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BID SPECIFICATION INFORMATION REQUIREMENTS AND BID EVALUATION FORM FOR ACTIVATED CARBON INJECTION SYSTEMS

INSTITUTE OF
CLEAN
AIR
COMPANIES

ICAC

The Institute of Clean Air Companies, Inc. (ICAC) is the national association of companies that supply stationary source air pollution control and monitoring systems, equipment, and services. It was formed in 1960 (under the name IGCI) as a nonprofit corporation 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 primary 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 citizens.

Bid Specification Information Requirements & Bid Evaluation Form for Activated Carbon Injection Systems

Date Adopted: March 2010

SUMMARY:

This publication contains forms and accompanying text for collecting data necessary to solicit bids from vendors for activated carbon injection systems, preparing specifications and bid documents, and for collecting the elements of and evaluating the bids received. Explanations and commentary are also included to aid the purchaser in writing complete specifications and properly defining parameters needed for design.

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1. HISTORY

This document is the first version of ICAC's Bid Evaluation and Specification for Activated Carbon Injection Systems, which was adopted in 2010, due to the development of new air pollution control markets for mercury control technologies for coal-fired power plants. The Mercury Control Technology Division, which covers mercury control topics, of the Institute of Clean Air Companies prepared this new document in order to assure that appropriate and consistent information for activated carbon injection system design and selection is provided to both vendor and purchaser.

2. OBJECTIVE AND SCOPE

The objectives of this publication is to help purchasers of activated carbon injection systems compile all information necessary for vendors to produce meaningful bids, and to enumerate those elements of the bids that the purchasers should consider in their evaluations of competing bids. This document does not recommend specific design criteria for the components of activated carbon injection systems. The design of activated carbon injection systems is dependant on many variables and purchasers may wish to include some or all of the items detailed in the evaluation elements of this document in their bid specifications.

3. ACRONYMS, UNITS, AND ABBREVIATIONS

AC	Alternating Current (Electrical)
ACFM	Actual Cubic Feet per Minute
ACI	Activated Carbon Injection
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	ASTM International
AWG	American Wire Gauge
°C	Degrees Celsius
CEMS	Continuous Emissions Monitoring System
CFD	Computational Fluid Dynamics
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COHPAC	Compact Hybrid Particulate Collector
dBA	Decibels
DC	Direct Current (Electrical)
DCS	Distributive Control System
DFGD	Dry Flue Gas Desulfurization
EPRI	Electric Power Research Institute
ESP	Electrostatic Precipitator
°F	Degrees Fahrenheit
FF	Fabric Filter
Hg	Mercury
HBr	Hydrogen Bromide
HCl	Hydrochloric Acid

HF	Hydrogen Flouride
HMI	Human Machine Interface
N_2	Nitrogen
H_2SO_4	Sulfuric Acid
MCC	Motor Control Center
MTW	Machine Tool Wire
MW_{net}	Megawatts Net
MW_{gross}	Megawatts Gross
NEMA	National Electrical Manufacturers Association
NO_x	Nitrogen Oxides
O_2	Oxygen
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
P&ID	Piping and Instrumentation Drawings
PAC	Powdered Activated Carbon
PLC	Programmable Logic Controller
PM	Particulate Matter
RATA	Relative Accuracy Test Audit
RPM	Revolutions Per Minute
SCA	Specific Collection Area
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulfur Dioxide
SO_3	Sulfur Trioxide
SSPC	Society of Protective Coatings
TEFC	Totally Enclosed, Fan Cooled
TENV	Totally Enclosed, Non-Ventilated
THHN	Thermoplastic High Heat-resistant Nylon-coated
TOXECON	Technology for Control of Power Plant Mercury Emissions
VFD	Variable Frequency Drive
w.c.	Water Column
WFGD	Wet Flue Gas Desulfurization
w.g.	Water Gauge

4. DEFINITIONS

Activated Carbon – A highly absorbent carbon obtained by “burning” coal, coconut shells, or other carbon based materials in the absence of oxygen forming a highly porous material with a very large surface area. Activated carbon applied to the control of hazardous air pollutants such as mercury from coal-fired power plants is typically derived from bituminous or lignite coals.

Activated Carbon Injection System – In an ACI system, powdered activated carbon (PAC) is injected into the flue gas at a location in the duct preceding the particulate matter (PM) control device, which usually is an electrostatic precipitator (ESP) or a fabric filter (FF). The PAC sorbent binds with the mercury in the flue gas while traveling through the ductwork and while in the PM control device. Subsequently, the mercury-containing PAC is captured in the PM control device.

Activated Carbon Bulk Density – Bulk Density is used to determine the weight of a fixed volume of activated carbon. The bulk density of activated carbon is usually measured in grams per milliliter or pounds per cubic foot.

ACFM – Actual Cubic Feet per Minute (ACFM) is the volumetric flowrate of flue gas based on the actual temperature, pressure, and humidity.

Air-to-Cloth-Ratio – Baghouse size for a particular unit is determined by the choice of air-to-cloth ratio, or the ratio of air flow to cloth area, typically expressed in feet per minute (cubic feet per minute of flow divided by square feet of fabric area). The selection of air-to-cloth ratio depends on the particulate loading and characteristics, control application, and the cleaning method used for the baghouse.

COHPAC™ – COHPAC is an EPRI licensed technology which is centered around the combination of an existing or new electrostatic precipitator with a high air to cloth ratio baghouse. The polishing size baghouse is placed in a separate casing downstream of the existing ESP and is referred to as COHPAC I configuration. With the COHPAC II configuration, one or more fields of the existing ESP’s casings is replaced with baghouse modules (COHPAC II).

Halogenated Activated Carbon – Halogenated activated carbons, also referred to as chemically treated carbon, are made by impregnating activated carbon with halogenated compounds. For coal-fired mercury control applications, bromine has been the primary halogenated compound applied to activated carbon.

Method 30A – U.S. Environmental Protection Agency’s Method 30A is a procedure for measuring the mass concentration of the total vapor phase mercury (Hg) emissions from stationary sources using an instrumental analyzer, which represents the sum of elemental Hg (Hg°) and oxidized forms of Hg (Hg^{+2}), in mass concentration units of micrograms per cubic meter ($\mu g/m^3$). This method is particularly appropriate for performing emissions testing and for conducting relative accuracy test audits (RATAs) of mercury continuous emissions monitoring systems (Hg CEMS) and sorbent trap monitoring systems at coal-fired combustion sources.

Method 30B – U.S. Environmental Protection Agency’s Method 30B is a procedure for measuring total vapor phase mercury (Hg) emissions from coal-fired combustion sources using sorbent trap sampling and an extractive or thermal analytical technique. This method measures elemental Hg (Hg°) and oxidized forms of Hg (Hg^{+2}), in micrograms per dry standard cubic meter (μg/dscm). This method is intended for use only under relatively low particulate conditions (e.g., sampling after all pollution control devices).

Motor Control Center – A motor control center (MCC) is an assembly of one or more enclosed sections having a common power bus and principally containing motor control units. The motor control center, through automatic or manual means, controls the operation of a motor or including starting and stopping the motor, motor speed, etc.

Mercury Treatment Resident Time – This is the amount of time that activated carbon has to react with mercury once the activated carbon is injected into the duct work prior to being collected in a downstream particulate control technology system or other process.

Specific Collection Area – The primary parameter used to compare electrostatic precipitator size and collection efficiency is the specific collection area. The specific collection area is the ratio of the total area of the collector plates to the gas volumetric flow rate. Specific collection area is expressed in ft^2/1000 acfm (sec./ft) in English units or m2/(m^3/sec) (sec./m) in System International units.

TOXECON™ – TOXECON I is an EPRI licensed technology involving the introduction of a sorbent between a primary particulate collector and a fabric filter system for control of mercury emissions. TOXECON II is an EPRI licensed technology that injects a sorbent in between fields of an ESP or ESP/baghouse hybrid in order to collect fly ash in the fields prior to the carbon injection.

5. INSTRUCTIONS FOR COMPLETING BID SPECIFICATION INFORMATION REQUIREMENTS (FORM 1)

These Bid Specification Information Requirements outline the basic data required for activated carbon injection system sizing and provide insight to aid in writing bid specifications. Complete and properly prepared specifications for activated carbon injection equipment are essential to assure the purchaser that the equipment will be properly designed and sized to satisfy control requirements, and to avoid the need for change orders and consequent added cost.

Enclosed are forms designed to ensure that all necessary data is provided with the bid specifications. These forms list pertinent data required for proper sizing of an activated carbon injection system or should insufficient or incomplete data be supplied, identify sources that may be consulted to acquire the necessary information. An appendix has also been added to this document containing a sample specification that would be written by a vendor for an activated carbon injection system.

All data pages are identified by major headings and sub-headings. Beginning with the first of the data pages, explanations are provided for clarification of the data required for each sub-heading. Commentary is also included to aid the purchaser in developing a meaningful bid request that will result in bids that provide properly sized equipment and the complete desired scope of work.

In general, activated carbon injection system industry experts and suppliers agree on the important parameters for system sizing. However, supplier databases and injection techniques may take into account different parameters, depending upon the individual supplier's experience and design basis. The forms and commentary provided with this publication seek to incorporate all data that might be expected to be used by activated carbon injection system vendors.

5.1 General Information

Information included under the heading "General Information" should be provided to help the bidder identify the location of the installation and the parties involved in specifying the equipment and evaluating the bids. Additional information regarding proposal requirements is also included in this section.

5.1.2 Purchaser. The purchaser of the equipment must be identified clearly. The purchaser may be different than the "User," or may be the same.

5.1.3 User. As with "Purchaser," the user should be clearly identified. The purchaser may provide financing for an installation, but not be the end user of the equipment specified.

5.1.4 Architect/Engineer. An architect/engineer, if used, will generally provide control over all technical aspects of the specification and subsequent installation. While information regarding the architect/engineer (address, contact name, and phone, etc.) is important, it is equally important that the purchaser or whoever is specifying the equipment point out to each bidder the contact or entity that will ultimately decide the technical requirements for the installation.

5.1.5 Plant Site Location. The site location refers to the ultimate installation site for the equipment including the boiler number in the case of multiple generators per site.

5.1.6 Equipment Type. The type of installation (new, replacement, or upgrade) must be identified. For example, a replacement unit or upgrade may require different labor or labor skills than a new installation.

5.1.7 Proposal Type. The type of proposal desired should be indicated. A specification for a firm priced proposal for purchase generally takes a great deal more time to develop than one for a budgetary proposal. Evaluation of firm bids for purchase will also take more time. Reasonable time periods for bidding and evaluation need to be allowed. Typical bidding times are 1-2 weeks for a budget, 2-4 weeks for a firm priced proposal, with longer time periods required for a turnkey proposal.

5.1.8 Freight Terms. Freight terms identify the party responsible for the payment of freight. Some of the commonly used terms to express the freight terms include: (1) "Prepaid" where the vendor is responsible, (2) "Collect" where the purchaser pays the freight, (3) "Prepaid/Collect Beyond" where the vendor or purchaser pays the prepayment portion with the remainder being the responsibility of the purchaser, (4) "Pre-pay" and "Add" where the vendor advances the freight charges to the carrier and then bills the purchaser.

5.1.9 Schedule Dates. Pertinent dates defining project scheduling requirements should always be supplied. These dates include:

- Proposal Submittal
- Award of Contract
- Engineering information such as loading diagrams, general arrangement/outline drawings, single line diagrams; P&IDs, and consumables
- Both preliminary and final drawing submittal dates required
- Final Inspection
- Equipment Delivery to Site
  - Field erected or pre-assembled
- Erection Start/Completion
- Mechanical Completion
- Plant, Boiler, or Other Process Equipment Outage
- Start-up
- Acceptance Testing

5.2 Bidder Scope of Supply.

The overall scope of the project must be clearly identified to ensure that the bidder includes all necessary work in his proposal. Check blocks are provided for each item on the checklist to ease completion of the data forms. Specification information should include details of each item that is checked under "Bidder Scope of Supply."

5.3 Process Information.

The following section will discuss the process information requested by vendors that is critical for proper design and sizing of activated carbon injection system equipment.

5.3.1 Process Description. Process information describes the process from which exhaust gas emanates. Activated carbon injection systems that are to be installed to treat utility boiler exhaust gases may require different bidder-proprietary sizing criteria than will activated carbon injection systems to be installed on industrial applications. It is extremely important, therefore, to fully identify the process on which the activated carbon injection system is to be installed, and to include all details important for activated carbon injection system sizing and design.

The major process related factors affecting activated carbon injection design include volumetric and mass gas flow rates, flue gas temperature, gas moisture content, mercury content in flue gas, sulfur trioxide (SO_3) levels in flue gas, etc. The configuration of the system is also required. Does it have an SCR/SNCR (ammonia slip) ESP or FF or a TOXECON system, DFGD or WFGD systems? Final configuration can affect the overall mercury reduction levels and PAC feed rates.

5.3.2 Flue Gas Analysis. In order to properly size and design an activated carbon injection system, it is essential that the purchaser identify all of the expected pollutants in the flue gas just upstream of the point of injection of the activated carbon. Typically, if on an existing boiler, an existing stack test is available or can be performed to identify the pollutant concentrations as well as other flue gas constituents. Care should be taken to ensure that a process/flue gas analysis is provided that will not result in unreasonable sizing and injection rates for the activated carbon injection system, and that will ensure compliance with emission limits over the full range of system operation.

Providing only the minimum and maximum values may result in bidders selecting the "worst case" values in order to meet compliance objectives. Using a combination of all such "worst case" values simultaneously can result in the selection of an activated carbon injection system that is oversized and more expensive. The purchaser should indicate "Design Values" for the process/flue gas that will ensure compliance with emission limits over the entire range of operation.

5.3.3 Mercury Speciation. Mercury speciation data in conjunction with information on existing or planned particulate and SO_2 control systems is useful in estimating the activated carbon requirements and sizing the ACI system.

5.3.4 SO_3 Interference. SO_3 has been shown to impede the ability of activated carbons to reduce mercury emissions. The specifications should indicate the expected level of SO_3

(ppmv) in the flue gas stream at the point of activated carbon injection. The specification should also indicate, if the particulate control device is an electrostatic precipitator (ESP), the degree of any SO_3 injection being used for fly ash conditioning.

5.3.5 **Temperature.** Carbons respond differently to the different temperatures so that the all possible temperatures that could be encountered during operation of an ACI system will need to be determined prior to selecting the type of activated carbon. The flue gas temperature for the following locations and scenarios should be provided: at the injection point, upstream and downstream of the air preheater, temperature range during normal and upset operating conditions. The specification should also stipulate whether or not the applicable permits/regulations require that the carbon injection temperature be monitored. The purchaser should indicate if the supplier is expected to supply and/or install temperature monitoring equipment at the injection point or if the data from the chimney flow monitoring system be sufficient.

5.3.6 **Treated and Non-Treated Activated Carbon.** The specification should indicate whether the ACI system being supplied will be injecting treated (e.g. impregnating PAC with halogenated chemicals such as HBr or HCl) or non-halogenated carbon.

5.3.7 **Carbon Injection Rate.** The specification should indicate the maximum injection rate, in pounds of activated carbon per hour that will be used by the activated carbon injection system. This is a key factor in determining the size of the storage silo as well as the size of the carbon feeder so that the carbon feeder can meter carbon at the maximum rate required. Typically, the PAC supplier determines the maximum injection rate of PAC when a reduction requirement is specified. However, this could be specified when a rate is required by a regulatory requirement or a limitation elsewhere in the plant (e.g. PAC injection rate may be limited by the ability of the particulate collection device to meet the existing opacity limit).

5.3.8 **Carbon Storage Volume.** Information needs to be supplied as to the expected volume or mass of activated carbon to be stored for proper sizing of silos. This information should include, at a minimum;

- Density of Carbon to be used for determining storage volume
- Density of Carbon to be used for storage system structural design
- Mass of Carbon to be stored at one time, or
  - Design flue gas flowrate at injection point (acfm)
  - Design carbon injection rate (pounds/million acf)
  - Storage time (hours, days, or weeks)

5.4 Activated Carbon Injection System Sizing, Performance, and Structural Design Criteria

5.4.1 **Sizing Criteria.** Operating conditions specified by the purchaser play the largest role in the proper sizing and design of an activated carbon injection system.

The sizing criteria for selecting the appropriate activated carbon injection rate include variables for mercury removal efficiency, gas volume, flue gas temperatures, and other parameters such as type of particulate removal device and overall system configurations. The volumetric and mass gas flow rates in acfm must be specified, in part to ensure a consistent basis for different vendors' designs. The basis for determining the specified flow rate should be included, as should the basis for guarantee testing. These values are typically based on stoichiometric, pitot tube or other calculations. If calculations are used, the maximum gas flow rates under any process conditions must be specified, as well as margins added for conservatism. Inlet mercury levels and required outlet emissions values should be presented in like units to ensure consistency and correctness in different bids.

5.4.2 **Test Method.** Reference test method and test equipment for measuring emission guarantee parameters should be included. Test methods should reference specific U.S. EPA methods such as 30A (Instrumental Method for Mercury Measurement) and 30B (Sorbent Trap Method for Mercury Measurement). Test methods should also be specified for measurement of any other criteria (such as CO_2 or O_2) necessary for determining emissions and compliance with emission guarantees.

5.4.3 **Transporting, Unloading, and Storage.** This section of the specification should address whether it is expected that the ACI system will be assembled on-site (i.e. field fabrication) or shop assembled and shipped as a complete or semi-complete system. This section should also request the supplier to provide information on equipment requirements for unloading the ACI system or its components at the site and also any special storage requirements.

5.4.4 Feeding. This section should address whether the carbon feeder is to be volumetric or gravimetric and what ancillary equipment (shut-off valves, etc.) is also to be supplied as a part of the activated carbon feeder.

5.4.5 Control. This section should address the control of the ACI system including any and all interfaces with existing plant instrumentation and controls. The purchaser should specify if there is to be any connections to the plant DCS or is the supplier expected to supply all PLC's necessary for control of the ACI system. Is the supplier expected to provide any HMI (Human-machine interfaces) panels? If the purchaser is intending on control of the ACI system from an existing DCS then the purchaser should determine whether DCS programming, including graphics, shall be by the supplier or the purchaser's personnel.

5.5 Additional Specification Information

Specification documents may need to include more information than is shown on the attached forms. Sections may be included discussing various activated carbon injection system and auxiliaries which the purchaser wishes to include in the specification. The following partial list should be considered:

- Access – the specification should include information as to the minimum access for maintenance and operation around equipment.
- Air Compressor or Blower
- Air Dryer
- Approved Sub-Vender List
- Configuration, including lighting and maintenance access doors to silo skirt or control box under/at the storage silo.
- Control Building/Equipment and Control Interface into Existing Plant Control Systems
- Degree of Erection (One or Two Piece Silo Design)
- Materials of Construction, Including Minimum Thickness of Silo Shell
- Model Study - Physical or CFD and the Criteria Pertaining to the Model Study (typically sorbent distribution RMS $< 15\%$ at plane of interest)
- Motor Control Center (MCC)
- Number of feed trains/silo (i.e. $2 \times 100\%$, $3 \times 50\%$, etc.)
- Type and Material of Activated Carbon Storage Silo
- Type and Material of Injection Lances

Some of these items are listed on the bid evaluation forms, which can be used as a checklist when writing the specifications.

The purchaser should supply layout drawings, indicating real estate restrictions, lay down areas, the arrangement of existing equipment, and the location and general layout of the new equipment.

6. INSTRUCTIONS FOR USING THE BID EVALUATION FORM (FORM 2)

Five columns are included on the bid evaluation form. The first column lists typical parameters or items that may be of interest during bid evaluation. Some of the items listed in the first column of the bid evaluation form may be "required" by the purchaser. By including a column marked "Required," the purchaser may use the evaluation form as a checklist to ensure that all requirements are included in the specification and that the bidders address such requirements.

The final three columns are provided for bid evaluation. Values provided by each bidder can be entered for each item in the first column for side-by-side comparison of each bidder's offering.

6.1 Additional Information

The purchaser may also require additional information, not included on the attached data sheets. For example, should guarantees or expected operation require reporting at "standard" or "normal" conditions, the purchaser must identify what defines those conditions.

FORM 1: BID SPECIFICATION INFORMATION REQUIREMENTS (to be completed by purchaser) – Sheet 1 of 3

GENERAL INFORMATION

■ PURCHASER

Name: ______________________________
Address: ______________________________
City/State/Zip: ______________________________
Contact ______________________ Phone: ______ - __________ Fax: ______ - __________
Email: ______________________________

■ USER

Name: ______________________________
Address: ______________________________
City/State/Zip: ______________________________
Contact ______________________ Phone: ______ - __________ Fax: ______ - __________
Email: ______________________________

■ ARCHITECT/ ENGINEER

Name: ______________________________
Address: ______________________________
City/State/Zip: ______________________________
Contact ______________________ Phone: ______ - __________ Fax: ______ - __________
Email: ______________________________

■ PLANT SITE LOCATION

Plant Name: ______________________________
Address: ______________________________
City/State/Zip: ______________________________
Contact: ______________ Phone: ______ - __________ Fax: ______ - __________
Email: ______________________________

■ EQUIPMENT TYPE

❑ New ❑ Replacement
❑ Upgrade ❑ Supplemental

■ PROPOSAL TYPE

❑ Firm ❑ Budget

■ FREIGHT TERMS:

____

■ SCHEDULE DATES

Pre-Bid Meeting: __________ Bid Due: __________ Contract Award: __________ Kick-Off Meeting: __________ Engineering Completion: __________

Submittal of Drawings:

Assembly Drawings: __________ Foundation Loading Drawings: __________ General Arrangement Drawings: __________ Instrumentation and Control Drawings: __________ Piping and Instrumentation Drawings: __________ Single Line and Other Electrical Drawings: __________

Material Delivery Start: __________ Material Delivery Completion: __________ Installation Start: __________ Installation Completion: __________ Unit Start-Up: __________

Performance Test “A”: __________ Performance Test “B”: __________

BIDDER SCOPE OF SUPPLY

	BIDDER REQUIRED	OWNER/ OTHER
Compressed Air System	❑	❑
Controls	❑	❑
Control Panel Components	❑	❑
Electrical Components Lighting, Receptacles, etc.	❑	❑
Feeder Hopper	❑	❑
Flow Modeling (Specify Physical or Computational)	❑	❑
Foundations	❑	❑
Sorbent Injection Manifold	❑	❑
Injection Lances	❑	❑
Interconnecting PAC Transport Piping with pipe supports	❑	❑
MCC	❑	❑
Emissions Monitoring Devices	❑	❑
PAC Storage Silo with all the auxiliary equipment (such as bin vent filter, pressure / vacuum relief valve, fluidizing system, discharge knife gate vale etc.)	❑	❑
Silo Fill Line Piping	❑	❑
Pneumatic Conveying System	❑	❑
Powdered Activated Carbon	❑	❑

FORM 1: BID SPECIFICATION INFORMATION REQUIREMENTS – Sheet 2 of 3

BIDDER SCOPE OF SUPPLY *(continued)*

	BIDDER REQUIRED	OWNER/ OTHER
Silo/Feed & Control Enclosure Accessory Items	❑	❑
Spare Parts	❑	❑
Startup and Performance Testing Support	❑	❑
Structures and Support	❑	❑
Volumetric or Gravimetric Feeder	❑	❑
Other	❑	❑
Sorbent Injection Ports	❑	❑
Access Platforms	❑	❑
Access to Silo Roof (Spiral Stair Tower or Ladder & Cage)	❑	❑
Material Handling Equipment – Jib Crane on silo roof	❑	❑
Duct Arrangement Drawings	❑	❑

PROCESS INFORMATION: (Must be provided by the owner or architect/engineer.)

■ PROCESS DESCRIPTION

Boiler Type ______________ Boiler Manufacturer & Model ______________ Number of Units ______________

Boiler Rating (MW-net) ______________ Boiler Rating (MW-gross) ______________

Fuel Type & Feed Rate ______________ Heat Input (mmBtu/Hr) ______________ Gross Unit Heat Rate (Btu/kW-hr) ______________

Flue Gas Temperature at injection point and through the AC flow path until it is collected in a particulate collection device.

- Injection Point ______________ - Upstream of Air Preheater ______________ - Downstream of Air Preheater ______________

- Operating Temperature Range at Normal and Upset Conditions ______________ - Other Location ______________

Process Output - Continuous ______________ - Peak ______________ - Design ______________

SO_3 Interference (If using ESP, indicate if using flue gas conditioning) ______________

Upstream Air Pollution Control Devices, (Include Details) ______________

Sorbent Type: Treated (Halogenated) or Untreated ______________

Duct Arrangement Drawing: ______________

■ FLUE GAS ANALYSIS

Constituent	% by Volume	lb/hr	Test Method
Hg ($\mu g/dNM^3$)	______	______	______
Hg° (elemental)	______	______	______
Hg^{+2} (oxidized)	______	______	______
Hg^{p} (particulate)	______	______	______
H_2O	______	______	______
N_2	______	______	______
CO_2	______	______	______
O_2	______	______	______
SO_2	______	______	______
SO_3	______	______	______
Other (specify) CO, NO_x, HCl, HF, HBr	______	______	______

■ FLY ASH ANALYSIS

Constituent	Maximum Value (% by Weight)	Minimum Value (% by Weight)	Design Value (% by Weight)
Ash	______	______	______
Carbon	______	______	______
Other	______	______	______

■ ATTACH TABLE FOR COAL ANALYSIS (Ultimate/Proximate type acceptable)

FORM 1: BID SPECIFICATION INFORMATION REQUIREMENTS – Sheet 3 of 3

ACTIVATED CARBON INJECTION SYSTEM SIZING & STRUCTURAL DESIGN CRITERIA (Choose either English Units or System International Units)

■ SIZING CRITERIA (English Units)

Gas Volume (acfm) ______
Mass Flow (lb/hr) ______

Flue Gas Temp. (°F)
- Injection Point ______
- Upstream of Air Preheater ______
- Downstream of Air Preheater ______
- Temperature Range
  Nomal Operation ______
  Upset Conditions ______

Gas Pressure (in. w.g.)
- Normal Operating - positive ______
- Normal Operating - negative ______
- Surge Pressure - negative ______
- Surge Pressure - positive ______

SO_3 (equiv) Inlet Loading (ppmv) ______
SO_3 (equiv) Inlet Loading (ppmvd) ______
SO_3 (equiv) Inlet Loading (lb/mmBtu) ______
SO_3 (equiv) Inlet Loading (lb/hr) ______

■ STRUCTURAL DESIGN CRITERIA (English Units)

Gas Temperature (°F) - Normal Operating ______
- Excursion (1 Hr) ______

Gas Pressure (in. w.c., static)
- Normal Operating - positive ______
- Normal Operating - negative ______
- Surge Pressure - negative ______
- Surge Pressure - positive ______

Site elevation (ft. above sea level) ______
Standard Barometric Pressure (in. Hg) ______
Standard Temperature (°F) ______

Design ambient temperature - Max (°F) ______
Design ambient temperature - Min (°F) ______

■ BUILDING CODE (Need to specify Building Code, eg., IBC 2007, etc…)

Access Live Load (lb/ft^2) ______
Roof Load (lb/ft^2) ______
Seismic Design Criteria ______

Snow Load (lb/ft^2) ______
Wind Load (lb/ft^2) ______
______

■ SIZING CRITERIA (System International Units)

Gas Volume (m^3/hr) ______
Mass Flow (kg/hr) ______
Gas Temperature – (°C) - Normal ______
- Excursion (1 hr) ______

Gas Pressure (mm w.c., static)
- Normal Operating - positive ______
- Normal Operating - negative ______
- Surge Pressure - negative ______
- Surge Pressure - positive ______

SO_3 (equiv) Inlet Loading (ppmv) ______
SO_3 (equiv) Inlet Loading (ppmvd) ______
SO_3 (equiv) Inlet Loading (kg/hr) ______

■ STRUCTURAL DESIGN CRITERIA (System International Units)

Gas Temperature (°C) - Normal Operating ______
- Excursion (1 Hr) ______

Gas Pressure (mm w.c., static)
- Normal Operating - positive ______
- Normal Operating - negative ______
- Surge Pressure - negative ______
- Surge Pressure - positive ______

Site Elevation (m above sea level) ______
Standard Barometric Pressure (mbar, mm Hg) ______
Standard Temperature (°C) ______

Design ambient temperature - Max (°C) ______
Design ambient temperature - Min (°C) ______

■ BUILDING CODE (Need to specify Building Code, eg., IBC 2007, etc…)

Access Live Load (kg/m^2) ______
Roof Load (kg/m^2) ______
Seismic Design Criteria ______

Snow Load (kg/m^2) ______
Wind Load (kg/m^2) ______

■ OPERATING CRITERIA (Need additional clarification)

Transporting Carbon ______
Unloading Carbon ______
Storing Carbon ______

Feeding Carbon ______
Control Systems ______

■ ADDITIONAL SPECIFICATIONS

FORM 2: BID EVALUATION FORM – Sheet 1 of 4

Bidder #1: ______________________ Bidder #2: ______________________

Bidder #3: ______________________

- **OPERATING & PERFORMANCE DATA**

	Required	Bidder #1	Bidder #2	Bidder #3
Design Basis - *English Units*				
Gas Volume (acfm)				
Mass Flow (lb/hr)				
Gas Temperature (°F)				
Gas Pressure (in w.c.)				
Compressed Air Consumption (scfm & pressure)				
Carbon Injection Rate (lb/mmacf)				
Carbon Storage Volume (ft^3)				
Carbon Type				
Untreated				
Treated				
Mercury Treatment Residence Time Estimated @ Full Load Conditions (sec)				
Number of Operating Trains				
Number of Spare/Redundant Trains				
Other				
Other				
Performance Data - *English Units*				
Mercury Control Level (% or lb/GWh)				
Duct Residence Time (sec) @ full load conditions				
Power Consumption (kW-hr)				
Noise Levels (dBA) (Within 3′ radius of source)				
System Reliability/Availability (%)				
Auxiliary Power Consumption (kW-hr)				
Compressed Air/Instrument Air Consumption				
Silo Vent Filter Opacity, %				
Silo Vent Filter Emissions, grains/scf				
Maximum Flue Gas Pressure Drop across Injection Lances at Unit Full Load, in W. C.				
Design Basis - *SI Units*				
Gas Volume (m^3/hr)				
Mass Flow (kg/hr)				
Gas Temperature (°C)				
Gas Pressure (mm w.c.)				
Air Consumption (scfm & pressure)				
Carbon Injection Rate (what units?)				
Carbon Storage Volume (m^3)				

FORM 2: BID EVALUATION FORM – Sheet 2 of 4

■ OPERATING & PERFORMANCE DATA *(continued)*

	Required	Bidder #1	Bidder #2	Bidder #3
Carbon Type				
Un-treated				
Treated				
Mercury Treatment Residence Time (sec)				
Other				
Performance Data - *SI Units*				
Mercury Control Level (% or μg/nm^3)				
Feeder Accuracy (%)				
Duct Residence Time (sec)				
Power Consumption (kW)				
Noise Levels (dBA)				
System Reliability/Availability (%)				
Mercury Treatment Residence Time (sec)				
Auxiliary Power Consumption (kw-hr)				
Other				
Silo Vent Filter Opacity, %				
Silo Vent Filter Emissions				
Maximum Flue Gas Pressure Drop across Injection Lances at Unit Full Load, bar				

■ AUXILIARY EQUIPMENT

	Required	Bidder #1	Bidder #2	Bidder #3
Storage Silo				
Manufacturer				
Quantity				
Material of Construction				
Construction (Welded or Bolted)				
Dimensions				
Wall Thickness				
Number of hoppers per silo				
Hopper Cone Angle, Degrees				
Storage Capacity				
Solids Density (Volume / Structural)				
Freeboard				
Pressure And Vacuum Design Rating				
Quantity of Level Detectors				
Number Of Shipping Pieces				

FORM 2: BID EVALUATION FORM – Sheet 3 of 4

■ **AUXILIARY EQUIPMENT** ***(continued)***

	Required	Bidder #1	Bidder #2	Bidder #3
Silo Loading Pipe				
Size				
Inside Diameter / Wall Thickness				
Capacity				
Maximum pressure in the loading pipe line				
Materials of construction				
Silo Loading Pipe Fittings				
Type of connection for fittings				
Type of connections for straight sections				
OSHA Approved Access to Silo Roof				
Compressed Air System for Carbon Injection System				
Silo Vent Fans				
No. / Silo				
Type				
Manufacturer				
Motor Horsepower				
Voltage / Current				
Silo Heaters				
Min Temperature Requirements in Silo Shell (C°)				
Silo Dust Collector/Bin Vent				
Type, Manufacturer, Air Consumption, Collecting Efficiency				
Others				
Silo Isolation Valves				
Manufacturer and Model Number				
Manual Valve / Pneumatic Valve				
Size				
Cylinder Size (if applicable)				
Rotary Feeder				
Manufacturer and Model Number				
Maximum feed capacity				
Maximum turndown				
Feeder Hopper				
Manufacturer				
Capacity				
Volumetric Feeder				
Manufacturer and Model Number				
Maximum feed capacity				
Maximum turndown				
Blowers				
Manufacturer and Model Number				
Rated capacity				

FORM 2: BID EVALUATION FORM – Sheet 4 of 4

■ **AUXILIARY EQUIPMENT *(continued)***

	Required	Bidder #1	Bidder #2	Bidder #3
Discharge pressure at rated capacity				
Outlet air temperature rise at rated capacity				
Eductor				
Manufacturer and Model Number				
Maximum Feed Capacity				
Distribution Manifolds:				
Manufacturer and model number				
Quantity				
Size				
Injection Lances				
Manufacturer				
Diameter				
Materials of Construction				
Quantity per Duct				
PAC Injection Transport Piping				
Pipe Material				
Pipe Size				
Schedule / Wall thickness				
Materials of Construction				
Straight sections				
Bends				
Recommended PAC transport velocity				
PAC Injection Transport Piping Fittings				
Type of connections for fittings				
Type of connections for straight sections				
Flow Model Included (Yes / No)				
Quantity of O & M Manuals				

NOTES AND ADDITIONAL INFORMATION:

APPENDIX A: SAMPLE BID SPECIFICATION FOR AN ACTIVATED CARBON INJECTION SYSTEM ON A COAL-FIRED POWER PLANT

I. SCOPE OF WORK

A. GENERAL SCOPE OF WORK

1. PAC System Supplier.

a. The Powdered Activated Carbon (PAC) System Supplier (Seller) shall design, procure, and provide a complete, fully functional system for receiving PAC from a bulk truck transport trailer, storing PAC in a bulk dry silo and feeding PAC on demand to the battery limits indicated on the drawings. Seller shall assist with erection and installation, check out and start-up as described herein.

b. The PAC storage and injection system shall include a PAC storage silo, silo vent filter, feeder skid, manual valves, rotary valves/feeders and instruments as required to provide a complete operating system, except as noted herein.

c. The PAC system feed skid shall be pre-assembled at the factory to the greatest extent possible and delivered to the site ready for installation. The silo vent filter shall be assembled to the extent practical prior to delivery to the site.

d. Seller shall design and provide the anchor bolts for all steel structures and supports that are in physical contact with the foundation and the design loads for foundation design.

e. All PAC system components shall either be located inside the silo under-skirt area, mounted on the silo exterior walls or on the storage silo top deck, or located inside a control and feed compartment separate from but located underneath the storage silo. An optional stand-alone electrical equipment building may be provided to house all ACI controls in lieu of under the silo skirt. Safe working clearance around equipment inside silo skirt and external buildings shall be provided.

f. Seller shall design and provide the sorbent distribution manifold(s) and all necessary injection lances, isolation valves and expansion joints to achieve suitable sorbent distribution upstream of the particulate collection equipment.

g. Provide logic diagrams that will allow the Purchaser to program control of the PAC injection system.

h. Provide any and all control graphics necessary for operation of the Purchasers control system with input from the Seller.

i. Provide any PLC's (If required) necessary for complete local control of the PAC system by the Purchaser. Instrumentation shall allow for control of the PAC system either from the locally mounted PLC's or from the Purchasers DCS.

j. Provide a complete compressed air system, with dryer(s) and receiver(s) to supply all compressed air required by the PAC system. (If Required)

k. Seller shall provide sorbent distribution manifold and injection lances as required. Seller shall also provide all necessary information required to install injection ports as required at the sorbent injection location.

2. Purchaser/Installation Contractor.

a. Install the following components that are located on the silo roof or are connected to the silo including but not limited to the vent filter, level switches, electric heater, exhaust fan, interior and exterior lights and switches, level transmitter, relief valve, fill piping and supports, ladder and rest platform, or spiral stairway, roof handrail, compressed and fluidizing air piping and tubing, knife gate valve, rotary valve and expansion joint.

b. Final field assembly, field interconnecting piping, conduit and cable, field electrical and mechanical terminations, and adjustments necessary to provide a complete operating system.

c. Design and install the PAC system foundation based on loads provided by Seller.

d. Provide all system controls via the facility DCS, conduit and wiring between DCS and system devices.

e. Provide breakers and motor starters for all 480 volt three (3) phase loads via a local motor control center, conduit and wiring between MCC and field devices and DCS. Motor voltage for electrical loads are very site specific. Alternatively, electrical/control building could be provided by supplier.

f. Provide breakers for 120 volt, single (1) phase, 60 Hz electrical power supply to the lights and convenience receptacles from a local lighting panel, conduit and wiring between lighting panel and field devices. Alternatively, electrical/control building could be provided by supplier.

g. Provide PAC transport piping and supports from the battery limits to Seller's supplied activated carbon distribution manifold point of usage.
h. Design, procure, and install materials necessary to install sorbent injection ports. Revise as necessary.
i. Design, procure, and install all supports required for sorbent distribution manifold located at injection location. Revise as necessary.
j. Design, procure and install, if necessary, access platforms at the sorbent injection location(s).

B. DESIGN PARAMETERS

1. The system shall be designed to meet the following requirements:
   a. Injection Location: *(Purchaser to specify)*
   b. Maximum Height Limitation: *(Purchaser to specify)*
   c. Maximum Silo Diameter: (~14 feet) *(Site specific)*
   d. Vent Filter Area: *(Purchaser to specify)* Filtering area and media can vary depending on process application.
   e. Maximum System PAC Feed Rate: *(Purchaser to specify)*
   f. Minimum System PAC Feed Rate: *(Purchaser to specify)*.
   g. Piping distance to PAC Injection Point *(Purchaser to specify, Supplier to verify distance from attached drawings)*.
   h. Number of LR Elbows in PAC Pipeline *(Supplier to estimate based on suggested routing by Purchaser)*.
   i. Elevation change to Injection Point *(Purchaser to specify)*.
2. The system shall be designed to meet all federal, state, and local codes and standards.
3. The system shall be designed in accordance with specific codes and standards referenced within these Specifications.
4. The system shall be designed for a non-classified area.

C. PAC SYSTEM SUPPLIER

1. The intent of this Specification is to procure a complete PAC injection system as described herein and as shown on the drawings completely designed and furnished by one (1) System Supplier.
2. The System Supplier shall have a verifiable history of design and manufacture of PAC injection systems and shall provide a list of similar project references.
3. The Purchaser shall have the right to decide if systems other than those designed specifically for use exclusively with Powdered Activated Carbon are acceptable.
4. The System Supplier shall provide purchaser a list of approved activated carbon sorbents which can be used with the injection system.

D. SUBMITTALS

1. The System Supplier (Seller) shall submit the following for review by the Engineer/Purchaser prior to beginning physical work on the project:
   a. A complete set of design drawings, including, but not limited to, piping & instrument diagram, general arrangement drawings, anchor bolt location drawings, equipment location drawings, electrical wiring schematics, logic diagrams and various project lists.
   b. A written system description that describes the proposed equipment, description of operation, start-up and operating instructions, and alarms and interlocks.
   c. A complete bill of material and a product data sheets for each proposed piece of equipment.
2. The submittal shall be provided as a single document, with identifying cover sheet, table of contents, and individual sections for the different pieces of equipment. The document may be bound in a three (3) ring binder. Documents shall be no smaller than 8½″ × 11″, except that design drawings shall be no smaller than 11″ × 17″.
3. Operation and maintenance manuals shall be furnished in accordance with the purchasers specifications.

E. STORAGE AND PROTECTION

Equipment shall be delivered to the site in the minimum shipments practical and shall be stored as required per design criteria and protected in accordance with the Seller's recommendations and these specifications.

F. FUNCTIONAL TEST

After the equipment has been installed and commissioned by the Installation Contractor, the Supplier shall perform a functional test, consisting of operating the equipment continuously for five (5) each 24 hour days, to demonstrate that the equipment operates as specified. Alternatively, a third party contracted by the Purchaser can provide this service. Thirty days prior to the functional test the Supplier shall submit a copy of the functional test plan to the Purchaser for their review and approval.

G. SYSTEM SUPPLIER'S SERVICES

1. The PAC System Supplier shall furnish the services of a factory representative as required to support installation, checkout, and start-up, and to supervise the functional testing and training as a part of the fixed firm price as described below. The Supplier's representative shall have full knowledge and experience in the installation, operation, start up and maintenance requirements of the type of equipment being installed.
   a. Two (2) trips to the site each for a period of five (5) each 8-hour days for the purpose of supporting the Installing Contractor during the erection phase of the project.
   b. One (1) trip to the site for a period of ten (10) each 8-hour days for the purpose of supporting checkout, start-up and the functional testing.
   c. One (1) trip to the site for a period of two (2) each 8-hour days for the purpose of training maintenance and operations personnel in the start-up, maintenance and operation of the system. Hours to support the field activities may vary depending on scope of required project.
2. The PAC System Supplier shall furnish the services of a qualified Suppliers representative as required to correct any PAC injection system deficiencies that are the responsibility of the PAC System Supplier. Such trips to the site shall be at the sole expense of the Supplier.

H. WARRANTY

The Supplier shall warrant the equipment against defective material and workmanship for a period of one (1) year from the completion of functional testing, not to exceed eighteen (18) months from the time of delivery of the equipment.

II. GENERAL SYSTEM DESCRIPTION

A. UNLOADING AND STORAGE

Dry PAC shall be pneumatically unloaded from a bulk truck transport trailer, utilizing the truck's compressor and hoses to transport the PAC through a carbon steel pipeline into the PAC storage silo. The PAC shall be stored in a welded carbon steel silo until utilized.

B. FEEDING

A combination of specially designed air fluidization nozzles, located in the discharge section of the silo, shall pulse compressed air into the bulk of the carbon, promoting mass flow from the flanged discharge connection. The fluidized PAC shall be fed from the silo into a gravimetric or volumetric feeder hopper by a rotary feeder, where it shall be temporarily stored until conveyed by the gravimetric or volumetric feeder into the drop tube and eductor inlet. The speed of the feeder shall be directly proportional to the amount of carbon measured by a loss of weight feeder or adjustable based on the density of the activated carbon being fed into the system. A variable speed motor shall be used to provide a wide range of carbon delivery rates from the feeder. Feeder design will vary with suppliers as there are some suppliers who do not use rotary feeders but use pneumatic knifegates and vibrating dischargers.

C. TRANSPORTING

Pneumatic conveying principles shall be utilized for transporting the PAC from the PAC feed system to the Purchaser's injection point. The compressed (motive) air shall be provided by a blower located near the injection system. A motive air stream shall pass through an eductor to draw the PAC into the transport pipeline and transport the PAC pneumatically as a dilute phase mixture to the injection point. Measures shall be provided to prevent the uncontrolled feeding of the activated carbon due to the vacuum of the eductor. The blower and eductor shall be sized such that the operation is virtually dust free and can pneumatically convey a wide range of injection rates. Pneumatic conveying design may vary with suppliers as some designs do not use eductor based systems. Alternatively, they may use other material handling equipment such as blow-thru rotary airlocks to deliver material into the conveyance pipeline.

D. CONTROL

The location for control of the PAC injection system shall be selectable by the Purchaser either at a local control panel (local PLC) or through a facility DCS control system located in the facility control room. Seller shall provide the necessary instruments for interlocks, sensors, alarms and trips to protect the system and identify upsets and/or failures. Under normal conditions, operator attention shall not be required.

III. SYSTEM EQUIPMENT

A. PAC STORAGE SILO

1. The bulk storage silo shall be a welded, carbon steel vertical cylinder with a conical bottom and a sloped roof. The silo shall be supported either by a full height, full diameter structural skirt complete with access doors or by structural steel above the control and feeding enclosure.
2. Design Loads: Design loads shall include the following loads acting separately or in combination:
   a. Dead weight of the structure.

b. Weight of powdered activated carbon based on 45 pounds per cubic foot for dead load.
c. Uniform Building Code or International Building Code, latest edition *(Purchaser to specify)*.
d. Transportation, handling, and erection loads.
e. Wind load per ASCE 7-98.
f. A live load of 100 pounds per square foot on the silo deck.
g. Wind and dead loads from the silo vent filter.
h. Dead load from the ladders, platforms and ancillary equipment.

3. The silo and anchor bolt system shall be designed by the silo manufacturer for the above noted loads acting separately or in combination.
4. The silo shall be supported by a concrete foundation designed and provided by the Purchaser or owners engineer, based on loads provided by the Silo Manufacturer.
5. Manufacture.
   a. The silo shall be fabricated of carbon steel plate with adequate thickness to withstand the full range of pressure or vacuum to which the silo is to be subjected. Conical bottom plates, the lower skirt (up to the cone) where the Suppliers design includes a skirt on the silo and the roof, shall be no less than 1/4-inch thick. Thickness will vary depending on height and seismic zone. The silo shall include lifting lugs, welded pads for external mounted components and pipe and conduit penetrations as required.
   b. The silo shall include a self-supporting roof with flanged openings for the silo vent filter, the vacuum/pressure relief manway, and the level-monitoring devices. The silo roof shall be sloped a minimum of ten (10) degrees to provide adequate drainage. The silo roof may have a jib crane with monorail hoist for raising top of the silo equipment such as the bin vent filter.
   c. The silo shall also include the following accessory items:
      i. Structural steel platform in the silo under-skirt area, where the Suppliers design includes a skirt area under the silo, approximately nine (9) feet above the floor for equipment access. The platform shall be fabricated structural members with galvanized grating.
      ii. The silo shall be secured with galvanized (or stainless steel) anchor bolts which can be attached to the base angle either directly or via clamp plate. Anchor bolts shall be designed to withstand both uplift and shear forces.
      iii. The silo shall be equipped to monitor PAC levels.
      iv. A 4″ ANSI 150# center top flanged connection for a radar type continuous level measurement sensor. It is recommended that the specification include an attachment (by the Purchaser) of acceptable suppliers of sub-systems and components.
      v. A 24-inch minimum diameter pressure and vacuum relief access manhole located in the silo roof. The manhole shall be capable of venting the maximum airflow that will occur in the PAC storage system including the airflow and surge that results when a delivery truck unloads. The manhole shall relieve pressure and vacuum in order to protect the silo.
      vi. A flanged penetration located on the silo deck for the silo vent filter.
      vii. Where the Suppliers design includes a skirt under the silo there shall be minimum two (2) fabricated steel access doors. The doors shall be hinged and complete with hardware and shall be flush mounted in the steel channel frame. The access doors shall be provided with a threshold, weather-strip and vent grill.
      viii. Access to the top of the silo shall be provided via a vertical, galvanized, OSHA approved steel ladder extending from the base of the silo to the intermediate platform(s) and on to the top of the silo or by a steel spiral stairway, or stair tower Any ladders shall be equipped with a galvanized steel OSHA approved safety cage and stairways shall be equipped with a handrail.
      ix. The silo shall be equipped with handrail and toe plate for the silo roof and platforms. The handrails shall be steel or aluminum pipe and shall meet OSHA standards. The toe plate shall be hot dipped galvanized steel.
      x. The silo shall be equipped with

penetrations and supports as necessary for installation of conduits and piping to the devices mounted external to the silo. No cutting and/or welding will be allowed on the silo after delivery without approval from the silo manufacture.

d. The silo shall be primed with a polyamide epoxy primer over a commercial SSPC SP-6 blast on the exterior surfaces and inside the under-skirt area. The exterior of the silo shall be coated with an Epoxy Primer and Polyurethane Enamel (or similar) topcoat of a color chosen by the Purchaser from the silo manufacturer's standard color chart. The silo top deck will be painted with a non-skid coating.

e. Receptacles and Lights: Provide waterproof, ground fault interrupting, duplex convenience outlets mounted on the roof and inside the silo skirt. Where the Suppliers design includes a skirt under the silo then the Supplier shall provide incandescent fixtures for mounting in the silo underskirt area. As required by Purchaser the Supplier may provide exterior high-pressure sodium lights for mounting on top of the silo. Provide lights switches for the interior lights.

B. SILO VENT FILTER

1. The PAC storage silo shall be equipped with a self-contained, open bottomed and flanged vent filter mounted to the top of the silo with the following features:
   a. Suitable for the continuous cleaning of the PAC conveying air vented from the storage silo during filling from bulk transport trailers.
   b. Pulse-jet filter type
   c. A pressure differential indicator and high differential pressure switch shall be provided.

C. SILO FILL LINE

1. A complete truck fill pipe assembly shall be furnished which will include 4-inch nominal diameter (4½″ OD), schedule 40 carbon steel pipe to convey the PAC from delivery truck into the silo. All bends in the fill pipeline shall have a minimum 2′-0″ radius and shall be designed for abrasion resistance. The fill pipe shall start at a point adjacent to the Truck Unloading Panel. The piping shall be supported with a suitable number of pipe supports to prevent movement and vibration.
2. The inlet end of the conveying pipe shall be provided with a 4-inch nominal quick disconnect male adapter and dust cap.

D. SILO DISCHARGE VALVE

The PAC storage silo discharge cone shall be equipped with a manually actuated knife gate valve. All wetted parts shall be constructed of 316 stainless steel and the valve shall be equipped with a manual actuator (e.g., handwheel, chainwheel).

E. SILO ROTARY FEEDER

The silo discharge cone shall be equipped with a rotary feeder for feeding the PAC from the silo into the feeder hopper.

1. The rotary valve shall have a displacement and rotation adequate to feed 150% of the maximum activated carbon feed rate during normal operation. The valve shall be of cast iron construction with flanged inlet and outlet connections. The rotor shall be machined steel with outboard bearings.
2. The design of the valve shall effectively isolate the rotor bearings from the process material. The valve shall be designed for use as a conveying feeder.
3. The drive motor shall be a minimum of ½ horsepower, 1,750 rpm, 480 volt, sixty (60) Hertz, three (3) phase, with a 1.0 service factor as operation of the valve is intermittent. The motor shall be TEFC or TENV and meet NEMA standards.
4. The motor shall be coupled to an oil bath lubricated gear reducer mounted on a support bracket extended from the valve body and shall drive the valve rotor through a chain and sprocket arrangement which is encased in an OSHA approved chain guard.
5. A vent shall be provided at the top of the feeder hopper to allow the escape of displaced air from the feeder hopper during refill. This vent line shall be directed to the inlet of the eductor, to the top of the silo, or to a filtration system.

F. FEEDER HOPPER

1. A PAC intermediate storage hopper shall be installed between the rotary valve and the volumetric feeder. The hopper shall have ample capacity for a product retention time of 20 minutes minimum, but not less than 5 cubic feet. The hopper shall be furnished with a flanged top cover and a flanged connection to the feeder.
2. The hopper shall be equipped with a level sensor to monitor and control the PAC level in the hopper.

G. VOLUMETRIC OR GRAVIMETRIC FEEDER

The feeder shall be of the variable speed control volumetric or gravimetric type, based on the Purchasers requirements utilizing a helical screw. The Supplier shall supply 2 × 100% feeders or 3 × 50%, for the PAC system.

Gravimetric feeders shall utilize a loss-of-weight principal of operation. Feeder shall meet the operating requirements as follows:

1. The feeder shall be capable of accurately feeding Powdered Activated Carbon (PAC with a density ranging from 25 pounds per cubic foot to 45 pounds per cubic foot) at a rate of *(Purchaser to specify minimum)* to *(Purchaser to specify maximum)* pounds/hour.
2. The feed screw shall be a helical design, constructed of 316 stainless steel and shall discharge the PAC through a discharge tube. The screw shall require no mechanical seal. All materials and design features shall be suitable for the material being handled.
3. The feeder/feeder drive motor shall be capable of delivering material at specified range as determined by purchaser.
4. The drive motor shall meet NEMA standards, TEFC, and shall be rated for inverter duty. The motor shall be 480 volt/3/60, 1750 RPM. The motor shall be powered and controlled from the PAC MCC. The feeder discharge shall be equipped with a drop tube that will guide the PAC from the feeder discharge tube into the eductor.

H. PNEUMATIC CONVEYING SYSTEM

1. Motive air shall be provided by a blower, as required to transport the maximum PAC requirements at the maximum distance and maximum injection point pressure.
2. Pressure indicating switches and or transmitters shall monitor the blower discharge for high and low alarms and the eductor inlet vacuum for high and low alarms.
3. Motive air piping between the blower and the eductor inlet shall be minimum schedule 40. PAC transport piping between the eductor outlet and the system battery limits shall be minimum schedule 40 carbon steel.
4. One or multiple convey line diverter valves are provided as needed to direct PAC from individual feeders to one or multiple convey lines which transport PAC to the flue gas duct(s). These valves shall be pneumatically or manually actuated and have valve position indicating switches.

I. COMPRESSED AIR SYSTEM

1. The Suppliers design may include a complete compressor system including motor, dryer, and receiver. Customer may supply instrument quality air to injection system to replace compressor. The capacity of the compressed air system shall be sufficient to supply all the compressed air needs of the PAC system. A 60-gallon dry air receiver tank shall be included in the Suppliers design to stabilize the compressed air pressure for the PAC system. The dry air receiver will be provided with relief valve, moisture drain, alarm pressure switch and pressure indicator. The dry air receiver shall be rated for 200 psig at 100 °F.
2. Pressure control valves shall be provided as required for proper operation of the subsystems.
3. Compressed air tubing shall be copper, ASTM B-88, Type K, hard drawn for 1″ or larger, with comparable solder joint fittings.
4. Fluidizing air tubing between the fluidizing solenoid valves and the fluidizing air nozzles in the silo discharge cone shall be ½″ size copper tubing ASTM B-88 Type K.

J. STRUCTURES & SUPPORTS

1. The PAC feed equipment with associated piping and instruments shall be mounted on a single support skid (s) fabricated from ASTM A-500 Grade B structural steel members. The structural members shall be of sufficient size to support the equipment without excessive deflection or vibration. Skid, brackets and conduit supports shall be fabricated in accordance with AISC.
2. All external carbon steel surfaces shall be blasted per SSPC SP6 commercial blast to obtain a 1.5 mil average profile.
3. All external carbon steel surfaces shall be primed and painted per manufacturers standard paint specifications.

K. SPARE PARTS

Spare parts shall be required as needed for one year. Spare parts will differ from various suppliers. Supplier shall provide a list of recommend spare parts such as:

- One Eductor
- One Point level switch
- One 2-way solenoid valve
- One Complete Set Vent filters
- One Variable Frequency Drive
- One Feeder drive motor

IV. CONTROLS

A. CONTROL WIRING PHILOSOPHY

1. The control wiring philosophy shall be such that all field control devices utilize normally closed contacts during normal operating condition.
2. A contact opening or an open circuit shall result in an alarm condition for the specific device.
3. Loss of power to a control device shall result in an alarm condition.

B. TRUCK UNLOADING CONTROL PANEL
A PAC Truck Unloading Control Panel shall be provided to facilitate unloading of bulk PAC transport trailers into the PAC storage silo. The control panel shall contain, lights, terminal blocks, switches, etc. as required and shall be mounted on the silo shell in close proximity to the silo fill pipeline.

C. PANEL FEATURES
The control panel shall be provided with the following items and/or features:

1. Panels shall be rated NEMA 4 or equivalent
2. Terminal blocks shall be provided for termination of all “field run” cables.
3. Terminal blocks for voltage of 120 volts and less shall be equal to Allen Bradley 1492-J6 (or equivalent) unless specified otherwise.
4. All selector switches, pilot lights, push buttons and other devices that are visible on the front of the panels shall have Lamacoid nameplates that are white with black letters.
5. Route all wiring in Panduit or similar wireways and separate into categories (i.e., 480 volt power, 120 volt control, etc.). AC or DC power wiring shall not run in any raceway with any type instrument wiring. Protect all wiring across panel hinges. Provide numbered terminal strips for all field-wiring terminations.
6. Wiring shall be stranded copper, 600 volt, MTW or THHN insulated, extra flexible type. Install a minimum of #12 AWG for all power wiring, #16 AWG for all control wiring and #18 AWG twisted shielded pair for analog signal conductors. Alternative wire types may be specified by purchaser if required.
7. Wiring at all terminals within panels, junction boxes, and field devices shall be numbered with shrink fit, machine printed labels.

E. ELECTRICAL COMPONENTS

1. 120 Volt Circuit Breakers: Allen Bradley 1492-CB or equivalent,
2. Control Relays: Allen Bradley type HA, Potter Brumfield type KRP or Square D type KP.
3. Selectors and Push buttons: 30.5 mm, heavy duty, NEMA 4X rated; contacts rated 10 amps continuous, 6 amps break at 120 VAC, equal to Allen-Bradley Type 800H.
4. Indicating Lights: 30.5 mm, heavy duty, NEMA 4X rated, 6 volt transformer type, equal to Allen-Bradley Type 800H.

F. CONTROL COMPONENTS.

1. Solenoid valves shall be brass body, soft-seated, with 120V AC solenoid coil. Solenoid operators shall be molded coil in NEMA 4. Maximum operating pressure differential capability shall be 100 psig. Solenoid valves shall not require a minimum pressure to either open or close. Valves shall be two-way or three-way, energize-to-close or energize-to-open as required for the application.
2. The point level probes used to monitor PAC level shall be oscillating tuning fork type, of stainless steel construction. Alternatively radar level transmitters may also be used.
3. Low air pressure and draft pressure indication and switches shall be Dwyer Photohelic or approved equal.
4. Compressed air pressure switches shall be Ashcroft B series, Square D Class 9012, or Allen Bradley Bulletin 836 or approved equal.
5. The silo vent filter differential pressure switch shall be a Dwyer series A3000. or approved equal

G. MONITORING DEVICES.

1. Up to two radar level-indicating transmitter shall be provided to continuously measure and display the level of PAC in the silo. The unit will be mounted via a flange located at the silo roof. The readout will be located on the DCS HMI. A 4-20mA signal shall be available for remote indication if desired.
2. The differential pressure across the silo vent filter shall be displayed continuously at the vent filter by a Dwyer Magnihelic Series A3000 differential pressure indicator or approved equal.
3. Pressure indicators shall be Bourdon tube type with solid front, phenolic plastic case and 4-1/2 inch dial. Indicators shall be Ashcroft Duragauge Style 1279 or approved equal.

H. STATUS & ALARM LIGHTS

1. The following status indications will be displayed on the facility DCS and shall be supported by Seller’s instrumentation:
   a. System Start Initiated.
   b. Blower Running.
   c. Air Pressure OK.
   d. Feeder Running.
   e. Rotary Feeder Running.
   f. Feeder Hopper Fill Cycle Enabled.
   g. Vent Filter Timer Enabled.
   h. Fluidizing System Operating.
   i. Convey Line Diverter Valve Position.
   j. PAC Silo Radar Level

2. The following alarms will be displayed on the facility DCS and shall be supported by Seller's instrumentation:
   a. PAC Silo Level High.
   b. PAC Silo Level Low.
   c. PAC Silo Level Low Low.
   d. Hopper Fill Cycle Malfunction.
   e. Feeder Malfunction.
   f. Blower Discharge Pressure High.
   g. Blower Discharge Pressure Low.
   h. Eductor Suction Vacuum High.
   i. Eductor Suction Vacuum Low.
   j. Compressed Air Pressure Low.
   k. Silo Filter DP High.
   l. Diverter Valve Position Error
3. The following status lights shall be located on the Truck Unloading Control Panel:
   a. Green - Silo Level Low - OK to Fill.
   b. Green - Vent Filter Sequencing.
4. The following alarm lights shall be located on the Truck Unloading Control Panel:
   a. Amber - Silo Level High - Stop Fill.
   b. Amber - Compressed Air Pressure Low
   c. Amber - Vent Filter DP High - Stop Fill

J. CONTROL SWITCHES

1. The following control functions will be located on the facility DCS and shall be supported by the Seller's equipment:
   a. Start PAC System pushbutton switch.
   b. Stop PAC System pushbutton switch.
   c. Blower On/Off/Auto selector switch.
   d. Feeder On/Off/Auto selector switch.
   e. Rotary Feeder On/Off/Auto selector switch.
   g. Alarm Acknowledge pushbutton switch.
   i. Fluidization System On/Off/Auto selector switch.
   j. Feed Rate Adjustment (lb/Hr or lb/MMACF).
2. The following control switches shall be located on the Truck Unloading Panel:
   a. Silo Vent Filter OFF/ON selector switch.
   b. Alarm Acknowledge pushbutton switch.
3. The following control switches shall be located in the silo under-skirt area:
   a. Three (3) each emergency stop pushbutton switches, one at each silo access door.

V. SYSTEM OPERATION

A. SILO LEVEL MONITORING AND FILLING.

1. The level of the PAC in the silo shall be monitored continuously by a Radar level detector that will send a signal to the level display located on the facility DCS control display.
2. When ample volume exists in the silo to accept a complete truckload of PAC, the signal shall trigger an input for "Silo OK to Fill". The signal shall be sensed by the DCS that will activate the PAC SILO LEVEL LOW alarm on the DCS and the SILO LEVEL LOW - OK TO FILL alarm and light on the Truck Unloading Control Panel. If additional PAC is not provided, the silo low-low signal will be uncovered by the PAC when the level is critically low. The signal shall be sensed by the DCS which will activate the PAC SILO LEVEL LOW-LOW alarm on the DCS. The silo low-low signal shall not stop operation of the PAC feed system, which shall operate independently of the PAC level in the silo.
3. The PAC storage silo will be filled by pneumatic road tankers, which will employ a trailer mounted blower to pneumatically transfer the PAC from the tanker into the silo. If the PAC level covers the silo high point the high signal shall activate.
4. During silo filling, the air that is utilized to pneumatically convey the PAC into the silo shall be discharged to the atmosphere through the silo vent filter. The vent filter shall be sequentially cleaned by pulses of air flowing in the reverse direction through the filter on a preset timed basis. Filter operation shall be designated as OFF or ON via a selector switch located on the Truck Unloading Control Panel. In the ON mode, the dust collector shall sequentially pulse clean the filter with air on a preset time interval continuously as long as the switch is in the ON position.
5. The VENT FILTER TIMER ENABLED indication located on the DCS Panel and light located on the Truck Unloading Control Panel shall be illuminated when the vent filter timer board is energized.
6. The differential pressure across the vent filter shall be monitored continuously by a locally mounted differential pressure switch. The switch shall activate on a differential pressure of 3 to 4 inches of water pressure across the bags. The DCS will sense a contact opening on high differential pressure and initiate an alarm if the differential pressure remains high for a pre-set period of time (usually 20 seconds).

B. FEEDER HOPPER LEVEL MONITORING AND FILLING.

1. The level in the volumetric feeder supply hopper shall be monitored to maintain a constant level in the hopper. When the PAC level in the feeder hopper falls below high level setpoint, a signal shall be sent to the DCS and a hopper filling sequence shall be initiated after a pre-determined amount of time.

2. When the hopper refill sequence is initiated, measures must be taken to ensure PAC is discharged from the silo in a safe and reliable manner. If air fluidization is required to promote sorbent flow, supplier shall ensure the fluidizing scheme matches the equipment and sorbent properties required for safe operation. Supplier shall ensure proper control permissives are engaged during normal operation to protect system from potential material handling hazards.
3. The hopper filling sequence shall stop when the high level signal has been triggered from with PAC.
4. The fluidization solenoids shall be pulsed on a timed basis, provided the feeder is operating, when the AUTO function has been selected. Additionally, selecting the MANUAL fluidize function on the DCS shall provide a single fluidization cycle.

C. PAC FEED.

1. Depressing the PAC SYSTEM START pushbutton on the DCS shall initiate the automatic start sequence and display SYSTEM START INITIATED indication on the DCS HMI.
2. The SYSTEM START shall initiate operation of the blower.
3. After the blower discharge pressure and the eductor vacuum have been established by pressure switches, the AIR PRESSURE ESTABLISHED indication on the DCS HMI shall be displayed. The system controls shall allow ten (10) seconds for motive and eductor vacuum to be established, otherwise the high or low blower discharge pressure alarm or the high or low eductor inlet vacuum alarm shall be initiated and the feeder shall not start until the problem is resolved and the alarm is cleared.
4. Thirty (30) seconds after blower discharge (motive air) pressure and eductor vacuum have been established, the volumetric feeder shall begin feeding PAC into the drop tube and eductor. The FEEDER RUNNING indication on the DCS HMI shall be displayed.
5. The operator shall manually set a fixed PAC feed rate in pounds per hour via the feeder control screen on the DCS HMI. The feed rate in pounds per hour shall be displayed on the DCS HMI.
6. The feeder shall maintain a constant injection rate in pounds per hour per megawatt or other parameter (such as mmcfm of gas flow). The injection rate shall be selected by operator from the DCS HMI.
7. If the feeder motor drive variable frequency drive faults or fails to start, a FEEDER MALFUNCTION alarm shall be initiated and the feeder shall be stopped.
8. The system shall provide PAC to the system until stopped by selecting the local PAC System STOP on the DCS. System STOP shall immediately terminate operation of the feeder and sixty (60) seconds later stop the blower, thereby, terminating system operation.

D. CALIBRATION.

1. The PAC injection system shall provide the means for calibration of the feeder on a regular basis. The Operator shall physically “catch” a weight sample over a timed period at a known feeder rpm, weigh the sample, calculate the actual pounds per hour at the maximum rpm and enter the feed rate into the system controls.
2. When the calculated feed rate is entered, the control system shall make the necessary adjustments to conform the controls and displays to the new calibrated feed rate.

E. ALARMS.

The alarm sequence shall operate essentially the same for all alarms. The alarm will remain active until cleared. For critical alarms, system operation shall be “locked out” until the alarm is cleared and reset via the DCS HMI. The following alarms shall be provided:

1. Silo Level High (Do Not Fill) - A silo level high alarm shall activate on the PAC Control Panel and on the Truck Unloading Panel when the silo is full and filling operations should be terminated. This alarm shall not have any effect on the filling operations or normal system operation, other than to provide an alarm, and shall automatically clear once the PAC level in the silo has fallen below the high point level probe.
2. Silo Level Low (OK To Fill) - A silo level low alarm shall activate on the PAC Control Panel and on the Truck Unloading Panel when the PAC level in the storage silo has fallen below the low point. The silo low level alarm shall indicate sufficient volume in the silo to receive a bulk trailer load of PAC. This alarm shall not have any effect on normal system operation, other than to provide an alarm, and shall automatically clear once the PAC level in the silo has covered the low level.
3. Silo Level LowLow - A silo level low-low alarm shall be activated on the PAC Control Panel when the PAC level in the storage silo falls below the low-low point

and indicates that the PAC level is critically low. This alarm shall not have any effect on normal system operation, other than to provide an alarm, and shall automatically clear once the PAC level in the silo has covered the low-low level .

4. Motive Air Pressure Low - A low motive air pressure alarm shall be initiated when the blower discharge pressure falls below a pre-set value. Operation of the feeder and blower shall be stopped when the alarm is initiated. The alarm must be acknowledged and reset prior to restarting the system.
5. Motive Air Pressure High - A high motive air pressure alarm shall be initiated when the blower discharge pressure exceeds a pre-set value. Operation of the feeder and blower shall be stopped when the alarm is initiated. The alarm must be acknowledged and reset prior to restarting the system.
6. Eductor Inlet Vacuum Low - A low eductor inlet air vacuum alarm shall be initiated when the eductor inlet (drop tube) vacuum falls below a pre-set value. Operation of the feeder and blower shall be stopped when the alarm is initiated. The alarm must be acknowledged and reset prior to restarting the system.
7. Eductor Inlet Vacuum High - A high eductor inlet air vacuum alarm shall be initiated when the eductor inlet (drop tube) vacuum rises above a pre-set value. Operation of the feeder and auxiliary hopper feeders shall be stopped when the alarm is initiated. The blower should be stopped approximately 2 minutes after alarm initiation. The alarm must be acknowledged and reset prior to restarting the system.
8. Feeder Hopper Fill Malfunction - The feeder hopper fill malfunction alarm shall be initiated if the time to cover the hopper high level probe, after the rotary valve has been given a start signal, exceeds a preset time interval.
9. Feeder Malfunction - A feeder malfunction alarm shall be initiated if the VFD is faulted. The alarm must be acknowledged and reset prior to restarting the system.
10. Silo Vent Filter DP High - The differential pressure across the vent filter bags shall be monitored at all times by a differential pressure switch mounted on the silo deck. This alarm shall not effect the filling operation or normal system operation and shall automatically clear when the differential pressure returns to normal.
11. Compressed Air Pressure Low - The air system pressure shall be monitored continuously by a pressure switch mounted on the compressed air receiver. The compressed air pressure low alarm shall be initiated when the air pressure has fallen below a pre-set pressure (typical set point ~80 psig).

VI. FIELD INSTALLATION

A. INSTALLATION

1. The Installation Contractor and or Seller shall perform the final field assembly, field wiring, field piping, and adjustments necessary to provide a complete operating system.
2. The Installation Contractor shall perform all fieldwork in accordance with the requirements of these Specifications and the information prepared by the PAC System Supplier.

B. FIELD PAINTING

1. Any equipment not shop painted shall be field painted by the Installation Contractor in accordance with these Specifications.
2. The Installation Contractor shall perform touch-up painting of all equipment as required to provide a protective coating in accordance with these Specifications.

C. CLEAN UP

Prior to acceptance of the Work, the Installation Contractor shall thoroughly clean all installed materials, equipment and related areas in accordance with these Specifications.

VII. OPTIONS

A. LOCAL CONTROL

1. A stand-alone control system shall be provided to control the sequences of events throughout the system and also provide alarms to enunciate problems and interlocks to protect the system.
2. The PAC system controls shall be contained within a PAC Control Panel, including HMI, PLC, power supplies, control relays, lights, terminal blocks, switches, etc. The complete PAC feed system shall be controlled from the PAC Control Panel. The control panel shall conform to the requirements herein.
3. Control of the PAC injection system shall be via a Human Machine Interface (HMI) located on the front of a locally mounted PAC System Control Panel. The HMI will have a color monitor with keypad or touch screen and will provide ample screens for easy control of the system. The HMI shall be an Allen Bradley Panel View Plus 1000 or approved equal.
4. A programmable logic controller (PLC) shall control the sequence of events throughout the system. Complete software documentation including a ladder logic diagram printout with a complete set of comments and a narrative description of the

sequence of operation shall be provided. The PLC shall be an Allen-Bradley, Model Compact Logix or approved equal.

B. CONTROL BUILDING
   1. Provide a pre-cast concrete or steel building to house the MCC, the control power transformer, the PAC Control Panel, the air compressor, the air drier and filters, and the dry air accumulator.
   2. The building shall be large enough to house all of the electrical power and control equipment needed for the proper and safe operation of the PAC system with space around the equipment sufficient for maintenance. The building shall have at least (1) access door measuring 3′-0″ W × 6′-8″.
   3. The building shall be equipped with a built-in air conditioner and heater to maintain the environment in the building.
   4. The exterior finish of the building shall be per the Purchasers requirements.
   5. The interior finish of the building shall be a smooth steel form finish.
   6. The building will arrive on site with all internal equipment installed, piped and wired to the greatest extent practical.
   7. Building engineering design and calculations shall be sealed by a Professional Engineer in the State of Manufacture.

C. COMPRESSED AIR SYSTEM
   1. Provide a complete stand-alone compressed air system capable of providing and storing the quantity and quality of compressed air necessary to sustain operation of the PAC injection system (minimum 20 scfm). The system shall include compressor, air receiver, refrigeration air dryer and filters, drain valves and a dry air accumulator.
   2. The compressor and drive motor shall be mounted on the air receiver. The compressor shall be belt driven with an OSHA approved guard. The air receiver shall have a minimum volume of 60 gallons, a minimum ASME rating for 150 psig, and shall be complete with drains, vents, pressure gauge, and pressure switch. The compressor shall be Quincy, Champion, Ingersoll-Rand or approved equal.
   3. The drive motor shall be 480 volts AC, 3-phase, Baldor Super-E Premium Efficiency or approved equal.
   4. The air drier shall be a non-cycling, refrigeration type drier capable of reducing the dew point of the maximum air requirements at 100 °F and 100 psig to 38 °F with an ambient temperature of 100 °F. The air drier shall be manufactured by Pneumatech, Zeks or approved equal.

D. POWER DISTRIBUTION
   1. Provide a PAC system 480 Motor Control Center (MCC) which shall contain a main disconnect breaker, motor circuit breakers, motor starters, power blocks, terminal blocks, breakers, fuses and control power transformer.
   2. A main disconnect breaker shall be provided to de-energize the MCC and the complete PAC electrical system.
   3. Motor circuit protectors, NEMA starters and overload protection shall be provided for each 480-volt AC motor.
   4. A 480-volt AC single phase (3-phase if required) to 120 volt AC single phase (3-phase 208/120 if required) transformer shall provide 120-volt AC power for control and equipment.
   5. A single breaker (3 pole 208/120 or single pole 120) shall be provided for isolation and protection of the control power system. Individual single-phase breakers shall be provided as required for distribution of 120 volt AC power.
   6. The MCC shall be an Allen Bradley Centerline Bulletin 2100 or approved equal.

E. SILO STAIRS
   1. Provide stairs and platforms on the exterior of PAC storage silo for access to the intermediate platform inside the silo skirt and to the silo roof.
   2. The stairs shall meet OSHA standards and shall be hot dipped galvanized with galvanized abrasive noseing. Handrails shall be standard diameter HDG. Stairs shall be 36 inches wide.
   3. Stairs shall be provided with intermediate platform for access to the platform located above the feeders.

F. PRE-ASSEMBLY
   1. The PAC storage and injection system shall be assembled to the greatest extent practical prior to shipment to the site. Seller shall install a structural floor in the silo under-skirt area and shall install all equipment in the silo under-skirt area, including but not limited to feeder skids, rotary valves, fluidizing air system, valves and piping, conduit and wiring, and junction boxes as required.

G. INSTALLATION
   1. Seller shall provide on-site installation, check-out, start-up, and performance testing of the PAC storage and injection system.
   2. Seller shall provide all equipment and incidentals necessary for a complete operational system.

INSTITUTE OF CLEAN AIR COMPANIES

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Ametek Process Instruments
Anguil Environmental Systems, Inc.
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Perma Pure
Philadelphia Mixing Solutions
Pollution Control Services
Potash Corporation of Saskatchewan, Inc.
Praxair, Inc.
PSP Industries
Red Ball Technical Gas Services
Restek Corporation
SCR-Tech
Solvay Chemicals, Inc.
Structural Steel Services, Inc.
TDC, LLC
Terra Environmental Technologies
Testo, Inc.
TGO Group, LLC
Thermon Manufacturing Co.
Universal Analyzers, Inc.
VIM Technologies, Inc.
WPS Industries
Zachry Construction Corporation

ICAC INSTITUTE OF CLEAN AIR COMPANIES

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