Comparison of Woodland and Transportation Fires

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Transportation Fires

US Air Flight 1549 [2009]

Continental Flight 3407 [2009]

Amtrak, Fallon, NV [2011]

Raytheon, El Segundo, CA [2011]

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Substantial Differences in Damage

US Air Flight 1549 [2009]

Miracle on the Hudson

Continental Flight 3407 [2009]

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Typical Materials and Items from Transportation Fires

- Luggage
- Clothing
- Shoes & Belts
- Coats & Furs
- Books & Papers
- Toys
- Jewelry
- Hard plastics
- Soft plastics
- Synthetic fabrics
- Natural fabrics
- Paper & Cardboard
- Glass & Metal

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Amtrak Train
Combustion Particulate

Truck on the crossing

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Stratification of Items by Fire Zone

Boxes Tested	Burn Zone	Adjacent Zone	Distant Zone	Outside of Zone
Zone	3	2	1	Control
Fire Damage	14			
Water Damage		9	8	
No Damage				1

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Combustion Particulate

Amtrak Train

- 6 pieces of luggage
  - Front and Sides
- Combustion Particulate
  - Closed-face 25 mm cassette, 0.8 um MCE @ 10 lpm
- SEM/TEM Analysis
  - % Char and Opaque [soot-like] particulate

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Six Soft-Surface Suitcases Percent Char

SAMPLE	Pre-Clean (%)	Post-Clean (%)	Reduction (%)
1	6	< 1	92
2	4	< 1	88
3	3	< 1	83
4 - 6	< 1	< 1	NA
Average	4.3	0.6	86

Cleaning process: 86% reduction in char

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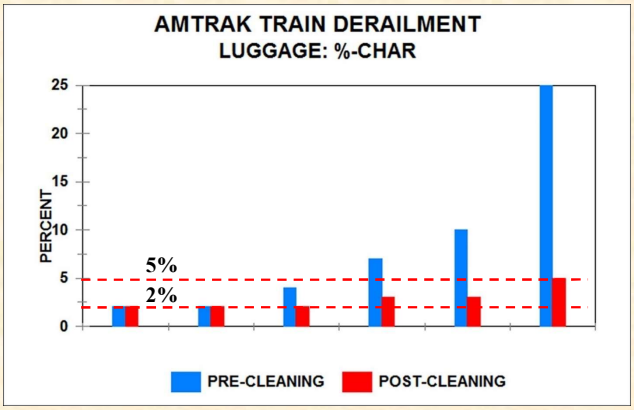
Combustion Particulate (Char)



Percent Char: Useful in assessing condition
Criterion: "Clean" ≈ 2% - 5 %

Compare with 3% criterion for Woodland Fires

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Six Soft-Surface Suitcases
Percent Opaques (Soot-Like)

	Pre-Clean (%)	Post-Clean (%)	Reduction (%)
Average	8.3	2.8	66
Field Blank	NA	3	NA

Average concentration for cleaned items similar to field blank of 3%

Criterion was not obvious for Woodland Fires

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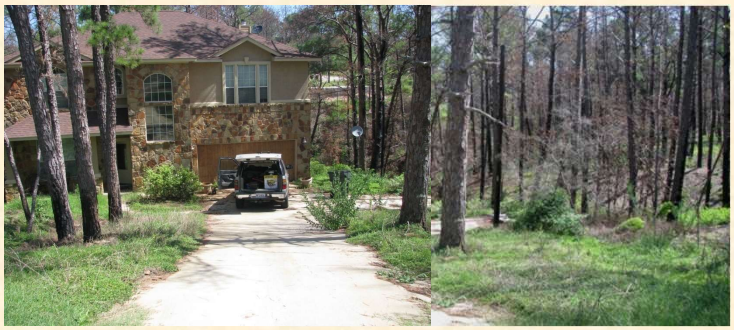
Woodland Fires



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Stratified Selection of Test Houses

Stratified into Four Groups Based on Restoration

HOUSE	GROUP	INTERIOR & CONTENTS
1	1	Professionally Cleaned, Walls Painted
2	1	Professionally Cleaned, Remodeled
3	2	Cleaned by Occupant, Steam Cleaned
4	2	Cleaned by Occupant
5	2	Cleaned by Occupant
6	3	Not cleaned, Not Occupied
7	4	Control, MDF Trim [Formaldehyde]
8	4	Control, Wood Trim

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Source of Carbon Particulate

Particulate source: burning wood & vegetation

Source	OC/TC Ratio	EC (%)
Vehicles (Avg)	0.58	---
Coal Burning	0.73	26%
Wood Burning (Dry)	0.81	12%
Exposed Houses	0.82 – 0.89	14%
Vegetation Burning	0.93	---
Forest Fire (Wet)	0.94	3%
Charcoal Cooking	0.95	---

Guideline on Speciated Particulate Monitoring
US EPA, RTP, 1998; Chow, J., Watson, J.

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Source of Carbon Particulate

Particulate source: Burning biomass

Source	OC/EC Ratio
Exposed Houses	≈ 8
Biomass Burning (1)	7.8 ± 30%
Coal Burning (1)	3.1 ± 20%
Fossil Fuel [Vehicles] (2)	0.3 – 0.4

(1) Kirpa, Sarin; Journal of Aerosol Science, 41(1):88-98, 2010
(2) Pioa, Cerqueirra, et al.; Atmospheric Environment, 45(34):6121-6132, 2011

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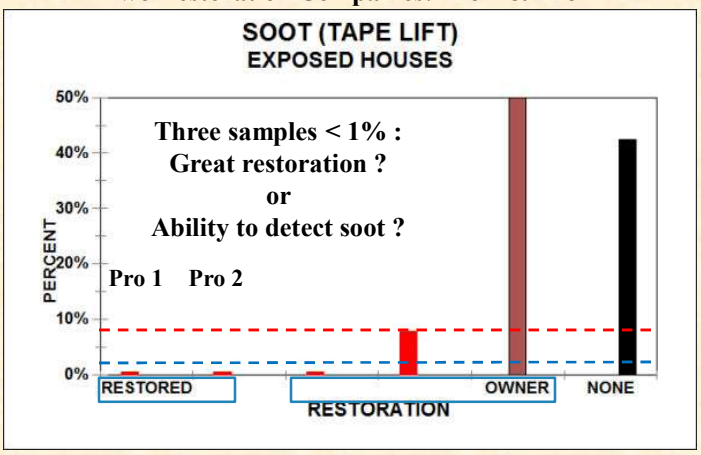
Percent Soot
Hard Surfaces by Tape Lift

Two Restoration Companies: Pro 1 & Pro 2



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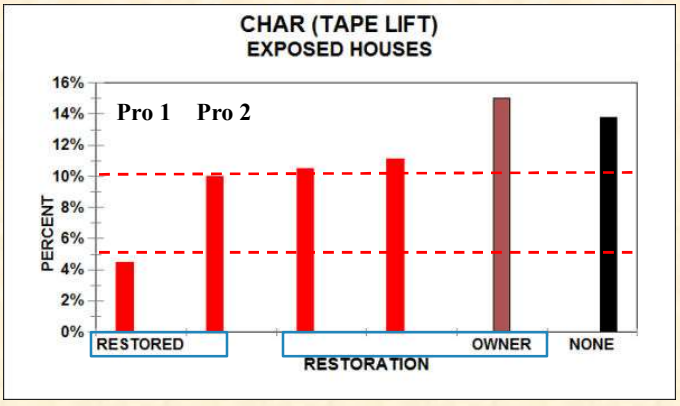
Percent Char
Hard Surfaces by Tape Lift



Restoration Company: Pro 1 v Pro 2
Decision Criteria for Char: 5% or 10% ?

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NIOSH 5040 Method

Total Carbon On Surfaces

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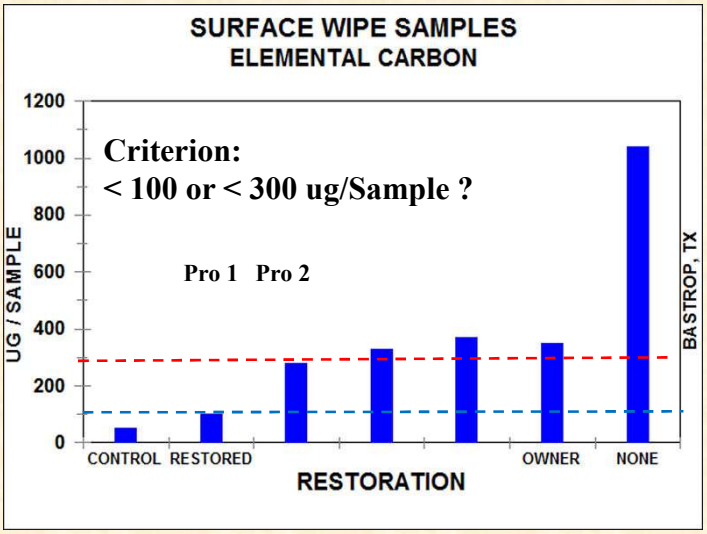
Hard Surfaces



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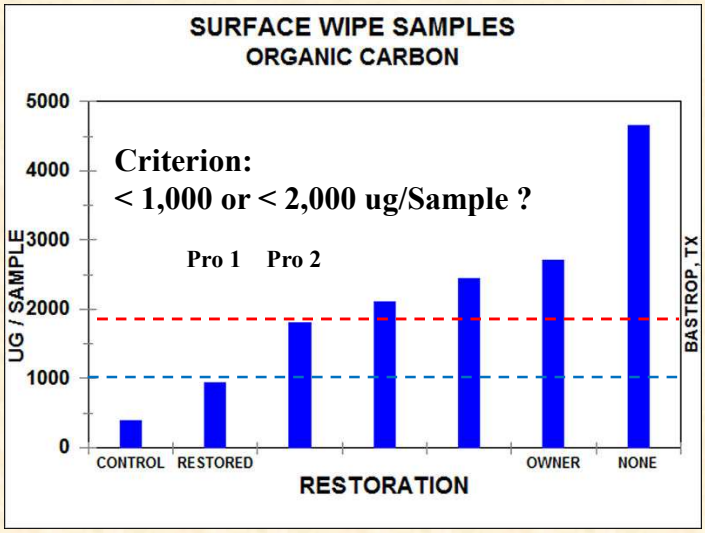
Hard Surfaces



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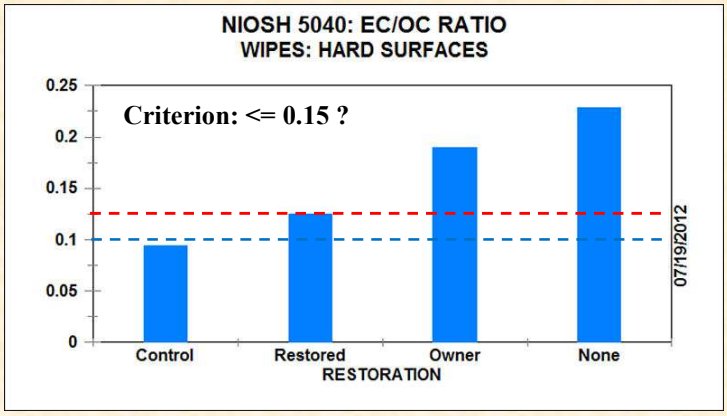
Ratio of EC/OC on Hard Surfaces

Ratio of EC/OC Was Associated with "Restoration Status"



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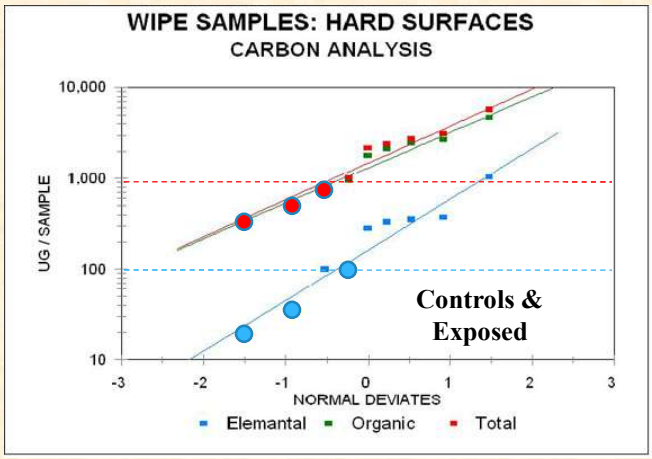
Hard-Surface Samples



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Decision Criteria: Restoration

Hard-Surface Samples

	UG / Sample	
PARAMETER	**MAXIMUM**	**"GOOD QUALITY"**
Total Carbon	**< 2,500**	**< 1,100**
Organic Carbon	**< 2,000**	**< 1,000**
Elemental Carbon	**< 400**	**< 100**

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Woodland Fire
Pre-Restoration Hospital Surfaces

UG/Sample

SAMPLE	OC	EC	TC	OC/TC	OC/EC
1	50	0.9	50	1.0	55
2	61	0.9	61	1.0	68
3	160	6.6	170	0.94	24
4	29	0.9	29	1.0	32
5	83	0.9	83	1.0	92
6	270	6	280	0.96	45
7	51	0.9	51	1.0	57
8	16	0.9	16	1.0	18
9	420	39	460	0.91	11
10	76	1.8	77	0.99	42
11	33	0.9	33	1.0	37
12	48	0.9	48	1.0	53
13	240	2.3	240	1.0	104

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Assessment

- OC/TC Ratio:
  - Consistent with wood and vegetation smoke
- OC/EC Ratio:
  - Consistent with biomass burning

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NIOSH 5040

Total Carbon on Soft Surfaces

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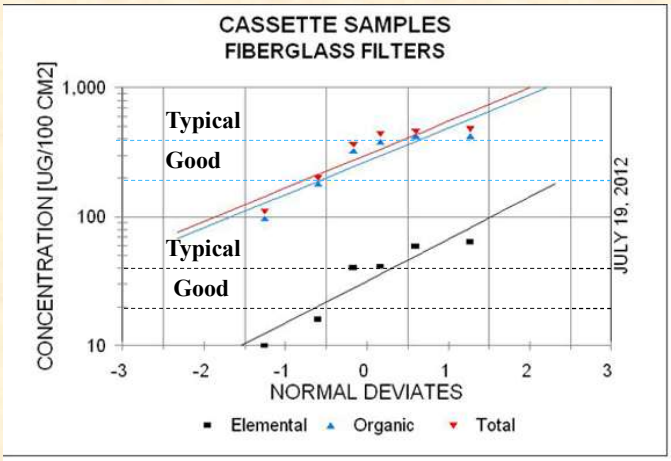
Soft-Surface Samples

Six Smoke-Exposed Houses



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Decision Criteria: Restoration

Soft-Surface Samples

	UG / 100 CM²	
PARAMETER	MAXIMUM	"GOOD QUALITY"
Total Carbon	< 500	< 250
Organic Carbon	< 400	< 200
Elemental Carbon	< 40	< 20

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Correlations with Char and Soot

ANALYTE	SURFACE	CARBON	R²
CHAR	HARD	Elemental	12%
CHAR	HARD	Organic	5%
CHAR	SOFT	Elemental	44%
CHAR	SOFT	Organic	48%
AVERAGE			27%
SOOT	HARD	Elemental	32%
SOOT	HARD	Organic	12%
SOOT	SOFT	Elemental	22%
SOOT	SOFT	Organic	13%
AVERAGE			20%

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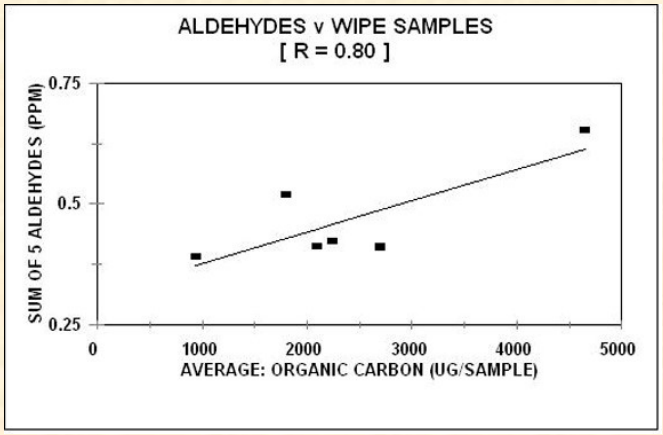
Organic Carbon on Hard Surfaces
Indicator of Hidden Contaminants?



Formaldehyde
Acrolein
Benzaldehyde
Acetaldehyde
Hexanal

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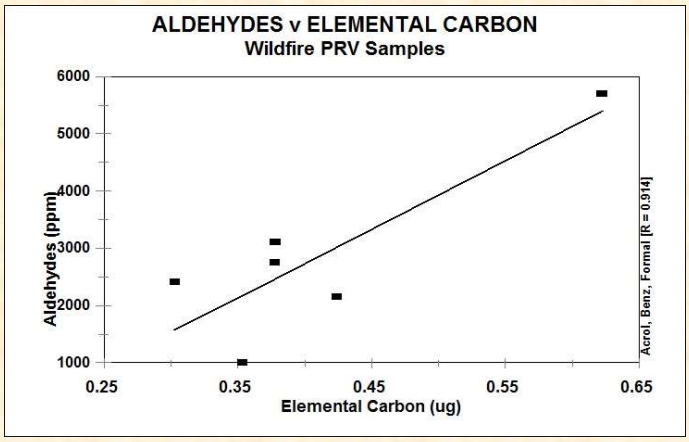
Elemental Carbon on Hard Surfaces
Indicator of Occupant Exposure?



Acrolein
Benzaldehyde
Formaldehyde

R = 0.914

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Correlations with Aldehydes

ANALYTE	SURFACE	CARBON	R^2
Aldehydes	HARD	Elemental	84%
Aldehydes	HARD	Total	72%
Aldehydes	HARD	Organic	68%
AVERAGE			75%
Aldehydes	HARD	Soot	52%
Aldehydes	HARD	Char	46%
AVERAGE			49%
Aldehydes	SOFT	Organic	15%
Aldehydes	SOFT	Total	14%
Aldehydes	SOFT	Elemental	12%
AVERAGE			14%

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Residential Risk Guidelines

Minimum Risk Level: Exposure levels posing minimal non-carcinogenic risk to humans for daily exposures

Acute MRL*:	Exposures 14 days or less
Intermediate MRL:	Exposures 15 – 364 days
Chronic MRL:	Exposures 365 days or more

	ATSDR MRL Values (ppb)		
Aldehyde	Acute	Intermed	Chronic
Acrolein	3	0.04	NA
Formaldehyde	40	30	8

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Occupant Risk: Formaldehyde

Acute MRL = 40.0 ppb

HOUSE	1	2	3	4	5	6	7	8
Formaldehyde*	51	37	76	110	98	80	30	14
Ratio: MRL	1.3	0.9	1.9	2.8	2.5	2.0	0.8	0.4
Ratio: Controls	2.3	1.7	3.5	5.7	4.5	3.6	1.4	0.6

*Parts per Billion (ppb)

Conclusion: The concentration of formaldehyde was greater than the MRL in five of the six smoke-exposed houses 8-months after the wildfire

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Occupant Risk: Acrolein

Acute MRL = 3.0 ppb

HOUSE	1	2	3	4	5	6	7	8
Acrolein (PPB)	300	340	300	310	200	540	130	105
Ratio: MRL	100	113	100	103	67	180	43	35
Ratio: Controls	2.5	2.8	2.5	2.6	1.7	4.5	1.1	0.9

Conclusion: The concentration of acrolein was greater than the MRL in all six smoke-exposed houses 8-months after the wildfire

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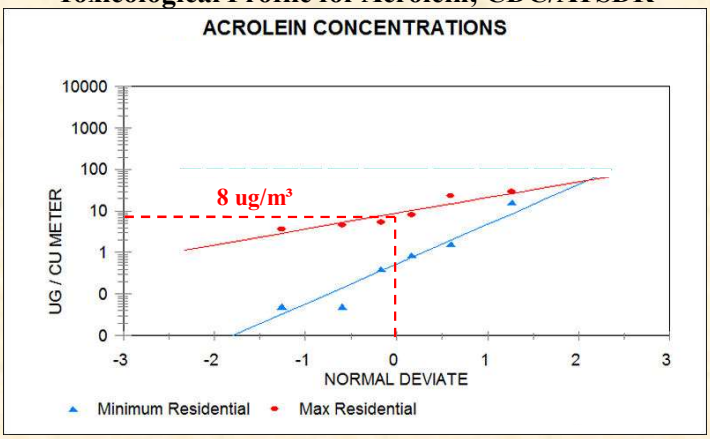
Acrolein Concentrations in Houses
Expected Range

Toxicological Profile for Acrolein; CDC/ATSDR



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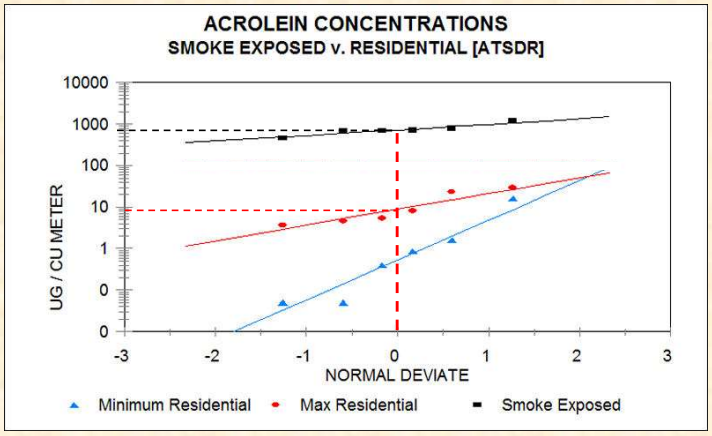
Exposures to Acrolein: 8-Months

Acrolein Was 100x the "Max" for Unexposed Houses



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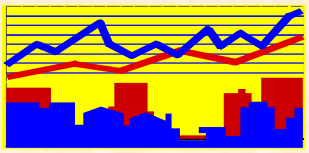

Indicators of Wildfire Contamination

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Decision Criteria: Restoration

Tape Lift Samples from Hard Surfaces

PARAMETER	MAXIMUM	"GOOD QUALITY"
Char (%)	10%	5%
Soot (%)	10%	5%

Criteria for soft surfaces ?

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Decision Criteria: Restoration

Carbon on Hard Surfaces

	UG / Sample	
PARAMETER	**MAXIMUM**	**"GOOD QUALITY"**
Total Carbon	< 2,500	< 1,100
Organic Carbon	< 2,000	< 1,000
Elemental Carbon	< 400	< 100

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Decision Criteria: Restoration

Carbon on Soft Surfaces

	UG / 100 CM^2	
PARAMETER	**MAXIMUM**	**"GOOD QUALITY"**
Total Carbon	< 500	< 250
Organic Carbon	< 400	< 200
Elemental Carbon	< 40	< 20

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Decision Criteria
Airborne Aldehydes

ALDEHYDE	CRITERIA
Composite*	< 150 ppb
Acrolein	< 150 ppb
Formaldehyde	< 30 ppb
Benzaldehyde	< 1 ppb

*Acrolein + Formaldehyde + Benzaldehyde

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Summary

- Soot and Char by Tape Lift
  - Most common method of assessing building-related contamination
  - Lack of a "standard" sampling method limits ability to compare sample results
  - Difficult to detect low percentages of soot
  - Difficult to sample soft surfaces

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Summary

- **NIOSH 5040 Method for Surface Carbon**
  - **Limited to Building-related Contamination**
  - **Standardized methods for sample collection and analysis**
    - **Results can be compared**
  - **Applicable to both hard and soft surfaces**
  - **Good sensitivity for both OC and EC**
  - **Information on particulate source**
    - **Ability to interpret percentages and ratios**

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Summary

- **NIOSH 2016 Method for Airborne Aldehydes**
  - **Standardized methods for sample collection and analysis**
    - **Results can be compared**
  - **Building contamination was associated with acrolein, formaldehyde, and benzaldehyde**
    - **Decision criteria derived from a stratified sample of test houses [Clean v Contaminated]**
  - **Occupant exposure potential was associated with acrolein and formaldehyde concentrations**
    - **Assess occupant risk**

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HARD SURFACES: NIOSH 5040

METHOD	PARAMETER	CRITERION
Wipe Sample	Elemental Carbon	100 ug/sample
Wipe Sample	Organic Carbon	1,000 ug/sample

Discriminate between conditions - Yes
Standard, quantitative method – Yes
Associated with health effects – Possibly
Exposure guidelines – No

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CARBON: SOFT SURFACES

METHOD	PARAMETER	CRITERION
Wipe Sample	Elemental Carbon	25 ug/100 cm^2
Wipe Sample	Organic Carbon	250 ug/100 cm^2

Discriminate between conditions - Yes
Standard, quantitative method – Yes
Associated with health effects – Unknown
Exposure guidelines – No

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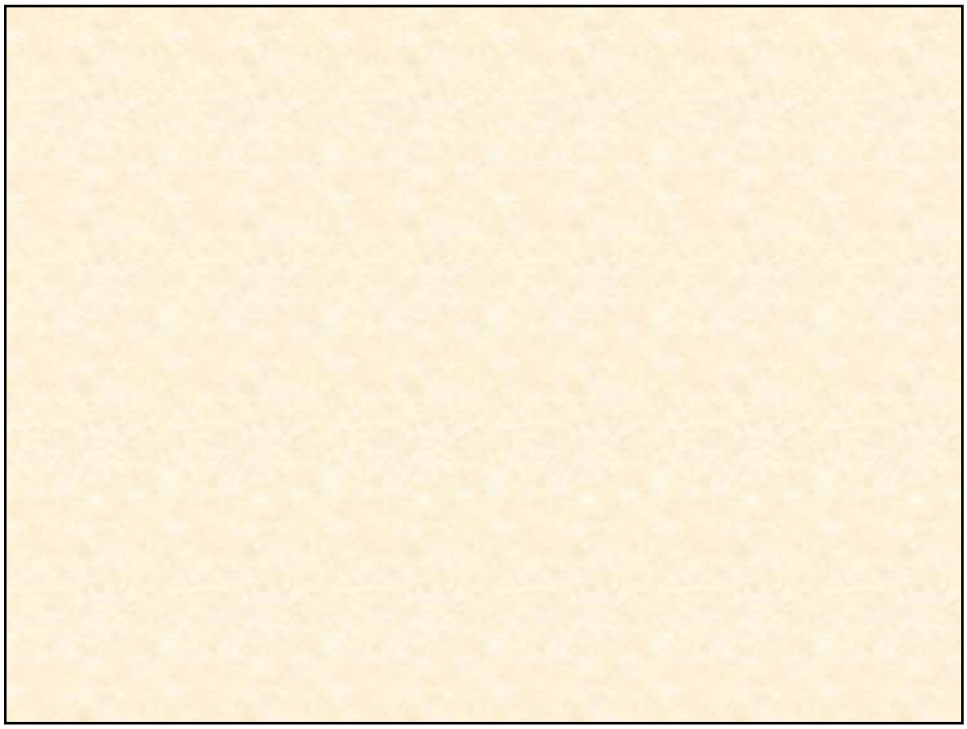

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