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Energy Star Laboratory Grade Refrigerator/Freezer Testing Concerns
January 22, 2009

Cabinet Uniformity

- Uniformity is important to many of the customer buying laboratory refrigerators and freezers
- Usable space inside a cabinet is sometimes determined by the customers uniformity requirements or specifications.
- Currently no standard uniformity protocol (test procedure) for the industry to follow
  - Large variation on how uniformity can be determined by manufacturers
  - Varying requirements by customers because no standard to follow

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Examples of Uniformity tests and protocols

- Customer #1
- 20 total probes
- Set point -20ºC
- Temperature measured in ºC
- Non-weighted probes
- Custom shelves
- Uniformity taken at predetermined locations
- Temperature measurements every five minutes over a period of 24 hours

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Tests continued

- Customer #2
- 16 total probes
- Set point 4 ⁰C
- Temperature measured in ⁰C
- Non-weighted probes
- Standard shelves
- Uniformity taken at opposite sides every other shelve
- Temperature measurements every five minutes over a period of 24 hours

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Testing continued

- Other half of chamber

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Tests continued

- Customer #3
- 12 total probes
- Set point -20 ℃
- Temperature measured in ℃
- Non-weighted probes
- Standard shelves
- Uniformity taken at opposite sides every other shelve
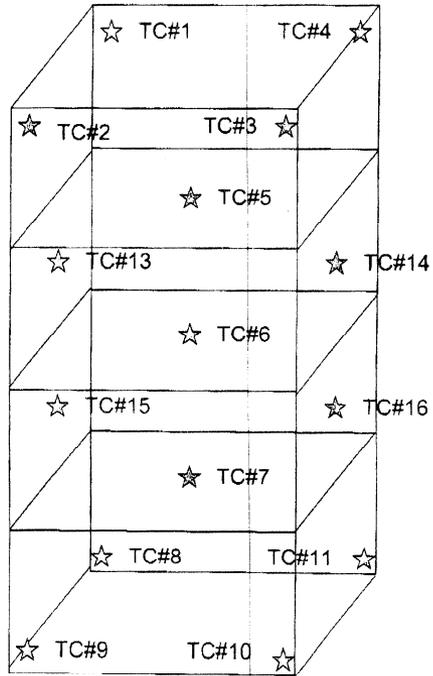- Temperature measurements every minute for 31minutes. Three 31 minute periods.

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Temperature testing

- Typical layout for temperature testing from customer
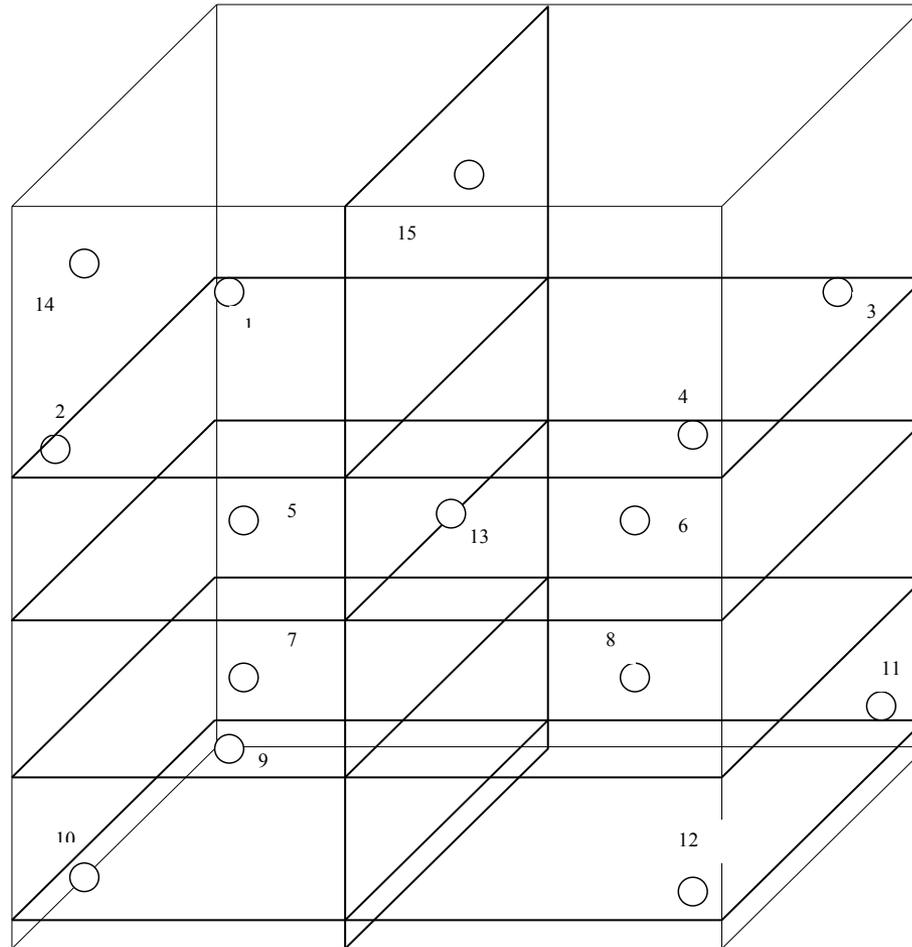
The unit has two doors on the front and a maximum of eight shelves. Thermocouple 14 is placed in the Bottle containing the display sensor and the chart recorder sensor. TC 15 is placed on the control sensor in the evaporator housing. TC's 1-4 and 9-12 are geometric corners. TC's 5,6,7,and 8 are centered on middle shelves on the left and right. TC 13 is placed in the cabinet center air.

Performed by:_____

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Reviewed by:_____

What effects cabinet uniformity?

- Static conditions
  - Ambient conditions
  - Airflow pattern inside of cabinet
  - Door design
    - Insulation
    - Seal
    - Construction (design and material)
  - Set point temperature
  - Types of shelves
  - Cabinet construction
- Dynamic conditions
  - Load in chamber
  - Door openings
  - Defrosting

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Suggestion for Determining Uniformity Specification

- Make Static condition test
  - This is the requirement of most customers
  - Cabinet is unloaded
  - Independent of shelving or inventory system
    - Location based on distance from geometric corners (eg 3″ of the geometric corner)
    - 5-5-5 thermocouple placement
      - 5 thermocouples on three planes in cabinet
      - First plane 3″ down from top, Second plane at geometric center, third plane 3″ from bottom
  - Un-weighted temperature measuring devices
    - Utilize thermocouples to measure temperatures at each location
      - Note that most loads are not that large (1ml to 250ml typical)
  - Time period for taking measurements
    - 3 hours of stable data
    - Data taken every 10 seconds for 3 hours
  - Determine actual mathematical method for uniformity
    - Statistical
  - Do not include defrost cycle –three hours before defrost cycle

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Sensor placement

Sensor placement inside cabinet
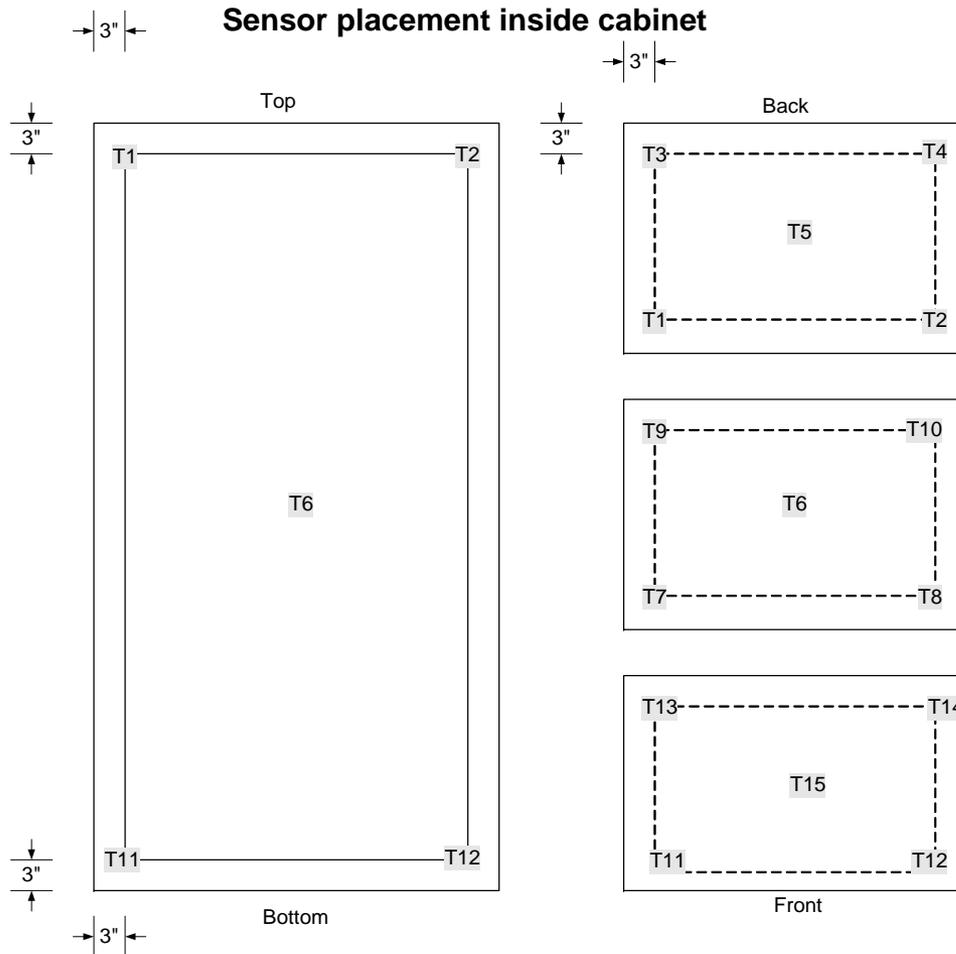
- 5-5-5 sensor placement
  - 3" from top in same plane
  - Geometric center
  - 3" from the bottom in same plane

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Mathematical methods for uniformity

- **Statistical**
  - Standard deviation at an interval and then a specification of 3 standard deviations of the average of all interval standard deviations.

$$s_N = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (x_i - \overline{x})^2} \, .$$

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Possible references for uniformity testing:

- ANSI/AHAM HRF-1-2002: Household Refrigerators/Household Freezers

- ISO 15502: Household Refrigerating Appliances - Characteristics and test methods

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