Laboratory Variation in Service Life Test Results Using the NIOSH Carbon Tetrachloride Test

A Pain in the Ankle for Test Labs

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Service Life Tests

GOALS ...

- To measure Effective Service Life of Air Purifying Respirator Cartridges
- To demonstrate Differences in Performance among APR Cartridges
- To provide a Basis for Specifications
  - "Effective" vs "Ineffective" Cartridges

Service Life Tests

Desirable ATTRIBUTES ...

- Measures Effective Life of APR Cartridges as described under GOALS
- Convenient to Perform
  - rapid and cost-effective
- Low Systematic and Random Error
  - Low Variation in replicate tests from known or unknown causes

Service Life Tests

(Organic Vapor)

Representative Challenge Agents ...

- It is not practical to Test EVERY Organic Vapor

- CARBON TETRACHLORIDE has been taken to "represent" all OVs
  - Popular industrial chemical
  - Well-adsorbed on carbon
  - Adsorption sensitive to moisture

Service Life Test Variability

(Organic Vapor)

Issues…

- CCl4 ”represents” all organic vapors under **42CFR84** in lab evaluation of Industrial APR Cartridges
- Carbon Tetrachloride Service Life is ***very sensitive*** to Humidity in Pre-Conditioning
- VARIABILITY is observed in CCl4 Tests
  - **Test-to-Test variation**
  - **Lab-to-Lab variation**

Questions & Test Method Evaluation

Concept...

If a test seems to give different results from repeat tests of similar Items, the Test Method may be questioned.

If questions are posed scientifically, They can form the basis of a Test Method Evaluation.

Service Life Test Variability

Questions...

- Do variations in Humidity and Temperature typically allowed in the current NIOSH Test cause substantial variations in measured Service Lives independent of the Test Item?
- How much does each parameter contribute to overall measured variation in Service Life?
- Is there a way to minimize any such errors?

Test Method Evaluation

Meaning of "Error"...

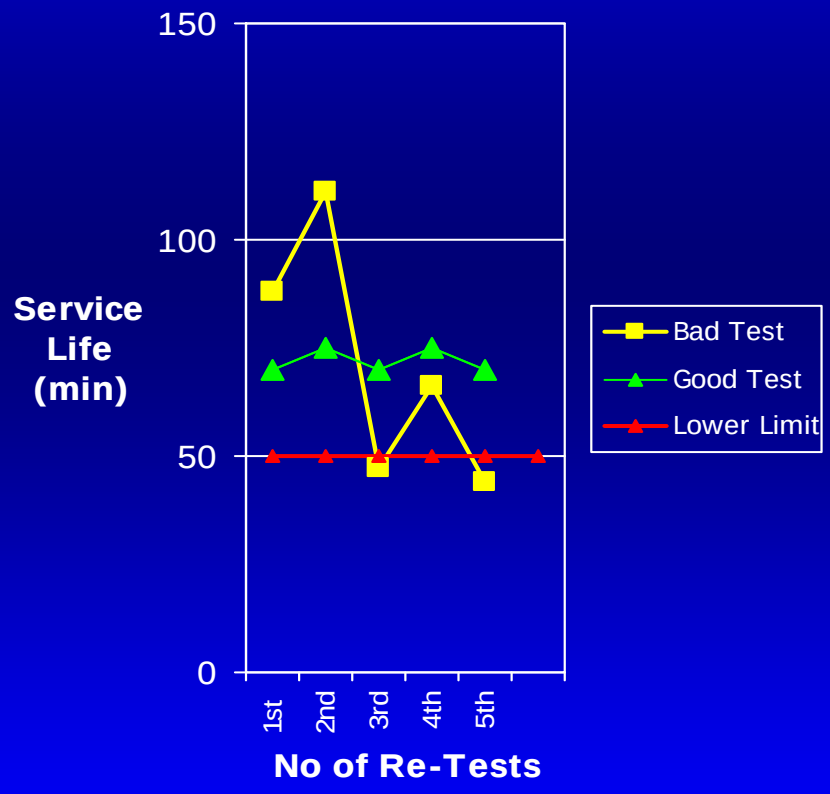
- ERROR = Variability Due to Extraneous Factors
  - Factors other than the TEST ITEM
  - Observed in REPLICATE TESTS

Significance ...

- In Evaluation of APR Cartridges ... VARIABILITY due to Extraneous Factors needs to be minimized.

Test Method Error (variation)

- Variation observed when the same Item is Re-Tested
- To evaluate Items fairly, Variability due to extraneous factors needs to be minimized



STUDY DESIGN

- Pre-Condition and Test APR Cartridges as described in 42CFR84
- Study the range of Temperature and Humidity variation commonly permitted
- Plot the effects of allowed Temperature and Humidity variation on Test Results

42CFR84.207
(Holy Writ)
NIOSH RCT-APR-STP-0046

4.3.4. Two cartridges or pairs of cartridges will be equilibrated at room temperature by passing 85 percent RH air through them at 25 lpm for 6 hours and then testing them at 50 percent RH, approximately 25oC, and 32 lpm continuous air flow rate containing 1000 ppm CCl4.

PROTOCOL
(Pre-Conditioning)

25 L/min, 25°C, &	25 L/min, 22.5°C, &	25 L/min, 27.5°C, &
– 80.0 %RH	– 80.0 %RH	– 80.0 %RH
– 82.5 %RH	– 82.5 %RH	– 82.5 %RH
– 85.0 %RH	– 85.0 %RH	– 85.0 %RH
– 87.5 %RH	– 87.5 %RH	– 87.5 %RH
– 90.0 %RH	– 90.0 %RH	– 90.0 %RH

Each separate pair of APR Cartridges pre-conditioned ***as per NIOSH STP 0046 with variations shown above****.*

PROTOCOL
(Testing)

- **All Cartridges tested Identically as per 42CFR84 except ...**
- **each separate APR Cartridge tested separately at half the Flow Rate specified for the Pair.**

1000 ppm CCL4 at 16 L/min

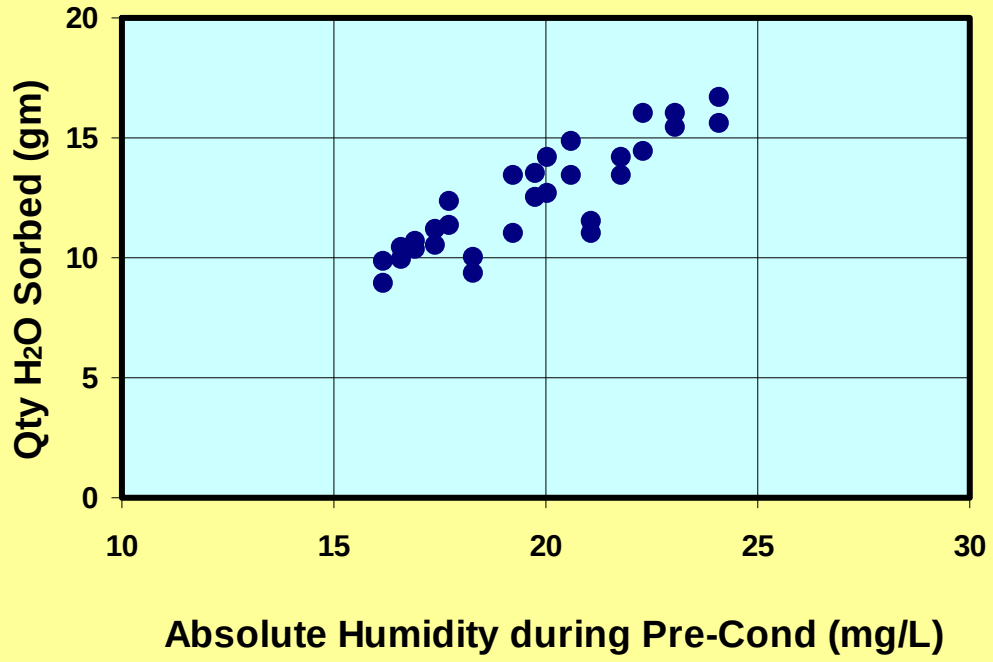
25^{O}C / 50 %RH

DEFINITIONS

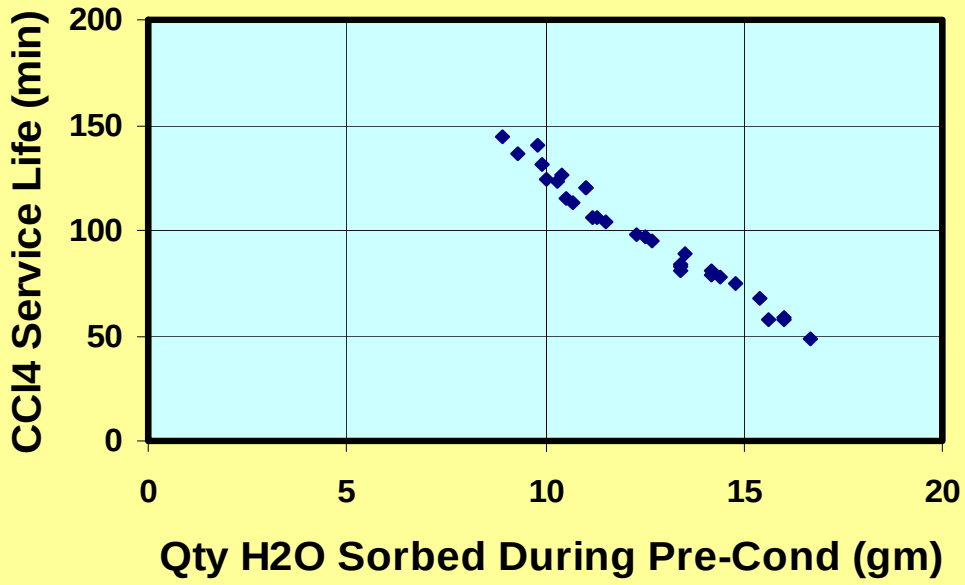
- **Relative Humidity**
  - **% of Saturation (Water in Air)**
- **Absolute Humidity**
  - **mg of Water per Liter of Air**

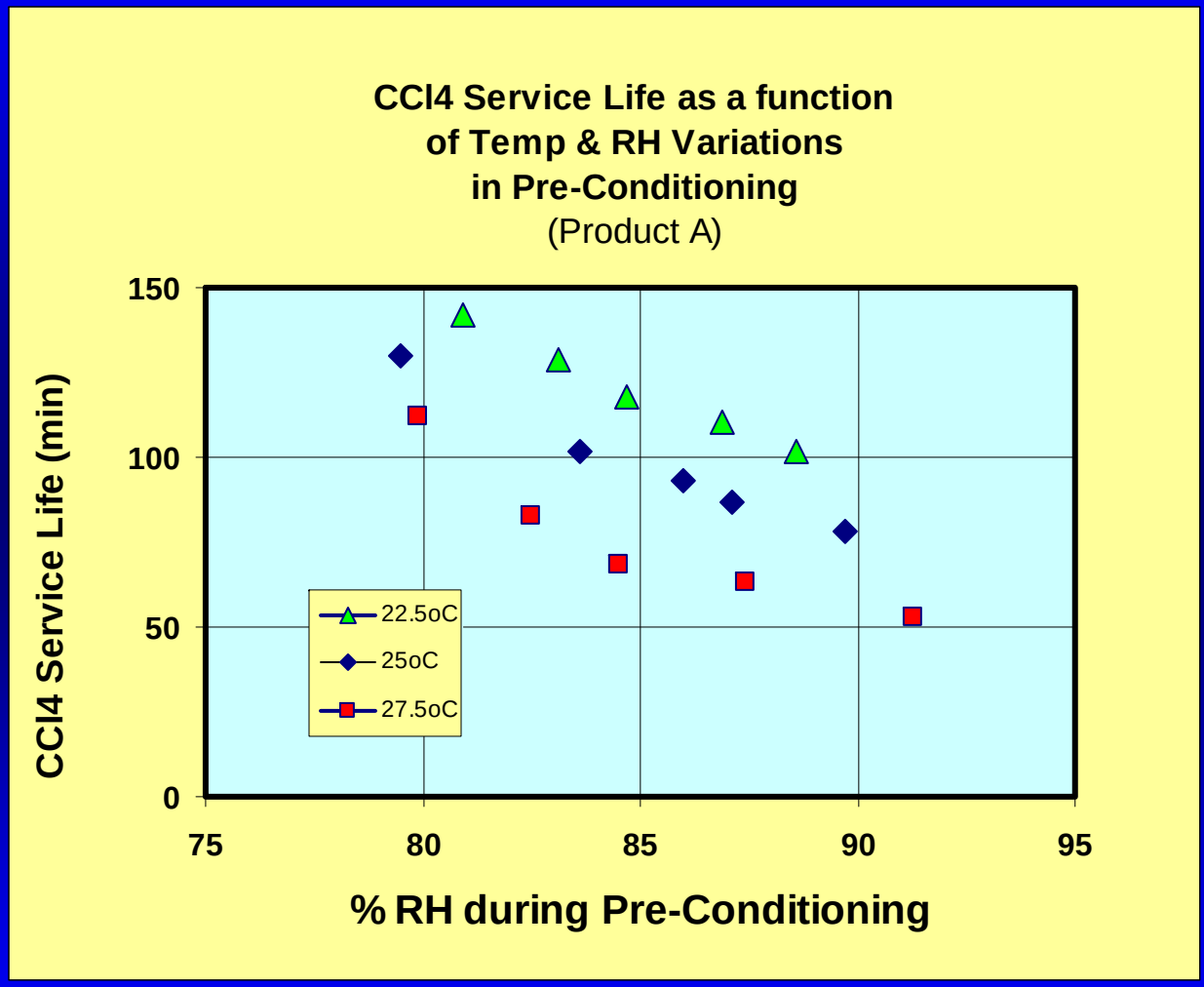
at fixed Absolute Humidity,
Relative Humidity increases
when Temperature decreases

Qty of H_2O Sorbed as a function of Humidity During Pre-Conditioning
(Product A)

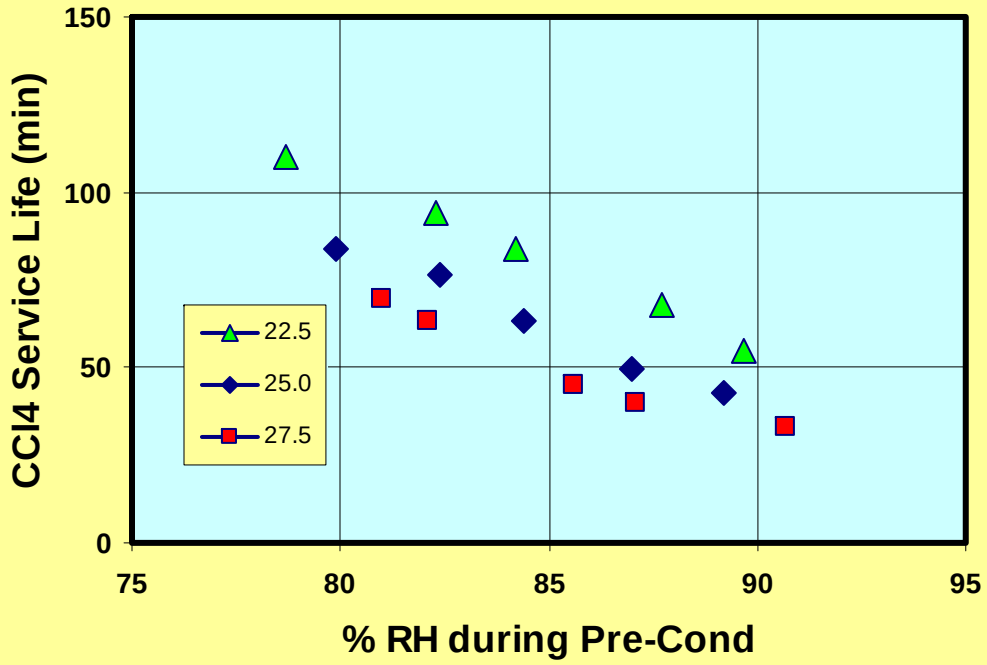


CCl4 Service Life as a function of H2O Loading of Cartridge
(Product A)

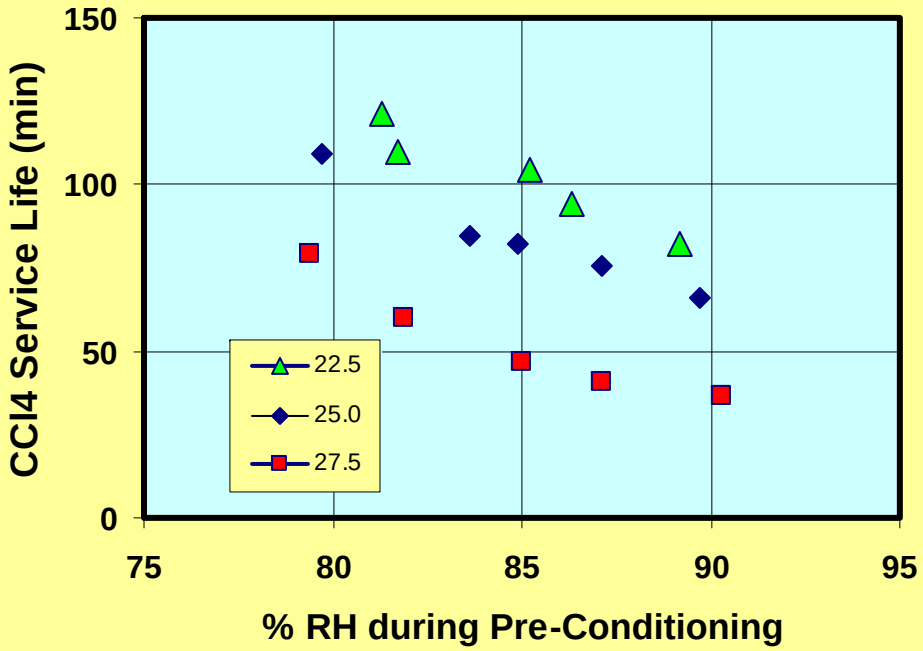



CCl4 Service Life as a function
of Temp & RH Variations
in Pre-Conditioning
(Product A)
150
100
50
0
CCl4 Service Life (min)
75
80
85
90
95
% RH during Pre-Conditioning
22.5oC
25oC
27.5oC

CCl4 Service Life as a function of Temp & RH Variations in Pre-Conditioning
(Product B)



CCl4 Service Life as a function of Temp & RH Variations in Pre-Conditioning
(Product C)



SUMMARY of RESULTS

- Test Variation induced by RH Variation of 85±5% RH
  - ± 25% variation (error) in measured Service Life

- Test Variation induced by Temp Variation of 25±2.5°C
  - ± 25% variation (error) in measured Service Life

- Test Variation induced by combined Temp & RH Variation
  - ± 50% variation (error) in measured Service Life

SUMMARY of RESULTS

- Test Variation induced by RH Variation of 85±3% RH
  - ± 15% variation (error) in measured Service Life

- Test Variation induced by Temperature Variation of 25±1°C
  - ± 10% variation (error) in measured Service Life

- Test Variation induced by combined Temp & RH Variation
  - ± 25% variation (error) in measured Service Life

Recommendations
(from Test Method Evaluation)

- Reduce allowed Temp variation during pre-conditioning and test to $\pm$ 1°C
- Reduce allowed %RH variation during pre-conditioning and test to $\pm$ 3% RH
- Adopt a new “representative” Challenge Agent

Afterward

It would be good to ...

- ...have more evaluation, and discussion of Chemical Challenge Test Methods for cartridges and canisters
- ...establish an APR Cartridge and Canister Proficiency Testing System