Mold in Colerain Township Fire Stations: A Growing Problem

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CERTIFICATION STATEMENT

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ABSTRACT

This applied research project utilized descriptive research to better understand the causes, effects, and remedies to a persistent mold growth problem within Colerain Township Fire Stations. The research questions asked were (a.) What factors lead to indoor mold infestations?, (b.) What, if any, are the health hazards associated with high levels of indoor mold?, (c.) If at all, have other fire departments experienced similar mold problems? and (d.) What have some other fire departments done to prevent mold growth in existing and future fire stations? The purpose of this study is to use the results to prevent further cost of mold removal from current and future Colerain Township Fire Stations and identify any potential health risks to personnel.

The procedures used to determine the answers to these questions included an extensive literature review and a set of designed surveys. The literature review revealed information from government agencies, industry standards, health organizations, and construction industries. The surveys were delivered to internal department members and external fire department organizations.

The procedure results revealed that Colerain Township is not alone in its fight against mold growth within the stations. Mold is a common organism that flourishes in specific environments and although not readily verified, does have potential health risks. Older buildings are more susceptible, but new ones are not exempt. While the problem is expensive to repair, not many organizations make specific efforts to prevent it.

Based on the research, recommendations will be made to improve the department's awareness of mold potential and ways to monitor humidity levels that may cause problems. In addition, a recommendation will be made to allocate money to educate a group of personnel to better oversee remodeling and new construction.

TABLE OF CONTENTS

INTRODUCTION

Statement of the Problem

What if a breathable hazard was circulating through the living quarters of the fire station 24 hours a day? Since 2008, two of Colerain Township's five fire stations were found to be infested with mold. In 2008, Station 26 underwent a large renovation due to the presence of mold. More recently, in 2011 Station 102 was also found to have large quantities of mold located in specific areas of the building. This station too, required an expensive renovation to alleviate the problem. The problem that this research project will address is the recurrent mold growth found in Colerain Township fire stations.

Healthy indoor air is recognized as a basic right. People spend a large part of their time each day indoors: in homes, offices, schools, healthcare facilities, or other private or public buildings. The quality of the air they breathe in those buildings is an important determinant of health and well-being (World Health Organization Regional Office for Europe, 2009, Foreword).

A Google Internet search of "fire station AND mold" showed that the Colerain Township Department of Fire and EMS (Colerain Fire and EMS) is not alone. This search revealed fire station closures or problems related to mold in (a) Hartford, NY (McKenna, 2011) (b) High Point, NC (Kimbrough, 2010) and (c) Oviedo, FL (wftv.com, 2010) to mention only a few.

Purpose of the Study

The purpose of this descriptive research is to identify and describe the causes, health effects, and remedies for indoor mold growth. The results of this research may be used to prevent further cost of mold removal from Colerain Township fire stations and identify any potential health risks to personnel.

Research Questions

The following questions will be answered by this descriptive research:

1. What factors lead to indoor mold infestations?
2. What, if any, are the health hazards associated with high levels of indoor mold?
3. If at all, have other fire departments experienced similar mold problems?
4. What have some other fire departments done to prevent mold growth in existing and future fire stations?

BACKGROUND AND SIGNIFICANCE

Colerain Fire and EMS originated in 1975 as the result of a merger between the Groesbeck and Dunlap Fire Departments. Colerain Township is the largest township in the state of Ohio in terms of population and area. Colerain Fire and EMS serves 60,144 residents and numerous visitors within its 43.5 square mile coverage area (Colerain Township Department of Fire and Emergency Medical Service, 2010). This service is provided from five fire stations within the township staffed 24 hours per day utilizing a combination staffing system. The combination system includes a total of 56 career and 120 part-time paid personnel.

Colerain Fire and EMS Station 26 is located at 3360 West Galbraith Rd. in Colerain Township, Ohio. It was constructed in 1965 as the third home of the Groesbeck Fire Department prior to the merger between the Dunlap and Groesbeck Fire Departments. The building is a 4,000 ft^2, single story structure constructed with cinderblock walls and a flat metal deck roof. The building is divided into three sections in its current configuration: (a) the apparatus bay housing six emergency vehicles; (b) the office space consisting of two offices, a training room, and a supply room; and (c) living quarters including a day room, bunkroom, and kitchen. This current configuration of the building is not its original. While square footage remains the same, the office and living areas have been remodeled since its original construction. In 1988, a project was completed that created additional office space. In 1993, a major renovation of the interior was completed. Offices and sleeping areas switched to opposite sides of the building, the kitchen was relocated, and an area for SCBA maintenance was converted to a locker room. No changes were made to the water supply or heating, ventilation, and air conditioning (HVAC) systems at that time.

In the early months of 2008, three personnel assigned to Station 26 began to complain of illnesses believed to be related to the building's indoor air quality (IAQ). The complaints revolved around a few common health problems. Recurrent headaches, cough, sinusitis, and upper respiratory complications were reported by personnel while in the building. Some complications subsided shortly after leaving and some lingered for up to a week. Complaints varied among personnel that were stationed there for a single shift or multiple shifts in a row (B. Miller, personal communication, June 1, 2011). No records existed that documenting whether any of the personnel requested sick time due to related symptoms, nor did any medical records indicate that the symptoms could be directly connected to the IAQ of Station 26. With only their suspicion of mold related illness, one employee requested a transfer from the station and another refused to work there whenever possible (B. Barnhorst, personal communication, June 1, 2011). On November 19, 2008, in response to the complaints, Colerain Fire and EMS requested PSARA Technologies, Inc. to conduct an inspection and sampling survey for mold spores at Station 26. The process included visual inspection of carpet, padding, inside of interior and exterior walls, and above the drop ceiling to identify suspect mold. Miscellaneous areas examined included sinks, refrigerators, toilets, and other areas where water is commonly found. Particular attention was given to visibly water damaged areas of the building. Humidity ranged from 17% to 27% and the temperature ranged from 66º F to 72º F throughout the building. The visual inspection found no visible evidence of mold in the accessible areas. Air samples were collected using an air-o-cell cassette in which "a calibrated amount of air is drawn through the cassette for 10 minutes" (PSARA Technologies, Inc., 2008, p. 6). They were then sealed and sent to EMSL Analytical in Westmont, New Jersey for analysis. The results are reported in counts per cubic meter (counts/m^3). Sample results are compared with the results of ambient air samples collected during the same time period of the same day. The air sampling results showed higher concentrations of mold growth structures in the vent from the bunk room side HVAC unit leading into the day room. The study showed 6,320 (counts/m^3) of Aspergillus mold in the bunk room side HVAC ducts versus 42 (counts/m^3) in the outdoor air. Other fungal genera were identified, but were categorized in either a low or rare concentration. The other fungal genera were: (a) Basidiospores, (b) Cladosporium, (c) Ganoderma, (d) Alternaria, (e) Curvularia, (f) Epicoccum, (g) Rust, (h) Pithomyces, (h) Bipolaris, and (i) Torula. As result of the survey and subsequent recommendations, the bunk room side HVAC system and duct work were replaced along with gutter and downspout repair, and replacement of the drop ceiling producing follow-up air sample results showing mold levels to be approximately 10 times less than the outdoor air sample (PSARA Technologies, Inc., 2008).

While the situation at Station 26 was resolved in 2008, a recent mold growth problem was discovered at Station 102 in July of 2011. The station is located at 11474 Colerain Avenue in Colerain Township. It is unclear as to the exact construction date, however it is believed that the original building was erected in the 1930's and is known to have been a filling/service station. It was the original Dunlap Fire Station that participated in the merger with the Groesbeck Fire Department creating the current Colerain Township Department of Fire (D. Brown, personal communication, August 30, 2011). The building is approximately 3,000 ft^2 built of cinderblock walls with a flat metal bar joist roof. As of 1998, the station has been occupied solely by the fire department housing a single engine company and the department vehicle maintenance garage. Prior to that date, the building was shared with the Colerain Township Police Department. The fire station portion of the building is separated into three areas: (a) the apparatus bay, (b) office areas, and (c) living areas. It is heated and cooled by two roof top HVAC units and a forced air furnace located in the kitchen closet. Water is supplied by the Cincinnati Water Works and septic system is located on the East portion of the property. Again, one of the employees, also involved in the initial complaints of a possible mold problem at Station 26 in 2008, recognized similar medical symptoms and problems with the building. Noticeable water leaks near a bunk room window, wet carpet, visible mold on the baseboards and around the furnace, and a continuously running dehumidifier in the bunk room were reported. The dehumidifier needed to be emptied up to four times per 24 hour shift (C. Ruwe, personal communication, August 30, 2011). Dehumidifiers draw air in, cool it below the dew point causing the humidity to condense on the coils and drain into a catch basin (Branson, 2003). PSARA Technologies was contracted again to test the IAQ at Station 102 resulting in elevated levels of mold found throughout the station with the most prevalent readings coming from the bunkroom. Due to these findings, significant repair or replacement was required including new drop ceiling, drywall, HVAC ducts, windows and roof repair.

Approximately 36% of the fire stations in the United States are at least 40 years old (United States Fire Administration [USFA], 2012). The possibility of similar mold related events grows as the existing fire stations age (Institute of Medicine, 2004). Mold remediation at Station 26 cost Colerain Fire and EMS $55,000.00 and Station 102 required $37,000.00 of additional funding (Colerain Township Department of Fire and Emergency Medical Service, 2011). The entire budget for building maintenance in 2012 is $120,000 (M. Vangen, personal communication, November 4, 2011). If those amounts were needed to be spent again they would respectively use 46% and 31% of the annual maintenance budget. As reported during an August 2011 officer’s meeting by Chief and Administrator Bruce Smith, the exact numbers are not yet final, but Colerain Fire and EMS was ordered to prepare for budget cuts of $1 million in each of the coming five years. These cuts equate to an 8.3% cut each year. To state the significance of the research, for the well-being of the Colerain Fire and EMS workforce it will be necessary to prevent uncontrolled infestations of mold within the work environment. In addition, the expense of potential medical claims and legal complications of a known, but not repaired problem emphasizes the need to understand any possible health effects and prevention of mold growth.

LITERATURE REVIEW

In the 1970's, the oil crisis sparked a movement toward tighter buildings in efforts to reduce energy consumption. The use of modern building techniques in these tight structures with drywall and particleboard vs. concrete and plaster, which have greater resistance to mold growth, has led to trapping conditioned air inside creating ideal conditions for mold growth (Pugliese, 2006). Mold is a living organism of the fungi kingdom within the world of biology. It comes in many shapes, sizes, and colors throughout the world. There are over 10,000 species of mold (Lankarge, 2003). It exists in beneficial forms like medicines, food, yeast, and alcoholic beverages, but also has forms that are potentially harmful to the human body. Mold thrives in dark, damp, warm environments feeding on any organic matter (Gay, 2005). The prevalence of dampness problems appears to increase as buildings age and deteriorate. One consequence of indoor dampness is new or enhanced growth of fungi and other microbial agents (Institute of Medicine, Committee on Damp Indoor Spaces and Health, Board on Health Promotion and Disease Prevention, 2004).

Mold is not usually a problem indoors unless mold spores land on a wet or damp spot and begin growing. If not remediated, mold growth can damage building contents and materials, potentially leading to decreased structural integrity. The health effects may vary from person to person based upon sensitivity and exposure. While there are many concerns to be addressed regarding indoor mold growth, standards or Threshold Limit Values (TLV) for airborne concentrations of mold, or mold spores, have not been set. There are no regulations or standards for airborne mold contaminate currently set by the United States Environmental Protection Agency (EPA) (2010). The Occupational Safety and Health Administration (OSHA) also agrees that no federal standards exist related to indoor mold concentrations (OSHA, 2010). Pugliese

(2006) describes two items of importance when determining mold level severity. Even though, the EPA and OSHA have set no values on indoor mold levels, finding higher concentrations inside compared to outside and finding species inside that are not present in the outdoor environment would indicate a problem. The Mold Services Group (2004) also uses a comparison between indoor and outdoor mold levels to determine if a problem may be present. Indoor levels are usually 30-80% of the outdoor level. Percentages above this range may be indicative of a contamination.

In order to identify hidden indoor mold concentrations, attempts have been made to measure Microbial Volatile Organic Compounds (MVOC), chemicals that produce the characteristic smells associated with some forms of mold. However, other sources of MVOC's, like perfume and cologne are readily present in many indoor environments rendering the expensive testing unreliable. Mycotoxins are another byproduct of mold growth that can produce harmful effects to humans. The mycotoxin produced by Stachybotrys or "black mold" has been highly publicized and responsible for people abandoning their homes (May, 2004)

With no existing IAQ standard for mold, most literature focuses on the prevention of moisture and humidity within buildings. The term "sick building syndrome" (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. In contrast, the term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants (EPA, 2010).

In the United States Department of Housing and Urban Development (HUD) Report to Congress (2005) it is also agreed that there is not a generally recognized definition of what is considered a dampness problem. Additionally, HUD reported the lack of scientific protocol and standards have hindered inspection, remediation and research.

In 2003, the Centers for Disease Control and Prevention (CDC) asked the Institute of Medicine (IOM) to review all studies regarding possible connections between damp or moldy indoor spaces and problems with breathing or allergies. The results of this review were published in the report. The Institute of Medicine (2004) concluded that sufficient evidence existed to associate exposure to damp indoor environments to the following health effects: (a) upper respiratory tract (nasal and throat) symptoms, (b) cough, (c) wheezing, (d) asthma symptoms in sensitized asthmatics, and (e) hypersensitivity pneumonitis.

Fisk, Eliseeva, and Medell (2010) examined the association of dampness or mold in homes with respiratory infections and bronchitis. From their work they concluded that statistically dampness and mold in buildings was associated with increased instances of the two health complications. However, they also noted that additional focused research would be needed to prove the associations were causal.

In Clearing the Air: Asthma and Indoor Air Exposure, published by The Institute of Medicine (U.S.) Committee on the Assessment of Asthma and Indoor Air, Division of Health Promotion and Disease Prevention (2000), it was agreed that sufficient evidence existed to prove an association between the exposure to mold and the exacerbation of asthma in sensitized individuals. However, it was also concluded that inadequate or insufficient evidence existed to prove an association between mold exposure and the development of asthma (Institute of Medicine (U.S.) Committee on the Assessment of Asthma and Indoor Air, 2000).

Health and Energy (2011) explains in detail many different ways of preventing mold growth within public or private buildings. The prevention of mold revolves around the prevention of excess moisture in the environment. While mold is known to thrive in moist areas, it does not require liquid to exist. Relative humidity (RH) is the key. An RH level between 65% and 99% is the only moisture needed to facilitate growth. Different mold species reproduce in different RH ranges. An RH level of less than 50% actually inhibits mold growth in the environment. With no current IAQ standards for mold, one way to detect the potential for mold growth is to measure the humidity. A humidity monitor also known as a hygrometer can be purchased relatively inexpensively at many local hardware stores for approximately $50.

Various types of equipment can be used to measure, monitor, and control moisture within a building. The previously mentioned humidity monitor can measure RH and temperature. A moisture meter can be used to track the drying process of damaged materials like carpet, drywall, wood, and concrete. It uses direct contact against a surface or a probe inserted into the material to measure the moisture. Humidistats turn on the HVAC system once the RH reaches a set percentage to maintain an acceptable level. Using high quality HVAC filter during a remediation process can help catch mold size particles which would not be caught by conventional filters (EPA, 2011).

The American Society for Testing and Materials (1994) discussed fungi related health effects and found that many organic building materials are produced in ways that virtually sterilize them. However, preventing mold spore intrusions after construction does not guarantee that fungal growth will not happen. During transport, storage, and installation the right combination of moisture and temperature can create an environment for fungal growth. Industry will inevitably market processed wood material that will better resist biological deterioration, but only time will tell of the success of such products (Ammann, Hogdson, Nevalainen, & Presant, 2008). The authors agree that controlling RH is important when preventing mold and that RH less than 50% is needed in cold weather. In hot humid weather HVAC units can fail or be subverted causing condensation on cold surfaces. The insulation of the duct work should be inorganic and smooth to assist in preventing mold growth. In humid areas where RH above 50% is present, hydroscopic materials like skin cells, a primary component of dust, are able to absorb enough water to produce the growth of many fungal species. When remediation is discussed by the authors, their views agree with May and May (2004) that small surface area jobs can be cleaned adequately using one part bleach to ten parts water solution as long as the source has been removed and rotten components are replaced.

The EPA's three levels of remediation (as cited in May and May 2004) include (a) the small level consisting of an area of 10 ft.^{2} or smaller, (b) the medium size area is between 10 ft.^{2} and 100 ft.^{2}, and (c) the large area being an effected space measuring over 100 ft.^{2}. They believe that any contaminated area exceeding the small size range should be professionally remediated. Should an attempt to remove the problem on your own be made, a containment-like area should be constructed around the area using plastic sheeting as a barrier and Tyvec suits and N95 masks for personal protection.

Chapter 20 of the Manual on Moisture Control in Buildings (American Society for Testing and Materials, 1994) recommends remedial and preventative measures in commercial buildings. Important notes include: (a) establish a quality assurance plan and follow it, (b) establish an inspection plan for the exterior envelope, (c) only use qualified and experienced technicians, (d) resist the temptations to take short cuts, (e) don't ignore viable alternatives when considering cost, and (f) realize that total replacement may be required when smaller tactics will be insufficient or non-cost effective.

Branson (2003) explains that early recognition and action regarding water leaks is the key to preventing further water related problems like standing water and decay, both of which harbor mold growth. He also describes the use of mechanical means to control the humidity levels within the structure. While low humidity (less than 30%) can be uncomfortable, high humidity (above 50%) provides an environment for mold to prosper. The use of vapor retarders depending on climate, dehumidifiers, whole-house fans, and air-to-air heat exchangers are highlighted as ways of managing and maintaining appropriate indoor humidity levels to combat the presence of mold.

Information found through the literature review was useful by providing Colerain Fire and EMS with facts regarding the origins of mold and providing a better understanding of key factors in its growth process. The review was also able to assist with the identification of health problems associated with indoor air quality and mold as they relate to individual sensitivities. The literature review helped to guide the internal surveys in determining how often possible mold related illnesses occur and what is done about it, if anything. In conjunction with external surveys, the literature review revealed techniques and costs for remediating and preventing further mold infestations within Colerain Fire and EMS. All information compiled will assist Colerain Fire and EMS in the development of a program that may provide early detection of problems and reduction of mold risks and cost.

PROCEDURES

This OFE applied research project (ARP) began with the identification of mold related problems with Colerain Township fire stations. Once the problem statement was developed, focused research questions were created to address specific topics within the mold problem. The information collected for this descriptive research study was based upon providing answers to the research questions. Literature from home inspectors, building contractors, Certified Mold Remediators (CMR), and Certified Mold Technicians (CMT) was reviewed. Other sources providing evaluative research included, scientific studies from the CDC, EPA, and IOM. This review provided information pertinent to answering research questions 1, 2, and 4. Personal interviews were conducted with (a) Division Chief Brad Miller on June 1, 2011 regarding complaints suspected mold related illness; (b) Division Chief Darrell Brown on August 30, 2011 to determine the history of Stations 26 and 102; (c) Ben Barnhorst and Captain Chris Ruwe on June 1, 2011 and August 30, 2011 to discuss their suspected mold related symptoms and recognition of mold in the fire station; (d) Matt Vangen, Building Maintenance Supervisor on November 4, 2011 to determine the impact of remediation efforts on the building maintenance budget; and (e) Chief Bruce Smith on August 26, 2011 regarding proposed departmental budget cuts in upcoming 5 years. Other documents, including: (a) purchase orders, (b) department history, and (c) air quality sampling reports were provided by Colerain Township. Lastly, internal and external surveys were conducted to find any similarities that could help to provide early detection of mold related illnesses and infestations, and recognize possible solutions to improve mold prevention or remediation in Colerain Township fire stations.

The internal surveys were distributed to all department personnel via The Internet using Surveymonkey.com as the medium. This method of delivery was chosen to increase the level of anonymity and increase the participation level. The personnel surveyed varied in rank and seniority. The return produced 52 completed surveys of 176. The questions were focused toward answering research question 2 by providing their experience or non-experience with mold related problems specifically within Colerain Township fire stations.

The external surveys were also delivered and returned via The Internet and Surveymonkey.com. Eighteen surveys were distributed to contacts made at the National Fire Academy. These contacts are officers from fire department organizations throughout the country, including Alaska. This national group was chosen to find some measure of extent throughout different organizations on a national scale. Additionally, different methods of remediation may be used in different regions of the country and could prove useful to Colerain Fire and EMS. An additional 10 external surveys were distributed by the same method to local fire department organizations. These 10 surveys were sent locally to find see how frequently indoor mold creates problems in fire departments near Colerain Township. Any additional information provided by local organizations could be relevant due to similar building construction techniques and climates. The questions in the external survey were designed to answer research questions 3 and 4. The results determined causes, frequencies, remedies, and similarities related to indoor mold growth in fire stations outside of Colerain Township. The external survey yielded 13 completed surveys.

The survey results were analyzed first for general information regarding the amount of returns and completeness. Secondly, the survey results were sorted as they relate to specific research questions. This data was analyzed and compared to information obtained through literature review in order create valid recommendations for Colerain Fire and EMS.

<u>Definition of Terms</u>

Air-o-cell cassette. An air sampling device in which a calibrated amount of air is drawn through, sealed, and tested (PSARA Technologies, Inc., 2008)

Alternaria. Dark olive green dry mold spore commonly found in soil, seeds, plants, and carpet. It is known to be a common allergen and is commonly found in water damaged buildings (Mold Services Group, A Division of GHH Engineering, Inc., 2004).

Aspergillus. Genera of mold found on many different textiles and organic materials such as soil, compost, stored grain, wood and paper. It is often found in water damaged carpet. It is a dry spore mold that can be carried by air making it a common cause of respiratory irritation and infection (Mold Services Group, A Division of GHH Engineering, Inc., 2004).

Basidiospores. A category of mushroom spores that are very common outdoors. Outdoor levels increase dramatically during periods of rain. High levels in wall cavity samples may be a sign of dry rot inside the wall (Mold Services Group, A Division of GHH Engineering, Inc., 2004)

Building related illness. When symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants (United States Environmental Protection Agency [EPA], 2010).

Cladosporium. The most common mold found in outdoor environments. Also found indoors on the surface of fiberglass duct liners and the interior of supply ducts. It is commonly associated with refrigerator foods because it can grow at 0˚ C. It is a common cause of hay fever, asthma, and is a known allergen (Mold Services Group, A Division of GHH Engineering, Inc., 2004).

Hypersensitivity pneumonitis. A rare chronic lung disease that occurs most often as a result of occupational exposures (Jefferey C. May, 2004, p. 40).

Mycotoxin. Chemical byproducts of mold that can cause illness in people and animals (Lankarge, 2003, p. 14).

Rust. Group of fungi that are plant pathogens, which do not normally grow indoors. They are brought inside as part of the normal influx of dust particles. Large amounts of dust can lead to elevated levels of these molds, as well as recent dusting (Mold Services Group, A Division of GHH Engineering, Inc., 2004).

Sick building syndrome (SBS). The situation in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified (EPA, 2010).

Limitations of the Study

Much of the text related to mold in buildings covers residences and commercial buildings, but is limited when specifically referring to fire stations. Fire stations typically represent portions of both residential and commercial occupancies therefore information pertaining to either can be relevant.

The internal survey, although anonymous, may provide limited results due to possible apprehension of answering the questions honestly. A fear of retaliation from officers who may not have reported problems appropriately does exist. A clear explanation of the anonymity of the survey at delivery was required. Returns may also be limited due to the amount of personnel hired after remediation having limited experience with the mold situation coupled with the loss of personnel who were employed during the original mold problem. Additionally, run volume on the day of delivery will dictate how many internal surveys will be distributed.

The external survey included the “other, please explain” option within survey answers that created a variety of answers that complicated data interpretation. This option was left as an option to produce as many solutions as possible.

Due to the complexities of mold growth and remediation, it should be noted that some survey participants may not be educated on the topic and may be unaware of the true origins or solutions to problems experienced within their own departments. These same participants may also be unable to obtain specific information regarding the cost of any actions taken by their department.

RESULTS

The internal survey (see Appendix 6) was sent to 176 Colerain Fire and EMS personnel. The survey was completed and returned by 52. The external survey (see Appendix 7) was sent to 28 fire department organizations and was completed and returned by 13.

The external survey was used to answer research question 1 regarding factors that lead to mold infestations and supported the reviewed literature stating that older buildings were more susceptible to mold problems. The survey showed that 55.6% of the fire stations that experienced mold problems were older than 25 years old. It also pointed out that leaking roofs were the leading cause of the mold problems claiming 4 of the 13 responses. Plumbing, ventilation and drainage problems were each responsible for 3 of the 13 mold infestations.

The internal and external surveys were used to help identify potential health hazards caused by mold and answer research question 2. While sinus and respiratory symptoms led the survey results in the nature of health complaints as was also suggested in the literature, few were confirmed by a physician. In the internal survey 34% reported sinus problems and 18% reported respiratory problems. Only 7.8% of those combined complaints were confirmed by a physician. The external survey similarly showed 58.3% reporting sinus problems and 41.7% with respiratory complaints. Of those complaints only 15.4% were physician confirmed. These results further support the literature’s view of the difficulty in proving that illnesses are actually caused by mold exposure.

Research question 3 asked if other fire departments had experienced similar mold related problems. The survey of other departments, locally and nationally, was answered by 12 of the 13 respondents and skipped by one. Of the 12 the answered 6 reported having similar problems and 6 reported no problems. This result showed that Colerain Fire and EMS is not alone in this area.

A solution for preventing mold growth in current and future fire stations was the focus of research question 4. While 40% of the surveyed departments admitted to spending \$0 - \$15,000 on mold remediation and 20% spent \$15,001 - \$30,000 few had any measures in place to prevent further problems. 80% of the respondents stated that no moisture control or detection devices were present and 20% only used dehumidifiers. Literature on the topic emphasizes humidity as the catalyst to mold growth and provides various means for its measurement. This fire department data however, shows that it is not monitored regularly within the field.

DISCUSSION

The research completed throughout this project has shown that Colerain Fire is not alone in its battle against mold. Survey results and Internet searches have shown that mold infestations are not an uncommon event. Mold is found in various shapes, sizes and colors producing varied results (Lankarge, 2003). It flourishes in dark and humid environments where it is known to deteriorate building materials and spread throughout a structure (EPA, 2010). As stated by Health and Energy (2011) humidity is a key factor in its ability to thrive, but was not readily monitored by Colerain Fire or other surveyed departments. Considering the relatively low cost of portable or fixed monitoring devices, it seems unreasonable that Colerain and other fire departments do not often use them in order to deter the high cost of mold remediation.

While mold can and does cause health problems, its effects vary greatly depending on the individual exposed and their level of tolerance. Those with allergies to specific mycotoxins and those with underdeveloped or reduced immune systems fare the worst. As shown in the literature review, sinus and respiratory problems are the most prevalent complications (IOM, 2004). Although the amount of response was not as high as the author expected, the data retrieved showed that Colerain Fire and other surveyed fire departments produced similar results as shown in Table 1 and Table 2. If this project or a similar version were to be repeated, personal delivery and immediate retrieval of the internal survey might provide a larger quantity of data.

Table 1

Amount and Nature of Specific Health Complaints Believed to be Caused by Mold Exposure Among Colerain Fire and EMS Personnel

Nature of Complaints	Number of Complaints
Sinus	17
Respiratory	9
Neurologic	1
Cardiac	0

Table 2

Amount of Personnel and Nature of Specific Health Complaints From Other Surveyed Fire Departments Believed to be Caused by Mold Exposure

Nature of Complaints	Number of Complaints
Sinus	7
Respiratory	5
Neurologic	0
Cardiac	0

Many of these health problems believed to be caused by mold exposure are neither reported nor confirmed by a physician. Even reported health problems are difficult to prove to be mold related, as many of the symptoms are similar to the common cold. Other variables like the time of year, weather conditions, personal encounters and transition through multiple locations also complicate finding a specific source.

Regular inspections and early recognition are key factors to reducing or avoiding the cost of mold mitigation (Branson, 2003). The discovery and quick repair of water problems in particular are important in minimizing damage. While older buildings are more susceptible to mold related problems, new and modern buildings are not exempt from damage (ASTM, 1994). Construction techniques and building materials during renovations and new construction projects must be closely monitored.

Table 3

Age and Amount of Fire Stations Requiring Mold Remediation in Other Surveyed Fire Departments

Age in Years	Number of Stations
0 to 5	1
6 to 15	3
16 to 25	1
Over 25	5

As Colerain Township Fire Stations age the potential for problems and expenses will increase. The identification of the causes and effects of mold problems throughout this project will be play a major part in preventing further problems in Colerain Fire Stations. Having the ability to relate illnesses and building conditions in Colerain Township to those noted in literature review and survey data should help the department recognize problems sooner than later. In addition, utilizing remedial and preventative maintenance techniques suggested by ASTM (1994) may assist in avoiding another $92,000 expense on mold problems. Implementing the recommendations provided in this ARP could allow Colerain Fire to avoid significant and unnecessary remediation costs. The department has already spent large sums of money to solve mold problems and should work diligently to prevent that in the future. With a shrinking financial outlook in the coming years, the allotment of relatively small amounts of money on training and monitoring equipment may spare Colerain Fire the effects of a potentially large remediation bill.

RECOMMENDATIONS

Based upon the research compiled throughout this project a series of recommendations are proposed. Initially, Colerain Fire and EMS should conduct a thorough department wide inspection that is led by the Building Maintenance Supervisor. This inspection should focus on finding any evidence of accumulated moisture including stained flooring, ceiling tiles and walls. Special attention should be given to older buildings, plumbing and HVAC supply and drain lines. Any areas found to have evidence of mold or moisture should be survey to find the source and be repaired immediately. Also included in this initial inspection should be a baseline measurement of humidity levels in various areas of each building using a portable hygrometer, after which, fixed hygrometers should be placed in areas where humidity levels near or above 50% are found.

Upon the completion of the initial inspection and baseline measurement, monthly scheduled humidity levels should be recorded by the station Captain and reported to the Building Maintenance Supervisor. Any trending toward rising humidity should be investigated to determine the cause and prevent a mold problem as early as possible. The existing dehumidifiers may be used in suspect areas until the source is identified.

In addition to the purchase of portable and fixed humidity monitoring devices, other funds need to be allocated to combat further mold problems. Funds should be secured to educate a team of people in past, present and future building trends and techniques. This team should play a greater role than merely assisting with mold inspections. Members should develop a quality assurance plan and follow up on each phase of any construction project. Whether new construction or a remodel this team should be able to monitor the techniques and progress of each project.

The implementation of these recommendations will provide a systematic review of Colerain Fire and EMS Stations. This will enable the department to identify and repair current problems that may otherwise lead to unnoticed and expensive repairs. Consistent monitoring will provide early recognition of problems and a dedicated team of educated personnel will reduce the potential for costly construction errors in the future.

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APPENDIX 1 – PERSONAL INTERVIEW QUESTIONS WITH DIVISION CHIEF BRAD MILLER, JUNE 1, 2011.

1. Who performed the mold testing at Stations 26 and 102?
2. Where can I obtain documentation related to the mold testing?
3. Where mold related health complaints made?
4. When were mold related health complaints made and who made them?
5. What kind of health problems were brought up?
6. Were any of the health complaints verified by a physician?
7. Did anyone claim time off work due to illness that was either believed or confirmed to be mold related?
8. Do you have any documentation that could be helpful in this research project?
9. Were any pictures taken during the remediation process?

APPENDIX 2 – PERSONAL INTERVIEW QUESTIONS WITH FIREFIGHTER BEN BARNHORST, JUNE 1, 2011.

1. Did you have health problems that you believed were somehow related to Station 26?
2. What was the time period of your health problems?
3. What kind of health problems were you having?
4. Did you report your suspicion to an officer?
5. How was your suspicion treated by the department?
6. Did you report your health problems to your doctor?
7. Were you normally assigned to Station 26?
8. Did your symptoms go away upon leaving the station?
9. Did you experience similar problems at other stations or other locations?
10. Did you experience any similar problems after the mold was removed from Station 26?

APPENDIX 3 – PERSONAL INTERVIEW QUESTIONS WITH DIVISION CHIEF DARRELL BROWN, AUGUST 11, 2011.

1. When was Station 102 built?
2. Was it originally a fire station?
3. What was the original use for the building?
4. Was the building ever added on to?
5. What was the original layout?
6. Were there any previously known water problems?
7. Where can I find further information on the history of the building?

APPENDIX 4 – PERSONAL INTERVIEW QUESTIONS WITH CAPTAIN CHRIS RUWE, AUGUST 30, 2011.

1. Did you have health problems that you believed were somehow related to Station 26?
2. What was the time period of your health problems?
3. What kind of health problems were you having?
4. Did you report your suspicion to your superior?
5. How was your suspicion treated by the department?
6. Did you report your health problems to your doctor?
7. Were you normally assigned to Station 26?
8. Did your symptoms go away upon leaving the station?
9. Did you experience similar problems at other stations or other locations?
10. Did you experience any similar problems after the mold was removed from Station 26?
11. How did you discover the mold problem at Station 102?
12. While at Station 102, were you having similar health problems to those experienced at Station 26?
13. Were health problems from Station 102 reported to or confirmed by a doctor?
14. Once the mold was removed, did you experience any further health problems that you believe were related to the building?
15. Did you use any sick time because of an illness believed to be related to the building?

APPENDIX 5 – PERSONAL INTERVIEW QUESTIONS WITH BUILDING MAINTENANCE SUPERVISOR MATT VANGEN, NOVEMBER 4, 2011.

1. Where was the mold located in Station 26?
2. How was it detected?
3. How much did it cost to repair the station?
4. How did that expense affect the building maintenance budget?
5. How much is actually budgeted for building maintenance?
6. What was learned from the situation?
7. Who else would have relevant information?
8. Were any pictures taken before or during the remediation process?

APPENDIX 6 – INTERNAL SURVEY

1. Have you ever noticed mold growth in a Colerain Township Fire Station?

   A. Yes

   B. No

2. If yes, which station?

   A. Station 25

   B. Station 26

   C. Station 102

   D. Station 103

   E. Station 109

   F. N/A

3. Did you report the mold growth to a supervisor?

   A. Yes

   B. No

   C. N/A

4. Was the mold growth addressed?

   A. Yes

   B. No

   C. N/A

5. If reported, how long did it take for the mold growth to be addressed?

   A. Immediately

   B. One day

   C. One day to one week

   D. One week to one month

   E. One month to six months

   F. More than six months

   G. Never

   H. N/A

6. Have you ever experienced health problems that you felt were related to mold growth in a Colerain Township Fire Station?

   A. Yes

   B. No

7. What was the nature of your suspected mold problem?

   A. Sinus

   B. Respiratory

   C. Neurologic

   D. Cardiac

   E. Other (Please specify)

   ____

8. Were any of your suspected mold related health problems confirmed by a physician?

    A. Yes

    B. No

    C. N/A

9. If reported, how long did it take for your health problems to be addressed by the department?

    C. One day to one week

    D. One week to one month

    E. One month to six months

    F. More than six months

    G. Never

    H. N/A

10. How much work time was lost due to a physician confirmed mold related health problem?

    A. One day to one week

    B. One week to two weeks

    C. Two weeks to one month

    D. More than one month

    E. N/A

APPENDIX 7 – EXTERNAL SURVEY

1. Have there ever been complaints of health problems suspected to be caused by mold growth in your fire stations?

    A. Yes

    B. No

2. How many complaints were confirmed by a physician to be mold related?

    A. 0

    B. 1 – 5

    C. 6 -10

    D. 11 – 15

    E. More than 15

    F. N/A

3. What was the nature of the complaints? (Multiple answers may be chosen)

    A. Neurologic

    B. Respiratory

    C. Cardiac

    D. Sinus

    E. Other (Please specify)

    ____

4. Have you fire stations required mold remediation/removal?

    A. Yes

    B. No

5. If so, how old were the fire stations when the problem was recognized? (Multiple answers may be chosen)

   A. 0 – 5 years

   B. 6 – 15 years

   C. 16 – 25 years

   D. Greater than 25 years

6. If identified, what was the source of the mold growth? (Multiple answers may be chosen)

   A. Plumbing

   B. Ventilation

   C. Drainage

   D. Leaking roof

   E. Other (Please specify)

   ____

7. How was the mold problem discovered? ? (Multiple answers may be chosen)

   A. Routine station inspection by department personnel

   B. Professional inspection in response to complaints

   C. Departmental inspection in response to complaints

   D. Accidentally

   E. Other (Please specify)

   ____

8. What kind of moisture control or detection devices were present? (Multiple answers may be chosen)

   A. Humidifier

   B. Dehumidifier

   C. Humidity monitor

   D. None

   E. Other (Please specify)

   ____

9. How was the mold problem resolved?

   A. Professional mold remediation/removal service

   B. In house (departmental) removal

   C. Other (Please specify)

   ____

10. What did it cost your department to resolve the mold problem?

   A. $0 - $15,000

   B. $15,001 - $30,000

   C. $30,001 - $45,000

   D. $45,000 - $60,000

   E. More than $60,000

   F. Unknown

   G. N/A