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GUIDELINES AND RECOMMENDED PRACTICES FOR PREPARING BID SPECIFICATIONS AND BID EVALUATIONS FOR SAMPLE TRANSPORT BUNDLES (STB)

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The Institute of Clean Air Companies, the nonprofit national association of companies that supply stationary source air pollution monitoring and control systems, equipment, and services, was formed in 1960 to promote the industry and encourage improvement of engineering and technical standards.

The Institute's mission is to assure a strong and workable air quality policy that promotes public health, environmental quality, and industrial progress. As the representative of the air pollution control industry, the Institute seeks to evaluate and respond to regulatory initiatives and establish technical standards to the benefit of all.

Guidelines and Recommended Practices for Preparing Bid Specifications and Bid Evaluations for Sample Transport Bundles (STB)

Date Adopted: September 2006

SUMMARY:

This document provides guidelines for specifying and collecting information necessary to solicit bids from manufacturers and suppliers of heated and unheated sample transport bundles for emissions monitoring systems. It includes example bid specifications, request for quote forms, and a bid evaluation form, with supporting discussion. The emphasis of this document is on the sample transport systems for stack sampling systems. Issues dealing with gas engine analyzer bundles have been omitted as they require information beyond the scope of this document.

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1. HISTORY

The ICAC Emissions Measuring Division prepared ICAC-EM-4 to assist in the process of purchasing appropriate, reliable sampling umbilicals, and to help companies specify and obtain systems that best meet their needs. The members of the ICAC Emissions Measuring Division are companies that supply emission and stack testing equipment and services. Members of the Division who made special contributions and provided oversight to the development of ICAC-EM-4 were Dekoron/Unitherm, Inc., Thermon Manufacturing Company, and Parker-Hannifin, Parflex Division.

2. OBJECTIVE AND SCOPE

The objective of ICAC-EM-4 is to help users of stack emissions monitoring systems to prepare a specification for the solicitation and evaluation of bids from manufacturers of sample transport systems. The intent is to provide a foundation for development of a purchase specification that can be prepared directly by the buyer, if desired, to reduce acquisition costs by minimizing or eliminating the need for third party consultants.

ICAC-EM-4 does not recommend specific values, suppliers, or designs. The general specifications provided are based on accepted practices, and are offered for informational purposes. Specific site conditions, applications, and monitoring requirements will dictate the actual system specifications and performance criteria.

3. DEFINITIONS WITH COMMENTARIES

Approval Agency - An organization that provides standards and testing in one or more countries where recognized or granted authorities to insure the safe and reliable operation of Sample Transport Bundles and their accessories. (Comment; North American agencies include the Canadian Standards Association, Factory Mutual Approvals, and Underwriters' Laboratories. Examples of international agencies include CENELEC, BASEEFA, PTB, and TUV-Rheinland.)

ASME - American Society of Mechanical Engineers. [Comment: ASME is an organization that develops, facilitates, and manages a number of Codes and Standards that relate to equipment and components used in industry. The most notable ones for this application are the ASME Piping Codes (B31.1 and B31.3) that provide the design and application properties for metal tubing and piping used in sample transport bundles.]

ASTM - American Society of Testing and Materials (Comment: ASTM develops and publishes standards for materials, constructions, and test methods for the materials used in sample transport bundles. ASTM Standards cover items like: material chemistry, surface appearance, physical, and thermal properties, dimensional tolerances of tubing, quality assurance procedures, and product marking. ASTM Standards do not state nor imply that a particular material or product is required or suitable for a specific application.)

ATEX - "Atmosphères Explosibles"; A set of guidelines established under Directive 94/9/EC of the European Parliament and the Council of the European Union for equipment to be used in potentially explosive atmospheres. (Comment: Any electrical equipment sold to or used in potentially explosive atmospheres in areas governed by the European Union must meet these guidelines.)

Blowback Line - A tube used to clear dust and debris from the in-line filter in the sample probe.

Burst Pressure - The pressure at which a tube experiences mechanical failure. (Comment: Values listed in most manufacturers' literature are for burst pressures at room temperature. Temperature affects burst temperature differently for different materials. Plastic tube materials are generally affected more with a change in temperature than metal tube materials. Additionally, the burst pressure values given assume a gradual increase in pressure. Tubing that receives a strong pressure spike, or impulse, may fail at pressures below the published burst pressure.)

Calibration Line - A tube used to transport calibration gasses from the analyzer to the probe. This line may be heated or unheated depending upon the analyzer system and test method used. (Comment: The composition of the calibration line is as important as that of the sample line. An improperly specified calibration line can result in loss of components in the calibration gas.)

CENELEC - The European Committee for Electrotechnical Standardization. It is one of the bodies formed in the European Union to draft and adopt Harmonized Standards for electrical devices.

CPD Heat Tracing - Constant Power Density (CPD) or constant wattage heating cables. These may be either series or "zone-type" parallel resistance heaters. [Comment: Parallel resistance or cut-to-length constant wattage cables are constructed of multiple heating zones connected in parallel. Each zone is comprised of a resistance heating wire wound around a pair of insulated bus wires. Some parallel heaters may be suitable for and designed for higher maintenance and exposure temperature. Some parallel heaters can be specified for sample lines with maintenance temperatures above 400°F (204°C) and with some having exposure temperatures of 550°F (288°C). Series resistance heaters, on the other hand, include MI (mineral insulated) heaters that can be designed for maintaining 800°F (427°C)]

Cross Linking - The process of chemically joining two or more molecules by a covalent bond. (Comment: This is a common process for stabilizing polymers found in semi-conductive "self-regulating" heat tracing and in some applications for polyethylene tubing.)

CEC - The Canadian Electric Code

CSA - Canadian Standards Association is a nonprofit, membership-based association working in Canada that develops safety and application standards for equipment and systems used in both hazardous and non-classified areas. (Comment: CSA Standards cover electrical design and safety issues much the same as the National Electric Code in the United States. However, CSA Standards also cover design and application issues that would be covered by Factory Mutual Approvals or Underwriter's Laboratories in U.S. applications.)

ECTFE - A copolymer of ethylene and chlorotrifluoroethylene. (Comment: One such material is marketed by Solvay Solexis under the trade name Halar. It has excellent resistance to harsh chemicals and permeation, but does not have the temperature rating of other fluorinated materials like PFA and PTFE. ECTFE is also stiffer than the other PTFE, PFA, or FEP and may kink if bent in a tight radius.)

Factory Mutual - U.S. based approval agency (Comment: FM US based approval agency (Comment: FM is one of the world's largest commercial and industrial property insurance and risk management organizations specializing in property protection. FM certifies industrial and commercial products used in hazardous and non-classified areas.)

FEP - Fluorinated Ethylene-Propylene co-polymer. (Comment: FEP is a melt-processable fluoropolymer with excellent clarity, flexibility, and chemical resistance. It is one of the three fluoropolymers most often used for sample and calibration lines. It has similar chemical resistance properties as PFA and PTFE, but a lower working pressure and operating temperature limit.)

Fluoropolymer - Fluoropolymers are a class of high-temperature polymer materials that exhibit excellent chemical resistance and temperature stability. (Comment: Their natural lubricity makes them the material of choice for sample and calibration lines used in gas sampling bundles. They have a limitation, however, in that they exhibit a characteristic porosity to certain molecules like carbon monoxide. This makes fluoropolymer tubing materials less acceptable for applications requiring very fine measurements, for example low NOX systems, or for non-diluted sampling systems.)

HDPE - High Density Polyethylene (Comment: HDPE tubing is used primarily for blow-back and air control lines. It has been used successfully for sample and calibration lines in dilution systems where the sample temperature is maintained at or below 140°F (60°C). HDPE has very good chemical resistance and strength. It is also extremely resistant to mechanical damage. It is quite stiff, and tends to kink if bent sharply.)

Halar -An ECTFE material marketed by Solvay Solexis. See also ECTFE.

Hazardous (Classified) Locations - Areas where there may be a volatile concentration of gases, vapors, dusts, or fibers that may ignite or explode. (Comment: These are grouped together by the potential for ignition and the degree of damage that may occur. The classifications vary based on the country or region used for the specification. In the United States, area classifications are defined in the National Electric Code, Article 500. Hazardous atmospheres are classified as Class I if the atmosphere contains gases or vapors, Class II if it contains dusts, and Class III if it contains fibers. Areas are further divided to those where the hazard is present during normal operation and those where the hazard is only present during maintenance or breakdown. For further information, refer to the National Electric Code, Article 500, or the Canadian Electric Code, Part 1, Section 18.)

Heat Tracing or Heating Cable or Heat Tape - A resistance heating element designed specifically for piping, tanks, and instrumentation. Though used in other applications, the focus here is for sample transport bundles.

IEC - The International Electrotechnical Commission is a global organization that prepares and publishes international standards for all electrical, electronic, and related technologies. (Comment: IEC Standards provide the basis for many global standards and those of different nations.)

IEEE - The Institute of Electrical and Electronic Engineers. (Comment: The IEEE develops design and engineering standards for many applications. IEEE Standard 515 covers manufacturers' benchmark testing, design, installation, and maintenance of electrical resistance heat tracing for industrial applications. The IEEE Standard 515 governs the basis for the design of Sample Transport Bundles.

LDPE - Low Density Polyethylene [Comment: LDPE tubing has many of the same properties as HDPE discussed above, but is not quite as stiff. The pressure rating of LDPE tubing is roughly one-half that of HDPE at the same temperature. HDPE and LDPE tubing exhibit much less permeability than PFA, FEP, or PTFE tubing at temperatures below 140°F (60°C).]

MI Heater - Mineral Insulated Heating Elements. [Comment: MI cables are a special class of series resistance heaters used in applications requiring high wattage (typically over 20 W/foot (66 W/m)] for heat up or high maintain temperatures (>400°F or 204°C), or for lower maintain temperatures with elevated exposure temperatures (i.e. freeze protection with exposures of over 450°F (232°C)]

Messenger Wire - Messenger wire is the general term for an insulated conductor or electrical cable (or fiberoptic cable) that connects a sensor or control device at the probe end of a sample transport bundle to the readout or controller in the analyzer enclosure. (Comment: Messenger wires are not used to carry power or to control auxiliary services. Messenger wires are used only for those devices that are an integral part of the analyzer system.)

MTR - Maximum Temperature Rating of a Sample Transport Bundle is the maximum temperature that the heated core of the bundle can withstand before the components are damaged. (Comment: MTR should not be confused with the maximum operating temperature of the bundle. A bundle may be designed to maintain the sample tube at a temperature far below its MTR.)

NEC - The National Electric Code, also known as NFPA 70, contains application and safety standards for electrical equipment and installations in the USA. (Comment: The NEC has also been adopted in other countries. It covers wiring methods and practices, electrical ratings, component descriptions, installation details and, special application standards. It also describes the requirements for installing electrical equipment in hazardous (Classified) areas that contain flammable or explosive mixtures of gases, dusts, and fibers. Equipment designed for use in these locations

(e.g., in a refinery or chemical plant) must meet the design requirements of the National Electric Code (or Canadian Electric Code in Canada) to be certified or approved by FM, CSA, or UL for use in these locations.

Nylon - Nylon is a trade name of DuPont Corporation for polyamid resins and compounds. (Comment: Nylon tubing has higher burst pressures and working temperatures than HDPE or LDPE tubing, but is very stiff. It finds limited use as small vacuum sensing lines in some analyzer systems. Typical systems use a single 1/8" OD x 0.012" wall tube running from the probe box to the analyzer.)

Orbitally Welded Tubing - Lengths of tubing can be joined together by a process known as orbital welding. In this process, the tube ends must be cut very flat and perpendicular to the axis of the tube. The two open ends are then aligned, pressed together and fused. (Comment: The orbital welding process has improved greatly since it was first used on the small, relatively thin-walled tubing found in analyzer systems, but it still presents some problems for analyzer applications. The heat involved in welding changes the structure of the austenitic stainless steel used in analyzer sample lines, making them more susceptible to corrosion caused by acid gases. This is one reason seamless tubing is used instead of welded tubing in those applications requiring stainless steel. In addition, the process leaves a lip around the ID of the tube at the weld site, which can trap particulates.)

PFA - PFA is a copolymer of tetrafluoroethylene and perfluoroalkyl vinyl ether. (Comment: PFA is a melt-processable fluoropolymer with excellent clarity, flexibility, and chemical resistance. This advantage plus its natural lubricity and temperature properties make it one of the best materials available for use in sampling systems. PFA can be used reliably for systems operating up to 450°F (232°C). Above this temperature, the tubing looses most of its mechanical strength, which may lead to kinking in bends or collapses when subjected to a vacuum. PFA is extruded, so the problem with sampling errors due to process aids seen with PTFE tubing does not exist. PFA compounds are available in many grades. The type used for sampling systems must be the "stress crack resistant" grades. The constant thermal cycling experienced (due to calibration) in analyzer systems can cause premature failure in PFA tubing fabricated from "general purpose" grades. The PFA used to produce the tubing should meet ASTM Standard D3307 Type II with a melt flow of 1.5 - 3.0 g/10 min per ASTM D1238.)

Polished Tubing - Seamless and welded metal tubing all exhibit a certain surface roughness after normal fabrication. A typical metal tube may have a surface roughness measuring 40-60 _-in Ra, which is acceptable for most gas analyzer applications [Comment: This roughness is generally measured in units of micro inches or micrometers (one micrometer = 39.37 micro inches) and is expressed as the average distance between the peaks and valleys in the tube surface. A discussion of units of measure used in surface finish appears below. This degree of roughness may trap particles that affect sampling accuracy when attempting to measure solutes in the parts-per-billion range; or provide sites for corrosive attack in applications involving mercury. Several methods are available to improve the surface finish of the tube ID. Some manufacturer's offer an additional draw pass, which improves the ID surface to 15-20 _-in Ra. Beyond this are numerous mechanical, chemical and electropolishing techniques that can provide finishes below 10 _-in Ra. Electropolishing provides an additional function as it selectively removes iron particles on the surface. This creates a surface that is more resistant to corrosive attack. Many of these treatments can only be performed on straight lengths of tubing; therefore, the tubing must be joined together with fittings or by orbital welding to get the length needed for the sample line. Fittings create pockets that trap particles and cold spots that cause condensation. Orbitally welding creates a small lip at the weld that can trap particles and the effect of the polish in the area around the weld.]

Power-Limiting Heat Tracing - Power-Limiting heating tapes are constructed similar to "zone-type' parallel resistance CPD heaters but use a special resistance wire that reduces its heat output in response to the heater temperature. [Comment: These heaters do not have an unqualified "T-Rating" so require "Stabilized Design" for determining runaway temperatures. Power-limiting cables can be used for maintaining temperatures above 300°F (149°C) with a maximum exposure temperature of 500°F (260°C)].

Power-Limiting Series Resistance Heating Wire - Also known as Self-Limiting Heating Wire is a special resistance wire alloy that reduces its heat output in response to the heater temperature. This wire provides protection against thermal runaway in applications where a high degree of flexibility or portability is required.

PTFE - Polytetrafluoroethylene, a fluoropolymer (Comment: PTFE compounds are generally fabricated by cold-forming or ram extruded and sinter-

ing a compressed powder. This material has excellent lubricity, chemical resistance, and the highest working temperature rating of the fluoropolymers. Unlike PFA or FEP, PTFE does not melt. The method of fabrication results in shorter continuous tubing lengths than seen with the melt-processable fluoropolymers. Another problem that can occur is due to processing aids needed during tubing fabrication. The hydrocarbon-based processing aids are normally driven off during the sintering process. However, traces could be left in the finished tube. This will lead to erroneous readings if the application is measuring total hydrocarbons or carbon monoxide.)

Ra - Ra, or "roughness average" is a unit of measure used in determining or defining surface finish or smoothness. It is the arithmetic mean of the distance between the peaks and the valleys in the profile of the tube surface, and is typically measured in micro-inches or micrometers.

RMS - Root Mean Square (Comment: RMS is a unit of measure used in surface finish measurements. It is the average of the distance between the peaks and valleys in the profile of the tube surface determined by the "root mean square" method. An RMS value of a profile will be less that the Ra value for the same profile.)

Resistance Temperature Detector (RTD) - RTD is a temperature sensor that employs a metal wire or foil, typically platinum, which exhibits a predictably consistent change in resistance in proportion to a change in the temperature of the sensor. (Comment: An RTD can provide extremely accurate temperature measurements. RTD sensors come in 2-wire, 3-wire, and 4-wire models. Only two wires are used as the sensor leads, the other wire(s) are used to compensate the reading for the resistance of the wire between the RTD sensor and the resistance measuring device, such as a controller or monitoring instrument.)

Sample Line - The sample line is the tube used to transport the gas sample from the probe to the analyzer.

Sample Transport Bundle (STB) - STB is a manufactured product that contains all the components needed to connect between the sample probe (initial sample acquisition point) and the gas analyzer, for the purpose of transporting the sample, operating, and calibrating the gas sampling system. These bundles are also known as "Heated Umbilicals," "Traced Bundles," and "Heated Sample Lines."

Seamless Tubing - Seamless tubing is produced by drawing a large blank through a series of dies or rolls to produce a continuous tube of the size and wall thickness required. (Comment: Seamless tubing advantages over welded tubing in gas analyzer applications are:

- Welded tubing exhibits a slight ridge on the ID which could trap particulates or sample components leading to measurement errors or plugs.
- The weld area is more susceptible to corrosion caused by acid gasses.
- Seamless tubing has a slightly higher pressure rating that welded tubing of the same material and construction.

Seamless tubing can be fabricated from a number of materials in many sizes and thicknesses. Analyzer applications generally use tubing with an outer diameter between one-eight inch and three-eight inch (3 - 12 mm) and fairly thin walls. Most tubes use ANSI Type 316L stainless steel, and are built to the standard specification called out in ASTM Standard A-269. Tubing should be supplied "bright annealed" to give the best interior and exterior finish, should be free of foreign material and lubricants and capped during shipment. The specifier may elect to have the tubing supplied "thermocouple clean" to specification S.3 of ASTM Standard A-632. This will insure that all particles and foreign materials are removed.)

Self-Regulating (Self-Limiting) Heaters - Generally these are continuous, parallel resistance heating cables manufactured from special conductive polymers as the heating element. These heaters vary their heat output in response to their temperature. (Comment: The specifications for each type heater vary with the manufacturer, so the sample line specifier must determine if the heater quoted meets their sample line requirements. There are three general classes:

- Low Temperature heaters are used primarily for freeze protection of dilution-type sample lines, but can be used for maintaining sample line temperatures up to 120°F (49°C). These heaters have a maximum exposure temperature less than 185°F (85°C).
- Medium Temperature heaters can be used for maintaining sample line temperatures up to 250°F (121°C) and are constructed from materials that will allow the heater to withstand intermittent temperature exposures ranging from 420°F (215°C) to 482°F (250°C) depending on whether the circuit is energized, or not.

- High Temperature heaters have the capability of maintaining temperatures up to 300°F (149°C) and may be able to withstand higher temperature upsets than those above.

Series Resistance Heaters - Series Resistance Heaters, also called resistance wire heaters, are insulated, copper or alloy wires laid alongside or wrapped around the sample line to be heated. (Comment: Unlike more common heaters listed, these must be individually designed for the size, length, and voltage of the sample line. These heaters are well suited for higher maintenance temperatures. Bundles can be designed for maintenance temperatures up to 625°C.

Silcosteel - Silcosteel™ is a registered trademark of Restek for sample line of fused silica coated stainless steel tubing and components. (Comment: This coating is to improve the resistance of stainless steel tubing to chemical corrosion. It does not, however, improve the surface finish of the tubing. The coated tube can be bent and worked without damaging the coating.)

Surface Finish - see “Ra” or “Polished Tubes”

Sulfinert - Sulfinert™ is a registered trademark of Restek for sample line of passivated, stainless steel tubing and components. (Comment: This treatment is specially designed to prevent adsorbsion of organo-sulfur compounds into the surface of stainless steel tubing and fittings or reaction of the compounds with the stainless steel.)

Teflon - Teflon™ is a registered trademark of DuPont for fluoropolymer resins. (Comment: Over the years the name Teflon has become synonymous with fluoropolymer resins. However, not all fluropolymers are “Teflon.”)

Thermocouple - A thermocouple is a temperature sensor that employs dissimilar metals joined at a “test junction” which produces a voltage in proportion to the temperature at the junction of the metals. (Comment: This sensor is considered by some to be more robust than an RTD temperature sensor, but not as accurate. Thermocouple sensors provide sufficient accuracy for most applications. The accuracy is degraded when the distance between the sensor and the readout is greater than 100 feet (30 meters). This is due to line resistance in the sensor wire and electrical noise that can cause errors at the readout. Accuracy can be improved by connecting the thermocouple sensor to an extension cable (which has lower losses than the thermocouple sensor wire) and using twisted/shielded thermocouple cables.)

Tray Cable - Tray cable is a class of electrical cables described in the National Electric Code. Tray cables are generally un-armored, plastic jacketed wire and cable bundles with single or multiple pairs or conductors. (Comment: Tray Cables are designed to be installed in metal cable trays (hence, the name) to provide power and control circuits in industrial applications. The cable tray provides protection and support, which allows these cables to be lighter and more flexible than those designed for other methods of installation. Tray cables can be used in some hazardous locations, if proper guidelines are followed.)

TUV - TUV-Rheinland Group is an international company that is certified as a Nationally Recognized Testing Laboratory (NRTL) and documents the safety and quality of new and existing products, systems, and services. (Comment: TUV provides a testing and certification service similar to FM Approvals, CSA, and UL.)

UL - Underwriter’s Laboratories Inc. is chartered as a not-for-profit organization to establish, maintain, and operated laboratories for the examination and testing of devices, systems, and materials to determine their relation to hazards to life and property, and to ascertain, define and publish standards for these items. (Comment: UL Standards can be used to certify the materials and components used in sample transport bundles, individually or as a system. Hazardous location installations rarely have component approvals only.)

UL94 - UL Standard 94 is titled “Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.” This standard details the test methods used to determine the flammability of the materials used for tubing, jackets, and heaters in sample transport bundles. (Comment: One common test is the VW-1 vertical flame test. In this test, a sample of the plastic is suspended from a test fixture. A flame is applied to the bottom of the sample for a regulated time, and then removed. The time required for the flame to extinguish, and the material’s mode of extinguishing form the basis of the VW-1 rating.)

Umbilical - Umbilical is the tubing or sample transport hose between a probe and an extractive analyzer, generally in a separate location, often located at grade. (Comment: “Heated umbilical” is another term used for the sample transport bundle addressed in this recommended practice.)

Virgin Fluoropolymers - Fluoropolymers that have not been previously molded, extruded, or otherwise processed prior to their use for a specific manufactured part or assembly. (Comment: Regrind mate-

rial is tubing or purging scrap that is ground into chunks or flakes and blended back into the material that comes out of the original package. Since the reground material has been heated to melt condition, it could have different properties than the original fluoropolymer. Additionally, dust and other contaminants can be attached to the regrind which can cause further deterioration of the material properties. However, some users define virgin fluoropolymers as material that can contain regrind from the same lot or batch.)

Welded Tubing - Welded stainless steel tubing is produced by forming a strip of stainless steel into the shape of a cylinder then longitudinally welding the edges to form a sealed article. The tubing is then given a slight draw to round it out, and is generally annealed in-line. (Comment: Welded tubing can be specified for calibration lines where corrosion and particulate concerns are not a factor. Most tubes use ANSI Type 316L stainless steel, and are built to the standard specification called out in ASTM Standard A-269. Tubing can be supplied "bright annealed" to give the best interior and exterior finish, but should be free of foreign material and lubricants and capped during shipment. The specifier may elect to have the tubing supplied "thermocouple clean" to specification S.3 of ASTM Standard A-632. This will insure that all particles and foreign materials are removed.)

Working Pressure - Working pressure is the maximum continuous pressure that a tube is designed to withstand during normal operation. (Comment: This value is arbitrarily set by the manufacturer. The value is generally one-third or one-quarter the burst pressure. Care should be taken to insure the working pressure rating of any tube is adequate for the application. Most working pressure tables seen in manufacturer's tables are for room temperature. Polymer tubes may lose up to 80percent of their room temperature working pressure capabilities when operated at the temperatures seen in many analyzer applications.)

4. BUYER'S RESPONSIBILITY

Sample transport bundles can be as simple as a single heated or unheated tube or a complex mixture of tubes, wires, cables, and heaters, depending upon the needs of the particular sampling system. It is the buyer's responsibility to determine the overall requirements of the transport system to insure it is adequate for the application, equipment, and test method being used.

If the buyer is the end user or consultant, he can call upon the expertise of the analyzer manufacturer or integrator to assist in developing a specification that meets the needs of the specific installation.

The purpose of the STB specification is to help the buyer to define specific designs and to assist them in identifying manufacturers and securing competitive bids from STB suppliers. The specification need not be a long or complex document, one or two pages or an annotated drawing will generally be sufficient. A STB specification may include some or all of the following topics, depending upon the complexity of the system:

4.1 Purpose

The purpose should be a brief statement defining the equipment and services requested, followed by a brief explanation of the application. For example: "This specification covers a sample transport bundle or heated tube bundle and associated accessories for a NO_X analyzer system."

4.2 Scope of Supply

The scope-of-supply section should clearly identify the products and services that the supplier is to provide. The buyer should identify the STB bundle(s) and length(s) required. Expected services section should list any requirements for documentation, installation support, certification and/or testing, training, spare parts, and maintenance. This section should also detail any national or local standards that must be met as well as requirements for third-party approvals or certifications.

4.3 Operating Conditions

This section covers conditions that affect the design, installation, and operation of the STB bundle. Ambient conditions must certainly include high and low ambient temperatures as well as any unusual local conditions, such as underground installations. Ambient specifications covering items like annual rainfall, snow loading, and seismic data are not relevant to this specification. STB operating conditions will include sample tube maintenance temperature and outer sheath temperature. Supplementary information that could affect the design or operation of the STB bundle should be covered. An example would be locating a tube flowing chilled air in the STB bundle. Available power, both voltage and current limitations, as well as the hazard classification of the installation should also be listed. Again, simplicity is the key. The specification may simply read that the bundle must operate within the conditions noted on the Design Sheet, and state the relevant safety factors.

4.4 STB Bundle Design

The STB Bundle Design section details the components used and the placement of each within the bundle. This section may take the form of a detailed list or an annotated drawing. The key is to

insure that each component is called out completely and included the following:

4.4.1 Size and material specifications for sample line tubing;

4.4.2 Size and material specification for auxiliary tubing (calibration tubes, blowback tubes other special-purpose tubing);

4.4.3 Type of heating element preferred (i.e. Self-Regulating, Power-Limiting, Constant Wattage, Mineral Insulated, or Series Resistance);

4.4.4 Type and location of bundle temperature sensors;

4.4.5 Type and specification for any power and/or control wires to be included in the STB bundle;

4.4.6 STB bundle limitations, such as maximum allowed outer diameter, maximum overall weight, and maximum allowed bending radius;

4.4.7 STB bundle jacket requirements, such as resistance to specific chemicals, ecological requirements (lead-free), or material requirements (halogen-free);

4.4.8 Specific requirements that must be met for a specific application.

Note: The number of tubes, sensors, and wires may not be called out directly in the specification. This information is found on the RFQ sheet for the STB Bundle.

Care must be taken to ensure the specification defines a bundle that can be reasonably manufactured. Occasionally, buyers will attempt to specify a bundle that attempts to meet too many conditions in a single product. For example, a bundle designed with a small sample tube to affect a quick response may not be feasible for long run lengths. In these cases, the buyer should work with the STB bundle manufacturer to provide a specification that meets the greatest number of requirements at a reasonable cost.

4.5 Documentation

The type, number, and quality of documents should be clearly specified if required. A vendor's standard documentation may be sufficient for most applications. The specification should state if the documentation is to be provided in written form or electronically.

4.6 Supplier Services

Supplier services include items such as installation support, acceptance testing, training, and commissioning services. Requirements for these services should be detailed and specific.

4.7 Additional Requirements

This section should include any applicable regulatory requirements, such as FM, UL, CSA approval, and ATEX or IEC certification or any additional requirements imposed by the buyer. At a minimum, the bundle must meet the design and operation criteria set down in ANSI/IEEE Standard 515-2004, "Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications." Additional requirements should be defined and assigned measurable acceptance criteria.

Two specifications developed according to the principles outlined above are provided as Appendix 1 and 2. Appendix 1 covers STB bundles designed for fixed CEM systems, while Appendix 2 covers bundles designed for portable or mobile operations. These specifications are offered only as guidelines. Site-specific conditions and regulations may require modification of these specifications.

5. SELECTING VENDORS

Before selecting a Manufacturer, the buyer must evaluate both their process requirements and their own abilities with respect to STB bundles. Experienced analyzer manufacturers and integrators may be fully qualified to install, commission, and operate a STB bundle, while smaller companies or end users may require substantial training and assistance. The buyer should select candidate vendors that can best meet their needs.

Potential sources of suppliers include the list of ICAC members, and various buyers' guides that list STB bundle manufacturers.

Criteria for selecting a vendor include:

- Experience in designing and building bundles for analyzer applications;
- Quality assurance programs;
- Technical competence and ability to work with buyer;
- After-sales support;
- General comfort with vendor;
- Warranty;
- End-user references.

Experience is critical and cannot be overlooked. There are a number of companies that can build heated and unheated tubing bundles; however, they may not be able to build the type of bundle that meets the needs of the analyzer industry.

The STB manufacturer should follow a regulated, documented quality program, such as ISO 9000-2000. The manufacturer's quality program should insure that the materials and workmanship used in the STB meet the level of craftsmanship needed for this exacting task.

The vendor must be willing to work with the buyer to insure that the bundle being specified meets the requirements of the application. Manufacturers should be willing and able to provide the technical merits of their product and fully explain the need for variations from the specification or additional options.

The warranty must be fair and enforceable, for the buyer, the vendor, and the manufacturer. The STB supplier must provide a written warranty for the entire bundle including all components within the bundle whether manufactured or out-sourced.

Reviewing the vendors against these points should allow the buyer to produce a short list of companies that supply a product to the customer's specifications, and expectations. The buyer can now evaluate the various designs to insure that they conform to the specification.

Note: While references are important, the buyer should remember that a vendor would not knowingly provide a bad reference for their products. However, discussions with the reference regarding their experience with the vendor may reveal important information.

6. EVALUATING THE PROPOSAL

Once bids are received, the buyer is faced with the important task of evaluating each to determine if it meets the needs of the application. A carefully written specification will usually assure that the product service will provide the intended performance.

Selection of the bidder solely on proposal price may lead to omission of components or services that must be purchased later, usually at a higher cost, or to a product that will not meet the requirements of the application.

The complexity of the bids received depends largely upon the type of bundle and the application. An STB requiring a single sample tube with freeze protection does not require the documentation needed for a multi-tube bundle with power and control wires and multiple temperature sensors. One process that helps the evaluation is to develop a checklist detailing the important technical and commercial features of the STB bundle. Reviewing each bid against the checklist will help identify bids where items were omitted or substituted, or areas where additional information is required. An example of an evaluation checklist is provided in Appendix 4.

APPENDIX 1
SAMPLE SPECIFICATION FORM - FIXED CEM SYSTEMS

1 Purpose: The following specification covers the materials and operating conditions for a Continuous Emissions Monitoring System's Sample Line "Heated Umbilical" Bundle for fixed installations.

2 **Scope of Supply:** The vendor will supply a sample transport bundle to the details supplied in this specification and the attached design sheet. Installation and commissioning tests will be provided by others.

3 **Operating Conditions:** The sample transport bundle shall be designed so that the sample line tube temperature will maintain above the temperature listed on the design request at the minimum ambient temperature listed with an ambient wind speed of 25 MPH (40 KPH). The design will provide a minimum safety factor of 20 percent based on the power required. The outer jacket temperature will be no greater than 140°F (60°C) when the sample line bundle is operating at design temperature with respect to the maximum stated ambient temperature.

4 **Design:** These umbilical bundles shall be designed using the criteria and standards set forth in ANSI/EEE Standard 515-2004: "Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications."

4.1 **Sample Line Tubing:** Sample line tubing shall be a minimum ID of 0.15in. (or 4,0 mm) for applications with a run length less than 100 ft (30 m), and 0.25in. (or 6,0 mm) for applications with a run length over 100 ft (30 m). Polymeric tubing wall thickness shall be at least 0.040in. (1.0 mm) for all applications unless provided with an overall metallic braid. Sample line tubing shall be:

- Virgin PFA Fluoropolymer meeting ASTM Standard D3307 Type II with a melt flow of 1.5 - 3 g/10 min per ASTM D1238.
- Virgin PTFE Fluoropolymer meeting ASTM Standard D3296.

Vendor will certify that tubing is fully cured and free of process oils and lubricants.

or

Sample line tubing shall be seamless ASTM Type 316L stainless steel meeting ASTM Standard A-269. This tubing shall be bright annealed and passivated per ASTM A-269, and

be "Thermocouple Clean" per ASTM A-632, Section S.3. All tubes shall be provided to the end user cleaned and capped to prevent entry of moisture, dirt and other foreign bodies.

or

Sample line tubing shall be seamless ASTM Type 316L stainless steel meeting ASTM Standard A-269. This tubing shall be bright annealed and passivated and have a fused silica layer on the ID. This tubing shall be "Thermocouple Clean" per ASTM A-632, Section S.3. All tubes shall be provided to the end user cleaned and capped to prevent entry of moisture, dirt and other foreign bodies.

4.2 Auxiliary Tubes: Unless otherwise specified, auxiliary tubes (blowback, calibration gas, sensing, air supply) will meet the requirements called out in 4.1. Tubes for calibration gases will be no smaller than 0.15" (4,0 mm) ID. Tubes for blowback will be 0.25 in. (6,3 mm) ID or larger.

4.3 Heaters: Electrically heated sample line bundles will be designed so that the sample tube operating temperature is at or below the maximum continuous power-on exposure temperature of the heating element specified by the manufacturer .If the design parameters indicate that this temperature is exceeded at specified ambient conditions, a means of regulating or limiting the heater surface. Surface temperature to the manufacturer's stated maximum must be used.

Parallel electric heating cables shall be approved by a Nationally Recognized Testing Lab to meet the design requirements set down in ANSI/IEEE Standard 515-2004 or CSA Standard C22.2 No.130-03. Bundles with electric heating elements designed for use in hazardous (classified) locations will be approved by a nationally recognized authority for use in the specified area.

4.4 Power and Control Wires: Power and control wires shall meet national and local electrical code requirements for the voltage and current seen during normal operation and for the type of use and area classification of application. The vendor shall show evidence that the wires are routed in the bundle in a manner so that the maximum temperature rating of the wire is not exceeded when the bundle is operating at maximum rated maintenance temperature at maximum ambient conditions and the wire is operating at maximum design current and voltage. The vendor shall show evidence that the wires and cables used in any bundle designed for use in a hazardous (classified) area are approved for use in that area.

4.5 Outer Jacket: The outer jacket shall be a continuous, weather resistant sheath. It will be designed to withstand atmospheric conditions seen during normal operation. It will also be designed to be resistant to chemicals or other environmental factors at the installation.

4.6 Minimum Bending Radius: Bundles will have a minimum-bending radius of no more than 6 times the bundle outer diameter for products operating at or below 400°F (204°C). Bending at the minimum bending radius shall not damage the outer jacket, causes loss of bundle thermal properties or reduction in sample flow.

5. Documentation: Vendor shall provide a data sheet indicating the operating characteristics and limitations of the bundle.

APPENDIX 2
SAMPLE SPECIFICATION FORM - PORTABLE RATA SYSTEMS

1 Purpose: The following specification covers the materials and operating conditions for a sample Transport Bundle or "Heated Umbilical" for use in portable monitoring operations.

2 Scope of Supply: The vendor will supply a sample transport bundle to the details called out in this specification and the attached design sheet, and an electronic temperature controller in a weatherproof enclosure designed to mate with andcontrol the specified bundle.

3 Operating Conditions: The sample transport bundle shall be designed so that the sample line tube temperature will be maintained above the temperature listed on the design request at the minimum ambient temperature listed with an ambient wind speed of 25 MPH (40 KPH). The design will provide a minimum safety factor of 50 percent based on the power required. The outer jacket temperature will be no greater than 140°F (60°C) when the sample line bundle is operating at design temperature at the maximum stated ambient temperature.

4 Design: These umbilical bundles shall be designed using the criteria and standards set forth in ANSI/IEEE Std. 515-2004: "Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications."

4.1 Sample Line Tubing: Sample line tubing shall be a minimum ID of 0.15 in. (or 4.0 mm) for applications with a run length less than 100 ft (30 m), and 0.25 in. (or 6.0 mm) for applications with a run length over 100 ft (30 m). Polymeric tubing wall thickness shall be at least 0.040 in. (1.0 mm) for all applications unless provided with an overall metallic braid. Sample line tubing shall be virgin PFA Fluoropolymer meeting ASTM Standard D3307 Type II with a melt flow of 1.5 - 3.0 g/10 min per ASTM D1238. Or sample line tubing shall be virgin PTFE Fluoropolymer meeting ASTM Standard D3295. Vendor will certify that tubing is fully cured and free of process oils and lubricants.

4.2 Auxiliary Tubes: Unless otherwise specified, auxiliary tubes (blowback, calibration gas, sensing, air supply) will meet the requirements called out in 4.1.Tubes for calibration gasses will be no smaller than 0.15" (4.0 mm) ID. Tubes for blowback will be 0.25 in. (6.3 mm) ID or larger.

4.3 Heaters: Electrically heated sample line bundles will be designed so that the sample tube maintenance temperature is at or below the maximum continuous power-on exposure temperature of the heating element specified by the manufacturer. If the design parameters indicate that this temperature is exceeded at specified ambient conditions, a means of regulating or limiting the heater surface temperature to the manufacturer's stated maximum must be used.

Electrical heating will be by series resistance heating cables only. Parallel heating cables are not permitted in this design.

4.4 Power and Control Wires: Power and control wires shall meet national and local electrical code requirements for the voltage and current seen during normal operation and for the type of use and area of application. The vendor shall show evidence that the wires are routed in the bundle in a manner so that the maximum temperature rating of the wire is not exceeded when the bundle is operating at maximum rated maintenance temperature at maximum ambient conditions and the wire is operating at maximum design current and voltage.

4.5 Outer Jacket: The outer jacket shall be a continuous, weather resistant sheath. It will be designed to withstand atmospheric conditions seen during normal operation. It will also be designed to be resistant to chemicals or other environmental factors at the installation. It must also be able to withstand mechanical abuse seen in reeling and unreeling, and operation in rugged terrain.

4.6 Minimum Bending Radius: Bundles will have a minimum bending radius of no more than 6 times the outer diameter for products operating at or below 400°F (204°C). Bending at the minimum bending radius shall not damage to the outer jacket or loss of bundle thermal properties or reduction in sample flow.

5. Documentation: Vendor shall provide a data sheet indicating the operating characteristics, and limitations of the bundle.

APPENDIX 3
COST AND DESIGN REQUEST FORM FOR SAMPLE TRANSPORT BUNDLES

Design Information: *Application:* Unheated ___ Freeze Prot _____ Temp Maint _____

Ambient Temps: Min _____ (Default −40°F / −40°C) Max _____ (Default 80°F / 27°C)

Desired Operating Temperature: Min _____ °F / °C Max _____ °F / °C

Max OD _____ (in / mm) *Max Jacket Temp:* _____ °F / °C

Tubes: ***Check if tube is unheated***

No. ____ Size _____ Wall _____ Type _____ ☐

No. ____ Size _____ Wall _____ Type _____ ☐

No. ____ Size _____ Wall _____ Type _____ ☐

No. ____ Size _____ Wall _____ Type _____ ☐

No. ____ Size _____ Wall _____ Type _____ ☐

No. ____ Size _____ Wall _____ Type _____ ☐

Electric Tracing: Heater Type Self Regulated ___ Constant Power Density ___ Power Limiting ____

MI ____ Series Resistance _____

Voltages Available _____ VAC ___ Phase

Area Classification: Ordinary___ CL I Div 2 ____ Zone 2 ____ T Rating Require _____

Agency Approval Required or Certification FM ____ CSA ____ CE____ ATEX ____ IEC _____

Will line be blown down / cleaned with steam Y ___ N ___ Steam Pressure or Temperature (MTR) ____

Messenger Wires / Sensors:

No. _____ Gauge and Type _____ No. _____ Gauge and Type_____

No. _____ Gauge and Type _____ No. _____ Gauge and Type_____

No. _____ Gauge and Type_____ No. _____ Gauge and Type_____

Temp Sensor: No. _____ Type _____ Location _____

Comments: _____

_____

APPENDIX 4
BID EVALUATION FORM

Note: Because this example form encompasses a variety of designs and applications, some of the items may not be relevant in all cases.

Sample Transport Bundle	Supplier 1	Supplier 2	Supplier 3
General Design			
Design Maintenance Temperature			
Design Safety Factor			
Maximum Continuous Exposure Temperature			
Maximum Intermittent Exposure Temperature			
Maximum Duration of Intermittent Exposure			
Minimum Installation Temperature			
Minimum Bending Radius			
Maximum Horizontal Support Distance			
Maximum Vertical Support Distance			
Does Sample Tube Bundle Carry 3rd Party Approvals?			
Agency Approving Bundle			
Approval Covers			
Entire Bundle			
Heater Only			
Sample Transport Bundle can be Cut-to-Length in Field			
Maximum Length that can be Trimmed			
Minimum Usable Bundle Length			
End Preparation			
Analyzer End Finished			
Sealed			
Leads Dressed			
Probe End Finished			
Sealed			
Leads Dressed			
Bundle Construction			
Sample Tube			
OD / Wall Thickness			
Material			
Grade/Specification			
Pressure Rating at Operating Temperature			

SAMPLE TRANSPORT BUNDLE *Continued from page 15*	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3
Calibration Tube			
OD / Wall Thickness			
Material			
Grade/Specification			
Pressure Rating at Operating Temperature			
Auxiliary Tubes *(used for)*			
Number			
OD / Wall Thickness			
Material			
Grade/Specification			
Pressure Rating at Operating Temperature			
Auxiliary Tubes *(used for)*			
Number			
OD / Wall Thickness			
Material			
Grade/Specification			
Pressure Rating at Operating Temperature			
Auxiliary Tubes *(used for)*			
Number			
OD / Wall Thickness			
Material			
Grade/Specification			
Pressure Rating at Operating Temperature			
Auxiliary Tubes *(used for)*			
Number			
OD / Wall Thickness			
Material			
Grade/Specification			
Pressure Rating at Operating Temperature			
Heater			
Type			
Power Output (Watts/Ft)			
Voltage			
Current Draw			
Startup			
Operating			
Circuit Breaker Size Required			

SAMPLE TRANSPORT BUNDLE *Continued from page 15*	SUPPLIER 1	SUPPLIER 2	SUPPLIER 3
Temperature Sensor			
Number Supplied			
Type			
Location			
Messenger Wire *(used for)*			
Number			
Gauge			
Type			
Voltage Rating			
Temperature Rating			
Listed / Approved			
Agency			
Messenger Wire *(used for)*			
Number			
Gauge			
Type			
Voltage Rating			
Temperature Rating			
Listed / Approved			
Agency			
Messenger Wire *(used for)*			
Number			
Gauge			
Type			
Voltage Rating			
Temperature Rating			
Listed / Approved			
Agency			
Messenger Wire *(used for)*			
Number			
Gauge			
Type			
Voltage Rating			
Temperature Rating			
Listed / Approved			
Agency			

Sample Transport Bundle *Continued from page 15*	Supplier 1	Supplier 2	Supplier 3
Messenger Wire *(used for)*			
Number			
Gauge			
Type			
Voltage Rating			
Temperature Rating			
Listed / Approved			
Agency			
Outer Jacket			
Type			
Material			
Jacket Temperature at Maximum Operating Conditions			
Documentation			
Certificate of Conformance			
Test Certificate Showing Factory Test Values			
Bundle Operating Parameters			
Installation / Use Instructions			
Commissioning Test Form			
Annual Test Form			
Warranty			
Warranty Period			
Warranty Period Begins			
On Invoice			
On Installation			
Warranty Covered by			
Installer			
Supplier			
Manufacturer			
Warranty Covers			
Materials			
Workmanship			
Installation			
Operation			

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VIM Technologies, Inc.
Zachry Construction Corporation

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