



ENVIRO TEAM

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Duct Liner Study

For

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Project ULTRATOUCH™

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ULTRATOUCH™ – Resistance to Microbial Growth in a Controlled Environment

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ULTRATOUCH™ is a natural cotton fiber duct liner which is treated with an EPA registered anti-microbial agent.

ULTRATOUCH™ was tested to determine its resistance to fungal growth in a controlled environment. The test simulated certain conditions that would be found inside a Heating, Ventilating and Air Conditioning (HVAC) system operating during the cooling mode, which may be favorable for fungal growth. The ULTRATOUCH™ natural cotton fiber was tested comparatively with conventional fiberglass duct liner, which is typically used in HVAC systems.

The testing was completed in the laboratories of Enviro Team – Advanced Scientific Laboratories -under controlled conditions. The test media (ULTRATOUCH™ natural fiber duct liner and conventional fiberglass duct liner) was inoculated with common indoor fungi. Both negative and positive controls were used to ascertain the viability of the test media.

Introduction

It is possible that the HVAC system is the primary source of microbiological contamination in an indoor environment. The reasons for microbiological contamination include the following:

- improper design
- improper installation
- improper filtration or bypass of filtration
- improper or no testing and balancing of the HVAC system
- improper airflow across coils
- inadequate or no insulation of ductwork which promotes condensation
- improper sealing of ductwork (vapor barrier)
- inadequate maintenance of the HVAC system (system hygiene)

The ability of the HVAC system to transport microbial agents throughout the occupied environment is of concern. Therefore, it was the intention of Bonded Logic, Inc., the manufacturer of **ULTRATOUCH™** Natural Fiber Duct Liner, to document and assess the factors associated with microbiological growth on duct liners by comparing the **ULTRATOUCH™** product with conventional fiberglass duct liner.

It is documented that fiberglass itself is not a food source for fungi, but that fiberglass duct liner may act as a sink for organic dust and in the presence of moisture, fungal spore germination can occur. **ULTRATOUCH™** incorporates natural cotton fibers that are intended to be used as an alternative to conventional fiberglass duct liner.

ULTRATOUCH™ reports that insulation fibers and the facing material are treated with an EPA registered anti-microbial agent and that the product has been tested to:

- ASTM C 411 and ASTM C 1071, UL 181 for Operating Limits – Temperature and Velocity
- ASTM E 84, UL 723 – Surface Burning Characteristics (Fire Hazard Classification -Maximum: Flame Spread 25, Smoke Developed 50)
- NFPA 90A & NFPA 90B – Fire Safety Standards (Meets requirements)
- ASTM C 665 – Corrosion Resistance (Pass)
- ASTM C 1338 & G 21 – Fungi Resistance (Pass – No growth)
- ASTM G 22 – Bacteria Resistance (Pass – No growth)

METHODS AND MATERIALS

Test media (**ULTRATOUCH™** natural cotton fiber duct liner and conventional fiberglass duct liner) were inserted into sanitized test chambers. Test Chamber #1 contained inoculated and un-inoculated fiber duct liner (negative control) along with malt extract agar plates (to show viability of organisms). Test Chamber #2 contained inoculated and un-inoculated **ULTRATOUCH™** media (negative control) along with malt extract agar plates. Both Test Chambers were under the same controlled conditions.

Random samples of both **ULTRATOUCH™** and conventional fiberglass duct liner were supplied to and/or procured by Enviro Team Group Inc.

Fungal inoculants were selected from those commonly found in indoor environments. They are known to reproduce in a range of temperatures from 59°F to 86°F and under different conditions of water availability.

Fungal inoculants selected:

Chaetomium sp.	Aspergillus niger	Stemphylium sp.
Curvularia sp.	Stachybotrys chartarum	
Mucor sp.	Penicillium chrysogenum	

Inoculate points for the test media included six on the airside facing material, six on the backside of facing material (where insulation is adhered to facing material), and six on the interior face of insulation that would be in contact with ductwork. These inoculate points were selected to test potential growth areas within the subject matrix (i.e. adhesives or foil backing).

Test chambers were designed to maintain relative humidity levels between 80-100% RH. Temperature levels were similar to those which may be experienced inside an HVAC system during the cooling mode when the cooling cycle is off (i.e. the fan is in the on position). This condition could enhance fungal germination. Temperature and humidity levels were data logged using Onset Dataloggers throughout the testing process.

Test chambers were sanitized prior to testing, and distilled water was used as a source of moisture to control relative humidity levels in the test chambers. A reheat element controlled by a Honeywell humidistat was incorporated for control of test environments.

Testing of media and controls was conducted with the following timelines:

24 hours, 48 hours, 72 hours, 5 days, 7 days, 14 days, 21 days, and 28 days. All data was logged and documented.

CATALOG OF MATERIALS

Test Chambers 1 & 2:

Both test chambers were constructed of glass (due to its inert properties), and the seals incorporated clear silicone. Both chambers were outfitted with a reheat element (fluorescent tube), and a line voltage humidistat for humidity control. The test chambers were covered with a plastic top, to help retain moisture control, and control particle settling on test materials.

Both test chambers were sanitized with laboratory grade methanol – Optima Methanol – Fischer Scientific Lot # 011265, with a molecular weight of 32 grams (rounded). Sanitization was conducted in the lab with the use of surgical gloves. All of the individual components of the test chamber and data loggers were sanitized using this method.

Distilled water was utilized to provide a source of moisture to control humidity levels in test chambers (without coming into direct contact with the sample media).

Reheat Elements:

Elements for both test chambers were Eclipse Model 24RFH, Voltage 120 vac, Wattage 17, Hertz 60, encased in a plastic housing inside of the test chamber tops. Cycling of elements was controlled by line voltage humidistats.

Line Voltage Humidistats:

Honeywell Model H46E1013 humidistats were mounted to a metal bracket and suspended in the test chamber. The reheat elements were powered by the humidistats in order to maintain desired humidity levels between 80-100% RH.

EXPERIMENTS

Discussion of Methodology

Fungi, when present in the environment, can portray many different growth characteristics based on the environmental factors exposed or presented to them. There are generally four main factors that have an absolute affect on fungi in their environment. These factors are:

- 1) Moisture
- 2) Temperature
- 3) Light
- 4) Nutrients

In order for fungi to grow in an indoor environment, water availability is the most critical factor. When present in a substrate, it supports growth along with the other factors listed above. Generally, if moisture levels are controlled outside the range of fungi, then the chances of any of the common indoor molds successfully growing is reduced. With that being stated, consideration of the other factors must be taken into account. If the moisture content on a substrate is below the optimum water activity (a_w) of a certain species, growth may still be achieved if the water activity (a_w) range is met, and sufficient temperature and nutrients are available to compensate.

Temperature affects fungal growth both directly and indirectly. It affects it directly by controlling the rate by which chemical reactions occur leading to growth. Indirectly, it affects growth through its control over water activity. With this taken into account for the study, the temperature inside the chambers varied so that temperature conditions remained somewhat dynamic, typical of conditions that may be found inside an air conditioning system.

Many fungi require light to stimulate spore production. Although it is not expected to find light in a duct system, light was added to enhance sporulation.

Nutrient availability is very important, as fungi are heterotrophs (need food from an external source). If the above criteria are met for growth but no nutrient source is available, the fungi cannot germinate.

To assess growth potential on the **ULTRATOUCH™** product, a range of different organisms were inoculated and differences were observed. The seven organisms chosen were:

- 1) *Aspergillus niger*- Commonly isolated in soil, plant debris and the indoor environment. It is an opportunistic organism with an optimum water activity of 0.97.
- 2) *Curvularia* sp.- Commonly isolated in soil, plants and cereals. *Curvularia* may cause infections in both humans and animals.
- 3) *Mucor* sp. – Commonly isolated in soil, plants and decaying fruit and vegetables. *Mucor* species has an optimum water activity range of 0.90 to 0.94.
- 4) *Penicillium chrysogenum* – Commonly isolated in soil, decaying vegetation and in the air. It has an optimum water activity range of 0.78 to 0.85.
- 5) *Stachybotrys chartarum* – Commonly isolated in contaminated grains, tobacco, insulator foams and water damaged buildings. It has an optimum water activity range of 0.91 to 0.94.
- 6) *Chaetomium* sp. – Commonly isolated in soil, seeds and cellulose substrates. It has an optimum water activity range of 0.91 to 0.94.
- 7) *Stemphylium* sp. – It is considered mainly a plant pathogen that is mainly distributed on decaying vegetation and present in soil.

Bonded Logic Ultratouch™ Results

Date	Growth +/-	Macroscopic Observations	Microscopic Observations
09/18/02	-	No growth on product or culture media, some humidity fluctuation.	None preformed
09/19/02	-	No growth on product but growth present on all culture media proving viability of organisms.	None preformed
09/20/02	-	No growth on product.	Lack of organism presence observed macroscopically for product confirmed. Un-inoculated product showed no presence of any organism.
09/21/02	-	No change	No change
09/22/02	-	No change	No change
09/23/02	-	No change	No change
09/24/02	-	No change	No change
10/01/02	-	No change	No change
10/09/02	+	Visual presence on the topside and underside of the inoculated product, but no growth on the interior. No growth on un-inoculated control.	<p>Topside or exterior surface:</p> <p>Topside or exterior surface has <i>Aspergillus niger</i> spores present as well as <i>Chaetomium</i> spores and hyphae.</p> <p>Interior Surface:</p> <p>The underside of the exterior or interior surface contained no growth.</p> <p>Underside surface:</p> <p>The underside had <i>Chaetomium</i> spores and hyphae present.</p> <p>Un-inoculated control showed no presence of any organism.</p>

Bonded Logic Ultratouch™ Results

Date	Growth +/-	Macroscopic Observations	Microscopic Observations
10/16/02	+	Visual presence on the topside, interior and underside of the product but no growth on the un-inoculated control.	<p>Topside or exterior surface:</p> <p>Aspergillus/ Penicillium spores. Chaetomium spores and hyphae.</p> <p>Interior Surface:</p> <p>Aspergillus/ Penicillium spores. Chaetomium spores and hyphae.</p> <p>Underside surface:</p> <p>Aspergillus/ Penicillium spores. Chaetomium spores and hyphae.</p> <p>No presence of growth on un-inoculated control.</p>

Fiberglass Duct Liner Results

Date	Growth +/-	Macroscopic Observations	Microscopic Observations
09/18/02	-	No growth observed, some humidity fluctuation.	None preformed
09/19/02	-	Growth present on all culture media proving viability of organisms.	None preformed
09/20/02	+	Growth present on the underside of the inoculated fiberglass.	<p>Presence of spores, <i>Aspergillus niger</i> and <i>Penicillium chrysogenum</i> on the underside of the inoculated fiberglass.</p> <p>Un-inoculated fiberglass showed no presence of any organism.</p>
09/21/02	-	No change	No change
09/22/02	-	No change	No change
09/23/02	-	No change	No change
09/24/02	-	No change	No change
10/01/02	-	No change	No change
10/09/02	+	Visual presence on the topside, interior and underside of the inoculated fiberglass.	<p>Topside or exterior surface:</p> <p>Topside or exterior surface has <i>Aspergillus niger</i> spores present.</p> <p>Interior Surface:</p> <p>The underside of the exterior or interior surface contains growth. Spores and hyphae of <i>Aspergillus niger</i> and <i>Penicillium chrysogenum</i> observed.</p> <p>Underside surface:</p> <p>The underside had present <i>Stachybotrys chartarum</i> spores and hyphae, <i>Penicillium chrysogenum</i> spores and hyphae, <i>Chaetomium</i> spores and hyphae as well as <i>Curvularia</i> spores.</p>
10/16/02	-	No change	No change

Discussion

As the study concluded, of all the seven fungi present, one was positively identified as growing on the **ULTRATOUCH™** insulation. It was identified as *Chaetomium* sp. with both spores and hyphae being present outside the area of inoculation. *Chaetomium* sp. spores range in size from 9 to 16 μm in diameter. Particles smaller than 5 μm can pass through a 30% dust-spot-efficient filter, which is typical of the filter most central air handlers can support. Other spores were found outside the areas of inoculation, but no hyphae were observed for those on the **ULTRATOUCH™**.

Viability of all the organisms present was clearly shown after forty-eight hours indicating that the moisture, temperature, light and nutrient availability was optimum for growth to occur. Of these factors, nutrient availability provided by the malt extract agar plates, was the only factor to differ.

The negative control at all stages of the study showed no growth.

After four weeks, the inoculated fiberglass insulation test media had fungal presence on all three surfaces outside the areas of direct inoculation. *Aspergillus niger* was the only organism present on the exterior surface suggesting that sporulation occurred. The underside of the exterior surface had spores and hyphae of both *Aspergillus niger* and *Penicillium chrysogenum* indicating growth occurred on this surface. On the underside, *Chaetomium* species, *Stachybotrys chartarum* and *Penicillium chrysogenum* had both spores and hyphae present outside their areas of inoculation, indicating growth. *Curvularia* sp. had spores present outside the inoculated area suggesting sporulation occurred.

After four weeks, only *Chaetomium* growth (spores and hyphae) occurred on all three surfaces of the inoculated **ULTRATOUCH™** test media. Hyphae are filamentous structures of fungi, and when present in significant numbers, constitute a mass of hyphae called mycelium. *Aspergillus niger* spores, but no hyphae, were observed outside the point of inoculation. This could be due to air currents or settling which may have occurred during the inoculation process.

The test media used in the study was visibly clean. The results show that under these conditions, growth can occur on these substrates. Growth occurred as the moisture content was in a range suitable for most of the inoculants. The light availability and temperature differentials should accommodate, at some point, all of the organisms. From the results, one can conclude that a nutrient source was available. The test media was not limited to sterile conditions. Common environmental isolates such as dust particles, skin flakes and other organic material most likely provided a nutrient source allowing for germination to occur. Fungi are capable of releasing enzymes to digest these organic compounds. They convert them into glucose, which can be absorbed. The reason that only some organisms grew and the others did not may be attributed to the fact that each organism has a different niche. The balance of all four factors was not optimal for these organisms.

Aspergillus sp. and *Penicillium* sp. are both reported common colonizers in HVAC systems; therefore we would have expected to see growth on the **ULTRATOUCH™** as we did on the fiberglass. Since the **ULTRATOUCH™** fibers were treated with an anti-microbial agent, inhibition may have occurred for most of these organisms. This stands true if the Ultratouch is compared to the fiberglass insulator. A greater diversity of organisms was present on the fiberglass. It is our

belief however, that either test media, regardless of its properties, can support fungal growth if a suitable layer of organic material is present.

Conclusion:

Under the conditions described in this study, growth did occur on both fiberglass and **ULTRATOUCH™** insulation. In comparing the results of the fiberglass insulation with **ULTRATOUCH™**, the data suggests that **ULTRATOUCH™** possesses potential antimicrobial activity against certain fungi common to indoor environments.

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