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## THE RICKARD VAV SYSTEM

### APPLICATIONS

VAV COOLING & HEATING

VAV COOLING WITH

### ADVANTAGES

ENERGY SAVINGS

INSTALLATION COST SAVINGS

SIMPLE SYSTEM DESIGN

SELF BALANCING

FULL FLEXIBILT

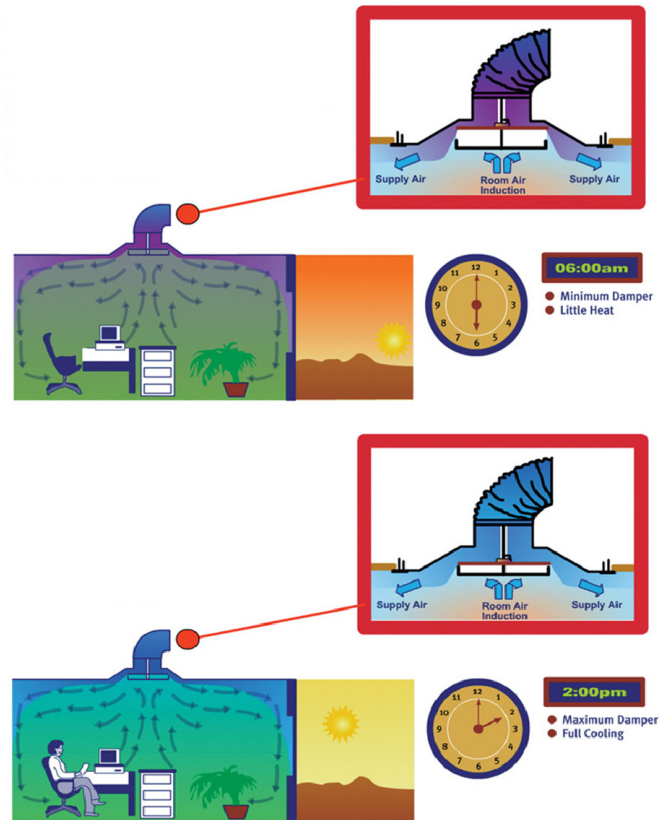
SUITS SMALL & LARGE BUILDINGS

NO REGULAR MAINTENANCE

EXCELLENT TURNDOWN RATIOS

LOW PRESSURE OPERATION

### VARIABLE GEOMETRY VAV SYSTEMS



### INTRODUCTION

#### WHY VARIABLE AIR VOLUME

With the introduction of **VAV** systems into the air conditioning industry a number of years ago, the idea of varying supply air volumes (at constant temperature) with room load variations, seemed to many engineers totally unacceptable. It went against all other contentions that reducing air volumes would result in insufficient room air. And then? The introduction of **VARIABLE GEOMETRY VAV AIR DIFFUSION EQUIPMENT!**

With the introduction of this equipment & design improvement to VAV systems, confidence was generated by the improved performance of the system. The world's increasing consciousness for the need to conserve energy accelerated the tendency of designers to use VAV as the most economical & efficient solution to the problems posed by the multi-zone requirements of modern buildings. Unquestionably no other system offers such low operating costs & flexibility in its application to multi-zone air conditioning diversities

### ADVANTAGES OF VAV SYSTEMS

**Fan power savings** are achieved under low load conditions, whether system volume reduction is carried out by means of vortex dampers, speed control or axial flow fan blade pitch control.

Large central air handling plants facilitate easy **free outside air cooling**.

**Savings on initial costs** can be effected in air handling/refrigeration plant & duct sizing by designing with cooling load diversities.

Separate air handling unit zone installations are not usually necessary because individual terminal control action takes care of the variations in volume & temperature requirements in every office or room. As a result, initial cost savings are made in air handling units, ducting & associated equipment.

**Simple system design** results in ease of operation, maintenance & system adjustment.

VAV Systems are virtually **self balancing**, thereby almost completely eliminating the costly time consuming air quantity procedures.

Through simple control changes, **FLEXIBILITY**, to suit partition changes is one of the major advantages of the system.

**In small & medium size systems**, direct expansion cooling or heat pump plants may be used, avoiding the greater cost & complications of water cooling & circulation equipment.

**Maintenance** & repair work is made easy as equipment is concentrated in central plant rooms.

#### TYPES OF VAV SYSTEMS

Reference to the following drawings show that VAV Systems can be divided into two main groups, namely:

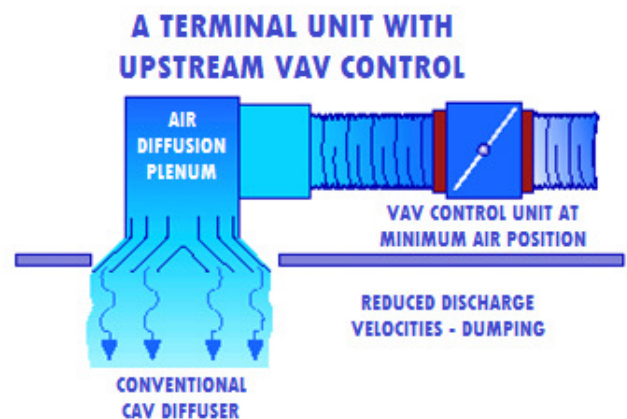
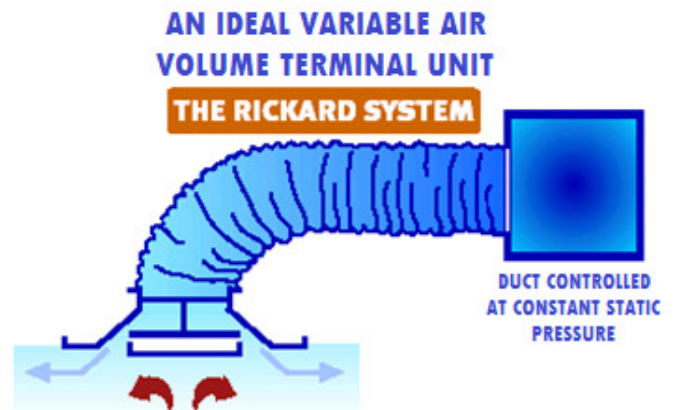
Those that control the volume of supply air at the point of entry into the room.

Those that control the volume of air further upstream in the system, such as in a VAV box.

The first group is by far the more effective & therefore the more generally desirable. Modern **VARIABLE GEOMETRY** room air entry device design, ensures good supply air distribution & effective room air movement when supplying down to as little as 30% of the maximum air flow without dumping or stratification.

The alternative VAV utilizes an air volume control device located a considerable distance upstream of the air diffusion unit & is therefore not able to take advantage of leaving air velocities to produce good secondary flows as in the case of the **VARIABLE GEOMETRY** type.

Under these circumstances, air volume regulation can cause cold air "dumping" & insufficient room air circulation. Systems such as these may be useful in internal zones or other applications which do not exhibit large load variations, such as shops with relatively constant internal heat gains.

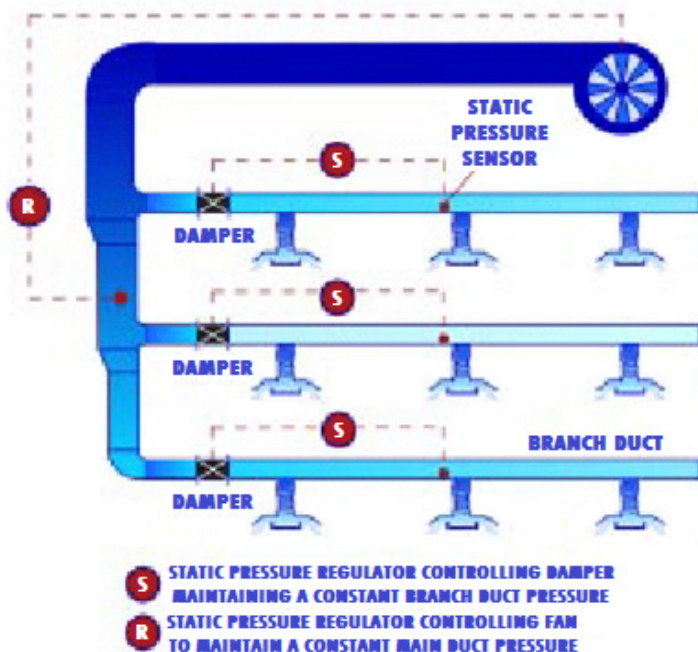


#### VAV SYSTEMS DESIGN

Generally the design considerations governing constant volume air conditioning systems can be applied to the design of air handling & distribution equipment for variable volume systems. Whilst the subjects of heat loads & air quantity or temperature calculations are fully dealt within such publications as the ASHRAE guide, the following general procedure is recommended:

1. Cooling & heating load calculations are made for every module or zone in the building so that the individual maximum & simultaneous maximum cooling/heating requirements & air quantities can be established.
2. The design temperature of supply air at the terminal (allowing for all normally calculated extraneous gains such as fan heat & duct wall heat pick-up) is arrived at by conventional psychometric calculations.
3. Individual maximum module or zone air volumes are calculated using the maximum room sensible heat gain figures & the temperature difference between supply air temperature at the terminal & design space temperature. These air volumes are then used to select the VAV diffusers.
4. Maximum simultaneous cooling & air supply requirements are then computed in order to establish the capacity of air handling units & central cooling plant. Care must be taken in design that ducting is adequately sized to convey the correct amount of air to every module or zone under all conditions.

### A TYPICAL SYSTEM IN OPERATION WITH PRESSURE CONTROL DAMPERS



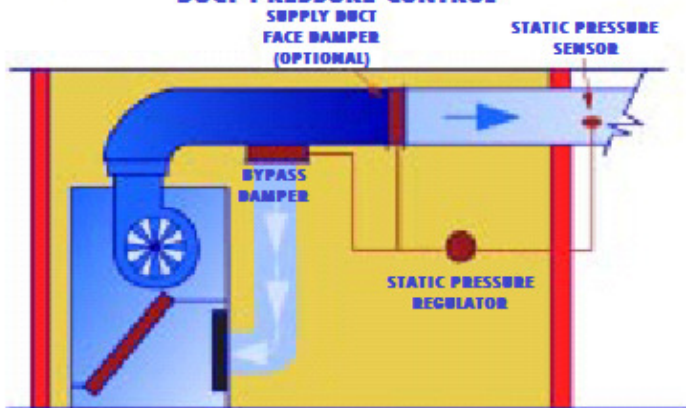
### OTHER DESIGN CONSIDERATIONS TO BE NOTED

#### CONTROL OF DUCT PRESSURE

The control of supply air duct static pressure within the design limits of the terminal units is an essential requirement of variable volume systems & such control is easily achieved by any or a combination of the following methods, depending on the size & configuration of the air distribution system:

1. Control of supply air duct fan output by means of static pressure regulator operating in conjunction with its capacity modulation device. In smaller systems this device need be no more than a good vortex damper although acceptable performance will probably be achieved with face & by-pass damper configuration.
2. Dividing the air distribution system into the most conveniently selected low pressure supply duct zones, supplied with low/medium pressure main ducts or risers, by the fitting of branch duct dampers operating in conjunction with branch supply duct static pressure regulators.

### AIR HANDLING UNIT SHOWING SUITABLE DUCT PRESSURE CONTROL



#### DUCT STATIC PRESSURE VARIATIONS

Design & manufacture discrepancies in supply duct systems are largely compensated for by terminal volume adjustment in response to thermostat action. Tolerances of -10% to +20% in duct static pressure will not materially effect correct functioning of variable volume terminal units. Under all terminal output conditions, duct pressure variations will be compensated for by temperature controllers which react to an incorrect supply of air by the terminal volume regulation. At minimum flow, variations in duct static pressure are normally slight as duct losses at low air flow are almost non-existent.

#### RECOMMENDED BRANCH DUCT PRESSURE

The determination of branch duct pressure should be governed by the noise levels to be satisfied, the area the conditioned air is to serve or throw & the duct pressure needed to deliver the flow required by load calculations. All these details are provided in the relevant sections of the RICKARD manual.

#### RECOMMENDED MAIN DUCT OR RISER PRESSURE

For economical fan operation, this pressure should be just high enough to accommodate main duct or riser pressure losses & design tolerances. With careful riser duct design it should not be necessary to require riser or main duct pressure to be more than 100Pa above branch duct static pressure.

#### POSITIONING OF STATIC PRESSURE SENSORS

In all cases static pressure sensors for branch ducts should be fitted in the branch ducts themselves & not in the feeder ducts to the individual terminals nor into the actual terminals. Generally it is recommended that static pressure sensors in branch ducts be fitted half or two thirds of the way between the duct pressure control damper or supply fan & the end of the relevant duct so that the most representative pressure is sensed.

#### BRANCH DUCT VELOCITIES

In the case of branch ducts serving terminal units, it is recommended that conventional criteria be used in the determination of branch duct velocities, & assuming that, depending on noise level requirements, these will typically be in the range of 3.5 to 6m/s.

In some cases slightly higher branch duct velocities are allowed because of the inherent noise attenuation properties of the terminal units & associated flexible duct connections. Generally a maximum of 7.5m/s is recommended. In smaller air handling units Of the fan-coil type incorporating light duty centrifugal fans, volume regulation is most easily achieved by fitting supply air duct restrictors & by-pass dampers. This system is also used when packaged air handling equipment is to be specified.

Cooling plants of the direct expansion type, generally cheaper to install & operate than chilled water generating plants, can be used for virtually every application. Limitations of this type of plant are imposed only by capacity. In the case of smaller plants where cooling is controlled in only one or two steps, the temperature sensor for cooling control should be placed in the "warmest" room.

This avoids short cycling of compressors, which would result if the off coil temperature were to be used for control.

**HIGH VELOCITY SYSTEMS**

Building space limitations may dictate the use of high velocity systems, obviously at an operating cost premium due to the resultant high fan operating pressures.

At the point of change from high velocity, pressure reducing dampers are required. Each damper unit may require a sound attenuator to reduce high velocity duct & damper noise generation through pressure reduction.

**VARIABLE GEOMETRY TERMINAL UNIT DESIGN**

Having discussed overall design, we now consider the advantages of the RICKARD VARIABLE GEOMETRY air diffusion concept. Essentially the concept utilizes the principal of varying the shape of the air diffusion device at the point of discharge into the air conditioned space. This ensures that constant air distribution patterns & room air induction rates are maintained from minimum to maximum flow conditions.

**THE PRINCIPAL OF OPERATION VAV COOLING/REHEAT SYSTEMS**

**COOLING**

During the cooling cycle each terminal unit, or group of terminal units, varies the volume of supply air at constant temperature to the air conditioned space in response to the output from a room or zone temperature controller. Generally the range of volume control is from 100% down to 30%.

The RICKARD range of VARIABLE GEOMETRY air diffusion equipment is so designed such that room air movement remains essentially constant even at minimum terminal air volumes. This is because lower volumes discharge at higher jet velocities.

**REHEATING**

Should the temperature in the room or zone fall below setpoint, thereby calling for supplementary heating, the terminal reheaters, when fitted, will be automatically energized. In this mode the heaters are only energized when the terminal unit is delivering minimum air so that energy consumption is kept as low as possible.

In a well designed system, when heating is required, the cold air supplied to the terminal unit is in fact obtained “free” by economy cycle damper operation thereby avoiding unnecessary reheating of previously cooled air.

**VAV COOLING/VAV HEATING SYSTEM**

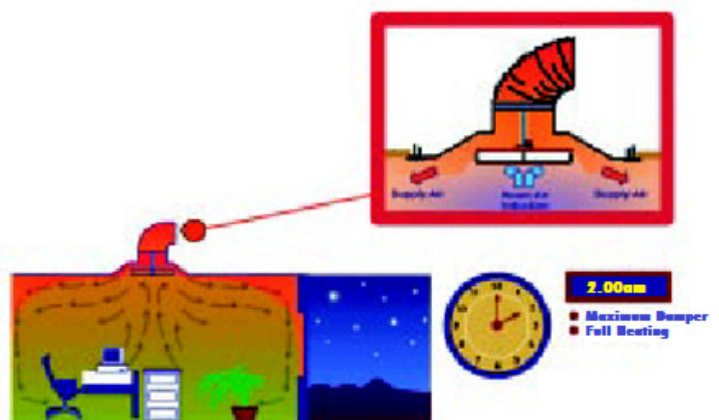
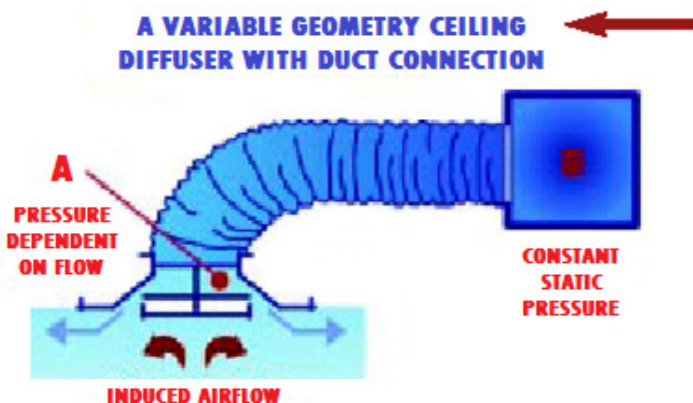
Through modern electronic technology, at low cost, the action of the conventionally controlled RICKARD VARIABLE GEOMETRY VAV terminal equipment may be reversed such that during the heating mode, a decrease in room temperature will cause an increased volume of pre-heated air to enter the air conditioned space. This is brought about electronic controller detecting that the supply temperature entering the VAV terminal is above room temperature. Therefore, through careful design & zoning considerations, the amount of reheat required could be substantially reduced without sacrificing flexibility or individual control.

**THE PRINCIPAL OF AIR FLOW MODULATION OF VARIABLE GEOMETRY VAV TERMINALS**

The adjacent diagram shows a supply air duct, a circular flexible connection & a RICKARD VARIABLE GEOMETRY VAV terminal. The terminal unit has a variable geometry air volume control device activated in response to room temperature conditions.

The static pressure in duct “B” is controlled at a constant level as the VARIABLE GEOMETRY control device varies the aperture of the terminal unit to modulate the flow of air. As the air volume flowing from “B” to “A” is decreased, the resultant static pressure in “A” is increased. Therefore, the increased static pressure at lower flow rates is converted to velocity pressure resulting in increased air velocity entering the air conditioned room.

Although mass flow at minimum supply air status is considerably reduced, the increased air velocity ensures good induction rate and hence excellent room air movement.



**THE PRINCIPLE OF AIR FLOW MODULATION OF VARIABLE GEOMETRY TERMINALS**

The RICKARD range of low pressure VAV air distribution equipment incorporating the VARIABLE GEOMETRY concept is available in several types which are VCD, VSD, VLN & WBD.