ARE YOUR HEPA FILTERS DOING WHAT YOU EXPECT THEM TO?

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The term HEPA (High Efficiency Particulate Air) Filter usually instills a level of comfort and confidence in those in the asbestos. lead, mold and radon remediation industries. HEPAs can be found in our AFDs (Air Filtration Devices) often used as air scrubbers and NAMs (Negative Air Machines), HEPA vacuums and even in our respirator filters. Basically, we use them anywhere that contaminated air is being moved. However, we recently found one instance where the HEPAs were the remediator's worst enemy !

Case History

Approximately 9 months ago, a fire occurred in a second floor condominium. Some water had been trapped in the 1st floor ceiling cavity as a result of the fire fighting efforts on the second floor. The trapped water was not properly dried out and resulted in extensive mold growth between the first floor and second floor units. Initial, pre-remediation mold sampling results showed very high levels of *Penicillium* mold spores in the air in first floor unit, even though very little mold was visible. Given these very high airborne mold spore levels, the mold remediation contractor was required to remove all the water damaged and moldy drywall. As a cleaning step in the mold remediation process, the mold remediation contractor was also required to "air wash" the condominium. After the air washing, a visual inspection was conducted of all remediated surfaces prior to allowing the contractor to apply a mold inhibiting sealer paint to the wood studs and ceiling joists.

A Problem Arises

After the surface sealing, post-remediation verification (PRV) air testing was performed. The air testing showed that remediation had reduced mold spore levels over 99%. However, the air testing results show that excessive mold spores were still present in the air in the unit. This result was unexpected, given that the visible inspection showed no mold growth remaining, all building surfaces had been dry for over 6 months and they had been sealed with a high quality mold inhibiting coating, and especially since the condominium had been air washed There simply was no likely place mold could still be growing.

Consequently, we decided to conduct some research into why this remediation failed PRV air testing. Very little research data exists about levels of mold spores and levels of particulates during mold remediation and air washing. This project gave us an opportunity to establish some documented information on these two parameters.

A recleaning date was scheduled with the remediation contractor. In order to conduct this research and document the effectiveness of the recleaning process, it was planned to measure both airborne particulate levels and airborne total mold spore levels simultaneously as the recleaning progressed.

The recleaning was to start with repeated air washing the entire unit until airborne particulate levels reached levels similar to the outside. During air washing, it was expected that particles and mold spores would be removed from the air by HEPA-filtered air

scrubbers in the condo unit and the HEPA-filtered negative air machines located in the two bedrooms. Make-up air would be the outside air. Since this was February, with snow cover on the ground, the outside air was relatively clean.

Once the airborne particulate levels were sufficiently reduced, then the surfaces of the unit were to be HEPA vacuumed and damp wiped. Then final air testing was to be conducted.

Particulate and Total Mold Spore Sampling Methods

Fine particulates were measured using an ARTI 6 band respirable particle counter. This included 0.3, 0 .5, 0.7, 1.0, 2.0, and 5.0 micron size particulates. Total mold spores were sampled using Air-O-Cels with analysis done by EmLAB.

Measurement of Airborne Particulate and Total Mold Spore Levels

Prior to the start of the air washing of the unit, baseline airborne particulate and mold spore samples were collected. The remediation contractor was then directed to turn on the air scrubbers and exhausts units and to start with the first air wash.

The remediation contractor then produced a shop vacuum cleaner to use for air washing the condominium. He removed the lid and motor, revealing a very dirty unit. He then poured the contents into a large black plastic bag, releasing a cloud of dust into the unit. He then wet wiped the shop vac and hooked up its hose to the exhaust port and started blowing down the unit. Clearly, this contractor had no concept on how to properly air wash a mold remediation project!

The contractor stated that this was the same set up he used when he reportedly air washing the condo as required in the scope of work. This shop vac was seriously deficient in producing sufficient air flow and velocity to properly air wash the condo. However, we decided to let him spend some time blowing air around, while we collected particulate and total mold spore data.

After about 10 minutes, we told the remediation contractor to stop using the shop vac because it was not adequate for air washing. He was then given a leaf type blower that we had available. The contractor was then directed to airwash the areas he had just completed. The use of this proper air washing device produced clouds of dust, debris and mold spores that were present in various spaces of the unit that his shop vac had not disturbed.

The increase in particulate and total mold spore levels during the first air wash are shown in Tables 1 and 2.

Typically, total mold spore levels in buildings that have been adequately air washed and cleaned are less than 1,000 spores/m^3. Also, total mold spore levels measured outside on this day were 150 spores/m^3. Therefore, the elevated mold spore levels found inside the condominium were not be coming from outside air. Clearly, the condominium had not been properly or adequately air washed and cleaned per the initial scope of work.

After this initial air wash, the air scrubbers and NAMs were allowed to operate to remove

the suspended airborne particulates and mold spores from the air for approximately 1 hour. This would allow at least 4 air changes of the air in the condo unit.

At an hour later, the second air washing of the unit was done. The recleaning crew then broke for lunch. The particle levels and mold spore levels present during the second air wash are shown in Table 3. The air scrubbers and NAMs were allowed to operate during this lunch break to continue to remove the airborne particulates and mold spores from the air for approximately 1 hour.

After returning from their lunch break, the 3rd air washing was started. The remediation contractor was also directed to start the final HEPA vacuuming of the floors and walls. The contractor used three backpack style HEPA vacuums to accomplish this tasks. The particle counts during the start of the 3rd air wash is also shown in Table 3 to compare it to the first two air wash levels.

As one can see in Table 3, the first air wash greatly increased the particulate levels from the initial quiescent samples. The second air wash showed less of an increase due to the HEPA exhaust of the initial 1st air wash and the dilution of the concentration with cleaner outside air. However, the 3rd air wash along with HEPA vacuuming, actually resulted in increased particulate levels. Clearly, a new source was generating significant levels of airborne particulates and mold spores.

The most obvious source was the HEPA vacuums. Consequently, all of the exhausts of the HEPA vacuums were checked for proper filtration using the ARTI particulate counter. The results of the HEPA filter discharge checks are shown in bold in Table 4.

As can be seen in Table 4, none of HEPA vacuums were adequately removing particulates and mold spores. HEPA filtered equipment is expected to remove nearly all particles from the air. Clearly, discharge levels of particles in the thousands are totally unacceptable. The exhaust from these vacuums was actually re-entraining the particles and mold spores into the air, rather than removing them. The contractor was requested to turn off and remove all of the HEPA vacuums from the remediation containment.

Based on the HEPA vacuum experience, we decided to also check the exhausts from the contractor's HEPA filtered air scrubbers and NAMs. Most of them were also found to be functioning improperly. Only one HEPA scrubber was actually functioning adequately. This was the newer, vertical HEPA air scrubber in the living room. Its discharge particle levels are shown as a reference for IEPs and remediation contractors for what HEPA filtering equipment should be discharging. (Note: These low particle levels are also the acceptable level for validating HEPA filters in drug and medical device manufacturing.)

The particle monitoring results in Table 4 clearly show that most of the HEPA air filter devices were not performing adequately. Consequently, the remediation contractor was requested to turn off and remove all of the malfunctioning equipment from the condo. The only equipment that remained were the new HEPA air scrubber in the living room and the two exhaust NAMs in the bedrooms that were discharging to the outside.

Once the defective equipment was removed, the particle counts in the condo dropped dramatically within 30 minutes. This is shown in Table 5 below.

As shown in tables 3 and 4, the defective equipment had essentially recirculated the particulates and mold spores for almost 4 hours from approximately 11 AM to 3 PM with no significant reduction in concentration (It was only after the defective equipment was removed that the particulate levels decreased to acceptable levels.

At this point, the contractor was allowed to perform the required wipe down of all surfaces prior to final air testing. This final wipe down was visually supervised to insure its proper completion. Air testing after this wipe down showed acceptable levels as shown at the bottom of Table 4.

Conclusions

Based on this research, it was concluded that the main reason this remediation failed the initial post-remediation verification testing was not due to additional mold spore reservoirs that had been unremediated, but due to defective HEPA-filtered air scrubbers and HEPA vacuums used by the remediation contractor. This equipment had simply recontaminated the environment as they attempted to clean it.

Advice for Remediation Contractors

What does this research mean for remediation contractors? Based on this research, it certainly appears that contractors need to validate the proper operation of their HEPA filter equipment, especially if they want to avoid paying the costs for recleaning when their equipment caused the contamination.

This HEPA validation should be done using a particle counter. If you don't have a particle counter, consider using a local IEP to provide this testing. In most cases, when a HEPA filter fails validation, the problem is a leak in the seal against the filter housing surface. You can actually measure this leakage by moving the particle counter around the edge to the filter and find where the leak is occurring. In the clean room industry, a light bead of silicone caulk is use to insure this seal. A food grade grease is also sometimes used.

You can also find a leak in the HEPA filter itself by scanning the filter surface with the particle counter. The HEPA could be damaged or degraded. If a hole is present in a HEPA filter that is still fairly new, it can be sealed with some silicone caulk. This is also a standard clean room practice. These techniques reduce the cost of validation of HEPA filters, since they does not always require HEPA replacement.

However, the use of HEPAs in certain atmospheres, particularly those containing oil mist, have been show to degrade many types of HEPA filters. If a filter is badly degraded, it will have to be replaced.

Advice for IEPs

What does this research means for IEPs? In the future, when there is a HEPA vacuum or recirculating AFD in the remediation area, you should always check the particle count from the discharge of the HEPA filter. If the particle count is not within the acceptable level for HEPA filters, the contractor should be required to repair or replace the equipment. We have already added this requirement to our scope of work specifications.

Opportunity for Further Research

Based on my years of clean room HEPA validation, I have always wondered, how well does portable HEPA filtered equipment function in actual use? Up to this time, an opportunity had not presented itself to explore this issue with respect to a contractor's remediation equipment. This Post-Remediaton Verification project provided an answer to this question. HEPA filters used in mold remediation need to be validated, just like in clean rooms.

However, more questions still need to be researched. For example, do HEPA filter units function well when new and then degrade over time due to rough handling, damage or deterioration of the HEPA filter or some other reason? Could they be defective straight from the supplier or manufacturer? Hopefully, some opportunities will also present themselves to answer these important questions.