Pacific Northwest NATIONAL LABORATORY

PNNL-SA-84186

Building Re-Tuning Training Guide: AHU Discharge-Air Temperature Control

Summary

The purpose of the air-handling unit (AHU) discharge-air temperature control guide is to show, through use of examples of good and bad operations, how the discharge-air temperature can be efficiently controlled.

When a building's supply fan(s) system is operational, the discharge-air temperature set point value should be automatically adjusting to internal/external conditions that will allow the supply fan to operate more efficiently. When the set point values are consistently at the same values (nearly constant) for a long period of time and during load conditions which otherwise would be advantageous for set points to change, these conditions should be detected by reviewing the graphs for further investigation. Failure to investigate or correct/mitigate, in all likelihood, will lead to increased fan, cooling and heating energy consumption.

Data needed to verify the discharge-air temperature control

To analyze and detect discharge-air temperature control problems, for single-duct variable-air-volume (SDVAV) air-handling units, the following parameters must be monitored using the trending capabilities of the building automation system (BAS):

- Discharge-air temperature (DAT)
- Discharge-air temperature set point (DATSP)
- Outdoor-air temperature (OAT)
- Zone reheat valve signal.

The recommended frequency of data collection is between 5- and 30-minutes. When analyzing the discharge-air temperature of the AHU, the trends to look for include:

- Is reset being used to control the discharge-air set point?
- Is the discharge-air temperature meeting set point, or do deviations occur?
- Is the discharge-air temperature set point too high or too low?
- Is the discharge-air temperature too cool (<55^{o}F) or too warm (>70^{o}F)?
- Does the discharge-air temperature remain relatively stable?

Is reset being used to control the discharge-air set point?

Ideally, the discharge-air temperature can be reset (increased in cooling mode) when the building operates at part load condition. Resetting discharge-air temperature will reduce the chilled water (compressor run time), reduce reheat energy and may increase the fan energy consumption. Figure 1 shows an example of an air handler that is running without a reset-schedule. The discharge-air temperature set point is set to a constant 52°F, and the actual discharge-air temperature never meets the set point. A reset-schedule should be implemented for this air handler based on the zones it feeds. Figure 2 shows another air handler in a different building that utilizes a reset-schedule for the discharge-air temperature. You can see that during the time of the day when the load is the highest (12 PM to 6 PM for Thursday), the discharge-air temperature is reset to 55°F.

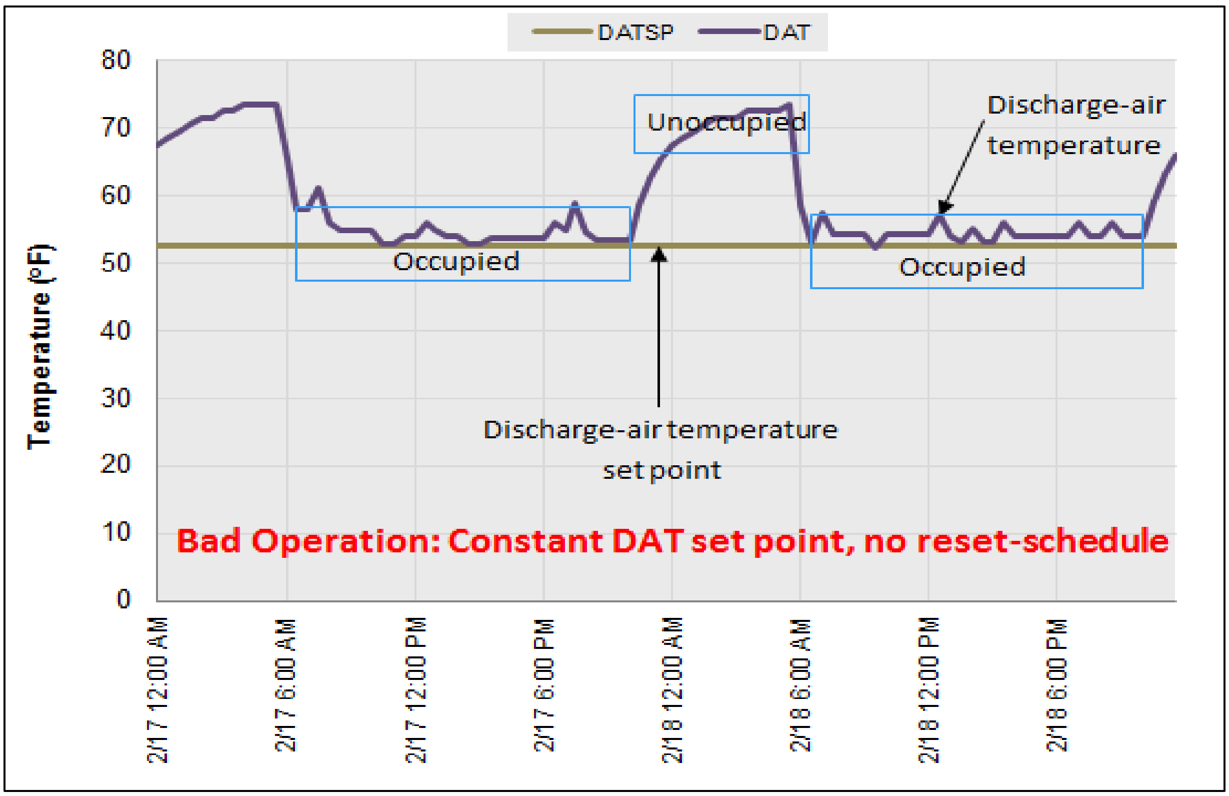

Figure 1: No discharge-air reset-schedule in place.

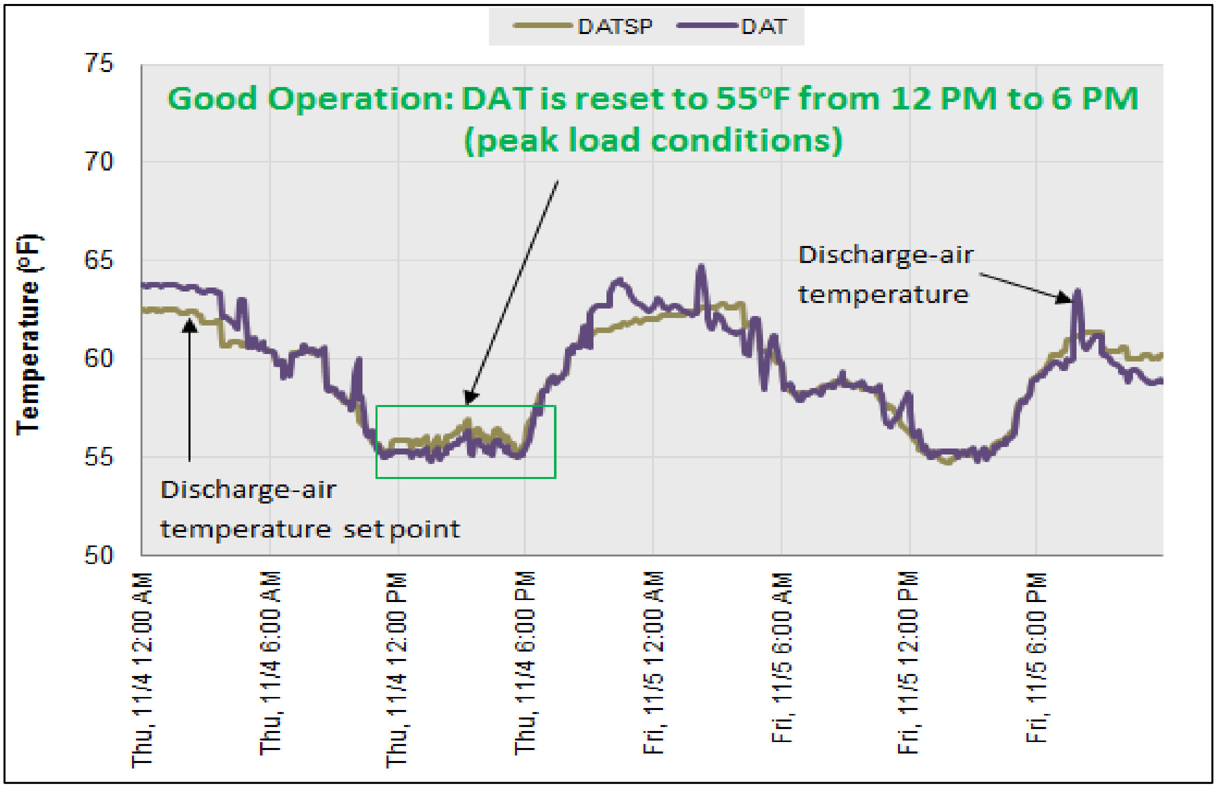

Figure 2: Air-handler with good discharge-air reset-schedule.

Suggested actions

Implementing a discharge-air reset schedule involves monitoring multiple variables. In general, operators use the outdoor-air temperature to reset the discharge-air temperature, but this isn't always the best solution because outdoor-air temperatures can't completely characterize what is happening inside the building. When adding a reset-schedule for discharge-air, the order of variable dependence should be zone conditions (number of zones in heating and cooling), return-air temperature, and then outdoor-air temperature. When basing the reset-schedule on zone conditions, the direct digital control (DDC) system should calculate the warmest zone temperature, coolest zone temperature, and average zone temperature (this is based on all but the three warmest and three coolest zone temperatures, when there are more than 10 zones served by the AHU). For AHUs that have fewer than 10 zones, resetting the discharge-air temperature should be based on the return-air temperature. By having an aggressive discharge-air reset-schedule, the discharge-air temperature can be set low enough to handle the peak cooling load caused by summer weather peaks, interior load peaks, or staffing peaks, but can then be set higher for all other times of the year when the building doesn't require low discharge-air set points.

Is the discharge-air meeting set point, or do deviations occur?

Figure 3 shows an example of the discharge-air temperature never meeting set point. The discharge-air set point is constant at 55°F, and during occupied hours, the discharge-air never reaches that set point. This could indicate that the AHU cannot satisfy the building's cooling requirements, bad proportional integral derivate (PID) loop control, leaking heating coil valve, or a bad/failing economizer control.

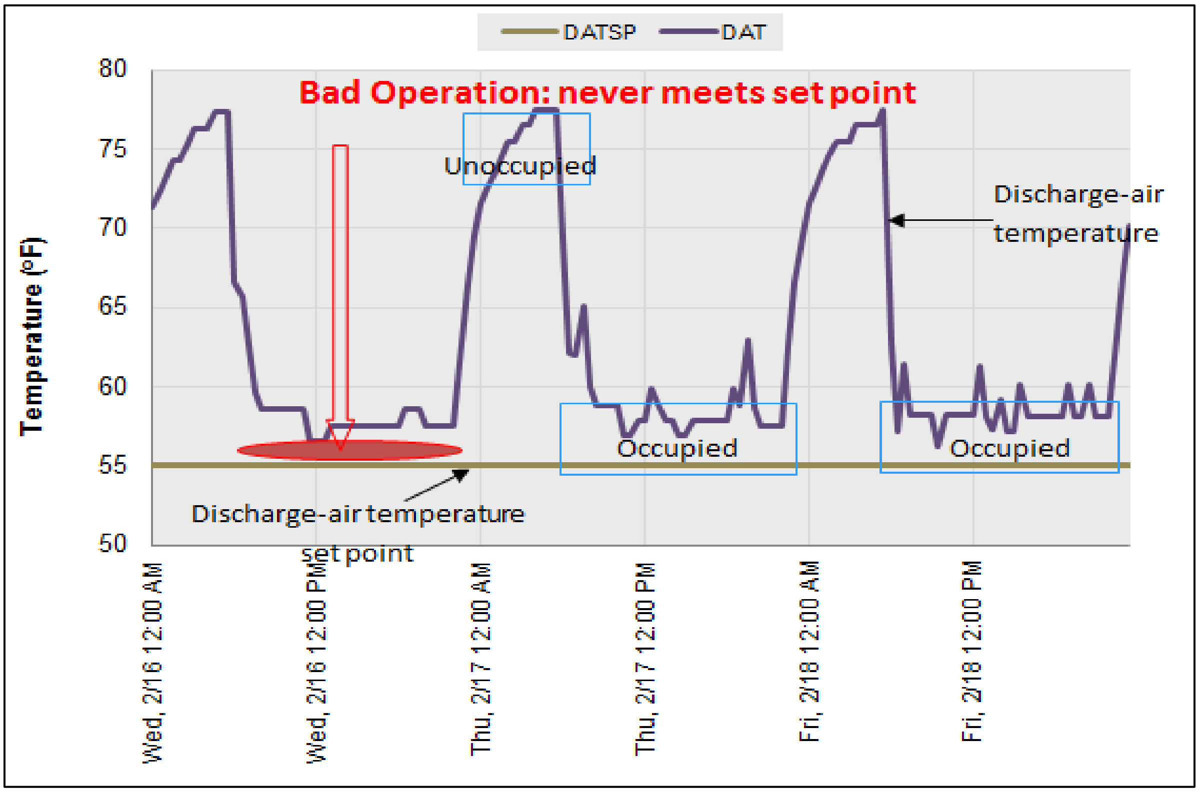

Figure 3: Discharge-air temperature never meets set point.

Figure 4 below provides an example of the discharge-air maintained at set point during occupied hours. When the system is off, the discharge-air gets warm while the set point remains unchanged, but when the building becomes occupied (roughly 6:00 AM), the discharge-air tracks immediately to the set point and follows that until the building becomes unoccupied (roughly 6:30 PM). During occupied hours, the building has a discharge-air temperature of roughly 60°F. This is an excellent example of an air handler operating with a good discharge-air reset schedule in place, which tracks the building load and cooling demand during occupied and unoccupied hours.

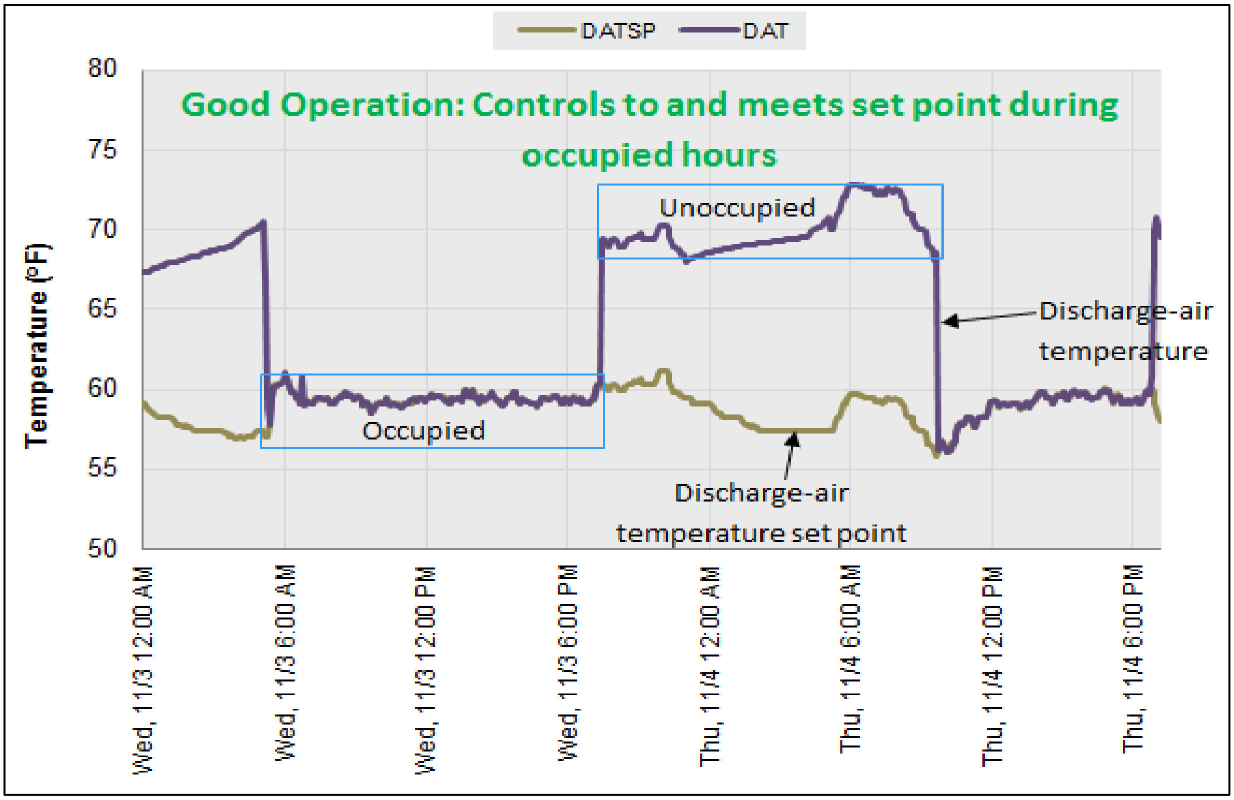

Figure 4: Discharge-air temperature controls to set point very well.

Suggested actions

If the discharge-air never meets set point, check the heating coil valve and make sure it is not leaking. Also check zone conditions (whether the majority of zones are calling for cooling, and damper position), static pressure, and fan speed. If there are zones calling for heating and the economizer is working properly, then the set point can be increased.

Are set points too high or too low; discharge-air temperature too warm or too cold?

Typically, the discharge-air set point should never be lower than 55°F or higher than 70°F. The set point can be a little lower than 55°F in climates with high relative humidity, however, where dehumidification is required. Figure 5 below shows the outdoor-air temperature, discharge-air temperature, and discharge-air temperature set point for an air handler in a commercial building operating in July. The set point for this air handler is 55°F, and it is very warm outside. Figure 6 shows the reheat valve signals for the 10 zones that this air handler serves. You can see that even though the temperature is very high during these 2 days, all but one of the zones is in reheat. This is an indicator that the discharge-air temperature for this air handler is too low and should be reset.

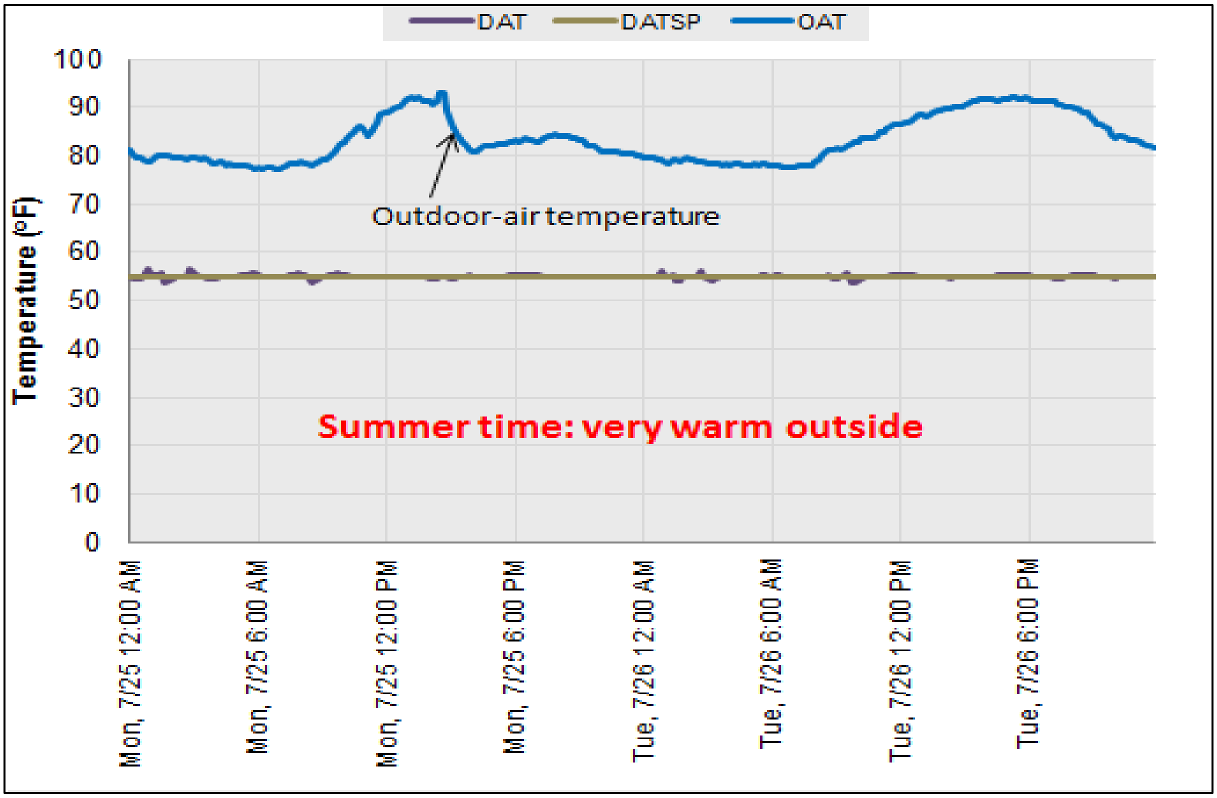

Figure 5: Discharge-air temperature and set point for an air handler.

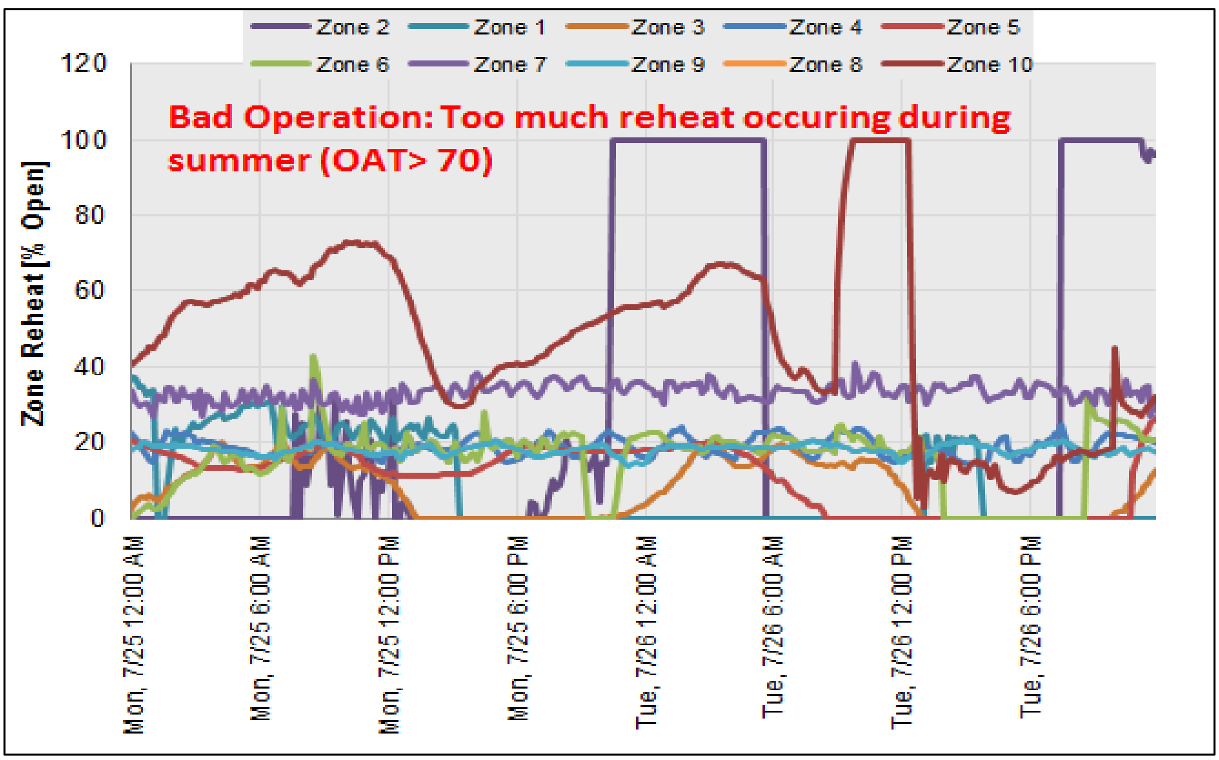

Figure 6: Reheat valve signals vs. time for zones served by AHU in Figure 5.

Suggested Actions

Discharge-air temperatures lower than 55^{o}F can cause overcooling, drafts, cold complaints, excess discharge-air pressure, offices' with portable heaters, and excess energy in reheating the overcooled zones. If you are supplying a discharge temperature below 55^{o}F, check and make sure that reheating isn't occurring in zones, because reheat must make up for all areas that are too cold from lower than needed discharge-air temperatures. The outdoor-air temperature should also be monitored. For example, if the OAT is <50^{o}F and OAT is used for discharge-air reset, then the discharge-air temperature can be initially set to 70^{o}F and adjusted according to building needs. If the OAT is >75^{o}F and OAT is used for discharge-air reset, then the discharge-air can be set to 55^{o}F and adjusted according to building needs. The building needs can be estimated by monitoring the zone conditions (number of zones in heating and cooling), and the reheat valves. You want to reset the discharge-air temperature to minimize reheat at the zone level, and keep the majority of the zones either in heating mode or cooling mode. Calculate the average zone temperature using the three warmest and three coolest zones. Remember that resetting the discharge-air temperature based on outside conditions alone isn't the best solution. Always look at the zone conditions in conjunction with the outdoor-air temperature and return-air temperature for AHUs serving more than 10 zones. For AHUs serving fewer than 10 zones, look at the outdoor-air temperature and the return-air temperature.

Do the discharge-air temperatures remain relatively stable?

If the discharge-air temperature changes rapidly throughout the day, then the PID loop might need to be tuned or sensors may need to be replaced as a result of inaccurate measurements. Figure 7 shows a building with a "hunting" discharge-air temperature. This temperature always hunts to meet the set point of 65^{o}F but can never stabilize. A "hunting" discharge-air temperature could be caused by simultaneous heating and cooling as a result of leaking control valves if two coils are present and central heating and central cooling systems are active. Figure 8 shows a very stable discharge-air temperature, which indicates good control for this unit.

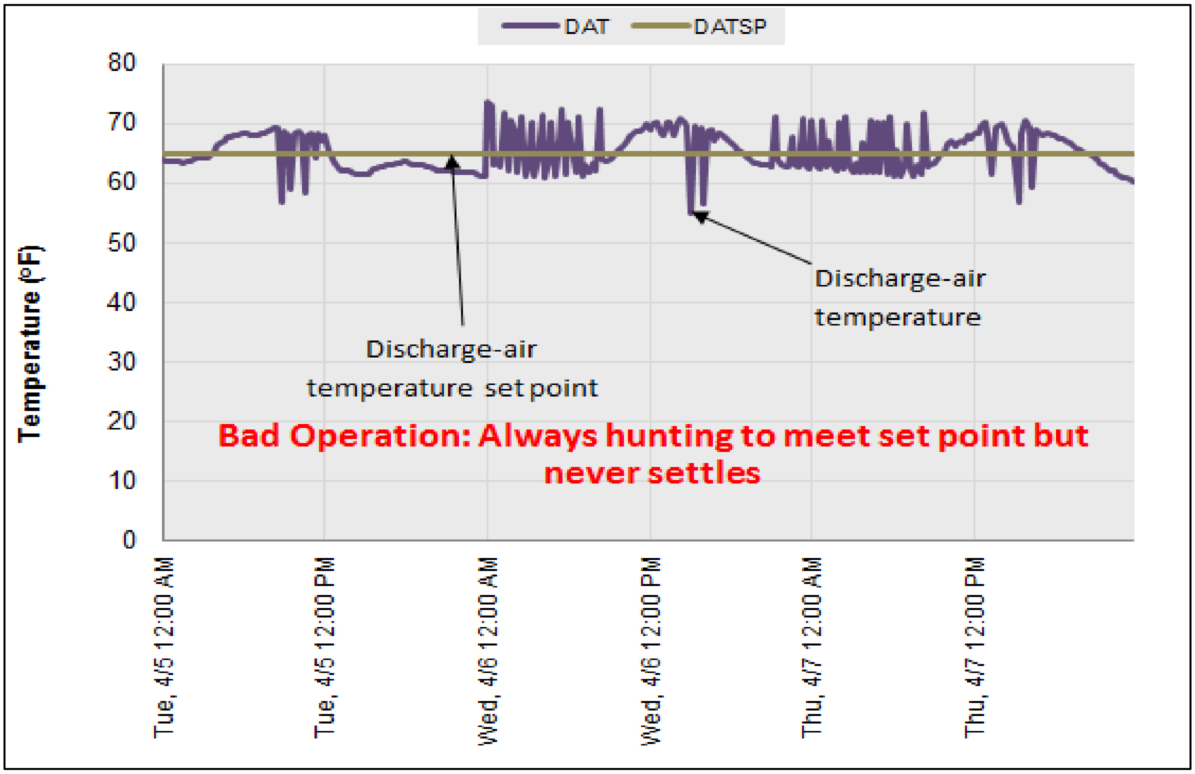

Figure 7: Unstable discharge-air temperature.

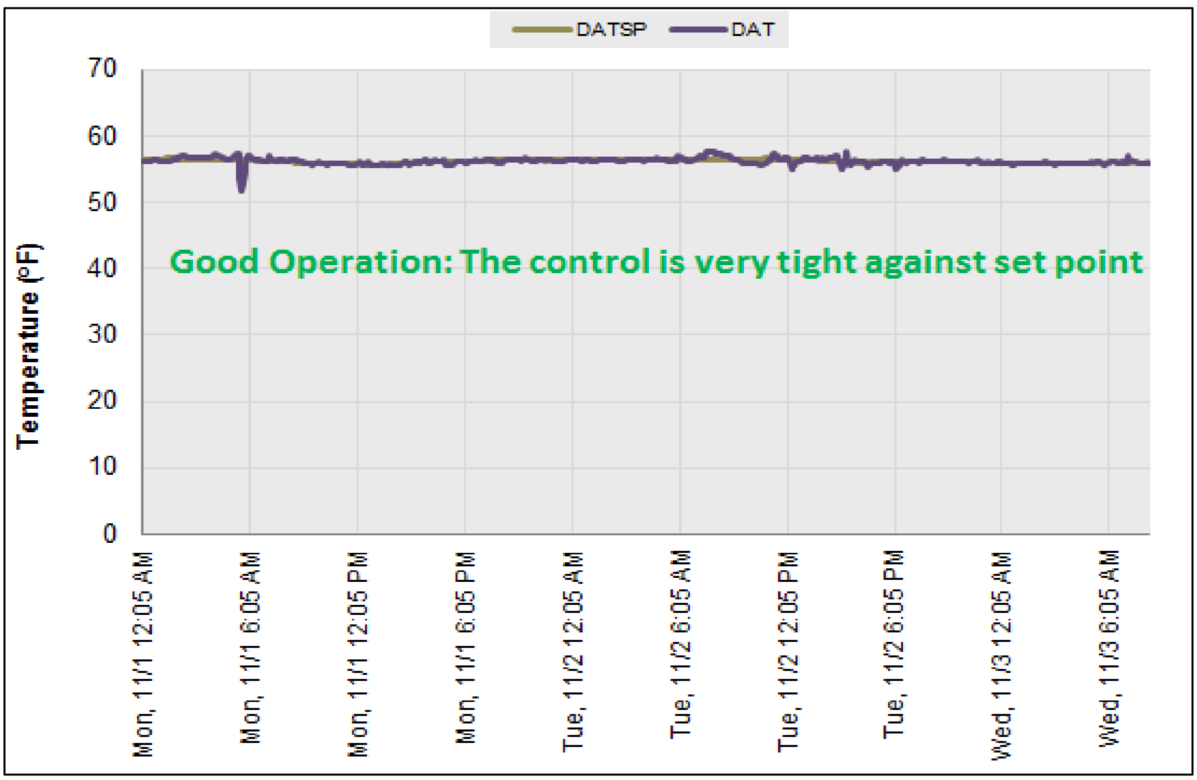

Figure 8: Discharge-air temperature very steady against the set point.

Suggested Actions

Check the outdoor-air lockouts for the heating and cooling PID loops and adjust accordingly (OA cooling lockout should be 50^{o}F or higher and OA heating lockout should be 60^{o}F or less) to help mitigate heating and cooling overlap. Also check for heating/cooling discharge temperature dead-band values to help mitigate heating and cooling overlap. Finally, check the location and calibration of the outdoor-air temperature sensor.