"Contamination Control in Data Centers
Gas Phase Filtration Case Studies"

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ABSTRACT

The paper will provide an overview of operational challenges faced by data centers and effective solutions by using latest Honeycomb and Gas Phase Filtration technology. It will also cover the case studies from industrial and commercial sector outlining the role and importance of gas phase filtration technology in controlling gaseous contamination.

For efficient working of data centers, data center managers have to overcome various operational challenges such as :

- Control of gaseous contamination, which is one of the major cause for electronic corrosion and hardware failures in data centers (As per ASHRAE white paper by TC 9.9 committee).
- Reducing maintenance costs and preventing data loss through uninterrupted working of electronic equipment.
- To maintain the severity level of G1 as per ISA 571.04 – 1985 standard to avoid electronic corrosion.
- To increase performance of IT resources and create a healthy working environment.
- To design and equip data centers with latest energy efficient solutions in order to reduce power costs.

Data centers may have harmful environment arising from infiltration of outdoor particulate or gaseous contaminants. They are more prone, if the offices are situated near to landfill sites, sewerage/drains, high density traffic, process industries, etc. Infiltration of these gaseous contaminants can lead to electronic corrosion, which can result in increased downtime, low productivity, electronic equipment disturbance and failure. Most of the challenges stated above, can practically be tackled by incorporating a Gas Phase Filtration equipment in data centers. A Gas Phase Filtration equipment removes contaminants and eliminates downtime by removing corrosive gases through the process of chemisorption.

Definition of Data Center

A data center or computer center is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and security devices.
(Source: Wikipedia)

IT operations are a crucial aspect of most organizational operations. One of the main concerns is business continuity; companies rely on their information systems to run their operations. If a system becomes unavailable, company operations may be impaired or stopped completely. It is necessary to provide a reliable infrastructure for IT operations, in order to minimize any chance of disruption.

India is on the verge of witnessing a boom in the Data Center space with the Data Center business currently already above Rs. 10,000 Crores.

What is contaminants?

The contamination can be broadly classified in two parts:

1) Particulate Contamination
2) Gas Phase Contamination

While the size of particulate contaminants is upto 0.1 microns which can be removed by using particulate filters; gas phase contaminants are usually much smaller. Figure 1 gives pictorial view of typical contaminants in and around data centers.

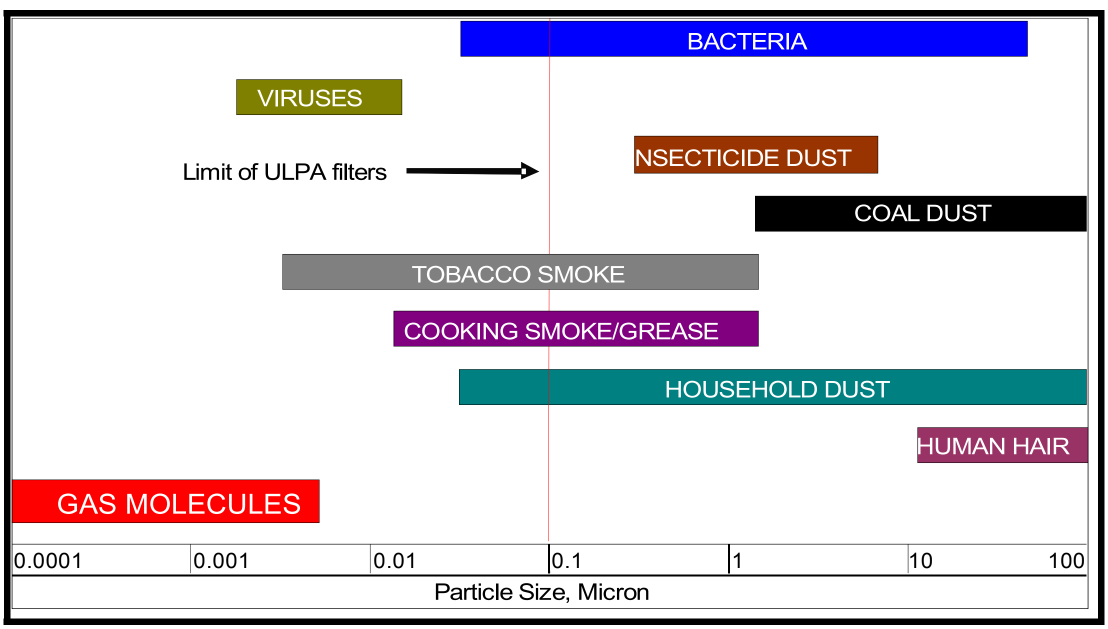

Figure 1: Particulate vs. Gaseous Contaminants

Effects of AIRBORNE CONTAMINATION on data center equipment can be broken into three main categories:

(a) **Chemical effect** - Dust settled on printed circuit boards can lead to components corrosion and/or electrical short-circuiting of closely spaced features.

(b) **Mechanical effect** - Include obstruction of cooling airflow, interference with moving parts, abrasion, optical interference, interconnect interference or deformation of surfaces.

(c) **Electrical effect** - Include impedance changes and electronic conductor bridging.

One mechanism by which dust degrades the reliability of printed circuit boards involves the absorption of moisture from the environment by the settled dust. The ionic contamination in the wet dust degrades the surface insulation resistance of the printed circuit board and, in the worst-case scenario, leads to electrical short circuiting of closely spaced features via ion migration.

Deliquescent relative humidity, the relative humidity at which the dust absorbs enough water to become wet and promote corrosion and/or ion migration, deter-mines the corrosivity of dust. When the deliquescent relative humidity of dust is greater than the relative humidity in the data center, the dust stays dry and does not contribute to corrosion or ion migration.

Leakage current due to dust that settled on printed circuit boards increases exponentially with relative humidity. Keeping the relative humidity in a data center below 60% will keep the leakage current from settled fine dust within the acceptable sub range.

Recommended Operating Environment

1. Data centers with or without air-side economizers must meet the cleanliness level of ISO class 8.
2. The deliquescent relative humidity of the particulate contamination should be more than 60%.
3. Data centers must be free of zinc whiskers.

For data center without air-side economizer, the ISO class 8 cleanliness may be met simply by the choice of the following filtration:

4. The room air may be continuously filtered with MERV 8 filters
5. Air entering a data center may be filtered with MERV 11 or preferably MERV 13 filters.

ASHRAE Recommended Environment for Temperature & Moisture (ASHRAE 2008, 2011)

Temperature	:	18°C (64.4°F) to 27°C (80.6°F)
Low-end moisture	:	5.5°C (41.9°F) dew point
High-end moisture	:	60% relative humidity or 15°C (59°F) dew point

Gaseous Contamination

For data centers located in areas which have traces of corrosive gases, Gas-Phase Filtration of inlet air and air in the data center is highly recommended.

Chief Sources of Contamination:

- Process Industries
- Oil Refineries
- Areas with high vehicular pollution.
- Sites close to dumping sites
- Sites close to open drains and treatment plants
- Land-fill sites
- Pulp and paper plants
- Fertilizers plant
- High density Traffic (e.g. Delhi)

Sulfur-bearing gases, such as Sulfur Dioxide (SO_2) and Hydrogen sulfide (H_2S) are the most common gases causing corrosion of electronic equipment. SO_2 and H_2S alone are not very corrosive to silver or copper but the combination of these gases with gases such as NO_2 and / or Ozone are very corrosive. The corrosion rate of copper is a strong function of relative humidity, while the corrosion rate of silver has lesser dependence on humidity.

Two common modes of IT equipment failures due to environmental contamination are as follows:

(A) Copper creep corrosion on printed circuit boards (refer Figure 2 and 3)

Corrosion of Copper plating to Copper Sulfide on PCBs and creeping of same. It leads to:

- Electrically shorting adjacent circuit-board features.

Effect of Gaseous Contamination on Data Center

Figure 2

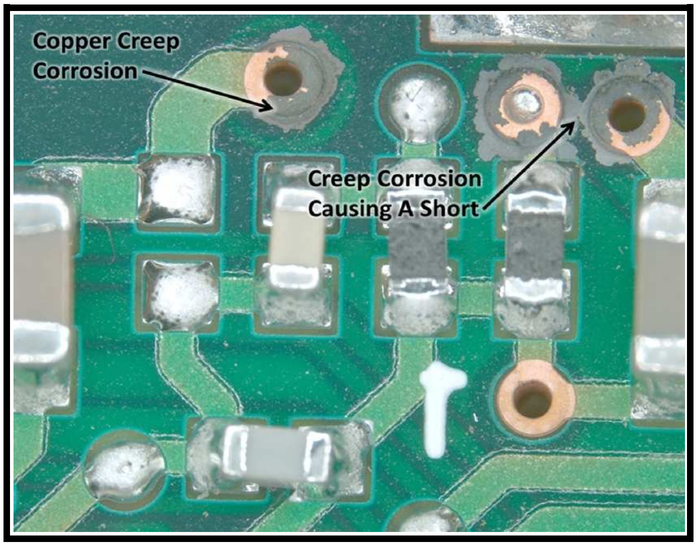

Figure3

(Source: ASHRAE Guidelines for data center)

(B) Corrosion of silver termination in miniature surface-mounted components (refer Figure 4 and 5)

- Corrosion of silver termination to silver sulfide which leads to loss of silver metallization – eventual open circuiting of components such as resistors.

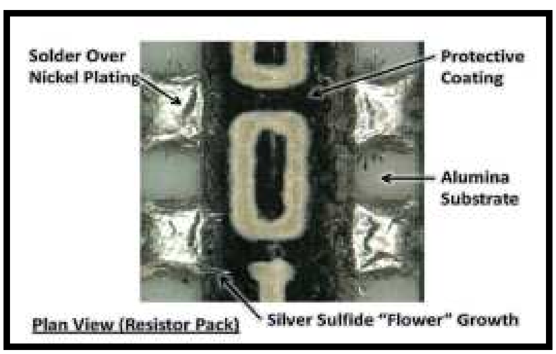

Figure 4

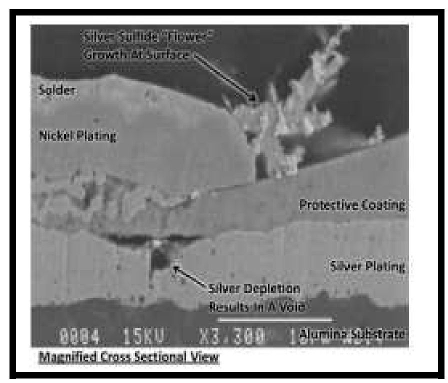

Figure 5

(Source: ASHRAE Guidelines for data center)

Reactive Monitoring

A low-cost, simple approach to monitoring the air quality in a data center is to expose copper and silver foil coupons (refer Figure 6) in the data center for 30 days followed by coulometric reduction analysis in a laboratory to determine the thickness of the corrosion produced on the metal coupons.

Corrosion Coupon

Figure 6

ASHRAE recommends that data center operators maintain an environment with corrosion rates within the following guidelines:

1. Copper reactivity rate of less than 300 Å/month

2. Silver reactivity rate of less than 200 Å/month

It is important to understand that while ISA standard - 71.04 (ISA 1985) is only based on copper corrosion levels, measuring of silver corrosion levels is as important for the following two main reasons:

a) Copper is not sensitive to Chlorine, a containment particularly corrosive to many metals.

b) Copper corrosion is overly sensitive to relative humidity.

Typical silver corrosion rate in one of data center in USA due to presence of SO2 & NO2 is given in Figure 7 as an example:

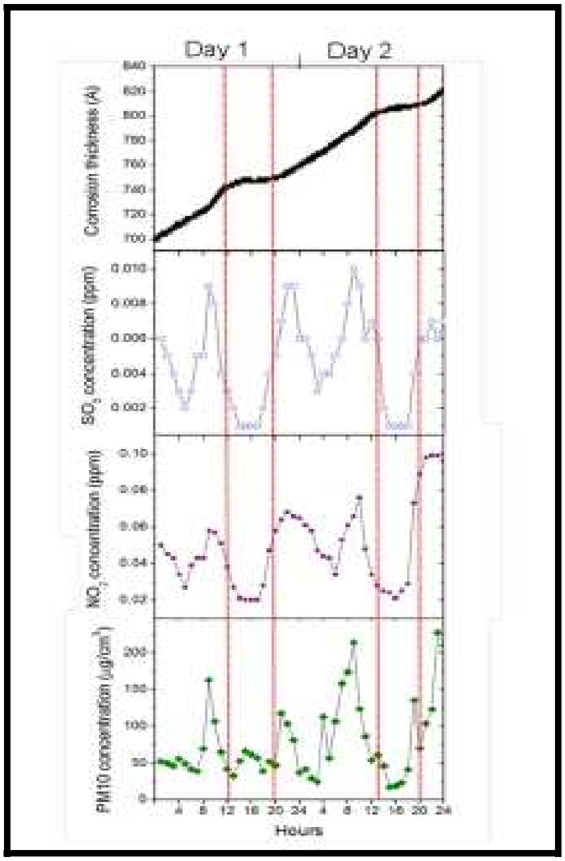

Figure 7 (Source: ASHRAE Guidelines for data center)

Based on test results of corrosion, it is possible to classify the environment into one of 4 severity levels as outlined in Table 1 below:

Corrosion Level in terms of (in Angstrom) as per ISA

Class	Severity Level	Copper Reactivity	Comments
G1	Mild	<300Å	An environment sufficiently well-controlled such that corrosion is not a factor in determining equipment reliability.
G2	Moderate	<1000Å	An environment in which the effects of corrosion are measurable and corrosion may be a factor in determining equipment reliability.
G3	Harsh	<2000Å	An environment is which there is a high probability that corrosive attack will occur. These harsh levels should prompt further evaluation resulting in environmental controls or specially designed and packaged equipment.

GX	Severe	>2000Å	An environment in which only specially designed & packaged equipment would be expected to survive. Specifications for equipment in this class are a matter of negotiation between user & supplier.

Table 1: Gaseous corrosivity levels as per ISA-71.04 (ISA 1985)

To understand this better, it is important to relate these conditions with typical levels of various corrosive gases (in ppb) in the controlled environment. The same are given in Table 2 below:

Parameters	G-1 Mild	G-2 Moderate	G-3 Harsh	G-X Severe
H_2S	< 3	< 10	< 50	> 50
SO_2	< 10	< 100	< 300	> 300
Cl_2	< 1	< 2	< 10	> 10
NO_X	< 50	< 125	< 1250	> 1250

Table 2: Classification of Reactive Environments

*** Note: All above figures are in ppb(parts per billion)**

In summary, data center equipment should be protected from corrosion by keeping the relative humidity below 60% and by limiting the particulate and gaseous contamination concentration to levels at which the copper rate is less than 300 Å per month and silver corrosion rate is less than 200 Å per month.

To help Data Center facility managers to take corrective steps in time, real-time monitoring is also recommended with gas-phase filtration air-cleaning systems, in order to track the efficiency of the filters. Two types of real-time reactive monitors are commercially available. One is based on measuring the rate of increase of corrosion product mass using a quartz crystal micro-balance. The other determines gaseous corrosivity by measuring the rate of electrical resistance increase of metal thin films.

How to create acceptable gaseous levels in Data Centers

There are mainly two ways of reducing gaseous contaminants in the environment which are as follows:

a) Wet Scrubbers
b) Dry Scrubbers

Wet Scrubbers:

Wet scrubbers operate on the principle of passing contaminated air thru the liquid media having properties to dissolve the unwanted corrosive gases. These scrubbers are normally used for protecting the external environment.

Dry Scrubbers:

In dry scrubbers the contaminated air is passed through adsorbant in granular form, impregnated with active chemicals to adsorb the unwanted gases and then nutralize/oxidise the same thru chemical reaction

This filtration principle is also known as Chemisorption. The contaminated impurities in air are adsorbed and is chemically neutralized. The contaminated air is passed through pre-filters which traps suspended impurities. The air stream is then passed through chemical media beds to chemically oxidize/ neutralize gaseous impurities. The air is then passed through particulate final filters before supplying into the data center. Typically, Chemical media beds are designed with media face velocity of 80 -125 FPM.

Chemicals in media beds get consumed over a time as these react with gases which are adsorbed in the media. The goal is therefore for the chemical filter to have the maximum amount of chemical for chemical reaction for a given physical size /geometry and air carrying capacity with minimum pressure drop. Till date, chemical filtration was being done by granular or pelletized media which causes substantial pressure drop hence requiring greater fan power leading to more power consumption for the same work done.

Typical configuration of Gas Phase Filtration System commercially available are:

a) Deep Bed Systems

b) Thin Bed Systems

Figure 8 below is depicting the working principle of these two systems:

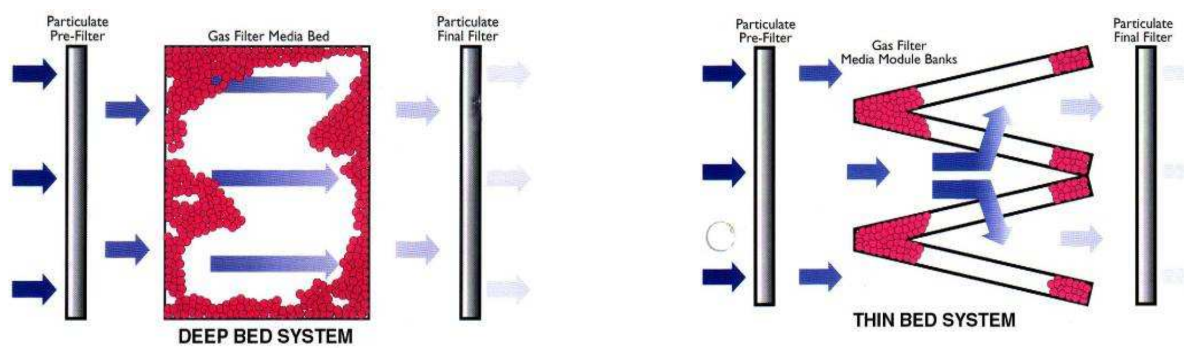

Figure 8

While effective in controlling the desired levels of corrosive gases in Data Centers, limitataions of these granular/ pelletised media based systems are:

a) Large footprints taking expensive commercial space

b) Bulky, difficult to install in multistory locations

c) Higher power consumption due to greater pressure drop

d) Difficult to replace consumed media due to general level of cleanliness required in Data Centers

Recent Developments in Gas Phase Filtration

Above limitation in using granular based dry scrubbers in commercial installations led to technologies allowing adsorbtion media in Honeycomb matrix to be impregnated with active chemicals in micropores of the substrate.

The new macro porous honeycomb matrix based chemical filter can hold very large amount of chemical for chemisorption and has ability to neutralize even ultra low concentration of gaseous contaminants. This new technology can remove contaminant gases, odorous gases or volatile organic compounds more efficiently and effectively from air supply stream.

These filters provide:

- Very large amount of impregnated active chemical (typically 15% for $KMnO_4$) for chemical reaction
- Better efficiency for a given physical size and geometry of the media matrix
- Enhanced air carrying capacity for a given pressure drop
- Air flows through the honeycomb matrix are designed typically at 400 to 600 fpm (2 to 3 mtrs/sec) unlike through the granular media bed at 80 to 120 fpm (0.4 to 0.6 mtrs/sec)
- Smaller foot print

To help better understanding of the various technologies available for gas phase filtration, Figure 9 below gives snap shot of Evolution of Gas Phase Filtration technologies.

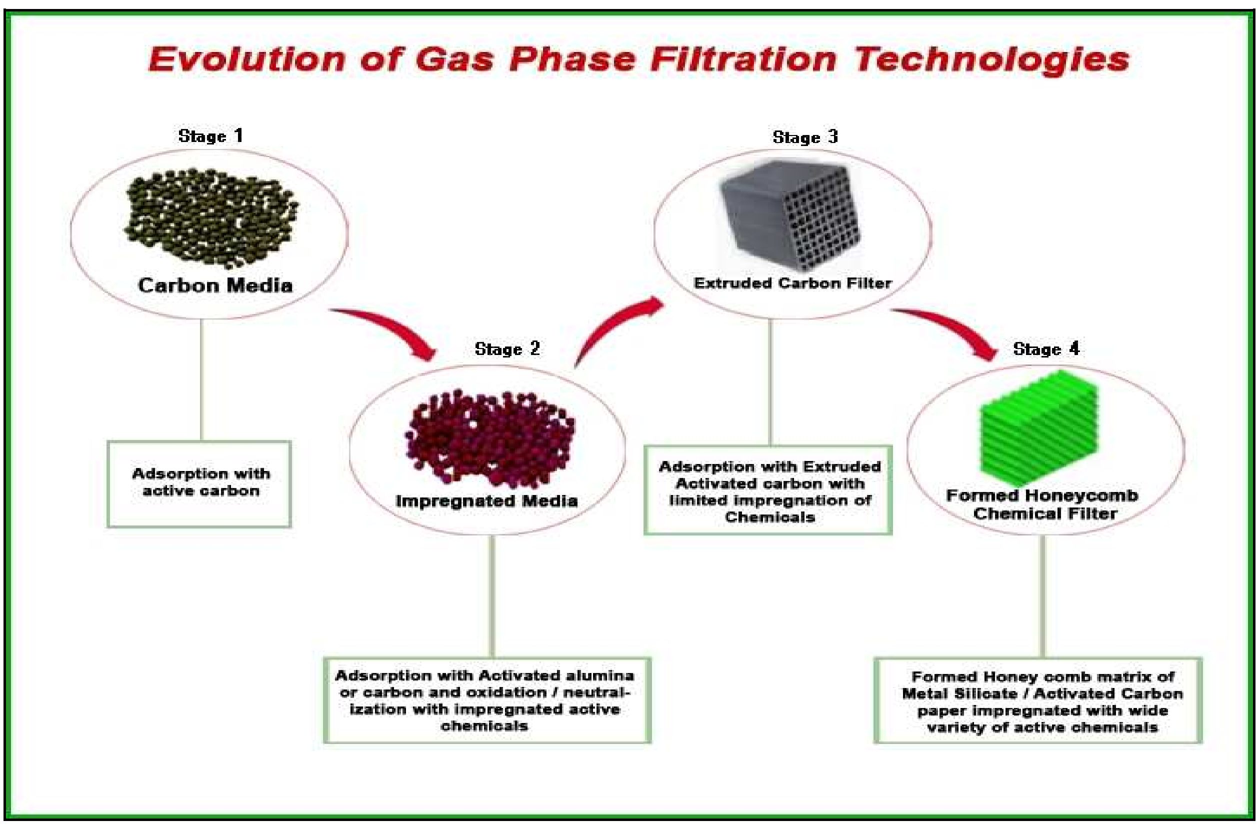

Figure 9: Evolution of Gas Phase Filtration Technologies

CASE STUDIES

OVERVIEW

Country	:	India
Location	:	Noida
Industry	:	IT
Client Name	:	XYZ Software Co
Application area	:	Server Racks

The Problem

Computer / Electronic Failure due to the presence of Hydrogen Sulphide Gas in the surrounding environment due to nearby large drain.

The Source of the problem

The source of the problem was an open drain containing untreated waste/sewerage water which blanketed the whole area with an obnoxious, foul odour. The odours were caused by the presence of hydrogen sulphide gas, which is continuously generated due to the gradual degradation of organic material in the sewerage. This was causing break down of computer systems and servers, disrupting work and resulting in loss of business. To add to the woes,people working in the plush air conditioned XYZ office were feeling extremely uncomfortable leading to loss in productivity. Furthering the problem was the wind direction. If the wind direction is towards the building from the contaminant generation zone, then the after effects is quite contrary to the one when it's been the other way round.

The Solution

The Airgineers helped XYZ solve the problem of frequent server/ computer failures and created comfortable working environment for staff. A Gas Phase Filtration system was installed inside the server room which sucks 300 CFM from the nearby facility area and 700 CFM from the room. Fresh air pressurize the room and recirculation air clean the room air. Computers no longer break down due to corrosion. Staff breathes fresh air .The air quality is of G1 class (least corrosion rate) inside the facility. The thin bed gas phase filtration units are self-contained units incorporating all particulate filters, chemical filters and supply fan. The unit sucks the outside air where dust is removed with the help of particulate filters and various other gases are removed with the help of special chemical filters.

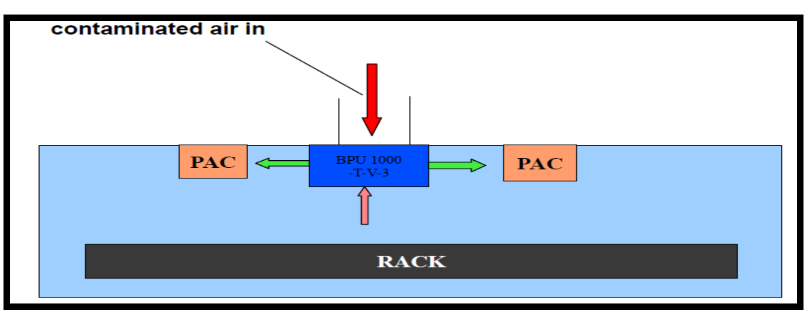

Figure 10

Installation System Flow Diagram

OVERVIEW

Country	:	India
Location	:	Mumbai
Industry	:	Telecom BPO
Client Name	:	XYZ
Application area	:	Server Racks

The Problem
The server in the data center was regularly facing break down causing and there was productive losses.

The cause of the problem
Cocktail of corrosive gases in the environment. This was due to the landfill area of Malad.

The Source of the problem
The company office was located in the Malad area of Mumbai known for its numerous landfill sites, waste dumping and drainage areas. The source of the problem was an open drain containing untreated waste/sewerage water which blanketed the whole area with corrosive gases and an obnoxious, foul odour.

Solution

Airgineers helped XYZ solve the problem of frequent server/ computer failures and created comfortable working environment for staff by installing gas phase filtration system. A Gas Phase Filtration system was installed outside the server room to maintain a positive pressure of air inside the server room .

The Airgineers solved the problem of frequent server failures by installing a deep bed unit, with 2000 CFM, which suck the fresh air remove dust and gases and supply the pure air to the room. In this way room pressurized with pure air . Computers no longer break down due to corrosion. The air quality is of G1 class (least corrosion rate) inside the facility.

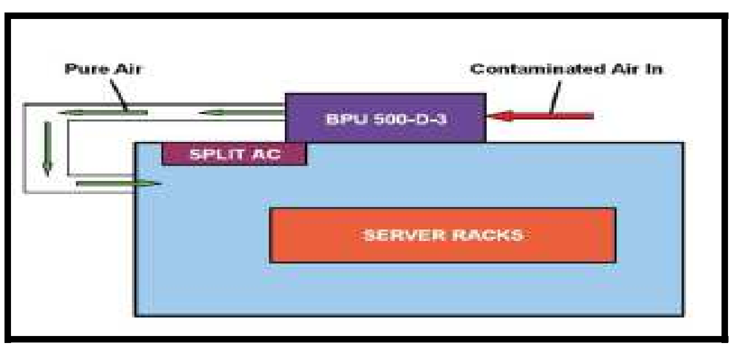

Figure11
Installation System Flow Diagram

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