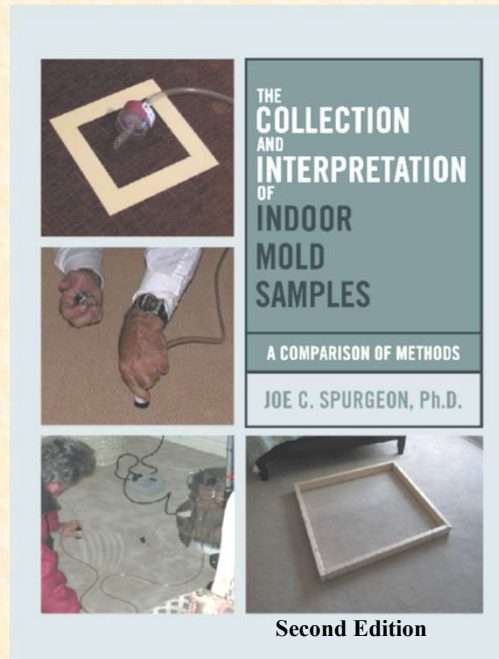


Soft Surface Samples

Part 2

Carpet and Soft Surface Sampling Methods

Joe Spurgeon, Ph.D.
CIH (1993-2013)
jospur46@gmail.com
www.expertonmold.com



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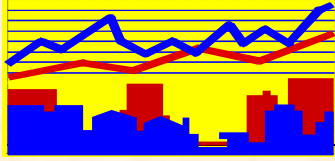
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Methods for Reporting Surface Dust

- **Weight-Analyzed Basis [Typical]**
 - Ignores the total weight of dust collected
 - Sample results are not standardized
 - Difficult to assess condition of the surface
- **Total-Weight Basis [Request]**
 - Based on the total weight of dust collected
 - But assumes the same sample area for all samples
- **Area Basis [Request; Preferred]**
 - Results are standardized, unbiased assessment
 - Health effects better associated with results reported on an Area-Basis compared to a Weight Basis
 - Allows numerical assessment criteria to be established

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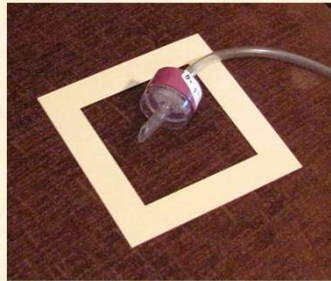
See Part 1 for a discussion of the three methods for reporting surface dust sample results.



Sampling Carpet Dust

Comparison of Micro-Vacuum Carpet Sampling Methods

Closed-face, Measured Area



Open-face, Variable Area



Open-face, Fixed Area



Three micro-vac sampling methods were compared to determine which method had the better utility for assessing condition.

Characterizing Clean, Dry Carpets

Want a method that is “repeatable” and with low “variability”

	Weight-Analyzed		Area Basis		
	cfu/mg	cfu/mg	cfu/100 cm ²	cfu/100 cm ²	cfu/100 cm ²
	CFVA	OFVA	CFVA	OFVA	OFFA
Samples	33	56	33	56	26
Range	160 X	557 X	1,000 X	1,720 X	14 X
GSD	6.5	3.2	10.4	4.0	1.9
GM	6.5	9.7	25	36	66

Repeatable means smallest RANGE and GSD

Sensitivity means highest GM

OFFA Method: lowest variability, highest sensitivity

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The samples collected using the CFVA and OFVA sampling methods were analyzed by the standard Weight-Analyzed Method and the Area Basis Method. The samples for the OFFA sampling method were just analyzed by the Area Basis method.

The objective was to assess the variability and sensitivity of the sampling methods. Therefore, clean carpets were sampled to avoid autocorrelation effects (it was assumed clean carpets would have an average value with a relatively small standard deviation). The least variable method (greatest ability to distinguish between conditions) would be selected for further testing.

Ranking of Carpet Sampling Methods

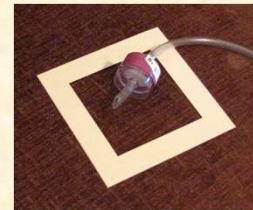
**Open-Face
Fixed Area**



**Closed-Face
Variable Area**



**Closed-Face
Variable Area**



**Least Variability
Most Reproducible
Highest Sensitivity**

**Highest Variability
Least Reproducible**

The OFFA sampling method was selected for validation testing (even though it was the best of the three methods, could it distinguish between conditions?)

Validating The OFFA Carpet Sampling Method

OFFA was the best performing method.

But did even the best-performing method “work”?

**Would results be associated with the fungal loading
in carpets?**

“Validation”

- **Are results associated with condition?**
 - **Carpets with low, moderate & high water-intrusion potential were sampled**
- **Does the method still “work” when samples are collected by multiple personnel?**
 - **Samples were collected in nine field offices by multiple field personnel**
- **Can numerical guidelines be established for carpet “cleanliness”?**
 - **Is there a rational, defensible basis for establishing decision criteria?**
 - **Clean v. Contaminated**

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This was a field study. The samples were actual project samples collected by project personnel. The conditions of the carpets were recorded by the project personnel.

The OFFA Method



- 25 mm PCM cassette
- 0.8 μm MCE filter
- Open-face
- Rate = 10 lpm
- 5 seconds / spot
- 20 spots / sample
- Cassette = 4.9 cm^2
- 98 cm^2 / sample

**Click-counter for counting
number of spots sampled**

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Hold the open-face cassette firmly in one spot without moving it for 5 seconds, then repeat for 20 spots. This both results in a measured area (area of a 25 mm circle is 4.9 cm^2) and creates a vacuum that reaches and samples the back of the carpet and carpet pad.

[1.] Control Carpets

Concentrations (cfu/100 cm²) on MEA
[Strategy and method valid for any analysis]

CARPET	NUMBER	MINIMUM	MAXIMUM	GM
Commercial, new; short-knap	8	3	19	6.0
Commercial, plush, well maintained	8	0.7	5.2	2.0

Range of fungal concentrations expected
in clean carpets

Max = 19 cfu/100 cm²

[2.] 59 Carpets Stratified by Water-Intrusion Potential

SAMPLES	LOCATION	CONDITION	GROUP
11	Control	Clean	1
15	Room Center	Clean	1
8	Sliding Doors	Potentially Colonized	2
18	Windows	Potentially Colonized	2
7	Water Intrusion	Colonized	3

**Wanted to know if the OFFA method could
distinguish between these carpet groups**

If not, then no utility for assessing condition

Stratified Sampling of Carpets (cfu/100 cm²)

$$100 \text{ cfu}/100 \text{ cm}^2 = (2,750 \text{ cfu}/\text{ft}^2)$$

TOTAL CFU	GROUP	GM	LCL_GM	UCL_GM
Control	1	109	67	176
Room Center	1	120	56	262
Sliding Doors	2	1,208	302	4,840
Windows	2	1,351	547	3,336
Water Intrusion	3	9,256	1,383	61,956

Group 1 ≈ 100

Group 2 ≈ 1,000

Group 3 ≈ 10,000

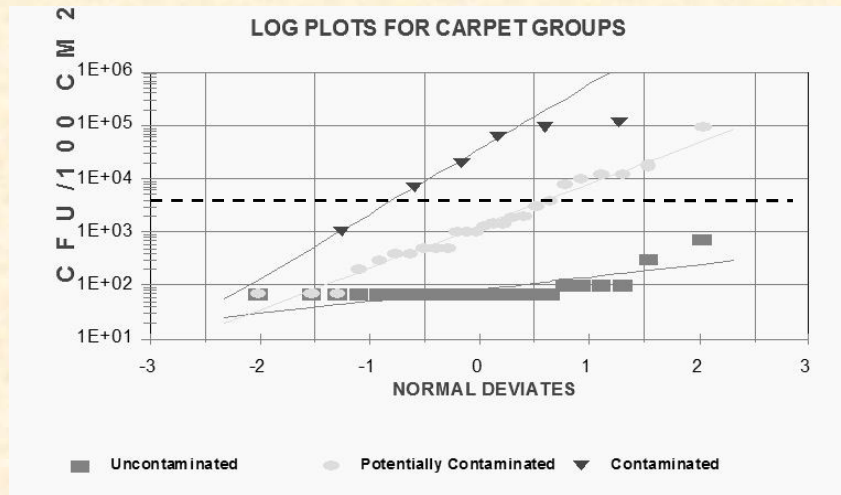
LCL – 95th percentile lower confidence limit

UCL – 95th percentile upper confidence limit

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First, the Geometric Mean (GM) concentrations of total fungi differed by about a factor of 10 for the three Groups of carpets – 110; 1,250 and 9,000. Second, the differences in GM between Group 1 and Group 2 were statistically significant. Group 1 carpets (clean carpets) could be distinguished from Group 2 and Group 3 carpets.

The number of spots that are sampled can vary. A minimum of 20 spots provided a limit of detection of less than 100 cfu/100 cm² for cultured samples. The sampled spots can all be collected under one window or over an entire room depending on the objective.



Professional Judgment v Guidelines
Errors: 2 in Group 1 and 3 in Group 2

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Were the results of the OFFA method consistent with professional judgment? Yes. 3 of the 26 Potentially Contaminated carpets (12%) were Clean by OFFA, and 2 of the 26 Clean carpets (8%) were Potentially Contaminated by OFFA.

Dominant Fungi

Median Concentrations (cfu/100 cm²)

Carpet Group	<i>Asp</i> spp.	<i>Pen</i> spp.	Total Fungi
Group 1	70*	74*	85*
Group 2	199	327	1,306
Group 3	574	16,189	20,892

Which species to use to assess level of contamination?

[Later office building example]

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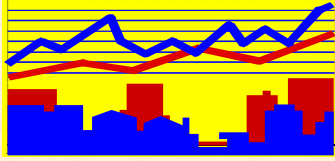
Wet, moldy carpets tend to eventually dry out. The “succession of fungi” principle means that wet-loving fungi that were the initial colonizers are replaced by dry-loving fungi such as *Cladosporium* and *Penicillium*. The data in this table indicate that *Penicillium* may be a good genus to use to assess the condition of previously wet carpet.

[3.] Decision Criteria: MEA Media

- **Group 1: Carpet condition acceptable**
 - Less than 300 cfu/100 cm²
 - Common environmental fungi dominant
 - Assessment: Uncontaminated: no evidence of water intrusion
- **Group 2: Potentially Colonized: evidence of possible damage**
 - 300-4,000 cfu/100 cm²
 - Contaminant fungi dominant
 - Assessment: Clean carpet professionally
- **Group 3: Colonized: evidence of substantial damage**
 - Greater than 4,000 cfu/100 cm²
 - Contaminant fungi dominant
 - Assessment: Remove and discard carpet

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These are just general guidelines, not hard rules. On-site assessment and professional judgment should take precedent. However, sampling using the OFFA method and the application of similar decision criteria may be useful in some projects.



Micro-Vac Soft Surface Sampling Methods

Soft-Surface Items

**IICRC
Condition 2 or Condition 3 ?**

Clean or Discard?

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This is a differential sampling method for determining if a soft surface item should be cleaned or discarded. It can be used during the initial inspection or during post-remediation verification disputes.

Closed-Face Filter Cassette

- **Contamination – Settled mold spores on the surfaces of items**
- **The closed-face cassette samples primarily the surfaces of the soft-surface items**
 - **Detects settled spores on the Surface of items**
 - **Contamination**



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Two sets of samples are collected from adjacent locations on the same item. The first set uses a closed-face filter cassette to sample the surface of the items.

Sampling Exterior Surfaces of Items

**Closed-Face Measured Area
(CFMA) Method**



**Area template
10 lpm airflow rate
2-minute sample
Perpendicular Pattern
qPCR analysis or culture
Results = $Sp-Eq/100 \text{ cm}^2$**



Open-Face FilterCassette

- **Colonization – Fungal growth on the surface and interior fibers of soft surface materials**
- **The open-face cassette detects surface spores plus deep-seated colonization by contaminant fungi**
 - **Surface Contamination plus Colonization**



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The second set uses an open-face filter cassette to sample the interior spaces of the same items.

Sampling Interior Spaces of Items

Open-Face Fixed Area (OFFA) Method



20 spots (Minimum)
Held firmly for 5 seconds in
one spot
10 lpm airflow rate
qPCR analysis or culture
Results = Sp-Eq/100 cm²

Area of cassette = 4.9 cm²
Each spot sampled = 4.9 cm²

1. Six-Story Office Building

- Remediation was in progress during sampling
- Therefore, could use culturable fungi since fungi still viable

- Older project
- Today we would use qPCR for analysis to speciate the fungi
- Strategy and logic apply to any method of analysis

Sampling Strategy

- **Control Area: Unaffected area of building**
- **Test Area: Extensive water intrusion**
- **Soft-surface items selected for testing**
 - **Two office chairs: 1 control, 1 test**
 - **Two cubicle panels: 1 control, 1 test**
- **Prior treatment of contaminated items**
 - **HEPA-vacuumed three times**
 - **Treated with Microban three times**
 - **No visible damage, odors, etc.**
 - **Occupant & Insurer could not agree on acceptability**

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Even though it was a six-story office building, only four items were included in the testing at the direction of the insurance company.

Test Items Sampled by Micro-Vacuum Cassettes

Penicillium (cfu/100 cm²)

Items	Control	Remediated
Chair, Surface	0	23
Chair, Interior	14	1,970
Panel, Surface	4	25
Panel, Interior	4	560

**Conclusion: Substantial difference in deep-seated
Colonization between the control and remediated items**

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Penicillium had been dominant in the carpet dust study and was dominant in this study. Conclusion: Substantial concentrations of contaminant Penicillium spores were still present in the interior spaces of the water-damaged chair and panel.

Conclusions

- Repeated HEPA-vacuuming of soft-surface items then treatment with Microban removed surface **Contamination** but did not remove deep-seated **Colonization**
- Differential sampling method was accepted by Insurer
 - HEPA-vacuuming a fourth time would not change the results
- Therefore, all soft-surface items in the water damaged areas of the facility were discarded
- “Validation” involved comparing the results with a set of controls

2. Post-Remediation Items

- **19 soft-surface items**
- **Sampled using the Differential Sampling Method with micro-vac cassettes**
- **The items had been**
 - **HEPA-vacuumed and Remediated**
 - **Stored for about a year by the Contractor**
- **Fungal spores probably no longer viable**

Assessing IICRC Condition 2

- **The closed-face cassette sampled primarily the surfaces of the soft-surface items**
 - **Detected Surface Contamination**
 - **Assessed IICRC Condition 2**
- **If no surface contamination**
 - **Acceptable condition**
- **If only surface contamination**
 - **Condition 2 item**
 - **Additional professional cleaning**

Assessing IICRC Condition 3

- **The open-face cassette sampled both the surface and the interior of the soft-surface items**
 - **Detected Surface Contamination plus deep-seated Colonization**

Detecting interior colonization:

(Open-face sample result) – (Closed-face sample result)

(Surface + Interior) – (Surface) = (Interior Concentration)

Assessing IICRC Condition 3

- **If no deep-seated colonization**
 - **Acceptable condition**
- **If deep-seated colonization**
 - **Condition 3 item**
 - **Discard**

Summary of Sample Results

Geometric Mean (GM) Concentrations
(spores/100 cm²)

Spore Type	Closed-face “Surface”	Open-face “Interior”
<i>Cladosporium</i>	283 [75%]	378 [25%]
<i>Asp/Pen</i>	75 [1%]	6,193 [99%]

99% of *Asp/pen* was located in the interior spaces of the 19 items: [Condition 3 Colonization](#)

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75% of the *Cladosporium* (common environmental spore) was on the surface of the 19 items while 99% of *Asp/Pen* (contaminant spore) was on interior surfaces.

Fundamentally Different Methods

- **Closed-face Cassette**
 - Detected only the deposition of surface spores
- **Open-face Cassette**
 - Detected surface contamination plus colonization of interior materials

Real-world Clients and Ethical Decisions:

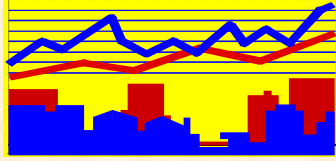
Insurance Company => Closed-face Cassette

Homeowner => Open-face Cassette

“Fair & Balanced” => Differential Method

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The inspector has the choice of sampling methods. A method can be selected that favors one party over the other or an unbiased method can be selected.



Soft Surface Samples

Part 2 Carpet and Soft Surface Sampling Methods