

US EPA ARCHIVE DOCUMENT

NRMRL-RTP-460
EPA Contract EP-C-05-060/TO56
December 2010

Environmental and Sustainable Technology Evaluation: Mold-Resistant Lonseal Flooring - Lonseal, Inc., Lonwood Natural

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Acronyms and Abbreviations

ACH	air changes per hour
ADQ	audit of data quality
ASTM	American Society for Testing and Materials
AATCC	American Association of Textile Chemists and Colorists
a_w	water activity
CFU	colony forming unit
DNPH	2,4-dinitrophenylhydrazine
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ESTE	environmental and sustainable technology evaluations
ERH	equilibrium relative humidity
ETV	environmental technology verification
g	gram(s)
GC/MS	gas chromatography/mass spectrometry
ISO	International Organization for Standardization
MC	moisture content
ML	microbiology laboratories
ML SOP	microbiology laboratory standard operating procedure
QA	quality assurance
QAM	quality assurance manager
QAPP	quality assurance project plan
QC	quality control
QMP	quality management plan
RH	relative humidity
RTI	Research Triangle Institute (RTI International)
sec	second(s)
SOP	standard operating procedure
spp	species
t	temperature in degrees Celsius
TOP	technical operating procedure
T/QAP	test/quality assurance plan
TSA	technical system audit
TVOC	total volatile organic compounds
VOCs	volatile organic compounds
Φ_g	microgram(s)
Φ_m	micrometer(s)
UL	Underwriters Laboratories

ACKNOWLEDGMENTS

The authors acknowledge the support of all of those who helped plan and conduct the verification activities. In particular, we would like to thank Dr. Timothy Dean, EPA's Project Manager, and Robert Wright, EPA's Quality Assurance Manager, both of EPA's National Risk Management Research Laboratory in Research Triangle Park, NC. We would also like to acknowledge the assistance and participation of our stakeholder group for their input.

1.0 INTRODUCTION

The U.S. Environmental Protection Agency's Office of Research and Development (EPA-ORD) operates the Environmental and Sustainable Technology Evaluation (ESTE) Program to facilitate the deployment of innovative technologies through performance verification and information dissemination. The ESTE program is intended to increase the relevance of Environmental Technology Verification (ETV) Program projects by responding to near-term needs identified by the U.S. EPA program and regional offices.

The ESTE program involves a three step process. The first step is a technology category selection process conducted by ORD. The second step involves selection of the project team and gathering of project collaborators and stakeholders. Collaborators can include technology developers, vendors, owners, and users. They support the project through funding, cost sharing, and technical support. Stakeholders can include representatives of regulatory agencies, trade organizations relevant to the technology, and other associated technical experts. The project team relies on stakeholder input to improve the relevance, defensibility, and usefulness of project outcomes. Both collaborators and stakeholders are critical to development of the project test and quality assurance plan (TQAP), the end result of step two. Step three includes the execution of the verification and quality assurance and review process for the final reports.

This ESTE project evaluated microbial resistant building materials. EPA's National Risk Management Research Laboratory contracted with the Research Triangle Institute (RTI) to establish an ETV/ESTE Program for microbial-resistant building materials. RTI convened a group of stakeholders representing government and industry with knowledge and interest in the areas of mold resistant building materials. The group met in May and July 2006 and recommended technologies to be tested. RTI then developed (and EPA approved) the "Test/Quality Assurance Plan for Mold-Resistant Building Material Testing¹." The tests described in this report were conducted following this plan.

Fungal growth and the resulting contamination of building materials is a well-documented problem, especially after the reports from New Orleans and the U.S. Gulf Coast post Hurricane Katrina. However, contaminated materials have been recognized as important indoor fungal reservoirs for years. For example, contamination with fungi has been associated with a variety of materials including carpet, ceiling tile, gypsum board, wallpaper, flooring, insulation, and heating, ventilation and air conditioning components²⁻⁵.

Exposure to fungi may result in respiratory symptoms of both the upper and lower respiratory tract such as allergy and asthma⁶. Everyone is potentially susceptible. However, of particular concern are children with their immature immune systems and individuals of all ages that are immunocompromised^{7,8}.

One approach to limiting exposure is to reduce the levels of fungi in the indoor space. For some sensitive individuals, limiting exposure through avoidance is an effective control method; however, avoidance is not always possible or practical. The investigation, development, and application of effective source controls and strategies are essential to prevent fungal growth in the indoor environment. Mold resistant building material is a potentially effective method of source control.

Figure 1-1 illustrates the combination of moisture and nutrients required for microbial growth on a material. Sufficient nutrients for growth may be provided by the material itself or through the accumulation of dust on or in the material. When sufficient nutrients are available, the ultimate determinant for microbial growth is availability of water. The more hygroscopic a material (e.g. wallboard) is, the more impact on the overall hygroscopicity the surface treatments may have.

A building is not a sterile environment, nor should it be. In fact, a building is frequently a reservoir for microorganisms. While many different types of microorganisms occupy indoor spaces, it is well-recognized that fungi can colonize and amplify on a variety of building materials if sufficient nutrients and moisture are present. These contaminated materials are known to be important indoor reservoirs. Fungal growth on natural and fabricated building materials can be a major source of respiratory disease in humans. Commonly, sufficient nutrients are available and water is usually the growth factor most limiting the establishment and growth of microbial populations. Sufficient moisture for growth may become available through water incursion from leaks and spills, condensation on cold surfaces, or absorption or adsorption directly from the indoor air. The amount of water required is not large, and materials that appear dry to cursory inspection may be capable of supporting microorganism growth.

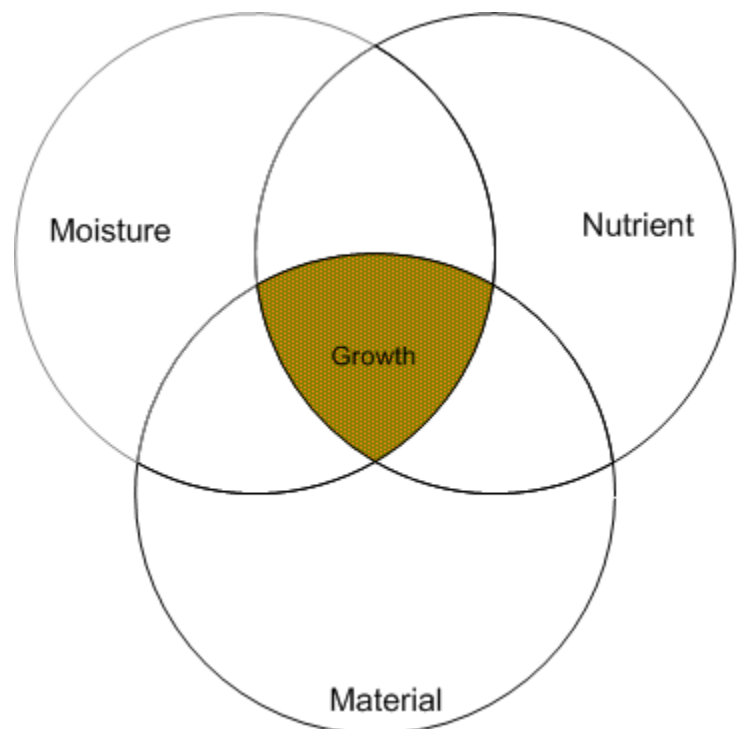


Figure 1-1. Diagram illustrating the conditions required for fungal growth on a material.

2.0 VERIFICATION APPROACH

The ESTE test program measured the mold resistance of Lonseal Lonwood Natural flooring. Since the EPA program office wanted testing performed on mold-resistant building materials, and Lonseal markets this flooring material as such, it was a good candidate for testing. Tests for emissions of VOCs and formaldehyde were also performed. An overview of the emissions procedures is found in the Appendix. The detailed test methods can be found in RTI's test/QA project plan¹.

2.1 TEST MATERIAL

The following description of the product was provided by the vendor and was not verified.

Lonwood Natural flooring is a sheet vinyl product with an embossed wood-grain texture. Constructed in multiple layers and embossed with distinctive wood grains, it is composed of resin, plasticizers, fillers, and pigments. The co-calendered wear layer is formulated to provide maximum resistance to foot traffic in most commercial and healthcare applications. The middle layer provides dimensional stability, sound-absorbing properties, and resiliency under foot. The backing layer provides strength and stability of the flooring and enhances the bonding strength of the adhesive. Mold resistance is conveyed by the addition of a proprietary chemical as a top layer formulation that is applied to the surface of the sheet vinyl through a calendering process. Figures 2-1 and 2-2 show the front and back surfaces of the material.



Figure 2-1. Front surface of material

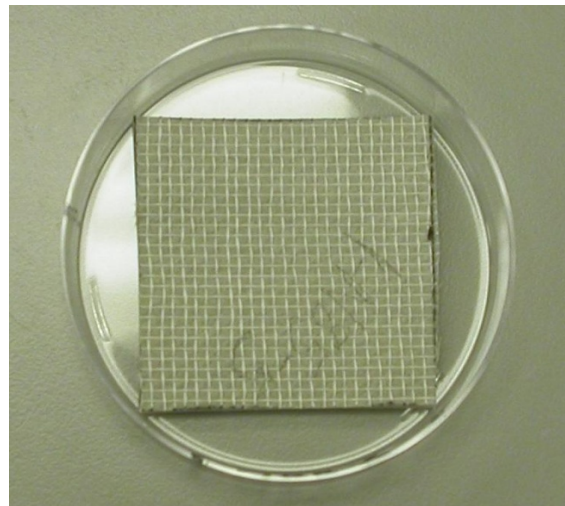


Figure 2-2. Back surface of material

2.2 TEST METHODS AND PROCEDURES

Mold resistance testing was performed following the guidelines outlined in ASTM 6329⁹. This method was developed as part of a more comprehensive project to apply indoor air quality engineering to biocontamination in buildings. One of the primary goals was to develop a scientific basis for studying indoor air biocontaminants. Available methods, including those from ASTM, AATCC, and UL, for evaluating the resistance of a variety of materials to fungal growth were surveyed. Although the basic principles were similar, a major concern was the way growth on the different materials was evaluated. Although quantitative methods for inoculation were employed by most of the methods, all assessed growth qualitatively as the endpoint. ASTM 6329⁹ evaluates growth quantitatively as the endpoint. The method has been successfully used to evaluate fungal resistance on a variety of materials including ceiling tiles and HVAC duct materials¹⁰⁻¹³.

2.2.1 Test Organisms

Selecting the “correct” test organism is critical to any test, therefore selection criteria were developed. The selection criteria used to choose the appropriate test organisms for this study were:

- (1) the reasonableness or likelihood of the test material being challenged by that particular organism when in actual use, and
- (2) that they cover the range of ERHs (equilibrium relative humidities) needed and bracket the ERHs where fungal growth can occur.

Two fungi were used as test organisms, *Aspergillus versicolor* and *Stachybotrys chartarum*. Each of them met the criteria. *S. chartarum* requires high levels of available water to grow and has been associated with a number of toxigenic symptoms. *A. versicolor* is a xerophilic fungus and capable of growing at lower relative humidities. Both are from the RTI culture collection (CC). The CC number for *S. chartarum* is 3075 and the organism was received from EPA NERL. *A. versicolor* is CC #3348, and it is a field isolate. Prior to initiation of the testing, their identification was confirmed by standard techniques.

2.2.2 Static Chambers

Clear plastic desiccators served as the static environmental chambers. The desiccators are sealed so there is no air exchange and the desiccators serve as good static chambers. A saturated-salt solution of

potassium chloride was used to maintain the humidity of the 85% ERH chamber. Sterile water was used for the 100% ERH chamber. Temperature was externally controlled and maintained at room temperature. Prior to use, the chambers were decontaminated and characterized. The ERH in each chamber was monitored with a hygrometer (Taylor model number 5565) that was placed inside the chamber.

2.2.3 Test Design

The Lonwood Natural flooring was cut aseptically with a razor blade into small pieces (at least 4 cm x 4 cm). The material was not autoclaved or sterilized in any way prior to inoculation. Therefore, in addition to the test organism inocula, any organisms naturally on both the top and bottom surfaces of the material had the opportunity to grow if conditions were favorable for growth. The test organisms are inoculated by pipette directly onto the surface of each test piece in sufficiently high numbers to provide an adequate challenge, but at a level that is realistic to quantify. The tests ran for 12 weeks. During the 12 week test period, data from four test dates, labeled Day 0, Week 1, Week 6, and Week 12 were evaluated. Day 0 samples provided the baseline inoculum level. A sufficient number of test pieces were inoculated simultaneously for all four test dates. All pieces for one material and one test organism were put in the same static chamber. The chambers were set to 100% equilibrium relative humidity (ERH) for the tests with *S. chartarum* and at 85% for *A. versicolor*. On each test date (including Day 0), five replicates of the test material pieces were removed from the chamber, each was placed separately in a container with sterile buffer, and extracted by shaking. The resulting suspension of eluted organisms was plated and microbial growth on materials was quantified by manually enumerating colony-forming units (CFUs).

The numbers of CFUs eluted on week 1, 6, and 12 were compared to the baseline at Day 0. The numbers of CFUs on each date are expressed as \log_{10} . The results are reported as the log change in CFUs between Day 0 and Week 1, Day 0 and Week 6, and Day 0 and Week 12. An extra test date was included to enable the QA review. The review had been scheduled for week 6, however scheduling difficulties made the review impossible on week 6 so additional samples were processed on week 7 for the audit.

2.2.4 Sample Preparation and Inoculation

Small (at least 4 cm x 4 cm) replicate pieces of test mold resistant flooring material and reference wood material were prepared and inoculated. To minimize error and demonstrate reproducibility, five pieces of each sample type were processed on each sampling date. Because there were four test dates, a

minimum of 20 pieces were prepared simultaneously. Each piece was placed on a separate labeled sterile Petri dish.

The fungi challenge suspensions were prepared by inoculating the test organism onto solid agar media, incubating the culture at room temperature until mature, wiping organisms from the surface of the pure culture, and suspending them in sterile 18-Mohm distilled water. The organism preparation was viewed microscopically to verify purity of spores (absence of hyphae). The test pieces were inoculated (usually with five 10 µL spots in an X configuration) by pipet onto the surface of the test piece and allowed to dry in the biosafety cabinet.

On each test date (including Day 0), the appropriate number of test pieces were removed from the static chamber, each placed in approximately 30 mL sterile buffer, and extracted by shaking using a vortex or wrist action shaker. The extract was diluted if needed and plated on agar media to determine the numbers of CFU.

2.2.5 Calculation of Mold Resistance

Changes in the numbers of CFU over time were quantified. The \log_{10} number of CFUs from test date x were compared to the \log_{10} number of CFU from Day 0 as follows:

$$\Delta \log_{10} CFU = \log_{10} CFU_{date\ x} - \log_{10} CFU_{Day\ 0}$$

where:

Δ CFU = the change in \log_{10} CFU between a test date (x) and Day 0

$\log_{10} CFU_{date\ x}$ = number of CFU \log_{10} on test date x

$\log_{10} CFU_{Day\ 0}$ = number of CFU \log_{10} on Day 0

The standard error of the means between the start date and the test date gives the statistical significance of the differences.

2.3 SUSTAINABILITY INDICATORS AND ISSUES

The verification organization requested information from the vendor that would, along with the test results for microbial resistance, assist in estimating impacts on solid waste disposal due to replacing building materials less frequently. Information was also requested on chemical additives that are claimed to confer microbial resistance. Also, the vendor was asked to provide any additional information relative to the environmental sustainability of the product such as recyclability/reusability of the product and disposability of the product and use of renewable resources or other criteria the vendor

deemed relevant to the environmental sustainability of the product.

3.0 RESULTS

3.1 MOLD RESISTANCE

The results for the mold resistance tests are shown in Table 3-1. Growth is measured by culture and is defined as at least a 1 log₁₀ increase in culturable organism over the baseline which was determined on Day 0.

Table 3-1. Log₁₀ CFUs for test material (Lonseal) and reference material (wood) on each test date (Mean ± SD)

Lonseal			
Week	<i>A. versicolor</i> 85% ERH	<i>S. chartarum</i> 100% ERH	Growth of Naturally Occurring Fungi 100% ERH
0	5.0 ± 0.1	5.0 ± 0.04	< 2.2 ± 0.0*
1	4.8 ± 0.1	NA	4.8 ± 0.6
6	4.4 ± 0.1	NA	6.0 ± 0.1
7	4.2 ± 0.01	NA	6.2 ± 0.2
12	4.1 ± 0.1	NA	6.4 ± 0.3
Reference Material			
Week	<i>A. versicolor</i> 85% ERH	<i>S. chartarum</i> 100% ERH	Growth of Naturally Occurring Fungi 100% ERH
0	4.9 ± 0.1	4.8 ± 0.1	< 2.2 ± 0.0*
1	4.7 ± 0.1	3.9 ± 0.2	2.6 ± 1.0
6	4.3 ± 0.2	NA	6.3 ± 0.0
7	4.1 ± 0.1	NA	7.0 ± 0.2
12	5.5 ± 0.4	NA	6.9 ± 0.3

NA = Not Available due to overgrowth by innate fungi

* = < 2.2 indicates 0 CFU detected at the minimum detection limit

The numbers of CFUs on each test and reference piece were Log₁₀ transformed and the mean and standard deviation calculated. The initial concentration is in the row labeled week 0 (day 0 inoculum). The results for the test organisms, *A. versicolor* and *S. chartarum*, are in columns two and three. The fourth column gives the CFUs for the fungi that were on the unsterilized surface of the test material at the initiation of the test.

At Day 0 the numbers of naturally occurring fungi were below the detection limit on both the test and the reference materials. However, the growth of a variety of fungal species (naturally occurring on the sample) was masking any *S. chartarum* growth on Lonseal and on the reference material (wood).

Figure 3-1 shows the log change in *A. versicolor* and Figure 3-2 shows the log change in the naturally occurring fungi that were on the surface of the material.

Neither the test material nor the reference material inoculated with *A. versicolor* and incubated at 85% ERH showed growth during the 12 weeks of the test. It was important to check that none of the changes made to the test material to make it mold resistant actually enhanced the ability of mold to grow over the positive control material¹¹

It was not possible to accurately assess whether or not the test material was resistant to the growth of *S. chartarum*. The growth of a variety of fungal species (naturally occurring on the sample) masked any *S. chartarum* growth on Lonseal and on the reference material.

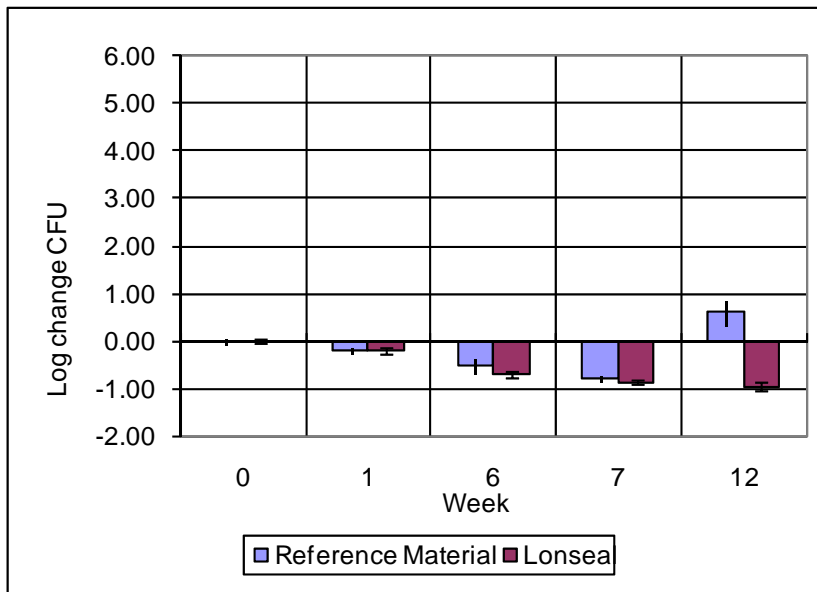


Figure 3-1. Log change in *Aspergillus versicolor* inoculated on the test material over 12 weeks on the wood reference material and Lonseal.

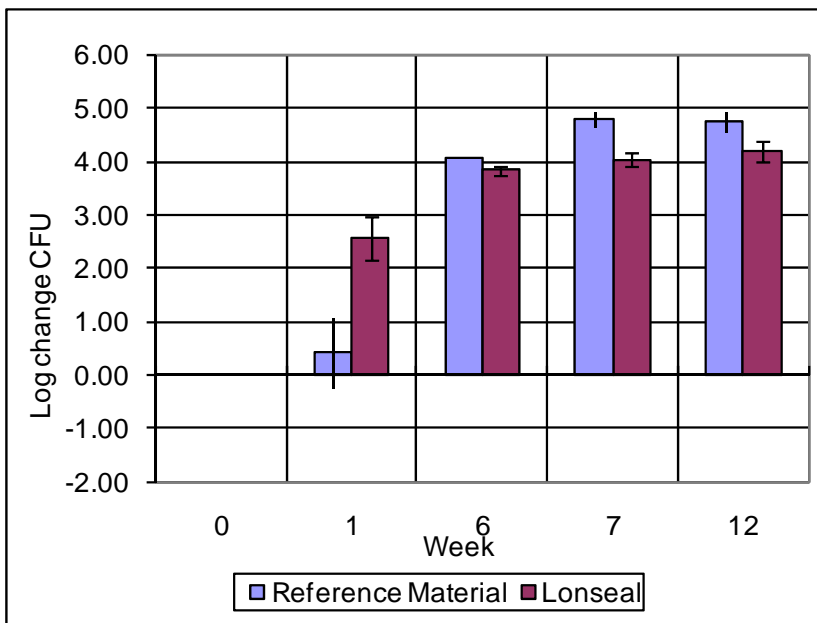


Figure 3-2. Log change in naturally occurring fungi (not inoculated) on the test material over 12 weeks on the wood reference material and Lonseal.

3.2 EMISSIONS OF VOCs AND FORMALDEHYDE

The emissions of VOCs and formaldehyde test results are presented in the Table 3-2. A summary of the method is found in Appendix A¹⁴.

Table 3-2. Test results for VOCs and formaldehyde emissions from Lonseal

VOCs and Formaldehyde Emissions*	
Emission Types	Minimum emission results
Total VOCs	< 0.5 mg/m ³
Formaldehyde	<0.1 ppm
Individual VOCs	< 0.1 TLV

*Individual pollutants must produce an air concentration level no greater than 1/10 the threshold limit value (TLV) industrial workplace standard (Reference: American Conference of Government Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, OH 45211-4438).

3.3 SUSTAINABILITY ISSUES

Sustainability is an important consideration in use of microbial resistant building materials. Lonseal supplied the following information about the sustainability of the Lonwood Natural flooring:

- Part of GreenMedic™ Microbial Resistant Collection
- The MSDS that was provided by the vendor was in Japanese. The percentage of the proprietary compound is 0.01-0.02%. It is a top layer formulation that gets applied to the surface of the sheet vinyl through a calendaring process. The compound is added to the formula in a mixer, and the product gets kneaded until ready for calendaring. The MSDS cannot be distributed.
- Over 40% post industrial recycled content; contributes toward LEED MR 4.1 and 4.2 for recycled content
- Part of GreenAir™ Collection: reformulated products that reduce VOC emissions by 80-90 percent
- Certified for low VOCs by GREENGUARD Environmental Institute
- Indoor Environmental Quality Credit 4.1 for low emitting adhesives
- Lonseal has a dedicated vinyl products recycling plant.

4.0 DATA QUALITY ASSESSMENT

The quality assurance officer has reviewed the test results and the quality control data and has concluded that the data quality objectives given in the approved Test/QA plan and shown in Table 4 have been attained.

The DQO for the critical measurement, quantitation of fungal growth on an individual test date, is found in Table 4-1.

Table 4-1. Data quality objectives

Test	Parameter	DQO		
		Precision	Accuracy	Completeness
Mold Resistance	Quantitation of fungal growth on an individual test date	± 5-fold difference	10% of the plates will be counted by a second operator. ± 20% agreement between the operators	100%

This verification statement discusses two aspects of Mold-Resistant Building Material Testing, mold resistance and emissions of VOCs and formaldehyde. Users of this technology may wish to consider other performance parameters such as fire resistance, service life and cost when selecting a building material.

According to the test/QA plan¹, this verification statement is valid for three years following the last signature added on the verification statement.

5.0 REFERENCES

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Appendix A
VOCs and Formaldehyde Emissions Testing

EMISSIONS REPORT FOR LONSEAL FLOORING MATERIAL

Two pieces of Lonseal flooring material, contained in a 7"x7"x2" cradle of aluminum foil, were tested in the small (52.7 L capacity) emissions chamber maintained at 25 °C and 50% relative humidity and subjected to an air exchange rate of 1 hr⁻¹. After equilibration of each sample for 6 hr¹, sequential samples for VOCs and carbonyls were collected from the chamber effluent for 20 and 120 minutes, yielding collection volumes of approximately 1.5 and 10 L for VOCs and 10 and 60 L for carbonyls². In addition to the test flooring material, replicate chamber blanks and the emission profile of a positive control material (vinyl show curtain liner) were collected. All sample collections and analyses were conducted in accordance with RTI's AIHA quality manual guidelines.³

VOC samples were collected on Carbopack B cartridges. A total of 100 ng of the internal standard, d8-toluene, was subsequently added to each cartridge by flash loading⁴ prior to analysis by thermal desorption-GC/MS on a DB-5 column programmed from 40EC - 225EC at 5 EC/min⁵. Calibration standards were prepared at two levels (3.5 µg; 6.9 ng) by flash loading of a 26-component VOC mixture (ethanol; isopropanol; acetone; dichloromethane; carbon disulfide; methyl -t -butyl ether; 2-butanone; 1,1,1-trichloroethane; 1-butanol; trichloroethene, 4-methyl-2-pentanone; toluene; hexanal; tetrachloroethene; m-xylene; n-nonane; 2-butoxyethanol; phenol; 1,2,4-trimethylbenzene; n-decane; 2-ethyl-1-hexanol; d-limonene; 1,2-dichlorobenzene; n-undecane; decamethylcyclsiloxane; n-dodecane) plus d₉-toluene internal standard in methylene chloride onto Carbopack B. In addition to quantitation of the individual analytes, total VOCs (TVOC) were determined by summing the integrated peak areas in the samples and blanks between the retention times of hexane and hexadecane. Two specific analytes, 4-phenylcyclohexene and styrene, were sought in each sample. Neither compound was detected in the samples or blanks. All detected analytes were quantitated against the toluene peak in the standards. No mathematical correction for the blanks was performed.

Carbonyl samples were collected on DNPH cartridges.^{2,6} Each cartridge was extracted by solid phase extraction (SPE) with 4 mL of acetonitrile and brought to a final volume of 5 mL with acetonitrile⁷. Subsequently, each extract was analyzed by HPLC/UV (365 nm) on a Deltabond Res AK column (4.6 mm x 25 cm, Keystone). The mobile phase consisted of (A) 45:55 acetonitrile:water and (B) 75:25 acetonitrile:water, using a 30 minute gradient from A to B and held at B for 5 minutes at a flow rate of 1 mL/min. Each cartridge was extracted by solid phase extraction (SPE) with 4 mL of acetonitrile and brought to a final volume of 5 mL with acetonitrile. Instrument calibration was accomplished using solutions prepared from a purchased aldehyde/ketone DNPH mix solution (15 µg/mL as formaldehyde, Supelco 47285-U) in acetonitrile. A six-point calibration curve was prepared with analyte amounts ranging from 0.0109 to 2.175 µg/ml. Individual carbonyls (formaldehyde, acetaldehyde, acetone, propionaldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, iso-valeraldehyde, valeraldehyde, o-

tolualdehyde, m-tolualdehyde, p-tolualdehyde, hexanaldehyde, 2,5-dimethylbenzaldehyde) were quantitated against the curve and were corrected for amounts found in blank samples. Total carbonyls were computed by summing the individual carbonyl species.

The results of the emission tests for VOCs and carbonyls are presented in Tables 1 and 2, respectively. For all samples, excluding the positive control, levels of VOCs and carbonyls were extremely small, near the detection limit for the method, and comparable to the levels found in the blanks.

Table 1. VOC emission results^a for Lonseal flooring material

Sample Id.	Toluene Chamber Conc. (mg/m ³)	TVOC Chamber Conc. (mg/m ³)	Toluene Emission Factor (mg/m ² ·hr)	TVOC Emission Factor (mg/m ² ·hr)
Chamber Blank ^b	0.009 (0.005)	0.25 (0.116)	0.015 (0.008)	0.43 (0.20)
Positive Control ^c	0.017 (0.007)	14.2 (1.1)	0.029 (0.012)	23.6 (1.8)
Lonseal flooring ^d	0.003 (0.003)	0.27 (0.13)	0.006 (0.005)	0.46 (0.43)

^a Mean (Standard deviation)

^b Mean of 3 determinations

^c Mean of 2 determinations

^d Mean of 6 determinations

Table 2. Carbonyl emission results^a for Lonseal flooring material.

Sample Id.	Formaldehyde Chamber Conc. (mg/m ³)	Total Carbonyls Chamber Conc. (mg/m ³)	Formaldehyde Emission Factor (mg/m ² ·hr)	Total Carbonyls Emission Factor (mg/m ² ·hr)
Chamber Blank ^b	<0.001	0.017 (0.013)	<0.001	0.028 (0.023)
Positive Control ^b	<0.001	0.012 (0.013)	<0.001	0.021 (0.022)
Lonseal flooring ^c	0.001 (0.002)	0.015 (0.012)	0.003 (0.004)	0.026 (0.021)

^a Mean (Standard deviation)

^b Mean of 2 determinations

^c Mean of 6 determinations

¹ Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products. American Society for Testing and Materials (ASTM) document D5116-97, 2008.

² Standard Operating Procedure for the Determination of Carbonyl and VOC Emissions from Building Materials Using a Small Environmental Chamber. RTI International document: EAR-LAB-001, 2010.

³ Quality Manual for the AIHA Accredited Laboratory No. 100600. RTI International document: RTI/0290365/08-01, January 2010.

⁴ Adsorbent Tube Injector System Operation Manual, Sigma-Aldrich/Supelco, Available at: http://www.youngwha.com/tech/upload/ATIS_system_T702019.pdf, 2010.

⁵ Standard Operating Procedure for the Analysis of Volatile Organic Chemicals By Thermal Desorption/GC/MS, RTI International document: EAR-GLC-004, 2010.

⁶ Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology). American Society for Testing and Materials (ASTM) document D5197-09, 2009.

⁷ Standard Operating Procedure for the Extraction and Analysis of Formaldehyde-DNPH from Active and Passive Media by HPLC, RTI International document: EAR-GLC-003, 2010.

Environmental and Sustainable Technology Evaluation: Mold-Resistant Lonseal Flooring - Lonseal, Inc., Lonwood Natural



Prepared by
Research Triangle Institute



For
U.S. Environmental Protection Agency
Office of Research and Development- Environmental Technology Verification Program

RTI International/EPA
September 2010

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THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM
Environmental and Sustainable Technology Evaluation (ESTE)



U.S. Environmental Protection Agency



Research Triangle Institute

ESTE Joint Verification Statement

TECHNOLOGY TYPE:	Mold-Resistant Flooring Product
APPLICATION:	Flooring
TECHNOLOGY NAME:	Lonseal Lonwood Natural
COMPANY:	Lonseal, Inc.
ADDRESS:	Carson, California

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection and sustainability by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer-reviewed data on technology performance to those involved in the purchase, design, distribution, financing, permitting, and use of environmental technologies. This verification was conducted under the Environmental and Sustainable Technology Evaluation (ESTE) element of the ETV Program that was designed to address agency priorities for technology verification.

This ESTE project involved evaluation of the mold resistance of Lonseal Lonwood Natural flooring. Tests for emissions of VOCs and formaldehyde were also performed. For this project Research Triangle Institute (RTI) was the responsible contractor for EPA Office of Research and Development, National Risk Management Research Laboratory (NRMRL).

This verification statement provides a summary of the test results for Lonseal Lonwood Natural flooring.

TECHNOLOGY DESCRIPTION

The following description of the product was provided by the vendor and was not verified. Lonwood Natural flooring is a sheet vinyl product with an embossed wood-grain texture. Constructed in multiple layers and embossed with distinctive wood grains, it is composed of resin, plasticizers, fillers, and pigments. The co-calendered wear layer is formulated to provide maximum resistance to foot traffic in most commercial and health care applications. The middle layer provides dimensional stability, sound-absorbing properties, and resiliency under foot. The backing layer provides strength and stability of the flooring and enhances the bonding strength of the adhesive. Mold resistance is conveyed by the addition of a proprietary chemical as a top layer formulation that is applied to the surface of the sheet vinyl through a calendaring process. Figures S-1 and S-2 show the front and back surfaces of the material.



Figure S-1. Front surface of material

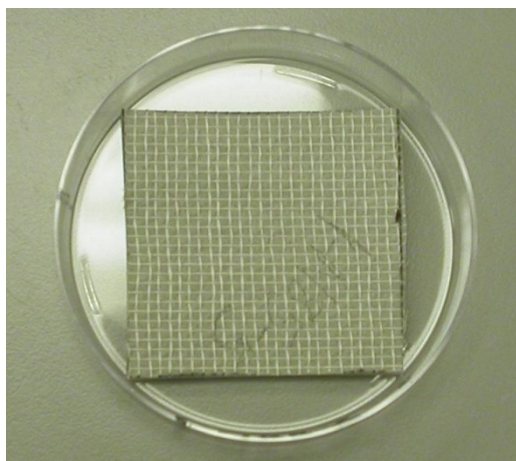


Figure S-2. Back surface of material

VERIFICATION TEST DESCRIPTION

Verification testing of the Lonseal Lonwood Natural flooring began on December 9, 2008 at the microbiology laboratories of RTI International and was completed on March 3, 2009. All tests were performed according to the ETV Program's "Test/QA Plan for Mold-Resistant Building Material Testing." Mold resistance testing was performed following the guidelines outlined in ASTM 6329. ASTM 6329 provides a quantitative endpoint for growth in a well-controlled, static chamber environment. The method has been successfully used to evaluate fungal resistance on a variety of materials including ceiling tiles and HVAC duct materials.

In overview, the Lonwood Natural flooring sheet was cut aseptically with a razor blade into a number of small test pieces (at least 4 cm x 4 cm). The material was not autoclaved or sterilized prior to inoculation. Therefore, in addition to the test organism inocula, any organisms naturally on both the top and bottom surfaces of the material had the opportunity to grow if conditions were favorable for growth. The test organisms were inoculated by pipette directly onto the surface of each test material piece in sufficiently high numbers to provide an adequate challenge, but at a level that is realistic to quantify. The tests ran for 12 weeks. During the 12 week test period, data from four test dates, labeled Day 0, Week 1, Week 6, and Week 12, were evaluated. Day 0 samples provided the baseline inoculum level. A sufficient number of test pieces were inoculated simultaneously for all four test dates. All pieces for one material and one test organism were put in the same static chamber. Because Lonseal is a flooring material, the reference material chosen for comparison was wood.

Two test organisms, *Stachybotrys chartarum* and *Aspergillus versicolor* were used. The static chambers were set to 100% equilibrium relative humidity (ERH) for the tests with *S. chartarum* and to 85% ERH for *A. versicolor*. On each test date (including Day 0), five replicates of the test material pieces were removed from the chamber, each was placed separately in a container with sterile buffer, and extracted by shaking. The resulting suspension of eluted organisms was plated and microbial growth on materials was quantified by manually enumerating colony-forming units (CFU).

The numbers of CFU eluted on test dates Weeks 1, 6, and 12 were compared to the baseline at Day 0. The numbers of CFU were expressed as \log_{10} . The results are reported as the \log_{10} change in CFUs between Day 0 and Week 1, Day 0 and Week 6, and Day 0 and Week 12. An extra test date was included to enable the QA review. The review had been scheduled for week 6, however scheduling difficulties made the review impossible on week 6 so additional samples were processed on week 7 for the audit.

Additional measurements included VOC and aldehyde emissions; these were performed by RTI following ASTM D5116-06.

VERIFICATION OF PERFORMANCE

The results for the Mold Resistance tests are presented in the Figures S-3 and S-4. Growth is measured by sporulation and is defined as at least a 1 \log_{10} increase in culturable organism over the baseline which was determined on Day 0.

Figure S-3 shows the log change from the inocula on Day 0 from *A. versicolor* and Figure S-4 shows the log change in the naturally occurring fungi that were on the surface of the material.

Neither the test material nor the reference material inoculated with *A. versicolor* and incubated at 85% ERH showed growth during the 12

weeks of the test. It was important to check that none of the changes made to the test material to make it mold resistant actually enhanced the ability of mold to grow over the reference material.

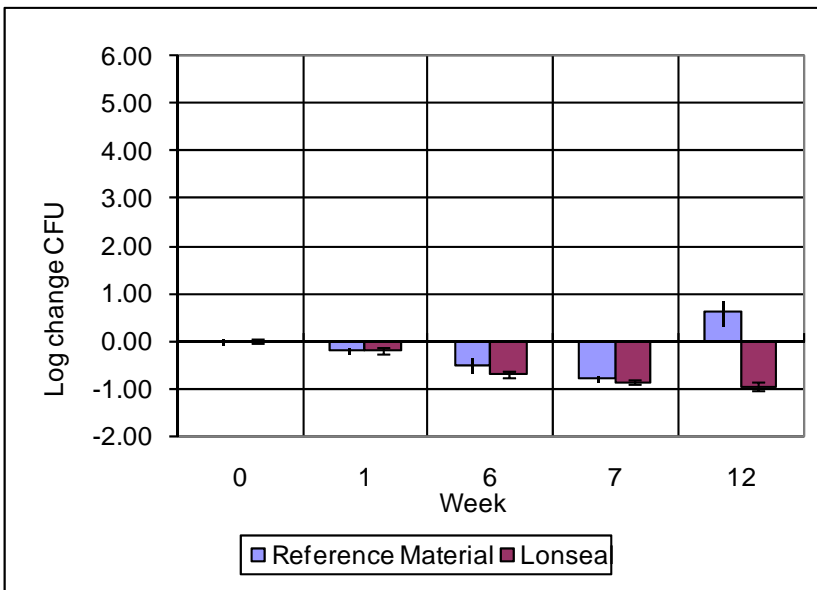


Figure S-3. Log change in *Aspergillus versicolor* inoculated on the test material over 12 weeks on reference material and Lonseal.

It was not possible to accurately assess whether or not the test material was resistant to the

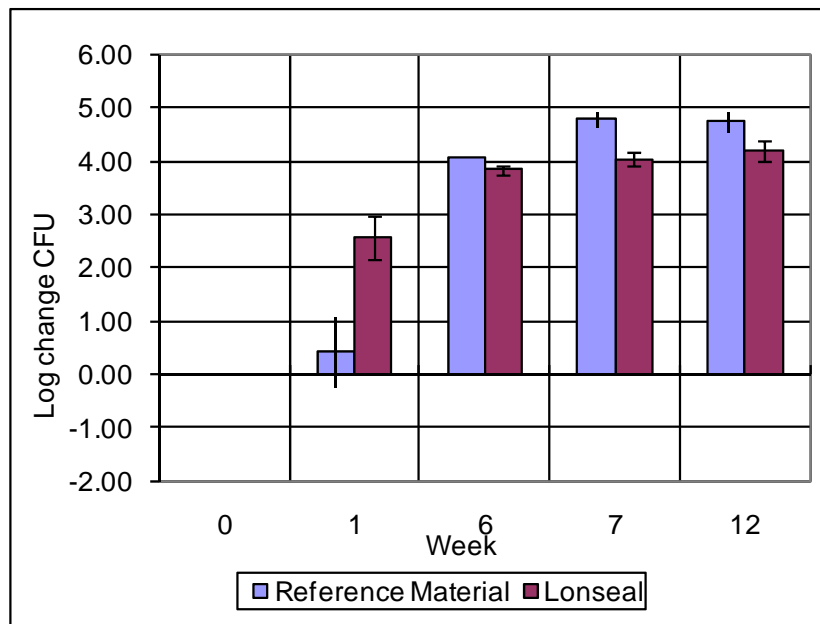


Figure S-4. Log change in *naturally occurring fungi* over 12 weeks on reference material and Lonseal.

growth of *S. chartarum*. The growth of a variety of fungal species (naturally occurring on the sample) masked any *S. chartarum* growth on Lonseal and on the reference material.

The quality assurance officer reviewed the test results and the quality control data and concluded that the data quality objectives given in the approved test/QA plan were attained.

The emissions of VOCs and formaldehyde test results are presented in Table S-1.

Table S-1. Test results for VOCs and formaldehyde emissions from Lonseal

VOCs and Formaldehyde Emissions*	
Emission Types	Minimum emission results
Total VOCs	< 0.5 mg/m ³
Formaldehyde	<0.1 ppm
Individual VOCs	< 0.1 TLV

*Individual pollutants must produce an air concentration level no greater than 1/10 the threshold limit value (TLV) industrial workplace standard (Reference: American Conference of Government Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, OH 45211-4438).

This verification statement discusses two aspects of Mold-Resistant Building Material Testing, mold resistance and emissions of VOCs and formaldehyde. Users of this technology may wish to consider other performance parameters such as fire resistance, service life, and cost when selecting a building material. According to the test/QA plan, this verification statement is valid for 3 years following the last signature added on the verification statement.

Details of the verification test design, measurement test procedures, and Quality Assurance/Quality Control Procedures can be found in the Test Plan titled *Test/QA Plan for Mold-Resistant Building Material Testing* (RTI 2008). Detailed results of the verification are presented in the Final Report titled *Environmental and Sustainable Technology Evaluation: Mold-Resistant Lonseal Flooring - Lonseal, Inc., Lonwood Natural* (NRMRL-RTP-460). Both can be downloaded from the ETV Program website (<http://www.epa.gov/etv/este.html#mrbmgw>).

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