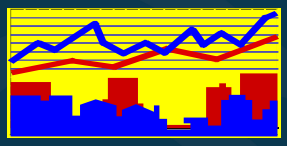

Joe Spurgeon, Ph.D.
Bayshore Environmental

Using ATP to Sample Personal Items following Transportation Accidents

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Background

- US DOT regulations require all personal items to be returned to the passenger or their estate following a transportation accident
- Remediation contractor hired to clean and remediate the collected items
- Post-Remediation Verification sampling has typically been by visual inspection
- US DOT wanted contractor to develop an objective method for assessing cleanliness

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Central Warehouse Facility
Ft. Worth, TX

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Receiving

Items brought into warehouse on refrigerated trucks

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Classified by Damage

Damage Zones 1, 2 and 3
Similar to IICRC Condition 1, 2 and 3

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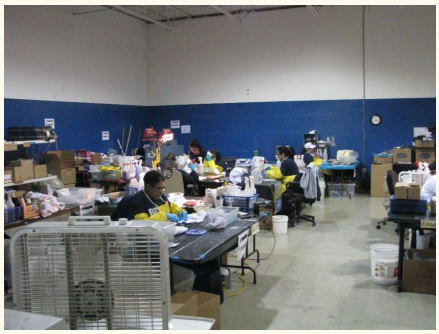
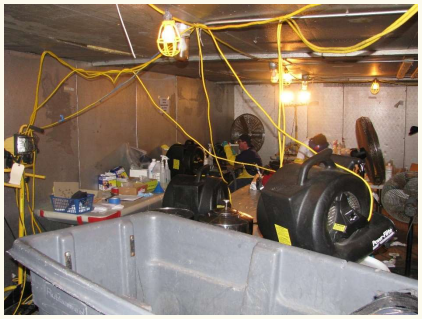
Work Stations

Multi-stage protocol used to process the items





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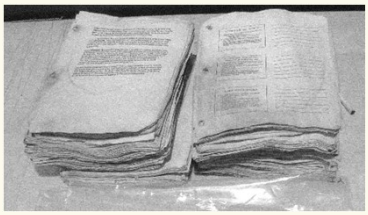
Freeze Drying



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Items Waiting for PRV Sampling

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Ready for Release

"Final Condition" and item storage

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Materials and Items

- 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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Common Contaminants

- Combustion Products
  - Soot, Char, Chemicals
- Water & impact Damage
  - Soil, Mold, Bacteria
- Biological materials
  - Blood, etc.
- Organics
  - Fuel, Hydraulics

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Focus of Presentation

- Microbial and biological contaminants
  - Adenosine Triphosphate (ATP)
- Combustion Products
  - Percent soot and char

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Sampling Methods

- Low tech, easy to use
  - Nontechnical personnel
  - Central facility
  - Mobile sites
    - Parking Lot
  - Remote sites
    - Amazon jungle

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ATP Method

- 3M Biotrace Luminometer
  - XL-100 swab
  - 4 sq-inch sample area, estimated
- ATP samples
  - Detect biological materials
- ATP concentration
  - Photomultiplier tube
    - Better sensitivity
  - Relative light units [RLU]
    - "Clean" < 500 RLU
    - "Typical" < 2,500 RLU

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ATP Samples

- 145 items sampled using ATP
  - 62 sampled for fungi and bacteria
    - MEA and DG-18 media (Fungi)
    - Heterotrophic Plate Count (HPC) [TSA]

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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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Objectives

- Verify condition after final cleaning
  - Survivable and non-survivable crash
- Assess utility of 14 processing steps
- ATP Test Parameters
  - Variability between replicate samples
  - Effect of temperature
- Effect of material type on acceptance criteria
  - Synthetic or natural fibers, hard or soft plastics
- Correlation of ATP with fungi and bacteria

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Transportation Accidents

US Air Flight 1549 [2009]

Continental Flight 3407 [2009]

Amtrak, Fallon, NV [2011]

Raytheon, El Segundo, CA [2011]

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Flights 1549 and 3407

US Air Flight 1549 [2009]

Continental Flight 3407 [2009]

Substantial difference in damage level

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Differences in Initial Condition

	Average Concentrations		
PARAMETER	US AIR 1549	CON 3407	RATIO
Condition	Survivable	Nonsurvivable	
ITEMS	19	37	
ATP (RLU)	170	130	0.8
Fungi (cfu/Swab)	5.1	184	36
HPC (cfu/swab)	481	703	1.5

Conclusions:

1.No statistical difference in ATP & HPC measurements

2. Significant difference in fungal concentrations

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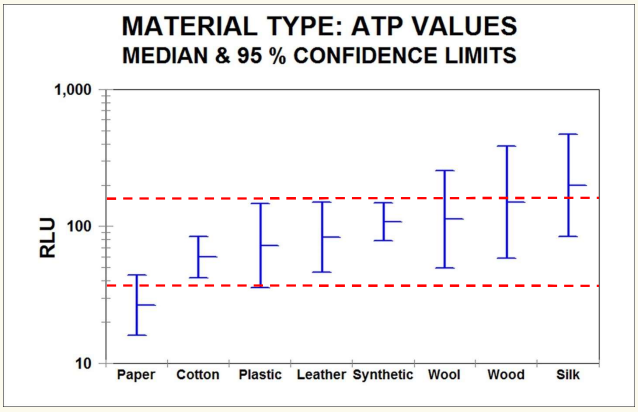
Differences by Material Group



No statistical difference

Materials could be assessed using the same "criteria"

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Raytheon Building

Helicopter crash into side of office building

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Mobile Work Site




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Stratification of Items

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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Items Separated by Condition

Slight damage: Mobile Site
Substantial damage: Central Warehouse

SITE	ITEMS Tested	MIN (RLU)	MAX (RLU)	95TH %-TILE
Mobile Site	22	12	98	114
Processing Center	44	11	350	418

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Amtrak Train
ATP and Combustion Particulate

Truck on the crossing

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ATP Measurements

Six Items: Two in Zone 2, Four in Zone 3

ATP	Receiving	"Cleaned"	Blanks
Number	6	6	2
Minimum	166	162	213
Maximum	3,878	719	231
Average	1,003	374	- - -
Median	553	329	- - -
95th %-tile	3,335	821	- - -

75% Reduction in 95th %-tile Concentration
63% Reduction in Average Concentration

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Six 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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Six Suitcases
Percent Opaque Particulate

	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

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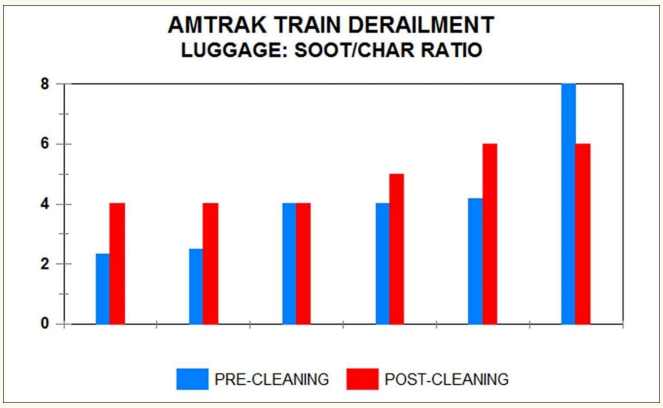
Combustion Particulate



Ratio not useful in assessing a change in condition

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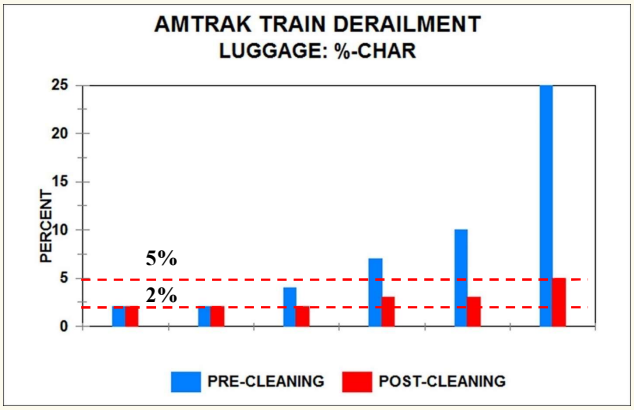
Combustion Particulate



Percent Char: Useful in assessing condition
Criterion: "Clean" < 5 % ?

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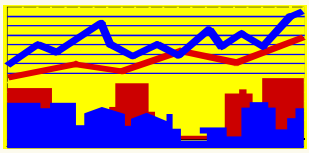

Utility of 14 Processing Steps in Cleaning Protocol

Could any steps be deleted?

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Efficacy of Cleaning Process
19 Items, Mixed Materials

Continental 3407& FBI Tucson, AZ

	RLU Values				
	Min	Max	Average	Median	95th %-tile
Receiving	22	1,107,100	233,378	33,278	8,397,167
Cleaned	15	488	161	94	624

Materials: Hard Plastic, Leather, Metal, Paper

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Items for Sampling

Sampled at various stages in 14-step process

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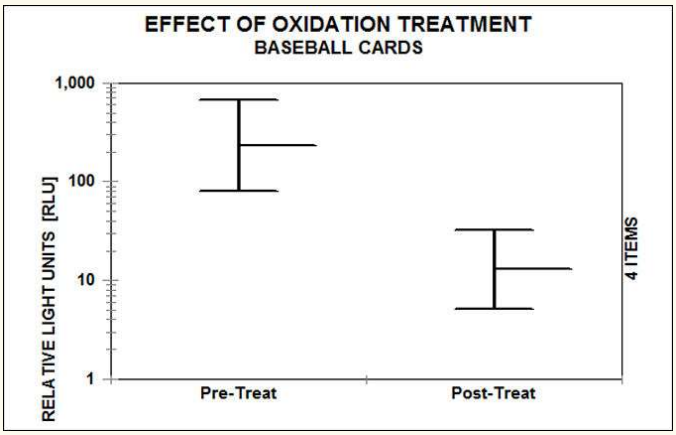
Results for One Step



8-fold reduction in ATP

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ATP Reduction for Process Steps

	RLU	Step 1	Step 2	Step 6	Step 7	Step 14
Pouch	4,387	100 %	22 %	8.2 %		0.2 %
Bag	1,779	100 %	22 %	33 %		1.6 %
Card 1	582	100 %			1.7 %	
Card 2	309	100 %			2.3 %	
Card 3	162	100 %			20.4 %	
Card 4	97	100 %			12.4 %	

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Reduction in ATP Concentration

		RLU Values			
	Number	Min	Max	Average	Median
Receiving	36	22	1,100,000	119,000	4,185
Cleaned	145	10	1,300	212	118
Final	140	9	1,222	122	69

Median: 98 % Reduction

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Criteria at "Final Condition"

Statistical Parameter	ATP (RLU)	Fungi (cfu)	HPC (cfu)
Sample Size	56	56	56
Geometric Mean	79.8	3.2	9.3
Arithmetic Mean	143.8	34.9	396.9
95th Percentile	499.2	33.4	489.9
"Criterion"	500	35	500

Increasing sample size from 56 to 140:
500 RLU or less included 97 % of samples

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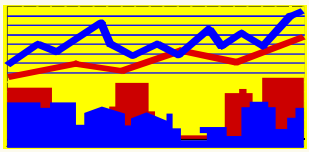

Characteristics of ATP Instrumentation

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Range and Discrimination

RLU values for a standard concentration of ATP*

DEVICE	RLU VALUE
Hygiena	22
Kikkoman	65
3M	435

*Whiteley, Greg; Moving Forward with ATP Testing for Cleanliness Monitoring and Hygiene Standard Setting. The Journal of Cleaning, Restoration & Inspection; 5:(2) 28-33, 2016

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Relative Instrument Performance*

30 replicate samples of test solution

MODEL	MEAN	95% CI**	RSD*
3M	89	76 – 102	7.4 %
MP	3,167	804 – 5,529	38.1 %
CH	1,391	0 – 2,991	58.7 %
NG	52	0 - 143	89.4 %

*Relative Standard Deviation
**Confidence Interval

*Whiteley, Greg; Moving Forward with ATP Testing for Cleanliness Monitoring and Hygiene Standard Setting. The Journal of Cleaning, Restoration & Inspection; 5:(2) 28-33, 2016

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Effect of Temperature on 3M Instrument

Six ATP Field Blanks

	72 °f	100 °f
Range	10 - 12	7 – 14
Average	10.6	9.8
RSD*	7.7%	24.2%

*Relative Standard Deviation

"Field" Temperature
- Slight effect (7.5%) on average RLU
- 314% increase in variability

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Test Variability v Field Variability of 3M Instrument

SOURCE	CONDITION	RSD
Whiteley	Test Solution	7.4%
Spurgeon	Field Blanks	7.7%
Spurgeon	Field Tests*	15% - 20%

*Uncontrolled for temperature effects

Whiteley, G.: Moving Forward with ATP Testing for Cleanliness Monitoring and Hygiene Standard Setting. IICRC Journal, p. 28; April, 2016

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Variability of ATP & Microbials

Controls: Six Cardboard Boxes

	ATP (RLU)	FUNGI* (CFU)	HPC (CFU)
Range	18 - 48	1.5 - 3	1.5 - 3
Average	31.7	0.8	0.8
RSD*	41.7 %	38.7 %	38.7 %

RSD for ATP was equivalent to the RSD for culturable fungi and bacteria

*Only *Stachybotrys chartarum* and *Penicillium corylophilum* were detected

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Variability of Field Measurements

Three Sweaters: Replicate Samples

	Back	Front
Range (RLU)	30 - 75	275 - 317
Average (RLU)	50	292
STDS (RLU)	22.9	22.1
RSD*	45.8 %	7.6 %

*Relative Standard Deviation

Standard deviation was relatively constant

Relative deviation decreased with the average RLU

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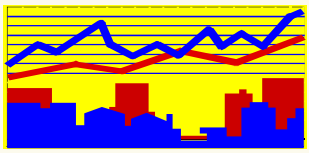

Comparison of ATP and Microbial Concentrations

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Average Values: Final Condition

MATERIAL TYPE	NUMBER	ATP (RLU)	FUNGI (CFU)	HPC (CFU)
Paper	21	60	1.0	68
Cotton	30	94	13	381
Plastic	14	113	0.3	2
Leather	29	129	155	85
Synthetic	5	153	2.3	860
Wool	7	159	0.3	2.3
Wood	6	239	357	2,026
Silk	9	246	0.6	48

Single criterion for ATP applied to all materials
All assessed as having acceptable ATP values

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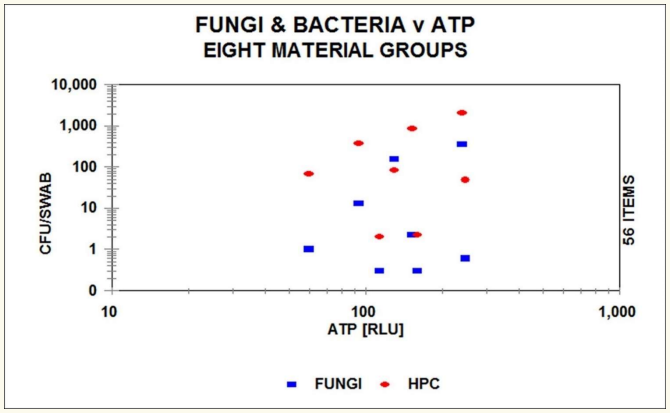
Correlation by Group at Final Condition



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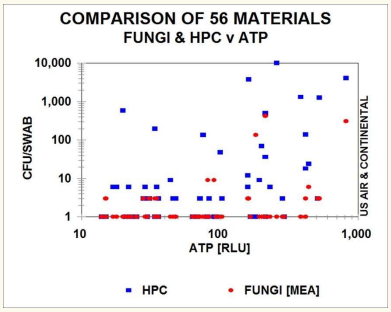
Correlation by Item at Final Condition



PARAMETERS	r-Values
Fungi v ATP	0.40
HPC v ATP	0.37
Fungi v HPC	0.21

Poor correlation between RLU values and microbial concentrations

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Questions?

Joe Spurgeon, Ph.D.
jospur46@gmail.com

www.expertonmold.com

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