# Enhanced Filtration Performance with AEM 5700 Antimicrobial Treatments: Laboratory and Field Studies

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## 1. Abstract

Air filters are part of the front-line for dealing with microbial problems in our modern buildings. Upgrading efficiency of air filters by adding a durable, safe and effective antimicrobial treatment can protect the air filter from abnormal fungal growth and improve the air quality of our buildings. With the proper choice of an antimicrobial agent applied to air filtration media, you can prohibit the growth of microbes on filter surfaces, reduce the number of microbial cells in the air stream, and reduce microbes in the indoor environment.

This paper describes test data from laboratory experiments where air filtration products treated with the ÆGIS Microbe Shield Technology were studied for the level of retrieval from the surface and the flow through of microorganisms. Filters treated with the ÆGIS Microbe Shield Technology reduced microbial activity in the filter matrix and downstream of the filter by 99.99%. Besides laboratory data, this report covers two real life field evaluations. These studies show clearly the utility and appropriateness of the ÆGIS Microbe Shield Technology as part of air filtration systems for the reduction of microbial growth on filters and the added benefits to air quality.

## 2. Introduction

Microbiological pollutants, as sources of irritants, sensitizers, discomforting products, toxicants and as disease causing agents, have enormous consequences on human productivity, comfort, health, and general well being. This fact clearly links microbes to the cause, effect, and remedy equation needed for establishing and maintaining indoor environmental quality.

But, as important and necessary as antimicrobials are, they cannot be used without serious safety considerations. Many chemical agents can and do exhibit excellent biocidal and antimicrobial properties, yet often with dangerous side effects and severe human and animal toxicity problems. The antimicrobial agent must not introduce toxicants into the environment, lose its effectiveness by dissipating before filter life expires, adversely affect filter efficiencies or static pressure characteristics, or allow for microbial adaptation.

The ÆGIS Microbe Shield Technology addresses these criteria completely. This technology has an outstanding toxicological and safety profile. Due to the chemical bonding of the active ingredient, the ÆGIS Microbe Shield Technology assures long lasting effectiveness without migration of the active ingredient into the environment.

The ÆGIS Microbe Shield Technology provides a powerful tool on air filters for dealing with one key element in the battle for improved indoor environmental quality – minimizing microbial infiltration via the air handling system.

## 3. Indoor Environmental Quality and the ÆGIS Microbe Shield Technology

### 3.1. Introduction

The indoor environment in any building is a result of complex interactions between a wide variety of conditions and situations – the building site, the building system itself (original architectural design and modifications), the climate, building use, and mechanical equipment systems. There are literally thousands of potential contamination sources inherent in these interactions. In the broadest sense, these

sources are the building materials, furnishings, moisture, manufacturing processes, machinery and equipment, activities, occupants, and the outdoors. If the contaminant sources are strong or if contaminants are allowed to concentrate, serious Indoor Environmental Quality (IEQ) problems occur. How serious and how costly the problems become is entirely within the control of the building's owners and managers. Technology is available to eliminate or at least minimize most serious pollutants. ÆGIS Environments, through its ÆGIS Microbe Shield Program, effectively controls and helps prevent IEQ problems, which are related to microorganisms – by far the largest single pollutant segment. One of the most critical parts of this program is the ÆGIS Microbe Shield Technology – a comprehensive package of application technology, chemistry, and intellectual property rights that transform normal material surfaces into active antimicrobial sites.

The following data are intended to provide a very general introduction to the role of air filtration in the IEQ equation and to explain in more detail the role that can be played by the incorporation of the ÆGIS Microbe Shield Technology into air filtration systems.

## 3.2. The Air Handling System

Great attention has been focused on the air handling system as a source and dispersal vehicle for a variety of pollutants. The debate on the "fault" of design, materials of construction, operating conditions, and maintenance is both unending and, to a large extent, unsolvable.

The most important fact out of this debate is that a clear mandate comes to upgrade and better maintain the filtration components of the air handling system.

## 3.3. General Pollutants

Pollutants can be classified in many ways, but, in general, they are divided into gases, liquids, solids, and sensory impactors. A second critical classification is between biologicals and non-biologicals. Finally, from the standpoint of both human significance and remediation, source considerations, such as single event or regenerative, are important. Regenerative sources may be either continuous or cyclic.

## 3.4. Microbiological Consequences

The contribution of microbiological pollutants as sources of irritants, sensitizers, discomforting products, toxicants and disease causing agents surpasses all other types of pollutants in their affect on human productivity, comfort, health, and general well-being.

## 3.5. A Unique Antimicrobial System

### 3.5.1. The Antimicrobial Technology of Choice for Air Filtration Products

A significant body of data[1] has been developed which supports the usefulness of using the ÆGIS Microbe Shield Technology as the antimicrobial technology of choice for air filters. These data are embodied in a series of patents and publications from Dow Corning Corporation, Burlington Industries, Baxter Healthcare, ÆGIS Environments, other corporations and university test laboratories.

The extraordinary safety profile of this technology, its unique chemical bonding capability, its subsequent durability and, most importantly, its proven real world control of bacteria, fungi and algae (without concern for adaptation and mutation[2]) permits its use on surgical drapes, nurses uniforms, hosiery, carpeting and "Air Filtration Products."

ÆGIS Environments has developed and implemented highly controlled application procedures and a comprehensive quality control program to achieve efficient and effective integration of the antimicrobial chemistry into air filtration media. This, bolstered by participation of the best air filter and air filter media companies, assures the quality and efficacy of all products, which reach the marketplace as a part of the ÆGIS Microbe Shield Program.

### 3.5.2. A non migrating Silane-based antimicrobial

The ÆGIS Microbe Shield uses a "bound" antimicrobial that was conceived and produced by Dow Corning Corporation, the world's leading producer of silicones, in the early 1970s.

Dow Corning Corporation utilized its unmatched

silicone chemical technology to incorporate a standard antimicrobial substance (a quaternary amine) into a silane. The result was extraordinary: The world's first odorless, colorless, non-leaching, durable, broad-spectrum antimicrobial with an unheard of oral LD50 of 12.65 g/kg (ordinary table salt is 3 g/kg) (Fig.1). Today Dow Corning produces the antimicrobial material in an ISO 9002 certified plant, but does it exclusively for ÆGIS Environments.

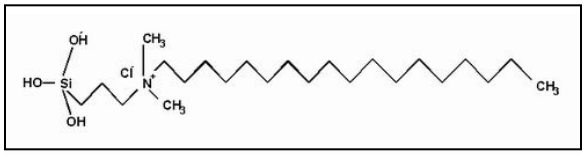


**Fig.1. The chemistry**

In contrast to most silicones, which are slippery, non-reactive materials, silanes are highly reactive materials which are used primarily as coupling agents and adhesion promoters and react with virtually all surfaces to alter the surface characteristics.

Applied in a single stage of the wet finish process, the attachment of this technology to surfaces is made even more durable by the silanol functionality, which enables them to homopolymerize. After they have coated the surface in this manner, they become virtually irremovable, even on surfaces with which they cannot react covalently.

The chemical bonding allows the treated surfaces to become antimicrobially active. Due to this bonding, the antimicrobial does not leach or volatilize from the treated surface.

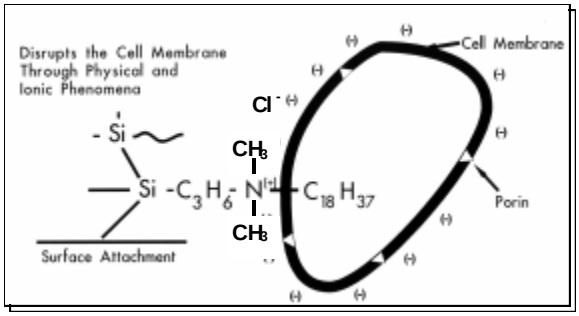


**Fig. 2. Cell disruption.**

### *3.5.3. The Antimicrobial Action*

On direct contact with a microorganism the technology works by disrupting (or rupturing) the cell membrane. This interrupts the normal life processes and destroys the cell (Fig. 2). Two forces cause the interruption: the quaternized nitrogen acts as an electrocuting charge and the 18 carbon link chain acts as a sword. The chemical nature of the polymer consists of the mass of cationic character created by the quaternized nitrogens and the oleophilibed of 18 carbon link chains. This structure is ideal for taking advantage of the anionic nature and the lipoprotein (fat-like) composition of microbial membranes in a way that, on contact, causes their disruption and the death of the cells.

The unique bonding and killing capacity of the ÆGIS Microbe Shield technology, with its one-two punch, allows it to effectively control an extremely broad spectrum of bacteria, fungi (mold, mildew and yeast), algae, and other one-celled organisms.

Because the ÆGIS Microbe Shield acts only on the membrane and does not lose strength over time, it doesn't create the conditions which allow microorganisms to adapt to its presence or develop resistance.

### *3.6. The Solution Meets the Need*

Air filters are part of the front-line for dealing with microbial problems in our modern buildings. Upgrading efficiency to ASHRAE (Association of Specialists in Heating, Refrigeration, and Air Conditioning Engineers) standards and practices, adding antimicrobial activity were considered critical elements for better indoor air quality. But, until the ÆGIS Microbe Shield Technology was developed, the existing technological, durability, and safety problems for antimicrobial treatments were unsolved.

An antimicrobial agent applied to air filtration media must minimize the growth of microbes on filter surfaces, reduce the chances for microbial grow-through, and should reduce the number of microbial cells in the air stream. Many chemical agents can and do exhibit excellent biocidal and antimicrobial properties, but the critical problem has always been the delivery of those desirable properties without dangerous side effects such as human and animal toxicity problems, minimal effective life, susceptibility to microbial adaptation and resistance, and degradation of filtration efficiency or static pressure characteristics. The ÆGIS Microbe Shield

Technology delivers antimicrobial capabilities and does so in a safe, long lasting way that enhances the filtration capabilities of many substrates.

## *4. Microbial Growth and Microbial Flow-Through on Air Filtration products*

### *4.1. Introduction*

A microbiologist views an air filter as a substrate that has the potential to support microbial growth and as a capture device to reduce the flow-through of microorganisms. The following discussions reflect on experimental observations and theoretical considerations appropriate to understanding microbial growth on untreated air filters vs. air filters treated with the ÆGIS Microbe Shield Technology and on a filter's ability to reduce microbial flow-through.

### *4.2. Microbial Growth on Air Filter Surfaces*

Air filter surfaces, soiled or not, are perfect environments for the growth of many types of microorganisms. Microorganisms need moisture, receptive surfaces, nutrients, and proper temperatures for survival, growth, and reproduction.

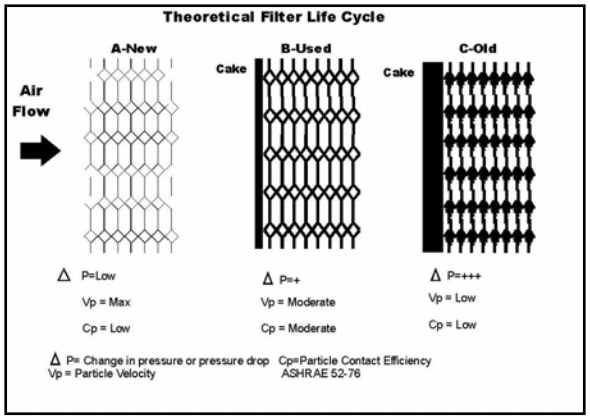


**Fig. 3. Theoretical Filter Life Cycle**

Moisture regain of various filter media, relative humidity of the air being filtered, the conditions of condensation, and the inevitable presence of the molecular water layer all provide the moisture necessary for fungal growth and, in extremes, provide for bacterial, yeast, and algal growth. Nutrients for growth are provided from finishing compounds, fiber lubricants, binding agents, surfactants, the filter medium itself, and dirt. Figure 3 is an illustration of a filter and provides us a view of how an air filter performs as it ages through use.

**"A-NEW"** shows a filter with very low pressure drop (P), a condition where particle velocity (Vp) is maximized reducing particle contract time. Filter efficiency is low and particle velocity is high. Since particle size, shape, texture and velocity dictate impact of particles such as microorganisms and their reproductive parts, the path of least resistance will rule these small particles and flow-through of microorganisms would be predicted, even in high efficiency filters.

**"B-USED"** illustrates a small build-up of dirt cake and a distribution of dirt within the matrix of the filter. Here the pressure drop begins to build, slowing down particles and increasing contact with the filter matrix fibers. As in "A-NEW", the microorganisms are ruled by the pathway of least resistance. This allows particles to move toward less soiled areas and pass through the filter. The filter matrix is loaded at this point, and, because nutrients and growth promoting conditions are present, microorganisms (particularly fungi) will grow on the cake and other soiled areas. This causes odors, staining and deterioration and produces metabolic products and reproductive parts that can cause irritation, sensitization, toxic response, or illness. No longer is the only source of microbes the recycled or make-up air. It is in a large part the filter itself.

**"C-OLD"** shows us a filter with a significant cake and a very considerable build-up of dirt within the filter matrix. The pressure drop (P) is now high and particle velocity is lowered, thus increasing particle contact. As microorganisms make their way through the cake, they are forced by the path of least resistance to the cleaner areas of the filter matrix and into greater certainty of fiber contact.

### *4.3. Microbial Flow-Through*

Once we understand that filter surfaces, with the right nutrients, temperature and moisture, support microbial growth, we can consider the consequences of such growth and the benefits of the ÆGIS Microbe Shield Technology. The earlier discussion of Figure 3 is instructive when we consider the physical phenomena affecting

flow-through and filter fiber contact. The ability to show benefits centers on whether sufficient contact with treated fibers can be effected to kill the contacting organisms and whether growth rates on the filters can be minimized to reduce flow-through and grow-through from microorganisms.

## 5. Test Evidence – AFTL Reports

### 5.1. Filter Performance Tests

There were concerns that applying an antimicrobial to filters might degrade efficiencies, change filtration characteristics or generally adversely alter the original product Air Filter Testing Laboratories, Inc. (AFTL), a leading independent air filter testing facility in Crestwood, Kentucky, performed filter performance tests and biological tests. Filters used for this test series were 24"X24"X2", pleated cotton/polyester blend. Tests were all conducted on pairs of filter specimens and all results averaged for accuracy of the data base.

**Table 1**
**ASHRAE 52-76 Testing**

| Test Parameters Filter | Treated Filter | Untreated |
|---|---|---|
| Initial Resistance | 0.24" W.G. (water gauge) | 0.33" W.G. |
| Initial Atmospheric Dust Spot Efficiency | 12.7% | 13.1% |
| Arrestance | N/A | N/A |
| Dust Fed to 1" W.G. | 120 g | 138 g |

These ASHRAE tests, Table 1, have shown that the filters treated with the ÆGIS Microbe Shield Technology have a lower resistance to the air pressure in the standard water gauge (W.G.) test, have slightly less weight gain in the dust spot efficiency test exposed to dust (12.7%) than the untreated control (13.1%), did not affect the arrestance or trapping capabilities (N/A – no affect), and allowed for less dust required (120g versus 138g) to attain 1" W.G. The ÆGIS Microbe Shield Technology enhanced the filter products by adding value and problem solving features that provided excellent antimicrobial effect, making the surface more antistatic, cationic, and hydrophobic. This all shows no negative effects on filter performance because of the treatment.

### 5.2. Biological Testing: Microbial Flow-Through

The test filters above were placed in test tunnels with airflow of 2000 CFM (cubic feet per minute) for microbial challenge. A BGI Nebulizer® arosolized a culture of *Micrococcus luteus* to impact the test filters. The nebulizer delivered $1.3x10^8$ cells over the test period. Andersen Viable Particle Samplers were placed both upstream and downstream and were fitted with nine retrieval plates of nutrient agar and used to collect microbial samples. The upstream retrievals were done in a pre-trial to determine dose and viability on the test retrieval agar. All plates were incubated and Colony Forming Units (CFU) were counted on a Quebec Colony Counter after 48 hours of incubation. A percent bacterial removal efficiency was calculated comparing the average upstream counts to the average downstream counts.

This procedure was used on new, clean ÆGIS Microbe Shield Technology treated filters. Additional tests were performed on the same filters after they had been ASHRAE dust loaded to 2.5 cm W.G. and 120g dust holding capacity.

Calculation of the flow through of the dust loaded (2.5 cm W.G., 120 g) filter surface: The total filter area was 3600 $cm^2$, so each 1 $cm^2$ area of filter surface received 36,111 organisms (130,000,000 / 3600). Results in the AFTL test report show that 247 organisms were retrieved on nine post filter impact retrieval plates representing 706 $cm^2$ of filter surface area.

Projecting on this rate of retrieval to the total filter area one calculates 1259 organisms as flow-through. (247 organisms retrieved x 3600 / 706)

### 5.3. Filter Surface Testing

After the filters were challenged with bacteria, the surface was tested for the test bacteria by a sterile swab rinse. This was done to determine a ratio of retained viable organisms versus viable organisms that flowed through the test filters. A 6.25 $cm^2$ area of the filter surface was used and a serial dilution retrieval was performed on

**Table 2**
AFTL- Treated Filter Surface Test After Insult[1]

| | |
|---|---|
| New. Clean filter - untreated | 68 CFU/Swab (6.25cm$^2$) |
| New, Clean Filter – ÆGIS treated | 14 CFU/Swab (6.25 cm$^2$) |
| Dust Loaded Filter – ÆGIS treated | 16 CFU/Swab (6.25 cm$^2$) |

1. Total insult of *Micrococcus luteus,* 1.3X10$^8$ colony forming units (CFU).

nutrient agar plates, incubated for 48 hours and counted on a Quebec Colony Counter.

As shown in Table 2, the sterile swab rinse retrieved 2,56 CFU/cm$^2$ (16/6.25 cm$^2$ test area) or 9216 CFU/Filter Face Surface Area (2.56), 14 CFU from the New, Clean Filter and 16 CFU from the Dust Loaded Filter. The untreated filter had 68 CFU retrieved.

## *5.4. Total Microbial Reduction of a Filter Treated with the ÆGIS Microbe Shield Technology*

These data provide us a view of the organisms retrieved from the surface and the flow-through organisms [9216 CFU (surface retrieved) + 1259 CFU (flow through retrieved) equal 10,475 CFU(total retrieved)]. These 10,475 organisms are a 4 log reduction, or over 99.99% reduction of the original 130,000,000 organism insult (1.3X10$^8$/ test surface).

These test results allow for the following observations:

1. The *Micrococcus luteus* was able to travel through the filter media as evidenced by the retrievals, therefore minimizing the chance that the organisms were mechanically trapped. *Micrococcus luteus* averages between 0.9 and 1.8 microns in size.

2. Contact with the treated surfaces does occur and does kill the organisms as evidenced in literature and the baseline runs of this study.

3. Treated filters reduce microbial activity in the dust load, in the filter matrix and downstream of the filter by 99.99% of challenge in AFTL's test protocol.

## *6. Flow-Through Testing*

## *6.1. Flow-Through Testing – Not Soiled*

AFTL ran a test series using a filter treated with the ÆGIS Microbe Shield Technology without a soil load. Results from the treated and the untreated control are listed in Table 3 and data

**Table 3**
Filter Treated with the ÆGIS Microbe Shield Technology
Flow-Through Reduction of *Micrococcus luteus*[1]
Unsoiled Filter

| Plate # | CFU[2] Upstream | CFU Downstream | % Efficiency |
|---|---|---|---|
| I | 121 | 47 | 61.2 |
| II | 146 | 78 | 46.6 |
| III | 134 | 69 | 48.5 |
| IV | 154 | 83 | 46.1 |
| V | 153 | 94 | 38.6 |
| VI | 199 | 101 | 49.3 |
| VII | 175 | 99 | 43.4 |
| VIII | 182 | 104 | 42.9 |
| IX | 195 | 92 | 52.8 |

Average Bacterial Removal Efficiency 47.7%

1. Tests run by Air Filter Testing Laboratory, Inc., Crestwood, Kentucky
2. Colony Forming Units

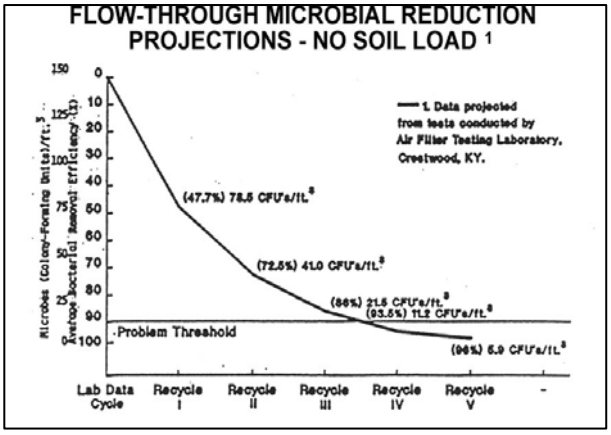


**Fig. 4. Flow-through microbial reduction projections – no soil load**.

**Table 4**

Filter Treated with the ÆGIS Microbe Shield Technology

Flow-Through Reduction of *Micrococcus luteus* Soil Loaded Filter

| Plate # | CFU2 Upstream | CFU Downstream | % Efficiency |
|---|---|---|---|
| I | 210 | 43 | 79.0 |
| II | 198 | 28 | 85.9 |
| III | 187 | 23 | 87.7 |
| IV | 213 | 20 | 90.6 |
| V | 208 | 25 | 88.0 |
| VI | 199 | 38 | 80.9 |
| VII | 203 | 29 | 85.7 |
| VIII | 221 | 23 | 89.6 |
| IX | 197 | 18 | 90.9 |

Average Bacterial Removal Efficiency 86.5 (%)
1. Test run by Air Filter Testing Laboratory, Inc., Crestwood, Kentucky
2. Colony Forming Units

projections are shown in Figure 4. The projection of the treated filter's 47.7% reduction to the recycling of air prevalent in most buildings, gives us an exciting view of performance.

In Figure 4 we have illustrated the laboratory test stand data obtained on the clean filter at AFTL. Assuming an initial dose of 150 CFU's/ft$^3$ of a contaminating organism, we can project further reductions as cycles of the air continue. Using this worst case scenario of microbial reduction, ultimate levels going through the filter are reduced below the 10 CFU's/ft$^3$ problems trigger level within only four cycles.

## *6.2. Flow-Through Testing - Soiled*

Results of this study are listed in Table 4. The average bacterial removal efficiency on this soil loaded filter treated with the ÆGIS Microbe Shield Technology was 86.5%. The extremes for the nine sample sites were Plate I (79.5%) and Plate IX (90.0%).

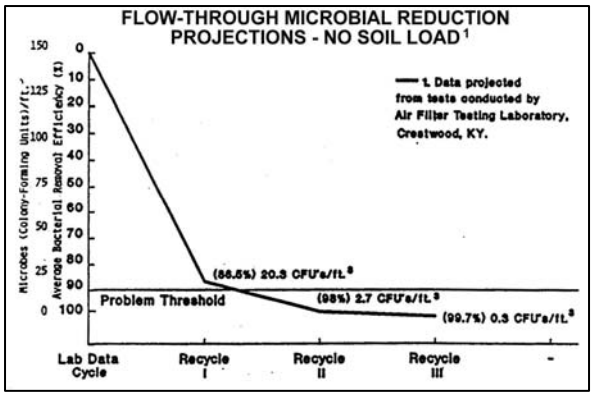


**Fig. 5. Flow-through microbial reduction projections – no soil load.**

The ability of this filter to reduce the test organism under soiled conditions supports the theoretical consideration of the flow-through of microorganisms seeking cleaner areas of the filter (due to the path of least resistance) where contact with the treated surfaces can occur. These data also support the performance of the antimicrobial as a chemical and physical entity. The radius of influence of the cationic and oleophilic ÆGIS Microbe Shield Technology favors contact with the anionic and lipid outer layer of microorganisms, hence contact and kill.

Figure 5 illustrates the projection for the soil loaded filter data in Table 4 (86.5% reduction in one cycle). Levels below the 10 CFU's/ft3 problem trigger level are reached in less than two cycles.

## *7. Field Testing*

### *7.1. Phoenix Study*

A study was undertaken by St. Luke's Medical Center, Phoenix, Arizona, to determine the effectiveness of the active ingredient of the ÆGIS Microbe Shield Technology when reacted to woven bag air filters against bacterial and fungal contaminants.

**Table 5**
Imprint Culture ÆGIS Microbe Shield Technology;
Treated and Untreated Bag Filters
St. Luke's Medical Center, Phoenix, Arizona

| Sample | Blood Agar | Mueller-Hinton | Total |
|---|---|---|---|
| Treated Filter | 9 | 7 | 16 |
| Untreated Filter | 21 | 35 | 56 |
| % Reduction | 57 | 80 | 71 |
| # Times More Effective | 2.3 | 5.0 | 3.5 |

A standardized mixed culture of *Staphylococcus epidermidis, Streptococcus viridens, Escherichia coli* and *Aspergillus niger* was applied to samples of treated and untreated filters. These samples were cut into 25X25 cm squares and incubated for eight hours at 37°C for 5-7 days, read, and the colonies counted. The eight hours was picked by the hospital as it represents a workday. The two agars were chosen to allow maximum growth of the full range of the test organisms.

This overall 71% reduction in a very heavy dose of bacterial and fungal contamination in nutritive carrier solution approaches levels of control seen in other studies. Note that in the growth of the retrieved cultures, none of the fungus (*Aspergillus niger*) was retrieved. A uniform reduction of the three test bacteria was observed. The results show absolute control of the test fungus and from 2.3-5.0 times more reduction of the test bacteria comparing treated to untreated filters.

## *7.2. Cancer Hospital Study*

Two side-by-side mechanically identical air handlers in a 12 story Research and Cancer Hospital were chosen to evaluate the effectiveness at reducing fungal growth on air filter elements and reducing the risk of contamination reaching the service areas (See Fig.6). These systems provided air to the 11th and 12th floor laboratory complexes in a pattern of Air Handler (AHU) 9 providing for one zone on the 12th floor and two zones on the 11th floor; AHU 10 providing for one zone on the 11th floor and two zones on the 12th floor. These units were in operation for approximately 60 days during the commissioning of this facility before the test began. Soil was very light in both units and all physical appearances were the same.

The pre-filters (A), bag filters (B), and post-

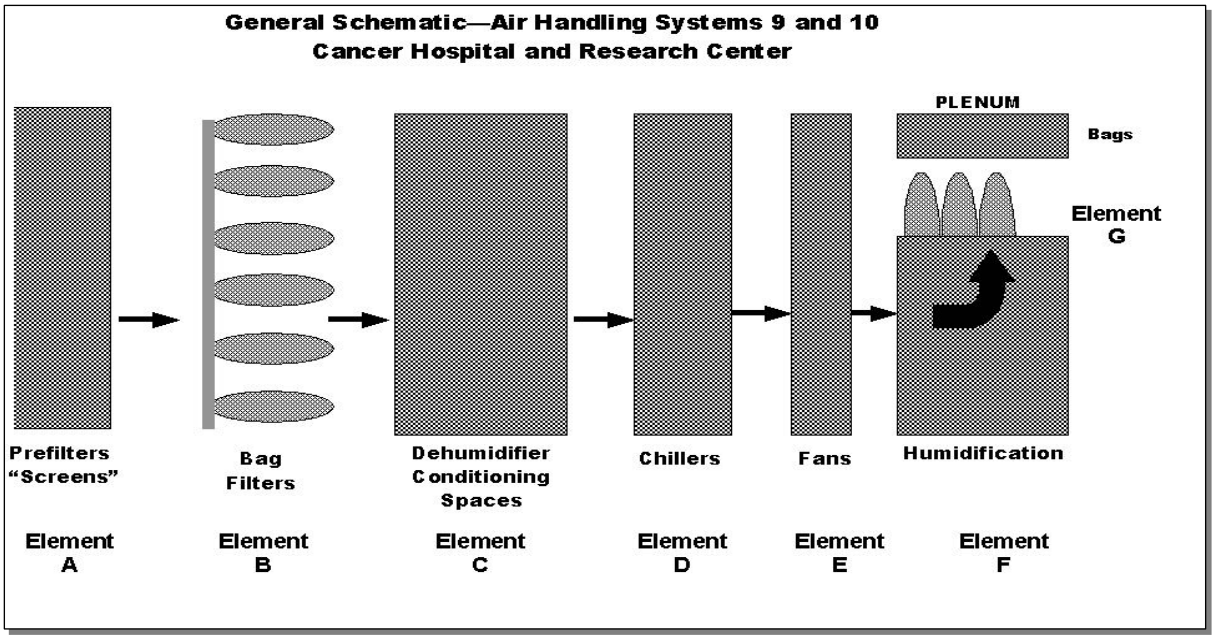


**Fig 6. Air Handling Systems 9 and 10. Cancer Hospital and Research Center**

**Table 6**
Cancer Hospital and Research Institute
Filter Treated with the ÆGIS Microbe Shield Technology and Untreated Systems
Observations 30 Days Post-Treatment
The pre-filters (A), bag filters (B), and post-chiller bag filters (G) were all treated with the active ingredient of the ÆGIS Microbe Shield Technology

| Air Handling System Element | Observations Thirty Days Post-Treatment | |
|---|---|---|
| | Treated | Untreated |
| A – Screen | No Difference | No Difference |
| B – Bag Filters | No Growth | Slight Growth |
| C – Dehumidifier | No Difference | No Difference |
| D – Chillers | No Difference | No Difference |
| E – Fans | No Difference | No Difference |
| F – Humidifier | No Difference | No Difference |
| G – Bag Filters | Slight Growth | Significant Growth |
| Post G Pressure | No Change | Increase 0.5" W.G. |
| Post G Particles | 196/$m^3$ | 808/$ml^3$ |

chiller bag filters (G) were all treated with the active ingredient of the ÆGIS Microbe Shield Technology to the quality control standards of ÆGIS Microbe Shield Quality Control Program. At the end of thirty days, the following observations were made: (Table 6).

The fiberglass filter screens appeared somewhat soiled but no differences between the treated and untreated systems were observed.

The dehumidifier, chillers, fans, and humidifier units showed no differences between the control and the treated systems.

The final bag filters just beyond the humidifiers had noticeable soiling, showed slight growth on the treated bags and significant growth on the untreated systems.

Readings of static pressure showed a significant pressure drop on the untreated filter (0.5" W.G.) whereas the treated filter showed no change from initial readings.

Using a laser particle counter set at 1.0 micron sensitivity, it was determined that the treated filter passed fewer particles (196/$m^3$) compared to the untreated filter, which passed four times as many (808/$m^3$).

The post chiller bag filter had a particulate sluffage differential of 300% more particles coming through the untreated filter system than the treated filter system. This in spite of the fact that the untreated filter evidenced a pressure drop of 0.5" W.G. from initial readings; as compared to the treated filter that did not change its pressure drop characteristics. The increased cake and pressure build-up on the untreated system, along with the increase of one micron sized particles and the physical observations of fungal build-up on the untreated system, allows for mildew growth and allows spore sized particles to enter the supply air stream. This field study provides insights into both growth on ÆGIS Microbe Shield Technology filters and untreated filters and on the flow-through consequences of such growth.

## *8. Conclusions*

Air filters in commercial buildings and residences are an essential component in establishing and maintaining indoor environmental quality. Air filters can be a barrier to microorganisms and, at the same time, can be an amplification site for microbial growth.

Test data from laboratory and field evaluations, as presented and referenced in this report, show clearly the utility and appropriateness of the ÆGIS Microbe Shield Technology as part of air filtration systems.

The efficacy of the ÆGIS Microbe Shield Technology has been clearly demonstrated in numerous patents, peer-reviewed publications and trade articles – all showing long-term, broad spectrum control of fungi, algae, and both Gram (+) and Gram (-) bacteria. The efficacy of the filter is greatly enhanced by the chemical bonding of the active ingredient – giving long-lasting effectiveness, and a better performance of the filter. Due to the covalent bonding of the active ingredient, microbiological adaptation becomes highly improbable.

The ÆGIS Microbe Shield Technology has an excellent toxicology and safety profile and has been marketed for years for healthcare products, consumer use products, and products used in commercial buildings. ÆGIS Environments has also established an operational capability at dealing with the broader sources of indoor environmental quality problems attributed to materials of construction, furnishings, equipment, and occupants.[3]

Treatment of a wide variety of substrates and products allows for a broad reduction of microbial habitats and transfer sites leading to greatly improved IEQ.

Data such as those cited above, and the properties of the ÆGIS Microbe Shield Technology allows ÆGIS Environments to bring to the Air Filter Industry – from the manufacturer to the end user – a powerful tool for dealing with one key element in the battle for improved IEQ.

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