HealthWay DFS Technology VS UVGI

I. Introduction and Background of HealthWay DFS Technology

The HealthWay DFS Air Purification System technology was originally developed through a government grant focused on germ warfare. The professional line of air cleaning by HealthWay is the only hybrid system to effectively address all three pollutant categories. It has been proven to capture 99.99% of all particles as small as .007 micron in size which is over 40 times smaller than the HEPA filtration standard. Our units are equipped with a gas and odor filter, which eliminate most gases. The patented DFS technology removes 99.99% of harmful viruses, mold, and bacteria passing through our system leaving nothing but fresh, pure, healthy air. This technology is currently used in hospitals, medical clean rooms, government buildings, and military applications.

This document compiles industry established performance criteria, comparison between conventional UVGI and the advanced Disinfection Filtration System DFS by HealthWay. The below referenced scientific evidence and results of field studies also highlights the side by side comparison between UVGI system and the advanced DFS in field applications such as in HealthCare, biotech cleanrooms and a pharmaceutical cleanroom equipped with a Disinfecting Filtration System (DFS) that significantly reduces airborne bioburden in cleanrooms. The DFS High Efficiency Particulate Air hybrid system traps and kills bacteria and also improves the filtration performance of a filter media by two to three orders of magnitude. In laboratory tests the DFS technology has been shown to kill *Staphylococcus epidermidis* and *Escherichia coli.* These field test results support laboratory testing and show that basically there is no airborne bioburden in both a Class 10 room, with terminal HEPA in addition to the DFS, and in a Class 1000 room that utilizes only the DFS without any terminal HEPA filters. When compared to DFS UVGI is not considered a stand-alone solution to air contamination problems but is an adjunct.

II. Laboratory Evaluation of the DFS

The DFS technology went through multiple third-party testings' of its efficiency, filter classification and effectiveness on a number of criteria pollutants. The tests were conducted by independent research institutes including Syracuse University BEES Lab and University of Buffalo IUCB. Additional filed studies in the area of clean room applications were conducted by Jaisinghani et al.8 have demonstrated the bactericidal properties of the DFS AKA "Electrically Enhanced Filtration EEF" under laboratory conditions. This study, conducted at Virginia Polytechnic Institute, is summarized in this section.

III. Results and Discussion

The results are summarized in *the Virginia Polytechnic Institute study*. In the absence of any voltage applied to the DFS unit (i.e., control tests), viable bacteria were recovered from one square inch of filter in the range of 1 x 105 CFU to 2 x 106 CFU. Counts greater than about 3 x 106 CFU were too crowded to be accurately counted and were considered to be too numerous to count. When high voltage was applied for four hours, the majority of the

bacteria were killed. The kill rate increased with increased voltage or with the first applied field strength (applied voltage divided by the distance of the ionizer wires from the control ground electrode), V/d1. At field strength (V/d1) of 4.2kV/cm, there was no growth after 24 hours of incubation. After 48 hours, there was either no growth or small (in size and in number) colonies grown. These small colonies were identified as *S. epidermidis*, and were identical in biochemical profile as the isolate used in the tests. It was concluded that four hour sat 4.2 kV/cm (V/d1) did not completely kill the *S.epidermidis*. If the bacteria were not all killed, some of them were damaged sufficiently so that no growth or very limited growth could occur after 24 hours incubation. When the ionizing time was increased to seven hours, over 99% of the bacteria (as compared to the control) were killed. When the applied field strength, V/d1, was increased to 4.5 kV/cm or higher, no growth occurred on any of the filter pieces except for one experiment. This exception may have occurred because the starting dose of bacteria for this experiment was three times higher than for the control and up to 10 times higher than for any other experiment. Nonetheless, there were still three to four logs of killing using an applied field strength, V/d1 of 4.5 kV/cm or higher, as compared to the control experiments. It should be noted that, in practice, bacteria caught on the filter are held within the ionizing field for an almost infinite amount of time, thus receiving an almost infinite radiation dosage. Hence, in practice, the killing efficiency should be higher even at lower field strengths. Similar results were obtained using *E. coli* in a previous study conducted with the DFS "AKA" EEF at the University of Wisconsin.

IV. Field Results in Cleanrooms

For summary of above described research & field results please see link below
http://www.ivtnetwork.com/sites/default/files/Cleaning-Validation-Volume-III.pdf

V. Efficiency and MERV Rating

The Efficiency of the DFS system is reported to be 99.999% @ 0.007 µm in comparison to HEAP standards 99.97 @ 0.3 µm. Additional ASHRAE Standard 52.2-2012 Filter testing and EN-1822-5 test (Efficiency / MPPS / Resistance) of the commercial 2000 SC DFS at air flow rate of 2000 CFM showed the filter exceeds the MERV 16 class.

VI. UVGI Process Description

A UV disinfection system transfers electromagnetic energy from a mercury arc lamp to an organism's genetic material (DNA and RNA). When UV radiation penetrates the cell wall of an organism, it destroys the cell's ability to reproduce. The effectiveness of a UV disinfection system depends on the characteristics of the airborne microorganism, the intensity of UV radiation, the time the microorganisms are exposed to the radiation, and the reactor configuration. For any one air filtration system design, disinfection success is directly related to the concentration of colloidal and particulate constituents in the air stream.

The main components of a UV disinfection system are mercury arc lamps, a reactor, and ballasts. The source of UV radiation is either the low-pressure or medium-pressure mercury arc lamp with low or high intensities. The optimum wavelength to effectively inactivate microorganisms is in the range of 250 to 270 nm. The intensity of the radiation emitted by the lamp dissipates as the distance from the lamp increases. Low-pressure lamps emit essentially monochromatic light at a wavelength of 253.7 nm. Standard lengths of the low-pressure lamps are 0.75 and 1.5 meters with diameters of 1.5 to 2.0 cm. The ideal lamp wall temperature is between 95 and 122° F.

VII. UVGI Air Disinfection

UVGI Air Disinfection systems are mainly grouped into four main types:

1. In-duct UV systems
2. Unitary UV systems
3. Upper-room systems (Passive)
4. UV barrier systems (Passive)

The upper-room and barrier system are passive disinfection systems that depend on local room air currents while in-duct UV system is a one directional forced air system with minimal dose exposure. These systems require the use of filters to control airborne contamination, especially when it comes to spores. UVGI is not a stand-alone solution to air contamination problems but is an adjunct when compared to the DFS system which is a comprehensive, high efficiency three pollutant category hybrid air filtration system.

Some of the air stream disinfection challenges are limited to the exposure time which depends on the airflow and dimensions of the ducts. The DFS filtration system unlike the air stream system is designed to capture and constantly expose captured microbe throughout the filter media to continuously deactivate and inhibit the microbial growth within the system leaving the air passing through free from contaminants. While some evidence demonstrated that UVGI is effective at reducing disease incidence comes mostly from upper-room UV systems, other studies on the incidence of respiratory infections at a daycare center showed a negligible reduction in illness (Dionne 1993).

VIII. Disadvantages of UV

- Low dosages may not effectively inactivate some viruses, spores, and cysts.
- Organisms can sometimes repair and reverse the destructive effects of UV through a "repair mechanism," known as *photoreactivation,* or in the absence of light known as "dark repair."
- A preventive maintenance program is costly and necessary to control fouling of tubes.
- UV disinfection is not as cost-effective in comparison with the DFS filtration system.
- There is no measurable residual to indicate the efficacy of UV disinfection.
- UV systems don't work on capturing particulates from the air of any size
- UV passive systems doesn't address contaminants outside the HVAC, Coils or in room air

Performance Criteria	HealthWay DFS FILTRATION SYSTEM	UV &UVGI
Filtration Efficiency	• Enable 99.999999 % system filtration efficiency down to 0.007 micron – at lower pressure drop of HEPA see table 1 • The technology addresses the viral size ultrafine particles arrest efficiently • System filtration efficiency - double HEPA filtration possible due to the lower pressure drop of the primary **DFS** filters. This eliminates the need for UVGI or additional terminal filters.	• Doesn't address capturing particles, including spores and viral size ultrafine particles efficiently • Efficiency is only linked to the intensity, wavelength 254-270 nm and dose of exposure/time but not in reducing any airborne particulates which are known to have adverse health effects including respiratory and cardiovascular diseases
Microbial inhibition & Bioburden	• **DFS** filters are highly energy efficient and result in extremely low bio burden in cleanrooms • They create high energy field that leads to deactivating viable microbes such as bacteria, fungus and viruses • Lower Bioburden of bacteria, viruses and fungus	• Works only if UV tube intensity is maintained constantly and when system is equipped with filters against UV • Destructive effects of UV can be reversed by *photoreactivation* • It requires UV tube to be free from dust and maintaining a high URV
Terminal cleanroom filters	• This is essential since HVAC systems can introduce contamination, which can clog or damage terminal filters. With DFS in Duct Filters, terminal filters should never require replacement or maintenance.	NA Typical designs requires terminal HEPA filters
Maintenance Costs	• Lower Maintenance Costs • DFS filters can last up to three times longer life than conventional UVGI	Higher maintenance cost due to life cycle and loading density
Achieving ISO classes	• The **HealthWay DFS** filters provide the necessary filtration for such applications. Only blank ceiling diffusers are required for these applications. • No terminals required for ISO Class 6 and above	NA Doesn't apply to cleanroom particulate count classes
Impact on electrical wiring seals and insulation material	• DFS system doesn't impact HVAC material or building material integrity	High radiation may deteriorate exposed building material
Filter Replacement	• Less filter replacement frequency • Filters replaced externally - less down time and total protection of cleanroom processes and equipment	NA
VOC mitigation	• Addresses Volatile Organic Pollutants with its optional VOC bank	Doesn't address any VOC pollutants
Safety	• Safe operation due to self-contained design	Higher risk of exposure to UV radiation which may lead to skin burns, eye damage

Table 1: DFS Bactericidal Test Summary using S. Epidermidis after 4 hours of air flow [Control= Conventional HEPA filter]

AVERAGE COLONIES		
Filter	***#/sq. inch of filter***	***% KILLED/ COMMENT***
Control	1.00E+06	No Additional Growth After 24 Hours
Control	1.02E+05	
DFS	0.00E+00	100% KILLED
DFS	3.44E+02	99.93% KILLED
DFS	0.00E+00	100% KILLED
DFS	0.00E+00	Some Growth After 48 Hours
DFS	0.00E+00	
DFS	6.26E+03	98.75% KILLED
DFS	5.44E+02	99.9% KILLED
DFS	2.16E+02	99.95% KILLED
DFS	3.51E+03	99.3% KILLED

Table 2: Summary of Some Field Tests:
Airborne Bioburden in the Encelle Class 1,000 cleanroom

Design Class 1,000	15 days		30days		45 days		60days	
	Cfu/ft3/ 24hr.*	Cfu/ft3/ 72hr*	Cfu/ft3/ 24hr.*	Cfu/ft3/ 72hr*	Cfu/ft3/ 24hr.*	Cfu/ft3/ 72hr*	Cfu/ft3/ 24hr.*	Cfu/ft3/ 72hr*
Device Testing	0.849	0.878	0	0	0	0	0	0
Coating	0	0.142	0.057	0.057	0	0	0	0
Formulations	0.538	0.566	0	0	0	0	0	0
Device	0.283	0.340	0.113	0.113	0	0	0	0
Manufacturing Refrigeration	0	0	0	0	0	0	0	0
Isolation	0.113	0.170	0.849	0.849	0	0	0	0

THE CLASS 1,000 ROOM HAS LOWER BIOBURDEN THAN A CLASS 100 ROOM!