

DUAL DUCT BOXES SUBZONED WITH THERMA-FUSER™ VAV DIFFUSERS

(Upgrading Dual Duct [Double Duct] Systems with Therma-Fuser Diffusers.)

GOALS

The goals of applying Therma-Fuser™ diffusers in a dual duct system may include:

- 1) **Individual temperature control.** A dual duct box that serves more than one space may become a Master Zone which is subzoned with Therma-Fuser diffusers to provide individual temperature control. This need occurs when each person has a different temperature preference. This need may also occur when heat releasing equipment such as a personal computer is installed or portions of the zone have a different operating schedule.
- 2) **Dramatic reduction in energy use** by eliminating the waste of blending heated air with cooled air.
- 3) **Reduce fan energy consumption.** Conversion from constant volume to variable volume will make possible significant savings in energy if fan speed control is added.
- 4) **Additional energy savings** (refrigeration and heating) from not overcooling or overheating any of the rooms in the Therma-Fuser subzones.
- 5) If the system utilizes a so called "economizer cycle," conversion to VAV will greatly reduce the energy waste of heating the cold mixture of the outdoor and return air. See "Reducing Economizer Cycle Energy Waste" toward the end of this chapter.

BACKGROUND

Dual duct design declined sharply when concern for energy conservation increased some 15 years ago. There are today many highly qualified engineers and technicians who have no occasion to look closely at dual duct. For this reason, a description of dual duct systems is provided toward the end of this chapter.

Two basic approaches can be taken to upgrade dual duct system:

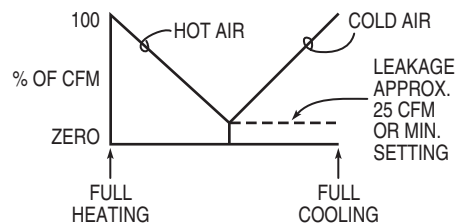
- 1) Eliminate blending hot and cold air in the dual duct box and subzone with Therma-Fuser diffusers. This meets all the basic goals without the cost and disruption of changing or replacing the ductwork or the air handling unit. This chapter concentrates on the details of how this can be done for both constant volume dual duct systems and variable volume dual duct systems.
- 2) Convert the air handling unit and ductwork into a single master zone and subzone with Therma-Fuser diffusers. A brief description of how this may be done is at the end of this chapter. Control of such a system is described in "Air Handling and Fan Coil Units." (Form 6.7)

METHOD OF UPGRADING

The Therma-Fuser type HC will adjust the air volume to control room temperature in the heating mode of operation when supplied with warm air from the duct, and in the cooling mode when supplied with cold air. If static pressure is maintained at a level of .25" wg or less in the supply duct to the Therma-Fuser diffuser, the sound level should be acceptable in an office space.

In retrofit of a dual duct zone to modular VAV, the existing box becomes a "Master Zone" which supplies one or more Therma-Fuser diffusers, each of which is a "subzone." The master zone selects either hot air or cold air for delivery to its subzones at a point in time. A subzone delivers the amount of air needed by its load. The master zone also controls static pressure in the duct supplying the Therma-Fuser subzones. Heating or cooling by the master zone is selected by a room thermostat, which will usually be the thermostat that controlled the existing box.

A major point is that *HEATING AND COOLING ARE NEVER BLENDED IN THE BOX.*



As the Therma-Fuser diffusers reduce cold air flow, the master zone responds to its static pressure controller positioning the cold air valve. When the master zone changes to heating, the cold valve is fully closed and the hot air valve modulates to supply Therma-Fuser subzone needs. A field adjustable minimum flow adjustment may be provided for the Therma-Fuser diffusers, but the master zone box supplies only hot air or cold air at one time.

When cooling is delivered by the master zone, it takes no heat from the boiler. When heating is delivered by the master zone, it adds no load to the chiller.

A second major point is that *AIR DISTRIBUTION FROM A THERMA-FUSER DIFFUSER WILL BE EXCELLENT THROUGHOUT AIR VOLUME REDUCTION.* The supply air opening varies such that velocity remains high although cfm is being reduced. Total air distribution at a 10% flow through a Therma-Fuser diffuser matches 50% flow through most fixed diffusers.

Most dual duct boxes fall into one of two general categories: separate air valves and a single air valve.

For both categories, detailed descriptions are provided of how to arrange supply of either hot or cold air and control static pressure.

Other box types exist and the basic concept of furnishing either hot or cold air while controlling static pressure applies.

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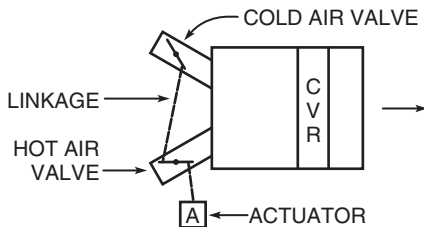


The Individual
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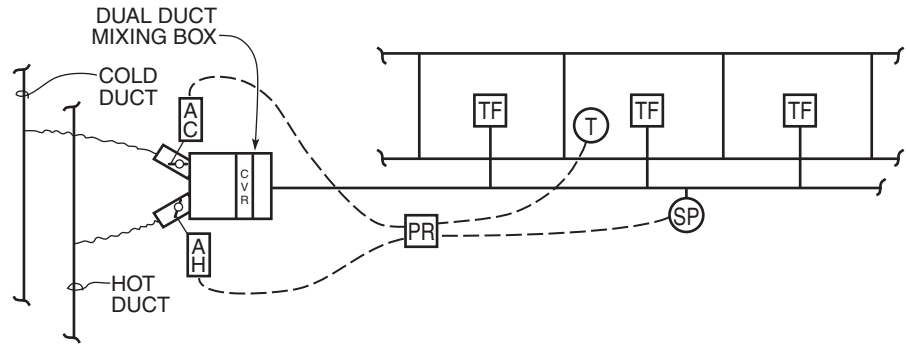
BOXES WITH SEPARATE AIR VALVES

A box that has separate air valves in the hot and cold inlets usually has a linkage that may be modified easily in the field. In retrofit, the linkage between air valves is disconnected, and a new actuator added such that each valve has an independent actuator. A new static pressure controller is added to sense air supply on the low pressure side. If physically feasible, the existing constant volume regulator should be removed, lessening fan resistance at full flow by a possible .75" to 1" wg.

When the master zone thermostat calls for cooling, the hot valve will close and the static pressure controller will modulate the cold air flow to match Therma-Fuser sub-zone needs. When the master zone thermostat calls for heating, the cold valve is closed and the same static pressure controller operates the hot valve.



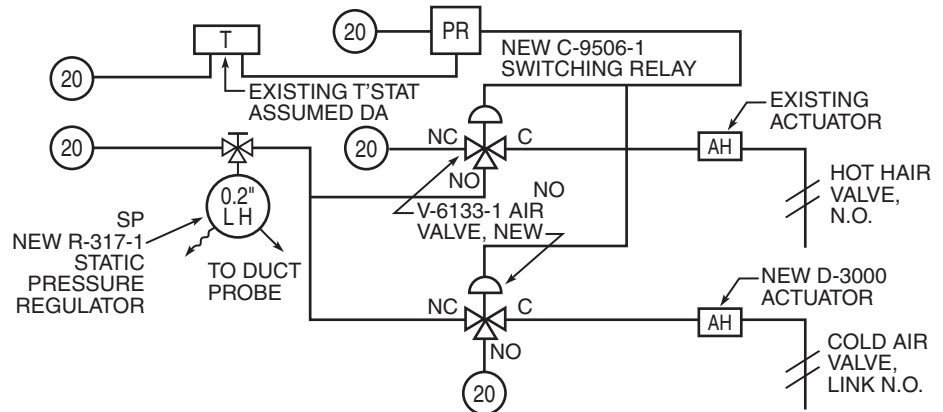
BOXES WITH SEPARATE AIR VALVES



LEGEND

- T:** EXISTING ROOM THERMOSTAT; ACCOMPLISHES HEATING-COOLING SELECTION.
- PR:** NEW PNEUMATIC RELAY; CLOSSES ONE AIR VALVE, AND PLACES THE OTHER UNDER THE CONTROL OF SP WHEN T CALLS FOR CHANGEOVER.
- AC:** COLD AIR VALVE ACTUATOR; CLOSSES ON HEATING MODE, MODULATES FROM SP ON COOLING MODE.
- AH:** HEATING ACTUATOR; CLOSSES ON COOLING MODE, MODULATES FROM SP ON HEATING MODE. ONE ACTUATOR MAY BE NEW, THE OTHER EXISTING.
- SP:** NEW STATIC PRESSURE CONTROLLER; OPERATES THE SELECTED AIR VALVE TO HOLD LOW PRESSURE DUCT AT 0.2" WG AS THERMA-FUSER DIFFUSERS VARY CFM. LOCATE DUCT PROBE ABOUT MIDWAY IN DUCT RUN.
- TF:** THERMA-FUSER TYPE HC; GOES INTO HEATING MODE WHEN SUPPLIED WITH WARM AIR; COOLING MODE WHEN SUPPLIED WITH COLD AIR. WHEN USED IN ROOM WITH T, SET T IN DEADBAND BETWEEN THE TF HEATING AND COOLING SETPOINTS.
- CVR:** EXISTING CONSTANT VOLUME REGULATOR MAY BE REMOVED IF PHYSICALLY FEASIBLE.

EXAMPLE OF PNEUMATIC CONNECTIONS USING JOHNSON CONTROLS. MODIFY AS REQUIRED TO RETAIN USEABLE EXISTING CONTROLS.



THERMA-FUSER DIFFUSER IN THE THERMOSTAT ROOM

It is recommended that Therma-Fuser diffusers be used in the room with the thermostat as well as other rooms. The Therma-Fuser diffuser and thermostat should be adjusted such that the Therma-Fuser diffuser in the room with the thermostat is nearly closed when changeover occurs, so that capacity to the

room does not change from full cooling to full heating causing rapid temperature change leading to rapid cycling. Do this by establishing a deadband in the temperature settings of the TF-HC used in that room and setting the thermostat in the middle of the deadband.

This is not as difficult as some situations requiring synchronization of controls, as one can easily see what a Therma-Fuser diffuser is

doing simply by looking at the position of the blades.

Examples:

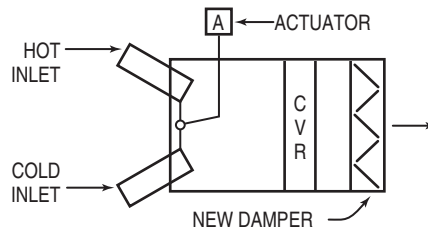
TF-HC Settings		Changeover Thermostat
Heating Stat	Cooling Stat	
70	74	72
72	76	74
74	78	76



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BOXES WITH A SINGLE AIR VALVE

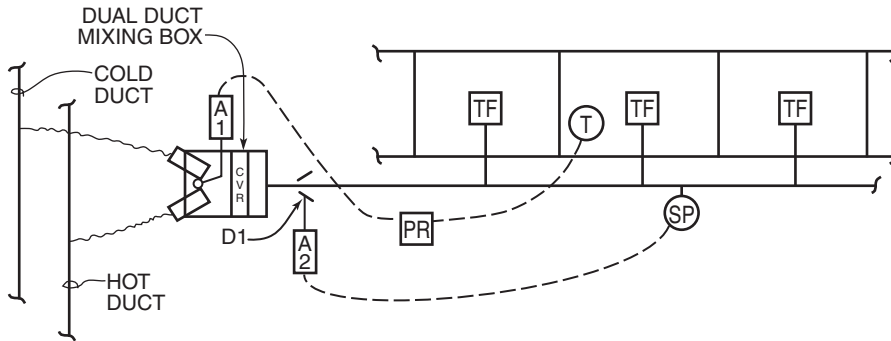
The boxes of some manufacturers use a single air valve or plug that opens one inlet as the other is closed. In retrofit, the master zone thermostat will open one inlet fully while closing the other and a new damper on the box outlet is modulated to control static pressure.



ZONES WITHOUT HEATING LOADS

Zones without heating loads, as may be found in interior spaces, do not require heating and may be converted to a cooling only zone by sealing off the hot duct. The best approach is to remove the hot duct and cap the connections. This Master Zone can be subzoned with VAV cooling only (Type C) Therma-Fuser diffusers.

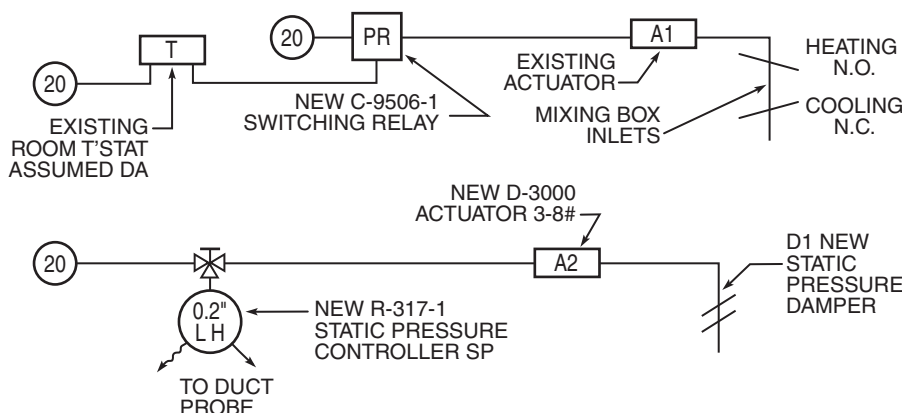
BOXES WITH A SINGLE AIR VALVE



LEGEND

- T:** EXISTING ROOM THERMOSTAT; ACCOMPLISHES HEATING-COOLING SELECTION.
- PR:** NEW PNEUMATIC RELAY; CONVERTS GRADUAL SIGNAL FROM T TO OPERATE A1 IN A TWO POSITION MANNER.
- A1:** EXISTING MIXING BOX ACTUATOR; WILL OPERATE TO OPEN HOT OR COLD INLET WHILE CLOSING THE REMAINING INLET.
- A2 & D1:** NEW STATIC PRESSURE CONTROL DAMPER & ACTUATOR.
- SP:** NEW STATIC PRESSURE CONTROLLER; OPERATES D1 TO HOLD LOW PRESSURE DUCT AT 0.2" WG AS THERMA-FUSER DIFFUSERS VARY CFM. LOCATE DUCT PROBE ABOUT MIDWAY IN DUCT RUN.
- TF:** THERMA-FUSER TYPE HC; GOES INTO HEATING MODE WHEN SUPPLIED WITH WARM AIR; COOLING MODE WHEN SUPPLIED WITH COLD AIR. WHEN USED IN ROOM WITH T, SET T IN DEADBAND BETWEEN THE TF HEATING AND COOLING SETPOINTS.
- CVR:** EXISTING CONSTANT VOLUME REGULATOR MAY BE REMOVED IF PHYSICALLY FEASIBLE.

EXAMPLE OF PNEUMATIC CONNECTIONS USING JOHNSON CONTROLS. MODIFY AS REQUIRED TO RETAIN USEABLE EXISTING CONTROLS.



FAN CONTROL

In retrofitting a constant volume fan system to variable air volume, fan capacity control should be considered for energy reduction. Also, some of the fans used in dual duct systems have a pressure capability that could damage ductwork if totally closed off. Several means of fan capacity control exist, but one rapidly gaining popularity is fan speed control by electrical variable frequency drive. Fan speed control allows dramatic energy reduction, as brake horsepower varies by the cube of the speed change. See Form 6.3.

HOT AND COLD DECK CONTROL

Another area of system control to be addressed is control of the hot and cold decks. For best Therma-Fuser diffuser performance, supply air temperature should not be higher than 120°F/49°C, or lower than 55°F/13°C. In most systems, this will be a matter of simply adjusting existing controls.

WORN OUT BOXES

If boxes are found that cannot be salvaged or otherwise are not cost-effective to retrofit, two air valves in parallel may replace the old box. The two air valves will usually be smaller and are almost certain to be less complex than a replacement of the old box in-kind. Two air valves in parallel utilize the control sequence for boxes with separate air valves.

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PROCEDURE TO UPGRADE TO MODULAR VAV

As with any retrofit situation, you must first determine exactly what is now installed, then decide what must be done to achieve the desired results.

This simply means that each box that is to be changed must be looked at. It very likely will fall into one of the two basic categories identified. This fact will determine

the control items to be added and the work to be done. In pneumatic systems, the components of one manufacturer can likely be used in the system of another, so you probably have a choice of component suppliers.

To proceed:

- 1) Select a box and determine which of the two retrofit schemes apply: boxes with sep-

arate air valves or with a single air valve.

- 2) Mark-up the appropriate control diagram (separate or single air valve) to maximize usage of existing controls, and to identify the new components required.
- 3) Retrofit one box and from that experience develop a step-by-step procedure to follow in similar zones.

Reducing Economizer Cycle Energy Waste

Some systems use cool outdoor air (when available) to replace refrigerated air. Typically, outdoor and return air are mixed to a temperature level that must be about the same as the cold deck temperature with the refrigeration system in operation. An interior zone doesn't know if it is 10°F/-12°C or 110°F/43°C outside; if it needs cold in July, it probably needs air just as cold in January. This control cycle, often called an "economizer," as applied to the system shown *MAY CAUSE MORE HEATING ENERGY TO BE WASTED THAN IS REQUIRED BY THE ACTUAL HEAT LOSS OF THE BUILDING.*

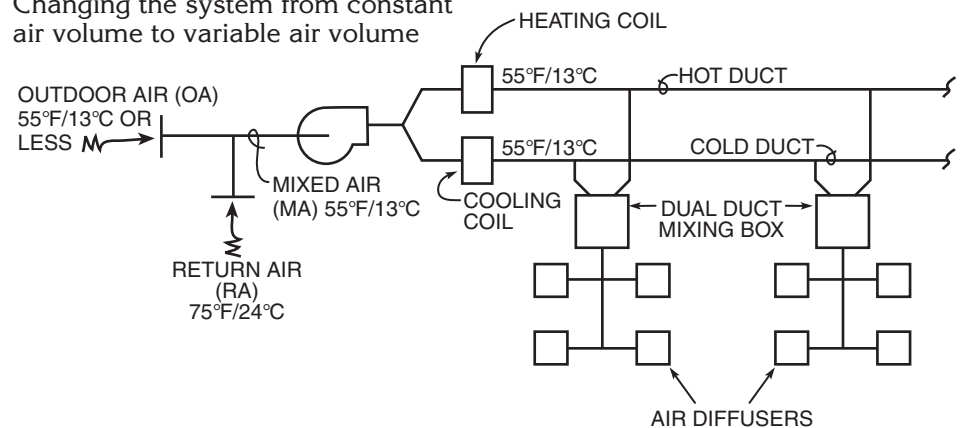
Air entering the heating coil is not 75°F/24°C return air as in some systems; it is 55°F/13°C mixed air!

In the single fan system at constant volume, assuming 75°F/24°C room temperature and a mixed air temperature of 55°F/13°C, and a constant volume of 20,000 CFM, the cooling capacity delivered by the Economizer to the building is $10,000 \text{ Btu/hr} \times (75^\circ\text{F}/24^\circ\text{C} - 55^\circ\text{F}/13^\circ\text{C}) \times 1.08 = 423,000 \text{ Btu/hr}$.

If room temperature is to remain at 75°F/24°C, heat must be added to the cooling from the Economizer. The heat will come from either (1) actual heat gains (cooling loads) in the space; or (2) heat from the heating coil in the hot deck. If the actual cooling load is 20% (it is cold weather), or 86,400 Btu/hr then the hot deck must add $423,000 - 86,400$ or 345,000 Btu/hr.

TO SAVE ONE BTU AT THE CHILLER, THE "ECONOMIZER" FORCES THE BOILER TO ADD 4 BTUs.

Changing the system from constant air volume to variable air volume



will not eliminate the waste, but will directly reduce the waste.

The net feasibility of the "economizer" in this system will require evaluation of the relative costs and availability of heating Btu's versus cooling Btu's and other factors of the individual application. *DO NOT BE SURPRISED IF YOU FIND THE OVERALL COST FAVORS CHILLER OPERATION OVER "FREE COOLING"* at least part of the time. Retrofit to VAV directly reduces the waste when cooling with outdoor air.

Description of Dual Duct Systems

SINGLE FAN DUAL DUCT

The most common dual duct system arrangement utilizes a single fan in the blow-through position relative to a heating coil in the "hot deck" position, and to a cooling coil in the "cold deck" position. The mixture of outdoor air and return air is cooled and delivered to the cold

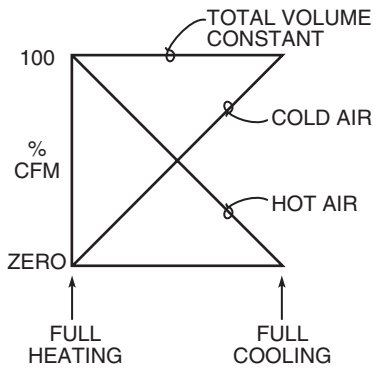
duct while air from the same mixture is heated and delivered to the hot duct. Hot air and cold air are blended in each mixing box as required to satisfy the zone needs as registered by the zone thermostat. A mechanical "constant volume regulator" limits total air flow from each box.

The constant volume dual duct system met simultaneous heating and cooling loads beautifully, but at great energy cost.



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Description of Dual Duct Systems—Continued



An example of the energy waste is seen when considering the “zero load” condition with a 75°F/24°C room; a condition when heat transmission losses are equaled by interior and perhaps solar heat gains. The room needs zero capacity (75°F/24°C supply air), as the air delivery rate (cfm) is constant. To achieve this neutral mixture, the box blends heated air with cold air.

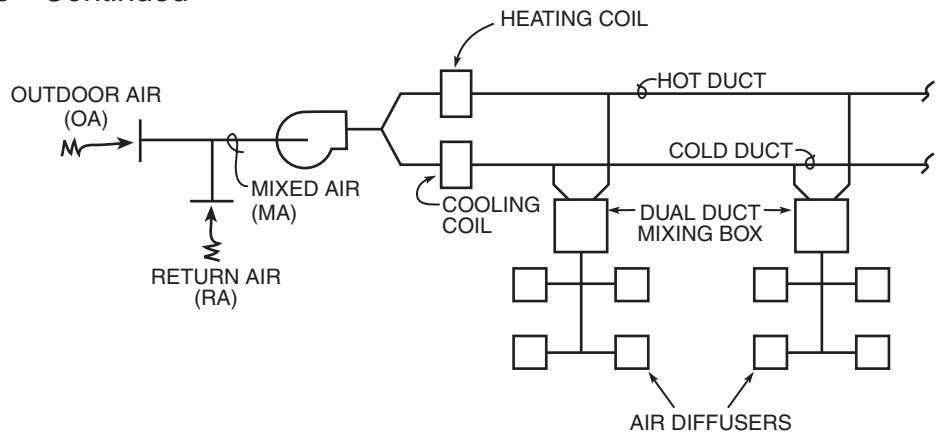
In the full cooling position, the hot air inlet is fully closed, the cold fully open. As room temperature drops, the cold air cfm is reduced while hot air cfm increases and total cfm remains constant. If a room has a need for 75°F/24°C supply air, this may be a 50-50 blend of air cooled to 55°F/13°C and air heated to 95°F/35°C.

Note that *THE WASTE IS DUE TO THE MIXTURE IN THE BOX, NOT DUE TO THE CHILLER AND BOILER BEING IN SIMULTANEOUS OPERATION*. A box that has its hot air valve closed takes no heat from the boiler, and a box with its cold valve closed adds no load to the chiller.

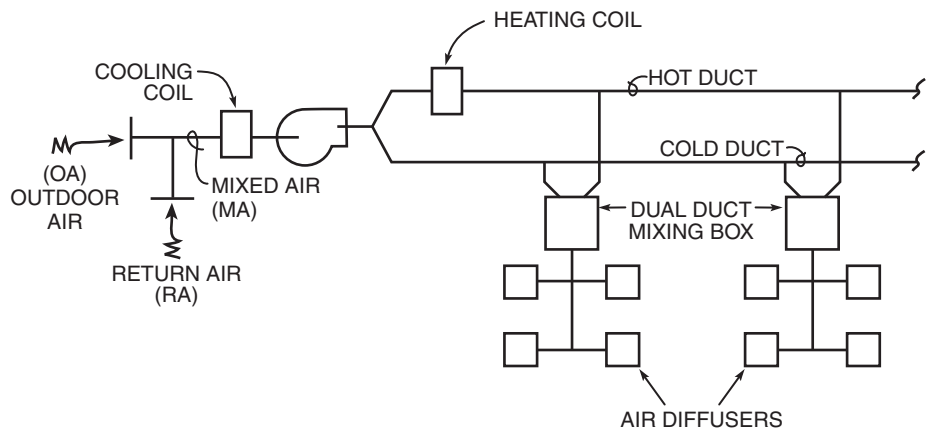
Cutting off either the boiler or the chiller will save energy, but will defeat the system design in failing to control the space. A very difficult and labor-intensive situation is created for the maintenance staff. Many occupant complaints may be expected, and the maintenance staff may be unfairly criticized.

Where regulations still forbid simultaneous availability of heating and cooling, retrofit to Modular VAV will greatly improve comfort. Expensive over-heating and over-cooling from the system will be prevented. The room with a personal computer will not continue to receive hot air beyond its needs, nor will room be overcooled due to special needs in other rooms. A Therma-Fuser dif-

SINGLE FAN DUAL DUCT



DUAL DUCT WITH DRAW-THROUGH COOLING COIL



fuser is far more than an automatic air balancing device, but it does include that benefit to the system and its maintenance staff. Unlike manual balancing which may correct one room’s problem while upsetting others, each module space is individually controlled with modular VAV.

Where heating and cooling may be simultaneously available, modular VAV clearly isolates the two for maximum efficiency.

TWO FAN DUAL DUCT

Some dual duct systems have separate hot and cold air fans. These usually introduce outdoor air through the cold fan only. As a result, all outdoor air is dehumidified, and the heating penalty for cooling with outdoor air is avoided. In this system, the heating coil receives return air only.

DUAL DUCT WITH DRAW-THROUGH COOLING COIL

Some dual duct systems have the

cooling coil in the draw-through position as shown above.

Such systems dehumidify all outdoor air rather than bypassing part of that (possibly humid) air over the hot deck. This system is used in high percentage outdoor air applications, and systems with the requirement to limit relative humidity beyond the ability of the system. Physically, this system is dual duct, but thermally, it is constant volume reheat. All of the air discharged from the fan is cold all of the time, regardless of load. Part of the air is reheated and blended with cold air at the box. Constant volume reheat is an even greater energy hog than constant volume dual duct where cooling is reduced as heating is added. In the draw-through system, cooling is constant as reheat is added. Obviously, varying air volume will have dramatic energy savings on this system.

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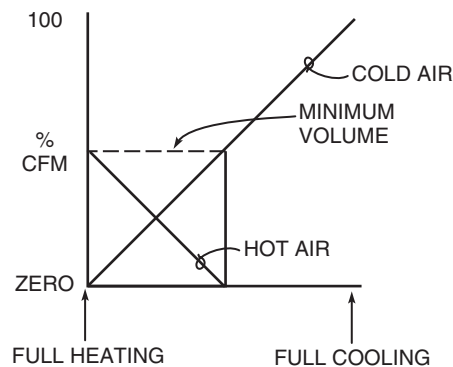
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When the heating source is cut off in this system, the result is total loss of room control. When a moratorium has been declared on simultaneous cooling and heating, this and other reheat systems are in trouble. Operators may attempt to lessen cooling by adjustment of supply air and/or chilled water temperature, but zoning has been eliminated.

VARIABLE VOLUME DUAL DUCT

Retrofit of constant volume dual duct boxes to variable volume dual duct has provided some reduction

in the mixing of hot air with cold air, but in many cases wasteful mixing does still occur. As shown,



cold air volume is reduced as the cooling load drops until a minimum cfm is reached. After that point, heating and cooling are blended.

As the cooling load reduces, cold air cfm is reduced until a minimum cfm level is reached, usually around 50%. As the load changes to heating, hot air and cold air are mixed until, at full heating, only hot air is supplied.

The minimum is seldom less than 50% due to poor performance of fixed opening diffusers at reduced air flow. Cold air may “dump,” and heated air is very likely to satisfy.

Converting Dual Duct Systems Into A Single Master Zone

Conversion of a dual duct system to a single master zone may be practical *if* loads are such that simultaneous heating and cooling is not required in the new single master zone. This may occur where perimeter heat is adequate for heating the building allowing the new single master to be cooling only.

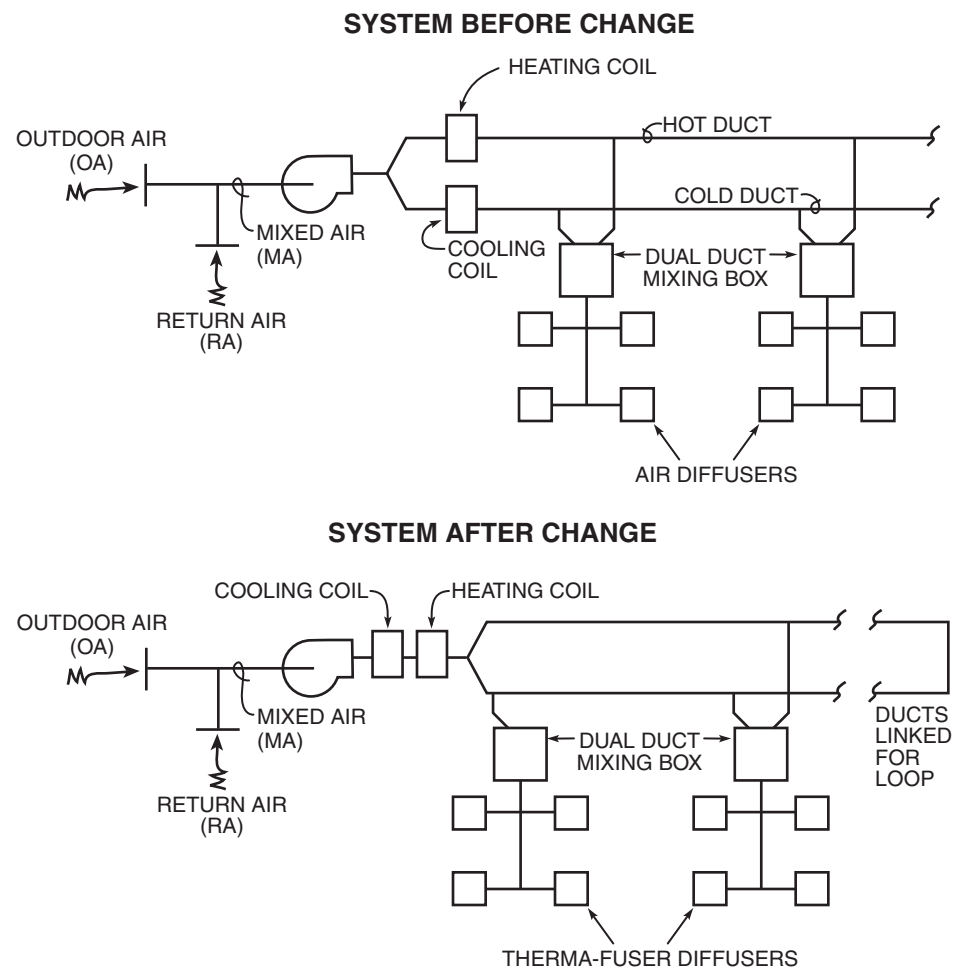
When making this conversion, the air handling unit is changed to place the cooling and heating coils in series as shown.

The hot duct and cold duct can be retained as parallel supply ducts. Consider linking them at the end to make a loop duct.

Dual duct boxes may be retained by using only one supply and capping both ends of the other alternating between the two trunk ducts. If not worn, the inlet valve in the active supply may be suitable for the static pressure control.

After reviewing the loads and recalculating the air volume required to be supplied through the two parallel ducts, it may be possible to supply at low pressure and eliminate the need for static pressure control at each dual duct box.

Therma-Fuser duffusers are then used to subzone the master zone. For control details, see Form 6.7 “Air Handling and Fan Coil Units.”



The Individual Temperature Control People
 1766 Sabre Street
 Hayward, CA 94545
 Tel: (510) 785-0510
 Fax: (510) 785-2517
<http://www.acutherm.com>
 e-mail: info@acutherm.com