PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplementary Conditions and the following Specification sections apply to all Work herein:
   1. Section 23 00 10 - General Requirements
   2. Section 23 00 20 - HVAC Scope of Work
   3. Section 23 05 07 - Design Conditions
   4. Section 23 05 13 - Motor Requirements for HVAC Equipment
   5. Section 23 05 50 - Access Doors and Color Coded Identification in General Construction
   6. Section 23 05 93 - Testing, Balancing, and Adjusting
   7. Section 23 21 13 - Pipe, Valves, Fittings, and Accessories
   8. Section 23 31 00 - Ductwork and Sheet Metal

1.2 SUMMARY

A. Furnish and install all air terminal units herein specified and as indicated on the Drawings.

1.3 REFERENCE STANDARDS

A. All air terminal units shall be designed, manufactured and tested in accordance with the latest applicable industry standards including the following:
   1. ASHRAE Standard 130 current edition
   2. ANSI/AHRI Standard 880 current edition
   3. Underwriters Laboratories UL Standard 1995
   4. Underwriters Laboratories UL Standard 1996

B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the Authorities Having Jurisdiction and suitable for its intended use on this Project. The entire terminal unit shall be UL or ETL listed as a complete assembly.

1.4 SUBMITTALS

A. The following submittal data shall be furnished according to the General Conditions and Section 23 00 10 and shall include, but not be limited to:
   1. Variable Primary Air Volume Fan-Powered Terminal Units* complete with capacity data, test data, construction details, physical dimensions, electrical characteristics, etc.
   2. Single Duct Variable Air Volume Terminal Units* complete with capacity data, acoustical and air performance test data, construction details, physical dimensions, etc.
   3. Acoustical and Performance Mock-Up Test Details complete with mock-up drawings and description of scope of work. Indicate air terminal unit lead time required, coordination requirements with Division 25, and name and location of the laboratory conducting the testing for approved by the Owner.
   4. Prior to execution of factory testing and lab testing, submit test procedures, recording forms, and test equipment cut sheets to Engineer for review. Refer to Section 23 00 20 titled “Scope of Work” for “Scheduling Procedures”.
   5. Factory Test Schedule.
   6. Factory Test Reports.
   7. Lab Test Schedule.
   8. Lab Test Reports.
   9. Manufacturer’s acoustical certification.

B. All items or equipment listed above with asterisks (*) shall be certified by the manufacturer using Manufacturer Certification “MCA” as set forth in Section 23 00 10. See Section 23 00 10 for certification requirements.

1.5 ACOUSTICS

A. Acoustical Mock-up: An acoustical evaluation shall be conducted on every size terminal unit at flow range which covers the scheduled design air volumes in a custom independent or manufacturer's acoustical laboratory mock-up to evaluate both radiated and discharge noise levels. The acoustical laboratory shall be acceptable to the Acoustical Consultant, Engineer and Owner.

1. For radiated sound, the mock-up shall consist of one (1) 20' x 12' closed plan office. Office shall be constructed of sheet rock walls. The terminal unit shall be located above the office ceiling and discharge ductwork shall be routed out of the ceiling cavity above the office. For discharge sound, the mock-up shall consist of two (2) 10' x 12' closed plan offices. Offices shall be constructed of sheet rock partitions extended slab-to-slab to simulate separation of the ceiling plenum. The terminal unit shall be located above one office and discharge ductwork shall be routed to the ceiling above the second "discharge noise" office.
2. The mock-up office ceiling plenum height shall be as indicated on the Project Architectural Drawings. The mock-up should be constructed with the base building ceiling tile, similar lighting fixtures with heat extract openings and/or return air grilles.
3. The air terminal unit shall be located over the base building standard lighting fixture at the height indicated on the Drawings. Provide two (2) Type "SD-A" perimeter slot diffusers or the supply diffusers indicated on the Drawings in the "discharge noise" office discharging the maximum airflow as scheduled in the Contract Documents.
4. Discharge ductwork shall be constructed as indicated on the Drawings. Connections to the terminal unit shall be "hard" or as indicated on the Drawings.
5. Supply air provided to the terminal units shall not affect the noise measurements. Duct construction, size and insulation shall be in accordance with the Drawings. The ductwork design should be capable of providing the system pressures without impacting the acoustical measurements.
6. The laboratory test setup and procedure shall be conducted in accordance with requirements approved by the Engineer and the Project Acoustical Consultant. Prior to construction of the test mock-up, the mock-up plans, details and proposed test procedures must be approved by the Engineer and Acoustical Consultant.
7. If the NC 40 criteria is not achieved at the scheduled design air volumes, the manufacturer shall be responsible to determine at what air volumes, at an inlet static pressure of 0.75" w.g. will the NC 40 criteria be achieved.
8. The laboratory test procedure shall be repeated with the terminal unit lined discharge ductwork as required by the Contract Documents replaced with unlined ductwork.
9. Mock-up tests may be witnessed by the Engineer, Owner and Project Acoustical Consultant.
10. If the terminal unit manufacturer has conducted the acoustical mock-up test specified herein or a similar two room type mock-up test in an acceptable laboratory with the Project's typical conditions and has demonstrated to the Engineer and Owner compliance with the specified acoustical performance, the previous acoustical testing will be accepted and will not need to be repeated. If the manufacturer has altered his terminal equipment construction from the original design and construction used in the previously approved test or if the equipment specified for this Project deviates in any manner from the previously approved test, the manufacturer shall repeat the mock-up testing for this Project using the specified equipment.

B. Sound Power Acoustical Performance:

1. Discharge Noise (no acoustical duct lining): The table below shows suggested maximums for reverberant room data taken as outlined in ANSI/AHRI 880, which may allow a particular terminal unit to comply with the mock-up requirement for this specification. The table is supplied strictly as a guideline. The mock-up criteria is the specification requirement. The basis of this table is an inlet static of 0.75" w.g., 3'-0" of acoustical flexible ductwork complying with ASHRAE acoustical performance on 90º elbow and maximum of 300 cfm per diffuser. The minimum distance of 10'-0" of unlined ductwork shall be provided before each and every diffuser connection to the secondary ductwork.

AIR DISTRIBUTION SYSTEM EQUIPMENT/TERMINAL DEVICE NOISE No Lining MAX PWL (dB re 10^{-12} Watt)		
Octave Band	NC-35	NC-40
2	67	71
3	64	69

AIR DISTRIBUTION SYSTEM EQUIPMENT/TERMINAL DEVICE NOISE No Lining MAX PWL (dB re 10^{-12} Watt)		
Octave Band	NC-35	NC-40
4	67	72
5	66	71
6	67	72
7	67	72

2. Radiated Noise: The table below shows suggested maximums for reverberant room data taken as outlined in ANSI/AHRI 880, which may allow a particular terminal unit to comply with the mock-up requirement, for this Specification. The table is supplied strictly as a guideline. The mock-up criteria are the specification requirement. The basis of this table is an inlet static of 0.75" w.g.

RADIATED SOUND POWER (dB re 10^{-12} Watt)		
Octave Band	NC-35	NC-40
2	64	68
3	57	62
4	53	58
5	50	55
6	50	55
7	53	58

C. Fan Powered Box CFM Range:

Fan Powered Box CFM Range		
Unit Size	Inlet Size	CFM Range
2	8	142 - 675
3	8	212 - 700
3	10	212 - 1100
4	10	401 - 1100
4	12	495 - 1300
5	12	495 - 1400
5	14	496 - 1700
6	14	519 -1700
7	16	708 - 2500

D. Subcontractor's Certification: The Division 23 Subcontractor shall submit written Manufacturer's certification that the air terminal units selected for this Project meet all the specified acoustical requirements with and without heating coils at the scheduled capacities.

1.6 WARRANTY

A. Comply with the requirements of the General Conditions and Section 23 00 10.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. These Specifications set forth the minimum requirements for VAV series fan powered terminal units. If it complies with these Specifications, VAV series fan powered terminal units manufactured by one of the following manufacturers will be acceptable:
   1. Carrier
   2. Krueger
   3. Nailor Industries
   4. Price Industries
   5. Titus

B. If they comply with these Specifications, VAV series fan-powered terminal unit hot water heating coils manufactured by one of the following manufacturers will be acceptable:
   1. Carrier
   2. Krueger
   3. Nailor Industries
   4. Price Industries
   5. Titus

C. If it complies with these Specifications, one of the following single duct variable air volume terminal manufacturers will be acceptable:
   1. Anemostat
   2. Carrier
   3. Krueger
   4. Nailor Industries
   5. Price Industries
   6. Titus
   7. Trane
   8. Tuttle & Bailey

2.2 VARIABLE PRIMARY AIR VOLUME FAN-POWERED TERMINAL UNITS

A. Furnish and install double walled variable primary air volume series fan-powered terminal devices as indicated on the Drawings. The devices shall have hard duct connections or as indicated on the Drawings. The devices shall be provided with a primary variable air volume damper that controls the primary air quantity in response to a temperature and/or relative humidity control signal. The devices shall contain a fan and motor assembly and A hot water heating coil where scheduled and/or indicated on the Drawings. The fan shall provide a constant volume of discharge air at all air blending ratios from minimum to maximum scheduled primary air quantities and zero to one hundred (0 - 100%) percent return airflow rates and shall be controlled in sequence as out-lined in Division 25. If a dynamic fan volume control sequence is specified in Division 25, the terminal unit manufacturer's ECM motor microprocessor controller shall be compatible with the Division 25 unitary controller to vary the fan volume in accordance with the sequence outlined in Division 25. The space limitations shall be reviewed carefully to ensure all terminal devices will fit in the space provided including National Electric Code clearances required in front of all panels containing electrical devices. Provide an access door or panel to service all internal components and a removable panel to service the fan and electric motor. Provide a factory installed 8-1/2" x 11" or larger yellow color vinyl sign with adhesive backing on the top, bottom AND both sides of terminal unit, which has red letters stating,

"**DO NOT BLOCK THIS ACCESS PANEL WITH PARTITIONS, PIPES, CONDUIT OR WIRE. CALL THE BUILDING OFFICE IF YOU HAVE A PROBLEM**".

Signs shall not cover any portion of any other labels applied to the terminal units. The access doors on all devices shall have captive and/or cam latches. Provide a filter rack with a 1" thick throw away filter to be used during construction. Refer to Section 23 40 00 titled "Air Filtering" for additional requirements. Filter shall be removed by the Mechanical Subcontractor after construction period and prior to air balancing and replaced after air balancing. The final construction air filter shall be removed by the Mechanical Subcontractor after the construction period when directed by the Owner.

Terminal unit manufacturer shall provide flow curves for the primary air sensor clearly labeled and permanently attached on the bottom or side of each fan terminal.
The device shall include all equipment and controls as required to provide a complete and operating system with at least the following equipment and controls:

1. Single point electrical connection for the voltage/phase as scheduled in the Contract Documents. See Electrical Drawings for power feeder arrangements. Cooling only terminal units and units with hot water heating coils shall be rated at 277V, single phase, 60 hertz. Terminal units shall be provided with an input heating, air conditioning rated (HACR) circuit breaker or disconnect switch sized and located as required to disconnect all ungrounded power conductors to all device electrical components.
2. Individual overcurrent protection devices as required to protect individual devices and transformers.
3. The primary valve shall be equipped with an inlet collar. A transition (SMACNA Construction Standard) shall be provided and installed by the Division 23 Mechanical Subcontractor if required to connect to the primary duct size shown on the Drawings. The fan powered terminal unit primary inlet size shall be selected by the manufacturer to provide primary flow velocities over the specified capacity range of the terminal unit, which are compatible with the primary inlet flow sensor and the unitary controller provided by Division 25. Terminal unit inlet sizes shall be confirmed with the Engineer. The inlet collar shall provide at least a 3-1/2" length with a 1/8" high raised single or double bead located approximately 1-1/2" from the inlet connection. The primary and fan design cfm settings shall be clearly and permanently marked on the bottom or side of the unit along with the terminal unit identification numbers. Provide a transformer with 24V AC secondary to provide power for the terminal unit controls. The VAV terminal unit manufacturer and the Division 25 Subcontractor shall verify compatibility of the multipoint flow sensors with transducer and DDC microprocessor furnished under Division 25 prior to bidding this Project. A test shall be conducted in an independent test laboratory or in the terminal unit manufacturer's laboratory approved by the Owner, by the terminal unit manufacturer and each of the bidding Division 25 Subcontractors to confirm the accuracy and compatibility of the DDC terminal unit unitary controller and control system with the fan powered terminal device at various primary flow rates from 300 fpm to 2000 fpm. If the terminal unit manufacturer and the Division 25 controller manufacturer have conducted the unitary controller compatibility test specified herein with the Project's typical conditions and control sequences and has demonstrated to the Engineer and Owner compliance with the specified performance, the previous compatibility testing will be accepted and will not need to be repeated. If either of the terminal unit construction, Division 25 unitary controller, or the specified control sequence has been modified in any way from the original design, construction, version or sequence used in the previously approved test, the manufacturer shall repeat the mock-up testing for this Project using the specified equipment and control sequence. The test may be witnessed by the Engineer and Owner. Test results shall be submitted to the Engineer and Owner for review within ten (10) days after the test.[
4. Fan motor assembly shall be a forward curved centrifugal fan with a direct drive motor. Motors shall be ECM variable speed direct current brushless motors specifically designed for use with a single phase, 277V and 60 hertz electrical input. Motor shall be complete with and operated by a single phase integrated controller/inverter that operates the wound stator and senses rotor position to electrically commutate the stator. An integral controller furnished by the terminal unit manufacturer shall provide a signal to the "ECM" motor to maintain scheduled supply airflow. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero (0) rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be direct coupled to the blower. Motor shall maintain a minimum of seventy (70%) percent efficiency over its entire operating range. Provide isolation between fan motor assembly and unit casing to eliminate any vibration from the fan to the terminal unit casing. Provide anti-back rotation system or provide a motor that is designed to overcome reverse rotation and not affect life expectancy. If they comply with these Specifications, motors and inverter assemblies manufactured by General Electric, or A.O. Smith will be acceptable.
    a. The manufacturer of the fan powered terminal units shall factory set the fan discharge volume indicated in the schedule and/or on the Drawings for terminal units, which operate at constant fan discharge volume. If the fan powered terminal unit manufacturer cannot accurately factory set the fan volume for constant speed fans and the cfm needs to be readjusted or tuned during the air distribution outlet field balancing procedure, the fan powered terminal unit manufacturer shall send factory technicians to the project site to adjust the ECM motor and the terminal unit manufacturer's microprocessor/pwm controller to the fan discharge volume indicated in the Schedules in the Contract Documents at no additional cost to Owner. Fan discharge volume shall be accurate within ±5% regardless of changes in static upstream or downstream of the terminal unit after it is installed in the field. Fan cfm is to be set with a set screw or digital meter. The terminal unit manufacturer

shall provide calibration chart correlating fan cfm to voltage input to the microprocessor/pwm device. Neither SCR's nor rheostats shall be an acceptable means of setting the fan cfm. One (1) speed adjustment device shall be provided by the terminal unit manufacturer to the Owner for field adjustment of the fan speed should construction or design changes become necessary. The factory settings for fan discharge volume shall be clearly marked on each terminal unit identification label.

b. For fan powered terminal units with dynamic volume control sequences as specified in Division 25; the fan powered terminal unit manufacturer shall provide an algorithm to the Division 25 subcontractor that will allow the Division 25 DDC controller to directly reset the terminal unit fan discharge volume; the Division 25 subcontractor shall field program the set points as indicated in the schedules in the Contract Documents.

c. A test witnessed by the Engineer or Owner shall be conducted by the fan powered terminal unit manufacturer in an independent testing laboratory or in the manufacturer's laboratory approved by the Owner, to confirm that the terminal unit and the fan motor as an assembly performs in accordance with this Specification. If the fan powered terminal device and DC motor as an assembly fails to perform as specified and as scheduled on the Drawings, the terminal unit manufacturer shall make adjustments and take all corrective action as necessary at the terminal unit manufacturer's sole expense.

5. The terminal unit shall be listed in accordance with UL 1995 as a composite assembly consisting of the terminal unit with or without the hot water heating device.
6. VAV Terminal Device Hot Water Heating Coils:
   a. Terminal unit hot water heating coils shall be installed completely within the terminal unit casing and enclosing the coil headers, "U" bends and the factory piping assemblies. Provide a hinged access door or hinged panel on the bottom of the terminal unit for servicing and cleaning the coil and to completely expose coil headers, hot water two (2) way modulating control valve (furnished by Division 25) and the ball type drain valves. Refer to Section 23 21 13 for ball valve specifications. At the terminal unit manufacturer's option, factory built piping assemblies containing such items as ball valves, automatic control valves, pressure/temperature test ports, etc., manufactured by Flow Design Inc., Dallas, Texas or HCI, Madison Heights, MI will be acceptable if they are installed as an assembly within the terminal unit enclosure at the terminal device manufacturing facility. The individual components shall comply with the specifications herein. All two (2) way control valves within the factory-built enclosure shall have unions on both sides for ease of removal.
   b. The Division 23 Subcontractor shall field install isolation ball valves outside each FPTU enclosure. Refer to Section 23 21 13.
   c. The factory hydrostatic or air pressure test of the coil and entire piping assembly shall be maintained for a minimum of one (1) minute after which each piping joint connection, etc., shall be examined to verify there is no evidence of weeping or leakage. If liquid was used for the pressure testing, it shall be completely drained and blown out of all coils and the internal piping system prior to shipment. If air pressure is used the entire coil and piping assembly shall be completely submerged under water. Hot water heating coils shall be constructed with copper tubes and either aluminum plate fins or spiral fins. Coils shall have a maximum of 14 fins per inch. Supply and return connections shall be on the same end of the coil and shall be ASTM B88-72, H23, I-59 Type "K" hard drawn seamless copper water pipe. Fins shall be bonded to the tubes by means of mechanical expansion of the tubes or by spiral winding under tension.
   d. Coils shall have galvanized steel casings on all sides no lighter than 20 gauge.
   e. Tubes shall be 1/2" or 5/8" O.D. shall be spaced approximately 1-1/2" apart and shall have a minimum wall thickness of 0.018". Hot water shall be equally distributed through all tubes by the use of orifices or header design. Water velocity in the tubes shall not exceed five feet per second. The water pressure drop through the coil shall not exceed 10'. Heating coil face velocities shall not exceed the maximum face velocity indicated in the schedules on the Contract Documents.
   f. Coils shall have manual air vent connections except on those return connections where the coil header piping is designed to be self-venting.
   g. Coils and piping assemblies shall be tested at one and one-half times the specified working pressure classification and/or as indicated on the Contract Documents.
   h. Coil ratings, calculations and selection data shall be in accordance with the applicable AHRI Standards and shall be submitted with the Shop Drawings.
   i. The complete heating coil piping assembly, including all of the listed appurtenances, shall be provided and factory installed by the terminal unit manufacturer. The coil and piping assembly shall be factory pressure tested.

j. All piping, valves and fittings shall be suitable for the working pressure shown on the Contract Documents. The internal piping shall be sized to limit the velocity to no more than 8 fps at maximum design flow.

7. The primary air damper shall be of a design that shall vary primary air supply in response to an electronic signal. Primary air damper close-off leakage shall not exceed four (4%) percent of the maximum AHRI rated primary air cfm as shown in the manufacturer's catalog for each size terminal unit at 1" w.g. inlet static pressure. Submit damper leakage test data to the Engineer for review. Damper linkage and actuator may be located inside or outside the terminal unit. If the primary damper actuator is located outside the terminal unit enclosure, it shall be located within the low voltage sheet metal enclosure or within the unitary controller. Damper connection to the operating shaft shall be a positive mechanical connection to prevent any slip page. Provide non-lubricated Delrin or bronze oilite bearings for the damper shaft. The primary air damper in conjunction with the DDC microprocessor furnished under Division 25 shall be selected to provide accurate control at low primary air velocities. The total deviation in primary airflow shall not exceed ±5% of the primary air cfm corresponding to a 300 fpm air velocity through the primary air damper at 0.2" to 1.0" w.g. inlet static variation or alternate low flow control logic shall be provided to offset low flow deviation, subject to Engineer's approval. The primary airflow fidelity shall be laboratory demonstrated and proven with any inlet configuration and inlet static variation from 0.2" to 1.0" w.g. Dampers shall be life cycle tested to at least 10,000 cycles.
8. A mixing chamber to provide mixing of primary air and plenum air from one hundred (100%) percent primary air to zero (0%) percent primary air, with a temperature variation four feet downstream of the device as specified hereinafter. The deviation of fan CFM supply air for terminal units equipped with constant speed motors and control sequences at design conditions and primary airflow rates from one hundred (100%) percent primary air to zero (0%) percent primary air shall not exceed five (5%) percent.
9. Provide duct inlet and outlet connections as indicated on the Drawings.
10. Sound attenuation of air stream noise and acoustical treatment of the terminal unit shall comply with the following criteria at 1.25" w.g. inlet pressure, 0.25" w.g. discharge pressure, and the specified design air volume scheduled on the Drawings. Radiated noise and discharge noise readings shall be recorded at 0.75" w.g.inlet static pressures.
11. Limit the terminal unit radiated noise to the maximum sound level indicated by an NC 40 curve in the occupied space when the terminal unit is installed above the ceiling material specified for this Project in another Division of the Specifications at an operating primary air inlet static pressure of 1.25" w.g. Refer to Paragraph 1.06 for additional acoustical requirements.
12. At the option of the terminal unit manufacturer, the acoustical performance of the fan powered terminal unit may be enhanced by providing an integral, harmonically tuned inlet chamber upstream of the mixing chamber. This harmonically tuned chamber shall provide a channel for the induction air into the mixing chamber. The entire assembly may be factory-built and provided as a single fan powered terminal unit assembly or provided in separate sections and field assembled. Field installed inlet chambers shall be provided with a neoprene gasket between the fan powered terminal unit and the inlet chamber. Interior lining in this chamber shall conform to the acceptable interior lining in the main unit.
13. A double wall galvanized sheet metal housing shall be provided for the terminal unit casing. The casing construction shall be a minimum 20 gauge outer sheet with a minimum 22 gauge perforated with twenty-five (25%) percent openings or 26 gauge solid inner sheet encapsulating minimum 3/4" thick, minimum 1-1/2 lb. density fiber glass insulation. The terminal units utilizing 22 gauge perforated inner sheets shall have reinforced foil faced fiber glass (FSK) insulation. The terminal unit's depth shall not exceed 20-1/8" unless otherwise indicated on the Drawings. Mounting connections for hanging the device by sheet metal straps shall be clearly identified on the housing. All components, including all controls and wiring, shall be factory installed, except the room sensor or thermostat. No field assembly will be allowed. The device shall be complete and suitable to accept the following field connections:
    a. Primary duct.
    b. Secondary duct.
    c. Single point electrical connection. See Drawings for control box locations required for each terminal device.
    d. DDC controller control signals and wiring.
    e. Room sensor connection.

B. The terminal unit shall be capable of operating throughout the full cataloged primary airflow range with an inlet static pressure of 0.25" w.g. or less. All down-stream static pressure requirements are to be supplied by the terminal unit internal fan. See the schedules on the Contract Documents for static pressure requirements.

C. The control sequence shall be as specified in Division 25.

D. Each size of each terminal unit to be used on this Project shall be completely laboratory tested for air performance and acoustics. The acceptability of the testing laboratory is subject to review by the Owner, Project Acoustical Consultant and the Engineer. The terminal unit manufacturer shall submit complete details, brochures, instrumentation information, etc., for review. The laboratory shall be capable of properly testing the largest terminal unit on this Project. The air volume listed on the Drawings for the terminal units shall be supplied for the test with the primary cold duct supplying 48ºF air and the plenum bypass air at 80ºF. At primary air damper or valve positions as indicated hereinafter and with an inlet static pressure of 0.20" w.g., 0.50" w.g. and 1.0" w.g., the mixing device shall be capable of producing a mixed air stream of which the temperature shall not vary more than 2.5ºF over the duct 48" downstream of box for each 30ºF temperature difference between the temperatures of the entering warm and cold air. The variation of temperature shall be proportionally less at smaller temperature differences. There shall be at least fifteen temperature readings made at the discharge outlet duct over the entire discharge area with the air entering the device in each of the following proportions:

1. Twenty-five (25%) percent cold air and seventy-five (75%) percent plenum air.
2. Fifty (50%) percent cold air and fifty (50%) percent plenum air.
3. Seventy-five (75%) cold air and twenty-five (25%) percent plenum air.
    a. Operation of the flow control device shall be demonstrated to repeat under all conditions of operation of the primary air damper or valve and duct pressures as specified hereinbefore. If the fan powered terminal unit manufacturer has conducted the hereinbefore specified air performance and air mixing tests and has demonstrated to the Engineer and Owner compliance with the specified criteria the previous testing will be accepted and will not need to be repeated. Test results shall clearly state fan performance at test altitude and at Project altitude. See Section 23 05 07 titled "Design Conditions".

E. After the manufacturer has submitted six (6) certified copies of the laboratory air performance and acoustical performance test results to the Engineer. The Engineer may witness the laboratory tests to verify compliance with the Specifications. See Section 23 00 10 for additional submittal and certification requirements.

F. The Division 25 Subcontractor shall furnish the FPTU-UC (unit controller) and flow transducers (if not integral with the UC) to the FPTU manufacturer's factory. The Division 25 Subcontractor shall supply written instructions and drawings containing sufficient information to enable the FPTU manufacturer to undertake the installation satisfactorily. The Division 25 Subcontractor shall visit the FPTU manufacturer's facility shortly after the commencement of production for this Project to ensure that the FPTU manufacturer's installation and wiring procedures are satisfactory. The FPTU manufacturer shall prepare a drawing of the wiring for the FPTU unit controller and all associated instrumentation and final control elements based on the information provided by the Division 25 Subcontractor. The FPTU manufacturer and the Division 25 Subcontractor shall both certify on the drawing that the drawing is correct and the drawing shall be submitted as a Shop Drawing for review by the Engineer. The Division 25 Subcontractor shall visit the FPTU manufacturer's facility at the completion of the first production run for this Project and prior to the shipping of any FPTU to the Project Site, to inspect the installation of the UC. The FPTU manufacturer shall not make any factory adjustments to the FPTU unit controller or enter any data into the FPTU unit controller in any way. All testing, entry of data and adjustments of any kind to the FPTU unit controller shall be undertaken by the Division 25 Subcontractor at the Project Site.

G. The FPTU manufacturer shall provide the following:

1. Multipoint flow averaging sensors with a minimum of four (4) measuring points parallel to the take-off point from the sensor in the primary air inlet on all terminal units. Sensors with measuring points in series are acceptable. The averaging sensor must provide a minimum pressure signal of at least 0.03" w.g. at a primary inlet velocity of 500 fpm. Fan powered terminal units, which are not equipped with the "ECM" fan motor shall have a multipoint flow sensor factory installed in each induction port. An averaging flow sensor of equal accuracy may be provided at the fan inlet in lieu of flow sensors at each induction port. UL listed (F-R) type tubing shall be factory installed as required for the flow sensors and bulkhead pressure fittings on the outside of the terminal unit enclosure.
2. 24V AC transformer.
3. 24V AC fan start/stop relay, if required. The fan and ECM motor may be started and stopped by the manufacturer's microprocessor/pwm controller.
4. Automatic fan speed adjustment device.
5. Sheet metal enclosure for the Division 25 Unitary DDC Controller (UC).
6. Primary air damper and linkage.

H. The FPTU manufacturer shall verify with the Division 25 Subcontractors submitting proposals on this Project prior to the bid date that:
   1. The pressure differential generated by the primary air multipoint sensors at the specified flow range is compatible with the instrumentation to be provided by the Division 25 Subcontractor.
   2. The damper shaft is compatible with the damper actuator of the FPTU DDC terminal unit controller provided by Division 25.
   3. If Division 25 terminal unit control sequences require dynamic speed control of the fan, the terminal unit manufacturer shall provide the required interface device to receive a 0 to 10V signal to adjust it automatically in response to control software/program resident in the Division 25 DDC terminal unit controller.
   4. The 24V AC power supply is adequate for the satisfactory operation of the control systems.
   5. The Fan control relays and two (2) way hot water valve are compatible with the FPTU unit controller.

I. All fan powered terminal units shall be identified on the bottom or side of the unit (minimum 1/2" high letters) and on the shipping carton, with the floor and box number that identifies it along with the CFM settings. Every unit shall have a unique number combination that matches numbers on the Coordination Drawings as to its location and capacity and is coordinated with the DDC controller and the Division 25 Shop Drawings.

J. The FPTU manufacturer will verify the operation of each fan powered terminal before shipment. Testing shall include at least the following:
   1. Apply electric power to the unit.
   2. Start the fan and verify fan rotates properly.
   3. The FPTU manufacturer shall factory or field adjust the GE ECM motor on constant speed fan powered terminal units without dynamic fan volume control sequences and associated controller/inverter to the discharge CFM indicated in the Schedules. (Refer to paragraph 2.03 A.6.a. hereinbefore.)
   4. Disconnect the primary air damper actuator from the DDC terminal unit controller. Provide separate power source to the actuator to verify operation and rotation of damper. Drive the damper closed and verify by feel or observation that damper is driven fully closed. Return primary air damper to the fully open position prior to shipment.
   5. Provide a written inspection report for each terminal unit signed and dated by the factory test technician verifying all terminal unit wiring and testing has been performed per the manufacturer's testing and quality assurance requirements.

K. The Division 25 Subcontractor shall provide the terminal unit manufacturer with a multicolor point-to-point wiring diagrams detailing the wiring of the DDC controller and other control equipment installed on the terminal device. The terminal unit manufacturer shall review and approve the wiring diagrams and coordinate any changes necessary with the control contractor. The terminal unit manufacturer shall incorporate the final version of the wiring diagram in his terminal unit Shop Drawing submittals along with a letter from the Division 25 Subcontractor stating his approval of the diagram. When the terminal units are released for fabrication and shipment, the Division 25 Subcontractor shall be provided with a shipping schedule and terminal unit manufacturer's factory order numbers along with requirements for tagging of shipments. Division 25 control devices for each and every release must be at the terminal unit manufacturer's facilities at least six (6) weeks prior to scheduled shipments.

2.3 SINGLE DUCT VARIABLE AIR VOLUME TERMINALS:

A. Furnish and install variable air throttling terminal units at the locations indicated on the Drawings. These terminal units shall be designed with one (1) inlet and one (1) outlet. The terminal units shall be designed to mount in the ductwork and shall be provided with a factory mounted electric motor operated volume control damper designed to maintain a variable air volume through the terminal unit at varying differential pressures across the device. The terminal unit inlet shall be sized by the terminal unit manufacturer to provide the maximum flow cross signal strength to the Division 25 BMCS unitary controller over the flow range of the VAV terminal device.

B. The casing shall be a double wall galvanized sheet metal enclosure. The casing construction shall be a minimum 22 gauge outer sheet with a minimum 22 gauge perforated inner sheet with twenty-five (25%) percent openings or 26 gauge solid inner sheet encapsulating minimum 3/4" thick, minimum 1-1/2 lb. density fiber glass. The casing shall be adequate to withstand 2.0" w.g. interior pressure. Casing leakage shall not exceed two (2%) percent of the maximum scheduled design airflow at 2.0" w.g. differential pressure across the casing.

C. The variable volume terminal unit assembly shall be furnished with a factory mounted inlet airflow sensor, a factory mounted electric damper actuator furnished by Division 25 and a factory installed pressure independent electronic DDC terminal unit controller furnished by the Division 25 Subcontractor to accurately detect and control the velocity through the unit to maintain a minimum and maximum volume regardless of inlet static pressure changes. If the variable volume terminal unit is equipped with an electric heater the heater airflow probe shall be located near the primary air damper in a high velocity area to minimize tripping of the heater during low flow conditions.

D. The primary control dampers shall be designed for tight closing. The maximum close off leakage at the fully closed position shall not exceed three (3%) percent of the maximum AHRI air cfm as shown in the manufacturers catalog for each size terminal unit at an inlet pressure of 2.0" w.g. The damper actuator motor shall be furnished by Division 25, and shall be mounted on the unit or internally mounted behind a full size access door with gaskets and easy access hardware. Provide non-lubricated Delrin or bronze Oilite bearings on the damper shaft. The overall depth of the VAV terminal unit including linkage, shall not exceed the maximum depth indicated on the Drawings.

E. The primary air damper in conjunction with the DDC unit controller furnished under Division 25, shall be selected to provide accurate control at low primary air velocities. The volume control assembly shall maintain the primary air volume within ±5.0% of the scheduled design minimum-maximum air volume indicated on the Drawings with differential static pressure variation of 0.20" w.g. to 2.0" w.g. Pressure drop through the terminal unit shall not exceed 0.25" w.g. at scheduled design air volume with no water heating coil. The Division 23 Subcontractor in association with the Division 25 Subcontractor shall set the required minimum-maximum air volume in the field. The unit shall be completely tested at the factory prior to shipment. The total deviation in primary airflow shall not exceed ±5% of the primary air cfm corresponding to a 300 fpm air velocity through the primary air damper at 0.2" to 1.0" w.g. inlet static variation or alternate low flow control logic shall be provided to offset low flow deviation, subject to Engineer's approval. The primary airflow fidelity shall be laboratory demonstrated and proven with any inlet configuration and inlet static variation from 0.2" to 1.0" w.g. Dampers shall be life cycle tested to at least 10,000 cycles.

F. The VAV throttling device shall be completely performance and acoustically tested in an acceptable laboratory. The acceptability of the laboratory and testing facilities is subject to review by the Engineer. The device manufacturer shall submit complete details, brochures, instrumentation, information, etc., for review. The laboratory shall be capable of properly testing the largest device on this Project.

G. The terminal unit shall be listed in accordance with UL 1995 as a composite assembly consisting of the terminal unit with or without hot water heating device.

H. Sound attenuation of air stream noise and acoustical treatment of the terminal unit shall comply with the acoustical criteria specified herein in paragraph 1.06 at 1.5" w.g. inlet pressure at the specified maximum and minimum design air volume scheduled on the Drawings. Radiated noise and discharge noise readings shall be recorded at 1.0" w.g., 1.5" w.g. and 2.0" w.g. inlet static pressures.

I. Single duct variable air volume terminals shall be similar to Nailor Industries Series 3000. Sizes and capacities shall be as indicated in the Contract Documents.

J. Refer to Division 25 for additional interface requirements.

PART 3 EXECUTION

3.1 INSTALLATION

A. All air terminal units shall be installed in accordance with the latest industry standards, per the manufacturer's recommendations and as indicated on the Drawings.

B. Fan Powered Terminal Device Mock-Up Requirements: Prior to the installation of multiple fan powered terminal devices, the Contractor shall install one of each size of the fan powered terminal devices as mock-up conditions generally representative of the typical ceiling plenum installation. The mock-up condition shall be complete with ductwork, tenant unit hangers, control, electrical connections and code clearances. The mock-up installations shall be located within one of the typical ceiling plenum areas of the project. The Contractor shall advise the appropriate Local Code Field Inspector, Engineer, and Owner's representative

after the mock-up is complete and ready for review and inspection. The Contractor shall arrange a time mutually agreeable to these parties so they can meet at the project site, review the mock-up installation, and determine any changes that need to be made for the installation to be acceptable to the Local Code Field Inspector. Issues regarding access and code NEC clearances plus obstructions and conflicts with other trades within the ceiling plenum will be discussed and mutually agreed upon. The mock-up condition, review of the mock-up condition by the appropriate parties, and the necessary modifications for the mock-up to become code compliant in the opinion of the Local Field Code Authority shall be completed prior to the installation of additional fan powered terminal devices. The Contractor shall account for this requirement in the schedule of construction so this procedure does not delay the construction progress. If multiple fan powered terminal devices are installed prior to the mock-up approval, the Contractor shall be responsible for the remedial work required to comply with the approved mock-up condition at no additional cost to the Owner. The Contractor shall provide advance notice to the appropriate parties of the fan powered terminal device mock-up inspection a minimum of seven working days prior to the meeting. If additional or follow-up field inspections of the mock-up modifications are required to establish the approval of the Local Field Code Authority, the Contractor shall provide these modifications and additional follow-up field inspections as required without additional cost to the Owner.

3.2 FACTORY TESTING

A. All air terminal units shall be tested in accordance with the latest applicable industry standards and as specified herein.

B. The Owner and/or Engineer may observe the air handling units for this Project under manufacture at the factory prior to shipment, if he so desires. The Mechanical Subcontractor shall notify the Owner and Engineer in writing at three (3) weeks prior to the first air handing unit production date.

3.3 FIELD TESTING

A. Prior to execution of field testing, submit test procedures, recording forms, and test equipment cut sheets to Engineer for review. Refer to Section 23 00 20 titled “Scope of Work” for “Scheduling Procedures”.

B. Refer to Section 23 05 93 for additional testing requirements for air terminal units.

END OF SECTION 23 36 00