O3 Sensor Hub Temperature Measurement

Overview

The O3 sensor hub uses an algorithm to monitor the temperature of a space at approximately 1 m (3 ft) off the floor. This algorithm is possible due to the sensor hub's use of sensor fusion—combining many sensor readings together with machine learning techniques to model temperatures. This document will explain in more detail how the measurements work.

Temperature Down Here, Sensor Hub Up There?

The most common question is how is it possible to measure the temperature at occupant height when the sensor hub is mounted on the ceiling?

The answer is that the sensor hub is actually modelling the occupant height temperature based on the readings it gets from the three internal temperature sensors. Two of the sensors are traditional temperature sensors. They are directly measuring air temperature up at the ceiling. The third sensor is an infrared sensor, which measures a large area directly underneath the sensor hub. The IR sensor covers an area that is roughly the diameter of the mounted height. For example, if you mount the unit on a 2.4 m (8 ft) ceiling, the IR sensor covers roughly a 2.4 m diameter. At 3 m (10 ft), it's looking at 3 m diameter.

So it's true, we're not really measuring the temperature at occupant height. We're modelling what the temperature will be down here based on everything the sensor hub sees up there.

So How Does This Model Work?

The algorithm is quite complicated, but here's an overview of how it works. Using a technique called Kalman filtering, we've produced a model for temperature measurements. We take the three temperature readings and feed them into the algorithm in real time. Each sensor reading is given a weighting towards the final temperature value. It's not just the current measurements that matter, the previous temperature readings are also fed into the model with their own weighting.

By running this model constantly, we achieve two things. The sensor hub is able to respond to temperature changes much more quickly than a traditional thermostat while also rejecting noise—that is, sudden spikes in temperature due to random events. Using this approach, we get the best of both worlds. We see the temperature rise or fall as it's really happening, without confusing the device because somebody walked underneath it.

In practice, what the modelling does very well is track the changes in temperature. The sensor hub makes an initial prediction as to what the temperature is, then follows along as the temperature moves up and down from there. However, because each room is different (air flow, heating sources, height of the ceiling, etc.), that initial prediction is likely to be off.

We find that it is typically off by one to two degrees Celsius. Fortunately, this offset is fairly constant and can be calibrated out.

Calibration

Calibration is a relatively straightforward process: you measure the temperature in the space where you'd like to control to. You don't have to be directly below the sensor hub, but the closer you are to it the better your calibration will be.

Compare the actual temperature to the reported temperature from the sensor hub, then apply the difference to the Calibration property for the AI object representing the calculated room temperature value (AI30s000, where *s* is the address switch setting of the sensor hub). That's it.

For the calibration to have the best effect, we recommend doing the following:

- Be as close to your setpoint as reasonably possible. The calibration should hold within plus or minus five degrees Celsius, but the closer you are to the control point the better it will be.
- When you calibrate, make sure the temperature in the space has been reasonably stable for at least 15 minutes prior. That is, don't go from 10 degrees to 20 degrees Celsius and then calibrate the reading as soon as you reach 20 degrees. Hold at approximately 20 degrees for 15 minutes and then calibrate.
- Try to calibrate within the sensor hub's IR envelope—the 2.4 to 3 m diameter under the unit mentioned above. But also make sure it isn't directly next to a heating or cooling source. Calibrate at approximately 1 m (3 ft) off the floor.

Placement of the O3 Sensor Hub

As mentioned above, you shouldn't calibrate the temperature reading of the sensor hub near a heating or cooling source. The other factor to consider is not to place the unit too close to a diffuser. It's recommended to put the sensor hub at least 1.3 m (4 feet) from a diffuser. At this distance the effect of the supply air will be negligible on the sensor hub.

Frequently Asked Questions

Here are some of the more common questions about temperature measurement using the sensor hub:

Can I calibrate the temperature reading outside of the range of the IR sensor?

We don't recommend this. The IR sensor is a major component of the temperature model and calibrating outside of its measurement area means that there is a weak relationship between the point you're controlling to and what goes into the model.

What happens if I calibrate with a large number of people in the space, but in normal use there is only one person using the room?

Technically, your calibration will be off. The extra people will show up as extra heat energy when you calibrate. How much extra is almost impossible to predict. The best approach is to calibrate as close to your set point as possible with the space being used as it would be under normal conditions.

What happens if a heat source is moved into the sensor hub's measurement range after calibrating?

Again, technically it will throw your readings off. But how much off is dependent on how much heat is produced. If it's a small source that's not active very often, it won't be noticed. If it constantly produces a significant amount of heat, then you would need to recalibrate under the most common conditions.

Isn't the IR sensor actually measuring the surface temperature of the floor or furniture beneath the sensor hub?

Not exactly. The IR sensor is measuring heat energy. Some surfaces do a very good job of reflecting heat energy and therefore show up to the sensor, but it is not a direct measurement of surface temperature.

What if sunlight shining through a window hits a desk or other area in the sensor hub's field of view? Won't this affect the temperature readings?

If the sunlight is shining for a significant amount of time, and covers enough area, yes it will be picked up by the unit. Bear in mind, though, in this situation the temperature in the space would actually be increasing anyway. This is not the same as a thermostat being exposed to direct sunlight for an extended period of time. Sunlight directly on a thermostat heats up the thermostat itself, which can cause false readings. Sunlight on an area under a sensor hub can cause the room itself to heat up, which will eventually be shown by the sensor hub.

Is 1.3 m (4 ft) really enough distance from a diffuser? Diffusers push a large volume of air across the ceiling.

This is true, but the major impact of a diffuser on the sensor hub is airflow. The flow rate decreases dramatically as you move away from the diffuser. Also, the plastic housing of the sensor hub acts as a Stevenson screen, protecting the sensors inside from a moderate amount of airflow. It's true that if you're right next to a diffuser the readings will be affected. But at the specified distance the airflow no longer is a concern.

How high can I mount a sensor hub? What if I have a very high ceiling in my facility?

The sensor hub has only been tested and verified at a height of 2.4 to 3 m (8 to 10 ft). While being slightly higher should not be a problem, there is a practical limit. The higher the unit is mounted, the less responsive the IR sensor becomes. We can't guarantee the algorithm will work properly past 3 m, and the IR sensor may become completely unreliable past 3.3 m (11 ft).