Using Surface Dust Samples to Assess Occupant Exposures to Mold

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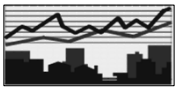

- **Qualified for**
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Topics

- **Collecting Dust Samples**
- **The ERMI Method**
- **Analyzing Dust Samples and Reporting Results**
- **Assessing Occupant Exposure Potentials**
- **HERTSMI (Briefly)**

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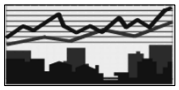

Collecting the Sample

A Critical Step

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Inspection Objectives

- **HOW WILL THE SAMPLES SUPPORT THE OBJECTIVE?**
- **Possible Objectives**
  - **Assessing Building-Related Contamination**
  - **Assessing Occupant Exposure Potential**
  - **Or Both**

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The Sampling "Rationale"

- **HOW WILL THIS SAMPLE SUPPORT THE OBJECTIVE?**
- **1st: Why am I collecting this sample, in this location, using this sampler?**
- **2nd: What do I expect to learn from the sample result?**
  - **What will it mean if the result is positive? If negative?**
- **3rd: How should the sample be analyzed to support the objective?**
- **4th: Which interpretation method should I use to support the objective?**

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Assessing HVAC Samples

- **Air Return Filter**
  - **Central collection point for airborne contaminants**
  - **Composite of what has been circulating in the air**
  - **Indicator of chronic occupant exposure *since changed***
- **Air Supply Grill**
  - **Distribution point for contaminants in HVAC system**
  - **Contaminants collected from the grill/boot were probably reaching the breathing zones of the occupants**

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Different Methods for Different Objectives

BUILDING CONTAMINATION	OCCUPANT EXPOSURE
• Airborne: 5-minute SIC samples, Total spore counts	• Airborne: 60-90 minute filter cassette samples with qPCR analysis
• HVAC: Inspect the cooling coils, return plenum	• HVAC: Sample the air supply grill • Dust: Air return filter • qPCR analysis

The Sample Describes the Environment

- **Koppen: "One of the primary challenges of assessing exposures (to environmental contaminants) is the collection of representative samples, with the sampling step typically contributing the largest variability."**

  [Koppen, R., et. al.; Determination of mycotoxins in foods: current state of analytical methods and limitations; Applied Microbiology and Biotechnology (May, 2010)]

- **A sample that is not representative of the fungal loading in an indoor space will not be representative of the occupant exposure potential in that space**

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Sampling and Interpretation Methods

- **Should consider meeting the "SOCS" criteria**
  - **Significance of the sample result**
    - **Numerical guidelines for interpreting the lab report**
  - **Objective decision criteria for interpreting the sample result (High, Low, Average)**
    - **Independent of training, experience, or bias**
  - **Consistent assessments of condition**
    - **across projects and between inspectors**
  - **Stable basis for assessment**
    - **Does not vary with local conditions**

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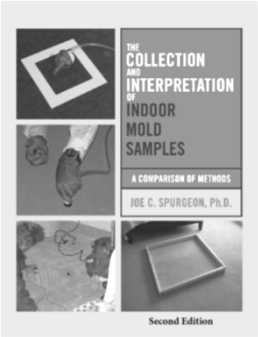
"Professional" Sampling Methods



Problems exist even with "standard" methods

My opinion:
Only one of these four sampling methods can meet the "SOCS" criteria and actually describe the exposure potential of a carpet dust sample

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Occupant-Collected Samples

Goal: A sample representative of the indoor environment and occupant exposure potential

Sampling Method	**Swiffer, combined locations (Bsmt+LR)**
Sample Size	**One sample collected on one day**
Sample Matrix	**Mixed surface types (Typical)**

- **Collecting a representative sample is actually not a simple task.**
- **Occupants may need as much guidance as possible when being asked to collect samples.**
- **Requires a knowledgeable and informed mentor and guide.**

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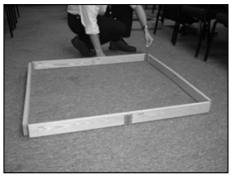
The ERMI Method

- **Unless the collection method looked like the photo, and it was collected from a carpet, it was not an ERMI sample, and should not be assessed using an ERMI score.**



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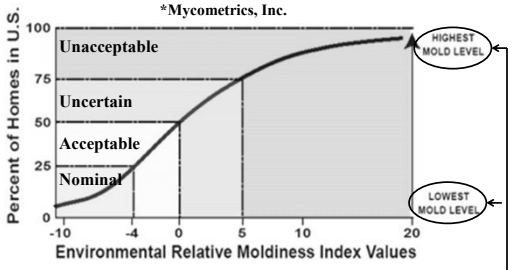
ERMI Score v Fungal Loading

***Mycometrics, Inc.**



Implies the ERMI Score is a measure of total fungal loading, but it is a difference (Gr 1 – Gr 2), not a total

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ERMI Score v Fungal Loading

Group 1	Fungal ID \ Unit	Spore E./mg	Spore E./mg
	Aspergillus flavus/oryzae	ND	ND
	Aspergillus fumigatus	ND	1
	Aspergillus niger	ND	2
	Aspergillus ochraceus	5	9
	Aspergillus penicilloides	4	730
	*Aspergillus restrictus**	ND	ND
	Aspergillus sclerotiorum	ND	ND
	Aspergillus sydowii	ND	<1
	Aspergillus unguis	ND	6
	Aspergillus versicolor	ND	530
	Aureobasidium pullulans	680	390
	Chaetomium globosum	ND	ND
	Cladosporium sphaerospermum	7	26
	*Eurotium (Asp.) amstelodami**	1	150
	Paecilomyces variotii	ND	ND
	Penicillium brevicompactum	ND	170
	Penicillium corylophilum	ND	74
	*Penicillium crustosum**	ND	29
	Penicillium purpurogenum	ND	ND
	*Penicillium spinulosum**	ND	1
	Penicillium variabile	ND	3
	Scopulariopsis brevicaulis/fusca	ND	ND
	Scopulariopsis chartarum	ND	4
	Stachybotrys chartarum	ND	140
	*Trichoderma viride**	ND	<1
	Wallemia sebi	ND	460
	Sum of Logs (Group 1):	4.98	25.36

ERMI Score not related to fungal loading

GR 1	GR 2	ERMI
10,000	1,000	+ 1
100,000	10,000	+ 1

ERMI can actually decrease as the fungal loading increases

GR 1	GR 2	ERMI
100,000	10,000	+ 1
100,000	50,000	+ 0.3

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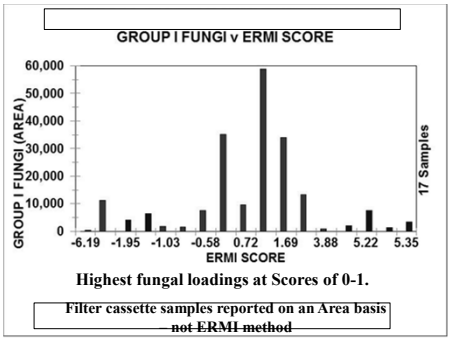
Group 1 Fungi v ERMI Scores



Highest fungal loadings at Scores of 0-1.

Filter cassette samples reported on an Area basis not ERMI method

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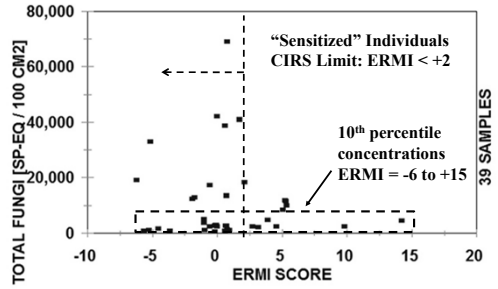
CARPET DUST SAMPLES

ERMI: TOTAL FUNGI v ERMI SCORE



CIRS [Chronic Inflammatory Response Syndrome]

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Characteristics of ERMI Scores

- ERMI scores only apply to carpet dust sampled using a specific sampling method
  - Not to mixed surfaces sampled using a Swiffer
- Results are reported on a Weight-Analyzed Basis rather than an Area Basis
  - Sample results cannot be compared
- Scores are calculated based on the difference between Group 1 and Group 2 fungi
  - Scores do not reflect total fungal loading (OEP)
- A score does not represent a unique fungal loading for assessing OEP

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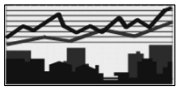

Analyzing Dust Samples and Reporting the Results

You Have Options

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Reporting Surface Dust Samples

- **How the sample results are reported by the laboratory affects the ability to assess BRC and OEP**
- **HOW SAMPLE RESULTS CAN BE REPORTED**
  - **Standard; Weight-Analyzed Basis: Sp-Eq/mg**
    - **Sp-Eq/mg of dust analyzed**
  - **Option 1; Total Weight Basis: Sp-Eq/mg x (total mg)**
    - **Sp-Eq/Sample**
  - **Option 2; Area Basis: [Sp-Eq/mg x (total mg)] / Area**
    - **Sp-Eq/in² Sp-Eq/100 cm²**

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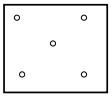
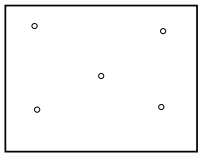
Carpet Dust Example

Failed Clearance: Selecting the Reporting Basis

Since the mold is in the dust and not in the fibers, results on a "weight" basis can be inaccurate & misleading



AREA = 100 MG of dust



- **Set Clearance Criteria (Mold/mg)**
- **Carpet cleaned**
- **1st Clearance Failed**
- **Re-cleaned carpet**
- **2nd Clearance Failed**
- **Problem**
  - **Larger area of carpet**
  - **But the same Mold/mg**

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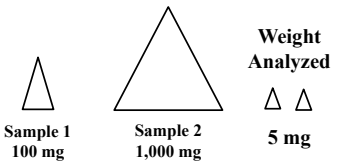
Standard Lab Procedure
Weight-Analyzed Basis

Lab SOP: Not weight the sample, Analyze 5 mg of sample



1,000 Sp-Eq detected in both 5-mg samples
200 Sp-Eq/mg reported for both 5-mg samples

If Condition ≈ fungal loading: Then 20,000 v 200,000 Sp-Eq

Inspector: Same Exposure Potential reported for both samples

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Area Basis

1. **Inspector measures the area that was sampled**
2. **Requests the result on a Total-Weight Basis as Sp-Eq/Sample**
3. **Divide Sp-Eq/Sample by the area sampled**

Sample results are standardized & can be compared - by accounting for sample weights & areas sampled

Lab Report	Sample 1	Sample 2
Area Sampled	6" x 6"	12" x 12"
Weight Collected	400 milligrams	1,200 milligrams
Weight Analyzed	5 mg	5 mg
Fungi Detected	1,000 sp-eq/5 mg	1,000 sp-eq/5 mg
Sp-Eq/mg	200 sp-eq/mg	200 sp-eq/mg
Sp-Eq/Sample	80,000 sp-eq/Sample	240,000 sp-eq/Sample
REPORT	320,000 sp-eq/ft^2	240,000 sp-eq/ft^2

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Area Basis

- **1st: Health effects were better associated with results reported on an Area Basis rather than Weight Basis**
  - **Ulrike Gehring, et al. β(1→3)-Glucan in House Dust of German Homes: Housing Characteristics, Occupant Behavior, and Relations with Endotoxins, Allergens, and Molds; Environmental Health Perspectives; 109: (2), February 2001**
  - **Paul J. Lioy, et al. Dust: A Metric for Use in Residential and Building Exposure Assessment and Source Characterization; Environmental Health Perspectives; 110: (10), October 2002**

2nd: Results reported on an area basis allow Conditions and/or Occupant Exposure Potentials to be compared

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Objective of Presentation

- **Now that I've "rained on your parade", what now?**
- **What follows is knowledge**
- **You can use it to**
  - **collect more representative samples**
  - **Assist occupants as much as possible in characterizing their environments**

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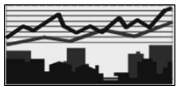

Assessing Occupant Exposure Potential based on total fungal loading

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The Sampling Methods

- **The data presented were collected using filter cassettes and surface swabs, so the data were not "ERMI" data**
- **Results were reported on an Area Basis rather than on a Weight-Analyzed Basis**

Just consider the implications of the concepts

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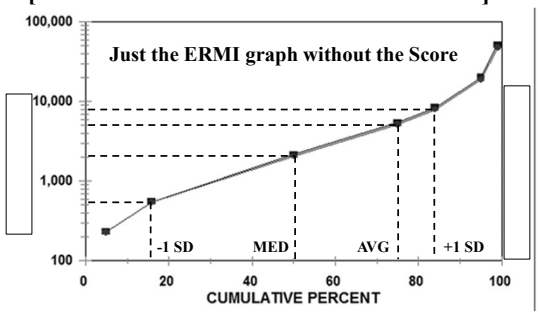
Concentration Distribution
[Concentration v Cumulative Percentile]



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Interpreting Percentile Concentrations

Percentile Concentration	Significance
84th %-tile	+1 "Std" Dev (Med)
73rd %-tile	[Average Concentration]
50th %-tile	Median Concentration
16th %-tile	-1 "Std" Dev (Med)

Assessing BRC: Use the Median (50th) Percentile

Assessing OEP: Use the Average (75th) Percentile
DOSE = [Average Conc X Time]

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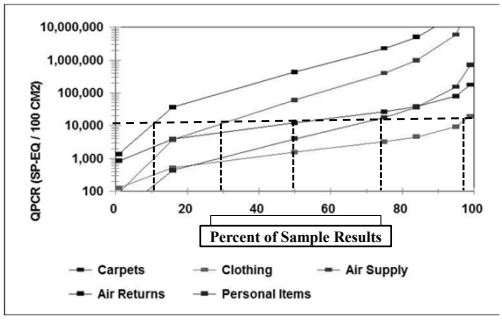
Impact of Surface Type

Total Fungi: Interpretation different for different surfaces



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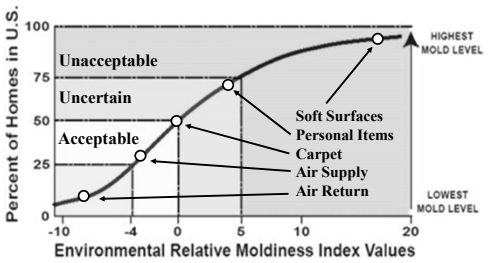
Sample Collection and Assessment

qPCR: 10,000 sp-eq/100 cm²



Conclusion: The surface sampled should be considered when assessing the sample result

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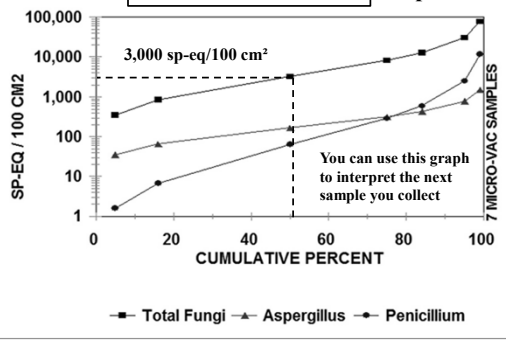
SOFT SURFACES

Micro-vacuum Cassette Samples



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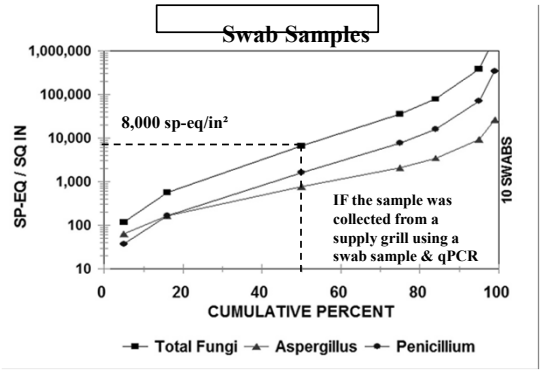
AIR SUPPLY GRILLS

Swab Samples



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Concentration Distributions: 93 Dust Samples

CP (%)	10.00	16.00	25.00	50.00	65.00	75.00	84.00	95.00
Aspergillus flavus/oryzae	2	2	3	6	7	10	13	22
Aspergillus fumigatus	8	13	23	61	102	163	279	737
Aspergillus niger	7	11	16	33	48	68	101	206
Aspergillus ochraceus	5	7	10	18	25	34	47	84
Aspergillus penicillioides	2	3	5	12	18	27	43	97
Aspergillus sydowii	4	6	8	13	17	22	30	51
Aspergillus versicolor	2	3	5	16	29	49	90	268
Aureobasidium pullulans	292	516	987	3,247	6,102	10,674	20,433	65,710
Chaetomium globosum	1	1	3	15	34	72	170	792
Cladosporium sphaerospermum	2	3	5	13	22	33	54	132
Eurotium (Asp.) amstelodami*	4	7	11	24	38	57	90	205
Paecilomyces variotii	2	2	4	8	12	18	27	59
Penicillium brevicompactum	25	43	79	239	430	722	1,320	3,908
Penicillium variabile	5	8	12	26	39	56	85	182
Scopulariopsis chartarum	4	6	9	20	31	46	72	162
Stachybotrys chartarum	3	4	6	20	34	54	93	245
Wallemia sebi	3	5	8	22	37	58	98	262
Alternaria alternata	12	19	31	78	127	196	323	794
Aspergillus ustus	2	4	7	19	32	52	91	247
Cladosporium cladosporioides 1	184	298	515	1,410	2,405	3,860	6,685	17,956
Cladosporium cladosporioides 2	8	14	29	110	221	411	845	3,083
Cladosporium herbarum	481	670	979	1,959	2,829	3,920	5,724	11,309
Epicoccum nigrum	5	9	19	72	146	273	562	2,064
Mucor amphibiorum*	6	9	15	40	67	105	178	459
Penicillium chrysogenum	10	17	31	95	172	290	534	1,595
Rhizopus stolonifer	8	11	17	35	52	73	109	225
Group 1	296	531	1,034	3,503	6,689	11,866	23,088	76,459
Group 2	1,199	1,693	2,507	5,148	7,539	10,571	15,654	31,721
Total Fungi	1,902	2,854	4,530	10,567	16,557	24,651	39,132	89,863

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Concentration Typical or Elevated?

Ratio of Group 1 (Contaminant) to Group 2 (Environmental) ERMI fungi for 93 residential dust samples

CP%	10%	16%	25%	50%	65%	75%	84%	95%
Gr 1	296	531	1,034	3,503	6,689	11,866	23,088	76,459
Gr 2	1,199	1,693	2,507	5,148	7,539	10,571	15,654	31,721
Ratio	0.25	0.31	0.41	0.68	0.89	1.12	1.48	2.41

- **1st: I use the distribution of Total Fungi for the 36 ERMI fungi rather than a score to assess Condition**
  - **Assess BRC, or Clean v Discard Decision**
- **2nd: I then use the distributions of the individual fungi to identify "Contaminants of Concern"**
  - **Assess Occupant Exposure Potential**

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What can we tell the physician?

Lab Sample Number Client Sample ID Sample Location Sample size	1138-1 CS929355 Filter-Carpet 5mg Dust	Quartile %-tile
EPA 36 Species Group -1	Spores E./ mg Dust	Spores E./ mg Dust
Aspergillus flavus	ND	
Aspergillus fumigatus	8	33%
Aspergillus niger	84	80% ○
Aspergillus ochraceus	28 ○	90% ○
Aspergillus penicillioides	4	18%
Aspergillus restrictus	12	30%
Aspergillus sclerotiorum	54	90% ○
Aspergillus sydowii	ND	
Aspergillus unguis	ND	
Aspergillus versicolor	45	70%
Eurotium (A.) amstelodami	41	60%
Aureobasidium pullulans	○ 2,246	85% ○
Chaetomium globosum	29 ○	40%
Cladosporium sphaerospermum	55	75%
Paecilomyces variotii	37	80% ○
Penicillium brevicompactum	ND	
Penicillium corylophilum	180	75%
Penicillium crustosum (group2)	ND	
Penicillium purpurogenum	ND	
Penicillium spinulosum	ND	
Penicillium variabile	6	33%
Scopulariopsis brevicaulis	36	65%
Scopulariopsis chartarum	6	52%
Stachybotrys chartarum	7	40%
Trichoderma viride	129	90% ○
Wallemia sebi	39	75%
I-Total Spores Detected	**3,046**	

CARPET DUST REPORT

Example: Actual Report

1. ***Aureobasidium***
2. ***Chaetomium***
3. **Fungal Loading**
4. **Six Contaminants of Concern**

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The HERTSMI-2 Method

- "***Health Effects Roster of Type Specific Formers of Mycotoxins and Inflammagens***"
- **Derivative of the 36 ERMI fungi**
- **The concentration ranges of five ERMI fungi are used to calculate the HERTSMI score**

Aspergillus Penicillioides
Aspergillus versicolor
Chaetomium globosum
Stachybotrys chartarum
Wallemia sebi

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HERTSMI: Percent of Total Fungi

Prevalence of HERTSMI-2 Fungi by Surface Type

93 Samples	*A pen*	*A ver*	*Chaet*	*Stachy*	*Wall*	SUM
Carpets	0.4%	0.4%	1.4%	0.6%	0.2%	3.0 %
Soft Surfaces	0.6%				0.5%	1.1 %
Clothing	0.7%				0.9%	1.6 %
Hard Surfaces		0.2%		0.1%		0.3 %
Air Return		0.2%			0.1%	0.3 %
Air Supply			0.1%			0.1 %

1. **HERTSMI scores can be based on less than 3% of the fungal loading, typically on 1% or less.**
2. **The sampling locations can obviously influence the results.**

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