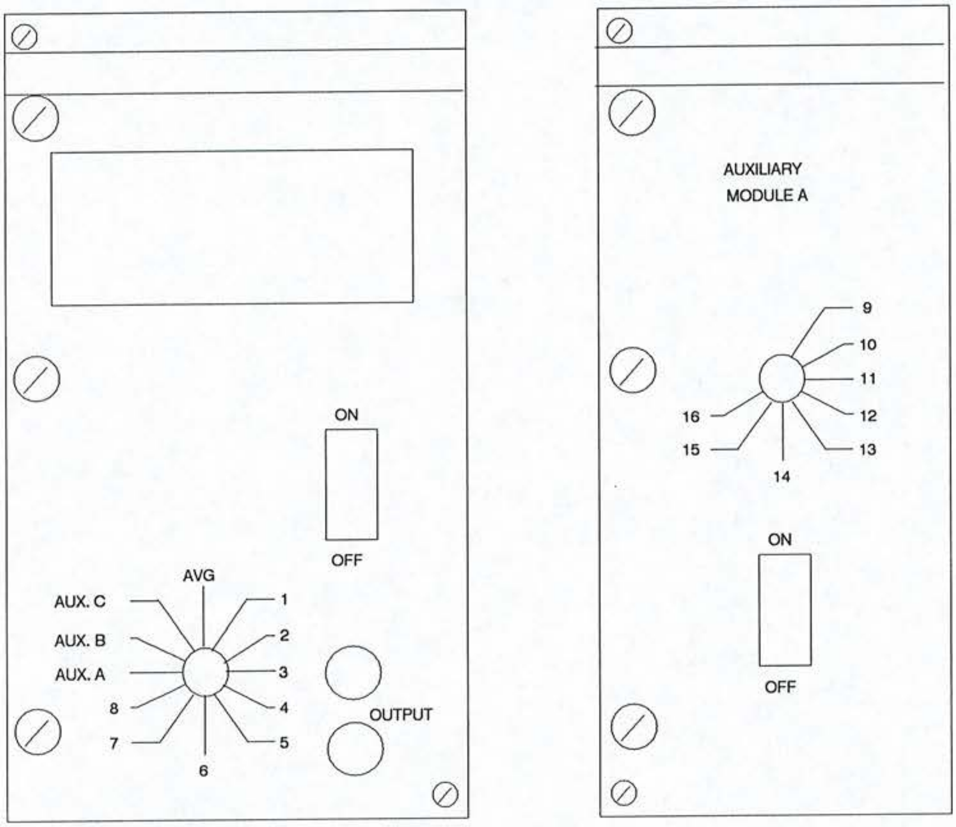
If there is flow in the plant vent or duct, the EVA system should be sensing the flow rate and providing an output signal. This may be verified by testing the output terminations in the electronics enclosure. Refer to the system drawings for specific terminal assignments.

If the EVA system contains one or more 151RM rack modules (shown in Figure 4-1), the following procedures may also be used to verify operation.

1. Select a sensor using the 151RM master panel rotary selector switch. If you have a digital LCD display, it should display the flow rate measured by the selected sensor.
2. If you do not have a display, you can monitor the sensor's measure flow rate by connecting a digital voltmeter to the output signal connector on the front panel of the 151 master module. A 0-5 Vdc signal corresponds to the system flow range.
3. Select a second sensor if desired. You might want to turn power off on the auxiliary modules (if installed), so that you can do a quick check to see if the average flow rate appears correct when compared to the flow rate measured by each of the sensors.

4. If the system appears to be averaging correctly and the flow rate is what you would expect, return the selector switch on the master panel to "AVG" and turn the power switch of the auxiliary modules back on.

Figure 4-1. *A 151RMD Master Panel with Auxiliary Module A*



4.2 Maintenance

The MetalClad sensor is virtually maintenance free. Experience has demonstrated the long-term stability of the calibrations performed on the system before shipment. However, in order to maintain NBS traceability on the instrument calibration, annual recalibrations are recommended.

Preventative maintenance for the EVA system consists of:

1. Checking and cleaning the sensor

2. Verifying the output signal

3. Power supply voltage checks

4.2.1 Checking and Cleaning the Sensor

The EVA sensors should be periodically examined every 90 days for typical applications. When the sensor is operating in particlarly dirty or particle-laden environments, it should be checked every 30 days. If the sensor is operating in clean-air applications an inspection of the sensor every 180 days may be sufficient.

If the sensor needs cleaned, use any solvent you believe is effective in removing the contaminants. Make sure that power is off during cleaning.

While the MetalClad sensor is rugged, it can be bent or broken by careless treatment. A bent sensor may develop a short and need to be replaced.

4.2.2 Verifying Output Signal

Follow the operational steps outlined in Section 4.1 to verify that the output signals are correct. The Kurz 4440 Portable Air Velocity Meter is also an excellent in-situ calibration tool. The 4440 is easy to use when copmparing readings and verifying functionality of an EVA sensor because the length of the probe extender allows the 4440 sensor to be positioned close to an EVA sensor.

4.2.3 Power Supply Voltage Checks

Refer to the drawings included with your system for information on the wiring interconnections and voltage check-points. Remember to check all fused units when power to any of the units seems to have failed.

End of Section 4

Section 5: Options

This section describes some of the more popular options available for the EVA 4000 systems. Refer to the drawings shipped with your system for a diagram of your system's wiring connections.

The following options are available for EVA systems placed in NEMA or Rack-Mount Enclosures:

- Sensor Construction Options
- Triple-Sting Integral Temperature Sensor
- Digital Display
- 4-20 mA Non-Isolated Output Module
- 4-20 mA Isolated Output Module
- 0-5 Vdc Isolated Output Module
- 0-5 Vdc Non-Isolated Output Module (Scaled to Eng. Units)

The following options are only available for EVA systems placed in Rack-Mount Enclosures:

- Temperature Module (Requires Temperature Optional Sensor)
- Digital Temperature Module (Requires Temperature Optional Sensor)
- Resettable Flow Totalizer
- Non-Resettable Flow Totalizer
- Dual Alarm Module
- Flow Totalizer/Alarm Module
- Model 40 Field Calibrator

5.1 Sensor Construction Options

5.1.1 HHT Sensor

The HHT option is for very high temperature environments. The HHT sensor, which includes special heat resistant cable, can be operated at temperatures up to 500° C.

5.1.2 Titanium Sensor

Titanium sensors are available for use in the most corrosive flows. Titanium is unexcelled in its resistance to corrosion.

5.1.3 Hastelloy Sensor

Sensors constructed of Hastelloy, a special corrosion-resistant high-nickel steel alloy, are also optionally available.

5.1.4 Tefzel Sensor Cable

Tefzel cable, which is available with or without any of the other options listed, is highly radiation resistant. It is designed for use in nuclear installations.

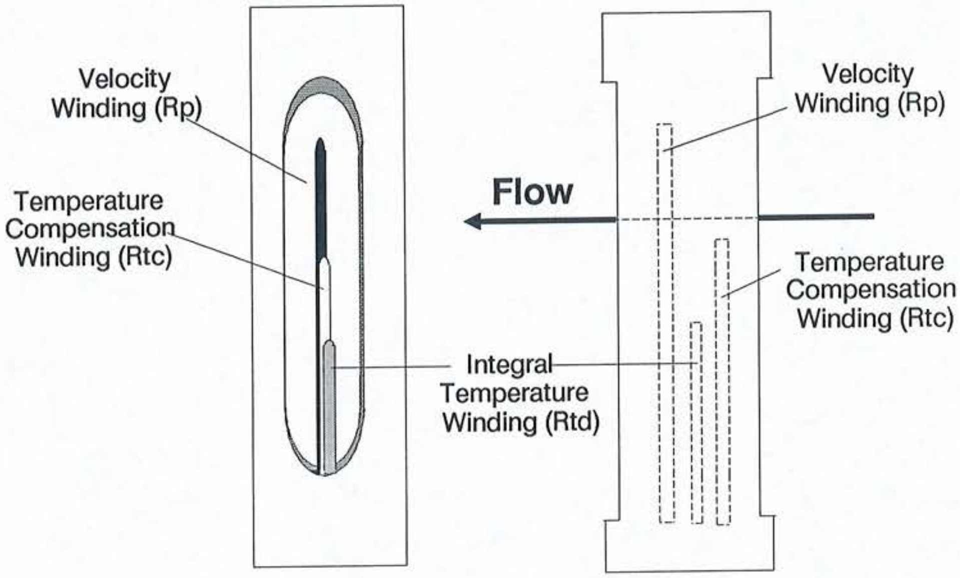
5.2 Triple-Sting Integral Temperature Sensor

The standard dual-sting sensor used in the EVA 4000 measures velocity only. For simultaneous temperature output, a triple-sting integral temperature sensor is required. The triple-sting sensor provides both a temperature and a velocity reading. It looks like the dual-sting sensor, except that there is a third winding (R_{td}), approximately half the size of the R_{tc} winding, located to the side of the other two windings.

The construction options for the triple-sting integral temperature sensor are the same as those for the MetalClad dual-sting velocity sensor.

Figure 5-1 shows a close-up view of the triple-sting sensor within its protective window.

Figure 5-1. *Integral Temperature Sensor: Two Views*



5.2.1 Temperature Sensor - Principle of Operation

The velocity sensor (R_p) and the temperature sensor (R_{tc}) function exactly as they do in the dual-sting sensor to provide a velocity reading. The third winding, the integral temperature sensor, determines the temperature in the duct or stack and sends a signal through two wires to its own current-transmitter board. The triple-sting integral temperature sensor thus requires two current-transmitter boards, while the dual-sting sensor requires only one.

For most purposes, only one triple-sting sensor per EVA system is necessary. Since the sensor measures both temperature and velocity, no additional sensor windows are required – if you determine that you need five velocity sensors, the triple-sting integral temperature sensor can function as one of those five.

5.3 Digital Displays

A digital LCD display is available for EVA systems installed in NEMA and rack-mount enclosures. If the EVA system is installed in a NEMA enclosure, the 193 System Electronics Enclosure should have a window that allows the display to be viewed.

When purchased with a rack-mount EVA system, the display will be provided in the 151RM module.

5.4 Model 131 and 131RM: 4-20 mA Non-Isolated Output Modules

A 131 or 131RM Non-Isolated 4-20 mA Output Module provides a non-isolated output from the linearizer to a device of your choice. The 131 is used in NEMA enclosures while the 131RM is a 1.4" wide rack module.

The 4-20 mA output is appropriate when the distance between the system electronics enclosure and the device receiving the linearized signal is such that a significant voltage drop would occur in the standard 0-5 Vdc signal. The 4-20 mA output is unaffected by distance, as long as the total resistance in the loop is less than 800 ohms.

The 131 and 131RM Non-Isolated 4-20 mA Modules can be used when there is no need to isolate the electronics of the receiving device from the electronics of the signal conditioner/linearizer module in the EVA system. These outputs are self-powered; you should **not** supply power over the 4-20 mA two-wire hookup.

5.5 Model 132 and 132RM: 4-20 mA Isolated Output Modules

A 132 or 132RM Isolated 4-20 mA Output Module provides an isolated output from the linearizer to a device of your choice. The 132 is used in NEMA enclosures while the 132RM is a 1.4" wide rack module.

The 4-20 mA output is appropriate when the distance between the system electronics enclosure and the device receiving the linearized signal is such that a significant voltage drop would occur in the standard 0-5 Vdc signal. The 4-20 mA output is unaffected by distance, as long as the total resistance in the loop is less than 800 ohms.

The 132 and 132RM Isolated 4-20 mA Modules can be used when the electronics of the receiving device should be isolated from the electronics of the signal conditioner/linearizer module in the EVA system. The 132 and 132RM modules have their own ground and are therfore electrically isolated from other electronics in the 151 signal conditioner/linearizer module. These outputs are self-powered; you should **not** supply power over the 4-20 mA two-wire hookup.

5.6 Model 133 and 133RM: 0-5 Vdc Isolated Output Modules

The 133 and 133RM 0-5 Vdc Isolated Output Modules provide a second 0-5 Vdc output, in addition to the standard 0-5 Vdc output. The 133 0-5 Vdc Module is used in NEMA enclosures while the 133RM is a 1.4" wide rack module.

The 133 and 133RM modules have their own ground and are isolated from the ground of the 151 signal conditioner/linearizer electronics. These output modules are calibrated for average velocity or total flow rate output.

5.7 Model 134 and 134RM: 0-5 Vdc Non-Isolated Output Modules

The 134 and 134RM 0-5 Vdc Non-Isolated Output Modules provide a second 0-5 Vdc output, in addition to the standard 0-5 Vdc output. The 134 0-5 Vdc Module is used in NEMA enclosures while the 134RM is a 1.4" wide rack module.

The 134 and 134RM non-isolated output modules share the ground with the 151 signal conditioner/linearizer electronics and are scaled to the total flow rate.

5.8 Model 161RM and 161RMD Temperature Output Modules

The 161RM Temperature Output Module and 161RMD Temperature Output Module with Digital LCD Display linearize the signal from the temperature winding in the optional triple-sting integral temperature sensor. The output from this module is 0-5 Vdc; 4-20 mA output is optionally available.

The 161RM is a 2.8" wide rack module while the 161RMD with the direct-reading LCD display is a 4.2" wide rack module. These options are only available as rack modules.

5.9 Model 101RM and 101SRM Flow Totalizer Modules

The 101RM and 101SRM Flow Totalizer Modules function like odometers, counting and recording the total units of flow that have passed the sensor. The modules accomplish this by converting voltage to frequency, which is then divided to yield the desired pulses for incrementing the mechanical counter

The six-digit mechanical counter holds its count during power-off states. Available units of flow include SCFM, Pounds Per Hour, or any other unit of your choice. The counter in the 101RM is not resettable to protect against accidental zeroing. The counter in the 101SRM can be reset to zero via a pushbutton on the front of the rack panel.

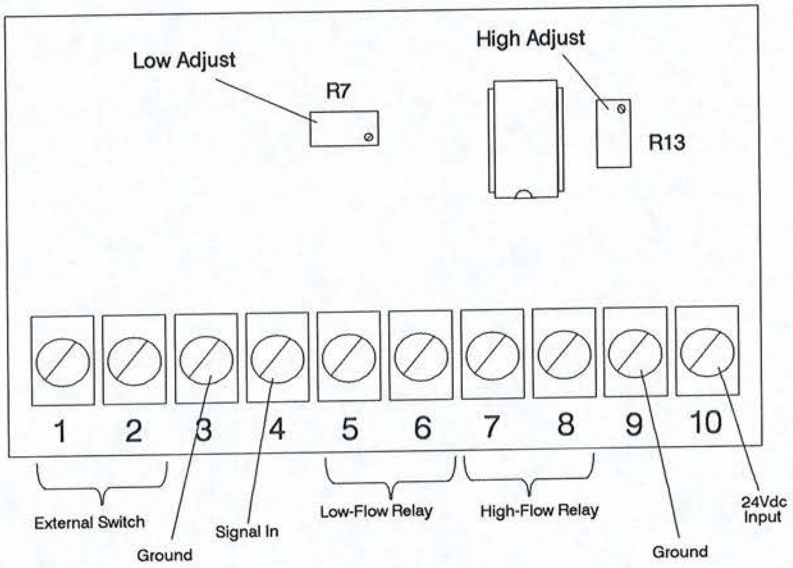
The 101RM non-resettable flow totalizer is a 1.4" wide rack module and the 101SRM resettable flow totalizer is a 2.8" wide rack module.

5.10 Model 111RM Dual-Alarm Module

The Model 111 dual-alarm board allows you to activate an audible alarm or other device of your choice based on the flow sensed by the EVA 4000. The board provides two relays, one of which is activated when flow drops below a specified minimum, and one of which is activated when flow exceeds a specified maximum. You set both maximum and minimum values by adjusting potentiometers on the 111 printed circuit board.

The low-adjust and high-adjust potentiometers, the wiring connections, and the terminal screws used to connect the 111 board to other devices are shown in the Figure 5-2 below.

Figure 5-2. *Model 111 Dual Alarm Board*



For half-amp relay contacts, the 111RM module is 1.4" wide. For higher amperage relay contacts, the 111RM is housed in a 2.8" wide module.

5.11 Model 101S/111RM Flow Totalizer/Alarm Module

This module combines the 101 six-digit resettable flow totalizer with the Model 111 dual-alarm board. The totalizer functions like an odometer, counting and recording the total units of flow that have passed the sensor. It does this by converting voltage to frequency, which is then divided to yield the desired pulses for incrementing the mechanical counter. The mechanical counter holds its count during power-off states. Available units of flow include SCFM, Pounds Per Hour, or any other unit of your choice.

The dual alarm board allows you to activate an audible alarm or other device of your choice based on the flow sensed by the EVA 4000. The board provides two relays, one of which is activated when flow drops below a specified minimum, and one of which is activated when flow exceeds a specified maximum. The 101S/111RM module is 2.8" wide.

5.12 Model 40 Field Calibrator

The Model 40 Field Calibrator (M40) is a piece of test equipment used as a field calibration device. The M40 was specifically designed to calibrate two-wire current loop transmitters designed and sold by Kurz and is especially appropriate for EVA systems. One or more digital multimeters (DMM) are required and operate in conjunction with the M40. M40 power is provided by the system under test.

Substitution of the M40 with the two-wire current transmitter in the loop allows signal substitution, thereby providing a means of simulating a flow signal input to the signal scaling electronics.

Two modules make up the M40. Simulation current is regulated by the first module. Switching and output signals are provided on the second.

The M40 and the signal scaling electronics module to be tested are connected by a cable. There are three different cables to choose from, depending on the module you want to test.

Operation of the M40 consists simply of making the proper interface connections between the M40 and the module under test, adjusting the substitution current level, and reading the signal output voltage and current.

Installing the M40 is a simple matter of removing the test module from the rack chassis and replacing its cable connections with the M40 cable provided. If more distance is desired between the test module and the rack chassis to facilitate test and calibration procedures, you can remove the power cord from the test module and replace it with the optional test power cord provided with the M40.

Contact your factory Kurz Representation for delivery and pricing information.

End of Section 5

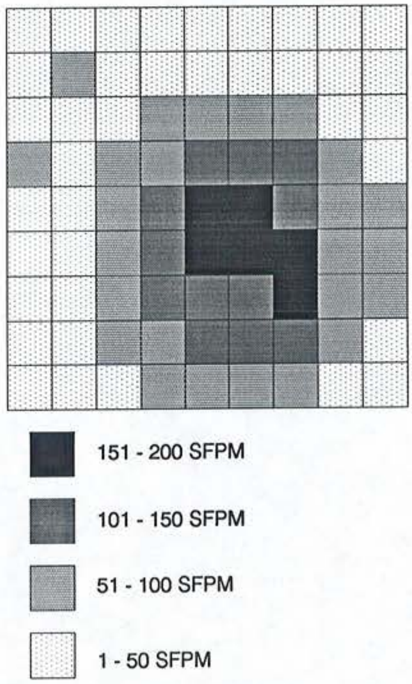
Appendix A: Installation Drawings

This appendix contains engineering drawings that provide the information necessary for you to install your system correctly. Schematic and component layout drawings, helpful when trouble-shooting your EVA System, are provided in Appendix E.

Appendix B: Sensor Placement Examples

Figure B-1 shows the same sample velocity profile shown in Figure 3-3 in Section 3. The examples in this appendix are based on that profile.

Figure B-1. *Sample Velocity Profile*

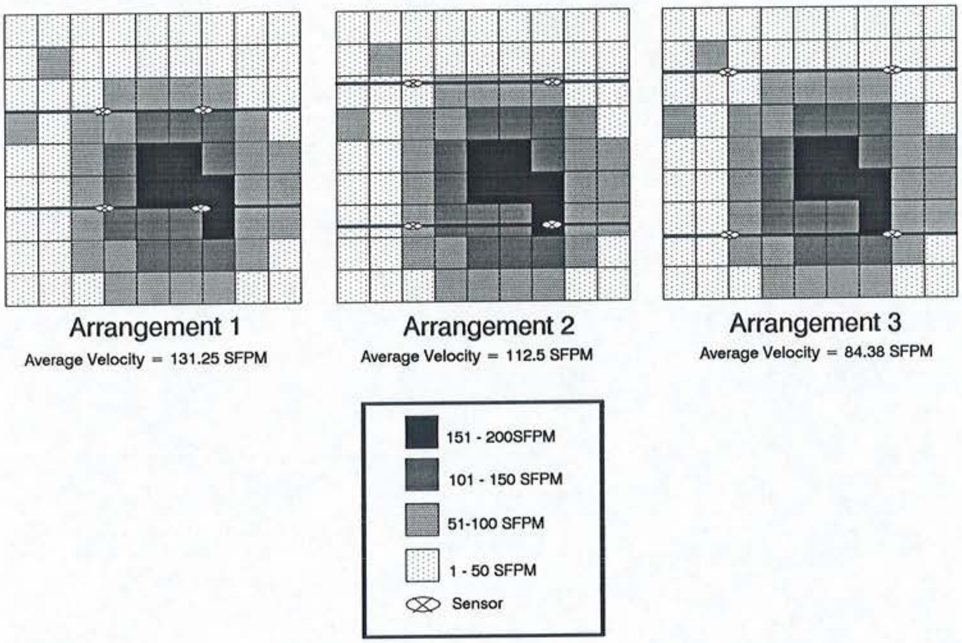


B.1 Method 1: Evenly Spaced Sensor Placement

To calculate the actual average velocity shown in the profile in Figure B-1, assign to each square in the profile the highest number in its range (i.e., each light square = 50), total the squares, and divide by 81. This yields an averaged velocity of just over 91 (91.36) SFPM. You would try to find an evenly spaced arrangement of sensors that would most closely approximate that average.

Three possible arrangements of four sensors are shown in Figure B-2.

Figure B-2. *Evenly Spaced Sensor Arrangements*



Note that, of the three arrangements considered, Arrangement 3 yields the average closest to that computed above.

B.2 Method 2: Equally Weighted Area Placement

To decide on the number of sensors in an equally weighted area placement scheme, consider the number and relative extent of the ranges shown on the velocity profile. The velocity profile shown in Figure B-1 contains four distinct ranges. Table B-1 shows the relative extents of each of those ranges.

Table B-1. *Relative Extents of Sample Velocity Ranges*

Range No.	No. of Units/Range	Approximate % of Total
1	38	47%
2	25	31%
3	12	15%
4	6	7%

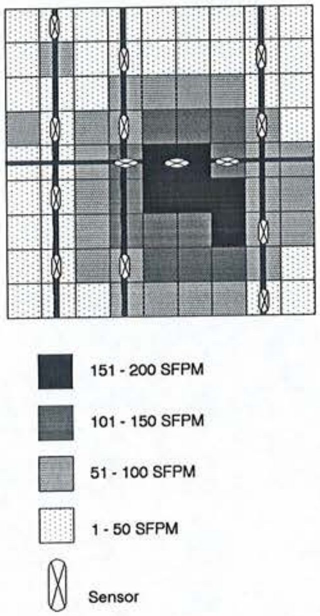
Since every sensor in an EVA is weighted equally with every other sensor, each sensor should ideally be monitoring an equal proportion of the total flow in the duct. Since Velocity Range 4 covers the smallest area, roughly 7% of the cross-sectional area, we could consider that area (7% of the cross section) the smallest significant area to monitor. Since 100% ÷ 7% = 14.29, 14 sensors would be required to monitor flow in the duct shown in Figure B-1. The sensors would then be distributed within the ranges as shown in Table B-2.

Table B-2. *Sample Sensor Distribution by Range*

Range No.	No. of Sensors	Calculation
1	7	14 x 47% ≈ 7
2	4	14 x 31% ≈ 4
3	2	14 x 15% ≈ 2
4	1	14 x 7% ≈ 1

Figure B-3 shows one possible arrangement of 14 sensors in the sample velocity profile.

Figure B-3. *Sample Velocity Profile Monitored by 14 Sensors*



The arrangement show in Figure B-3 yields an average reading of 89.28 – significantly closer to the computed average than any of the four-sensor, evenly spaced arrangements show in Figure B-2.

A total of 14 sensors is reasonable if the duct shown is, in fact, fairly large[1]. If, however, the duct is fairly small, say 2’ x 2’, you might want to use as few as four sensors[2]. Figure B-4 shows one possible arrangement of four sensors in the sample velocity profile.

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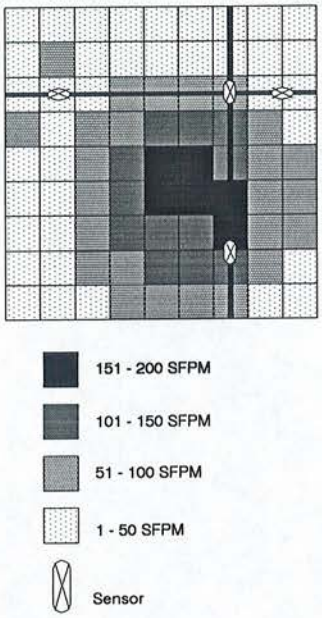
[1] If the duct is 9’ x 9’ or 81 ft^2, each of 14 sensors would be monitoring about 5.79 square feet of cross-sectional area, a little more than the maximum given as a rule of thumb at Step 6 in Section 2. In that case, you might want to go to 17, or even 18 sensors.

[2] The number of sensors used should always be at least as large as the number of distinct velocity ranges shown in the velocity profile. Therefore, a duct with a velocity profile like the one shown should be monitored by at least four sensors, regardless of its size.

Figure B-4. *Sample Velocity Profile Monitored by Four Sensors*

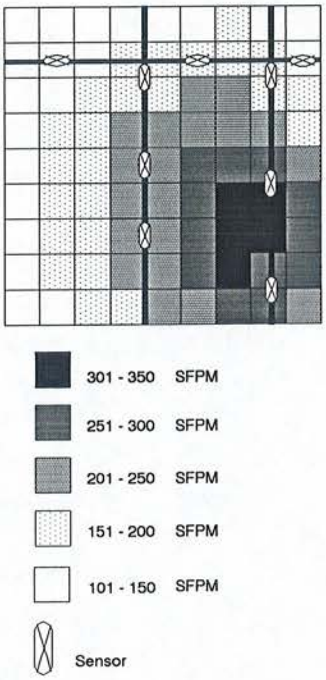


Note that, when only four sensors are used, Range 1, at 47% of the total cross-sectional area, accounts for two of the sensors, leaving only two additional sensors to monitor ranges 2, 3, and 4. In the arrangement shown, one sensor is used to monitor Range 2, and one sensor is placed at a point where ranges 3 and 4 meet. Clearly, the velocity picture this arrangement will yield is much "grainier" than the one obtained with 14 sensors arranged as shown in Figure B-3. Still, it is likely to be somewhat more accurate than an arrangement based on Method 1.

In fact, the arrangement shown in Figure B-4 yields an average reading of 93.75 SFPM. This is significantly better than any of the four-sensor arrangements shown in Figure B-2, and only very slightly less accurate than the 14-sensor arrangement shown in Figure B-3.

Figure B-5 shows the same velocity profile monitored by nine sensors. The figure nine was arrived at more or less arbitrarily; it represents a midpoint between the high of fourteen and the low of four already illustrated.

Figure B-5. *Sample Velocity Profile Monitored by Nine Sensors*



This particular arrangement of nine sensors yields an average reading of 91.66 – even more accurate than the 14-sensor arrangement shown in Figure B-3. It should be borne in mind, however, that a larger number of sensors will better handle changes in profile as overall velocity changes. And it is, of course, changes in profile that make a multipoint system necessary.

B.3 EPA Method 1

Applicability: EPA Method 1 is specifically applicable to particulate-sampling applications and applications where velocity rather than volumetric flow is desired. Although EVA sensors do, in fact measure volumetric flow, EPA Method 1 can still be an aid in determining their placement. EPA Method 1 is applicable to gas streams in ducts, stacks, and flues, provided that:

1. The flow in the line is not cyclonic or swirling.
2. The line is at least 12 inches in diameter or 113 square inches in cross-sectional area.

3. The measurement site is at least two line diameters downstream and at least one half line diameter upstream from the nearest flow disturbance.

   (In fact, the standard Method 1 procedure requires that the measurement site be at least eight diameters downstream and two diameters upstream from any flow disturbance. The EPA does, however, provide an alternative method when the measurement site meets the minimum criteria but not the more desirable eight and two criteria—refer to the full text of EPA Method 1.)

Equivalent Diameters: The EPA Method 1 procedure for determining the number of monitoring points in a line depends on the diameter of the line to be monitored. In the case of square or rectangular lines, Method 1 provides a formula for calculating an *equivalent diameter*:

$$D_e = \frac{2\,LW}{(L + W)}$$

where

D_e = equivalent diameter

L = length of line cross section

W = width of line cross section

Determining the Number of Monitoring Points: Table B-3 specifies the number of monitoring points required by EPA Method 1, according to the diameter or equivalent diameter of the line to be monitored.

Table B-3. *Minimum Number of EPA Method 1 Monitoring Points*

Line Diameter (or Equivalent)	Number of Monitoring Points
12 - 24 in	8 (circular lines)
12 - 24 in	9 (rectangular lines)
over 24 in	12 (circular or rectangular)

Note that Table B-3 is applicable only when the monitoring site is at least eight line diameters downstream and two diameters upstream from the nearest flow disturbance. The procedure for determining the minimum number of monitoring points when those criteria cannot be met is more complicated and is not discussed here – refer to the full text of EPA Method 1.

Determining the Location of Monitoring Points: Once you have determined the number of points to be monitored, divide a cross section of a square or rectangular duct into that number of equal areas, laid out as specified in Table B-4.

Table B-4. *Cross-Section Layout for Square or Rectangular Lines*

Number of Points	Matrix Layout
9	3 x 3
12	4 x 3
16	4 x 4
20	5 x 4
25	5 x 5
30	6 x 5
36	6 x 6
42	7 x 6
49	7 x 7

Except for the first two (the minimum layouts), the layouts shown in Table B-4 are recommendations rather than requirements – EPA Method 1 allows for alternative configurations. Thirty-six monitoring points could, for example, be laid out in a 3 x 12 matrix instead of a 6 x 6 matrix. In general, aim for equal areas that are as nearly square as possible.

After dividing the line cross section into the appropriate number of equal areas, plot a monitoring point in the center of each area.

B.4 EPA Method 2

Applicability: EPA Method 2 is specifically applicable when volumetric flow rates are desired. Physical restrictions on the applicability of EPA Method 2 are the same as those for Method 1 described at B.3. above.

EPA Method 2 procedures for determining the number and location of monitoring points are the same as those specified in EPA Method 1. The bulk of EPA Method 2 is devoted to specifying the necessary apparatus and procedures for determining volumetric flow using pitot tubes and related differential-pressure devices. Because Kurz EVA sensors directly measure mass flow without any ancillary equipment, most of EPA Method 2 is not applicable to a discussion of an EVA system. (EPA Method 2 would, however, be appropriate for checking the calibration of an installed EVA system calibrated in units of mass flow – refer to the full text of EPA Method 2.)

B.5 ANSI Method N13.1-1969

ANSI Method N13.1-1969 deals specifically with gas flow sampling for particulate radioactive contamination. This method was developed with older pitot-tube-type instruments in mind. It specifies one monitoring point per square foot of cross-sectional area. Although one monitoring point per square foot may be appropriate for establishing an initial velocity profile, Kurz does not feel that such a large number of points is necessary for day-to-day monitoring when modern electronic instruments like the EVA system are used.

End of Appendix B