# Design Do's and Don'ts for VAV Systems

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# UNIFIED FACILITIES CRITERIA (UFC)

# HEATING, VENTILATING, AIR CONDITIONING, AND DEHUMIDIFYING SYSTEMS

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U.S. ARMY CORPS OF ENGINEERS

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# APPENDIX C
# DESIGN DO's AND DON'Ts FOR VAV SYSTEMS

## C-1.00 Introduction

C-1.01 Scope and Criteria. This appendix is intended for use by qualified engineers who are responsible for preparation and review of plans and specifications for construction of VAV, HVAC, and dehumidifying systems. It complements the requirements of NAVFACENGCOM and DOD manuals and instructions for the construction of HVAC systems. The designer is reminded that normal construction and maintenance problems encountered with all types of HVAC systems are not covered here, but should be fully considered in the design.

C-1.02 Excellent Facilities. The objective of HVAC system design is to provide excellent places to work and live for Navy and Marine Corps personnel. The goal is not only to minimize the life cycle cost of the facilities, but also to maximize the performance of the people who use the facilities. VAV systems offer enhanced comfort by allowing economical flexibility in zoning, better temperature control, better passive humidity control at part load, and greater energy efficiency.

C-1.03 Importance of Design. Navy VAV systems often do not perform as the designer intends. An investigation of the causes of failure shows that considerable improvement in the success of VAV can be achieved by special attention to good design practices. This appendix is intended to provide feedback to alert the designer to recognize those areas where careful attention can prevent deficiencies commonly found in Navy VAV systems.

a) VAV systems incur problems for the same basic reasons that other types of air conditioning systems do. They are either improperly designed, constructed, or operated and maintained.

b) Deficiencies in design often result from both technical and practical aspects of the design. Improper practical decisions often occur in the following areas: (1) lack of consideration of the constructability of the design, (2) failure to appreciate the importance of designing systems that can be operated and maintained, and (3) failure to communicate in sufficient detail the design intent and thus leaving too many decisions to the contractor.

c) Deficiencies in construction, inspection, and acceptance occur primarily in three areas: (1) the system may not be installed as designed, (2) the system is installed to meet requirements of the design and submittals but quality of workmanship is such that the system will not function properly, and (3) although construction might be satisfactory in all respects, acceptance testing is of poor quality and latent defects in the systems go undetected.

d) Operation and maintenance deficiencies can occur from insufficient or improper training, the system receiving inadequate operating and maintenance attention, and the system receiving well meaning but misguided operation and maintenance attention.

e) A failure in any of these areas can be fatal to the successful operation of a VAV system.

C-1.04 System Simplicity. The most common fault of the majority of designs is that the systems are too complicated to work reliably. Some systems never work initially, others fail because Naval operation and maintenance personnel do not understand them sufficiently to keep them working as designed. The chief area of concern is control systems. A designer is always tempted to add features to improve performance and conserve energy but must weigh the potential benefits against the additional cost and complexity. Feedback: On the average, systems have too many features and are too complex for the needs of the Navy. The designer should design systems that err toward simplicity, at the expense of features, and require minimum maintenance.

C-1.05 Early Coordination. Having experienced numerous problems on VAV systems, the Navy wishes to have a high level of interaction between the designer and the Engineer in Charge and will often want to give the designer more direction than is normal. To minimize design changes, it is important that there be good communication. This is particularly true in the early stages of the design. The designer shall communicate his design intent and the critical concepts of his proposed system, including simplicity in operation and maintenance, at the first submittal opportunity. This will prevent the necessity of changing the concept of the design.

C-1.06 Dry Climates. Many Naval facilities are located in humid climates and so there is a tendency to tailor design guidance for humid areas. There are also many Naval facilities located in dry and cold climates. The practice associated with design in these facilities can be considerably different. The designer must be careful to fit his design to the area where he is working. Typical conditions in dry and cold climates are that: the relative humidity is low; the daily dry bulb range is high; the outdoor air economizer is effective (at least for night purging); the sensible heat ratio is high and systems are often designed primarily to handle the sensible load and to let the room relative humidity float as it will. Naval facilities located in dry and cold climates may require modifications to the criteria listed below.

C-1.07 Selection of Type of Control System. Design control systems as simple as possible to provide adequate control and give careful consideration to the following when selecting the type of control system:

a) Pneumatic Controls. Pneumatic controls seldom work consistently well in Naval facilities. Pneumatic controls require frequent maintenance and calibration at a level that is not usually performed by Naval personnel. Pneumatic systems are prone to fail from water or oil in the compressed air. Many pneumatic control systems are never set up properly by the installing contractor. Even hybrid control systems (e.g., DDC with pneumatic actuators) can have similar problems because the electric-to-pneumatic transducers have small passages that are vulnerable to moisture and oil in the compressed air. All other things being equal, pneumatic control is not a good choice for the control system; but if operation and maintenance personnel are expert in pneumatic controls, have adequate funds for maintenance, and refuse to use state-of-art systems, pneumatic systems may be justified.

b) Electric Control. For the sake of simplicity, electric VAV terminal unit controls may be used in conjunction with pressure dependent (PD) terminal units (refer to par. C-2.10). This type of zone temperature control requires only the simplest of control sequences and therefore, will be easier for Naval operation and maintenance personnel to understand and maintain. Electric controls for the central equipment (e.g., CHW valve and control, etc.) are in common use and are suitably rugged, however, may not be accurate enough for the application.

c) Analog Electronic Control. If pressure independent (PI) terminal units are used, it will be necessary to have electronic controls. Analog electronics usually introduce additional levels of complexity whose advantages can be outweighed by the likelihood that they will not be understood by

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the operating and maintenance personnel. It is recommended that electronic controls be used with as simple a sequence as possible.

d) DDC. DDC is the state-of-art of control systems and is in common use throughout the industry. Navy DDC systems are distributed (have controllers located near the equipment being controlled) and usually include a means for the operator to diagnose HVAC operation from a remote location. A DDC system is the system of choice for Naval projects if the facility operating and maintenance personnel are qualified in DDC systems or, at least, are willing to take the recommended training and make a sincere effort to properly use DDC. The designer should not overdesign the DDC system, should make it simple, and as user friendly as possible. It is critical that quality DDC sensors be used which have long term (5 years) stability to minimize maintenance and calibration while providing accurate conditions. DDC systems may incorporate energy management strategies in addition to normal control functions with little or no additional cost.

C-2.00 Do’s and Don'ts

C-2.01 Do not oversize the system. Do not add safety factors in load calculations. The calculation methods already have an adequate safety factor included. Feedback: Many Navy VAV systems are significantly oversized. This not only costs more, but it handicaps the system in performing the already difficult task of providing comfort under difficult part load conditions commonly seen in humid, coastal environments where many Navy installations are located. Because of the inherent diversity factor in VAV systems, they are more "forgiving" of capacity shortages than are constant volume systems.

C-2.02 Use computerized load calculations based on the ASHRAE transfer function method. The manual use of the total equivalent temperature difference/time averaging (TETD/TA) method or the cooling load temperature difference/cooling load factor (CLTD/CLF) methods are not as accurate and require engineering judgment which typically leads to unnecessary conservatism.

C-2.03 Design for diversity. Select central air handling equipment and heating/refrigeration systems for "block" loads. Spread diversity appropriately through the supply ducts, taking full diversity at the air handling unit, and lessening diversity

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when moving away from the air handling unit toward the VAV terminal units, until no diversity is taken at the distant VAV terminal runouts.

C-2.04 Design and specify for both peak and part load conditions. Submit design calculations verifying that careful consideration has been given to the following areas:

a) Consider the psychrometric performance of the cooling coil (taking into account the method of capacity control) during difficult off peak conditions when the room sensible heat ratio can be significantly reduced. Select appropriately difficult off peak conditions for analysis. At a minimum, show how the system will perform when sensible load due to solar is lost while latent loads remain constant. This is not necessary in dry climates. The VAV system may operate with 100 percent outside air during warm-up or on maximum heating days.

b) When selecting a fan for a VAV system, submit design calculations verifying the system has been analyzed at the following three points: (1) normal peak load (including diversity), (2) maximum cooling load (no diversity with VAV box dampers open), and (3) minimum cooling load (with VAV boxes at the minimum flow condition). The supply fan should be scheduled/specified (cfm and pressure) to satisfactorily meet all three of these operating points. Submit design calculations and a typical fan performance curve showing all of these points plotted. A fan should never be selected which will become unstable or overload anywhere on its operating curve.

c) Consider limiting the size of VAV air handling units to 10,000 cfm for flexibility and ease of maintenance. Plan for units to serve zones with different exposures to achieve unit diversity.

d) VAV terminal boxes should be sized with both maximum and minimum flows in mind. Schedules should indicate cfm, neck velocity, pressure drop, and noise criteria at both maximum and minimum flow (refer to par. C-2.11).

e) For air distribution devices, the minimum allowable "throw" should be scheduled for both maximum and minimum flow conditions.

f) If an outside air injection fan is used to maintain minimum ventilation, select a fan with a "steep" fan curve which will maintain a relatively constant flow regardless of mixing box pressure. This analysis will be similar to that used for specifying the supply fan. Knowing the range of total static pressure expected in normal operation of the supply fan, estimate the expected range of mixing box pressures. Select the fan to deliver design minimum ventilation at an average system operating point (typically less than design peak). With this method of selection, the fan will deliver slightly more than design under peak flow conditions and slightly less than design under minimum flow conditions. The fan should be scheduled/specified to satisfactorily meet flow requirements at each of these three operating points.

g) Submit detailed computerized design calculations (this is mandated by the static regain method for sizing) which indicate the amount of diversity used for sizing ductwork and where the diversity was applied.

h) It is recommended that the system be designed for 8 to 12 air changes per hour with a minimum supply airflow of 4 air changes per hour.

C-2.05 Design supply ductwork using the static regain method. This will require computerized ductwork design analysis. Design return ductwork using the equal friction method. The static regain method keeps the static pressure in the supply system more nearly constant throughout. This enhances the inherent control stability of the system. It also greatly assists in naturally balancing airflow through the system minimizing any advantage for using PI terminal boxes. Using the static regain method requires that more attention be given to the design of the duct system but this is effort well spent.

C-2.06 To control humidity and for simplicity, design for a constant cooling supply air temperature. The leaving air temperature should be controlled using a chilled water valve modulated to maintain supply air temperature as sensed by a leaving air sensor. Resetting the supply air temperature upwards increases the sensible heat ratio of the coil and leads to high space relative humidity and poor indoor air quality. The potential to save refrigeration energy by raising the cooling supply air temperature is more than offset by the increased fan energy needed to move more air. In addition, changes in supply air temperature can lead to condensation on and around diffusers. Exception: There are cases where, to prevent overcooling at minimum flow or to minimize reheating, resetting the cooling supply air temperature might be appropriate. Also there are cases in dry climates where it would be permissible to vary supply air temperature.

C-2.07 Do not use a return air fan in a VAV system. Measuring and control requirements for tracking the return air fan with the supply air fan are too demanding to work in a Naval VAV system. In most cases a return fan is unnecessary to return air to the HVAC unit. In cases where the pressure drop in the return duct exceeds the drop for outdoor air, the mixing box may be at a lower suction pressure. Select outside air and return dampers with this in mind.

C-2.08 Economizers should be used when significant benefits can be shown. (Clearly dry or cold climates are cases where economizers can be effective.) Feedback: Economizers in Navy VAV systems fail in a majority of cases due to complex arrangements. Keep economizer systems simple and use only outdoor air dry bulb sensors for changeover. The economizing feature can save a lot of energy in many applications but the designer must confer with the appropriate NAVFACENGCOM EFD or EFA when using this design.

a) Economizers should have outdoor air dry bulb type changeover instead of outdoor air versus return air comparators or enthalpy type changeovers.

b) Economizers should only be used when the system can be designed with gravity relief. Return or relief fans should not be used.

C-2.09 Maintaining Ventilation Air. In most systems there are circumstances under which satisfying the cooling load will not adequately ventilate the space. Unless it can be shown that this is not the case, the designer shall design a positive means of maintaining ventilation rates during minimum flow conditions, to maintain IAQ. Select minimum positions of VAV terminal units to meet this requirement. Note: It is impossible with a VAV system to absolutely maintain a minimum ventilation airflow to any space. The best that can be done is to maintain a constant ventilation airflow on a per air handling unit basis and recognize that ventilation will be improved in any zone that is shorted by mixing between rooms (especially in zones where fan-powered boxes are used) and shorted rooms tend to be those where people and lights are not present, and thus the ventilation requirements are lower anyway. Use ASHRAE Standard 62 to maximize IAQ.

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To maintain a constant outside air quantity being drawn in and supplied by the AHU, a separate outside air injection fan or PI VAV box should be used. Use of an injection fan is encouraged rather than a PI VAV box because it is a more reliable method of providing constant ventilation from a simplicity and maintainability viewpoint. The designer should be aware that PI units rarely work properly in Navy installations because of maintenance problems with PI velocity sensing hardware/controls. Properly working PI units, however, would be a more accurate means of providing a constant flow throughout a given range of mixing box pressures. A PI unit should be considered if the range of mixing box pressures expected is such that it would be difficult to specify a fan which would deliver acceptable flows throughout the range of pressure.

C-2.10 Pressure Dependent (PD) Boxes. The use of PD VAV boxes rather than PI boxes is recommended. Feedback: PI velocity resetting controls are often a significant contributor to failure of Navy VAV systems. When determining the type of VAV terminal units to use in a system, give careful consideration of the following feedbacks:

a) The most important feature touted for PI units is that they respond to fluctuations in system pressure and thus enhance control stability by reducing "hunting." However, when the supply duct system has been properly designed for static regain, there is no clear evidence that the use of PI units results in greater zone temperature control stability than when using PD units. The transfer functions and time constants in a typical VAV unit control are such that the potential benefits of velocity resetting are nullified by the disadvantages of the additional and complicated control loop.

b) PI controls claim to render the whole system virtually self-balancing. However, in a system with PD controls and a well designed static regain duct system, the VAV dampers respond to changes in load sensed by the thermostat and respond to balance the air in a similar way.

c) Maximum and minimum airflow limiting is a feature that is inherent with PI control units. However, there is some question as to how well the velocity sensors used for this purpose actually measure flow (setpoints are at the extreme low end of their range). Some manufacturers say the velocity loop readily drifts out of calibration and must be auto-calibrated regularly by using a DDC system. The problem is worse at lower airflow. A differential pressure flow ring or flow cross is accurate only down to about 400 fpm (which unfortunately might be as high as 33 to 50 percent of maximum flow in many cases). Since desired minimum flow will usually be less than this, the differential pressure PI is not accurate for controlling minimum flow. The other common method uses a hot wire anemometer or similar device for sensing. This is not very good because the sensor is a single point in the inlet duct rather than a multi-point device (as used by the flow ring described above). It would only be accurate for a box that had many diameters of straight duct upstream (not the usual case). In addition, the response time is too slow for good PI control.

d) Minimum flow can be set on PD units by installing mechanical stops, by setting the actuator stroke through linkage adjustments, or by other similar means. These are straightforward testing and balancing procedures.

e) PI costs somewhat more than PD on the average, is much more complicated for maintenance personnel, and the additional control components are more prone to failure.

f) If PI is used, however, the designer must be careful to specify that supply maximums and minimums are checked after the equipment is installed. Factory adjustments have proven to not be an adequate guarantee that the installed equipment will function as needed.

C-2.11 Carefully consider the throttling characteristics when selecting the type and size of VAV terminal units. The installed characteristic curve of a throttling damper expected to modulate supply air to a space, is a function of the inherent characteristic curve of the device and the ratio of the system pressure drop to the drop across the damper at maximum flow. As the pressure drop of the damper at maximum flow is reduced (by selecting larger and larger dampers for a given flow rate--a practice promoted by the desire to save fan energy), the installed characteristic tends to move across the spectrum toward quick opening characteristics. The geometry of butterfly dampers tends to exaggerate this shift. With dampers specially designed to retain linearity, this shift can be greatly reduced.

a) A shift toward quick opening increases the gain of the control component, i.e., a smaller part of its stroke is actually used for control. This is detrimental to the stability of the control system. The common tendency of selecting dampers with very low pressure drops can result in control that is nearly

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"two-position." It is better to pay some fan energy penalty and have a system that provides more stable control. Properly sized control dampers will be smaller than fan casings and have greater maximum flow pressure drops than those usually used.

b) If PI terminal units are used, sizing becomes even more critical. Oversizing the boxes to reduce maximum flow pressure drop results in low neck velocities, which in turn create problems for PI flow measuring devices. To minimize problems with sensing minimum flows in PI VAV boxes, size the box such that at minimum flow, the neck velocity will be at least 500 fpm.

C-2.12 Give special attention to linkages (VAV terminal unit damper, fan inlet guide vanes, and controllable pitch vanes). Feedback: Problems due to poorly designed/constructed linkages are very common in Naval VAV systems. Either specifically describe linkage requirements (because manufacturers are so different, this may be difficult for VAV terminal units) or at least require detailed shop drawings of linkages and pay close attention to them. Finally, linkages should be included in the specifications as a specific item to be performance checked during the acceptance testing of the system.

C-2.13 Pay close attention to Contractor's responsibility of coordinating which of his subcontractors provides VAV terminal units/controls/actuators. Feedback: Contractors' lack of coordination of the VAV terminal unit and controls often leads to problems which go undetected. Even though DOD specification policy recognizes only the Contractor as the single entity, and not the subcontractors (thus not stating who does what), careful attention to submittals in this area will avoid many problems. To help with this, the VAV boxes, thermostats, and associated equipment should be specified as a system and the Contractor be required to make his submittal for all items at the same time.

C-2.14 Whichever of the available methods of selecting supply air outlets is used, consider the full range of flow rates expected. Recognize the effects of room geometry on satisfactory performance (e.g., the Coanda effect depends upon having a flat ceiling, without interruptions, etc.).

a) It is recommended that VAV supply diffusers be of the linear slot type capable of supplying air horizontally along the ceiling utilizing the Coanda effect to provide good air distribution. In cooling only applications, the diffusers should be located centrally in the space and blow in all directions. In exterior spaces with fan-powered boxes, the location depends on the magnitude of the heating load. If the heating load is less than 250 Btuh per linear foot of exterior wall (including infiltration), the diffuser should again be located centrally and blow in all directions. If the heating load is between 250 and 400 Btuh per linear foot of exterior wall, the diffuser should be located near and parallel to the exterior wall and blow horizontally back into the room.

b) Diffusers which have operable internal dampers for varying airflow should not be used in lieu of conventional duct-mounted terminal units in a VAV system design.

C-2.15 Locate the static pressure sensor, for modulating fan capacity, out in the supply duct system, not at the fan discharge. Expect some field adjustment to be required to find the best location. In many systems, the first location is two-thirds the distance from the supply fan to the end of the main trunk duct. Sensors shall have proper static sensing elements.

Provide protection against overpressurization of the supply duct. This should be accomplished by a high limit duct static pressure sensor located at the fan discharge. This sensor should turn off the supply fan if the duct static pressure rises above setpoint and require manual reset of the supply fan.

C-2.16 Balancing dampers should not be necessary for VAV systems. If the supply ductwork is designed properly using the static regain method (refer to par. C-2.05) and VAV terminal units are properly sized/selected (refer to par. C-2.11) and set up properly during commissioning, the system should be sufficiently self-balancing.

C-2.17 Use round ducts wherever space availability permits. Round ducts are acoustically superior to rectangular ducts and normally cost less. In high velocity systems, the additional friction losses of duct walls and balancing dampers of rectangular ducts cause the system to be inherently less stable. Round ducts also produce less noise than rectangular ducts.

C-2.18 To save construction expense, it is now common to serve ceiling outlets with short runs of flexible duct. Limit the length of flexible duct and avoid bends to minimize duct friction drop. Figure these pressure drops, and do not show longer runs

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on the drawings than you allow in the specifications. Seek self-balancing by having equal lengths of flexible ducts instead of long and short runs on the same system.

When designing VAV systems, do not use flex duct upstream of the terminal VAV box (i.e., between the air handling unit and the VAV box). Use flex duct only to make terminal runs to diffuser boots and limit applications to straight runs of no more than 5 feet. Hard duct 90 degree elbows should be used to connect the flex duct to the diffuser boot. Do not use flex duct for elbows.

C-2.19 Many zones in Navy buildings do not need heating. These include zones in a building in a cooling only climate or completely interior zones in any climate. In these situations, a recommended control sequence is as follows: the air handling unit supplies a constant cold temperature (say 55 degrees F) air. Each VAV box modulates from maximum position (fully open) to minimum position (fully closed) through the control range of the room thermostat. The justification for allowing full close-off in interior zones, in light of IAQ concerns, is that the people load plus lights in an interior zone are substantial, usually amounting to 50 percent of the zone load or more. This is true for perimeter zones in a cooling only climate also, but to a lesser extent. So, if people are present, and thus the lights are on, the load will be above the minimum anyway. Therefore, the minimum is not needed. If the people are gone and the lights are out, the load may fall below where a ventilation determined limit would come into play, but since the people are gone, no ventilation is needed.

C-2.20 For zones that need heating, there are two recommended situations. For the very cold climate when the peak heating load on the exterior wall is greater than 400 Btuh per linear foot of wall (including infiltration), a separate skin heating system may be used consisting of baseboard hot water convectors. Two-position electric spring-return control valves should be installed in each zone. Thus each perimeter zone will be served by a VAV terminal unit for cooling and a corresponding section of hot water convector for heating. The zone thermostat should control both the VAV damper actuator and hot water valve actuator in sequence at the cooling and heating setpoint. The VAV damper should have a mechanical minimum position for ventilation air which would be field set during the testing and balancing phase of installation.

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a) For a mild or moderate heating situation when the peak heating load on the exterior wall is less than 400 Btuh per linear foot of wall, the following arrangement is recommended. Each zone should be served by the series fan-powered VAV box with a hot water heating coil and overhead supply diffusers. The thermostat should modulate the VAV damper closed to the mechanically field set minimum position at the cooling setpoint. On the further drop in space temperature to the heating setpoint, the hot water valve should open (using a modulating electric spring-return actuator) to allow control of heating. An alternate arrangement uses a parallel fan-powered VAV box with heating coil. The VAV box fan motor should be started when the VAV damper closes to a supply rate of 4 air changes per hour.

b) Since the use of fan-powered boxes adds several hundred dollars per zone of first cost, the zoned baseboard heat option (described for very cold climates) may be considered, even in mild climates.

c) In perimeter zones there will be a need to setback the temperature in many buildings when there is no occupancy. This is generally accomplished by a night setback thermostat which can bring the heating system back on line to maintain the setback temperature.

C-2.21 In perimeter zones with a VAV cooling system and a separate perimeter heating system, design controls so that occupants cannot adjust thermostats for simultaneous heating and cooling. This can be done by using a thermostat with cooling and heating setpoints integrated so that ranges of possible adjustment do not overlap.

C-2.22 Systems that are to be shut down or setback during unoccupied periods can present special problems. The greatest load will occur during start-up. The supply air or coil shall be capable of bringing the temperature back to design in a reasonable time without ill effects. For instance, the designer must be careful that the temperature of supply air during start-up is not too far below the room dew point temperature to prevent condensation on diffusers.

Specify a method for building warm-up after setback. Many systems contain totally interior zones that have been designed without heat. The space, after setback over a weekend, can require an unacceptably long period of time to come up to temperature. This warm-up sequence could be accomplished by using a microprocessor-based thermostat with a built-in automatic

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changeover. The warm-up cycle would be as follows: in the morning the air handling unit is turned on (typically by the same device that turned the unit off for setback). A central hot water coil in the AHU is activated, and the thermostats are signaled to warm-up action. During the warm-up the interior zone thermostats thus open up the air dampers to warm up the space to the thermostat setpoint. After the warm-up period, the thermostats are signaled to return to normal action for cooling and the AHU hot water coil is deactivated.

C-2.23 The designer should be aware that pneumatic damper actuators provided are often inadequately sized and are not capable of performing their specified duty. Paying special attention to submittals in this area or specifying pilot positioners could help avoid many problems.

C-2.24 Note that use of air troffer lighting return may reduce design air volume to an undesirable low air distribution level (in non-fan-powered systems).

C-2.25 Modulate the capacity of the supply fan, giving attention to the method chosen. Be aware that all of the available methods, including variable speed, inlet guide vanes, controllable pitch vane axial, and even discharge dampers, have problems in Navy VAV systems. Feedback: Inlet guide vanes are often found to be inoperable due to poor maintenance. They are not the trouble-free devices that the designers think they are. It is recommended that supply air fans under 10 horsepower be forward curved fans with inlet guide vanes. Supply fans larger than 10 horsepower should be equipped with a variable frequency drive (VFD). When designing a system with a VFD, the following guides may be of help.

C-3.00 Sequence of Operation. For suggested sequence of operations, refer to par. 8.5.

C-4.00 System Commissioning. For recommended commissioning procedures, refer to pars. 8.6 and 8.6.7 which specifically address VAV systems.

C-4.01 Operation and Maintenance Personnel Training. It is suggested that training sessions of operation and maintenance