

CSHE/APIC Meeting

California Society for Healthcare Engineering

Membership

Open to individuals actively employed in healthcare facility engineering.

Embraces plant, bio-medical, and telecommunications disciplines.

Members join one of 11 local chapters across four professional categories.

Education

Exchange ideas and keep abreast of operational disciplines through chapter meetings and seminars.

Coordinates facility engineering programs in community colleges and apprenticeships.

Chapters meet regularly featuring industry speakers on crucial healthcare engineering issues.

Affiliations

Proudly affiliated with the American Society for Healthcare Engineering (ASHE).

ASHE is the largest affiliated society of the AHA, representing 2,500 healthcare engineering experts.

Publications

The CSHE Engineering News delivers code reviews, board activities, and engineering research.

Information sharing is a major asset, with many peer-written articles reprinted in national trade journals.

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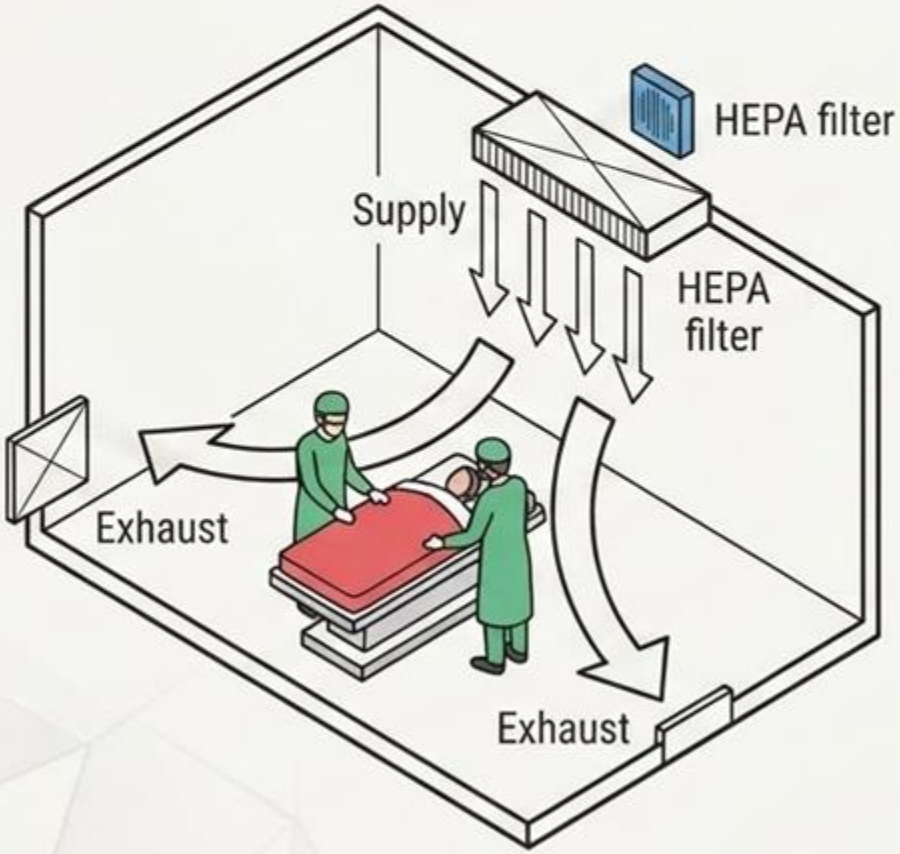


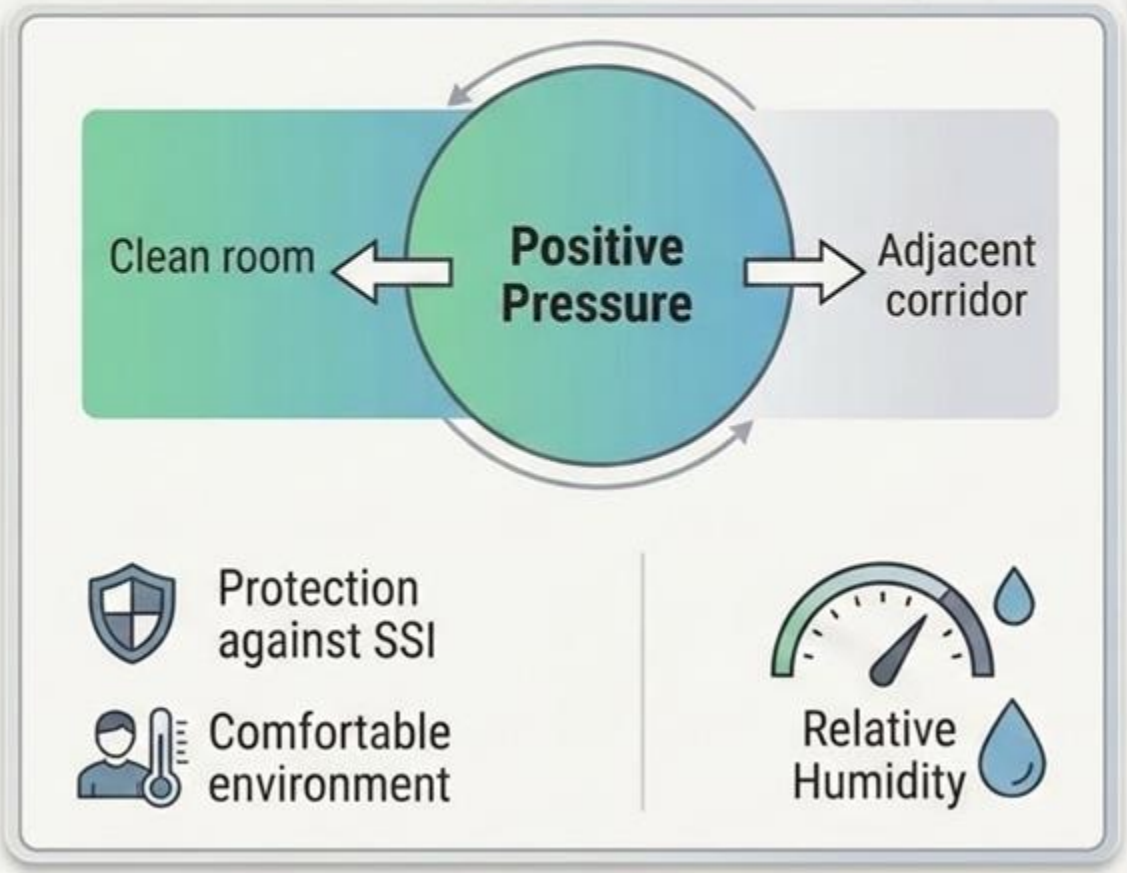
Anthony Crawford
Immediate Past President

Fundamental PERSPECTIVES AND CONSIDERATIONS:

"Hospital OR Ventilation 101"

Infection Prevention and Relative Humidity





The Challenge: Operationalizing Ventilation Design

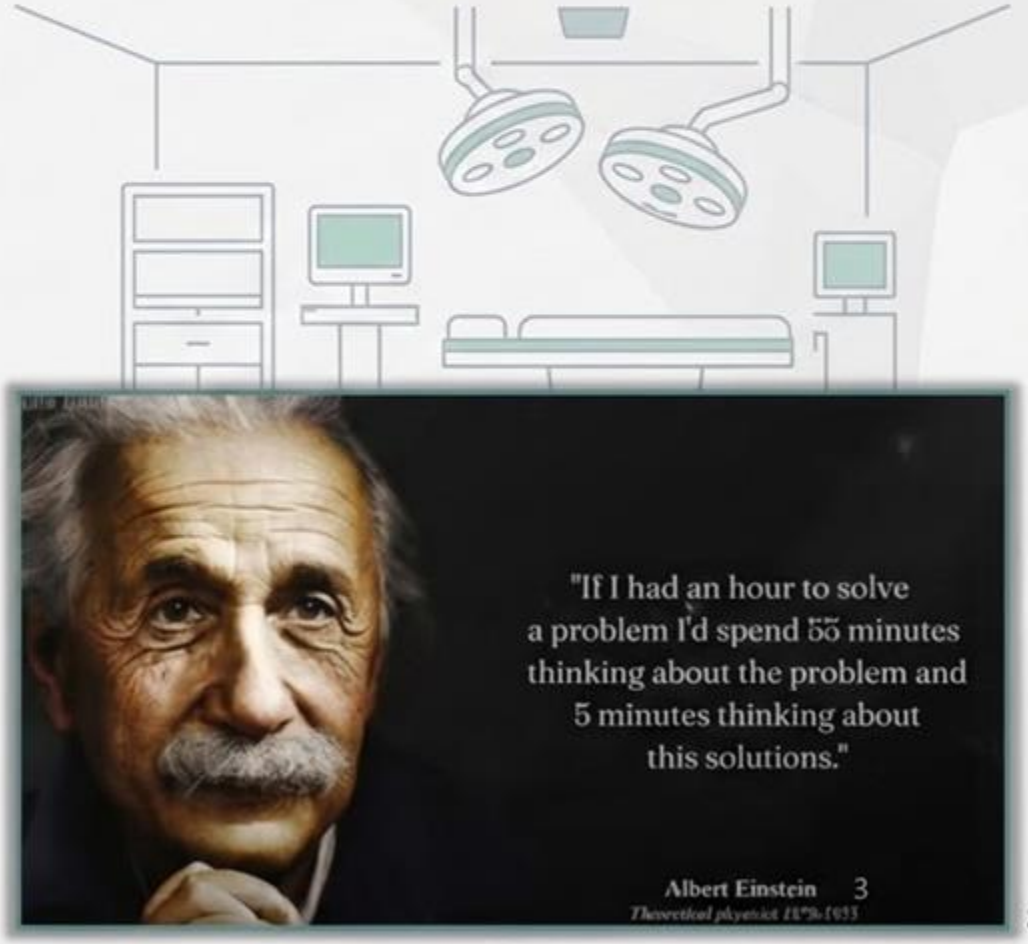
To incorporate and reconcile **defined ventilation system design requirements** into **operational practices** designed to provide environmental control for comfort, asepsis, and odor in health care facilities.

PROTECT PATIENT
Against SSI

ENSURE
Comfortable & Safe Environment

MAINTAIN
Adequate Indoor Air Quality

AVOID OR Delay or Shut Down
Manage Cost, Surgeon Time, & Patient Hardship



Some KEY TERMS

(A TRUE road to agreement and partnership is UNDERSTANDING)

Relative Humidity

NOTE: At 100% relative humidity, the air is completely saturated and cannot hold any more water vapor, which often leads to condensation, rain, or dew.

- RH plays a critical role in maintaining healthy indoor environments by regulating moisture levels and forestalling the growth of harmful microorganisms



Dew Point

IP Takeaway: Humidity affects comfort, supplies, condensation risk, and microbial growth.

Relative Humidity and Its Impact on the Immune System and Infections
https://www.nlhpnm.org/chatats/relative-humidity and Infections

Key Ventilation Metrics: Simplified

CFM

Cubic Feet per Minute. Measures the ***volume*** of air an HVAC system moves.

WHY is it important?

Vital for assessing system capacity and performance.

ACH

Air Changes per Hour. Calculates the number of times total air in a room is replaced.

WHY is it important?

Standard indicator of mechanical ventilation efficacy.

Pressure Differential

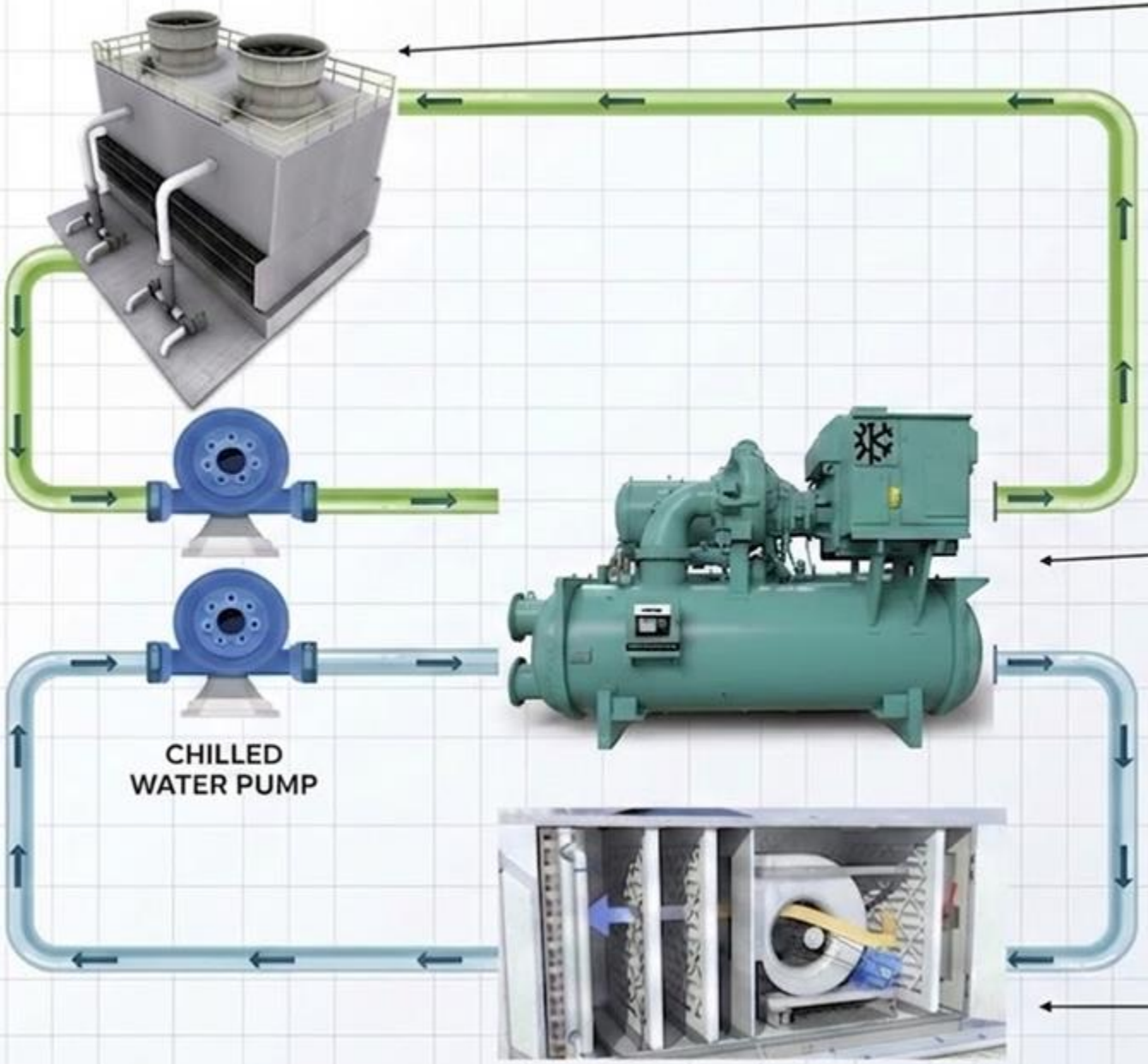
Air flow and pressure relationship relative to adjacent areas.

WHY is it important?

From an infection prevention standpoint, current mechanical ventilation literature stipulates that **"Design of the ventilation system shall provide air movement that is generally from clean to less clean areas."**

ACH = how much air; pressure = where air moves.

AIR CONDITIONING SYSTEM - Simplified



The Condenser Water Loop (COOLING TOWER)

The condenser water loop connects the chiller's condenser to the cooling tower. The condenser water absorbs the heat that the refrigerant dropped off in the chiller. Because it has absorbed all this heat, **it is now warm water and gets pumped up to the cooling tower**

The Refrigerant Loop (the CHILLER)

Inside the Chiller evaporator, the chemical **refrigerant** goes through a huge pressure drop. Because the pressure is so low, the **refrigerant boils** and evaporates at a very low temperature (-40°F), pulling heat out of the indoor air.

It then travels to the **condenser,** where it drops off all that extracted heat.

The Chilled Water Loop (AHU) ***IP TAKEAWAY***



Outside/ return air ❯ filters ❯ heating/ cooling ❯ supply air ❯ room ❯ return/ exhaust

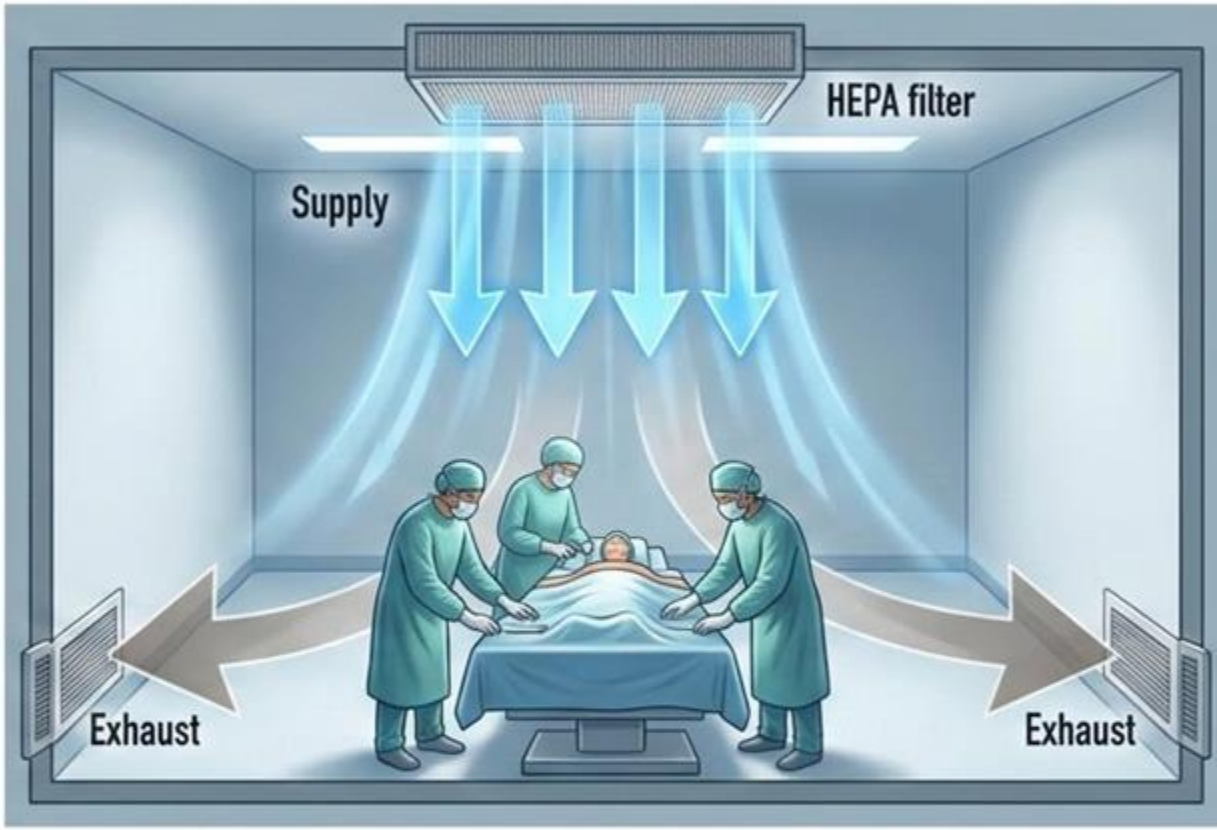
Circling back to …

ACH

Air Changes per Hour – A calculation of **(theoretically)** how many times the total volume of air within a room is replaced in one hour.

This doesn't necessarily mean that every cubic inch of air from all corners of the room is exhausted and replaced X times per hour

This is WHY the direction of clean air and the **FILTRATION** efficiency is so important **to preserve the integrity of the sterile field**



Nerd ALERT

$$\frac{CFM * 60}{RoomVolume}$$

California Mechanical Code

filtration design efficacy levels for Operating Rooms

HEPA filters represent very strict, hospital-grade standard,

capturing **99.97%** of all particles **0.3** microns in size.

Therin lies the true BULWARK of environmental infection prevention

Filtration requirements vary by space. Do not assume HEPA—verify with Facilities.

TABLE 4-B
FILTER EFFICIENCIES FOR CENTRAL VENTILATION AND AIR-CONDITIONING SYSTEMS IN GENERAL ACUTE CARE HOSPITALS, ACUTE PSYCHIATRIC HOSPITALS, OUTPATIENT FACILITIES, AND LICENSED CLINICS[1]

AREA DESIGNATION	MINIMUM NUMBER OF FILTER BANKS	FILTER EFFICIENCY % FILTER BANK (MINIMUM EFFICIENCY REPORTING VALUE MERV)[5]		
		NO.1[1]	NO.2[1]	NO.3[1]
Orthopedic operating room, bone marrow transplant operating room, organ transplant operating room	3	30% (8)	90% (14)	99.97%[3] (17)
Protective environment rooms	3	30% (8)	90% (14)	99.97%[4] (17)
Angiography; cardiac catheterization labs; operating rooms; interventional imaging procedure rooms; delivery rooms nurseries; patient care, treatment, cystoscogy, cesareon operating room, diagnostic, and related areas; airborne infection isolation rooms; areas providing direct patient service or clean supplies such as sterile and clean processes, and patient area corridors	2	30% (8)	90% (14)	- -
...ies	2	30% (8)	80% (13)	- -
...tive, med staff support areas, ...ee, spiderl holding areas		30%	-	-

REGULATORY and STANDARDS perspectives

The origin of NFPA 99, *Health Care Facilities Code* dates back to the **1930s** and a series of **dangerous operating room explosions.**

- These disasters gave rise to the NFPA's specialized safety rules and standards.
- Penned specifically for medical facilities.
- Covering critical areas:
  - Electrical systems.
  - Medical gases.
  - **VENTILATION**.



REGULATORY and **STANDARDS** perspectives

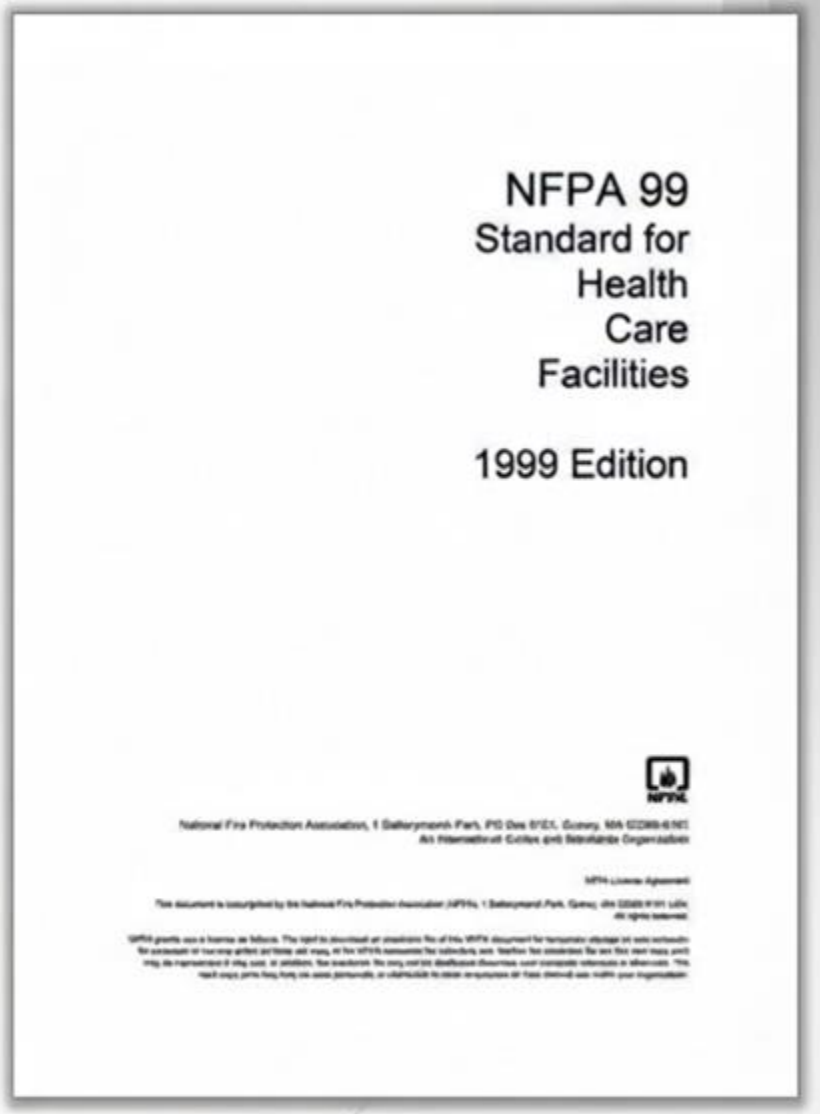
Older editions of NFPA 99 required operating rooms to maintain an RH of **at least 35%** primarily to **prevent static electricity build-up**

Given the fact that modern anesthetics are nonflammable, and lower humidity levels are much easier to maintain…

To that end, CMS issued a **Categorical LSC Waiver** that provided this flexibility .

The memo also RECOMMENDED that RH not exceed 60% in these locations.

The memo also **RECOMMENDED** that RH not exceed 60% in these locations.



REGULATORY ROADMAP TO COMPLIANCE

How Federal, State, and Joint Commission mandates converge on critical ventilation standards

CMS & FEDERAL

The Centers for Medicare & Medicaid Services demands absolute alignment with core health codes:

42 CFR §482.41(c): Hospitals must meet and proceed in accordance with the **Health Care Facilities Code (NFPA 99)**.

Applies to the 2012 editions of both the LSC (NFPA 101) and HCFC (NFPA 99).

CALIFORNIA STATE

Strict state codes dictate mechanical design and real-time operational maintenance:

Title 22 §70855: HVAC systems must maintain comfortable temperatures and meet plans in effect at construction approval.

24 CCR §402.1.3: Mechanical ventilation must comply explicitly with **ASHRAE 170** standards.

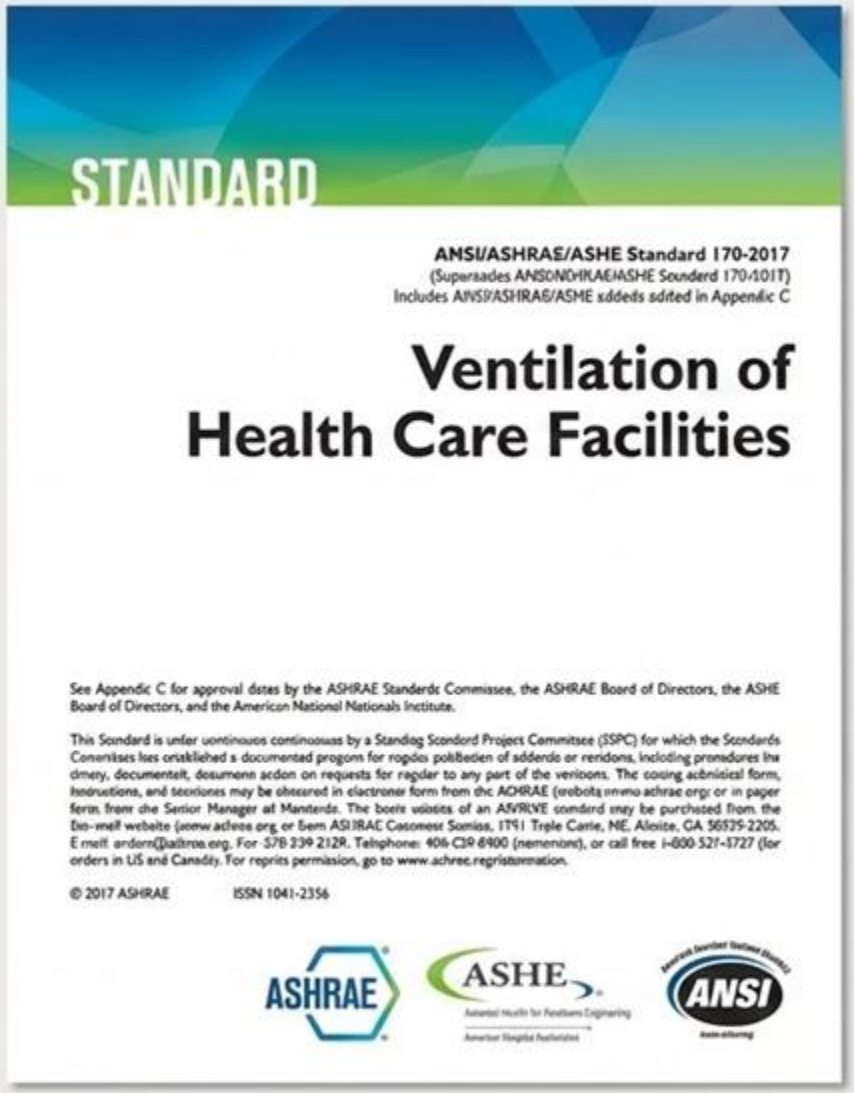
JOINT COMMISSION

Accreditation guidelines enforce physical environment controls:

PE 04.01.01 EP3: Requires proper ventilation, lighting, and temperature across pharmaceutical, patient care, and food areas.

EP1 Mandate: Explicitly requires proceeding in accordance with the 2012 Health Care Facilities Code.

CONCLUSION: All regulatory roads converge directly on **NFPA 99 Section 9.3.1** and **ASHRAE 170** ventilation standards.



ANSI/ASHRAE/ASHE Standard 170, Ventilation of Health Care Facilities is one of a family of documents that offers guidance, regulation, and mandates to designers of health care facilities.

Standard 170 originated with an agreement between ASHRAE and the Facilities Guidelines Institute … that an ASHRAE standard would provide the best location for ventilation requirements for the health care industry.

2. SCOPE

2.1 The requirements in this standard apply to patient care areas and related support areas within health care facilities, including hospitals, nursing facilities, and outpatient facilities.

2.2 This standard applies to **new buildings, additions to existing buildings, and those alterations to existing buildings** that are identified within this standard.

Ventilation Parameters for Surgery and Critical Care (ASHRAE Standard 170-2017)

Function of Space	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	Design Relative Humidity (k), %	Design Temperature (l) °F/°C
SURGERY AND CRITICAL CARE							
Critical and intensive care	NR	2	6	NR	No	30-60	70-75/21-24
Emergency department public waiting area	Positive	4	12	Yes	No	20-60	60-88/20-24
Intermediate care (r)	Negative	2	12	Yes	No	Max 65	70-75/21-24
Laser eye room	Positive	3	15	NR	No	Max 60	70-75/21-24
Medical/anesthesia gas storage (r)	Negative	NR	8	Yes	NR	NR	70-75/21-24
Newborn intensive care	Positive	2	6	NR	No	30-60	72-78/22-24
Operating room (m), (o)	**Positive**	**4**	**20**	**NR**	**No**	**20-60**	**68-75/22-24**
Operating surgical cystoscopic rooms (m), (o)	Positive	4	20	NR	No	20-60	68-75/20-24
Procedure waiting (m), (d)	Positive	3	15	Yes	No	Max 60	70-75/21-24
Recovery room	NR	2	6	NR	No	20-60	70-75/21-24
Substerile service are	NR	2	6	NR	No	NR	70-75/21-24
Trauma room (crisis or shock) (c)	Positive	3	15	NR	No	20-60	70-75/21-24
Treatment room (d)	NR	2	6	NR	No	20-60	70-75/21-24
Triage	Negative	2	12				
Wound intensive care (burn unit)	NR	2	6				
INPATIENT NURSING							
All anteroom (u)	(e)	NR	10				
All room (u)	Negative	2	12				
Combination AII/PE anteroom	(e)	NR	10				
Combination AII/PE room	Positive	2	12				

Noter NR = no requirement

ing or temporarily open. Simple visual methods such as smoke trail, ball-in-lube, or fluttership shall be permitted for verification of air-flow direction.

o. *Surgeons or surgical procedures may require room temperatures, ventilation rates, humidity ranges, and/or air distribution methods that exceed the minimum indicated ranges.

p. Treatment rooms used for bronchoscopy shall be treated as bronchoscopy rooms. Treatment rooms used for procedures with nitrous oxide

CALIFORNIA GACH LICENSING REGULATIONS

Cal. Code of Regulations. Title 22 § 70855 - Mechanical Systems:

Heating, air conditioning and ventilating systems shall be maintained in operating condition to provide a comfortable temperature and to **meet the new construction requirements** in effect at the time plans were approved for the facility.

Those requirements are found within the **CMC** and are **identical** to the parameters within ASHRAE TABLE 7.1

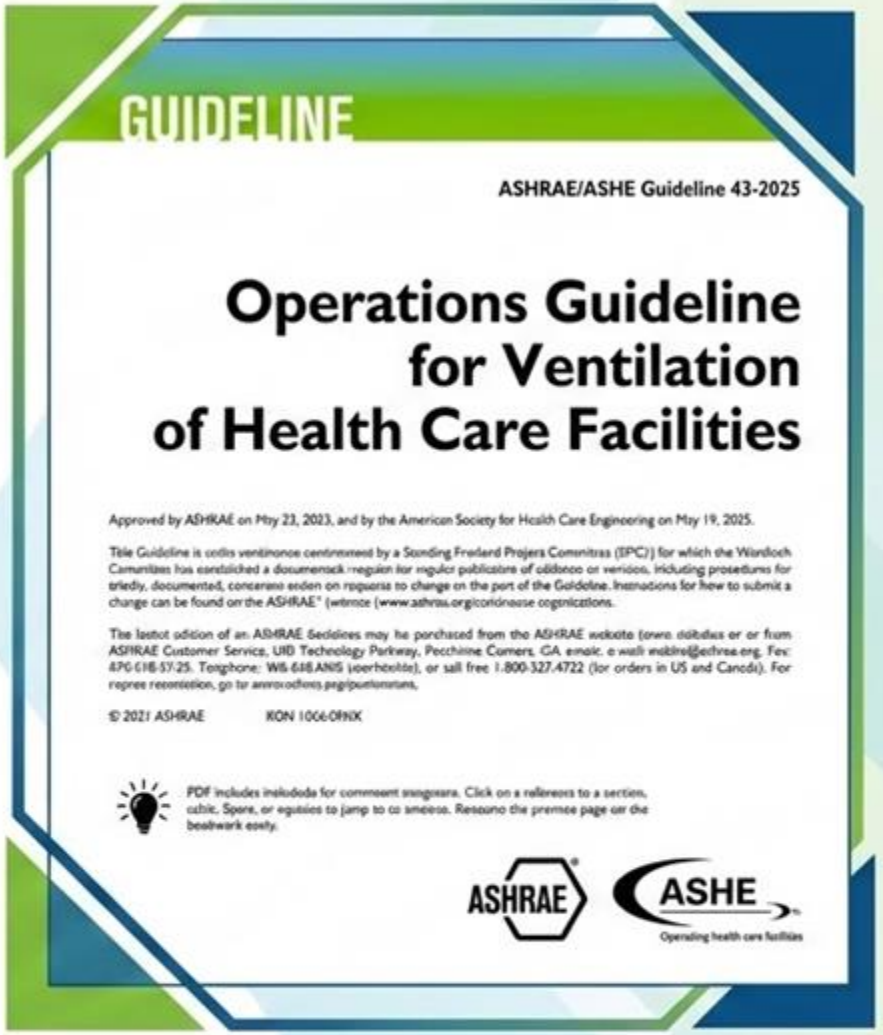
TABLE 4-A

PRESSURE RELATIONSHIP AND VENTILATION REQUIREMENTS FOR GENERAL ACUTE CARE HOSPITALS, SKILLED NURSING FACILITIES, INTERMEDIATE CARE FACILITIES, CORRECTIONAL TREATMENT CENTERS, OUTPATIENT FACILITIES, AND LICENSED CLINICS

FUNCTION OR SPACE	PRESSURE RELATIONSHIP TO ADJACENT AREAS (f) (n)	MINIMUM OUTDOOR ACH	MINIMUM TOTAL ACH	ALL ROOM AIR EXHAUSTED DIRECTLY TO OUTDOORS (j)	AIR RECIRCULATED BY MEANS OF ROOM UNITS (a)	DESIGN RELATIVE HUMIDITY(k), %	DESIGN TEMPERATURE (l),°F/°C
Operating room, *hybrid operating room* (m), (n), (o)	Positive	4	20	NR	No	20-60	68-75/20-24
Operating/surgical cystoscopic room (m), (n), (o)	Positive	4	20	NR	No	20-60	68-75/20-24

ASHRAE 43

Operations Guideline for Ventilation of Health Care Facilities



FORWARD

Health care organizations are challenged to meet a series of ***unclear and sometimes*** conflicting heating, ventilating, and air-conditioning (HVAC) standards and guidelines established by a variety of professional organizations.

Making the situation more difficult is that some standards like ASHRAE/ASHE 170, *Ventilation of Health Care Facilities*, ***are design standards that do not apply to operations*** but are applied as an operational standard by ***authorities having jurisdiction***.

Also complicating the issue is the enforcing of differing versions of the various standards at different instances in the building lifespan.

Infection RISKS associated with low and high RH are covered in the literature and are an <u>area of active research</u>.

In recent years, more research has been published regarding the risks of having the RH below 40% which creates a tighter RH range than the minimum level of 20% currently required by ASHRAE/ASHE Standard 170.

- **The facility is encouraged to evaluate these infection risks in determining the established facility RH range.**



A comprehensive understanding of the etiological profile of SSIs **is imperative** for optimizing therapeutic strategies aimed at reducing their incidence.*

**ASHRAE Technical Committee 9.6, Healthcare Facilities*

ACCORDING TO RECENT CDC LITERATURE



RISK FACTORS:
HIGH HUMIDITY CAN LEAD TO CONDENSATION, COMPROMISING THE STERILITY OF SURGICAL EQUIPMENT.



ENVIRONMENTAL CONTROL:
PROPER HVAC MAINTENANCE AND MONITORING OF TEMP/HUMIDITY IS REQUIRED FOR INFECTION RISK MITIGATION, ESPECIALLY DURING CONSTRUCTION.



TEMPERATURE INTERACTION:
MINOR FLUCTUATIONS DO NOT SIGNIFICANTLY IMPACT INFECTION RATES. PROPER CONTROL REMAINS ESSENTIAL TO PREVENT BACTERIAL INFECTIONS.



RESEARCH INDICATES THAT EVERY 1G/KG INCREASE IN SPECIFIC HUMIDITY RAISES THE ODDS OF SSI BY 3%. WHILE **NO SIGNIFICANT RISK FROM MODERATE FLUCTUATIONS**, MAINTAINING CONTROLLED, **LOWER HUMIDITY (30–60%)** IS RECOMMENDED.



Organizations are encouraged to evaluate infection risks through a **Multidisciplinary Team of SMEs**, in determining the established facility RH range. Considerations include:

- Development of mold and mildew in high-RH air **(over 85%)**
- Shelf life and integrity of sterile supplies and equipment calibration
- Transmission of airborne and droplet diseases
- Survival rate of pathogens
- Decreased effectiveness of hand hygiene and surface cleaning because of surface recontamination
- Discomfort of the surgical team

So even after best efforts, there is **RH drift or deviation** ("HUMIDITY CONTROL EVENTS"). What should we do?



This literature recommends the following **Operating Protocols during Humidity Control Events**

The designated **Multidisciplinary_Team** should **PLAN** for be available to respond to humidity control events and assesses the following:

- Severity and consistency of the RH deviation
- Infection risk to patients of the scheduled procedures
- Level of clinical staff, patient, and support family members' comfort
- Confidence of the facility engineer in a timely resolution
- Occupied or unoccupied status of the perioperative space

POLICIES & PROCEDURES

THE ESTABLISHMENT AND DOCUMENTATION of the facility's ability and methodology to **accurately convey** and **operationalize** **their capabilities and responsibilities** in both normal and emergency situations.

Protocol Triggers

This includes standardized (yet customized) **protocol** for perioperative care areas **when mechanical systems are unable to maintain environmental conditions** within the desired range(s) established by the facility for their specific operations and **protected areas ---**



PROTECTED AREA DEFINITION

In other words, any space where the lack of specific air flow, temperature, relative humidity, and/or pressure relationships could result in harm.

PRACTICAL Contingency Planning

Humidity Control Events in Perioperative Care Areas

ASHRAE

Developed by ASHRAE Technical Committee 9.6, Healthcare Facilities

Procedures should include **Possible Responses** to Humidity Control **Events**.
RISK BASED - Consider extent AND duration of the deviation and FOR EXAMPLE:

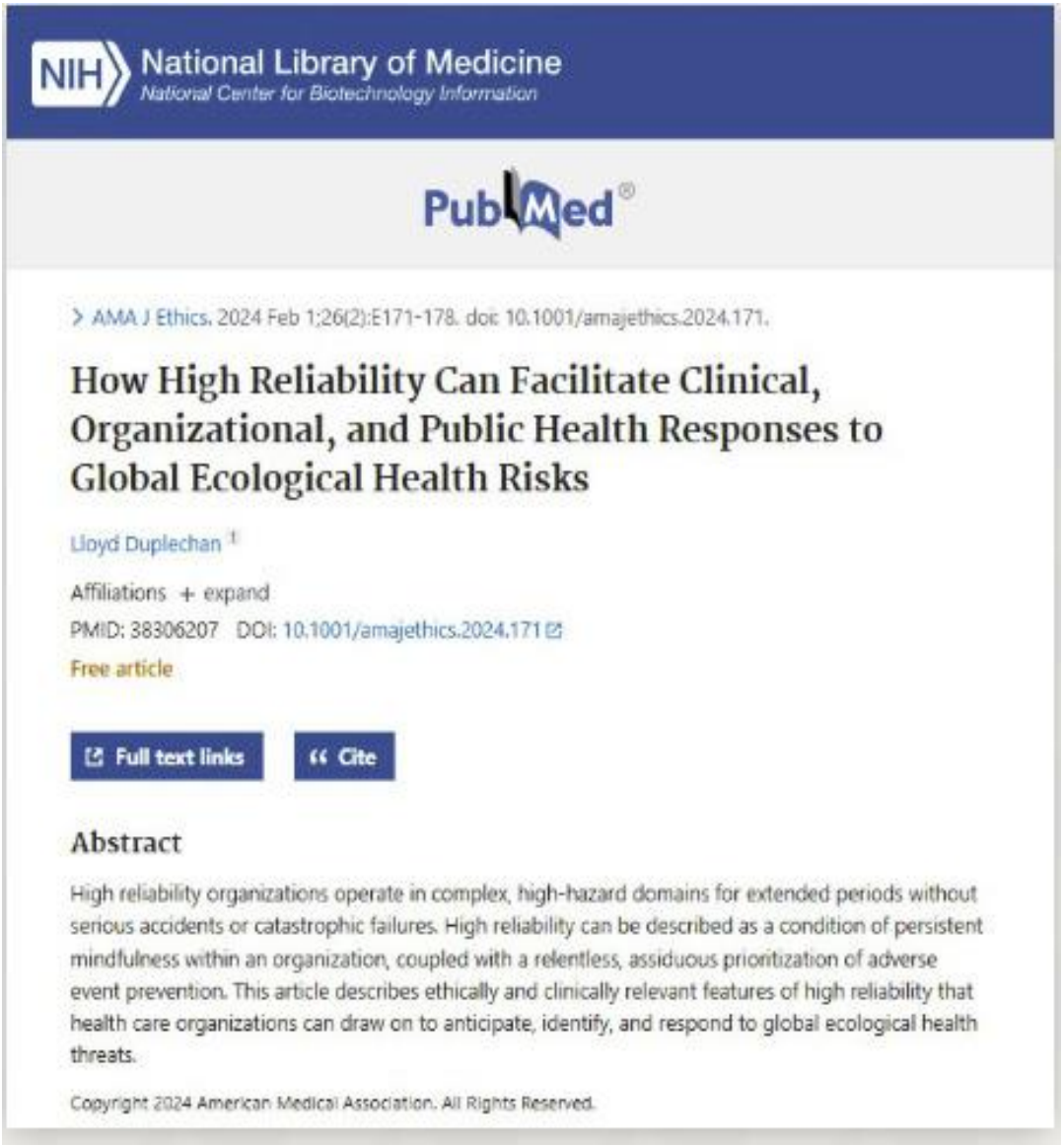
When the **upper RH limit is exceeded**, there are two responses for the TEAM to take:

OPERATING PROTOCOLS DURING HUMIDITY CONTROL EVENTS

- If the RH is up to 5% above the upper RH limit for **over 6 hours**, the facility engineer should take corrective action and adjust the mechanical system to bring the RH down.
- The Team should convene if the RH is out of range for **more than 12 hours**.
- If the RH is up to 5% above the upper RH limit for **more than 24 hours**, the internal Team should consider halting operations for repairs.

ASHRAE

Developed by
ASHRAE Technical Committee 9.6, Healthcare Facilities



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> AMA J Ethics. 2024 Feb 1;26(2):E171-178. doi: 10.1001/amajethics.2024.171.

How High Reliability Can Facilitate Clinical, Organizational, and Public Health Responses to Global Ecological Health Risks

Lloyd Duplechan [1]

Affiliations + expand

PMID: 38306207 DOI: 10.1001/amajethics.2024.171

Free article

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Abstract

High reliability organizations operate in complex, high-hazard domains for extended periods without serious accidents or catastrophic failures. High reliability can be described as a condition of persistent mindfulness within an organization, coupled with a relentless, assiduous prioritization of adverse event prevention. This article describes ethically and clinically relevant features of high reliability that health care organizations can draw on to anticipate, identify, and respond to global ecological health threats.

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Let's not be HASTY or too Quick to go with the simplest approach:

One of the 5 PRINCIPLES of HRO (#3 Reluctance to Simplify)

Novelist Jack Kerouac once said, "***One day I will find the right words, and they will be simple***."

With all due respect to Kerouac's commitment to simplicity and other common principles like the "KISS" method or Occam's Razor (the law of parsimony),

Do not yield to the temptation to quickly oversimplify for the sake of simplicity, speed or convenience.

Some (Engineering) RESPONSE and RECOVERY TACTICS

How do I REMOVE moisture from the AIR??

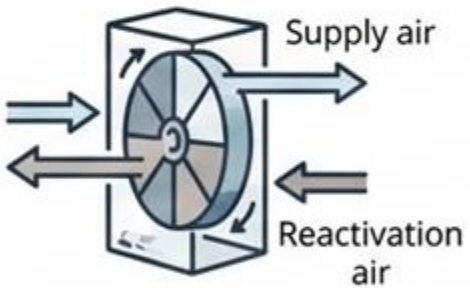
There are two main dehumidification methods that are common in hospitals: using a **low-temperature** chiller or using **desiccants**, materials designed to absorb moisture.

Low-temperature chiller method



- This method uses a chilled-water system to bring the mixture of incoming ventilation air and return air to the correct temperature, usually about 40 degrees.

Desiccant method



- Desiccant dehumidification is accomplished using specialized dehumidifiers containing a desiccant wheel that absorbs and releases moisture. These wheels it air streams, one for supply air and the other for reactivation air

A few CLOSING THOUGHTS

The condition and quality of the ambient air are **not static**

It is important to understand the operations and capabilities of your HVAC system

Avoid using published **Building and Design standards** (by themselves) to establish operational parameters and procedures

Organizations should establish a **multidisciplinary TEAM**

Develop comprehensive policies based on pragmatism and RISK Assessments – **Control the response narrative *responsibly***

Plan and operate with **mutual trust and interdependence**

A Safe OR environment relies on the wide swath of people with complementary EXPERTISE

- ✔ Clinical
- ✔ Epidemiology
- ✔ Infection Prevention
- ✔ EVS/Sanitation
- ✔ Indoor Air Quality (Engineering)
- ✔ Utilities and Equipment



- Clinical
- Epidemiology
- Infection Prevention
- EVS/Sanitation
- Indoor Air Quality (Engineering)
- Utilities and Equipment

When developing a practical set of policies and procedures, consider the following

LAWS and LITERATURE

42 CFR §482.41(c) Standard: Building Safety

PE 04.01.01. EP3 “the hospital has proper ventilation…”



General design requirements



Putting ST 170 into Operational Practice



To manage response actions

Any questions?

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