

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"...

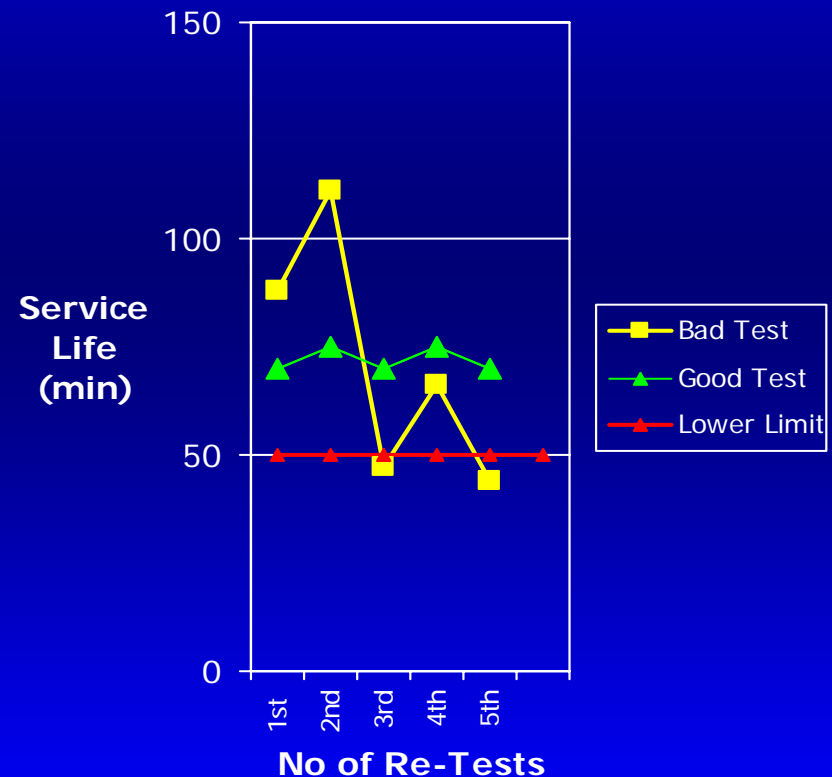
- ERROR = Variability Due to **Extraneous Factors**
 - Factors other than the TEST ITEM
 - Observed in REPLICATE TESTS

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 25°C, and 32 lpm continuous air flow rate containing 1000 ppm CCl₄.

PROTOCOL (Pre-Conditioning)

25 L/min,
25°C, &

- 80.0 %RH
- 82.5 %RH
- 85.0 %RH
- 87.5 %RH
- 90.0 %RH

25 L/min,
22.5°C, &

- 80.0 %RH
- 82.5 %RH
- 85.0 %RH
- 87.5 %RH
- 90.0 %RH

25 L/min,
27.5°C, &

- 80.0 %RH
- 82.5 %RH
- 85.0 %RH
- 87.5 %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.

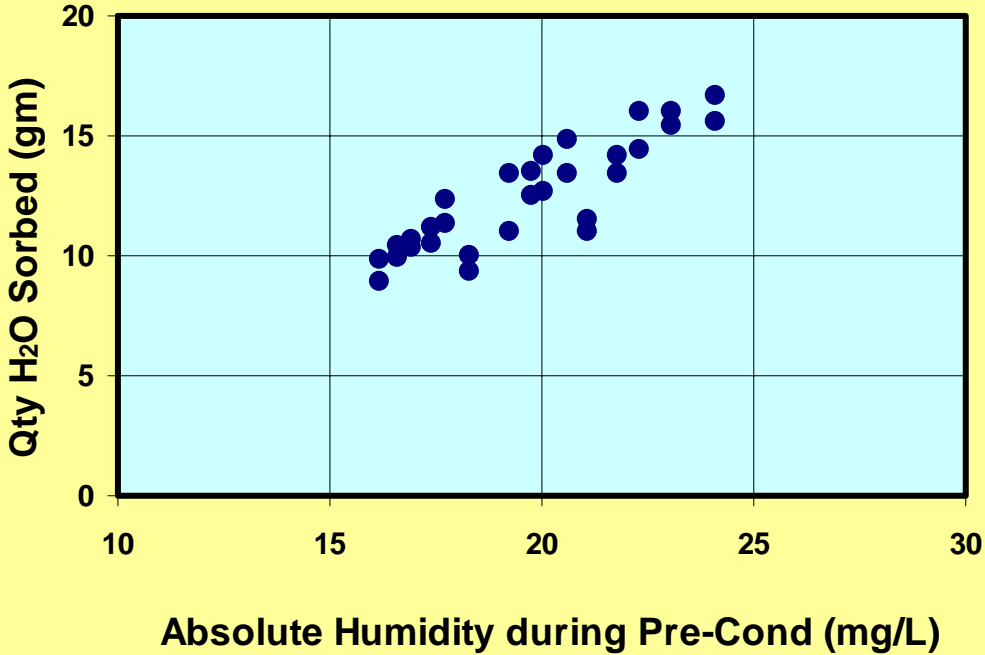
1000 ppm CCL4 at 16 L/min
25°C / 50 %RH

DEFINITIONS

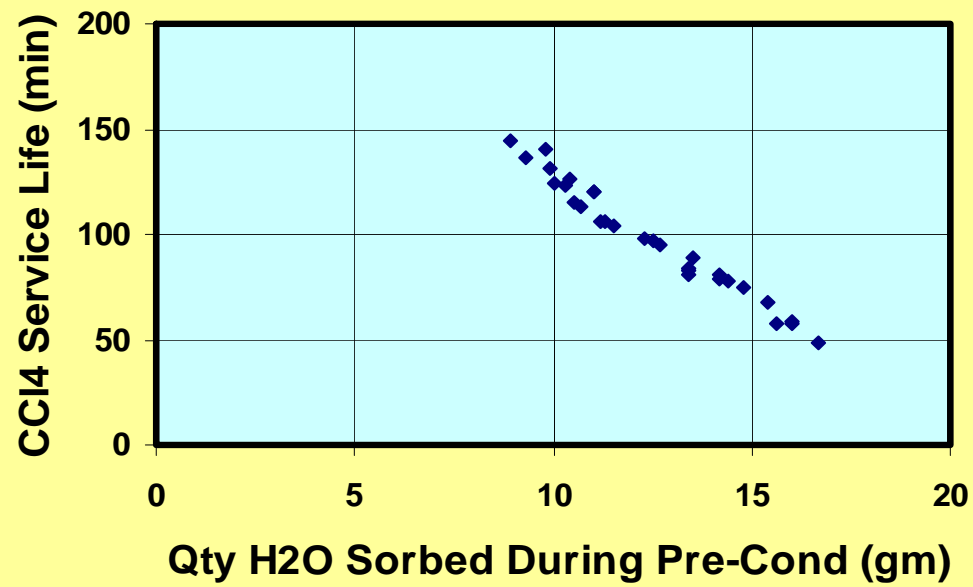
- **Relative Humidity**
 - % of Saturation (Water in Air)
- **Absolute Humidity**
 - mg of Water per Liter of Air

*at fixed Absolute Humidity,
Relative Humidity increases
when Temperature decreases*

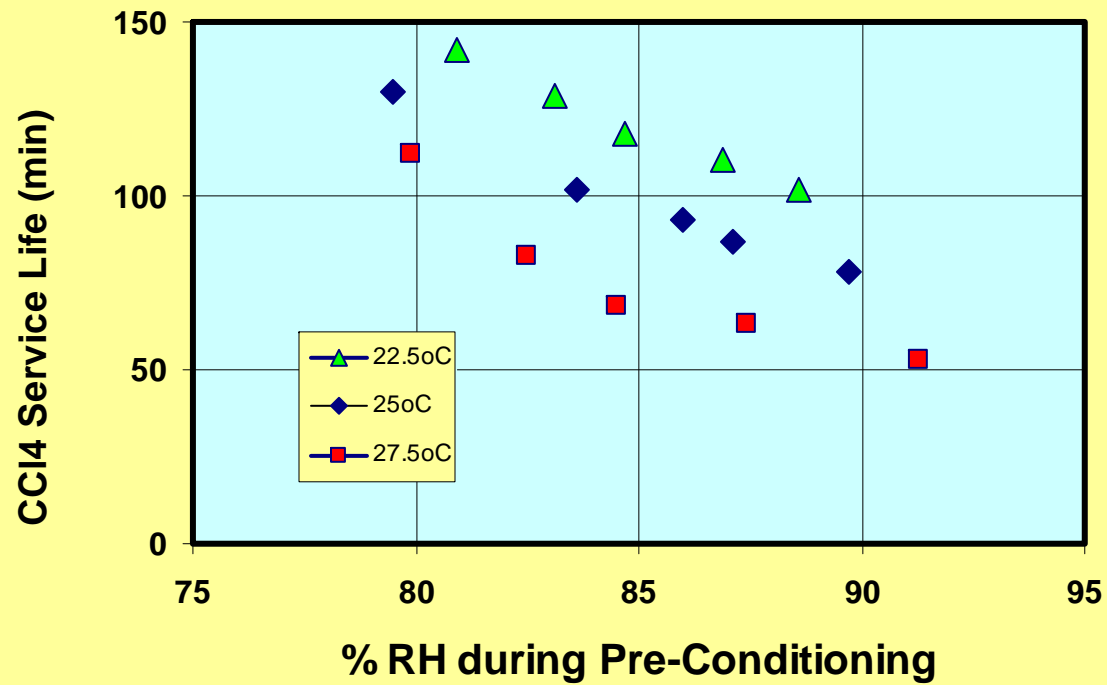
**Qty of H₂O Sorbed as a function
of Humidity During Pre-Conditioning
(Product A)**



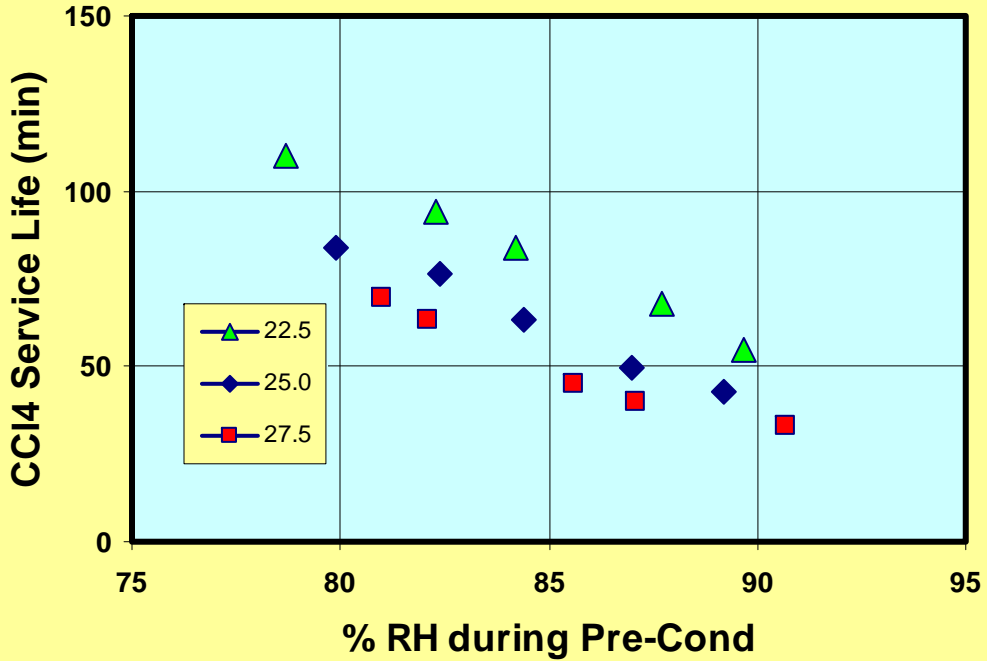
**CCl₄ Service Life as a function of
H₂O Loading of Cartridge
(Product A)**



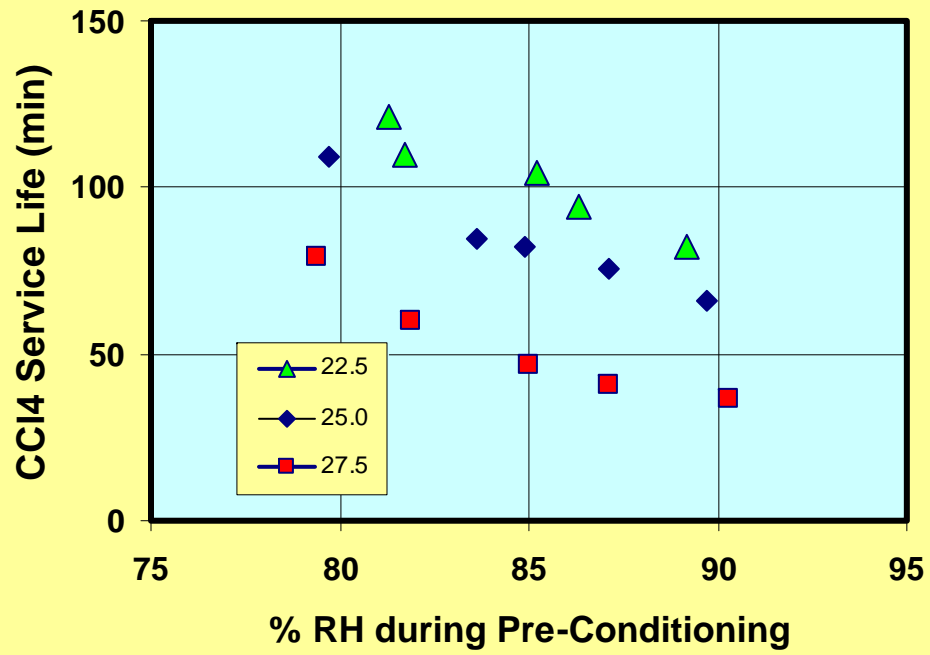
**CCI4 Service Life as a function
of Temp & RH Variations
in Pre-Conditioning
(Product A)**



**CCI4 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 $85 \pm 5\%$ RH
 - $\pm 25\%$ variation (error) in measured Service Life
- Test Variation induced by Temp Variation of $25 \pm 2.5^\circ\text{C}$
 - $\pm 25\%$ variation (error) in measured Service Life
- Test Variation induced by combined Temp & RH Variation
 - $\pm 50\%$ variation (error) in measured Service Life

SUMMARY of RESULTS

- Test Variation induced by RH Variation of $85 \pm 3\%$ RH
 - $\pm 15\%$ variation (error) in measured Service Life
- Test Variation induced by Temperature Variation of $25 \pm 1^\circ\text{C}$
 - $\pm 10\%$ variation (error) in measured Service Life
- Test Variation induced by combined Temp & RH Variation
 - $\pm 25\%$ variation (error) in measured Service Life

Recommendations

(from Test Method Evaluation)

- Reduce allowed Temp variation during pre-conditioning and test to $\pm 1^{\circ}\text{C}$
- 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