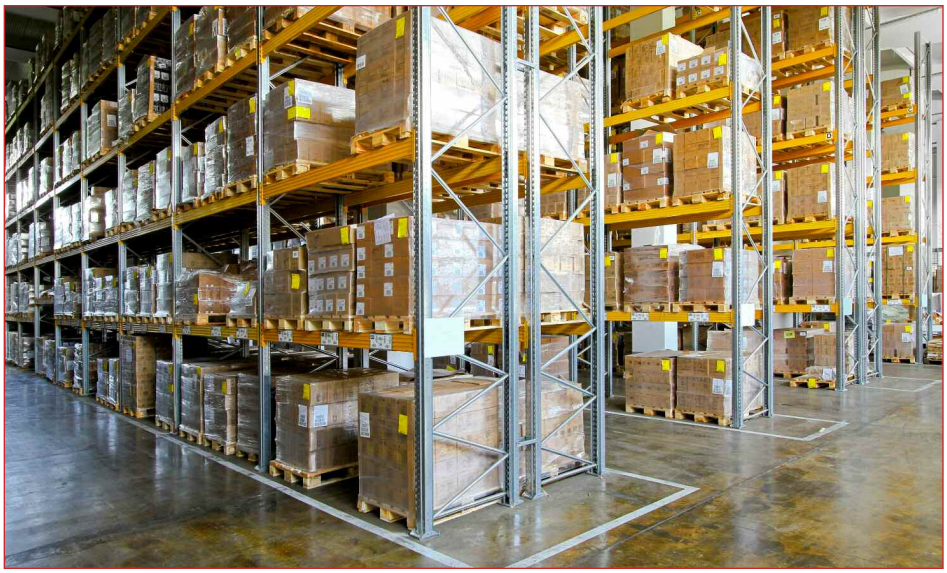
Making Sense of Sensor Numbers and Placement

How many sensors do I need for a mapping study?



There are many factors that are in play for the number of sensors required. It would be nice if there was a simple formula such as one sensor per square foot or per square meter. A formula sometimes can be used as a general rule of thumb, but even if the space to be mapped is homogenous and symmetrical, there are still other considerations to think about. Is there a heat or cold source for the system to be mapped? Is there a fan that can affect air flow? Is there something blocking air flow such as a shelf or product? Is there a theoretical gradient of some type, like an upper corner (hot) or lower drain (cold)? All of these factors can play a role in the number of sensors required.

For mapping studies involving equipment such as incubators or ovens, ask the manufacturer about positioning the sensors and how many they recommend using. The manufacturers have the most experience with their own equipment and should have a good understanding of your industry standards. Manufacturers can tell you details about the location for sensors that may be important when it comes to idiosyncrasies or characteristics of their specific piece of equipment and the associated system (i.e., hot or cold spots). Many times the mapping testing completed in the factory test are duplicated for field mapping. This may provide a better chance of a successful mapping study. If there is a problem, it will be easier to speak with the original manufacturer with what may be wrong with the system, or your sensor placement if you base the placement on the factory testing.

When mapping equipment or open areas that do not have a resource such as an equipment manufacturer, you may want to perform a quick study of the area with just a few sensors. This will provide you with a general range of the gradient you will be mapping. Start a quick study with a survey of the area and look for potential areas of temperature or humidity fluctuations. HVAC ducts, doors, equipment skids, are all common sources of temperature fluctuations. You will want to capture these areas before starting the actual mapping so that you are not later surprised by large variants. The larger the gradient, or the more uneven the recordings, the more sensors you will need to use for the mapping study. If you perform this quick study without calibration, you should still record the sensor locations. You can then perform another study and switch any sensors that appear out of range to see if "the problem moved with the sensor". If you swap the hottest and coldest locations for example, and the results are the same as the first study, then you can be sure that a real problem or variation may exist.

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Why is sensor placement important?

Sensor placement is important to establish areas of concern for product placement or storage. Proper sensor placement also helps in proving that your system is repeatable and within the tolerances set for the space. ***Not*** placing sensors in areas to avoid a study failure is counterproductive and may lead to serious product quality problems. Another result from proper sensor placement is detecting equipment/system issues that need to be corrected, repaired, or modified to ensure that a high quality, consistent product is produced.

Why not just place lots of sensors everywhere?

Taking a position of simply placing lots of sensors in many places to cover all of the possible variances can be detrimental to an effective study. The mapping should be well thought out and methodical. Having too many sensors will lead to unneeded complexity, additional costs, and a lot more time in report generation, data analysis, and calibration support.

If sensor placement is so important, why is there not any set rule?

The number of variables in spaces, equipment, and product placement is so vast that a few hard set rules are impossible. A set rule may create a situation in which system irregularities are missed and product quality is jeopardized. Rules may also lead to someone working around a rule instead of creatively thinking about the intended reason for the mapping.

The interior of a CO_2 incubator.

Why do I need to document sensor placement?

Documenting sensor placement is very important to both you and an approver or regulator. It's critical to know where the sensors are located when reviewing data. For example, if you have one or two sensors that are not in agreement with the majority of sensors, you will need to know the location for potential trouble shooting of the system.

If you have to defend your sensor placement to a regulator, it is always better (and a must to some regulators) to produce a document detailing the numbers, placement, and the theory for those determinations. An annotated digital photo detailing the sensor locations along with some details of the logging sensors and hardware go a long way in conveying the physical layout to a regulator. A picture presents a more precise representation for studies covering spaces like, storage areas, chambers with product, or manufacturing areas than descriptive content in a document. This also saves a lot of time during the creation of the document. Many times people use sketches or drawings, but a digital photo can present the actual spaces with product and potential heat or cold sources that are not shown or missed during creation of the sketch. If a problem occurs in future mappings, having a photo from past mappings can help identify a problem created by a change made to the system.

Remember that your data might be questioned years later by an inspector and they will ask for sensor placement long after you have concluded your study. Simply stating that they were evenly distributed will not be a sufficient answer.

Is it worth the time and effort for mapping a space?

Not mapping a space can ultimately be costlier in the loss of product quality and may produce regulatory review or fines. If there is any question about mapping an area, planning, executing, and documenting the mapping will provide piece of mind that is one more step toward a quality system producing a quality product.

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