Anemostat's line of ***Replace-N-Save*** retrofit kits and valves, benefit both the building owner and facilities personnel responsible for maintaining the HVAC system and paying the electric bill.

Buildings constructed using air terminals with pre-1975 technology probably consist of either a single duct or dual duct constant volume system. These constant volume air terminals are tremendous workhorses, but unfortunately, they are also tremendous users of energy, due to their design and high operating pressures. Anemostat provides both internal and external retrofit solutions where the existing air terminals can be upgraded at a significantly lower cost as compared to a complete "tear-out & re-install" of new equipment. Good reasons to consider retrofitting an existing system:

1. ***Occupancy comfort / health / productivity***
   Older units are subject to wear and deterioration as is any equipment of the same age. This may mean that the original design intent and system capacities are no longer being satisfied. Poor productivity or high incidence of occupant illness may be related to poor thermal comfort and ventilation rates caused by equipment failure or lack of performance.
2. ***Energy Costs***
   Energy costs will never go down – the only way to combat increases in energy is with increased efficiency.
3. ***Minimized Disruption***
   External retrofits require minimal duct disturbance. Internal retrofits typically can be completed in less than 60 minutes, working through the access door in the bottom of the air terminal. Total building retrofit can be staged and completed during unoccupied hours, often by the building maintenance staff.
4. ***Equipment depreciation***
   Any tax depreciation benefit from the original equipment is long gone.

Energy Savings Analysis

In a conventional, constant volume dual duct air terminal with a mechanical constant volume regulator, the cold air capacity varies inversely to the hot capacity. Therefore, as the space temperature drops, the cold supply air capacity decreases and simultaneously the warm air flow rate increases and the total CFM delivered to the space is constant, see diagram 6. An Anemostat internal retrofit kit will reduce the capacities required for temperature control, while reducing the operating pressure requirements. Retrofit control loops are typically sequenced with the existing inlet dampers and a multitude of control strategies are possible. As the space temperature drops, the cold air volume is decreased to minimum capacity before the warm air damper opens. Thus, most of the temperature control is achieved by operating the air terminal with a variable capacity between minimum and 100% of the design capacity. Based on heating loads, the hot air volume may stay at minimum flow (diagram 7), or a dual maximum strategy can be utilized (diagram 8).

Energy savings occur with Anemostat retrofit kits because of reduced air flow rates, reduced operating pressures, and the elimination or reduction of simultaneous mixing of hot and cold air flows. With a typical operating setpoint at 75% flow through the cold duct, the fan discharge pressure can be reduced to less than 75% of the design requirements. Also, with a 25% capacity reduction, the fan operating power is reduced by 35%.

Many older constant volume systems may be operated as variable volume systems, with considerable energy savings, without any loss of occupant comfort. The conversion of the existing systems to variable volume often can be accomplished by the building maintenance staff, with minimal disruption to the occupants.

Typical Dual Duct Terminal With Mechanical Constant Volume Regulator

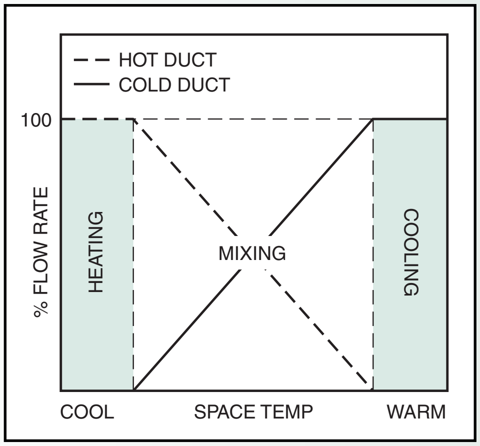


Diagram 6

Variable Total Air Flow With Mixing At Minimum Flow

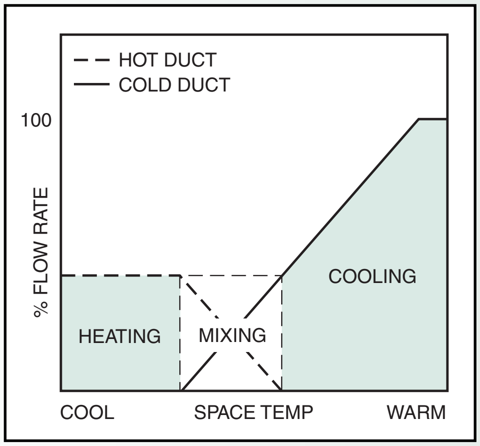


Diagram 7

Dual Maximum Variable Total Air Flow With Mixing At Minimum Flow

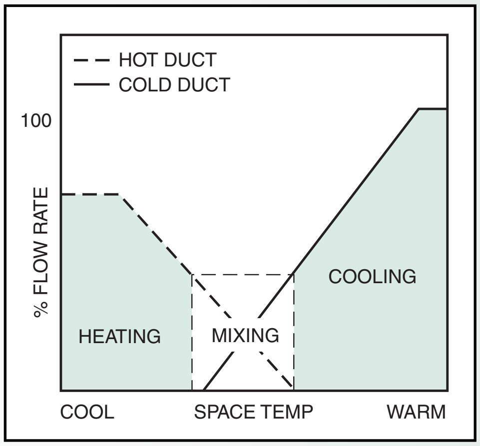


Diagram 8

EXAMPLE ENERGY SAVINGS CALCULATIONS

A constant volume dual duct air terminal is upgraded with (2) RF-3 retrofit kits as shown in figure 5:

DUAL DUCT - CONFIGURATION D2
• Existing Dampers & Regulators Removed

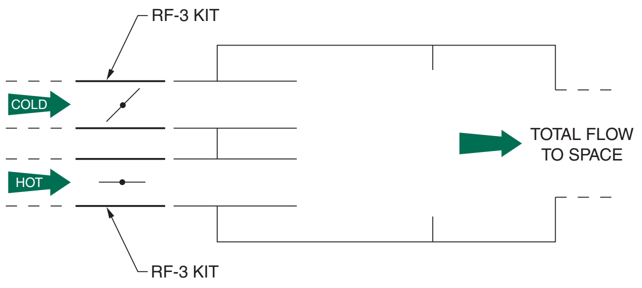


Figure 5

Constant Volume Cooling Cycle Assumptions

- 1000 ft^2 exterior zone
- 70% cold air / 30% warm air (return air) – average cooling cycle mixture
- Cooling ΔT = 20°F (75° space temp - 55° entering air temperature)
- Heating ΔT = 8°F (return air temp rise – return used for warm supply duct)
- 2 CFM/ ft^2
- 2000 CFM Constant Volume Air Flow
- 1250 hours of operation per 1/2 year
- $.10 / kWH
- 75° F space temperature

Calculate:

1. Total cooling load capability:
   100% x 2 CFM/ ft^2 x 1.08 x 20°FΔT = 43.2 BTUH/ ft^2
2. Cold & warm air mixture
   (during average cooling cycle condition):

   A = 70% cold air x 2 CFM/ ft^2 x 1.08 x 20°FΔT = 30.24 BTUH/ ft^2 Cooling

   B = 30% warm air x 2 CFM/ ft^2 x 1.08 x 8°FΔT = 5.18 BTUH/ ft^2 Heating
3. Average cooling load required:

   A – B = 30.24 – 5.18 = 25.06 BTUH/ ft^2 Cooling
4. With RF-3 retrofit kit installed on the cold duct, calculate CFM of cold air required to meet average cooling load:

   (25.06 BTUH/ ft^2 Cooling) / (1.08 x 20°FΔT) = 1.16 CFM/ ft^2 (a reduction from 2.0 CFM/ft^2)

Cooling Cycle Energy Savings:

Fan H.P. Reduction (based on 1000 CFM/HP):

(2.0 HP – 1.16 HP) x .746 kW / HP x $.10 / kWH x 1250 hours per 1/2 year = $78.33 / 1000 ft^2 / 1/2 yr

Refrigeration Savings: 5.18 BTUH/ ft^2 x 1 ton / 12,000 BTUH x 1 HP / .75 Ton x .746 kW / HP x $.10 / kWH x 1,000 ft^2 x 1250 hours per 1/2 yr = $53.76 / 1000 ft^2/1/2

Constant Volume Heating Cycle Assumptions

- 1000 ft^2 exterior zone
- 80% cold air / 20% warm air (return air) – average heating cycle mixture
- Cooling ΔT = 15°F (70° space temp - 55° entering air temperature)
- Heating ΔT = 30°F (100° entering air temp - 70° space temp)
- 2 CFM/ ft^2
- 2000 CFM Constant Volume Air Flow
- 1250 hours of operation per 1/2 year
- $.10 / kWH
- 70° F space temperature

Calculate:

1. Total heating load capability:
   100% x 2 CFM/ ft^2 x 1.08 x 30°FΔT = 64.8 BTUH/ ft^2
2. Hot & cold air mixture (during average heating cycle condition):

   A = 20% cold air x 2 CFM/ ft^2 x 1.08 x 15°FΔT = 6.48 BTUH/ft^2 Cooling

   B = 80% warm air x 2 CFM/ ft^2 x 1.08 x 30°FΔT = 51.84 BTUH/ft^2 Heating
3. Average heating load required: B – A = 51.84 – 6.48 = 45.36 BTUH/ ft^2 Heating
4. With RF-3 retrofit kit installed on the hot duct, calculate CFM of hot air required to meet average heating load:

   (45.36 BTUH/ ft^2 Heating)/(1.08 x 30°FΔT) = 1.4 CFM/ft^2 (a reduction from 2.0 CFM/ ft^2)

Heating Cycle Energy Savings:

Fan H.P. Reduction (based on 1000 CFM/HP):

(2.0 HP – 1.4 HP) x .746 kW / HP x $.10 / kWH x 1250 hours per 1/2 year = $55.95 / 1000 ft^2 / 1/2 yr

Heat Pump Savings: 6.48 BTUH/ ft^2 x 1 ton / 12,000 BTUH x 1 HP / .75 Ton x .746 kW / HP x $.10 / kWH x 1,000 ft^2 x 1250 hours per 1/2 yr = $67.14 / 1000 ft^2 / 1/2 yr

Summary of Savings:	1 Year Savings / 1000 ft^2
Cooling:	
Fan Horsepower	$78.33
Refrigeration Horsepower	$53.76
Heating:	
Fan Horsepower	$55.95
Heat Pump Horsepower	$67.14
Depreciation = Product Cost / Yrs Useful Life = $250 / 5	$50.00
First year savings / Air terminal	$305.18
plus any federal, state, or utility credits available	
(Savings will vary based on assumptions. A specific analysis should be performed for any retrofit candidate.)	

GENERAL RETROFIT GUIDELINES

1. Control Systems - Anemostat retrofit kits are available with pneumatic, electronic analog, or direct digital controls. Sequences shown are typical for pneumatic controls, but similar strategies can be utilized with electronic analog or DDC systems. Pneumatic control systems will typically require a main air source (20 psi) – compressed air capacity should be reviewed for this additional requirement.
2. Mechanical Regulators - Existing mechanical regulators typically require high static pressures to operate. There may be one or more regulators in the air terminal based on the original design capacity. In most cases, removing the regulator(s) altogether will result in additional fan energy savings. Regulators left in place will limit the maximum flow rate delivered to the space, but provide pressure independent flow control only at the constant volume flow setting of the regulator. Regulators that are left in place should be checked to verify operation.
3. Inlet Dampers – Existing inlet dampers are often used with retrofit packages to obtain the flow sequence desired. Worn or leaking dampers should not be used as part of the control system. There are many alternate retrofit solutions to obtain the sequence desired, without using the existing dampers. Removal of existing dampers / linkages, when not used, may result in lower operating pressure requirements and energy savings at the fan.

TABLE 67: EXTERNAL RETROFIT CONTROL SEQUENCES

Existing Air Terminal			Retrofit Sequence #
Type	**# of Actuators**	**Sequence**	
Dual Duct	1 – Crosslinked	C.V. Mixing	ED1
Dual Duct	2	C.V. Mixing	ED2
Single Duct w/ Reheat	None	Constant Volume	ES1
Single Duct	1	VAV (Max to 0)	ES2
System Powered	Air Bladder	VAV High Pressure	EP1

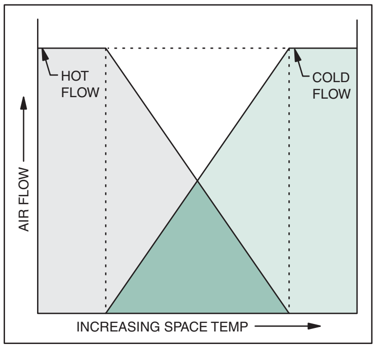


Diagram 9: Typical Flow Diagram For Existing Constant Volume Mixing Terminals. Configurations ED1 & ED2

EXISTING DUAL DUCT - CONFIGURATION ED1
• Constant Volume Regulator
• Common Inlet Damper Actuator Linked To Both Valves

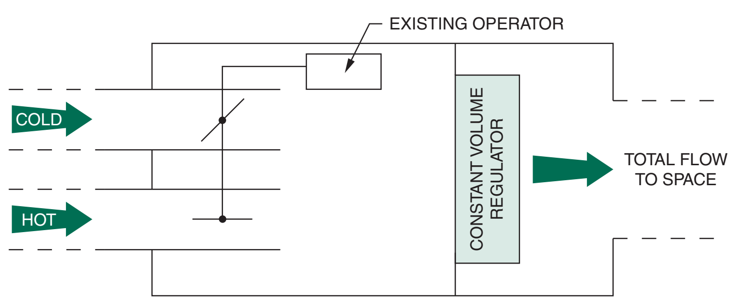


Figure 6

EXISTING DUAL DUCT - CONFIGURATION ED2
• Constant Volume Regulator
• Actuator On Each Inlet Damper

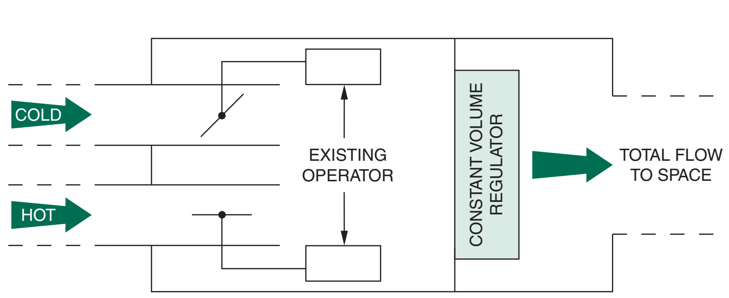


Figure 7

SEQUENCE ED1A

Existing terminal gutted or fixed open (ideal for worn components)
No Mixing or Overlap Mixing

- Add RF-3 Kit on both hot and cold duct
- VAV pressure independent cold & hot air flows
- Mixing accomplished by overlapping reset ranges or setting Cold Min > 0

SEQUENCE ED1B

No Mixing

- Add RF-1 kit on cold duct. Use existing actuator. Remove Regulators.
- VAV pressure dependent cold & hot air flows
- Alternate - leave existing CV regulator(s) in place for pressure independent max flows
- Max flow rates are dictated by CV regulators, if left in place

SEQUENCE ED1C

No Mixing

- Add RF-3 kit on cold duct. Use existing actuator. Remove Regulators.
- VAV pressure independent cold. Pressure dependent hot air flow.
- Alternate - leave existing CV regulator(s) in place for pressure independent max hot flow
- Max hot & cold flow rates are dictated by CV regulators, if left in place

SEQUENCE ED1D

No Mixing

- Add RF-3 kit on cold duct, RF-6 on hot duct uses existing actuator. Remove Regulators.
- VAV pressure independent cold and hot air flows.

SEQUENCE ED1E

Conversion to Single Duct

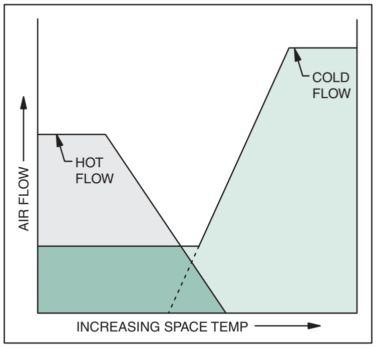
- Add RF-6 kit on cold duct. Remove hot duct and cap.
- Use existing cold damper & actuator.
- VAV pressure independent cold air flow
- Remove CV regulator(s)
- Apply to hot duct for VAV heating only.

SEQUENCE ED2A

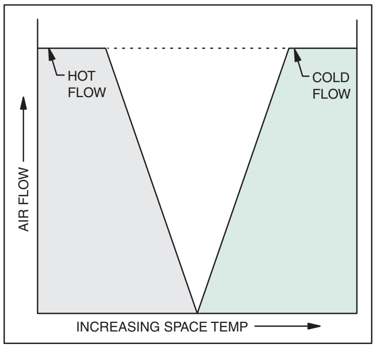
No Mixing / Minimum Mixing

- Add RF-6 Kit on both hot and cold duct.
- Existing actuators and dampers utilized with RF-6 kits.
- VAV pressure independent cold & hot air flows
- Mixing accomplished by overlapping reset ranges or setting Cold Min > 0

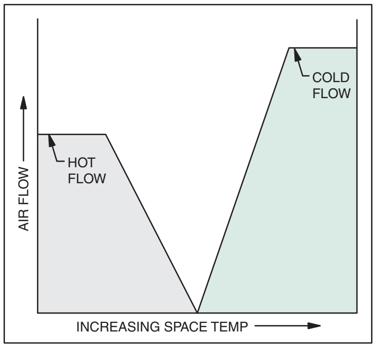
SEQUENCE ED1A, ED2A



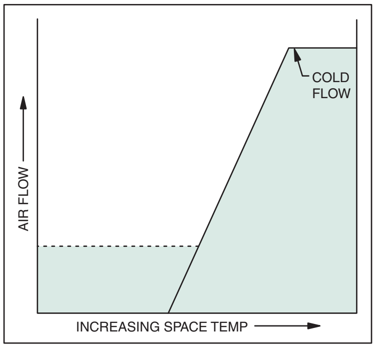
SEQUENCE ED1B



SEQUENCE ED1C, ED1D



SEQUENCE ED1E



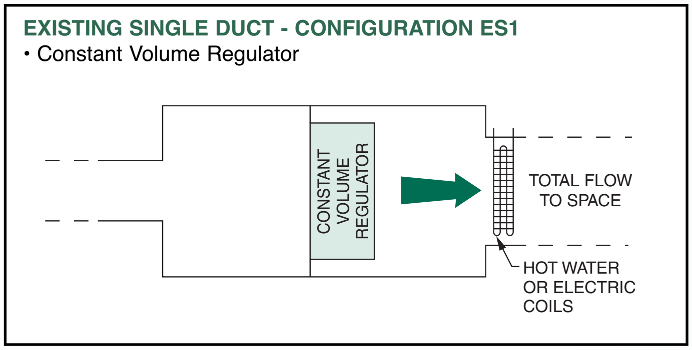


Figure 8

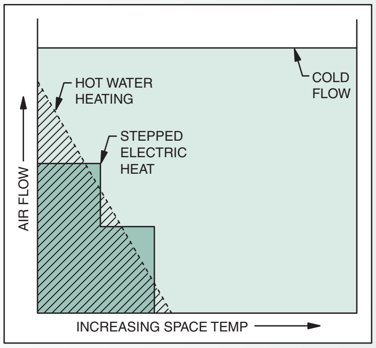


Diagram 10: Typical flow diagram for existing constant volume single duct terminals with reheat.

SEQUENCE ES1A

Max-Min VAV

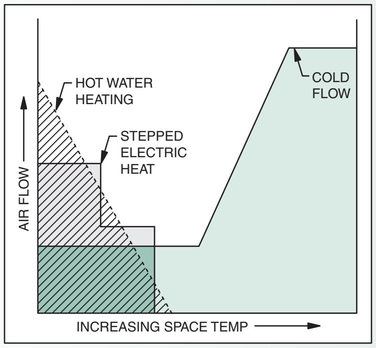
- Add RF-3 kit to inlet duct. Remove Regulators.
- VAV pressure independent airflow with minimum flow for reheat

SEQUENCE ES1B

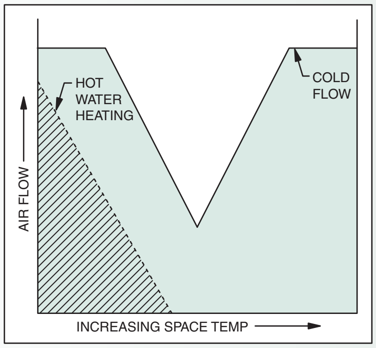
Dual Maximum VAV w / hot water heat

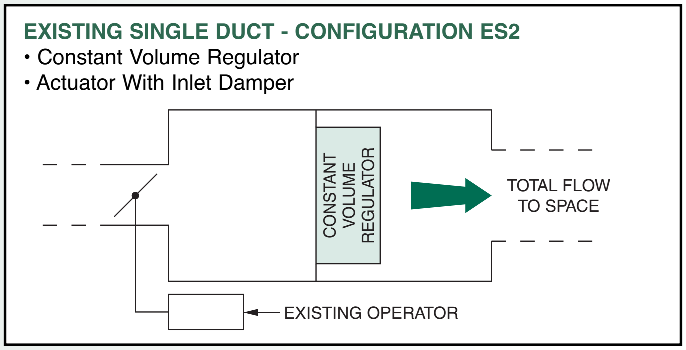
- Add RF-3 kit to inlet duct. Remove regulator(s).
- VAV pressure independent airflow with maximum flow for reheat

SEQUENCE ES1A



SEQUENCE ES1B





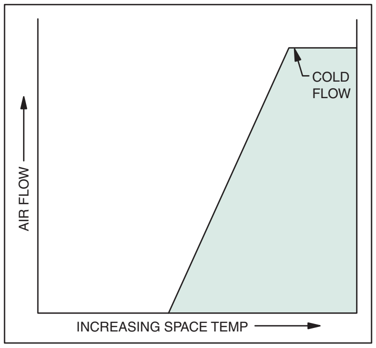


Figure 9

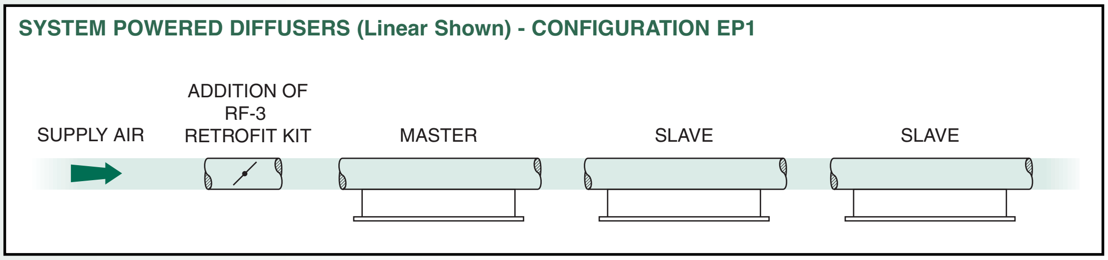


Figure 10

SEQUENCE ES2A

Max-Min VAV

- Add RF-6 kit to inlet duct. Use existing damper and actuator.
- Remove regulator(s).
- VAV pressure independent airflow

SEQUENCE ES2B

Max-Min VAV

- Add RF-3 kit to inlet duct. Remove existing damper or block open.
- Remove regulator(s).
- VAV pressure independent airflow

SEQUENCE ES1P

Retrofit of System Powered Air Diffusers
Max-Min VAV

- Add RF-3 kit to inlet duct.
- Disable diffuser bladder (removal of pressure tube from bladder may be required)
- VAV pressure independent airflow

SEQUENCE ES2A, ES2B, ES1P