# Suggested Specifications

## Model Series 3000 Basic Unit

### Section 15840

**1.01** Furnish and install **Nailor Model 3000 Single Duct Variable Volume Terminal Units** of the sizes and capabilities as indicated on the drawings. Units shall be pressure independent with (pneumatic, analog electronic, DDC) controls. Units shall reset to any flow between 0 and the maximum cataloged airflow as allowed by the specific controller.

**1.02** The entire terminal unit shall be designed and built as a single unit. The units shall be provided with a primary variable air volume damper that controls the air quantity in response to a (pneumatic, electric, analog electronic, or DDC) thermostat. The units shall also include all options such as electric or hot water heating coils, attenuators and access doors. The space limitations shall be reviewed carefully to insure that all units will fit into the space allowed.

**1.03** Unit casing shall be 22 gauge galvanized steel with round or flat oval inlets with 5 ½" (140 mm) deep inlet duct dollar for field connection. Outlets shall be rectangular and configured for slip and drive connections. Casing leakage downstream of the damper shall not exceed 1% @ 1" w.g. (250 Pa). High side casing leakage shall not exceed 2% @ 3" w.g. (750 Pa).

**1.04** Damper assemblies of 16 gauge galvanized steel shall be multiple opposed blade construction arranged to close at 45 degrees from full open to minimize air turbulence and provide near linear operation. Damper blades shall be fitted with flexible seals for tight closure and minimized sound generation. Damper blades shall be screwed through the shaft to insure that no slippage occurs. Blade shafts shall pivot on corrosion free Celcon® bearings. In the fully closed position, air leakage past the closed damper shall not exceed 2% of the nominal catalog rating at 3" w.g. (750 Pa) inlet static pressure as rated by ASHRAE Standard 130.

**1.05** The terminal units shall be capable of operation as described herein with an inlet static pressure of 0.10" w.g. (24 Pa) from 0 to 2000 fpm. (The sequence of operations should be described here, if not part of the temperature controls specifications.) Each unit shall be complete with factory mounted (pneumatic, electric, analog electronic, or DDC) controls. Gauge tap ports shall be supplied in the piping between the flow pick up and the controller.

**1.06** Each unit shall be constructed with single point electrical (and pneumatic) connections. All electrical components shall be ETL or UL listed or recognized and installed in accordance with the National Electrical Code. All electrical components shall be installed in a control box. The entire assembly shall be ETL listed and so labeled.

**1.07** Each unit shall be internally lined with ¾" (19) dual density fiberglass insulation. Edges shall be sealed against airflow erosion. Units shall meet NFPA 90A and UL 181 standards.

**1.08** All sound data shall be compiled in an independent laboratory and in accordance with the latest version of ARI Standard 880 and ANSI/ASHRAE Standard 130. All units shall be ARI certified and bear the ARI certification label.

**The following specification (digital controls by Div. 17) is recommended where an independent laboratory test and performance verification is required.:**

# Single Duct VAV Terminal Units - Models 3000, 30RE and 30RW

### Section 15840

**PART 1 – GENERAL**

**1.01 RELATED DOCUMENTS**

A. The requirements of the General Conditions, Supplementary Conditions, and the following specification sections apply to all Work herein:

1. Section 15 - - - General.
2. Section 15 - - - Scope of Work.
3. Section 15 - - - Design Conditions.
4. Section 15 - - - Electric Motors and Controllers.
5. Section 15 - - - Access Doors and Color Coded Identification in General Construction.
6. Section 15 - - - Ductwork and Sheet Metal.
7. Section 15 - - - Testing, Balancing, and Adjusting.

**1.02 SUMMARY**

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

**1.03 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. ANSI/ASHRAE Standard 130-96.
2. ARI Standard 880-98.
3. Underwriters Laboratories UL Standard 1995.
4. Underwriters Laboratories UL Standard 1996.

**1.04 QUALITY ASSURANCE**

A. 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 authority having jurisdiction, and suitable for its intended use on this Project. Space limitations shall be reviewed to ensure that the equipment will fit into the space allowed.

B. All equipment and material to be furnished and installed on this Project shall be run tested at the factory and results of that testing shall be tabulated and provided to the engineer when the equipment ships to the job site. See paragraph 2.03 G for specific requirements.

**1.05 SUBMITTALS**

A. The following submittal data shall be furnished according to the Conditions of the Construction Contract, Division 1 Specifications, and Section 15 - - - General and shall include but not be limited to:

1. Single Duct Variable Air Volume Terminal Units, complete with capacity data, test data, construction details, physical dimensions, electrical characteristics, etc.

**1.06 ACOUSTICS**

This acoustical specification describes sound power levels as tested to ARI 880 and ASHRAE 130.

A. Sound Power Acoustical Performance:

1. Discharge Noise: Maximum permissible sound power levels in octave bands of discharge sound through discharge ducts from terminal units operated at an inlet pressure of 1.0" w.g. and the maximum amount of air volume shown on the Project Mechanical Drawings leaving the terminal unit and entering the reverberant chamber shall be as follows:

# Suggested Specifications

## Single Duct VAV Terminal Units – Models 3000, 30RE and 30RW (continued)

| Octave Band | NC-35 | NC-40 |
|---|---|---|
| 2 | 67 | 71 |
| 3 | 64 | 69 |
| 4 | 67 | 72 |
| 5 | 66 | 71 |
| 6 | 67 | 72 |
| 7 | 67 | 72 |

**Table 1.** Maximum Discharge Sound Power Levels (dB re $10^{-12}$ Watts).

2. Radiated Noise: Maximum permissible radiated sound power levels in octave bands of radiated transmission from terminal units operated at an inlet pressure of 1.0" w.g. and the maximum scheduled air quantity in an installed condition over occupied spaces shall be as follows:

| Octave Band | NC-35 | NC-40 |
|---|---|---|
| 2 | 64 | 68 |
| 3 | 57 | 62 |
| 4 | 53 | 58 |
| 5 | 50 | 55 |
| 6 | 50 | 55 |
| 7 | 53 | 58 |

**Table 2.** Maximum Radiated Sound Power Levels (dB re $10^{-12}$ Watts).

**1.07 WARRANTY**

A. Manufacturer shall warrant equipment for one year from start up or 18 months from shipment.

**PART 2 – PRODUCTS**

**2.01 UNAUTHORIZED MATERIALS**

A. Materials and products required for the work of this section shall not contain asbestos, polychlorinated biphenyl's (PCB) or other hazardous materials identified by the Engineer or Owner.

**2.02 ACCEPTABLE MANUFACTURERS**

A. These Specifications set forth the minimum requirements for single duct VAV terminal units. If they comply with these Specifications, single duct VAV terminal units manufactured by one of the following manufacturers will be acceptable:

1. Nailor Industries.

**2.03 SINGLE DUCT AIR VOLUME TERMINAL UNITS**

A. Furnish and install single duct VAV terminal units as indicated on the Drawings. The units shall be designed and built as a single unit and provided with a primary variable air volume damper that controls the primary air quantity in response to a temperature control signal. The damper construction shall be rectangular with multiple opposed blades designed to operate on a 45° arc. Blades shall be 16 gauge galvanized steel, single thickness construction with heavy-duty gasket glued to the blades. Units shall be suitable for pressure independent operation with digital (DDC) controls. The units shall contain a damper assembly as described above and [electric or hot water] heating coils where scheduled and/or indicated on the Drawings. The space limitations shall be reviewed carefully to ensure all terminal units will fit into the space provided including National Electric Code clearances required in front of all panels containing electrical devices. Unit shall be fully lined with at least ¾" thick, dual density fiberglass insulation that complies with NFPA 90 for fire and smoke resistivity and UL 181 for erosion.

Any exposed edges shall be coated with approved sealant to prevent erosion. Casing leakage shall not exceed 2% of terminal rated airflow at 1.5" w.g. interior casing pressure. All high side casing joints shall be sealed with approved sealant and high side casing and damper leakage shall not exceed 2% of terminal rated airflow at 3" w.g.. Unit casing shall be minimum 22 gauge, galvanized steel with round or flat oval inlets and rectangular outlets.

Terminal unit manufacturer shall provide flow curves for the primary air sensor clearly labeled and permanently attached on the bottom or side of each terminal unit. At an inlet velocity of 2000 fpm, the differential static pressure for any unit size, 4 – 16 shall not exceed 0.10" w.g. for the basic unit.

The unit shall include all equipment and controls as required to provide a complete and operating system with at least the following:

1. Single point electrical connection for the voltage/phase as scheduled in the Contract Documents. See Electrical Drawings for power feeder arrangements. Units, heaters and/or transformers shall be rated at [**24, 120 or 277**] single phase as scheduled in the contract documents.

2. A door interlocking disconnect switch for units with electric heaters. All disconnecting devices shall be sized and located as required to disconnect all ungrounded power conductors to all internal electrical components.

3. Individual overcurrent protection devices as required to protect individual units and transformers.

4. The primary inlet shall be equipped with an inlet collar sized to fit the primary duct size shown on the Drawings. The inlet collar shall provide at least a 5 ½" length with a ⅛" high raised single or double bead located approximately 1 ½" from the inlet connection. The primary airflow (cfm) settings shall be clearly and permanently marked on the bottom of the unit along with the terminal unit identification numbers. Each terminal unit shall incorporate a Nailor Diamond Flow sensor with four pick up points on each side to insure that with typical duct turbulence, the controller fidelity shall be +/- 5% of set volume even with a hard 90° elbow at the inlet. Static variation of 0.5" w.g. to 6.0" w.g. shall not affect the flow reading. Provide a transformer with 24 volt AC secondary to provide power for the unit's controls and the Division 17 controls. The VAV terminal unit manufacturer and the Division 17 Building Controls Subcontractor shall verify compatibility of the multipoint flow sensors with transducer and DDC microprocessor furnished under Division 17 prior to bidding this Project.

5. The outlets shall be rectangular and suitable for slip and drive duct connections. Casing shall have mounting area for hanging by sheet metal straps from a concrete slab or shall be supplied with angle brackets for mounting on all thread rods.

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

7. Heating Options [**Insert Electric or Hot Water Coil specification**]

8. The terminal unit shall be capable of operation as described herein with inlet static pressure of .10" w.g. at 2000 fpm of primary air. [The sequence of operation should be described here if not part of the temperature controls specifications.] The primary air damper shall be of a design that shall vary primary air supply in response to electronic signal. Primary air damper close-off leakage shall not exceed 2% of the maximum ARI rated primary air cfm as shown in the manufacturer's catalog for each size terminal unit at 3" w.g. inlet static pressure.

# Suggested Specifications

## Single Duct VAV Terminal Units – Models 3000, 30RE and 30RW (continued)

Submit damper leakage test data to the Engineer for review. Damper connection to the operating shaft shall be a positive mechanical through bolt connection to prevent any slippage. Provide non-lubricated Celcon® or bronze oilite bearings for the damper shaft. The primary air damper in conjunction with the DDC microprocessor furnished under Division 17 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.

9. Provide duct inlet and outlet connections as indicated on the Drawings.

10. The casing construction shall be a minimum 22 gauge galvanized sheet metal lined with a minimum ¾" thick, dual density, minimum 1 ½ lb. density fiberglass insulation. The terminal units shall not exceed the depth indicated on the Drawings. Mounting connections for hanging the unit 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 unit 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 unit.

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 0.10" w.g. or less. See the schedules on the Contract Documents for static pressure requirements.

C. The control sequence shall be as specified in Division 17 (DDC by others).

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 independent 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. See paragraph 1.06 A for acoustic guidelines. The air volume listed on the Drawings for the terminal units shall be supplied for the test with the primary cold duct supplying 55°F air.

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 single duct VAV terminal unit manufacturer has conducted the hereinbefore specified air performance 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. See Section 15 - - - titled "Design Conditions".

E. After the manufacturer has submitted 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 15 - - - for additional submittal and certification requirements.

F. All terminal units shall be identified on the bottom of the unit (minimum ½" 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 contractor's coordination drawings as to its location and capacity and is coordinated with the DDC controller and the Division 17 Building Control System submittal drawings.

G. The terminal unit manufacturer will verify the operation of each single duct VAV terminal unit before shipment. Testing shall include at least the following:

1. Apply electric power to the unit.

2. Energize the electric heat through the electric heating coil relay. Verify the signal with a voltmeter and ammeter to ensure proper heater operation.

3. De-energize the electric heating coil and verify the signal with a volt-meter to ensure the heater is de-energized.

4. If DDC controls are mounted, 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.

# Options

## Electric Heat

## Insert following paragraphs:

**7 (A). Single Duct VAV Terminal Unit Electric Heating Coils:**

a. Electric heating coils shall consist of open coils of high grade nickel and chromium resistance wire or nichrome elements and insulated with ceramic insulators in galvanized steel brackets, supported in heavy gauge galvanized steel frames. Each unit employing an electric heating coil shall be constructed and installed in accordance with the requirements of the local authorities and shall be UL or ETL listed specifically with the heater as a component of the terminal unit device.

b. Coils shall have the capacities indicated in Contract Documents. Coils rated up through 5 kW shall be single phase, 277 volt, 60 hertz and coils larger than 5 kW shall be three phase, four wire, 480Y/277 volt, 60 hertz. Electric heating coils up to and including 4 kW shall be single stage. Electric coils above 4 kW shall be two stage.

c. Terminal bolts, nuts and washers shall be of corrosion resistant materials. Coils shall be constructed so the installation may be accomplished in accordance with the provisions of the National Electrical Code, for zero clearance. Coils shall be given a 2000 volt dielectric test at the factory.

d. Automatic reset thermal cutouts shall be furnished for primary protection with manually resettable limit switches in power circuits for secondary protection. Both devices shall be serviceable through terminal box without removing heating element from the terminal device. The air pressure safety cutout pickup probe shall be remotely mounted near the volume control damper for maximum fidelity.

e. Heating coils shall have a terminal box and cover, with quiet type built-in magnetic step controlled contactors for each circuit, branch circuit fusing for each branch circuit on heaters over 48 amps per the NEC, and an air flow safety interlock switch for installation in the heater control enclosure. Contactors mounted in

## Suggested Specifications
### Single Duct VAV Terminal Units – Models 3000, 30RE and 30RW (continued)

terminal units that are located above the ceiling in tenant occupied spaces shall be mercury step type. Provide a 120 or 24 volt control power transformer with an integral or separately mounted primary and/or secondary overcurrent protection device in accordance with NEC requirements.

f. All wiring of built-in devices shall be brought to clearly marked terminal strips. A complete wiring diagram shall be permanently attached to the heating coil panel cover.

g. Electric heating coils shall be designed for operation with the DDC controller and control system as specified in the Division 17 Specifications.

h. Electric heating coils and the associated control panels shall be constructed as a component of the entire terminal unit and mounted in the discharge attenuator downstream of the terminal unit. The resulting unit, including the heater and the VAV damper shall be no longer than 31 ½" in length.

i. The manufacturer shall prove adequate even airflow over the electric heating coil under the full range of airflow scheduled (minimum to maximum) to prevent uneven heating of the electric coils. The terminal device shall be listed in accordance with UL 1995 and UL 1996 as a composite assembly consisting of the VAV terminal device and the electric heating device.

j. Shop Drawings shall be submitted for review as specified in Section 15 - - -. These Shop Drawings shall indicate specifically the exact construction, materials, internal wiring, NEC working clearances, etc., of the terminal units and electric heating coils to be furnished under these Specifications.

### Hot Water Heating Coil
### Insert following paragraphs:

**7 (B). Single Duct VAV Terminal Device Hot Water Heating Coils**

a. Terminal unit hot water heating coils shall be mounted on the discharge of the unit with slip and drive connections. Provide an access door or panel on the bottom of the attenuator section of the terminal unit for servicing and cleaning the unit.

b. Hot water heating coils shall be constructed with copper tubes and aluminum plate fins. Coils shall have a maximum of 10 fins per inch. Supply and return connections shall be on the same end of the coil. Fins shall be bonded to the tubes by means of mechanical expansion of the tubes. Fins shall be at least .0045" thick.

c. Coils shall have galvanized steel casings on all sides no lighter than 22 gauge.

d. Tubes shall be ½" O.D. and shall be spaced approximately 1 ¼" apart, and shall have a minimum wall thickness of 0.016". 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 feet. Heating coil face velocities shall not exceed the maximum face velocity indicated in the schedules on the Contract Documents.

e. Coils shall be tested by air pressure under water. Coils shall be tested at 300 psig static pressure for 250 psig working pressure or as indicated on the Contract Documents.

f. Coil ratings, calculations, and selection data shall be in accordance with the applicable ARI Standards and shall be submitted with the Shop Drawings.

## Control Specifications (select one)
### Pneumatic Controls (Pressure Independent)

1. The terminal unit manufacturer shall provide factory mounted pressure independent controls which can be reset to modulate airflow between zero and the maximum cataloged capacity. Maximum airflow limits or mechanical volume regulators are not acceptable.
2. Each unit shall be supplied with a **Nailor** Diamond flow sensor with four pick-up points on each side to ensure that controller fidelity shall be within ± 5% of set volume under various same size duct inlet conditions and inlet static variation of 0.05" – 6.0" w.g. (12 – 1500 Pa). The sensor shall amplify the sensed velocity pressure and provide a minimum differential pressure of 0.03" w.g. (7.46 Pa) at 500 fpm (2.54 m/s) inlet velocity. Flow measuring taps shall be furnished with each terminal.
3. The reset volume flow controller shall have a constant reset span regardless of the minimum and maximum airflow settings selected. Reset span shall be adjustable from a minimum of 5 psi up to a maximum of 10 psi. Reset start point shall be adjustable from 3 – 10 psi. Controller air bleed off through the flow sensor is not acceptable. Controller shall be field convertible for direct or reverse acting. The compressed air consumption of the controller shall not exceed 1.0 SCFH at 20 psi. Acceptable controller is Kreuter CSC-3011 or equal.
4. Reset volume controller shall be factory calibrated and set for the scheduled maximum and minimum airflow settings. Flow measuring taps and flow charts shall be supplied with each terminal unit for field balancing and adjustment of airflow. All pneumatic tubing shall be UL listed fire retardant (FR) type. Each terminal shall be supplied with a label showing unit type, size, tag location, minimum and maximum airflow settings and control sequence number. Pneumatic spring return actuators shall be provided and factory mounted by the terminal unit manufacturer.
5. Reset volume controller shall be factory set and calibrated for operation with a direct/reverse (select one) acting room thermostat.

The actuator/damper connection shall be factory mounted to fail to a normally open/closed (select one) position upon loss of control main air pressure.

### Analog Electronic Controls (Pressure Independent)

1. The terminal unit manufacturer shall provide factory mounted pressure independent analog electronic controls which can be reset to modulate airflow between zero and the maximum cataloged capacity. Each terminal shall be equipped with a label showing unit type, size, tag location, minimum and maximum airflow settings and control sequence number. Controls shall be factory calibrated and set for the scheduled minimum and maximum flow rates.

2. Each unit shall be supplied with a **Nailor** Diamond flow sensor with four pick-up points on each side to ensure that controller fidelity shall be within ± 5% of set volume under various same size duct inlet conditions and inlet static variation of 0.05" – 6.0" w.g. (12 – 1500 Pa). The sensor shall amplify the sensed velocity pressure and provide a minimum differential pressure of 0.03" w.g. (7.46 Pa) at 500 fpm (2.54 m/s) inlet velocity. Flow measuring taps shall be furnished with each terminal. All pneumatic tubing shall be UL listed for fire retardant (FR) type.

3. The velocity controller shall have a constant 2° F (1.11°C) reset span regardless of minimum and maximum airflow limits. It shall include an onboard flow-through transducer utilizing twin platinum

# Suggested Specifications

## Single Duct VAV Terminal Units – Models 3000, 30RE and 30RW (continued)

resistance temperature detectors and shall be capable of controlling a velocity set point from 0 – 3300 fpm with an accuracy of 3%. The controller shall allow all airflow adjustments to be made from the matching room thermostat. The thermostat shall be furnished by the terminal unit manufacturer and provide a live velocity readout and feature semi-concealed set point slider(s) and set point indicator(s) and thermometer with a fahrenheit (centigrade optional) scale plate.

4. The terminal shall have a 24 VAC combination controller/ actuator single assembly. The actuator shall be of a direct drive design and provide a minimum torque of 50 in. lbs. (5.6 Nm). The actuator shall be of the floating reversible type and include a magnetic clutch, adjustable stops and a gear disengagement button. A tri-color LED shall indicate green for opening, red for closing and white for satisfied damper positions. Power consumption of the controller/actuator shall not exceed 4 VA.

5. The terminal manufacturer shall provide a Class 2, 24 VAC control transformer with internal current limiting protection. All controls shall be installed in an approved NEMA 1 enclosure.

## Digital (DDC) Controls (Pressure Independent) Factory Mounting Procedure

1. The terminals shall be equipped with pressure independent direct digital controls supplied by the control contractor under the automatic temperature controls Division 17 and mounted by the terminal unit manufacturer. The control contractor shall, in addition to sending the controls to the terminal unit manufacturer, provide technical data sheets for all components to be mounted, including dimensional data, mounting hardware and method, as well as application specific wiring and piping diagrams for each terminal type as depicted on the schedules and mechanical drawings.

2. Controls shall be compatible with the pneumatic 'Diamond Flow' multi-point averaging flow sensor supplied by the terminal manufacturer. The sensor shall have four pick-up points on each side to ensure that controller fidelity shall be ± 5% of set volume with any typical air turbulence in the duct and any typical flex inlet condition and with an inlet static variation of 0.05" w.g. to 6.0" w.g. (12 – 1500 Pa). The sensor shall amplify the sensed velocity pressure and provide a minimum differential pressure of 0.03" w.g. (7.46 Pa) at 500 fpm (2.54 m/s) inlet velocity. Flow measuring taps and flow curves shall be furnished with each terminal.

3. Controls shall be configured and field calibrated in the field by the control contractor after terminal installation has been completed. Pneumatic tubing shall be UL Listed fire retardant (FR) type. Each terminal shall be supplied with a label showing unit type, size and tag location.

4. The terminal manufacturer shall provide a Class 2, 24 VAC control transformer with internal current limiting protection and disconnect switch. All controls shall be installed in an approved NEMA 1 enclosure supplied and installed by the terminal manufacturer.

**Notes:**