Structural Pasteurization:

A Case Study of State-of-the-Art Technology

for Remediation of Water Damaged and Pest Infested Buildings

Allison Taisey, BCE

Northeastern IPM Center
Cornell University

Sean P. Abbott, Ph.D.
Natural Link Mold Lab

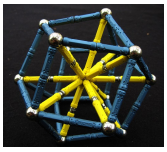
Dave Hedman, CEO
ThermaPure™ Heat

LEADING THE NATION TO HEALTHY HOMES, FAMILIES, AND COMMUNITIES

Dave Hedman, CEO
ThermaPure™ Heat

David Hedman is the co-inventor, and patent holder, of the new ThermaPureHeat process for pasteurizing buildings. The National Society of Professional Engineers awarded the technology as the "Best New Product in the Nation" for insect application. The ThermaPure process has been used in the remediation of anthrax, Hantavirus, mold sites, and many other biological contaminates. David received his academic training at Stanford University in Engineering and Economics. David has received extensive flight training, and is currently a licensed commercial pilot.

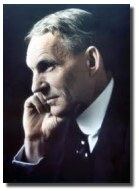
New Technology



Without changing our patterns of thought, we will not be able to solve the problems we created with our current pattern of thought.

Albert Einstein

Overview of ThermaPureHeat®



"If I had asked people what they wanted, they would have said faster horses."
Henry Ford

- **New Technology**
  - **Patented**
  - **Chemical Free – "Green"**
- **Pasteurization of Structures**
  - **Historical Perspective**
  - **Not Sterilization**
  - **Lethal Temperatures**
  - **Benefits of Technology**
  - **Target Markets**

Overview of ThermaPureHeat®

- **Engineered Application of Heat**
  - **Whole Structure**
  - **Portion of a Structure**
  - **Contents/Containers**
- **Purpose**
  - **To Dry Structures**
  - **To Kill Target Organisms**
  - **To Improve Indoor Air Quality**

ThermaPure Certified

- Company and Individual Heat Technician Certification
- Qualifications
  - Certified Heat Technicians are the most thoroughly trained and qualified in the industry
  - All practical field methods are tested
- Training
  - Training manual that is over 300 pages of science and experience
  - Technicians successfully complete ThermaPure® training with both classroom and field application

Special Equipment

- Fans
- HEPA Filtration
- Heaters
  - Indirect Fired
  - Direct Fired
  - Hydronic – Heat Exchangers
  - Electric
  - Infrared
- Heat Damage Materials
- Portable Ducting System
- Temperature Monitoring Equipment
- Moisture Monitoring Equipment

Need for Green Technology

31 Jan 2011, TRENTON - An $860,000 penalty was imposed today by the Department of Environmental Protection on TVF Pest Control of Newark for misapplication of hazardous pesticides in residences to control bedbugs, Commissioner Bob Martin announced.

"This is an issue of public health and welfare," said Commissioner Martin. "Bedbug infestation is a growing problem in New Jersey and across the nation. The DEP is sending a strong and clear message in this case that when companies put residents at risk by intentionally misusing pesticides in dealing with bedbugs they will be dealt with severely."

Pasteurization

Prior Research:

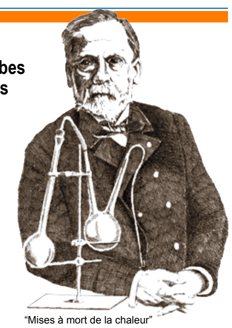
- Louis Pasteur 1854-1864
- Pasteurization of liquids and food
- Pasteurization of soils
- Wastewater management
- Heat treatment of wood in lumber industry

Thermal Death Point:

- Function of temperature and duration coupled with biomass and environmental factors.

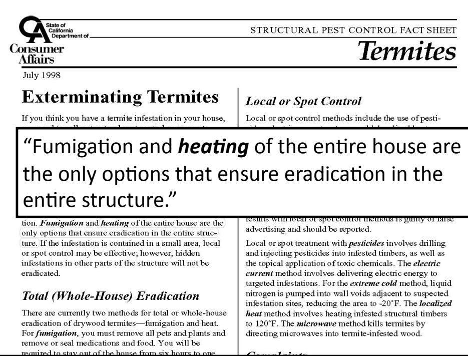
What Is Structural Pasteurization?

- Structural Pasteurization
  - A process to reduce indoor microbes and chemicals to acceptable levels without damage to the structure.
- Engineered Application of Heat
  - To a Structure
  - To a Portion of a Structure
  - To the Contents
- Purpose
  - To Dry Moist or Wet Structures
  - To Kill Target Organisms
  - To Improve Indoor Air Quality



"Mises à mort de la chaleur"
L. Pasteur, 1862

Structural Pest Control Board



STRUCTURAL PEST CONTROL FACT SHEET

Termites

July 1998

Exterminating Termites

Local or Spot Control

"Fumigation and ***heating*** of the entire house are the only options that ensure eradication in the entire structure."

tion. *Fumigation* and *heating* of the entire house are the only options that ensure eradication in the entire structure. If the infestation is contained in a small area, local or spot control may be effective; however, hidden infestations in other parts of the structure will not be eradicated.

Total (Whole-House) Eradication

There are currently two methods for total or whole-house eradication of drywood termites—fumigation and heat. For *fumigation*, you must remove all pets and plants and remove or seal medications and food. You will be

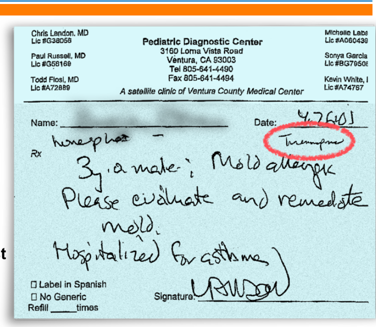
advertising and should be reported.

Local or spot treatment with *pesticides* involves drilling and injecting pesticides into infested timbers, as well as the topical application of toxic chemicals. The *electric current* method involves delivering electric energy to targeted infestations. For the *extreme cold* method, liquid nitrogen is pumped into wall voids adjacent to suspected infestation sites, reducing the area to -20°F. The *localized heat* method involves heating infested structural timbers to 120°F. The *microwave* method kills termites by directing microwaves into termite-infested wood.

ThermaPureHeat

Prescription

Dr. Chris Landon, MD
Pediatric Pulmonologist



Allison Taisey, BCE

Northeastern IPM Center
Cornell University

Allison Taisey is a board certified entomologist whose mission is to help the US housing industry reach the point where no resident is living in a high-level infestation of public health pests. Through a HUD-USDA interagency agreement, she runs the StopPests in Housing Program for the Northeastern IPM Center at Cornell. Outside of her work at Cornell, she has worked for the NYC Department of Health, Modern Pest Services, BedBug Central, and the National Center for Healthy Housing. Allison is an active member of the Entomological Society of America, the National Pest Management Association, and Pi Chi Omega.

Pest threats to your structure

Photo credit: Scott Bauer
USDA-ARS, Bugwood.org

- Termites
- Carpenter Ants
- Carpenter Bees
- Decay Fungi
- Wood Boring Beetles

CA 5 Year Study

Conducted by Dr. Vernard Lewis U.C. Berkeley Phase 2, Efficacy Study, *Villa Termiti*

Lumber Dimension	Board Length (cm)	Location	No. Alive	No. Dead	Percent Mortality
1 by 8	151.1	Attic	0	201	100
1 by 8	219.7	Attic	0	783	100
4 by 4	94.	Attic	0	160	100
1 by 8	144.8	Wall	0	289	100
1 by 8	178.6	Wall	0	106	100
2 by 4	221.0	Wall	0	149	100
1 by 8	104.1	Subarea	0	465	100
1 by 8	177.8	Subarea	0	350	100
1 by 4	91.4	Subarea	0	70	100
Test 1 Overall Values			0	2,573	100

Other pests

- Rodents
- Bed Bugs
- Cockroaches
- Fleas
- House Dust Mite

Bed Bugs

"There's absolutely no reason to think that this bed bug problem is going to subside on its own. When you look at where we'll be in two years' time and the rate of increase it's going to be very serious. This is the most challenging pest problem for the developed world in a generation."

-Dr. Michael Potter, University of Kentucky

Integrated Pest Management

1. Inspect and monitor
2. Identify
3. Determine the scale of response
4. Respond
   - Biological control
   - Non-chemical control (ex: ThermaPureHeat®)
   - Changing people's behavior
   - Chemical control
5. Evaluate effectiveness

STOP Pests in housing

www.StopPests.org stoppests@cornell.edu @StopPests facebook.com/StopPests youtube.com/user/StopPests

Sean P. Abbott, Ph.D.

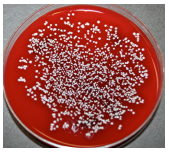
Natural Link Mold Lab

Sean P. Abbott, Ph.D. is a microbiologist specializing in indoor contamination issues and President of Natural Link Mold Lab in Reno, Nevada. Dr. Abbott has lectured for the University of Nevada, Reno, Medical Microbiology and Immunology Graduate Studies program, and has taught Fungal Biology and Medical Mycology at the University of Alberta, Edmonton, Canada. With over 20 years experience, Dr. Abbott has 30 publications including research on airborne biological hazards, microbial contamination of the indoor environment, and opportunistic human pathogens. Current research interests include antimicrobial efficacy testing, insect/arthropod vectors of microbes, and indoor environmental quality (IEQ) monitoring.

natural link MOLD LAB

The Science

- **Overview: Structural Pasteurization**
- **Thermal Death Points**
- **Antimicrobial Efficacy**
  - **Historic and Current Research**
  - **Bacteria, Fungi, Viruses, Protists**
  - **Allergens**
- **Aerosol Generation and Capture**
  - **Odors and VOC's**
- **Health Effects**



Thermal Death Point

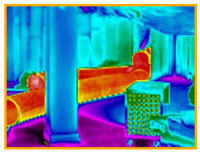
Thermal Death is a function of Temperature and Duration

Therefore: higher temperatures for short times achieve similar results as lower temperatures for longer times

Thermal death point temperatures and time duration achieved in laboratory conditions may not produce the same results in the field because field conditions include more complex variables.

Structural Pasteurization

- **60-65 C (140-150 F) for 2-4 Hours**



Thermal Death Point Insects & Protista

Specimen	Temp. (F)	Time	Reference
Adult German Cockroach	120 F	27 Min	Forbes & Ebeling, 1987
Bedbug – Adults and Nymphs	113 F (45 C)	15 Min	Gulmahamad 2002
Bedbug - Eggs	113 F	60 Min	Gulmahamad 2002

Cryptosporidium parvum	72.4 C/ 1 Min	Fayer (1994)
Giardia lamblia	50 C/ 1 Min	Cerva (1955)
Entamoeba hystolytica	60 C/ 1 Min	Chang (1943)

Thermal Death Point Fungi

Target Contaminate	Lethal Temp	Duration	Reference
Wood Fungi (Staining Fungi)	151F / 66C	75 Minutes	Compendium of Soil Fungi, pg., 106 (Chidester, 1937, 1939)
Basidiomycotina	122F / 50C	N/A	Compendium of Soil Fungi, pg., 107 (Hulmes, Franks)
Poria – Wood Eating Fungi	151F / 66C	75 Minutes	Compendium of Soil Fungi, pg., 106 (Chidester, 1937, 1939)
Fomes (*Fomitopsis rosea*)	151F / 66C	75 Minutes	Compendium of Soil Fungi, pg., 106 (Chidester, 1937, 1939)
Stachybotrys chartarum	140F / 60C	30 Minutes	Compendium of Soil Fungi, pg., 745
Aspergillus alutaceus	144F / 62C	20 Minutes	Compendium of Soil Fungi, pg., 82
Aspergillus candidus	144F / 62C	N/A	Compendium of Soil Fungi, pg., 84
Aspergillus ustus	144F / 62C	25 Minutes	Compendium of Soil Fungi, pg., 119
Aspergillus niger	145F / 63C	25 Minutes	Compendium of Soil Fungi, pg., 103
Alternaria alternata	145F / 63C	25 Minutes	Compendium of Soil Fungi, pg., 103

Thermal Death Point Bacteria

Aeronomas hydrophila	50 C/ 3 Min	Gordon (1992)
Campylobacter spp.	75 C/ 1 Min	Bandres (1988)
Escherichia coli	65 C/ 1 Min	Bandres (1988)
Legionella	66 C/ 45 Sec	Sanden (1989)
Mycobacterium avium	70 C/ 3 Min	Robbecke (1992)
Salmonella spp.	65 C/ 1 Min	Bandres (1988)
Shigella spp.	65 C/ 1 Min	Bandres (1988)
Vibrio cholera	55 C/ 1 Min	Roberts (1979)
Yersinia enterocolitica	60 C/ 30 Min	Frazier (1988)

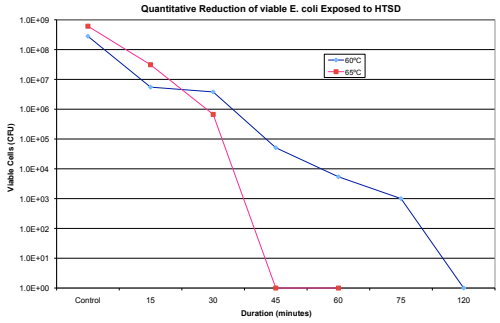
Structural Pasteurization

Research implications (Abbott et al, 2011[1]) :

- Convective dry heat can be used to sanitize building materials *in situ*
- Typically used in conjunction with structural drying and traditional microbial remediation
- Allows sanitization of entire structures, portions of structures, contents
- Provides hygiene benefits by reducing overall levels of microorganisms in indoor environments
- Reduce risk of bacterial disease transmission
- 'Green' process, no antimicrobial chemicals, no development of resistant bacterial strains
- Mortality of *E. coli* – Attained at 60°C (140°F) for 2 hours

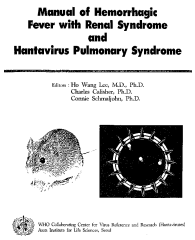
[1]Abbott, S.P., L. Chase and M.C. Villines. 2011. Efficacy of structural pasteurization for reduction of viable bacterial levels in indoor environments. Proceedings Indoor Air 2011, 583:1-6.

Bacterial Reductions



Viruses

- Hanta Virus dies at 140° in 30 minutes
  - Manual of Hemorrhagic Fever and Hantavirus Pulmonary Syndrome. World Health Organization. Pg. 196.



Allergens: Dust Mites, Molds

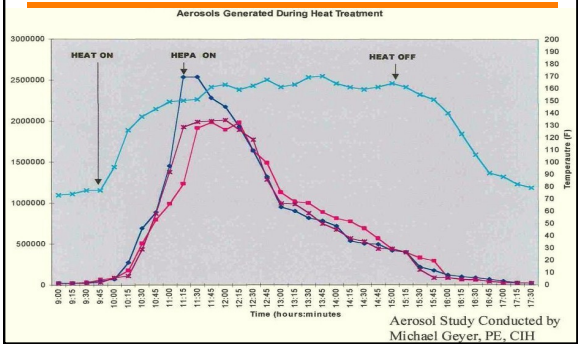
- Thermal Death – Dust Mites
  - >60 C (140°F) - >60 Minutes
- Allergen Denaturing
  - Dust Mites - Der f1
  - 80 C / 176°F - 60 Minutes reduced to 12% of Control[1]
  - Gradual Curve Starting at 140°F
- Other Allergens - Molds
  - *Aspergillus fumigatus*
  - May be affected similarly

[1]Cain, G. et al. 1998. The effect of dry heat on mite, cat, and dog allergens. Allergy.

Engineered To Manage Aerosol

- Many Microorganisms are Associated with Airborne Transmission – Aerosol Transmitted Disease
  - Bacteria – *Mycobacterium*, *Streptococcus*, *Staph. aureus*
  - Viruses – Norovirus, Rotovirus, Adenovirus, H1N1
  - Fungi – *Aspergillus*, *Cryptococcus*
- Aerosolized particulates – biological and non-biological
  - Respiratory hazards (allergens, toxins, irritants)
- Capture of aerosolized particles important part of building sanitation, through use of HEPA filtration

Aerosol Management



Odors and VOC's

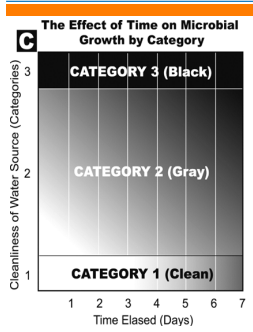
- Odors correspond to chemicals dissolved in air or Volatile organic compounds (VOC's)
- Off-gassing from building materials increases in wet structures
- mVOC's from microbial growth
- Heating increases volatilization and can eliminate odor sources

- Temp. 110 - 130ºF
- Vapor pressure differential
- Hours to days
- Move as much air as possible
- Maximize exhaust
- Air scrub with carbon filtration

Potential Applications of Structural Pasteurization

• Sewage loss in buildings	➢ E. coli, fecal coliforms
• Floodwater contamination	➢ Bacteria, fungi, virus, protists
• Water-damaged buildings	➢ Mold, bacteria
• Insect infestations	➢ Bed bugs, dust mites, etc.
• Hospitals and Health Care	➢ MRSA, Legionella, virus
• Schools and Day Care	➢ Bacteria, virus
• Food Processing and Agricultural facilities	➢ Bacteria, fungi, virus, insects
• Overall building hygiene	

Effect of Time on Contaminants



FACT: *Microorganisms are always present in the indoor environment.*

A ***Whether water is categorized*** *as clean, gray or black, when there is a water intrusion and ...*

B ***... it is not responded to promptly, microorganisms will amplify.*** *While the amplification will not be immediately noticeable, the greater the length of time, the greater the amplication.*

C ***With the passage of time,*** *microorganisms present in any category of water intrusion will begin to amplify.*

IICRC 500 Standard, Page 88

Survival on Surfaces

Contaminant	Type	Typical Survival w/ o Sanitization
Echovirus / Rotovirus	Virus	Up to 3 weeks / months
E. coli	Bacteria	Over 10 months
Enterococcus faecalis	Bacteria	Up to 16 weeks
Cryptosporidium parvum	Protist	Up to 6 Months
Mold spores	Fungi	Months to years

Health Effects In Damp Buildings

- In the Aftermath of Katrina - "Workers and Returning Residents Should Use Appropriate Personal Protective Equipment and Exposure Mitigation Techniques to Prevent Morbidity and Long-Term Health Effects." (Solomon 2005)
- Presence of Mold Odor in a Home was Associated with a 2.4 fold Increased Incidence Rate of Asthma Among Children. (Jaakkola et al. 2005)
- 10% chance of Asthma to a child Increases to 14% chance in a Damp Structure. (Burge 2007)
- IOM Committee concluded in 2004 that there is Sufficient Evidence of a Causal Link between Indoor Dampness and Upper Respiratory Tract Symptoms, Cough, Wheeze, frequency and severity of Asthma Symptoms (IOM 2004)

ThermaPure® Case Studies

- Precision Environmental
  - Brooks Institute
  - Tropicana Gardens
  - Yosemite Park

"Our perspective is that not everyone has deep pockets so we need to offer customers an alternative and let them decide how to manage risk."
ThermaPure Licensee

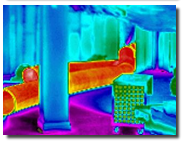
"You can't build a reputation on what you are going to do."
Henry Ford

Case Study
Brooks Institute

- Storm water, sediment and other debris impacted a large percentage of the buildings.
- Preliminary testing revealed elevated mold spore counts and high moisture levels.
- School didn't want to have facility shut down during school year.

Case Study
Brooks Institute

- High temperatures used to dry and pasteurize the structure.
- Removal of carpeting and materials reduced.
- Completed in two weeks.
- Met fungi and bacteria clearance requirements.
- Thousands of dollars saved.
- Business interruption reduction was significant issue.



Case Study
Tropicana Gardens

- General upgrade to facility
  - Significant moisture issues
  - Mold and bacteria
  - Termites

- Minimal disruption to summer use of facility
- Time constraints - project needed to be completed during summer
- Budget

"I wanted to be able to tell parents that we had taken care of the mold problem everywhere we had found it because we had used the process throughout the property,"

Kent Dunn, Project Manager, Tropicana Gardens

Case Study
Tropicana Gardens

- Physical removal of biomass and damaged materials
- ThermaPureHeat® to dry moisture and reduce mold, bacteria and insects.
- $4.5 million saved in total costs.
- No loss of summer use revenue.
- Facility open at start of school year.

Case Study:Yosemite Park:
Hantavirus Disinfection

- Deadly Hantavirus Pulmonary Syndrome
- Yosemite National Park
- 44 Separate Buildings
- NPS Chemical Free Objectives
- Preservation of Native Rodents

Case Study:Yosemite Park:
Hantavirus Disinfection

- Met Efficacy Requirements
- Met Chemical-Free Objectives
- Inaccessible Areas
- Repeat Projects
- Preserved the Little Varmints

More Case Studies…

- Multi Symptom home
- Formaldehyde Bake-Out
- Unknown Target in School
- Custom Home in Orange County

"Our perspective is that not everyone has deep pockets so we need to offer customers an alternative and let them decide how to manage risk."
ThermaPure Licensee

"You can't build a reputation on what you are going to do."
Henry Ford

Case Study: Mold, Bacteria and Pest Remediation

- **Mold, Rodents, Flies,Termites, Asbestos**
  - **Single-Family Residence**
  - **Property Condemned By City of Thousand Oaks**
  - **Reclusive Tenant**
  - **Mold, Rodents, Flies, Termites**
  - **Saturated Walls and Flooring**
  - **Downright Nasty!**

Case Study: Mold, Bacteria and Pest Remediation

- **Mold, Rodents, Flies, Termites, Asbestos**
  - **Mold Spores Reduced To Less Than 1/3 of Background**
  - **Moisture Reduced <15%**
  - **Termites Killed**
  - **Odors Reduced**
  - **Bacteria Destroyed**
  - **Property Saved**

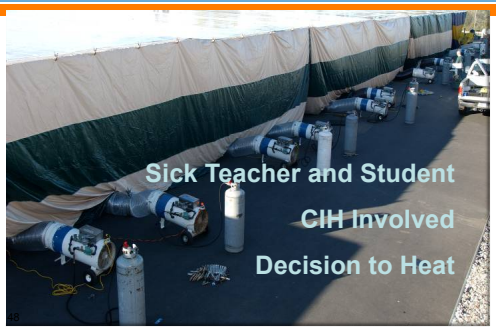
Case Study: Formaldehyde Bake-Out

- **6 Month Old Residence**
- **Strong Odor Present - Off-gassing Suspected**
- **Multiple Health Issues**
- **Family was Forced to Move Out**
- **Builder Wanted to Solve Problem**

Case Study: Formaldehyde Bake-Out

- **Builder Wanted 1-Day Heat Application**
- **Heated at 160ºF**
- **Heated for 6 Hours**
- **Odors Eliminated**
- **Formaldehyde Levels Reduced 54%**
- **85ppb to 39ppb**
- **Family Returned**

Case Study: Unknown Target – School

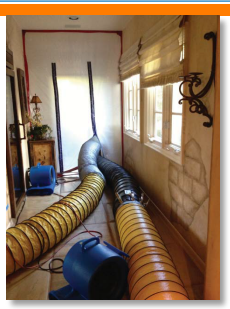


Case Study: Unknown Targets – School

- No Damages to Structures
- School's Staff & Kids Felt Better
- Provided a Solution

Case Study: Custom Home in Orange Co.

- Water loss from Bath line ran all night
- Custom built home
  - Hand painted murals
  - Specific finishes
  - Complex construction
  - Fire Sprinklers
  - Wine cellar
  - Enhanced security system



50

Case Study: Custom Home in Orange Co.

Location	TPH Actual Xactimate	Traditional Xactimate	$ Savings	% Savings	Other Costs
Custom Home – Orange Co.					
Water Extraction - Structural Drying	$ 27,087	$ 8,666	$ (18,421)	-213%	
Reconstruction Costs		$ 42,889	$ 42,889	100%	
Additional Living Expense (ALE)	$ 750	$ 10,500	$ 9,750		
Secondary Damage - Mold or Bacteria					Unknown
Time Required to Pre-Loss Condition	3 days	42 days			
Totals	$ 27,837	$ 62,055	$ 34,218	55%	$ 51 -

Questions and Discussion

Thank You

StopPests in Housing

- Rachel Riley, Government Technical Representative
- U.S. Department of Housing and Urban Development's Office of Healthy Homes and Lead Hazard Control
- U.S. Department of Agriculture's National Institute of Food and Agriculture
- Promoting Integrated Pest Management in Affordable Housing: USDA Special 2012-04039

Northeastern IPM Center

For more information

Allison Taisey
- stoppests@cornell.edu
- facebook.com/StopPests
- @taiseybug | @StopPests
- www.stoppests.org

Sean P. Abbott, Ph.D
- Natural Link Mold Lab, Inc.
- sabbott@naturallinkmoldlab.com
- www.nlmlab.com

Dave Hedman
- davehedman@yahoo.com
- 805.641.9333
- ThermaPureHeat.com