Southeast Florida Society of Energy Professionals
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Energy, Economics, and Indoor Air Quality

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AdvanTek

IAQ and Energy Efficiency

- Some energy efficiency measures can result in IAQ problems.
  - VAV with fixed system outdoor air flow
  - reduction in OA / exhaust airflow rates
  - extreme temperature setbacks
- Some IAQ improvement measures can increase energy costs.
  - raising OA flow and/or exhaust flow
  - installing high-efficiency filters
  - controlling high humidity

Preventing and Solving IAQ Problems

- *Which IAQ technology is best?*
- *What is the cause of the IAQ concern?*
- *What is the best way to find a solution?*

"Simply put, the best solution is the one that permanently solves the root cause of the IAQ problem at the lowest possible cost."

Symptomatic *vs.* Real *Solutions*

- Problems often worsen or resurface following symptomatic treatments.
  - carbon filters or ozone to reduce odors
  - portable dehumidifiers or space heaters
- Identification of the ***Root Causative Factors*** leads to a permanent solution and lower energy costs.
  - Begin with an investigation to determine the source of contaminants, amplification/incubation sites, and pathways to the occupants.

Contaminant Sources

- Building Materials and Furnishings
  - adhesives, photocopiers, new carpet, wet or damp carpet, cabinetry or furniture made of certain pressed wood products, fresh paint, asbestos-containing insulation, ...
- Cleaning and Maintenance Chemicals
- HVAC Systems
  - biological contaminants, deteriorated fiberglass duct liner, cooling towers, drain pans, condensate leaks
- Combustion Sources
  - oil, gas, wood, and tobacco products
- Outdoor Sources
  - pesticides, vehicle exhaust, spores, pollen, ozone, radon ...

Biological Contaminants

- *bacteria, molds, mildew, viruses, animal dander, dust mites, cockroaches, pollen*
- Contaminated HVAC systems are breeding grounds for biologics and can readily distribute spores and toxins.
- *Biologics need high moisture, moderate temperature, and a food supply.*
- By controlling relative humidity the growth of biologics can be minimized.

The Dirty Dozen (**energy factors*)

1. Carpet that is not regularly steam cleaned
2. Ceiling Tiles that are wet
3. Condensate Drain Pans with standing water
4. *Low Efficiency Filters and Filter Bypassing
5. *Fresh Air Amount that is too little or too much
6. Fresh Air Intake near contaminant sources
7. *Coils that are not clean or regularly cleaned
8. *Leaking or non-existent ducts
9. Ponding of rain water on roof or ground
10. Cooling Tower near fresh air intakes
11. *Dehumidification Capacity that is inadequate
12. *Uncontrolled Airflow into Building

9 of 12 are HVAC factors
**6 of 9 are Energy factors*

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Which are the Real Solutions?

Heat Pipes

Preconditioner

REHEAT

Activated Carbon

OZONE

Duct Cleaning

Desiccant Dehumidifier

Ionization

Enthalpy Wheel

Electrostatic Precipitator

Filtration

?

Purge Cycle

Photocatalytic Oxidation

$

Ultraviolet Irradiation

Microwave Atomization

Space Pressurization

LPS Exhaust

Humidistat

Subcooling

Dual Pass AHU

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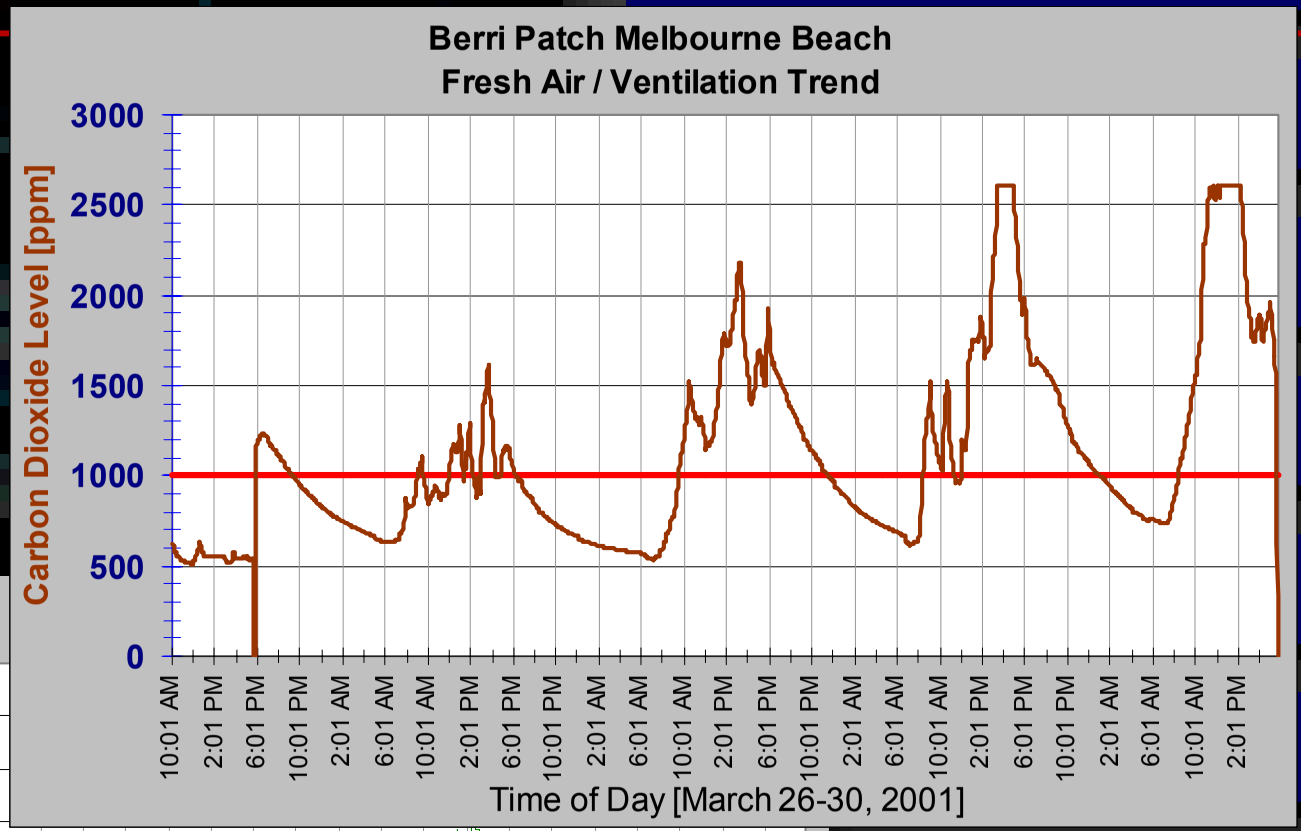
They boil down to 3 Solution Types

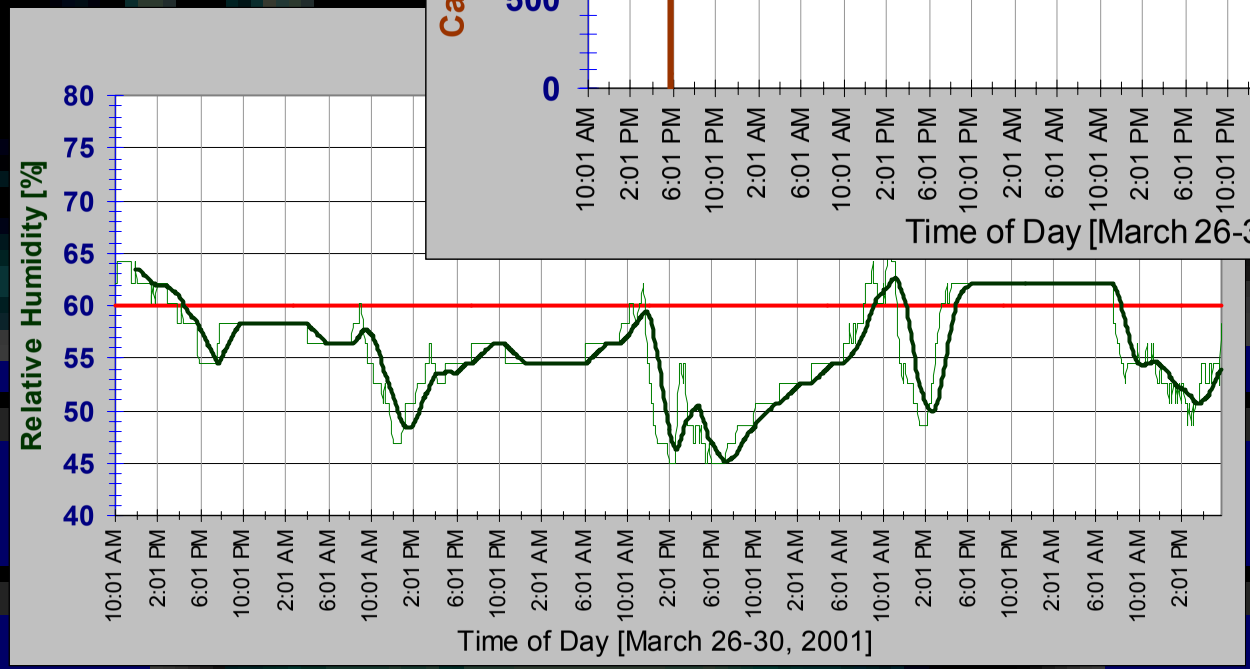
- **Source Control**
  - Eliminate or control the sources of pollution
- **Ventilation**
  - Dilute and exhaust pollutants through outdoor air ventilation
- **Air Cleaning**
  - Remove pollutants through proven air cleaning methods

Ventilation

- ASHRAE Standard 62.2*n* *(public review 9/24/01)*
- Two OA requirements: People + Area
  - Offices, Hotels, Auditoriums, Courtrooms: 5 cfm per person + 0.06 cfm per square foot.
  - Classrooms: 10 cfm per person + 0.12 cfm per sq ft
- Minimum Exhaust Rates
- "Air-cleaning devices for ozone shall be provided when the expected one hour average concentration is above 0.16 ppm"

Ventilation Effectiveness



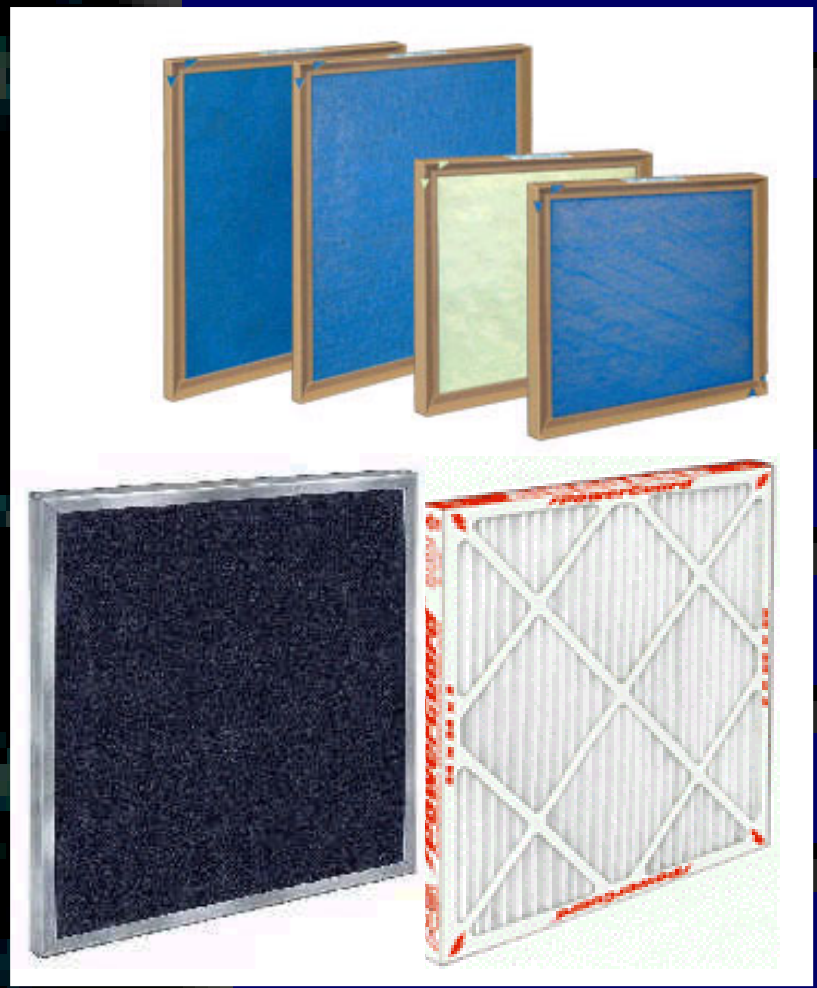


Pressurization

- Exhaust outflow less than OA inflow
- Keeps outdoor contaminants out
- Minimum 0.03 to 0.05 in.wg (7 to 12 Pa)
- Differential cfm depends on tightness
- Define airflow between building zones
- Predict zone pressures using software
- Test, adjust & balance upon installation
- Control via airflow tracking or dP sensor

Filtration

- 52.2 Efficiency Rating
  - Pollen, Dust Mites
    - MERV-4
  - Mold, Spores
    - MERV-8
  - Some Bacteria
    - MERV-12
  - Smoke, Toner
    - MERV-16
  - Viruses - HEPA



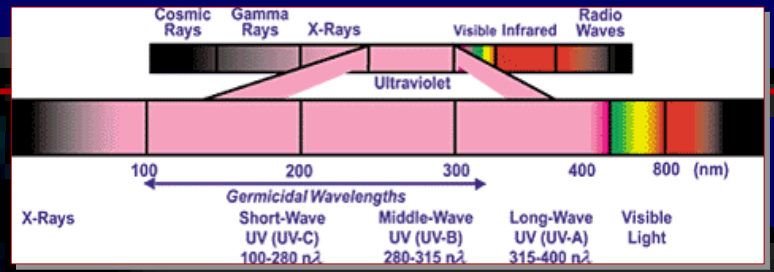
Ozone Generators

- Marketed to remove odors and contaminants - proven for water, can be misleading for air
- Ozone is a toxic gas with vastly different toxicological properties from oxygen.
- Ozone Exposure Limits - OSHA, NIOSH, FDA, EPA are 0.05 to 0.10 ppm to avoid respiratory irritation or lung damage.
  - **At these levels, *ozone has little potential to remove indoor air contaminants.***
- **Dosage is critical**

Ozone Generators

- Ozone reacts very slowly (weeks to months) with some pollutants found in indoor air.
  - Ozone reacts with "new carpet odor," but produces more aldehydes and results in higher VOC levels.
  - Ozone reacts with the tobacco aromatic Acrolein.
  - Ozone does not remove particulates such as pollen.
- 5x to 10x OSHA level needed to control airborne fungi and bacteria, a health concern if people are present.
- Some generators can produce 0.12 to 0.30 ppm under certain conditions (rated 500 to 4000 mg per hour).

Ultraviolet Light



- Short-wavelength (UVC)
  - three UV wavelength ranges are: UV-C, from 100 nanometers (nm) to 280 nm; UV-B, from 280 nm to 315 nm; and UV-A, from 315 nm to 400 nm
- UVGI - Ultraviolet Germicidal Irradiation
  - deactivates the DNA of bacteria, viruses and molds and thus destroys their ability to multiply and cause disease
- Proven very successful for water decontamination
- Key is Dosage = Intensity x Duration

An IAQ-ENERGY-HVAC Link

- Excess humidity and poor maintenance leads to microbial contamination.
- Biologics cause most IAQ problems in hot & humid climates such as Florida.
- HVAC systems *[should]* control humidity.

The most energy efficient humidity control strategies cost 60-70% less to operate than the most common least efficient method (reheat).

Estimating Energy Costs

- Using reheat for dehumidification increases energy costs by about 25%. Energy efficient methods can lower costs by 15% to 20%.
- Each 1000 cfm of fresh air costs ~$1000 per year
- Filter pressure loss of ½-inch requires 0.1 hp per 1000 cfm and costs $50 per year. MERV-11 filter replacement cost is $30 to $60 per year.
- UVC energy cost per 1000 cfm is $25 per year.

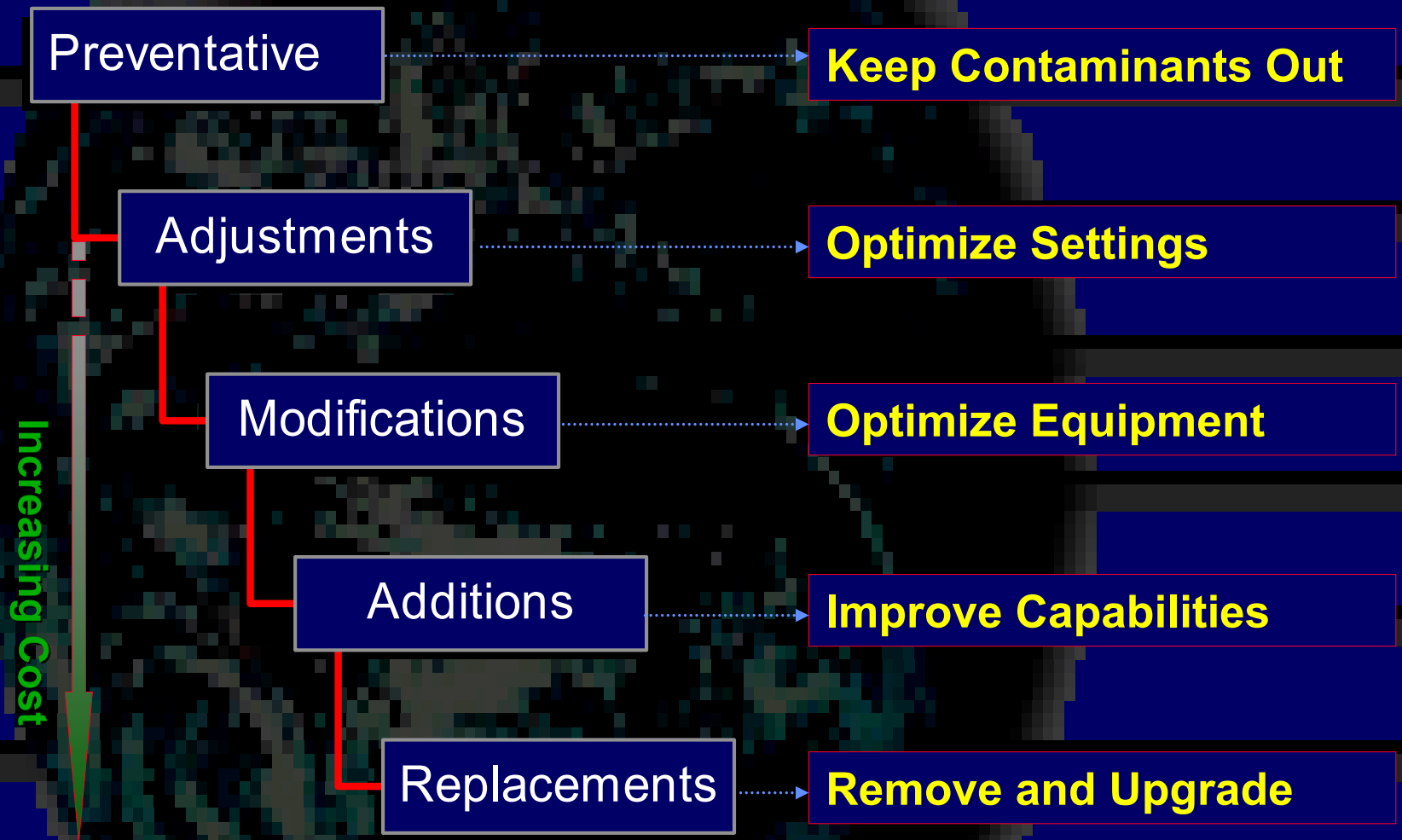
Jacksonville FL, 1 kW/Ton, EER 12, $0.071 per kWh, 24/7 - 8760 hours

Phased Diagnostic Approach

- **Classification of Solutions into a five-level system**
- **Lowest cost measures are the first to be considered**
- **Most expensive options are treated as a last resort**

"...provides the framework for a consistent, cost-based method of developing and implementing the best solution from among numerous mutually exclusive possibilities."

5-Phase Approach



Humidity-Related IAQ Problems

- Biologics can make you sneeze, trigger allergic reactions, cause rashes, watery eyes, hoarseness, coughing, dizziness, lethargy, breathing problems, and digestive problems.
- Fungi and bacteria find moisture and nourishment in HVAC system coils, ducts, and cooling towers.
- Excess space humidity allows microbial growth on ceiling tiles, wall paper and in carpet. Cleaning and replacement is costly.

Humidity-Related Design Practices

- Much of the U.S. is outside of the hot & humid climate region.
- Required fresh air flow rates were greatly increased in 1989 to improve IAQ.
- Key HVAC system dehumidification practices date back to the very earliest days (c. 1935)
- Increased R-values and lighting efficiencies have reduced the sensible cooling load.
  - **For these and many other reasons, HVAC systems often do not adequately dehumidify.**

'Top 10' Design Warnings

1. Constant or uncontrolled outside air flow
2. Outside air fraction greater than 20%
3. High efficiency lighting system
4. High R-value roof and windows, shaded site
5. Complex footprint with many joints
6. Numerous wall and roof penetrations
7. Large exhaust fans or exhaust hoods
8. Equipment oversized for rapid cool-down
9. Variable or unpredictable occupancy
10. Suspended ceiling used as return air plenum

Comprehensive Approach

- Indoor Air Quality Building Education and Assessment Model (I-BEAM) software capabilities:
  - Track energy, maintenance and IAQ costs
  - Document, track and improve productivity
  - Refine preventive maintenance program for IAQ
  - Better manage housekeeping services for IAQ
  - Track an indoor air quality audit
  - Provide documentation that the building is following IAQ building practices
  - Reduce liability exposure from IAQ complaints

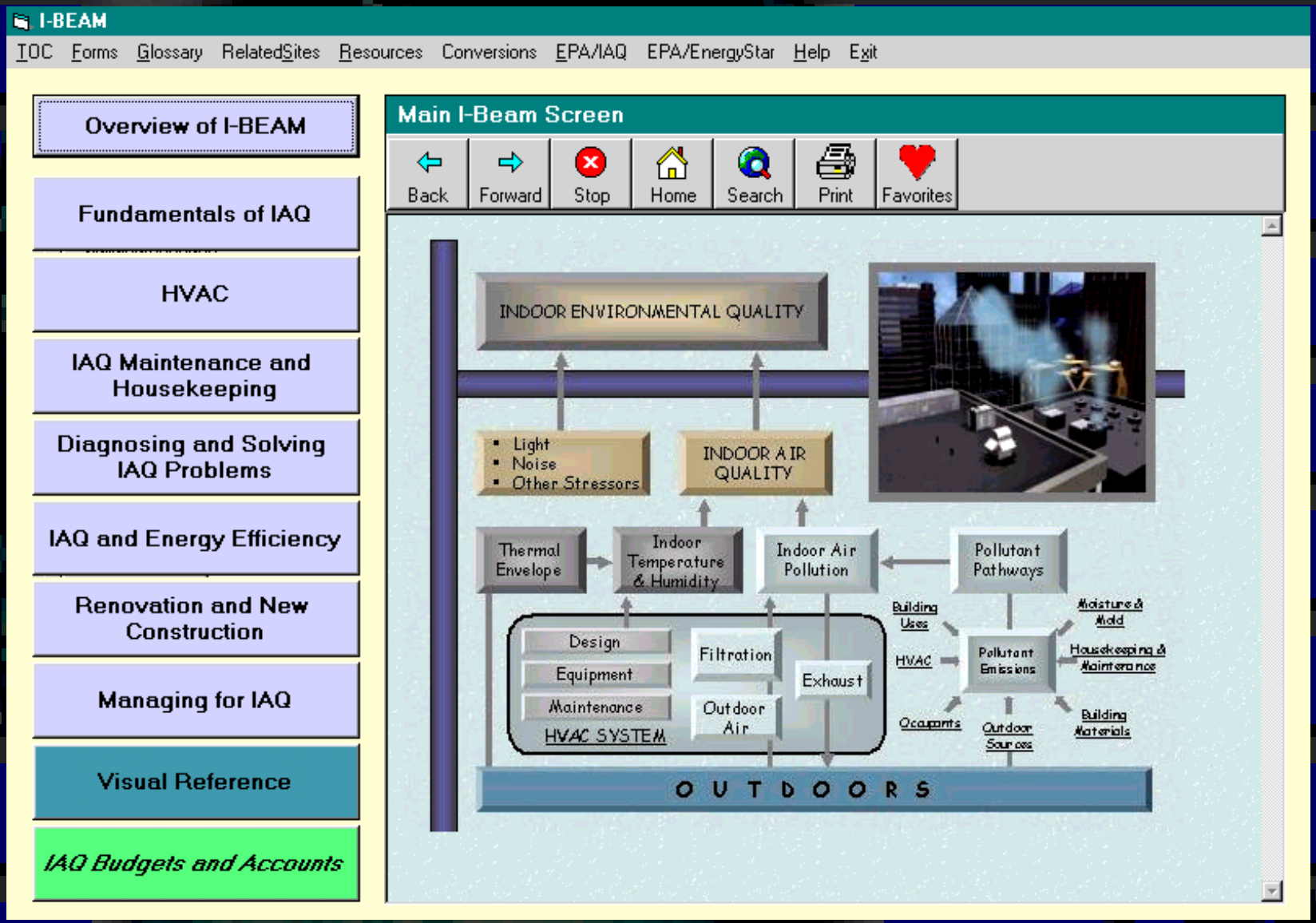
Good IAQ is Crucial

- Customer Comfort
  - Associated with gross revenue
- Employee Productivity
  - 18% of retail employees have IAQ complaints
- Lower Energy Costs
  - Reducing expenses directly increases profit margin

For Example, say gross sales are $20 million per year for a retail business. Payroll is 10% of this amount ($2 million), energy costs are 1% of this amount ($200,000) and net earnings are 5% ($1 million).

IAQ measures could reduce energy costs by 10% (savings of $20,000 per year)**, and may also increase employee productivity by 2½%** ($50,000 per year) **due to improved comfort, health, and customer perception.**

IAQ Management Software



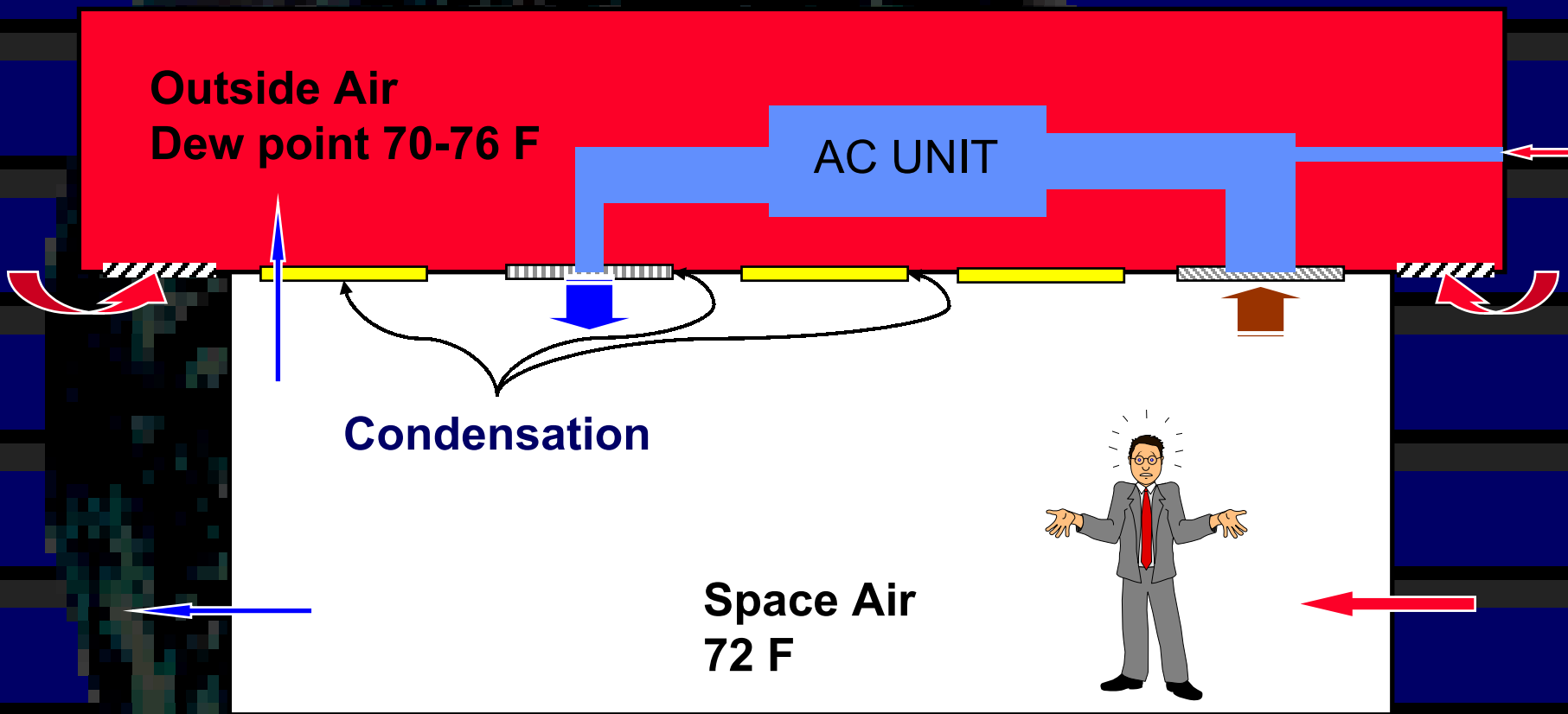
Case Studies

- Case Study #1
  - Facility: Health & Fitness Center, Orlando
  - Problem: Mold Growth on Ceiling Tiles
- Case Study #2
  - Facility: County Library, Tampa
  - Problem: Employee Illness

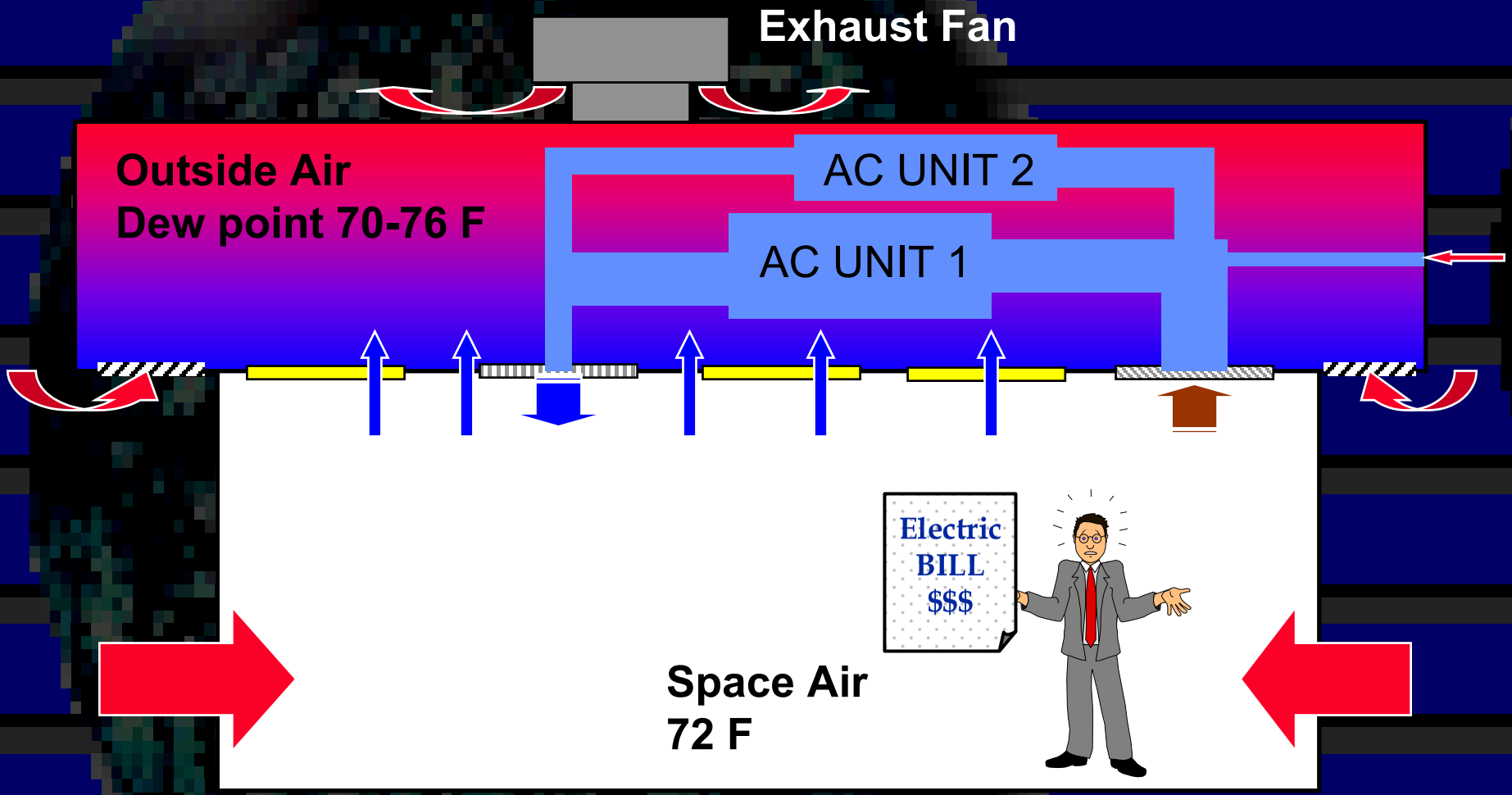
Case Study #1: Fitness Center

- Symptoms included:
  - Mold growing on ceiling tiles
  - Sagging ceiling tiles
  - Water dripping from light fixtures
- Symptomatic "solution":
  - A very large exhaust fan had been installed to "vent humid air out" of the space above the suspended ceiling.

Case Study #1: Fitness Center



Case Study #1: "Poor Solution"



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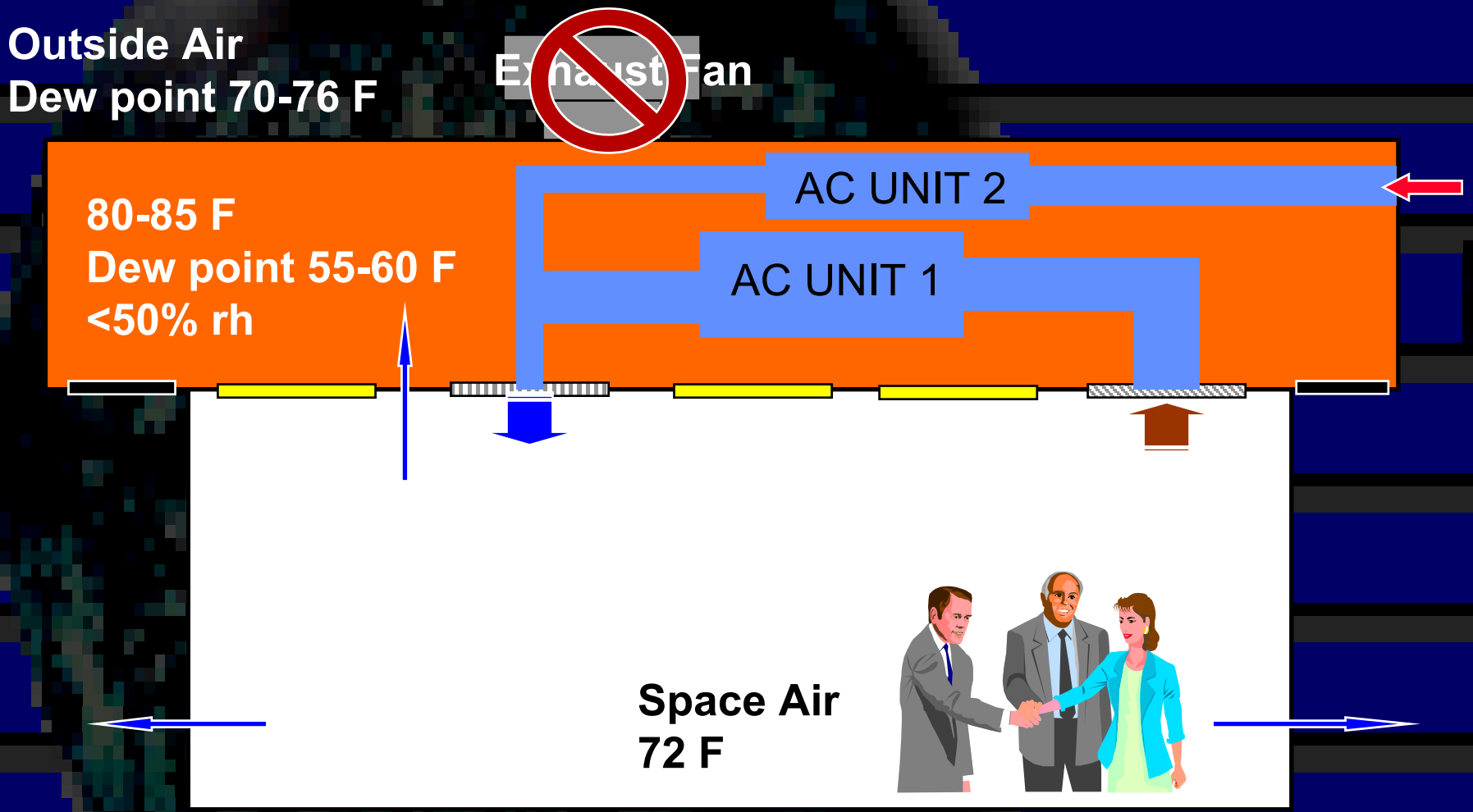
Case Study #1: "Real Solution"



Case Study #2: County Library

- Symptoms Included
  - Humidity of 70-90%rh
  - Mold Growth on Books
  - High Incidence of Worker Illness
- A phased diagnostic approach was used to develop solutions at each cost level.
- Project savings of $110,000 plus $40,000 per year in energy savings compared with the proposed desiccant pre-conditioners.

Case Study #2: County Library

- Findings:
  - Ceiling return plenum vented to outdoors
  - Excess, contaminated outside air flow rate
  - Low-efficiency filters
  - Mold growth on tiles and roof trusses
  - Thick fungus growing in cooling coil
  - Air bypassing filters -- filters too small
  - Glue fumes from bookbinder
  - Low dehumidification capacity

Case Study #2: Moldy Ceiling Tiles

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Case Study #2: Moldy Ceiling Return Air Plenum

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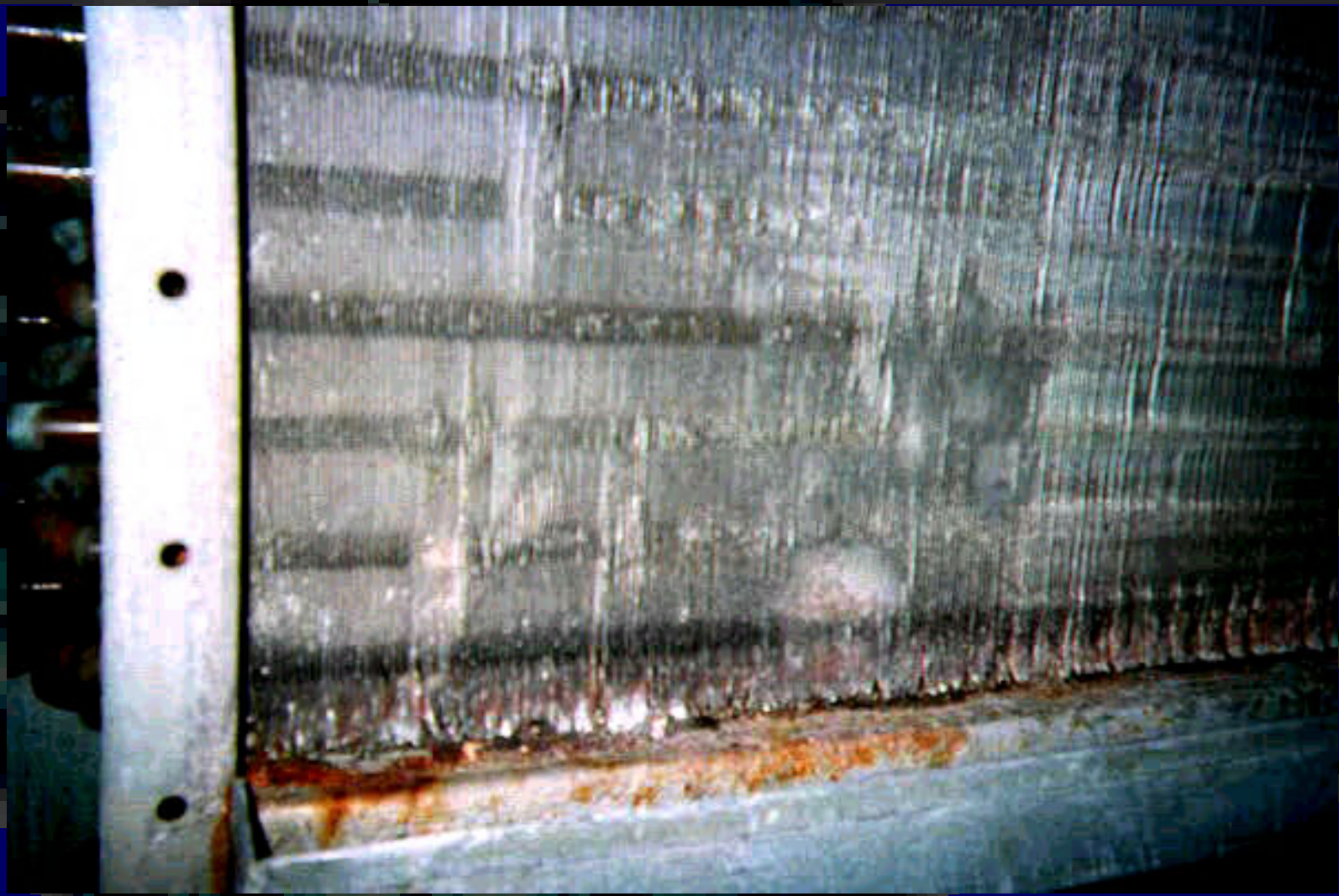
Case Study #2: Moldy Cooling Coil



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Case Study #2: Mold Near Fresh Air Intakes

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Case Study #2: Mold in Roof Ponds

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Case Study #2: Cooling Tower Near Intakes

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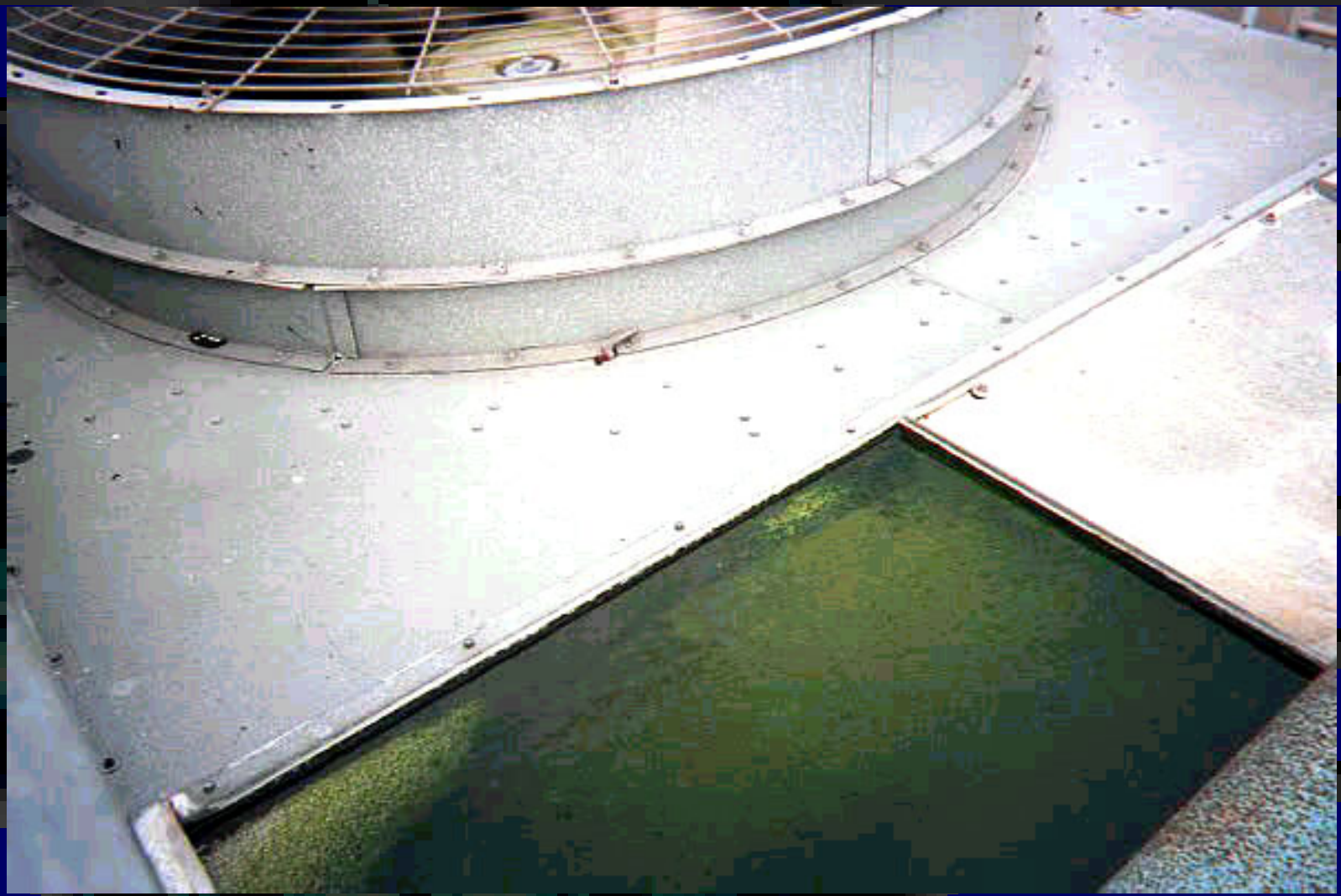
Case Study #2: Tower Water Contaminated



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Case Study #2: I. Preventative Measures

- Sealed return plenum from outdoors
- Cleaned and sanitized coil and AHU
- Cleaned roof and cooling tower
- Installed MERV-11 pleated filters
- Repaired exhaust fan over bookbinder
- Books cleaned or replaced

RESULT:

+ Humidity levels dropped to 55-80% rh (from 70-90%)
+ Fewer complaints, some mold growth continued

Case Study #2: II. Adjustments

- Set outside air flow to proper amount
- Reset TXV superheat setting
- Set fan speed and cfm to design spec

RESULT:

+ Humidity levels dropped to 50-70% rh
+ Fewer complaints and no new mold growth

Case Study #2: III. Modifications

- Installed automatic damper on outside air intakes to close when unoccupied
- Installed occupancy sensors to control bookbinder and rest room exhaust fans
- Installed transfer grilles between binding area, office, and stack areas

RESULT:

+ Humidity levels dropped to 50-60% rh
+ Complaints subsided

IAQ Projects can pay for themselves

PROJECT SAVINGS AND COSTS					
	SAVINGS	% SAVED	COST	AROR	PAYBACK
ENERGY SAVING PROJECTS					
CHILLER VARIABLE SPEED DRIVE	$ 10,037	5%	$ 50,000	9.4%	5.0 yrs
SUPPLY FAN VARIABLE SPEED DRIVES	24,971	12%	50,443	32.9%	2.0
CHW PUMP VARIABLE SPEED DRIVE	4,835	2%	10,575	29.9%	2.2
ECONOMIZER [86,000 CFM]	2,861	1%	8,000	21.9%	2.8
CHILLER - TOWER DDC OPTIMIZATION *	1,969	1%	4,500	28.3%	2.3
LIGHTING CONTROLS	7,079	4%	15,303	30.3%	2.2
REDUCE NIGHT LOAD BY 40%	5,679	3%	7,750	52.0%	1.4
SUBTOTAL SAVINGS PROJECTS	$57,432	28%	$146,570	24.7%	2.6
REPLACE COILS AND FILTERS †					
REPLACE COOLING COILS			$52,738		
INSTALL HIGH EFFICIENCY AIR FILTERS			14,438		
SUBTOTAL COILS AND FILTERS			$67,175		
REMEDIATION					
ENGINEERING AND OVERSIGHT			21,375		
CONTAMINANT REMOVAL♥			$52,040		
TOTAL✣	$57,432	28%	$287,160	9.3%	5.0

MAIN POINTS

- The best solution permanently solves the root cause of the IAQ problem at the lowest possible cost.
- Symptomatic solutions are rarely permanent ones.
- Real solutions often provide the added benefits of lower energy costs and increased productivity.
- The best solution can be identified with a phased diagnostic approach.
- IAQ projects can pay for themselves with energy savings.