ENERGY-SAVING STRATEGIES: ADJUSTING FAN SPEED

Goal: To use a variable speed drive (VSD) or variable frequency drive (VFD) to reduce the speed of fans on an air handling unit to achieve energy savings when occupancy is low with minimal impact on the preservation environment.

Advantages	Disadvantages
Often simple mechanical control	Potential to forget to restore equipment to normal operation
Can result in significant energy savings	A VSD or VFD is needed to adjust fan speed

Description of Potential

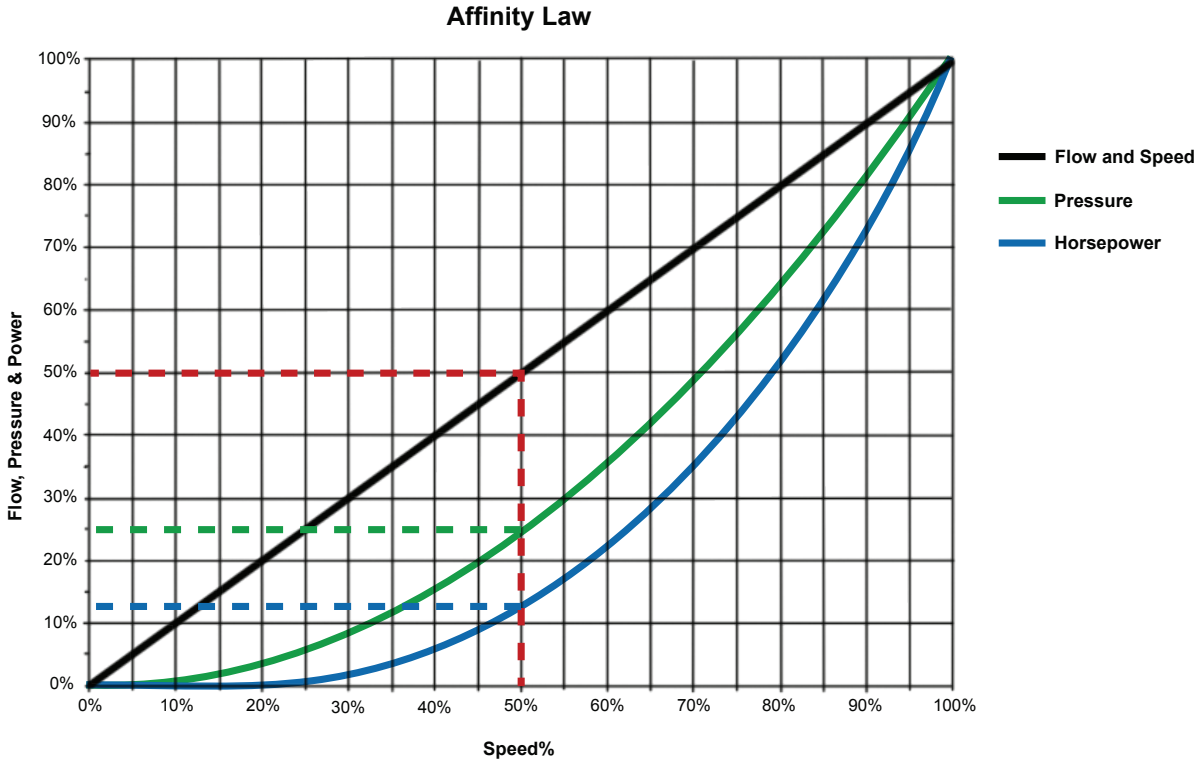
The fan motors on air handling units (AHU) account for most of the electrical consumption of a unit. Depending on an original design and the energy loads in the AHU zone, it may be possible to operate the fans on an air handling unit at reduced speeds. Zones that see little energy load returned back to the unit, but where the fans are running at 100% capacity, are good candidates for this strategy. Reduced fan speeds use significantly less power than maximum operation and can often be employed, typically during unoccupied or low occupancy times, but occasionally during regular operating hours as well. During this reduction of power the coils in the HVAC system operate as normal, but reducing the air flow results in less energy work, allowing for significant energy savings over time at both the fan and individual coils and components.

A reduction in fan speed is not meant as a means to manipulate the temperature or relative humidity within a space. The goal is to reduce the fan speed operation without changing the downstream air conditions, and should have little to no effect on the quality of the preservation environment for the collection.

Fan speed reduction will have an effect on the number of air changes within a facility. Required air changes per hour are typically dictated by building and construction codes based on maximum potential occupancy of the space. However, most buildings/zones are rarely at their maximum occupancy, creating a situation where reduced operation may be feasible even during occupied hours. As long as the set points are being met, and the appropriate amount of outside air is introduced for occupancy needs, reductions in fan speed can often be conducted with minimal impact on occupants in the zone.

To adjust fan speeds an AHU must have a VFD installed on the motor. These drives vary the frequency and voltage supplied to a fan motor in order to alter the speed, impacting the rate of air flow moved by the fan. The physical result is similar to using a dimmer switch on a residential fan or light fixture. The VFD is often controlled by a BMS. It is common for fan speed to be altered based on downstream pressure within the system – as pressure increases, usually as a result of closed VAV boxes, the fan speed reduces.

The relationship of fan speed, power and flow is expressed through fan affinity laws. Using the affinity laws, one can see how the fan power consumption does directly relate to the fan speed and the flow of the air. Any given reduction in fan speed results in a cubic reduction in fan horsepower. Slowing the fan speed down to 50% may mean a 50% reduction in the flow of air but will also yield an 87% reduction in horsepower. Strategies like this can be effective to save energy when space loads are minimal and less air flow is needed, during occupied or unoccupied hours. By installing and using a VFD you can control the fan to adapt the air flow to the needs of the environment (see the fan power graph below which shows fan power in relation to air flow).



Understanding this relationship can help a facility manager determine how air flow will be affected based on the reduction of fan speed. This will also help estimate how much energy will be saved at the fan motor.

Requirements:

- A VFD for reducing the fan speed
- Ability to program system operation
- Automated control of mechanical system and VFD are preferable
- Knowledge of hours of operation and/or work schedule for the facility
- Data logging within the VSD/VFD to record fan amps (if you want to quantify energy savings)
- Data logging within the mechanical system (if quantified energy savings at individual components are desired)
- Data logging in the collection space (to monitor the storage environment for any potential changes)

Critical Data Points:

- Preservation
    - Space data from each space affected by the system during the adjustments
    - Identification and monitoring of potential microclimate areas that may fluctuate differently than the rest of the space
- Energy
    - Data from each location in the system where a component can mechanically work on the air:
        - Return air
        - Mixed air
        - Pre-heated air
        - Cooled air
        - Heated/supply air
        - Fan amps
        - Downstream reheats
        - Others (as needed)

Pre-Testing:

- Verify the hours of operation and staff work schedule for the facility
- Notify all staff of fan speed and airflow adjustments – occupants may feel less air movement if experiments are conducted during occupied hours

System Notes:

- Verify the type of system that serves your space
- Verify that there is a VSD/VFD on the fan

Selection Criteria/Variables That Impact Potential:

- Building Envelope:
    - Due to reduced air volume during the fan speed adjustment the air pressurization in the facility may change. This may cause a positively pressurized space to become neutral or a neutral space to become negatively pressurized.
        - Infiltration of outside air may produce microclimates causing the temperature in some areas to drop lower than desired. This could impact the relative humidity level
        - Areas of concern: near doors, windows, open plenum returns, stairwells, etc.

- Occupancy:
    - Staff who work after hours may notice reduced air flow in the space
        - Complaints to facility managers may result in unforeseen adjustments
        - Test results may be skewed if facility mangers or staff members alter fan speeds due to complaints
- Space Load:
    - Ensure that staff are not using independent space heaters that can be left on and may add extra heat to the space
- Power:
    - Verify that in the event of a power outage the system operation is restored and the system is working properly
- Mechanical System:
    - Some fans are not capable of operating at low speeds
        - Consult your facilities or maintenance personnel for possible limitations to the fan operation
    - A reduction of the fan speed may lead to a slight gain or reduction in temperature as the air crosses the coils

Shutdown Experimentation (Test) and Implementation:

PREPARATION:

- Complete documentation, data gathering, and analysis steps for the system/spaces in question
- Use the Selection Criteria above to review whether the system is a good candidate for fan speed adjustments
- Confirm that appropriate data gathering capabilities are deployed and determine who will pull and check data, and how often
    - The frequency of data pulls and analysis is up to the institution and is based on staff scheduling and the level of risk management desired for a particular collection space. Common approaches include:
        - A daily walk-through of the space to be sure that normal daytime set points are being held
        - Weekly data pulls from loggers to analyze data
- Determine test parameters:

- Occupied space fan speed setbacks
    - Use caution when testing fan speed setbacks during occupied hours
    - Occupied spaces have specific amounts of air changes required due to use. Fan speeds should be selected that consider human comfort as well as meeting code requirements.
    - If testing in occupied spaces is desired be sure to meet the desired amount of air changes required by code for the space
- Continue to use the typical temperature and relative humidity set points; do not try to experiment with fan speed alterations and set point changes simultaneously
- Length of fan speed adjustment test
    - Typically, an initial test should be allowed to run for two weeks. Environments can respond differently based on outdoor weather conditions—two weeks is a reasonable compromise between gathering a representative sample set for a season and limiting any long-term risk
    - Set a start and end date for the test period
    - The fan speeds that will selected can be introduced at any time of the year depending on loads from the AHU zone.

- Communicate the fan speed adjustments to collections and facilities staff responsible for managing the areas involved:
    - Discuss the potential impact on human comfort in the space
        - Be sure staff do not use alternative methods of heating during the testing period. This will impact the energy load in the space, potentially influencing the experiment. If the experiment is successful, normal space set points should be maintained.
        - Propose a start and end date for the test period and make sure that this fits with departmental needs
        - Set up a communication structure during the test period for any environmental complaints or work-orders associated with comfort or temperature complaints

ON THE TEST START DATE:

- Facilities staff should physically confirm that the fan speed adjustments are in place
- Facilities staff should notify team members on the day that the testing starts
- Collections staff should notify other staff members on the day that the testing starts

DURING THE TEST PERIOD:

- It should be verified that the fan speed adjustment was initiated
- Facilities staff should be sure to forward any complaint calls to the facilities team representative
- Daily walk-through of test space and check of space dataloggers for any deviation from the desired temperature and relative humidity (Collections staff)
- Follow schedule for data retrieval from space and mechanical systems
- Regular check of BMS for alterations in system operation (Facilities staff)
- First data retrieval as per test schedule
    - Look for evidence of fan speed reduction in data from the fan amp logger
        - Adjustments should appear as a reduction in fan amps
        - BMS interface may be able to trend fan speeds as a secondary check to confirm operation
        - If the adjustments do not appear to be employed, work with facilities staff and/or controls technicians to find and resolve the problem
    - Initial evaluation of results of test adjustments
- If the results of the initial evaluation are acceptable, continue using fan speed adjustments until the end of the testing period

AT THE END OF THE TEST PERIOD:

- Conduct a final walk-through of systems and spaces
- Retrieve and upload data from space and mechanical system dataloggers
- Conduct final analysis of the test data as a team
- Meet with collections and facilities staff that manage the area to discuss any observations on their part during the test period and communicate the results of the final data analysis to them
- Results of analysis will determine the next step:
    - If test results were favorable
        - Continue using the adjusted fan speeds
        - Consider using a slower speed
    - If test results were not favorable
        - Consider altering the test in some manner (raising the fan speed) to achieve more acceptable results

- If testing of all strategies for that AHU are complete, remove mechanical system dataloggers and reset them to be used in experimentation for other systems
- Compile, quantify, and report test results to appropriate Administrative staff

IMPLEMENTATION/MAINTENANCE:

Once the team has determined the appropriateness of the fan speed adjustments the process enters the implementation/ maintenance phase. At this point, the team should be satisfied that they have decided upon an optimal fan speed and hours combination to save the most energy without impacting the preservation conditions in the zone.

- Document all adjustments made to fan speeds
    - Add the fan speed adjustments to the schedule for the AHU, both in programming and in any written documentation

Evaluating Test Results

SPACE DATA

- There should be no change in downstream conditions.

MECHANICAL SYSTEM DATA

- Use the datalogger on the fan (installed by a qualified electrician or maintenance technician) to see if the fan is modulating correctly.

REMINDERS FOR MAXIMIZING EFFECTIVENESS

Be sure to fully inform staff:

- In occupied spaces inform staff of fan speed and airflow adjustments in advance – the air may feel "still" compared to normal air movement.
- Remind staff to communicate issues to the environmental management team, and to avoid adjusting space set points during the experimentation phase.

Fan Speed Log Sheet for Zone/AHU#

[Organization Name]

Collection Staff:
Facilities Staff: Fan Amp Logger: Yes No

Mechanical System Logger Locations:
Outside Air/Preheated Air Cooled Air Downstream Reheat
Heated Air Supply Air Mixed Air Return Air Other_____

2 Week Test

Date	Fan Speed 'Normal'	Normal Operating Hours	Fan Speed Adjusted	Adjusted Operating Hours	System Return to Normal	Notes
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	
					Yes / No	

Daily Walkthrough Log: Check if System and Space are affected

Mon	Tues	Wed	Thurs	Fri	Sat/Sun

Daily Log: Verify that the System Returns to Normal Operation

Mon	Tues	Wed	Thurs	Fri	Sat/Sun

Daily Check of the BMS System:

Mon	Tues	Wed	Thurs	Fri	Sat/Sun

Weekly Data Pull

Post Tests:

Did the fan speed reduce as expected: Yes No

Did System return to normal operation: Yes No

Are the fan speeds worth continuing: Yes No

NOTES: