Mapping Made Easy

Sensor Placement for GxP Temperature Mapping

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Vaisala Team

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Vaisala in Brief

- We serve customers in weather and controlled environment markets.
- 80+ years of experience in providing a comprehensive range of innovative observation and measurement products and services.

Vaisala - Life Science

Our Offering
Provides measurement instrumentation, continuous monitoring systems and validation systems for regulated or highly controlled life science environments.

Our Goal is to help customers
- Reduce risk of lost product
- Reduce their risk of failing to meet GxP regulations and guidelines
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VAISALA
History

2011

- Health Canada
  - GUI-0069 – Guidelines for Temperature Control of Drug Products during Storage and Transportation

- ISPE
  - Good Practice Guide: Cold Chain Management

History

2012

- PDA

- CDSCO (India)
  - Guidelines on Good Distribution Practice for Biological Products
History

2013

- CFDA (China)
  - Good Supply Practices for Pharmaceutical Products

- EMA (Europe)
  - (2013/C 68/01) Good Distribution Practice of Medicinal Products for Human Use

- USP 36
  - Chapter <1079> Good Storage and Distribution Practices for Drug Products

2014

- EMA (Europe)

- PIC/S
  - PIC/S Guide: Good Distribution Practice for Medicinal Products
History

2015

- WHO
  - Temperature mapping of Storage Areas
    - Technical Supplement to Report Series, No. 961

History

2016

- ISPE
  - Good Practice Guide: Controlled Temperature Chamber Mapping and Monitoring
Goals

- Review Mapping Regulations
- “Make Mapping Easy”
  - 5 Rules for Sensor Placement
- Review Current Guidance on Sensor Placement

Regulations and Mapping

- The regulations don’t tell us how to map, or even to map.

Regulatory Summary
  1. Determine if environmental parameters affect product quality.
  2. Do stability testing to determine appropriate storage specifications.
  3. Ensure that storage spaces are controlled to meet specifications.

- Mapping and monitoring is industry GMP response to #3.
- Therefore, regulations aren’t helpful for sensor placement!
Resources for Sensor Placement

- Tradition and Precedence
  - What has been done at your facility before?

- Equipment
  - What equipment do you already have?

- Science
  - What makes sense based on scientific principles?
  - Guidance

5 Rules for “Mapping Made Easy”

- Map the Extremes.
- Map in 3 Dimensions.
- For Large Spaces, Map Storage Only.
- Identify and Address Variables.
- If it’s worth mapping, it’s worth monitoring.
Rule 1: Map the Extremes

- Extremes of Geometry
  - Place sensors at each end of the storage area.

- Extremes of Conditions
  - Apply validation principle of worst cases

Parts of a Cube

- Corner – 3 planes
- Edge – 2 planes
- Side – 1 plane
- Space – 0 planes
Parts of a Cube

Rule 1: Map the Extremes

- Corner – 3 planes
- Space – 0 planes

Corollary 1A: If $\leq 2m^3$, use $9 + 1$. 
9 spots = worst case?

- **Air Flow:**
  - Corners have least air circulation.
  - Center has most air circulation.

- **Heat Exchange:**
  - Corners have the most exposure (3 planes)
  - Center has the least exposure (0 planes)

How many? Where? < 20m³
How many? Where? < 20m$^3$

- TOP
- SIDE
- FRONT

How many? Where? < 20m$^3$

- TOP
- SIDE
- FRONT
Corollary 1B: If $\leq 20m^3$, use 15 +1.

Guidance describes 9 +1 and 15 +1

- ISPE Good Practice Guide: Cold Chain Management
- ISPE Good Practice Guide: Controlled Temperature Chambers
Rule 2: Map in 3 Dimensions.

3 planes.
Left to right.

3 planes.
Top to bottom.
Rule 2: Map in 3 Dimensions.

3 planes.
Front to back.

Corollary 2A: If $\geq 20m^3$, use Stacks of 3.

High
Middle
Low
Stacks of 3, in 3 dimensions.
Stacks of 3, in 3 dimensions.
Corollary 2A: If $\geq 20 m^3$, use Stacks of 3.

High
Middle
Low
Corollary 2B: Remove sensors if possible.

- Remove “extra” sensors.
- 15 +1 diagram.
- With “Stacks of 3, in 3-D”, it would have 27 sensors.

Stacks of 3, in 3 dimensions.
Stacks of 3, in 3 dimensions.

“Completing a three-dimensional temperature profile should be achieved by measuring points at not less than three dimensional planes in each direction/axis—top-to-bottom, left-to-right, front-to-back…”

Rule 3: If $\geq 20\text{m}^3$, map storage only.

- As the space gets larger, it is not necessary to map hallways and access areas.

- Map only the shelves and areas where product is actually stored.

- Requires controls to prevent storage in wrong areas.
  - SOPs
  - Training
  - Signs

More published support...

“Completing a three-dimensional temperature profile should be achieved by measuring points at not less than three dimensional planes in each direction/axis—top-to-bottom, left-to-right, front-to-back, where product will be present.”

Rule Summary (so far…)

- Rule 1 – Map the Extremes
  - Corollary 1A – If $\leq 2m^3$, use 9+1.
  - Corollary 1B – If $\leq 20m^3$, use 15+1

- Rule 2 - Map in 3 Dimensions
  - Corollary 2A – If $\leq 20m^3$, use Stacks of 3
  - Corollary 2B – Remove Sensors if Possible
Rule Summary (so far…)

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- Rule 2 - Map in 3 Dimensions
  - Corollary 2A – If $\leq 20m^3$, use Stacks of 3
  - Corollary 2B – Remove Sensors if Possible

- Rule 3 - If $\geq 20m^3$, map storage only.

It’s just guidance. It’s a place to start.

“…additional points may be needed depending on airflow sources/characteristics, shelving (storage locations), external temperature sources, and previous experience with similar units and their thermal behavior.”

– ISPE Good Practice Guide: Cold Chain Management (2011)
More from USP 36 Chapter <1079>…

- The following factors should be considered during temperature mapping of storage locations:
  - Size of the space
  - HVAC Locations
  - Sun-facing walls
  - Low ceilings or roofs
  - Geography
  - Airflow
  - Outside temperature variability
  - Weekly workflow variation
  - Equipment movement
  - Storage patterns of product
  - Equipment capabilities
  - SOPs.

Rule 4: Identify Variables

- Volume
- Temperature \( \Delta \)
- Height
- Exterior Walls
- Construction Materials
- Doors and Windows
- Lighting
- Gradients
- HVAC Vents and Returns
- Air Circulation
- Control Sensors
- Energy Sources
- Racks and Shelving
- Traffic Patterns
- Human Factors
Volume

Temperature △
Height

Exterior Walls
Construction Materials

Doors and Windows
Lighting

Gradients
HVAC Vents and Returns

Air Circulation
Control Sensors

Energy Sources
Racks, Shelves, and Product

Traffic Patterns
Rule 4: Identify Variables

- Place sensors near representative variables!

- Adjust ideal “grid” to intersect variables.
Distance Between Points

Distance (X)

Temperature

Distance Between Points

Distance (X)

Temperature
Distance Between Points

Distance Between Points

Distance Between Points
Distance Between Points

Temperature

Distance (1/16X)
Rule 5: If it is worth mapping… It is worth monitoring.

- Find the hot and cold spots and place sensors.
- Select the right monitoring solution.
- Qualify the monitoring system.

“Temperature monitoring… documents the temperatures during the qualification and operation. It allows conclusions on whether the product is stored and shipped within the approved temperature range. Therefore, an appropriate temperature monitoring strategy should be selected and qualified.”

Rule Summary (so far…)

- Rule 1 – Map the Extremes
  - Corollary 1A – If \( \leq 2m^3 \), use 9+1
  - Corollary 1B – If \( \leq 20m^3 \), use 15+1
- Rule 2 - Map in 3 Dimensions
  - Corollary 2A – If \( \leq 20m^3 \), use Stacks of 3
  - Corollary 2B – Remove Sensors if Possible
- Rule 3 - If \( \geq 20m^3 \), Map Storage Only
- Rule 4 – Identify Variables
- Rule 5 – If it is worth Mapping, it is worth Monitoring

What about product temperature?

- It’s always best to measure air temperature.
  - Worst case scenario provides best challenge.

“It is normal practice to use air temperature as the reference source for the stored [product]...” and is ‘the worst case representation of the stored product temperatures.”

- ISPE Good Practice Guide: Cold Chain Management (2011)
What about mapping humidity?

- The same concepts apply, but concerned with sources of moisture.

- Use the same number of sensors unless you have an expert who understands humidity theory.

“Where relative humidity is a critical factor, then humidity sensors could be located in the same locations – or fewer locations used with the impact of the temperature considered for other locations – as absolute humidity will be very similar throughout the space.”

- ISPE Good Practice Guide: Cold Chain Management (2011)

Summary

- Reviewed Mapping Regulations

- Explored 5 Rules for Sensor Placement for Mapping Storage Areas

- Reviewed Mapping Guidance
Thank you for your time!

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If you want more...