Michael Geyer, PE, CIH, CSP
Hot, Hot, Hot; Using Heat for Remediating Buildings

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This week we welcomed Michael Geyer of KERNTEC Industries in Bakersfield CA to discuss the use of heat in remediating residential and commercial buildings. Mr. Geyer has 30+ years of hands-on experience in construction, engineering, and environmental sciences Mr. Geyer has worked on thousands of tasks over the course of hundreds of projects, some exceeding $80-million in value.

He is an expert in mitigating chemical-biological contaminants in buildings, conducting property conditions assessments, improving indoor air quality, mitigating vapor intrusion, characterizing landfill gas, and building off-grid homes.

His unique construction experience has been valued by developers building on compromised property (e.g., Brownfields) with known chemical or biological hazards. He specializes in high-hazard construction efforts and those impacted with methane, hydrogen sulfide, hazardous chemicals, and biological contamination.

Nuggets mined from today's episode:

When did you first use heat for remediation? After working in construction trades for several years Michael decided to go to college. Arriving at college in the mid 1970s with $50 in his pocket; he worked his way through college replacing wet rotten bathrooms in off-campus student housing. Young and feeling invincible, he removed wet moldy materials without PPE and used heaters and fans to speed dry and reduce construction time requirements. On one project, the fire department showed-up when a neighbor saw black smoke (black dust & mold spores) exiting a window. He got pneumonia twice from high exposure to mold spores.

After finishing college he went to work in the environmental field and learned about lead, asbestos, heavy metals, etc. Dave Hedman, from Precision Environmental, approached Michael for assistance in developing a patent. Michael describes Dave Hedman as a visionary who combined methods from HAZMAT abatement with engineering, safety requirements and heat to remediate buildings. Michael assisted Dave in developing the Therma Pure processes. 20% of heat remediation is "art". While anyone can apply heat technology and dry a single family home, they'll "booger-up" bigger jobs if they try to deploy the same methods when different circumstances warrant a different approach.

What is your definition of thermal remediation? It is analogous to pasteurization. For example: Dirty milk run through a pasteurizer becomes healthy milk. Materials, structures and spaces can be "pasteurized" through the use of heat. Whereas pasteurization doesn't remove organisms from the milk, it denatures them, HEPA filtration can be used to remove airborne particles released during a heat-treatment project.

What are your strategies when deploying heat as a remediation tool? Different projects warrant different temperature range requirements; Michael uses 3 different temperature ranges.

1. ***"Bake-out"*** is a gentle heat-treatment method with the goal of driving-off volatile and semi-volatile hydrocarbons that may be present. A bake-out typically involves lower temperature targets (<125F max), over an extended period of time (days or weeks), with elevated air-exchange rates during the treatment effort. "I use this method most often after a recent construction effort and the new materials and furnishings are afflicting a person who has sensitivity to VOCs." The goal is not to dry or kill anything, just accelerate off-gassing the offensive chemical vapors. Over the course of a few days, the bakeout process lowers formaldehyde emissions to what would be expected after a year or two of normal aging/off-gassing.
2. ***"Dry-out"*** is performed on water-damaged buildings. A Dry-out involves higher temps: target temperature of 155°F +/- Δ5 held at 60-120 minutes Depending upon the thermal mass and volume of the structure it takes 24- to 72-hrs or more to complete –depending upon how moist the structure is, with moderate air exchange. More often than not, gross water is extracted

and saturated building materials are removed prior to heat-treating. A "Dry-out" useful in wet structures and/or mold remediations is quickly attained with a saturation temperature of 155°F. To effect biological control Its important that heat have the opportunity to transfer into materials raising their temperature to 155°F including interstitial spaces. At these elevated temperatures the building will dry out and microbial growth will not amplify. This is the important difference between incubation temperature and lethal temperature. Incubation temperature amplifies microbial growth and lethal temperature destroys microbes. All buildings have a built-in biological load. Heat treatment can reset the biological clock. Restoration firms relying upon dehumidifiers for drying, remove wet materials and begin to clean. They can't completely clean interstitial spaces between sole plate and studs, fire blocking, etc. Heat drying is also great for architecturally important buildings and can reduce soft demo. The heat raises temperature which raises vapor pressure which pushes moisture into the air where it can be removed.

3. *"Bio-kill"* A third strategy is to affect a biological kill of a Group A pathogen, an infectious disease.*. *["Group A streptococci are extracellular bacterial pathogens which produce a variety of pyogenic infections involving the mucous membranes, tonsils, skin, and deeper tissues, including pharyngitis, impetigo/pyoderma, erysipelas, cellulitis, necrotizing fasciitis, toxic streptococcal syndrome, scarlet fever, septicemia, pneumonia, and meningitis. Pathogenesis of Group A Streptococcal Infections Madeleine W. Cunningham*]* With this strategy killing pathogens is the priority and collateral damage to furnishings and building materials is a secondary concern. In a residential structures a temperature of 195°F is attained and maintained for 24-48 hours. This elevated temperature will kill most pathogens and remediation workers can, more often than not, wear Level-C PPE Ensemble rather than the Level-B if clearance sampling proves it is safe. Moreover, the obnoxious odors of putrescine and cadaverine are gone. While not claiming to be a sterilant, post heat-treatment microbial counts can be reduced to 1-2 CFUs per CM^2 or less. "I have yet to use heat

to kill-off anthrax spores. They are VERY heat-tolerant. I use a different approach to kill heat-tolerant spores."

Distribution Uniformity. In order to be effective using heat as a treatment method, success is highly dependent upon the distribution uniformity of the heat. Hot air tends to rise to the ceiling and it is cooler at the floor elevation. This stratification must be eliminated if heat-treatment is to be effective – the whole structure, as best possible, needs to be heated uniformly. In order to accomplish this, a significant number of fans need to be placed inside the structure to eliminate stratification by creating very turbulent air currents inside the space being heated. Most failures I see in heat-treatments is often due to the remediation contractor not installing a sufficient number of interior fans. Distribution uniformity is key!!!

How to blow hot air. Installing a lot of fans inside a structure during a heat-treatment creates very aggressive air turbulence. This will create A LOT of airborne particulate matter (PM). I want to emphasis … A LOT!!! In order to control the PM heat-tolerant HEPA-filtered fan units need to be deployed inside the structure concurrently with deploying the heat. Fans run continuously during heating and continue to operate during the entire cool-down process. While this may sound a bit complicated, it is very easy to do. That said, this is the second most frequent failure I see during heat-treatments – insufficient air-scrubbing/filtering. The consequence … lots of PM everywhere. I have testified against several contractors that have failed to control the aerosol/PM from their remediation efforts. Given how easy it is to control airborne PM, there is no excuse not to. Home-owners re-entering into a "dusty" home often will become ill really quickly. Inhaling excessive PM will cause all sorts of allergic-like reactions. In one case, it almost proved fatal.

Incubation temperature versus lethal temperature. In a water-damaged building, the ramp-up (or increase) in temperature is critical to control/achieve. 90F to 110F is ideal temperature for explosive growth and amplification of molds, bacterial, protozoa, etc. This "incubation" temp needs to be moved through as quickly as possible to avoid bio-amplification. Not hard to achieve, but needs attention to detail to be successful.

How many fans should be used when heat-treating a house? The goal is aggressive air turbulence, most contractors don't use enough fans. One fan for average size bedroom, larger rooms and rooms with higher ceilings require more. Michael likes to place fans on the floor pointing toward the ceiling. High ceilings sometimes require pedestal fans. Hot air is a poor way to transfer BTUs and will generate particulates. Michael recommends fans be equipped with heat-tolerant filters suitable for use at high temperatures and axial fans move more air (more CFM) than squirrel cage fans.

A customer named "Allen". Allen (an MCS sufferer) commissioned his new home be built with low emission building products, plaster-coated walls and ceilings, ceramic tile floors, etc., etc. After completion, Allen couldn't enter the home without his skin flushing red and difficulty breathing due to off-gassing VOCs. After exhausting other remedial options, Allen contacted Michael. Michael felt the finish on the wood cabinets might be causing the VOCs. Using fans, multiple propane heaters and a single manifold exhaust duct; Michael began applying gentle heat 120°F to the home. Multiple fans provided turbulent air which prevented stratification. After several days Michael's photoionization detectors (PID) confirmed levels were significantly reduced and now within acceptable parameters. On days 7 & 8 Allen still reacted at a 20' distance from the 24" exhaust flex-duct. On day 11 Allen didn't react at a distance from the exhaust and Allen slowly approached the exhaust duct and placed the exhaust duct over his head for several minutes. His head emerged from the duct and he said "the smell is gone and I can breathe". The house was allowed to slowly cool down and the doors and windows were opened. Allen walked all through the home without reacting and felt he could finally safely move-in to his new home..

Bonehead moment. It was winter and a new 60' x 220' building was under construction in a northern latitude. It was in early stages of framing when it got hosed by a rainfall event which turned into a snow-fall. The building had a 60-in high crawlspace where mold was beginning to grow from the trapped moisture. The outdoor temperature was 20°F. Snow was shoveled off the tongue and groove OSB subflooring above and heat was applied to the crawl space below. Propane fueled direct-fired heaters were what was available for the project. The drying plan was to blow hot air through one end of the crawlspace and exhaust through an opposing stem-wall. NOTE - Water vapor is a byproduct of burning

propane! Given that the outdoor temperature was 20F and the building materials were 20F, the condensing water vapor became snow at the far end of the crawlspace. After shoveling the snow out of the crawl space, Diesel generators and electric heaters were used to dry the building.

Safety is an important consideration on heat remediation projects.

- Techs will periodically need to enter and exit spaces being treated to adjust fans and exhaust duct placement based on temperature profiles.
- Techs should wear heat monitors and CO monitors.
- Use of remote temperature sensors is a must ….lots of them.
- Worker exposure to significant heat 140°F for more than 3-5 minutes is a hazard that needs careful planning to maintain safety.
- The higher the temperature the lower the worker exposure time.
- Dry-out target temperatures of 155°F +/- Δ5 are held at 60-120 minutes.
- Engineer hot air in and engineer exhaust air out. Hot dry air is a poor way to transfer BTUs, but it works if properly deployed
- HEPA fans need heat-tolerant filters.
- Confined space consideration and safety concerns.
- Projects need an awake and aware operator on site 24/7
- CO is a big issue around direct fired heaters,
- Need to check for fuel leaks with LEL meters.
- When high temp is being utilized workers should wear cooling vests.
- When using indirect heat, GFIs, watertight connections, to protected from the elements (wet ground, etc.).
- Security, big openings needed for ducting warrant 24/7 attention.
- Fire watch is a must.

Be aware of heat intolerant materials!

- Stay under 165°F with heat intolerant materials.
- Sensitive building materials to high heat include: fresh paint, new flooring, plastic laminates, glue-joints in fresh cabinetry, etc.
- Draperies and window treatments, rubber seals on windows, rubber seals within ABS plumbing drains can also be a heat intolerance issue.

Lingering odors? If odors remain after heat-treatment, typically it is an indicator that the heat-treatment was not effective, e.g., poor distribution uniformity? Or growth and amplification of a biological? Not sure? If heat is deployed properly, there should be no odors post-treatment. This said, I once deployed heat to a home in a bake-out, and post-treatment there was a horrible odor. A quick assessment and we found the baby-diaper pail half-full of composting diapers that were rank … and that is putting is nicely. We failed to identify it prior to deploying the heat. Things like that should be removed prior to heating a space. All heat-intolerant items need to be removed or protected prior to heat-treating. Diaper pails are now on our checklist. Once that pail was removed and the home ventilated, no other odor was present.

Final comments:

- Bakeout is inappropriate for wildfire related odors; bakeout does not remove fire related particulate.
- Pick your battles … heat is not effective in all circumstances.
- Inexperienced contractors using heat in multi-unit buildings can inadvertently drive moisture, insects, etc. from one unit to another. Insects die at 127°F-132°F, they know it, and when threatened will crawl away to safety
- Heat remediation is 50% common sense, 30% science and 20% art.
- Heat remediation is flexible, scalable and non-chemical.

Z-Man signing off

Trivia:

Name the 1953 novel presenting a future American society where books are outlawed and “firemen” burn any that are found?

Answer:

Fahrenheit 451 by Ray Bradbury

Answered by Doug Kohnen