

SECTION 230923.14 FLOW INSTRUMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Duct and plenum airflow measurement device (AMD) with temperature measurement and remote transmitter.
- B. Duct and plenum AMD with temperature and humidity measurement and remote transmitter
- C. Small duct and terminal box AMD with temperature measurement and remote transmitter.
- D. Small duct and terminal box AMD with temperature measurement and integral transmitter.
- E. Fan airflow AMD with temperature measurement and remote transmitter.
- F. Probe AMD/damper assembly for outdoor air intakes, return air intakes and exhaust air intakes.
- G. Fan inlet AMD/backdraft damper assembly.
- H. Small duct AMD/airflow regulator valve assembly.

1.2 RELATED SECTIONS

- A. [Note to engineer: Insert appropriate section number where you will place the intake configuration specification] Air handling units
- B. [Note to engineer: Insert the appropriate section number if you allow the AMD temperature measurement to be used in lieu of the specified temperature measurement] Temperature Sensors
- C. [Note to engineer: Insert the appropriate section number(s) if you allow the AMD humidity, dewpoint and/or enthalpy measurement to be used in lieu of the specified humidity, dewpoint and/or enthalpy measurement] Humidity, Dewpoint and Enthalpy Sensors

1.3 REFERENCES

- A. UL-873, Temperature Reading and Indicating Equipment
- B. UL 60730-1, 60730-2-9, Automated Electrical Controls
- C. FCC Part 15

1.4 SUBMITTALS

- A. Submit under the provisions of Section 013000
- B. Provide the following:
 - 1. Equipment schedule.
 - 2. Product overview and technical specification.
 - 3. Placement guide.
 - 4. Sensor density table.
 - 5. Probe installation guide.
 - 6. Wiring guide.
 - 7. Startup guide.

- C. Independent Test Reports: Provide a copy of each of the following test reports:
 - 1. NIST Report of Airflow Calibration
 - 2. CHEMIR Test Report on Sensor Exposure to Salts and Acids.
 - 3. UL Certificate Report
 - 4. CE Certification form (European shipments)
 - 5. FCC Part 15 compliance report.
 - 6. BTL Certification Report.
- D. Quality Assurance
 - 1. Manufacturer Qualifications: Company specializing in manufacturing thermal dispersion airflow measurement devices with minimum ten years documented experience.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Store products in an environment that is protected from rain, snow and/or condensing moisture.
- C. Handle with care during installation.
- D. Protect sensors from construction debris and remove all debris that may enter the air distribution system prior to system startup.

1.6 SYSTEM STARTUP AND VERIFICATION

- A. Startup and verify products in accordance with manufacturers procedures in the operations and maintenance manual.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturer: EBTRON, Inc. located at 1663 Hwy. 701 S, Loris, SC 29569, USA. Phone 1-800-232-8766. Fax: 1-843-756-1838. Web: EBTRON.com. Sales e-mail: Sales@EBTRON.com
Local sales representative <https://ebtron.com/#rep-finder>.
- B. Substitutions: Not permitted.
- C. Requests for substitutions that meet the specification requirements will be considered in accordance with the provisions of Section 016000.

2.2 GENERAL REQUIREMENTS AND EXCLUSIONS

- A. Provide one thermal airflow measuring device (AMD) for each location indicated on plans, schedules and/or control diagrams. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
- B. Each AMD shall use the principle of thermal dispersion to determine the actual or mass airflow rate of the airstream. Differential pressure-based devices, including pitot tubes, pitot arrays, piezo-rings and devices measuring the pressure drop across a louver, damper or obstruction are not acceptable.
- C. Each AMD shall be provided with one or more sensor probes having one or more sensor nodes per probe.

- D. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. The airflow of each sensor node shall be determined using one self-heated and ambient temperature sensing thermistor. Devices using indirectly heated thermistors to determine the airflow rate are not acceptable. Devices using chip thermistors of any type or packaging are not acceptable. Devices using platinum wire RTDs or similar "hot wire" devices are not acceptable.
- E. Thermistors shall be potted in an engineering thermoplastic assembly using water-proof, marine epoxy and shall not be damaged by moisture, direct contact with water or exposure to atmospheric acids. Provide a copy of an independent laboratory report to verify compliance with this requirement.
- F. All internal wiring in the probe tube shall be chemical and abrasion resistant Kynar® coated copper.
- G. All connections to internal wires in the probe tube shall be solder joints or welds. Connectors of any type in the probe tube are not acceptable.
- H. Each thermistor shall be independently calibrated to NIST traceable temperature standards to establish the resistance-temperature characteristics for the determination of airflow and temperature. Devices using interchangeable, curve-matched, thermistors are not acceptable.
- I. Each sensor node shall be independently processed by the transmitter prior to averaging and output.
- J. The specified sensor accuracy shall include the combined uncertainty of the sensor nodes and transmitter. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with the specified sensor accuracy over the entire operating range.
- K. Installed accuracy shall include the uncertainty of the AMD and the additional uncertainty that results from the placement of the AMD in the airstream. The specified installed accuracy is based on the AMD being installed in accordance with manufacturers published placement and installation guidelines.
- L. Transmitters shall be microprocessor-based and operate automatically after brownouts and/or transient power interruptions.
- M. All printed circuit boards shall be have gold plated interconnects, edge fingers, and test points.
- N. Remote transmitters shall have an LCD and four-button user interface.
- O. Remote transmitters shall be mounted in a location protected from moisture, rain and snow with an ambient temperature between -20 and 120 °F [-28.9 to 48.9 °C] and a humidity range between 5 and 95% RH (non-condensing). Provide a weatherproof enclosure and mount away from direct sunlight when outdoor mounting is required.
- P. Probes with remote transmitters shall be "plug and play", not require matching to the transmitter, and be provided with a UL listed, FEP jacketed, plenum rated cable and connector plug. Devices using PVC jacketed cables to connect sensor probes to the transmitter are not acceptable.
- Q. All components of each AMD shall be RoHS2 compliant.
- R. Each AMD shall be UL/cUL listed as a final assembly.
- S. Each AMD shall be FCC-Part 15 compliant. Compliance shall be demonstrated by an independent test laboratory.
- T. European shipments shall be CE marked. Compliance shall be demonstrated by an independent test laboratory.
- U. Devices with a BACnet network connection shall be BTL tested and listed.

2.3 DUCT AND PLENUM AMD WITH TEMPERATURE AND HUMIDITY MEASUREMENT AND REMOTE TRANSMITTER

- A. Basis of Design: EBTRON model GTx116e-PC.
- B. Each AMD shall be suitable for installation in ducts and plenums; including air handling equipment cabinets and outdoor air intakes to determine the airflow rate, velocity-weighted temperature and humidity of the airstream. Humidity and enthalpy shall be calculated using the velocity weighted temperature, humidity and on-board pressure sensor.
- C. Provide one to four gold anodized 6063 aluminum [*optional*: polished 316 stainless steel] probes and one remote transmitter.
- D. Probes shall have integral 304 stainless steel mounting brackets for insertion, internal or standoff mounting.
- E. Probe connector plug and receptacle pins shall be gold plated.
- F. Each sensor node shall be individually wind-tunnel calibrated at 16 points to NIST traceable airflow standards and have an accuracy of $\pm 2\%$ of reading over the entire operating range. Provide a copy of the NIST calibration report for the reference standard used to calibrate the production tunnels used to calibrate individual sensor nodes. Reference standards calibrated to third-party NIST traceable labs are not acceptable. Devices claiming AMCA certification are not acceptable.
- G. Provide up to 16 sensing nodes per measurement location as required for the opening size and published sensor density tables to achieve an installed airflow accuracy of $\pm 3\%$ of reading ($\pm 5\%$ of reading on close coupled outdoor air intakes) between 0 and 5,000 fpm [0 to 25.4 m/s] over a temperature range of -20 to 160 °F [-28.9 to 71.1 °C] and a humidity range between 0 and 100% RH (non-condensing).
- H. Provide the velocity weighted temperature of the airstream with an accuracy of ± 0.15 °F [0.08 °C].
- I. [*optional*: This product may be used for temperature measurement when the required measurement location for temperature is satisfied by the measurement location of the AMD.]
- J. Provide humidity measurement (/H option) capable of determining the velocity-weighted humidity, velocity-weighted enthalpy, or dewpoint of the airstream. The humidity sensor shall have the following accuracy at 77 °F [25.0 °C]:
 - 1. $\pm 2\%$ of reading between 20 and 80% RH.
 - 2. Better than $\pm 4\%$ of reading at all other % RH at 77 °F [25.0 °C].
- K. The humidity sensor shall have a temperature coefficient of 0.07% RH/ °F [0.13% RH/ °C].
- L. Annual drift shall not exceed 0.5% RH/year.
- M. [*optional*: This product may be used for humidity, enthalpy or dewpoint when the required measurement location for humidity, enthalpy or dewpoint can be satisfied by the measurement location of the AMD.]
- N. Provide low and high airflow alarms with a user defined setpoint and tolerance.
- O. The airflow rate, temperature, humidity, enthalpy or dewpoint, airflow alarm and system status alarm shall be visible on the transmitters display.

- P. Provide one of the following output transmitter models:
1. GTA116e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals.
 2. GTC116e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one isolated RS-485, field selectable (BACnet MS/TP or Modbus RTU) network connection.
 3. GTM116e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one isolated Ethernet, field selectable (BACnet Ethernet, BACnet IP, Modbus TCP or TCP/IP) network connection.
 4. GTF116e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one isolated Lonworks Free Topology network connection.
 5. GTU116e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one USB Flash Drive (Thumb drive) memory device for logging average and individual airflow rates, temperatures, and psychrometric measurements at user specified time intervals.
- Q. Transmitters with analog output signals shall provide:
1. One linear output signal for airflow.
 2. One linear output signal for velocity-weighted temperature or one binary signal for the airflow alarm or system status alarm.
 3. One linear output signal for velocity-weighted humidity, velocity-weighted enthalpy, or dewpoint when the /H option is provided.
- R. Transmitters with network capability shall provide the airflow, velocity-weighted temperature, velocity-weighted-humidity, velocity-weighted-enthalpy, dewpoint, airflow alarm status, individual sensor node airflow and temperature data and device fault status.
- S. Transmitters shall be provided with a 16-character by two-line, backlit, alpha-numeric LCD.
- T. Provide a Bluetooth, low-energy interface and free Android® or iOS® software that allows real-time airflow, temperature and humidity monitoring and airflow and temperature traverses. Software shall capture, save and/or e-mail airflow/temperature/humidity data, transmitter settings and diagnostics information. [replace section with the following for installations that do now allow any radio devices: Transmitters shall not be provided any radio transmitter or receiver.]
- U. Each AMD shall be powered by 24 VAC (22.8 to 26.4 VAC under load) and have a maximum power requirement of 22 V-A.

2.4 SMALL DUCT AND AIR TERMINAL AMD WITH TEMPERATURE MEASUREMENT AND REMOTE TRANSMITTER

- A. Basis of Design: EBTRON model EF-x2000-T.
- B. Each AMD shall be suitable for installation in round duct, 4 to 16 inches in diameter, to determine the airflow rate and velocity weighted temperature of the airstream.
- C. Provide one mill finish 6063 aluminum [*optional*: polished 316 stainless steel] probes and one remote transmitter.
- D. Probes shall have integral 304 stainless steel mounting brackets for insertion mounting.
- E. Each probe shall be individually wind-tunnel calibrated at 7 points to NIST traceable volumetric airflow standards. Devices claiming AMCA certification are not acceptable.
- F. Provide up to 2 sensing nodes per measurement location as required for the opening size and published sensor density tables to achieve an installed airflow accuracy of $\pm 3\%$ of reading between 0 and 2,000 fpm [10.16 m/s] over a temperature range of -20 to 160 °F [-28.9 to 71.1 °C] or between 0 and 3,000 fpm [15.24 m/s] over a temperature range of 0 to 160 °F [-17.8 to 71.1 °C] and a humidity range between 0 and 100% RH (non-condensing).
- G. Provide the velocity weighted temperature of the airstream with an accuracy of ± 0.15 °F [0.08 °C].

- H. [*optional*: This product may be used for temperature measurement when the required measurement location for temperature is satisfied by the measurement location of the AMD.]
- I. Provide low and high airflow alarms with a user defined setpoint and tolerance.
- J. The airflow rate and temperature, airflow alarm and system status alarm shall be visible on the transmitters display.
- K. Provide one of the following output configurations:
 - 1. EF-A2000-T: Two non-isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals.
 - 2. EF-N2000-T: One non-isolated RS-485, field selectable (BACnet MS/TP or Modbus RTU) network connection.
- L. Transmitters with analog output signals shall provide:
 - 1. One linear output signal for airflow.
 - 2. One linear output signal for velocity weighted temperature or one binary signal for the airflow alarm or system status alarm.
- M. Transmitters with network capability shall provide the airflow, velocity weighted temperature, airflow alarm status, individual sensor node airflow and temperature data and device fault status.
- N. Provide a contact closure relay that can be assigned to the airflow alarm or system status alarm. The relay shall be capable of passing 3 Amps at 24 VAC or 30 VDC or be configured to drive an LED.
- O. Each AMD shall be powered by 24 VAC (22.8 to 26.4 VAC under load) and have a maximum power requirement of 8 V-A.

2.5 SMALL DUCT AND AIR TERMINAL AMD WITH TEMPERATURE MEASUREMENT AND INTEGRAL TRANSMITTER

- A. Basis of Design: EBTRON model EF-x1000-T.
- B. Each AMD shall be suitable for installation in round duct, 4 to 16 inches in diameter, to determine the airflow rate [*optional*: and velocity weighted temperature of the airstream].
- C. Provide one mill finish 6063 aluminum [*optional*: polished 316 stainless steel] probes and one remote transmitter.
- D. Probes shall have integral 304 stainless steel mounting brackets for insertion mounting with an integral transmitter attached to the end of the probe.
- E. Each probe shall be individually wind-tunnel calibrated at 7 points to NIST traceable volumetric airflow standards. Devices claiming AMCA certification are not acceptable.
- F. Provide up to 2 sensing nodes per measurement location as required for the opening size and published sensor density tables to achieve an installed airflow accuracy of $\pm 3\%$ of reading between 0 and 2,000 fpm [10.16 m/s] over a temperature range of -20 to 120 °F [-28.9 to 48.9 °C] or between 0 and 3,000 fpm [15.24 m/s] over a temperature range of 0 to 120 °F [-17.8 to 48.9 °C] and a humidity range between 0 and 100% RH (non-condensing).
- G. EF-A1001-T and EF-N1000-T: Provide the velocity weighted temperature of the airstream with an accuracy of ± 0.15 °F [0.08 °C].
- H. [*optional* EF-A1001-T and EF-N1000T: This product may be used to for temperature measurement when the required measurement location for temperature is satisfied by the measurement location of the AMD.]

- I. Provide one of the following output configurations:
 - 1. EF-A1000-T: One non-isolated, DIP switch selectable (1-5/0-5 VDC or 2-10/0-10 VDC) analog output signal.
 - 2. EF-A1001-T: Two non-isolated, DIP switch selectable (1-5/0-5 VDC or 2-10/0-10 VDC) analog output signal.
 - 3. EF-N1000-T: One non-isolated RS-485, DIP switch selectable (BACnet MS/TP or Modbus RTU) network connection.
- J. Transmitters with analog output signals shall provide:
 - 1. One linear output signal for airflow.
 - 2. EF-A1001-T: One linear output signal for velocity weighted temperature.
- K. Transmitters with network capability shall provide the airflow, velocity weighted temperature, individual sensor node airflow and temperature data and device fault status.
- L. Each AMD shall be powered by 24 VAC (22.8 to 26.4 VAC under load) and have a maximum power requirement of 5 V-A.

2.6 FAN AIRFLOW AND TEMPERATURE MEASUREMENT WITH REMOTE TRANSMITTER

- A. Basis of Design: EBTRON models GTx108e-F
- B. Each AMD shall be suitable for installation in fan inlets to determine the airflow rate and velocity weighted temperature of the airstream.
- C. Provide throat, face, forward, cantilever or flare mount adjustable brackets for each sensor node.
- D. Each mounting bracket shall have integral 304 stainless steel mounting feet or integral zinc plated steel mounting feet for mounting in or on the fan inlet.
- E. The AMD shall not affect the airflow or sound performance of plenum fans.
- F. Provide the following number of sensor nodes based on fan type. All sensors shall be connected to a single, remote transmitter. Fan array models shall calculate the airflow of each fan individually prior to outputting the total airflow rate and have a built-in alarm capable of removing a failed fan from the total airflow calculation.
 - 1. GTx108e-F/SI: SWSI Fans: 2
 - 2. GTx108e-F/DI: DWDI Fans: 2 per inlet
 - 3. GTx108e-F/A: Fan Arrays:
 - 1) One to four fans: 2 per inlet
 - 2) Five to eight fans: 1 per inlet
- G. Each sensor node shall be individually wind-tunnel calibrated at 16 points to NIST traceable airflow standards and have an accuracy of $\pm 2\%$ of reading over the entire operating range of 0 and 10,000 fpm [50.8 m/s] over a temperature range of -20 to 160 °F [-28.9 to 71.1 °C] and a humidity range between 0 and 100% RH (non-condensing).
- H. Provide the velocity weighted temperature of the airstream with an accuracy of ± 0.15 °F [0.08 °C].
- I. *[optional: This product may be used to for temperature measurement when the required measurement location for temperature is satisfied by the measurement location of the AMD.]*
- J. Provide low and high airflow alarms with a user defined setpoint and tolerance.
- K. Provide a fan fault alarm when installed on fan arrays.
- L. The airflow rate, temperature, airflow alarm, fan fault alarm and system status alarm shall be visible on the transmitters display.

- M. Provide one of the following output transmitter models:
1. GTA108e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals.
 2. GTC108e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one isolated RS-485, field selectable (BACnet MS/TP or Modbus RTU) network connection.
 3. GTM108e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one isolated Ethernet, field selectable (BACnet Ethernet, BACnet IP, Modbus TCP or TCP/IP) network connection.
 4. GTF108e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one isolated Lonworks Free Topology network connection.
 5. GTU108e: Three isolated, field selectable (4-20mA, 0-5/0-10 VDC) analog output signals and one USB Flash Drive (Thumb drive) memory device for logging average and individual airflow rates, temperatures, and psychrometric measurements at user specified time intervals.
- N. Transmitters with analog output signals shall provide:
1. One linear output signal for airflow.
 2. One linear output signal for velocity weighted temperature or one binary signal for the airflow alarm or system status alarm, or one multi-state signal for the fan array fault alarm (/An models only).
- O. Transmitters with network capability shall provide the airflow, velocity-weighted temperature, airflow alarm status, fan array fault alarm (/An models), individual sensor node airflow and temperature data and device fault status.
- P. Transmitters shall be provided with a 16-character by two-line, backlit, alpha-numeric LCD.
- Q. Provide a Bluetooth, low-energy interface and free Android® or iOS® software that allows real-time airflow, temperature and humidity monitoring and airflow and temperature traverses. Software shall capture, save and/or e-mail airflow/temperature/humidity data, transmitter settings and diagnostics information. [replace section with the following for installations that do now allow any radio devices: Transmitters shall not be provided any radio transmitter or receiver.]

2.7 PROBE AMD/DAMPER ASSEMBLY FOR OUTDOOR AIR INTAKES, RETURN AIR INTAKES, AND EXHAUST AIR INTAKES

- A. Basis of Design:
1. Outdoor Air Intakes: EBTRON Model AIR-IQ2
 2. Non-ducted Return Air and Exhaust Air Intakes: EBTRON Model AIR-IQ
- B. Provide one GTx116e-P+ or GTx116e-PC AMD in a factory assembled control damper assembly.
- C. Provide an aluminum extruded Control Damper Assembly:
1. Provide an extruded aluminum (6063T5) sleeve, not less than .080" [2.03 mm] thick, for factory mounting of the specified duct and plenum AMD.
 2. Provide an aluminum radiused entry flare not less than .060" [1.52 mm] thick.
 - 1) AIR-IQ2: Provide a 1-inch [25.4 mm] radius flare.
 - 2) AIR-IQ: Provide a 3-inch [76.2 mm] radius flare.
 3. Provide extruded aluminum (6063T5) damper frames, not less than .080" [2.03 mm] thick and 4" [102 mm] deep. Frame to be assembled using mounting fasteners. Welded frames are not acceptable.
 4. Provide extruded aluminum (6063T5) damper blade profiles.
 5. Blade and frame seals shall be extruded silicone. Seals shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals are not acceptable.
 6. Provide a dual bearing system composed of Celcon inner bearings, fixed around a 7/16" [11.1 mm] aluminum hexagon blade pivot pins, rotating within a polycarbonate outer bearing inserted in the frame. Single axle bearing, rotating in an extruded or punched hole shall are not acceptable.

7. Provide a hexagonal, adjustable length, 7/16" [11.1 mm] control shaft that is an integral part of the blade axle. A field-applied control shaft is not acceptable.
8. Linkage hardware shall be installed in the frame side, complete with stainless steel trunnions and cup-point trunnion screws for a slip-proof grip. Dampers that do not provide stainless steel trunnions are not acceptable.
9. Control Dampers shall be AMCA rated for Leakage Class 1A at 1 in w.g. [0.25 kPa] static pressure differential. Standard air leakage data to be certified under the AMCA Certified Ratings Program.
10. Provide either opposed blade action or parallel blade action.
11. Control dampers shall be custom made to required size, with blade stops not exceeding 1¼" [31.7 mm] in height.
12. Dampers shall be designed for operation in temperatures ranging between -72 °F (-57.8 °C) and 212 °F [100 °C].

2.8 FAN INLET AMD/BACKDRAFT DAMPER ASSEMBLY

- A. Basis of Design: EBTRON Model FAN-IQ
- B. Provide one GTx108e-F AMD mounted in a factory assembled backdraft sensor assembly.
- C. Provide an aluminum extruded Backdraft Damper Assembly:
 1. Provide a 1-inch aluminum radiused entry flare, not less than .060" [1.52 mm] thick, for factory mounting of the specified fan inlet AMD.
 2. Provide extruded aluminum (6063T5) damper frames, not less than .080" [2.03 mm] thick and 8" [203 mm] deep. Frame to be assembled using mounting fasteners. Welded frames are not acceptable.
 3. Provide extruded aluminum (6063T5) damper blade profiles, not less than 0.09" [2.28 mm] thick. Blades shall be designed with a rounded head to reduce pressure loss.
 4. Blade and frame seals shall be extruded silicone. Seals shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals are not acceptable.
 5. Provide a dual bearing system composed of Celcon inner bearings, fixed around a 7/16" [11.1 mm] aluminum hexagon blade pivot pins, rotating within a polycarbonate outer bearing inserted in the frame. Single axle bearing, rotating in an extruded or punched hole shall are not acceptable.
 6. Provide a hexagonal, adjustable length, 7/16" [11.1 mm] control shaft that is an integral part of the blade axle. A field-applied control shaft is not acceptable.
 7. Linkage hardware shall be installed in the frame side and constructed of aluminum and corrosion resistant, zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip.
 8. Backdraft dampers shall be custom made to required size, with blade stops not exceeding 1¼" [31.7 mm] in height.
 9. Dampers shall be designed for operation in temperatures ranging between -72 °F [-57.8 °C] and 212 °F [100 °C].