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Mr. George P. Morey
Arlington Duplicate Bridge Club
528 North Fielder Plaza
Arlington, TX 76012

Re: IAQ Assessment
Site: 528 North Fielder Plaza
Arlington, TX

LABORATORY REPORT: B6SA0114-1

Armstrong Forensic Laboratory, Inc. (Armstrong), at the request of Arlington Duplicate Bridge Club, evaluated the Club's meeting space at 528 North Fielder Plaza, Arlington, Texas. The purpose of the onsite evaluation was to establish, to the extent possible, the indoor air quality related to airborne mold spores as well as document evidence of surface water damage including surface mold growth.

No single report can be a definitive statement of all possible opinions due to evidence that may be presented sometime after its release; however, Armstrong has made every effort to provide all opinions related to the referenced case based on the facts that have been reviewed through document review, current industry practice related to this type of project as well as education, training and experience directly or indirectly related to this type of project.

Resources referenced within this report and the corresponding attachments are summarized in Attachment A. Attachment B: provides information on water science and mold growth. Attachment C provides a discussion of infrared thermography.

Investigation

The subject property is a single-story commercial space located adjacent to a small grocery market. For purposes of this report, the space faces east and is constructed on slab foundation with a dead air space above a suspended ceiling tile system. The interior of the space is comprised of a Front Meeting Room and a Back Meeting Room that includes a kitchenette area. The interior is primarily textured and painted walls with the flooring a mixture of commercial carpeting and tile. The space is fully furnished and serviced by two (2) heating, ventilation, air conditioning (HVAC) systems.

It was reported to Armstrong that the Tenant/Occupant is concerned with possible issues associated with accidental release of water from the refrigeration/freezer systems of the adjacent market that have impacted the flooring and possible wall cavity of the common wall. Discussion of water science and mold growth in occupied spaces is included as Attachment B. Visual observation of the space found no evidence of current water damage or surface mold growth. Infrared thermography was utilized to establish if there was hidden evidence of potential water intrusion. Discussion of infrared (IR) imaging is included as Attachment C. Discussion of all assessment findings are detailed in the report section ***Discussion***.

Sampling Plan

Armstrong collected air samples for total bioaerosols as well as surface tape lift samples from the carpeting in the Front and Back Rooms. Table 1.0 details the samples collected. All samples were collected using validated industrial hygiene and environmental techniques. Due to weather at the time of the inspection, no outside sample was collected. Armstrong will review the inside samples with historical outdoor sample results for interpretation purposes.

The samples were transported to Armstrong without incident and the analyses completed utilizing validated methodologies. The analytical data are presented in the Data Tables section of this report. Table 2.0 details the air sample results and Table 3.0 details the surface sample results.

Industry Standards and Guidelines

There are no federal, state or local standards for IAQ related to airborne mold spores. There are a number of reasonable guidelines established to assist an Assessor in the evaluation of these types of environments for airborne mold spores; Attachment C includes a discussion of a few of these guidelines.

Discussion

Visual Observations:

The limited assessment included visual inspection of the interior, to the extent possible. No indications were noted that active or latent water intrusion was present along the wall common with the market. There is evidence of random past water sources from above – possibly roof or condensation build up on mechanical piping in the dead air space.

Infrared Thermography Findings

It is possible, under the right conditions, to detect moisture hidden behind interior walls with an infrared camera. The temperature difference associated with the presence of moisture on/within certain materials will generate different thermal readings. Infrared inspection is a fast, non-invasive method to discover possible moisture intrusion within a building. Infrared inspection does not directly detect the presence of water or mold; rather it may be used to find moisture potential where mold can develop. Further discussion of thermographic imagery is provided in Attachment C. Thermographic images were viewed using an IR-InSight® portable infrared imager. There were no areas with evidence of possible water damage that could represent surface mold growth. There were at least two areas, each approximately 2 - 3 square feet, where the temperature differential suggests there may be limited or no insulation present beginning approximately 3 feet above the finished floor. Again, there are other possible, non-moisture related, reasons for the darkened areas identified in the infrared images.

Sample Results

The air samples collected for total bioaerosol evaluation indicate that the indoor air has not been negatively impacted by airborne mold spores. (Table 2.0) All samples collected from indoor locations have total mold concentrations significantly lower than historical outdoor concentrations. Additionally, individual mold groups with potentially important concentrations identified in the indoor samples are also below historical outdoor concentrations.

The surface sample results (Table 3.0) indicate that there is not a significant accumulation of mold related debris in the flooring.

Conclusion and Recommendations

There is no visible evidence of current water intrusion or water damage, including surface mold along the common wall with the market. There is limited evidence of past water intrusion from the roof or condensation in the dead air space above the suspended ceiling, however, there is no evidence of active mold growth. Infrared imaging indicates there may be a few areas within the common wall between the Club space and the Market where insulation may be missing or ineffective.

Armstrong recommends having a discussion with the lessor about removing the current wall material from the common wall between the Club and the Market and improving the insulation and/or replacing the wall material with a more moisture resistant material. Additionally, identification of possible roof leaks or areas of the mechanical/piping system(s) in the dead air space above the suspended ceiling is recommended. In the interim, replacement of the ceiling tiles that become impacted from the limited moisture source(s) is recommended.

Plans to replace the carpeting within the space was noted. Armstrong encourages the Tenant/Occupant to request measures be taken during the remodeling to limit distribution of the accumulated debris in the material.

The concentrations of airborne mold spores inside the Residence do not present an indoor air quality concern at this time.

Respectfully submitted,
Armstrong Forensic Laboratory, Inc.

Original signed by:

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Table 1.0: Sample Descriptions

Laboratory ID	Sample Description	Media	Sample Time/Volume	Analysis
B6-0114A-001A	1A. Front Room	AOC	75L	Total Bioaerosols
B6-0114A-001B	1B. Front Room	Tape-Lift	NA	Microscopical Examination
B6-0114A-002A	2A. Back Room	AOC	75L	Total Bioaerosols
B6-0114A-002B	2B. Back Room	Tape-Lift	NA	Microscopical Examination

End of Table 1.0

Table Notes (these notes apply to reference numbers notated in the data tables following the listed mold species):

1. Fungi included in this genus may be considered respiratory allergens and may be known to cause allergenic reactions in hypersensitive individuals simply by being present, indoors or outdoors, at levels considered higher than typical airborne concentrations.
2. Fungi included in this genus may be considered opportunistic pathogens and may infect an individual whose immune system is not functioning properly due to illness.
3. Fungi included in this genus may be capable of producing mycotoxins. Mycotoxins are secondary toxic metabolites, believed to be present in the largest quantities on the mold spores, and their function is as a mold's defense mechanism. The relationship between airborne mycotoxins and human health effects has not been established or documented however; ingestion of food related aflatoxins has been known to cause reactions in certain people.
4. Amerospores include *Penicillium, Aspergillus* and *Trichoderma* spores that cannot be differentiated on this media. These genera are known to contain possible respiratory allergens. Some species have been reported to produce mycotoxins. A small number of species included in this group may be opportunistic pathogens.
5. These are mold hyphae that have not produced any spores under laboratory conditions. Without spores, fungal identification is not possible.

Table 2.0: Total Bioaerosols by AFL-SOP 3.01.101						
Laboratory ID	B6-0114A-001A			B6-0114A-002A		
Client / Field ID	1A			2A		
Sample Description	Front Room			Back Room		
Date of Sample	1/21/2016			1/21/2016		
Date of Analysis	1/21/2016			1/21/2016		
(See Table Notes)	Count	Result	%	Count	Result	%
Alternaria spp. (1, 2, 3)						
Amerospores (4)	11	147	69	8	107	67
Arthrinium spp.						
Ascospores (1)						
Basidiospores						
Bipolaris spp. (1, 2, 3)						
Chaetomium spp. (1, 2, 3)	1	13	6			
Chrysosporium spp. (2)						
Cladosporium spp. (1, 2, 3)	2	27	13	4	53	33
Curvularia spp. (1, 2)						
Epicoccum spp. (1)						
Fusarium spp. (1, 2, 3)	2	27	13			
Helminthosporium spp. (1)						
Hyphae Fragments						
Microsporum spp. (2)						
Monilia spp. (1, 2)						
Nigrospora spp. (1)						
Pithomyces spp. (3)						
Stachybotrys spp. (3)						
Torula spp.						
Ulocladium spp. (1)						
Total Mold	**16**	**214**	**100**	**12**	**160**	**100**
Total Pollens						
Fibrous Glass						
Background		Light			Light	
Sample Volume (L)		75			75	
Detection Limit		13			13	
Units	cts	cts/m^3	%	cts	cts/m^3	%
End of Table 2.0						

Table 3.0: Surface Tape-Lifts by AFL-SOP 3.01.103		
Laboratory ID	B6-0114A-001B	B6-0114A-002B
Client / Field ID	1B	2B
Sample Description	Front Room	Back Room
Date of Sample	1/21/2016	1/21/2016
Date of Analysis	1/21/2016	1/21/2016
(See Table Notes)	%	%
Alternaria spp. (1, 2, 3)		
Amerospores (4)		
Bipolaris spp. (1, 2, 3)		
Cellulose Fibers	15	15
Chaetomium spp. (1, 2, 3)		
Cladosporium spp. (1, 2, 3)		
Curvularia spp. (1, 2)		
Epicoccum spp. (1)		
Epithelial Cells	25	25
Fibrous Glass		
Fusarium spp. (1, 2, 3)		
Hairs	5	3
Hyphae Fragments		
Insect Parts		
Nigrospora spp. (1)		
Pollen		
Quartz Dust		
Stachybotrys spp. (1, 3)		
Wood Fibers		
Amorphous Dust & Dirt	55	57
Total Relative Particulate	**100**	**100**
*And Hyphae.		

End of Table 3.0

Attachment A: Resources and References

Agency for Toxic Substances and Disease Registry (ATSDR) website: www.atsdr.cdc.gov.

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs®) and Biological Exposure Indices (BEIs®), 2013.

AIHA, *The Industrial Hygienists Guide to Indoor Air Quality Investigations*, (1992).

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE); Thermal Environmental Conditions for Human Occupancy - ASHRAE Standard (ANSI/ASHRAE 55-1992) (1992).

Bearg, David W., *Indoor Air Quality and HVAC Systems,* Lewis Publishers, Boca Raton, Florida, (1993).

Brooks, Bradford O., *Understanding Indoor Air Quality*, CRC Press, Boca Raton, Florida, (1992).

California Environmental Protection Agency (CaEPA), Office of Environmental Health Hazard Assessment (OEHHA), *Determination of Acute Reference Exposure Levels for Airborne Toxicants*, (March, 1999).

Centers for Disease Control (CDC), National Center for Environmental Health (NCEH) Website: www.cdc.gov/nceh/.

Consumer Product Safety Commission (CPSC), An Update On Formaldehyde, Publication 0075, January 2013. www.cpsc.gov/PageFiles/121919/AN%20UPDATE%20ON%20FORMALDEHYDE%20final%200113.pdf.

Environmental Protection Agency (EPA) Indoor Air Quality Web Site: www.epa.gov/iaq/pubs.

Gammage, R.B. and D.M. Weekes, eds., *The Practitioner's Approach to Indoor Air Quality Investigations*, AIHA Publications, Fairfax, Virginia (1990).

Gammage, R.B. and B.A. Berven, eds., *Indoor Air and Human Health*, Lewis Publications, New York, New York (1996).

Gallego, Eva, et. al., *Determining Indoor Air Quality and Identifying the Origin of Odour Episodes in Indoor Environments*, Journal of Environmental Sciences, 21(2009) 333 – 339 (2009).

Institute of Medicine (IOM), *Clearing the Air: Asthma and Indoor Air Exposures*, IOM, Committee on the Assessment of Asthma and Indoor Air, National Academy Press, Washington DC (2000).

IOM, *Indoor Allergens: Assessing and Controlling Adverse Health Effects*, IOM, Committee on the Assessment of Health Effects of Indoor Allergens, National Academy Press, Washington DC (1993).

Meyer, B., et. al., eds, *Formaldehyde Release from Wood Products*, American Chemical Society (ACS), ACS Symposium Series 316, (1986).

Molhave, L., et al., *Total Volatile Organic Compounds (TVOC) in Indoor Air Quality Investigations*, Indoor Air 1997; 225 – 240 (1997).

National Air Duct Cleaners Association (NADCA), *ACR 2002: Assessment, Cleaning, and Restoration of HVAC Systems*, (2002).

NADCA 1992-01: *Mechanical Cleaning on Non-Porous Air Conveyance System Components*, (1992).

NADCA, *Introduction to HVAC System Cleaning Services*, (1995).

National Institute for Occupational Safety and Health (NIOSH) website: www.niosh.gov.

Ness, Shirley A., *Air Monitoring for Toxic Exposures: An Integrated Approach*, Van Nostrand Reinhold, New York, New York, (1991).

O'Reilly, J. T., Hagan, P., Gots, R., Hedge, A., *Keeping Buildings Healthy, How to monitor and prevent Indoor Environmental Problems*, John Wiley & Sons, Inc., New York, New York (1998).

Texas Commission on Environmental Quality (TCEQ) Toxicology Division website: www.tceq. state.tx.us/implementation/tox/.

TCEQ Effects Screening Levels (ESLs) published September 2008, website: (www.tceq.texas.gov/toxicology/esl/list_main.html.

Texas Department of State Health Services (TxDSHS) website: www.dshs.state.tx.us/iaq.

TxDSHS, *Voluntary Indoor Air Quality Guidelines for Government Buildings*, effective December 22, 2002.

U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED®), *New Construction and Major Renovation Reference Guide* (ver. 2.2), 3rd Edition, (October 2007).

Attachment B: Background Information on Water Science and Mold Growth

Water can exist in all three forms of matter: liquid (bulk), solid (ice) and gas (vapor or steam). Moisture (water) can be transported in both the vapor and liquid phase by diffusion, convection, capillary suction, wind pressure and gravity (water pressure). At room temperature, water will exist in equilibrium between its gas and liquid phases. Thus, liquid water will flow "downstream" and can travel through or around certain materials. In the case of standard building materials, the wetness of the material is dependent on several variables: the amount of available water, the contact time, the length of time wetted, and the length of time between non-wet periods. It is the amount of wetness (moisture content) and the period of wetness of the building material(s) that will dictate the potential for surface mold activity.

Molds have an absolute requirement for water. That is, specific molds require a specific amount of water to grow. The term "water activity" (a_w) is used to describe and quantify this requirement. A_w is a measure of the moistness of a substrate and is expressed as a decimal value directly related to the substrate's relative humidity (RH). Water activity is an important indicator of a material's ability to support microbial growth.

Practically speaking, if the water activity in materials is limited below an a_w of 0.65, virtually no microbial growth will occur on even the most susceptible materials. Likewise, when building materials are saturated with water, the mold – even those with excessive moisture requirements – will not grow until the building material has begun to dry out and the water activity reduces to the optimal range; a condition that may be delayed for extended periods of time.

Mold growth requires specific conditions for growth: water - in a specified range; temperature - in a specified range; and organic matter for food. The building materials provide the appropriate food source. The temperature of a typical residential structure is well within the range of many different fungal species. However, the presence of uncontrolled water does not always lead to surface mold growth. This is due to the requirement for a specified amount of water (moisture content) for a specified period of time (growth rate) of the mold. Many molds will begin to grow within 24 hours of having available water activity above 0.65 (65%); however, mold growth visible to the unaided eye requires an extended period of time (3+ days) and the more extensive the growth, the longer the time period required. Some mold species require over 7 days to begin growth and greater than 2 weeks to become visible to the unaided eye.

When water flows downstream, contact time is lowered and the wetted material will self-dry quickly; therefore, readily observable visible surface mold growth is not expected. Thus, the water is hidden from the occupied space because it is either contained within the wall cavity, or behind cabinetry or furnishings. Only after the building material has been wetted, dried, and wetted over the course of several days/weeks may the observable signs of water intrusion (those visible to the occupied side) become noticeable; it will take even longer for actual mold growth to be sustained.

<u>General Water Damage Information</u>

Water that may impact the interior of a structure can be placed into one of three categories. These categories are described by the Institute of Inspection, Cleaning and Restoration Certification (IICRC) as:

> **Category 1 Water –** That which is clean at the releasing source and does not pose a hazard if consumed by humans. Category 1 water may become progressively contaminated as it mixes with soils on or within floor coverings or building assemblies (walls, decking, subflooring). Time and temperature, which promote the growth and amplification of microorganisms in water, can cause Category 1 water to degrade. <u>Examples</u>: burst water pipes, failed supply lines on appliances, vertically falling rainwater.

Category 2 Water – That which begins with some degree of contamination and could cause sickness or discomfort if consumed by humans. As with Category 1 water, time and temperature can cause Category 2 water to become progressively more contaminated. Examples: waste water from appliances (dish/clothes washer) or commodes that may contain urine but does not contain fecal matter and rainwater.

Category 3 Water – That which is highly contaminated and could cause death or serious illness if consumed by humans. Examples: sewage, rising flood water from rivers and streams, ground surface water flowing horizontally into homes.

Water can originate from within a building (Category 1, 2 or 3) or it can enter a building from the outside. There are two ways in which water can enter a building. The first involves falling or windblown water (e.g., rain) that enters as a result of damage to roof components or wall assemblies. The second involves water traveling horizontally along the surface or ground. This type of water may contain silt and soil contaminants that can also infiltrate into structure, generally through doors or around foundation walls.

The examples of water categories included are illustrative only. There may be unseen conditions that change the water category to a higher, more severe level. As an example, clean water (Category 1) can pick up toxins, pesticides, heavy metals, organics, etc. from contact with surfaces and be transformed to a Category 3 quality condition.

Air and Surface Evaluation Guidelines

There are currently no federally mandated standards for assessing IAQ or indoor environmental quality (IEQ) in industry or for the general public. The American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) has developed voluntary standards relating multiple disciplines and building systems. The Indoor Air Quality Association (IAQA) has consolidated these ASHRAE voluntary standards and many other standards, guidelines and professional reports to develop a single reference document for Indoor Air Quality Evaluation (IAQA, 2000). Attachment D lists some of these guidelines currently referred to in the industry.

Several organizations have developed guidelines for assessing airborne biological contamination. Each of these recommend evaluating airborne mold levels against the levels existing outdoors, under the premise that the inside air should not be higher than the outside air. Additionally, presence of microbial species identified indoors, but not outdoors, or above levels identified outdoors, should be interpreted as an indicator of indoor sources.

- Indoor concentrations of "environmental" fungi should be lower than outdoor concentrations and should follow the outdoor pattern. To accomplish this, the following should be monitored:
  - Compare indoor/outdoor total concentration ratios;
  - Compare levels of particular species of fungi identified indoor and outdoor samples; and
  - Identify the presence of indicator genera or species in indoor samples.
- Risk management investigation should be initiated if the following indicator genera or species (aka microorganisms of interest) are confirmed to be present:

Aspergillus flavus	*Fusarium moniliforme*
Aspergillus fumigatus	*Stachybotrys chartarum*
Aspergillus versicolor	

There are currently no standards for assessing surface microbial contamination. Several organizations have developed guidelines for determining acceptable levels of surface contamination in occupied spaces under different conditions. Most of these address the air conveyance system (ACS). The most prevalent guideline is that visible fungal growth should be remediated.

The National Air Duct Cleaners Association (NADCA) has published guidelines for cleaning non-porous components of air conveyance systems (NADCA, 1992). The guidelines hinge on the initial visual inspection conducted immediately after cleaning has been performed. Further levels of cleanliness incorporate measurable levels of total surface contamination. Non-porous surfaces should be cleaned to a total dust level below 1.0 milligram of particulate per 100 square centimeters of surface area sampled (1.0 mg/100 cm^2). NADCA currently has no guideline specifically for fungal contamination.

Professionals have adopted a number of guidelines (NYCDH, EPA, etc.) as the industry standard of care for managing surface mold, regardless of the fungal species identified. These Guidelines have established that a "few or trace amounts of fungal spores in bulk/surface sampling should be considered background". Higher concentrations or the presence of hyphae and conidiophores may indicate fungal colonization and/or accumulation (NYCDH, 2000).

The Institute of Inspection Cleaning and Restoration Certification (IICRC) organization published *IICRC S520: Standard and Reference Guide for Professional Mold Remediation*. This document defines three (3) "conditions" for microbial presence within structures: Condition 1 is considered "normal fungal ecology"; Condition 2 is considered to be settled spores (directly or indirectly from a Condition 3); and Condition 3 is considered to be "actual growth" on indoor surfaces (active or dormant; visible or hidden). The intent of the IICRC S520 standard is to provide basic instructions for returning an indoor area to a Condition 1 status. This document, while a useful tool for professionals, does not fully define "normal fungal ecology".

Again, mold on surfaces does not correlate directly to mold spores in the air. The greatest exposure risk is through direct contact with the mold spores or inhalation of the mold when the material is disturbed.

Attachment C: Thermographic Imaging

It is possible, under the right conditions, to detect moisture located behind interior walls with an infrared camera. The temperature difference associated with the presence of moisture on/within certain materials will generate different thermal readings. Infrared inspection is a fast, non-invasive method to discover possible moisture intrusion within a building. Infrared inspection does not directly detect the presence of mold; rather it may be used to find moisture where mold may develop. The limitations to obtaining accurate infrared images pertain to the ability of the surface being scanned to emit heat energy. Gypsum in interior walls emits heat energy quite well, whereas highly reflective surfaces and water do not.

The primary tool for evaluating this type of thermal performance of building materials is infrared thermography. Thermography can identify surface temperature variations, which may relate to problems in the structure, thermal bridging (insulation), moisture content or air leakage.

Two possible methods for heat loss in building materials are conduction and air leakage. Both methods can be identified from the differential surface temperature with infrared thermography.

Conductive Losses

Problems associated with conductive heat loss include: missing insulation, improperly installed or compressed insulation, shrinkage or settling of various insulating materials; excessive thermal bridging in joints between walls and the top and bottom plates; moisture damage to insulation and building materials; heat loss through multi-pane windows with a broken seal; leaks in water pipes; damaged heat ducts; location of, or leakage in buried steam lines, water lines or underground sprinkler systems, etc.

Air Leakage

Air leakage is the passage of air through the building envelope, wall, window, joint, etc. Leakage to the interior is referred to as infiltration and leakage to the exterior is referred to as exfiltration. Excessive air movement significantly reduces the thermal integrity and performance of the envelope and, therefore, can be a major contributor to energy consumption in a building.

In addition to energy loss, air leakage can result in condensation to form within and on walls. This can create many problems; reduce insulation R-value; permanently damage insulation; conditions appropriate for microbial activity; and seriously degrade materials. It can rot wood, corrode metals, stain brick or concrete surfaces, and in extreme cases cause concrete to spall, bricks to separate, mortar to crumble and sections of a wall to fall jeopardizing the safety of occupants. It can corrode structural steel, re-bar, and metal hangars and bolts with very serious safety and maintenance issues. Virtually anywhere in the building envelope where there is a joint, junction or opening, there is potential for air leakage.

Identification of thermal irregularities and the resulting thermal pattern can be evaluated to determine whether the pattern indicates a problem with the insulation, air leakage, the building structure or water intrusion. Issues associated with insulation are typically identified through regularly shaped color change in an infrared image. Air leakage, particularly those involving moisture intrusion are typically identified through irregularly shaped color change on in infrared image. Direct water intrusion is also typically identified through irregularly shaped color change on the infrared image and occasionally will include gradient color change as the water content of the building material varies.