MICRO AIR QUALITY (μAQ) STATION DESCRIPTION AND DESIGN PHILOSOPHY

1. INTRODUCTION

Air Quality Design, Inc. is developing a small, rugged, easily deployable, self-contained instrument enclosure that will house and provide shared resources for two internal air quality instrument benches plus a variety of externally mounted sensors. The enclosure, referred to as the Micro Air Quality station, or μAQ, will provide power, cooling, vacuum, computing, calibration, and communication resources in an environmentally sealed enclosure that can be mounted on a variety of existing infrastructure such as communication towers, light or utility poles, etc. The purpose of the enclosure is to eliminate the need for expensive monitoring stations or mobile laboratories for long-term monitoring or episodic measurement system deployments. The design of the system is a commercial extension of a similar air monitoring system we have designed and built for the US military over the course of the last several years. The experience gained in that exercise in terms of weight, thermal, power, and data management will be brought to bear in design of the μAQ. Descriptions of the design parameters of the μAQ system are presented below.

2. SYSTEM DESCRIPTION

2.1 ENCLOSURE.

The μAQ system will be based on a locking, aluminum enclosure nominally 32 x 32 x 12 inches in size. The enclosure will be environmentally sealed to IP 56 or better, and will provide EMI shielding. The enclosure can be characterized as a host for two or more client instruments and will include all shared resources including power, temperature control, vacuum, computing, calibration, and communication. In addition the enclosure will provide one or more shared sample points that may be configured to meet the needs of the client instrument (e.g. heated inlet, PM exclusion or size segregation). An optional sampling boom will be designed to accommodate the possible need to locater the sample inlet some distance from the enclosure. The enclosure will include two compartments that will be configured as separate thermal control zones. One compartment will be temperature controlled using thermoelectric cooling/heating at approximately 30 ^{o}C to house the available instrument benches. A separate compartment will house thermally-resistant, heat generating, components such as power supplies and pumps. This compartment will be environmentally sealed as well but will include heat-changers in communication with the ambient environment. Our expectation is that the weight of the enclosure will be about 80 pounds. If the included instrument benches are on the order of 20 pounds each, the total enclosure weight will be about 120 pounds.

2.2 INSTRUMENTATION CAPACITY AND FORM FACTOR.

Our plan is to include adequate resources in terms of space, power availability, and cooling capacity for two gaseous air pollutant instrument benches in the climate controlled zone of the enclosure. Additional instrumentation will be available on the outside of the enclosure, notably the meteorological sensor package and possibly a particle spectrometer. Our rationale for developing the enclosure as a two-instrument package is based on a survey of the US EPA monitoring networks, which revealed that the majority of the air monitoring stations in the US are one- and two-parameter installations. That said, the μAQ will be scalable by design in that multiple, differently-equipped μAQ enclosures can be collocated and configured to communicate with one another and share a single portal for external data communication.

The form factor for the instrument modules, calibration module, inlet component modules, power supply and computer modules will be lightweight aluminum boxes with standardized, plug-and-play electrical and pneumatic connectors that attach to the enclosure backplane. We expect to offer a remote docking station that will provide power, data and vacuum resources to facilitate field maintenance of the various modules.

2.3 AVAILABLE INSTRUMENTS.

We expect to develop instrument benches for a wide variety of chemical and physical parameters of importance to atmospheric and air quality monitoring and analysis. Our initial focus will be to develop instruments that are commercially available and have already been designated as EPA reference or equivalent methods. Additional instruments will be developed depending on market demand. We have already developed benches based on the Teledyne-API models 200EU

(NO_x), 100EU (SO_2), and 465L (O_3) instruments. Our plan is to develop benches for the comparable TEI i-series instruments and to expand the spectrum of measurements to include $NO_{x,y}$, $SO_{2,4}$, O_3, CO, and PM mass. We also plan on offering the Vaisala WTX-520 meteorological sensor package, the Ocean Optics HR4000GC solar spectrometer, the Grimm Portable Aerosol spectrometer, and the MetOne model 212 particle profiler as optional instruments that will not occupy either of the two gas instrument bench spaces. An additional bench that has already been developed is a hydrocarbon measurement system based of sample pre-concentration with photo-acoustic detection. The various instruments will be mounted in modular boxes that will feature plug-and-play installation and will be hot swappable. The data system will automatically recognize which instrument has been installed and adjust data acquisition accordingly.

2.4 COMPUTING, COMMUNICATION, AND DATA STORAGE.

The μAQ will include a PC-104 based computer that will serve as the host for serial- or Ethernet-based communication with the instrument benches and system resources such as the calibration system. The computer will include software to acquire signals from the client instruments, store collected data using an on-board solid-state disk drive (ca. 64 GB), and to provide resource control (including control of the calibration system, climate and sampling control, etc.). In addition the system computer will be interfaced to a secure Internet appliance such as the NetBurner which will be used to provide either wired or wireless URL addressability for the unit. We will include addition wireless communication hardware (802.11) for local communication (e.g. system audit technician) and for communication between multiple μAQ units at the same site that are sharing one Ethernet connection. All station parameters, including both instrument signals and housekeeping parameters will be available via the Ethernet connection. In addition we expect to provide adequate system memory to allow installation of a database software program appropriate or required for a given air sampling network. Stored data will be configured so that it is compatible for automatic “data push” via Internet to the EPA AirNow system.

2.5 CALIBRATION CAPABILITIES.

The μAQ will include a filter/absorbent-based zero air generator for use with all of the available instrument benches. A calibration system based on small, nonrefillable, high-pressure cylinders will be included for instrument span checks and calibrations (Air Liquide, Scotty-type cylinders). The calibration system will be under computer control, allowing automatic operation and automatic dynamic dilution for multi-point calibration. The enclosure will include an external port that will allow introduction of calibration gases for periodic system audits.

2.6 POWER CAPACITY.

The μAQ will include a universal AC input, 1 kW DC power supply capable of providing power for all of the system components. The primary voltage output will be 24 VDC. DC/DC voltage converters will be installed within each modular instrument bench enclosure to provide the specific voltages required by their instruments and hardware.

2.7 CLIMATE CONTROL

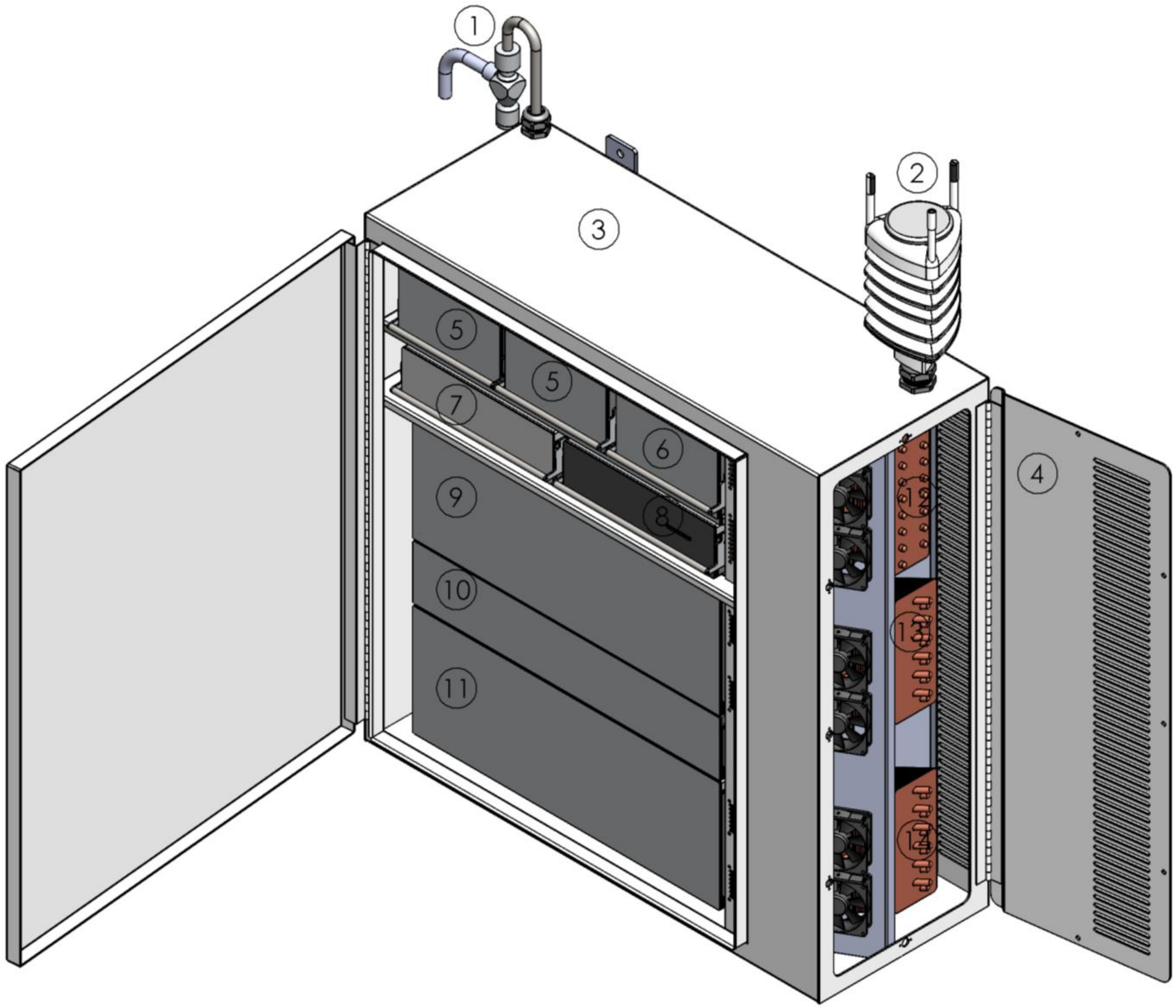
The μAQ's thermoelectric-based heating and cooling air conditioner will be designed for the enclosure that will provide a cooling capacity of 300 W for the insulated instrument bench portion of the enclosure. A heat-exchanger will be used on the non-cooled portion of the enclosure. The system will be designed to operate through an ambient temperature range of -40 to 60 ^{o}C.

2.8 ENCLOSURE MOUNTING.

The μAQ enclosure includes 4 heavy-duty mounting tabs that can accommodate a Unistrut® frame or other structural members that will allow mounting of the enclosure to a wide variety infrastructure types using readily available hardware and components. We expect to offer optional kits for mounting to communication towers, light and utility poles, and scaffolding. Other mounting needs can be readily accommodated through use of the available Unistrut® hardware offerings.

2.9 CURRENT DESIGN

The current design for the μAQ Station is shown in **Figure 1**. We have the main enclosure in hand and are progressing with fabrication of the TE air conditioners and heat exchangers. Our plan is to have the prototype system operational by the end of 2010.



1. Sample inlet/cyclone
2. Vaisala Met sensor
3. Aluminum chassis, 32x32x12"
4. Heat pump access door
5. Instrument #1/#2 inlet components
6. Dual common vaccum pumps
7. AC-DC power supplies
8. Fanless computer system
9. Instrument Chassis #1
10. Calibration system
11. Instrument Chassis #2
12. Heat Exchanger for top compartment
13. TE air conditioner #1, 150 Wcapacity
14. TE air conditioner #2, 150 W capacity

Figure 1. Sketch of the μAQ station current design showing the major components.