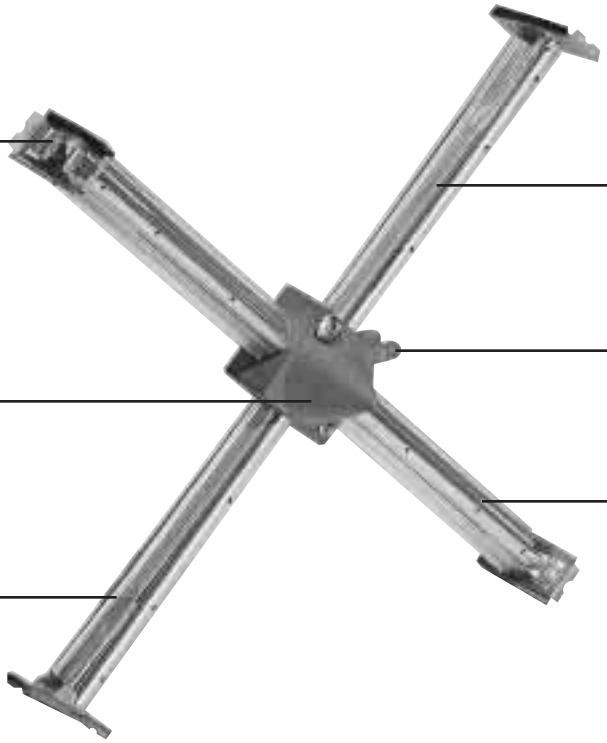
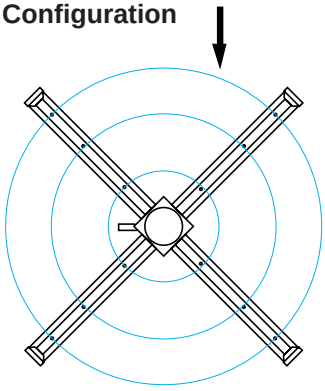
FLOW SENSING
FLO-CROSS® SENSOR

Tuttle & Bailey®



Upstream and Downstream Concentric Ring Sensing Port Configuration



Patent No. 4,453,419

- Accurate to +/- 5% throughout the catalog operating range.
- Sensing arms sample the inlet cross section mitigating turbulent flow effects.
- Barbed fittings positively lock plastic tubing.
- 24 total sensing ports provide a differential pressure (ΔP) output proportional to the average duct velocity.
- Amplification baffles strengthen ΔP signals to levels three times higher than standard Pitot tube readings.
- Center manifolds average velocity profiles and reduce pulsations from dynamic ΔP signals.
- Sensing tube construction eliminates signal loss due to leakage.
- Concentric ring sensing port configuration imitates major flow testing standards by locating them at the center of equal areas.
- Corrosion resistant construction.

FLO-CROSS SENSOR PERFORMANCE PARAMETERS/FORMULAS

Size	Area (FT^2)	Cv	K†
04	.0819	209	2.8
05	.1296	315	3.0
06	.1883	462	2.9
07	.2578	612	3.0
08	.3382	817	2.9
10	.5319	1250	3.0
12	.7691	1792	3.0
14	1.0500	2474	3.0
16	1.3745	3235	3.0
24	2.6321	6522	3.0

- Flow (CFM) = Cv x $\sqrt{\Delta P}$
- ΔP (inches W.G.) = K x $\left(\frac{FPM}{4005}\right)^2$
- FPM = $\frac{CFM}{\text{Area (sq. ft.)}}$
- 500 to 3000 FPM Nominal Velocity Range

†(K) is the amplification factor

General
Tuttle & Bailey terminal units are available in a no control configuration or with pressure independent volume control. The volume controller maintains a pre-set volume and responds to thermostat control between maximum and minimum set points. Factory installed electric heat and hot water coils provide reheat.

Controls
The controller monitors a differential pressure signal from the sensor as air flows in the duct section of the terminal. This differential signal is used to control the volume of air, which passes through the terminal. As room temperature changes, a signal is sent to a reset actuator on the controller to change the volume set point to satisfy the zone demand.

Packaging
Terminal units are packaged in cartons and/or are crated prior to shipment.

Storage
Units should not be stored outdoors. Units should be covered to protect against dirt, moisture, etc. Cartons may be stacked, but not over 5 cartons high. Crates must not be stacked.

Handling
Do not handle terminal units by damper rod extension, tubing connections, Flo-Cross® sensor, or other external attachments. Be careful not to damage controls when removing units from shipping containers.

Initial Inspection
Once items have been removed from the shipping container, check carefully for damage to duct connections, coils or controls. File damage claim immediately with transportation agency and notify Tuttle & Bailey.

Unit Identification
Terminal units are assembled as indicated on unit label. Each unit is supplied with an identification label, as shown.

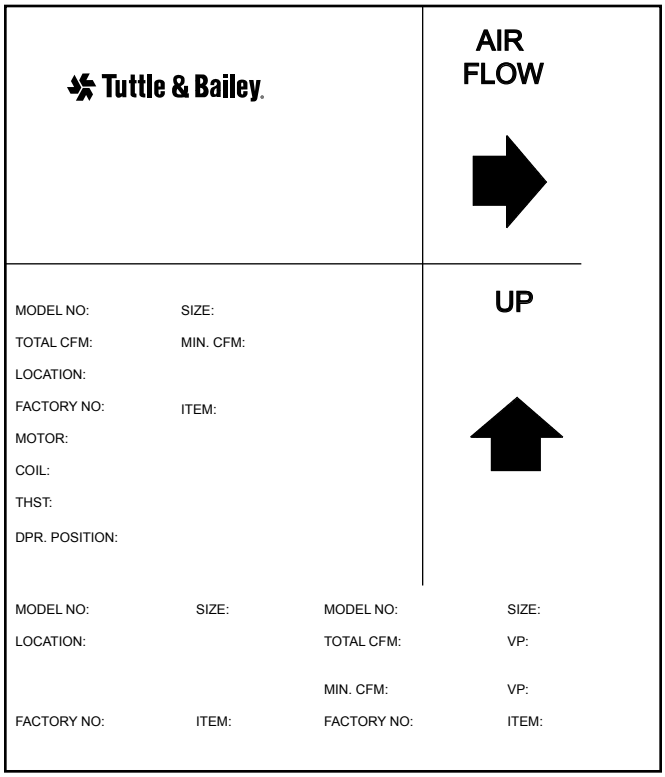
Installation Precautions
Check that construction debris does not enter unit or ductwork. Do not operate the central-station air-handling fan without final or construction filters in place. Accumulated dust and construction debris distributed through the ductwork can adversely affect unit operation.

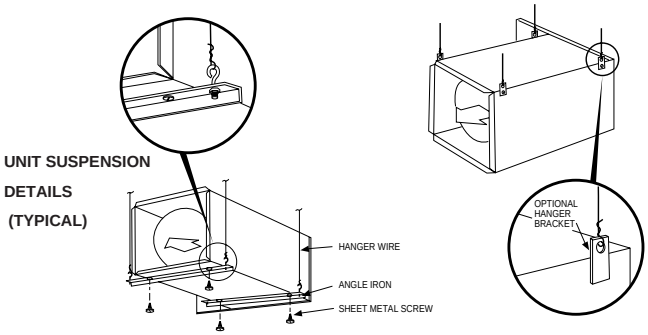
Service Access
Provide service clearance for unit access.

Codes
Install units in compliance with all applicable code requirements.

Warranty
All Tuttle & Bailey furnished items carry the standard Tuttle & Bailey warranty. Control components and items furnished by others, whether or not installed at Tuttle & Bailey's factory, are not warranted by Tuttle & Bailey.

UNIT IDENTIFICATION





Installation

INSTALL UNIT

1. Move unit to installation area. Remove unit from shipping package. *Do not handle by controls, Flo-Cross® sensor, or damper extension rod.*
2. Install the field-supplied angle iron or accessory hanger to the terminal unit. Avoid interference with internal parts or access panel. Optional hanger brackets also available.
3. Suspend units from building structure with straps or hanger wires. Secure the unit and level it in each direction. Note that reheat coil is in heavy end of unit.

MAKE DUCT CONNECTIONS

1. Install supply ductwork on unit inlet collar. Check that air supply duct connections are airtight and follow all accepted duct installation procedures.
2. Install the discharge duct. Seal and insulate duct as required.

Pipe Pneumatic Controls

1. Pipe control as shown on the control package diagram for the specific installation. These diagrams may be obtained from the local Tuttle & Bailey representative.

   Using 1/4 in. OD FR plastic tubing (or other piping as required by local codes), connect main, thermostat and optional hot water valves or Pressure-Electric (P/E) switches to the volume controller/actuator at interface connections A and B.
2. Care must be exercised to select the proper spring rate for hot water valves in order to sequence the valve with the damper. Recommended spring rates are shown on the control package piping diagrams.
3. The P/E switches for sequencing stages of electric heat are set at the factory according to the table below. See specific control package application sheet for P/E switch requirements.
   The P/E switches activate reheat stages in this way: with a reverse acting thermostat, as the room temperature falls, the damper closes to minimum flow. As the room temperature continues to fall, the branch line pressure from the pneumatic thermostat rises until the first stage on a N.O. P/E switch closes, activating the first stage or reheat. If the room temperature continues to fall, the rise in branch pressure will activate the second and third stages.

   When used with a D.A. thermostat, normally closed P/E switches maintain full electric reheat when the room temperature (and pressure) is low. As the temperature rises, the P/E switches open, de-energizing stages of electric heat.

   The P/E switches can also be set in the field, using gages to accurately locate the required pressure. Care must be taken to provide sufficient differential pressure between separate switch settings.

P/E SWITCH SETTINGS (psig)

STAGES	NORMALLY CLOSED P/E (Open on Rise)			NORMALLY OPEN P/E (Close on Rise)		
	1	2	3	1	2	3
1	7			9		
2	7	6		9	10	
3	7	6	5	9	10	11

Wire Electronic Analog Controls

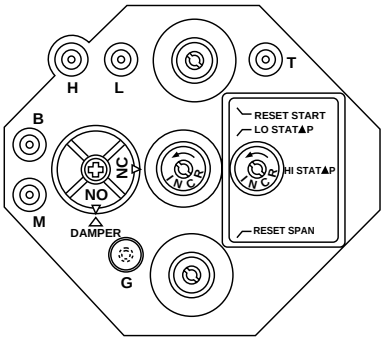
1. Wire controls using the control package diagram. The control diagrams may be obtained from the local Tuttle & Bailey representative.
2. Remove the controller wiring access door by pulling back on the access door's tab and lifting upward. The access door will now lift off and provide access to the wiring terminations.
3. Wire, or cable, access is via two 5/8" diameter snap-in shutter bushings located on the rear of the controller's cover.
4. Connect the controller to the thermostat as follows:
   - Terminal "16VDC" to thermostat terminal "+".
   - Terminal "IN" to thermostat terminal "T1" for cooling or "T2" for heating air flow. NOTE: If minimum and maximum velocity limits will be set at the controller, then use "T3" for cooling and "T4" for heating.
   - Terminal "OUT" to thermostat terminal "V1" for velocity readout at thermostat.
   - Terminal "—" to thermostat terminal "—". Connect the CSP to a 24VAC, -15/+20%, 50/60 Hz, power source.
   - Terminal "~" to the phase side of the 24VAC transformer.
   - Terminal "—" to the neutral or ground side of the transformer.
5. Replace the wiring access door by inserting the door's two hinge-tabs into the matching slots on the controller's cover, press down until the tab clicks in-place.

Tuttle & Bailey offers a wide variety of factory-installed controls. The controls provide pressure-independent control as well as various applications for minimum and maximum flow, hot water, electric heat, warm-up and sequencing control.

Volume controllers are used to provide a variety of control functions and applications. Each control combination is identified on the unit nameplate.

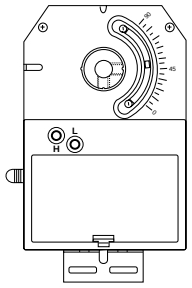
Operation of units with pneumatic or electronic analog controls are dynamically verified using statistical process control.

Pneumatic Controller



- Flo-Cross® Sensor—integral to the volume control system for the most accurate flow sensing available.
- Field adjustment—of maximum and minimum air flows easily made with screwdriver and integral flow chart.
- Reset span—adjustable from 0 to 10 psig (factory set at 5 psig), when set, remains constant regardless of maximum/minimum air flow adjustments.
- Low air consumption—0.017 SCFM at 20 psig.
- Direct or reverse acting—thermostat action is field adjustable.
- Adjustable start point—from 0 to 10 psig to sequence with auxiliaries such as reheat coils.
- Damper action—field adjustable for normally open or normally closed.
- Controller mounted—with adjustments and tubing facing down for easy access from below.
- 15-25 psig—clean dry air source required for operation.
- Actuator attaches to damper shaft with positive lock crankarm, eliminating improperly adjusted linkage.

Electronic Analog Controller



- Flo-Cross® Sensor—integral to the volume control system for the most accurate flow sensing available.
- Field connections—easily done to clearly marked terminals.
- Volume adjustments—can be made at the wall thermostat or controller.
- Gear disengagement—button to simplify calibration and troubleshooting.
- Tri-color LED—indicates actuator action, green=open/red=close/white=satisfied.
- Control options—include: proportional control, hot water or electric reheat, dual minimum, building automation interface.

Direct Digital Controls

Tuttle & Bailey factory mounts the Direct Digital Controls (DDC) of major manufacturers which simplifies the integration of Tuttle & Bailey terminal units into Building Automation Systems. All the benefits of DDC are available to each individual zone. Tuttle & Bailey will factory mount, pipe and wire specified control components on the Tuttle & Bailey terminal unit. When required, an optional enclosure is available to protect control components.

The exclusive, patented Flo-Cross® Sensor is compatible with most DDC controls on the market today and is recommended for applications requiring factory mounting of DDC controls. The Flo-Cross® Sensor's high level of accuracy, regardless of inlet conditions, makes it an excellent match to the superior performance of DDC systems.

Control package drawings are available outlining the control manufacturer equipment and, factory provided equipment. All are shown on a complete piping and wiring diagram.

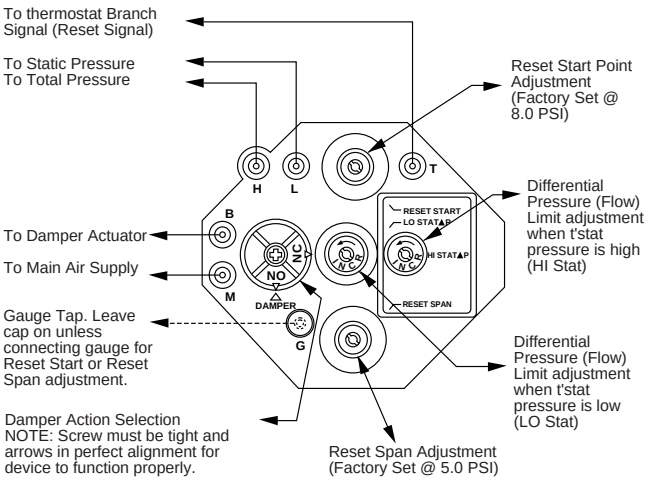
Tuttle & Bailey also offers terminal units without controls, with or without the Flo-Cross® Sensor for field mounting of DDC equipment.

START-UP
CONTROLLER DIAGRAMS

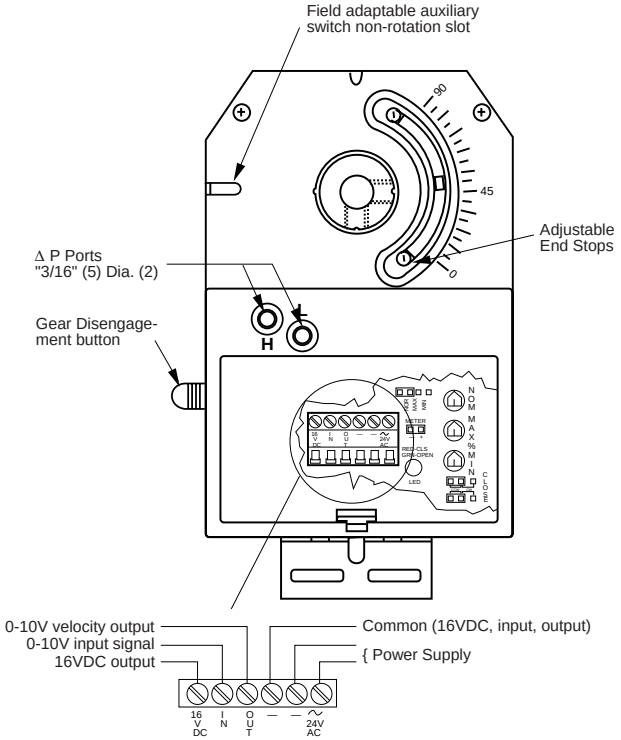
General
Air volume delivery to the conditioned space is controlled by the modulated opening and closing of a damper within the terminal unit. The damper is positioned by the actuator and volume controller.

System Check
1. Check that all controls, control box, and ductwork have been properly installed and set per installation instructions and job requirements.
2. Check that final filters have been installed in the air-handling apparatus. Dust and debris can adversely affect system operation.
3. Check electrical system and connections of any optional electric reheat coil. If hot water reheat is used, check piping and valves per job drawings.
4. Check pneumatic control system for proper control air pressure at terminal unit.
5. Check that all air duct connections are tight.
6. See that all balancing dampers at terminal outlets are in full-open position.

CONTROLLER DIAGRAMS



FIELD ADJUSTMENT OF AIRFLOW SETTINGS ON TYPICAL PNEUMATIC CONTROLS (SEE CONTROL PACKAGE DIAGRAM FOR SPECIFIC INFORMATION)



FIELD ADJUSTMENT OF AIRFLOW SETTINGS ON TYPICAL ELECTRONIC ANALOG CONTROLS (SEE CONTROL PACKAGE DIAGRAM FOR SPECIFIC INFORMATION)

CALIBRATION

Tuttle & Bailey

All volume controllers are factory set for maximum and minimum airflow according to sales order requirements. The requisite aiflow settings are found on the unit identification label. Other airflow settings may be obtained by field adjustment.

Pneumatic Controls

To change the settings, refer to pages 30 and 31, and proceed as follows:

1. Connect pressure gage or inclined manometer to high and low taps.
2. Refer to flow curves located on terminal side to determine differential pressure for specified maximum and minimum airflow.
3. Direct acting cooling or reverse acting heating.
   a. Adjust LO STAT DP to the desired minimum air flow limit with 0 PSI (or a pressure less than the reset start point) at port T.
   b. Adjust HI STAT DP to the desired maximum air flow limit with 20 psi (or a pressure greater than the reset start point plus reset span) at port T.
4. Reverse acting cooling or direct acting heating.
   a. Adjust LO STAT DP to the desired maximum air flow limit with 0 PSI (or a pressure less than the reset start point) at port T.
   b. Adjust HI STAT DP to the desired minimum air flow limit with 20 PSI (or a pressure greater than the reset start point plus reset span) at port T.

	Direct Acting Cooling	Reverse Acting Heating	Reverse Acting Cooling	Directing Acting Heating
LO Stat DP Adjustment	Minimum Limit	Minimum Limit	Maximum Limit	Maximum Limit
HI Stat DP Adjustment	Maximum Limit	Maximum Limit	Minimum Limit	Minimum Limit

Disconnect pressure gage and recap flow taps. Reset Start is factory set at 8 PSI. To field adjust proceed as follows:

1. Connect an accurate gauge to the G port.
2. Regulate thermostat pressure, to port T, to the desired startpoint pressure.
3. Adjust Reset Start to indicate 0 PSI on G port gauge and then adjust Reset Start to indicate a pressure slightly higher than 0 PSI, i.e. 0.1 PSI.
4. Replace cap on G port.

Reset Span is factory set at 5 PSI. To field adjust proceed as follows:

1. Connect an accurate gauge to the G port.
2. Regulate thermostat pressure, to port T, to 20 PSI.
3. Adjust Reset Span to indicate the desired span on G port gauge. Reset Span adjustments will affect the HI STAT DP. Reset Span must be adjusted first or HI STAT DP will require readjustment. Deviation from the factory set 5.0 PSI reset span will effect the differential pressure range of 1.0" W.C. of the pneumatic controller. An increase or decrease of the reset span will directly and proportionally effect the differential pressure range.

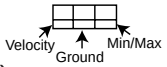
   LO STAT DP adjustment will affect the HI STAT DP, LO STAT DP must be adjusted first or the HI STAT DP will require readjustment.
4. Replace cap on G port.

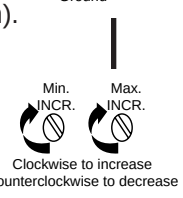
Electronic Analog Controls

(Thermostat Checkout/Calibration Procedures)

The thermostat (CTE-5100 Series) operates on a 16vDC power supply from the CSP controller and outputs a 0-10vDC signal on the T (?) terminals; T1 in the cooling mode (DA) and T2 in the heating mode (RA). In general, T1 and T3 are used for the cooling mode, T2 and T4 for heating. T1 and T2 are adjustable to limit min. and max. flow. T3 and T4 have a fixed 0-10vDC output signal.

1. Required Tools
   A. 1/16" hex/key wrench.
   B. Small flat blade (1/8") screwdriver.
   C. Digital volumeter capable of displaying a 0-10vDC range which will display in hundredths of vDC.
   D. HSO-5001 Test Leads (optional for meter taps).
2. Remove Thermostat Cover: Thermostat cover is removed by loosening the setscrews on each side of the thermostat. Using a 1/16" hex/key wrench turn the setscrews clockwise until cover is loose.
3. Check Voltages
   A. Verify 16vDC between (+) and (-) terminals.
   B. Measure "T (?)" to "-" for output voltage. Use calibration procedures below to adjust limits if desired. Adjust set point above and below current room temperature and observe changes in appropriate 'T' voltage. Remove set point slider stops (HFO-0027) if necessary.
4. Always Adjust Minimum flow limits first
5. Maximum limits must always be greater than minimum limits. If in doube, turn Max. limit fully clockwise (increase) before proceeding. NOTE: Dials rotate approximately 200° (8:00 to 4:00). DO NOT force dial beyond stop.
6. Connect voltmeter to the meter caps (Using HSO-5001).
   A. The two holes on the right are for the min. and max. reading.
   B. Move to the left to measure actual flow (must be wired to controller for this option).
7. Adjust set point to request Min. flow**
   A. D/A cooling stat; Set point <Room-temp.
   B. R/A cooling stat; Set point >Room-temp.
   C. Set maximum flow as desired using the max. dial.
8. Adjust set point to request Max. flow**
   A. D/A cooling stat; Set point <Room-temp.
   B. R/A cooling stat; Set point >Room-temp.
   C. Set maximum flow as desired using the max. dial.





NOTE: Do not use excessive force on dials. They should turn freely and effortlessly.

****NOTE: Limits may be set at the CSP or the CTE thermostat. If setting the min/max limits at the CTE thermostat the CSP's min. dial must be fully CCW to "0" and the max. dial set fully CW to "100". This will ensure that the CSP will not have any affect on the limits.**

Electronic Analog Controls

GENERAL

NOTE: See the logic board diagram on page 31 for terminal locations.

PRE-CHECK PROCEDURE
1. Determine if a 24V AC power supply, -15%, +20%, is wired to the power supply terminals.
2. Determine if the controller has been installed properly on the terminal box.
3. Determine if the minimum and maximum flow limits have been properly set (see page 32).
4. Determine if the thermostat is wired correctly.
5. Space temperature must be between 70° to 80°F.

FLOW CONTROLLER
To test the actuator's motor operation:
1. Temporarily disconnect the thermostat reset connection from terminal "IN".
2. Jumper "IN" terminal to the "16VDC" terminal.
3. The CLS/OPN bi-color LED should be "green", and the CSP's shaft drive hub should be rotating the damper open.
4. The damper should go to the full open position. If the maximum limit was set at the CSP, then the damper will only go the maximum setting. If the damper is rotating closed, the "CLOSE" jumpers must be changed. (Refer to ROTATION below)
5. Jumper "IN" terminal to the "—" terminal.
6. The CLS/OPN bi-color LED should be "red", and the CSP's shaft drive hub should be rotating the damper closed.
7. The damper should go to the full closed position. If the minimum limit was set at the CSP, then the damper will only go to the minimum setting. If the damper is rotating open, the "CLOSE" jumpers must be changed. (Refer to ROTATION below)

The Damper Rotation is factory set for a counter-clockwise (CCW) to close rotation. For clockwise (CW) to close rotation, move the two "CLOSE" jumpers from CCW to CW.

Pneumatic Controls

If the unit does not respond to the thermostat changes when the air handling system is in normal operation, proceed as follows:

VISUALLY INSPECT UNIT FOR DAMAGE
Check for kinked or disconnected tubing, broken taps or components, incorrect piping and plugged orifice taps.

CHECK THERMOSTAT
1. Consult manufacturer's recommendations.
2. Check maximum pressure output. If pressure is below 13 to 20 psi:

    a. Ensure sufficient main pressure.
    b. Ensure thermostat is mounted flush to vertical surface.
    c. Replace thermostat.

CHECK RESET CONTROLLER
Insert gage (0-30 psi) in line to reset actuator from thermostat. As thermostat branch pressure changes from 3 to 13 psig, reset actuator shaft should retract and extend in accordance.

DA will extend on space temperature increase.
DA will retract on space temperature decrease.
RA will retract on space temperature increase.
RA will extend on space temperature decrease.

If reset controller does not respond, replace.

CHECK POWER STROKE DAMPER ACTUATOR
Connect restricted main pressure directly to damper actuator. Damper should extend and retract as air is applied and removed. If not, replace actuator.