The Role of Antimicrobial-Coated Ductwork in Indoor Air Quality

McGill AirFlow Corporation

An enterprise of United McGill Corporation—
Founded in 1951

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Overview

Poor indoor air quality (IAQ) is a growing, national problem, especially in our schools. A major cause of poor IAQ in newer school buildings is our "tighter" construction methods that trap pollutants inside, resulting in "Sick Building Syndrome." Newer school buildings are becoming "sick". In older buildings, a deteriorating HVAC system often becomes a source of pollutants. Poor and/or infrequent maintenance of the HVAC systems in both new and older buildings only makes things worse. And a significant increase in "mold-related" claims nationwide is causing many insurers to raise their premiums. The cost of attacking these problems and renovation/building to meet predicted increases in school population is staggering.

The health effects of poor IAQ on our children and their teachers range from discomfort to a major increase in allergies and asthma, and even respiratory illnesses. In addition, a growing number of studies demonstrate that environmental problems in schools, including poor IAQ, have a negative impact upon learning.

Some IAQ problems can be prevented by proper system design, selection and maintenance of duct and air filters, and selection of routine controls monitoring airflow and environmental conditions. And proper HVAC cleaning prevents ducts from becoming breeding grounds for bacteria, molds, and mildew.

McGill AirFlow Corporation's SilverGuard™ antimicrobial ductwork is a safe new technology that inhibits the growth of microorganisms on its coated surfaces, providing schools with a new element in the effort to ensure good indoor air quality.

Overall concern for indoor air quality is at an all-time high. Market Facts, an international market research firm, conducted an ongoing nationwide survey for Chelsea Group[1], a leading indoor air quality strategic consulting company, on July 7-9, 2000 and April 2001. More than 95 percent of those surveyed in 2000 rated indoor air quality "somewhat important" or "very important" – a 20 percent increase from the response in a similar study by Underwriters Laboratories (UL) in 1977. In the 2001 survey, 70 percent of the respondents expressed concern that the quality of the air in their homes and workplaces could have an adverse effect on their families or co-workers.[2]

Indoor Air Pollution

A major factor in poor air quality is the indoor air pollution which occurs when mold, bacteria, and fungi that exist everywhere in the environment enter our buildings through air duct intakes, or multiply in the ducts themselves. These microorganisms put out spores that grow wherever they have access to dust, dirt, and the minerals found in moisture. Buildup of potentially harmful microbes in ductwork increases the probability of an IAQ problem, especially if the duct is tapped or shaken during operation and the mass of "live" microorganisms is released into the breathing space of the building's occupants.

How dangerous can indoor air pollution be?

According to American Society of Refrigeration and Air Conditioning Engineers (ASHRAE), "Building occupants can (also) become colonized or infected by fungus and bacteria that may grow within the building and HVAC system. The associated diseases include invasive aspergillosis, legionelloisis and histoplasmoisis (ACGIH Bioaerosols Committee 1999; Manses and Bureau 1997). Improved HVAC operation and maintenance, building envelope design, space pressure control and filtration are keys to reducing these infections. Important non-infectious biological agents indoors include viable and non-viable fungus and bacteria, animal dander, and allergens from dust mites, cockroaches and plants (Committee on Health Effects of Indoor Allergens 1993; Committee on Asthma and Indoor Air 2000; Manses and Bureau 1997). Prevention and remediation of moisture problems, good housekeeping and adequate HVAC operation and maintenance practices can reduce indoor concentrations of these agents" (Air Quality Position Document approved by ASHRAE Board of Directors June 28, 2001).

Causes and Effects of Poor Indoor Air Quality

Sick Building Syndrome (SBS) is becoming increasingly common. It occurs when pollutants are trapped inside a building, causing potential health problems for occupants.

"Today, commercial buildings and homes are built tighter than ever for energy efficiency, but this traps pollutants and moisture inside, which provides ideal conditions for mold growth. The key to preventing mold growth is to control moisture in the indoor environment and changing the way we build and operate buildings. In addition, new technologies are needed that will eliminate the danger from 'toxic mold' where it exists and prevent mold growth at its source," said George Benda, chairman and CEO of the Chelsea Group, during an interview for the World Business Review (WBR), a television series hosted by former Secretary of State Alexander Haig that began airing on the Public Broadcasting System (PBS), major networks, and various cable outlets in November 2001.

An important cause of poor indoor air quality in older school buildings is deterioration and poor maintenance.

"Today, an estimated 30 percent of school facilities in the U.S. are aging and in need of repair, and one in five schools has reported IAQ problems. Due to the natural aging condition of school facilities nationwide, spurred by delayed facility maintenance, students and staff are exposed to a wide variety of contaminants in all areas of the school building. Failure to deal adequately with indoor air quality issues may go unnoticed, but eventually can take a large toll on the health, comfort, and performance of students and staff, particularly those with respiratory ailments such as asthma and allergies. Young children are especially susceptible to asthma attacks and other allergic reactions when exposed to a wide variety of environmental allergens and chemical components highly concentrated in school facilities" (The Council of Educational Facility Planners International [CEFPI] News Release February 14, 2002).[3]

Every school day, an estimated 14 million American children attend deteriorating public schools (Rebuild America's Schools, Washington D.C. 2001).[4]

In the American Society of Civil Engineers 2001 Report Card for America's Infrastructure, the nation's schools received a grade of D-. Due to either aging or outdated facilities, or severe overcrowding, 75 percent of the nation's school buildings are inadequate to meet the needs of school children. Since 1988, the total need has risen from $112 billion to $127 billion (American Society of Civil Engineers, Reston, Virginia July 31, 2002).

Maintenance cutbacks can lead to IAQ problems (ALA 1997; Sieber et al 1996). The cost of the associated health effects, discomfort and loss of productivity may be far greater than the presumed savings from the avoided maintenance (Fisk and Rosenfeld 1997). Shifting from reactive to preventive maintenance contributes to improving IAQ, and should be planned for during building design and material selection. Interior HVAC surfaces must be accessible and cleanable to avoid microbial amplification, especially in high moisture areas such as cooling coil drainage pans and humidification systems. Moisture intrusion that is not rapidly corrected can lead to fungal contamination and material damage (ALA 1997). Cost-saving cleaning strategies leave many buildings dirty (ASHRAE [American Society of Heating, Refrigeration and Air Conditioning Engineers] IAQ Position Document 2001).

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1. Chelsea Group, headquartered near Chicago in Itasca, Illinois, specializes in strategic and marketing consulting to major corporations for enhanced positioning of products and services relating to the indoor environment. Their website is <http://www.chelsea-grp.com>. Phone 1-800-626-6722.
2. During the Chelsea Group's 2001 survey, 1,000 adults were interviewed by telephone over a three-day period. Participants were selected from all available residential telephone numbers in the contiguous United States, using a random sampling technique.
3. The Council of Educational Facility Planners International (CEFPI) was founded in 1921 as the National Council on Schoolhouse Construction and is recognized internationally for its leadership in school building issues relating to planning, design, and construction. Fostering and disseminating best practices in school planning, CEFPI is a not-for-profit organization representing nearly 3,000 members in the United States, Canada, and other nations worldwide.
4. Rebuild America's Schools is a coalition of national organizations and school districts from around the country working to build national and local support for Federal School Modernization Bonds and other initiatives to help local communities build and modernize public schools. Rebuild America's Schools, "What is RAS?" July 31, 2002 <http://www.modernschools.org/need/>.

Poor IAQ Has a Negative Impact upon Children's Health

A U.S. government study states, *"More than 8 million children have problems which can be traced to poor IAQ"* (Charlene Bayer, *ASHRAE IAQ Applications, Summer 2000*).

According to researcher Charlene Bayer, Ph.D., Georgia Tech Research Institute, IAQ should be a top priority in schools because children, who are still developing physically, are more likely to suffer due to indoor pollutants. Also, the number of children with asthma has increased 49 percent since 1982 (ASHRAE News Release July 27, 2000).

Poor IAQ Negatively Impacts Learning

Poor IAQ in our schools not only puts our children's health at risk, it affects the learning process. A growing number of studies indicate that poor IAQ has a negative effect on educational achievement.

CEFPI has long supported the premise that the quality and design of an educational facility have a direct correlation to student success, impacting student behavior and achievement (CEFPI News Release July 1, 1999).

A recent CEFPI Brief on Educational Facility Issues, "Do School Facilities Really Impact a Child's Education?" by John B. Lyons, found that students who attend better school buildings have test scores ranging from 5 to 17 percentile points higher than students in substandard facilities.

Another study commissioned by CEFPI, "Facilities Conditions and Student Test Performance in Milwaukee Public Schools," by Dr. Morgan Lewis, examined the facility-achievement relationship using some of the best data yet available. The study used measures of the condition of 139 schools and test scores of students over a three-year period, plus other information about student characteristics including enrollment by racial/ethnic group, attendance, truancy and suspension rates, mobility and the percent of students eligible for free or reduced-price lunches. One of the most significant findings of this study is that when differences in the individual ability of students are controlled (by using Reading scores as an independent variable), measures of school facilities explain more of the differences in test performance across schools than indicators of the backgrounds and attendance/behavior patterns of the students. These findings suggest that facility condition may have a stronger effect on student performance than the combined influences of family background, socio-economic status, school attendance and behavior.

Addressing the Problem of Poor IAQ

Research in this area is underway.

- CEFPI is currently accepting proposals for research assessing the impact of school facilities on teaching and learning. Under the *Where Children Learn* program, the Council will fund up to three research projects this year.
- The Environmental Protection Agency (EPA) and CEFPI are working together to promote the *IAQ Tools for Schools* program uniting the facility and environmental health aspects of the nation's schools and their relationship to indoor air quality. School Building Day, April 19, 2002, was hosted by CEFPI and supported by The Environmental Protection Agency.
- The EPA is looking forward to partnering with CEFPI to help educate schools about indoor air quality solutions, according to Mary T. Smith, the director of the EPA's Indoor Environments Division.

You can stop microorganisms from growing if you control moisture, temperature, or the nutrient supply.

Spores are the beginning of the problem. Microorganisms (mold, bacteria, and fungi) exist everywhere in our environment. They easily enter buildings attached to clothing and through duct system air intakes. Spores proliferate through moisture, especially in areas with standing water or condensation on surfaces. They feed on dust, dirt, and the minerals in water.

Temperature is a critical element in spore proliferation. Spore proliferation is heaviest between 40°F and 120°F. "Contrary to popular belief, high indoor humidity levels can be an issue in nearly all geographic locations, not just in areas where hot, humid conditions prevail. Whenever high relative humidity levels exist at or near a cold, porous surface, moisture adsorption increases and moisture-related problems (such as increased health risks from mold growth and premature replacement of equipment and furnishings) become likely" (John Murphy March 2002).

Only moisture can truly be controlled. The technology exists to monitor and control percent of RH below the 50-60 percent level where microbial growth is a potential problem. However, moisture problems will continue to exist somewhere in the building envelope.

Remediation and Prevention

We can attack the problem of indoor air pollution in two ways: remediation and prevention.

Remediation

The common way to deal with toxic molds is to remove water-damaged, mold-infested building materials. Cleaning is preferred for molds on surfaces and in duct systems.

Closing buildings and doing necessary remediation can be expensive. For example, when mold was found in a suburban Cincinnati, Ohio school, the cleanup shut down the school for two days and cost approximately $10,000 (*The Columbus Dispatch* September 5, 2001).

The demand for duct cleaning services is rising. Ductwork can become a harbor for bacteria, mold, mildew and other fungi. Ads depict what poorly designed and maintained duct systems can look like in a short time. It's a gruesome picture! Although cleaning temporarily removes these contaminants, they often come back unless the cause is eliminated. (Some duct cleaners offer spray-on antimicrobial coatings to lessen microbe growth on duct surfaces between cleanings. But they are rarely a viable solution because of cost, mess, and coverage issues.)

Prevention

Once remediation has been completed, prevention of future problems becomes an issue. Prevention involves three major factors:

1. Proper HVAC system design, including airflow design in the duct system.
2. Proper selection and routine maintenance of air filters, and regular duct cleaning.
3. Proper selection of routine controls monitoring airflow and environmental conditions.

Even if we properly design and install duct systems, select appropriate humidifiers and filters and continuously monitor and maintain them, these measures can still fall short of preventing microbial growth.

A New Element in Preventing Poor IAQ

McGill AirFlow Corporation's SilverGuard™ ductwork — with a antimicrobial coating is a way to prevent microbial growth. SilverGuard inhibits growth of bacteria, mold, mildew and other fungi in HVAC duct systems. SilverGuard's antimicrobial protection lasts as long as the coating remains on the surface of the ductwork.

Although silver is an antimicrobial agent, an antimicrobial coating is not a substitute for duct cleaning. Coated surfaces must still be cleaned of dust and debris periodically.

SilverGuard is available for all of McGill AirFlow's duct and fittings, including round, flat oval, and rectangular, single-wall, single-wall lined, and double-wall construction. Standard materials are G-60 galvanized and S304 stainless steel. All duct and fittings have metal thicknesses and reinforcements conforming to 1995 SMACNA HVAC Duct Construction Standards. The antimicrobial compound is applied to the inside surface of the ductwork, indicated by blue pigment. Application to the exterior surfaces is upon request.

The Natural Protection of Silver

SilverGuard antimicrobial-coated steel ductwork from McGill AirFlow provides the natural protection of silver. This technology is proven successful in controlling the growth of bacteria, mold, mildew and other fungi.

Silver is a proven antimicrobial. It is used in medicine for Crede's prophylaxis (silver nitrate drops for newborns), burn treatment bandages and salves, catheters, heart valve suture rings, dental fillings, and over 58 FDA-approved silver-based products. The ingested Lethal Dose rating of silver (LD50) is less than that for table salt.

Fabrication of SilverGuard

To fabricate SilverGuard ductwork, McGill AirFlow uses steel coated with an epoxy that includes the antimicrobial compound, a patented zeolite that encapsulates the silver ions. The coating is formulated to allow the metal to be pressed, drawn, bent, roll formed and otherwise fabricated, without loss of coating or efficacy. Spot-welded and fully welded joints are possible without harming the coating.

The coating is applicable to 300°F, and the ceramic structure is stable up to 1600°F.

The epoxy is baked onto the surface of chemically treated galvanized and stainless steels. Factory cleaning and pre-treatments ensure coating adhesion.

A coil process is used to apply the coating. A mill-certified coating thickness of 0.2-0.3 mil is applied to both sides of the steel. The coating is cured at temperatures above 500°F. Galvanized carbon steel and stainless steel pre-coated ductwork are currently available.

This process is in contrast to post-coating, which requires 20-25 mil wet coating to ensure a 10-15 mil dry coating thickness. The increased thickness of post-coating is required to ensure adequate coverage due to inconsistencies of field application.

Antimicrobial Compound

Zeolite is an aluminosilicate ceramic with an open structure. In 1983, the Japanese developed a zeolite matrix with sodium ions residing in its structure. When they replaced the sodium ions in their zeolite matrix with silver ions, microbes, which feed on nutrient minerals in water, ingested the silver ions. This caused a breakdown in the molecular structure of the microbes and stopped growth.

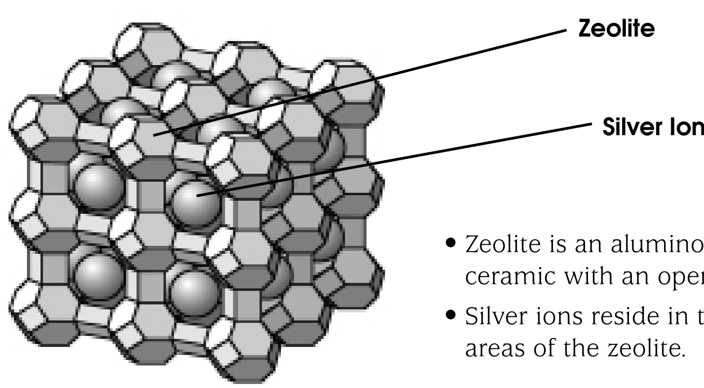
Figure 1 shows how silver ions reside in the open areas of the zeolite.

The Japanese developed and patented this antimicrobial zeolite and have used it in paints, flooring, kitchenware, and consumer products. In the U.S. it is used in footwear, water bottles, clothing, and medical applications.

How SilverGuard's Antimicrobial Coating Works

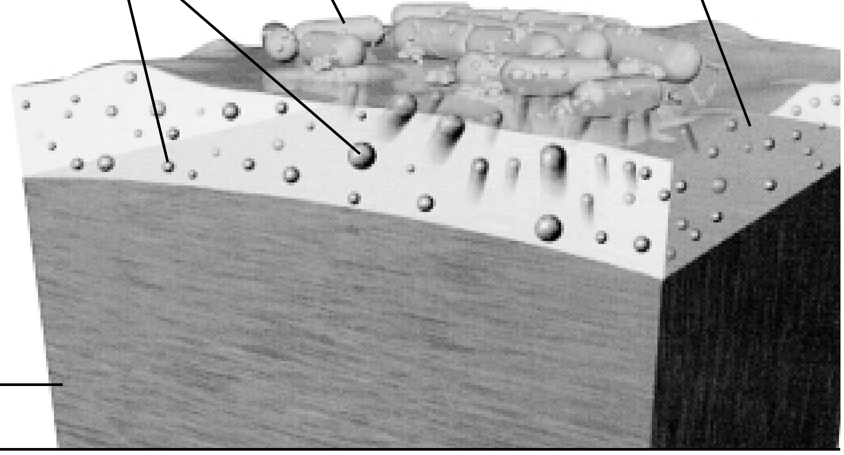
To grow, microbes feed on mineral ions in water, dust, and dirt. The zeolite compound acts as an ion pump to exchange silver ions with other ions (NA+ Ca+, etc.) present in moisture. The silver ions are released from the zeolite on the surface of the steel. They exchange with the mineral ions microbes feed on. The ingested silver ions block microbe reproduction. This controlled release of silver ions offers long-lasting protection. As little moisture as is present on the surface of a table (ambient moisture) is all that is needed to begin the process, which will continue until it reaches equilibrium. **(Figure 2)**

Figure 1: Antimicrobial Compound



- Zeolite is an aluminosilicate ceramic with an open structure.
- Silver ions reside in the open areas of the zeolite.

Figure 2: How the Antimicrobial Coating Works



- Zeolite acts as an ion pump to exchange silver ions with other ions (Na+, Ca+, etc.) present in moisture.
- This mechanism provides a controlled time release of silver ions.

Test Results

The antimicrobial compound is registered by the United States Environmental Protection Agency as a bacteriostatic agent for use in treated articles under 40 CFR 152.25 (a). This data substantiates the efficacy of the antimicrobial compound. The data does not support or endorse health claims for treated articles.

In its ionic form, silver works actively against a broad range of microbes, including bacteria, fungi (mold, yeast), and algae. It is effective against over 600 species of microorganisms, including:

E. coli (Escherichia coli) bacteria (Data provided by Prof. K. Cowan, Miami University). After 24 hours, there was no evidence of E. coli on animicrobial-coated steel coupons; whereas there was an increase on non-treated steel coupons.[5] **(Figure 3)**

Listeria bacteria, prevalent in the food industry (Data provided by Prof. K. Cowan, Miami University).[5] **(Figure 4)**

Pseudomonas, prevalent in the hospital industry (Data provided by Silliker Laboratories).[6] **(Figure 5)**

For most microorganisms, the antimicrobial-protected surfaces are free of microbial growth in three to four hours. **Figure 6** shows a test of E. coli concentration remaining on the surface of stainless steel with the antimicrobial compound.[7]

Certifications and compliances have been granted from the following agencies:

- Food and Drug Administration (FDA). Listed for food contact FCN000047.
- Environmental Protection Agency (EPA). Reg. No. 71227-1 – Registered for food contact and use in HVAC components.
- National Sanitation Foundation (NSF). Standard 51 – Approved for use in Food Zones. NSF/3-A 14159-1-1999 – Approved

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5. M.M. Cowan, *Antimicrobial Efficacy of AgION™-Coated Stainless Steel* (April 10, 2001), Miami University, Unpublished. This study investigates in vitro antimicrobial efficacy against three bacteria: Escherichia coli (E. coli), Listeria monocytogenes and Staphylococcus epidermis, as well as the fungus Aspergillus niger. Bacterial inhibition assays were conducted using antimicrobial-coated and uncoated (control) 2 inch x 2 inch stainless steel coupons. Coupons were inoculated with bacteria suspended in either broth or phosphate buffer. At various times over a 24-hour period, the bacterial viability was tested by serial dilution and plating of the solution rinsed from coupon surfaces.
6. Ellen Vestergaard and Michael Curiale, *Efficacy of an Antimicrobial Compound in the Reduction of Microorganisms on Stainless Steel* (December 20, 2000), Silliker Laboratories Group, Inc. antimicrobial-treated steel was tested with pathogens of concern to the meat industry, including: E. coli, L. monocytogenes, Salmonella and S. aureus. Also included were typical spoilage organisms, including pseudomonads and lactic acid bacteria. Organisms were applied to treated and untreated (control) steel coupons, 3 inches x 3 inches, and samples were analyzed after 3, 6, 24, 48 and 72 hours.
7. AgION Technologies L.L.C. is a Wakefield, Massachusetts-based biotechnology company engaged in antimicrobial and materials research and development.

for use in Meat and Poultry Processing Equipment Product Zone.

- Underwriters Laboratories (UL). Standard 723 (ASTM E84) – Smoke and flame spread essentially zero.

Durability

The epoxy coating on SilverGuard duct components contains an antimicrobial compound that is 5 percent to 7 percent zeolite by weight. Silver ions make up 2 percent to 3 percent of the zeolite. There is enough zeolite on the surface to ensure effectiveness of the product is maintained even if the coating is scratched up to a width of 1/4 inch. A SilverGuard antimicrobial touch-up paint is available to repair surface scratches in the field. The antimicrobial benefit lasts as long as the coating remains on the steel. Coating life is a function of use and the associated surface moisture. Accelerated humidification, salt-spray and cleaning testing have shown the coating maintains its effectiveness for the life of the product.

To clean a SilverGuard antimicrobial surface, apply a mild detergent with a soft sponge or cloth, rinse, then air dry. Abrasive cleansers should be avoided to prevent coating damage.

Figure 3: Steel Samples Inoculated with E. coli

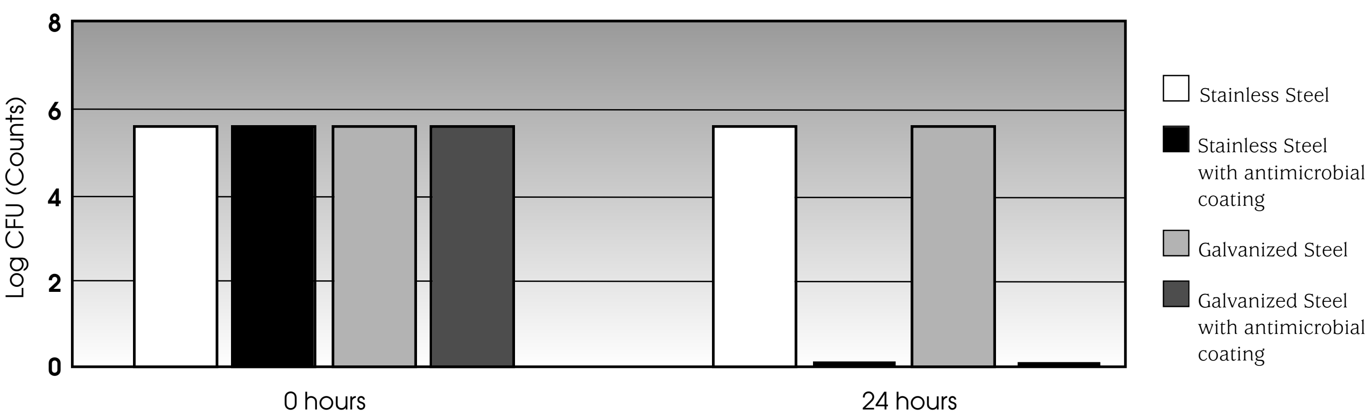


Figure 4: Steel Samples Inoculated with Listeria

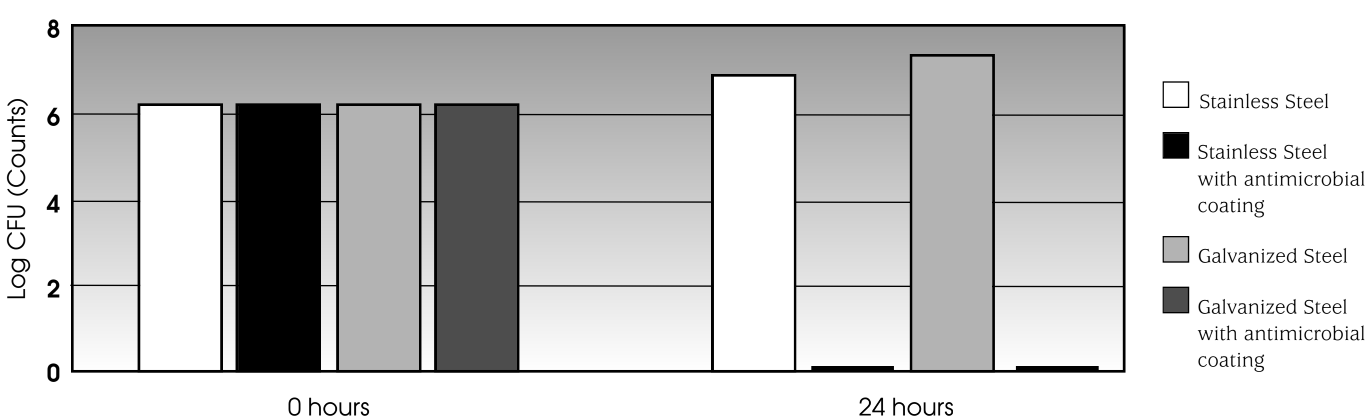


Figure 5: Stainless Steel Inoculated with Pseudomonas

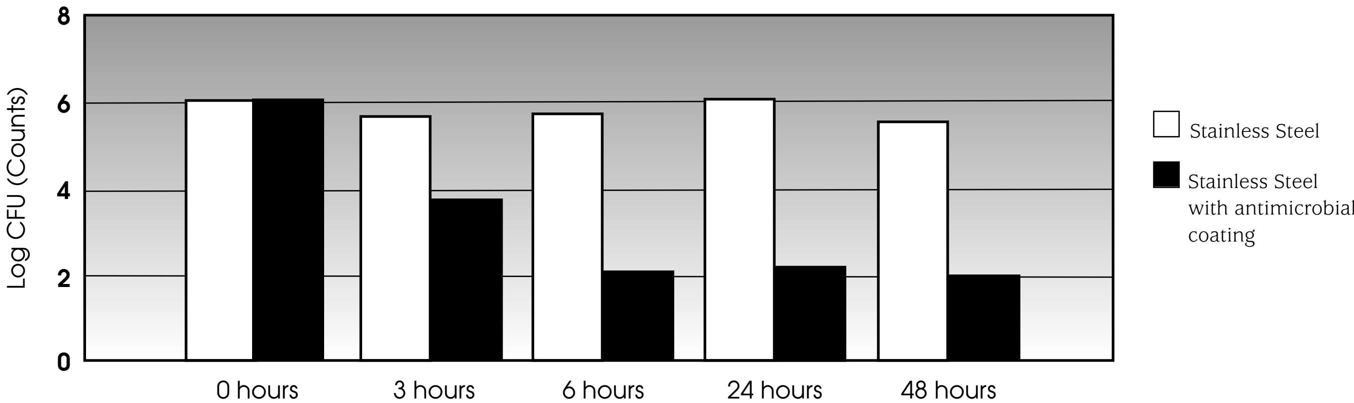
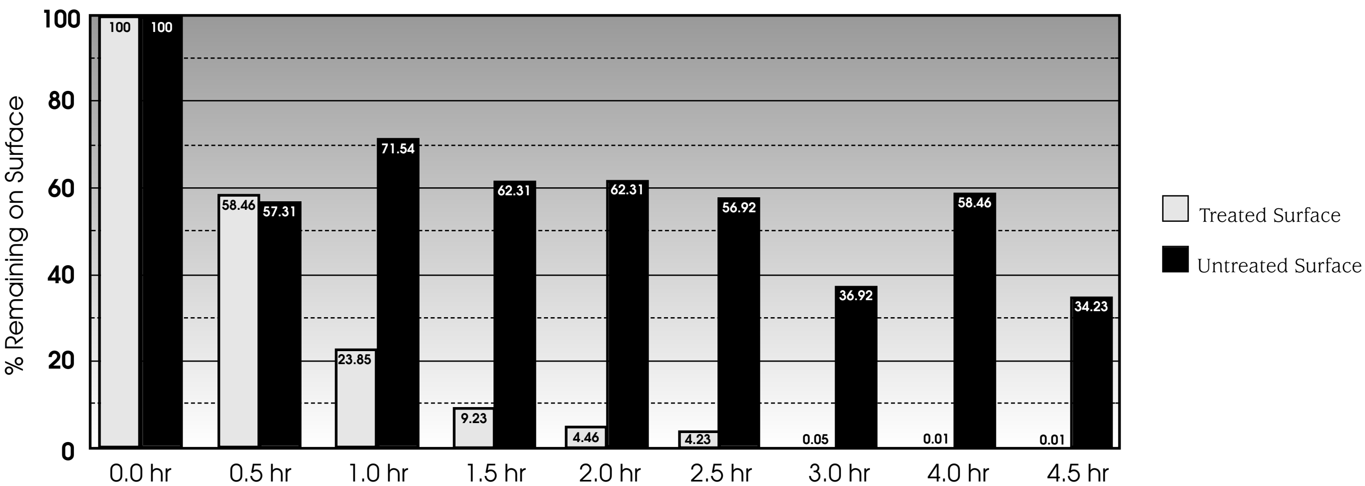


Figure 6: Example Test of E. coli Concentration Remaining on the Surface of Stainless Steel with Antimicrobial Compound



Additional Benefits

Selecting an epoxy coating offers an added benefit of chemical corrosion resistance.

Coated steels are more stain resistant and easier to clean. Their reduced surface friction also aids in formability.

The epoxy coating on the exterior surface serves as a good paint primer. Therefore, SilverGuard ductwork installed in non-painted exposed duct systems can have an attractive "metallic pewter" look or be painted to match the interior decor. Outdoors, the epoxy coating protects the galvanized surface from erratic "white-rust." SilverGuard is equal in cost to PVC-coated ductwork (UNI-COAT®) and would make a comparable substitute in underground installations. SilverGuard can be fully welded.

SilverGuard is an excellent alternative for pool installations. Besides the microbial protection, the epoxy coating adds chemical and moisture corrosion protection.

SilverGuard™ is a trademark and UNI-COAT® is a registered trademark of United McGill Corporation.

Summary

Concern over IAQ is at an all-time high. People are concerned about the quality of the air they breathe in their homes and workplaces and in the schools their children attend. Parents are willing to spend money on IAQ-related products.

These concerns are being addressed. Government, major non-profit organizations, and business are all working together to improve IAQ in America's schools. Although it's difficult to isolate environmental factors that negatively impact learning, more and more studies are being done. Organizations such as CEFPI, National Education Association (NEA), the EPA, Rebuild America's Schools, the American Society of Civil Engineers, and the Georgia Tech Research Institute are becoming involved. Federal money and private funds are increasingly available to help renovate our schools.

The need is great. The average public school building in America is forty-two years old and was not designed to meet the demands of current and future technology. Renovation to support technology often requires changes to building structure, such as wiring and electric capacity, air conditioning, and ventilation.

Now is the time to renovate/build for the future. The U.S. Department of Education forecasts a 25 percent increase in public school population by 2006. It estimates that $60 billion will be required to build new schools to meet expanding enrollment. According to an NEA state-by-state survey of state education officials, the nation's public school districts need $268 billion for infrastructure to repair and modernize existing schools (Rebuild America's Schools, Washington D.C., March 6, 2002).

Good indoor air quality is essential for both new and renovated school facilities – and it is achievable. Although testing for bacteria is time-consuming and expensive and uses old-fashioned methods,[8] we are making progress in technology to prevent/clean up microbial contamination. A growing number of products will clean up current problems and help prevent future infestation. SilverGuard antimicrobial ductwork works with those products to inhibit growth of microorganisms in ductwork. Specifying SilverGuard for renovation and new construction projects adds a new element of prevention to help schools achieve and maintain good IAQ.

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8. Vincent Miller, "New Instrumental Technologies for Bioaerosol Detection and Quanitification," *INVIRONMENT Professional* (December 2001), pp 4-6.

Appendix

How Ionic Silver Affects Microbes

Silver ions are released from the coating, come in contact with microbes, and the microbes are inhibited from reproducing. Researchers presented findings for ionic silver's antimicrobial mechanism, a simplified version of which follows: Monovalent or ionic silver has an affinity for hydrogen ions, joining with them on the sulfhydryl groups present in microbes, disrupting electron transfer and respiration in bacteria and other microbes. Other non-ionic forms of silver employ other, equally effective mechanisms, such as catalyzing the interaction of atomic oxygen (O) with the sulfhydryl group resulting in an OH molecule and a sulfur bond that prevents further respiration within the microbe.

Additional Research/Articles

A sample of research and articles supporting the efficacy of silver as an antimicrobial agent follows. This technical data is provided to substantiate the efficacy of the antimicrobial compound and is not intended to support or endorse any public health-related claims for treated articles.

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Coating Life and Application

The coating life is a function of the application and surface wear, but could average between 10-30 years depending on the thickness of the coating and the wear it receives.

The antimicrobial compound is blended into an epoxy resin. The epoxy resin is applied to steel using a conventional coil coating process. The antimicrobial coating is available as a clear paint system, a tinted system or a fully pigmented system.

Although silver is a powerful antimicrobial agent, an antimicrobial coating is not intended as a substitute for duct cleaning. Coated products must still be cleaned to ensure the surfaces will be free of destructive microbes.

Products incorporating the antimicrobial compound may be subject to regulation under the Federal Food, Drug, and Cosmetic Act or the Federal Insecticide, Fungicide and Rodenticide Act.

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