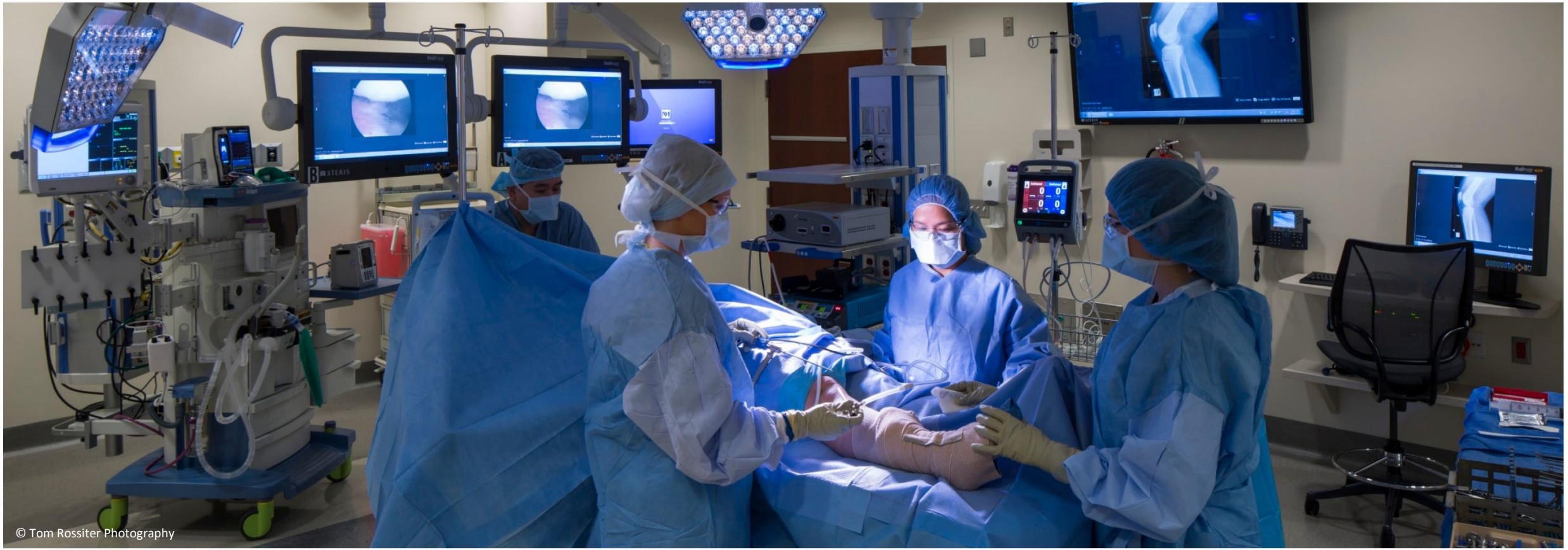
WISCONSIN HEALTHCARE ENGINEERING ASSOCIATION (WHEA)

Operating Room Temperature and Humidity Control



© Tom Rossiter Photography

Webinar: July 12, 2018

Affiliated Engineers

Presenter Introduction

KEVIN OTTE, PE
Mechanical Engineer
608-236-1218
kotte@aeieng.com

ABHISHEK AJANSONDKAR
Mechanical Engineer
608-236-1236
aajansondkar@aeieng.com

Agenda

Why do we care about OR temperature and humidity control?

How do we meet OR temperature and humidity requirements?

How do we control OR temperature and humidity?

How can we save energy and operational costs while maintaining OR temperature and humidity?

Why do we care about OR temperature and humidity control?

Why do we care about OR temperature and humidity control?

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

SPS 364.0300 Health care facilities. (1) This is a department rule in addition to the requirements in IMC chapter 3: In addition to the requirements in this code, the heating and ventilation systems for health care facilities only shall conform to the applicable provisions of The Facility Guidelines Institute (FGI) Guidelines for Design and Construction of Health Care Facilities, except as provided in sub. (2).

Note: The Guidelines for Design and Construction of Health Care Facilities are not intended for use in the design or construction of HVAC systems for other types of institutional health care facilities including community–based residential facilities (CBRFs) or residential care apartment complexes (RCACs).

(2) (a) The requirements in parts 1 and 5 of FGI guidelines are not included as part of this chapter.

(b) This is a department rule in addition to the requirements in part 6 of the FGI guidelines: Addenda a, b, d, e and f for ASHRAE 170 are included as part of this chapter, except as provided in sub. 2.

(c) Substitute the following definition for the corresponding definition listed in ASHRAE 170 section 3: "Alteration", has the meaning as given in IEBC section 202.

Note: IEBC section 202 defines "alteration" as "any construction or renovation to an existing structure other than a *repair* or *addition*. Alterations are classified as Level 1, Level 2, and Level 3".

History: CR 06–120: cr. Register February 2008 No. 626, eff. 3–1–08; CR 10–103: renum. to (1), cr. (2) Register August 2011 No. 668, eff. 9–1–11.

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

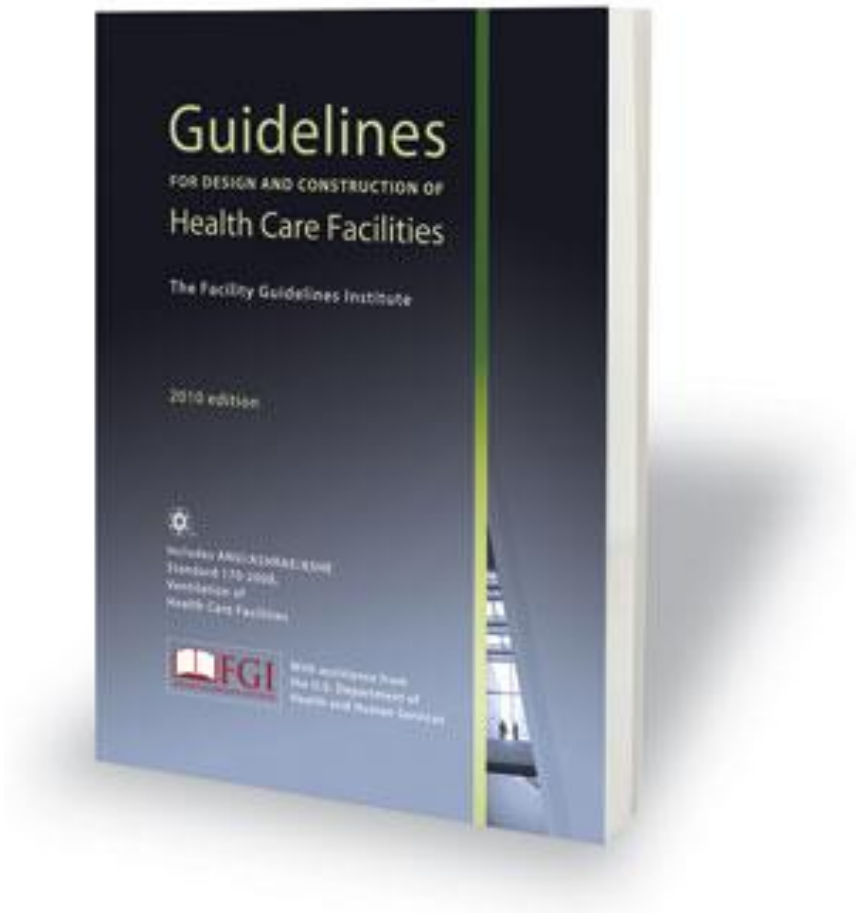
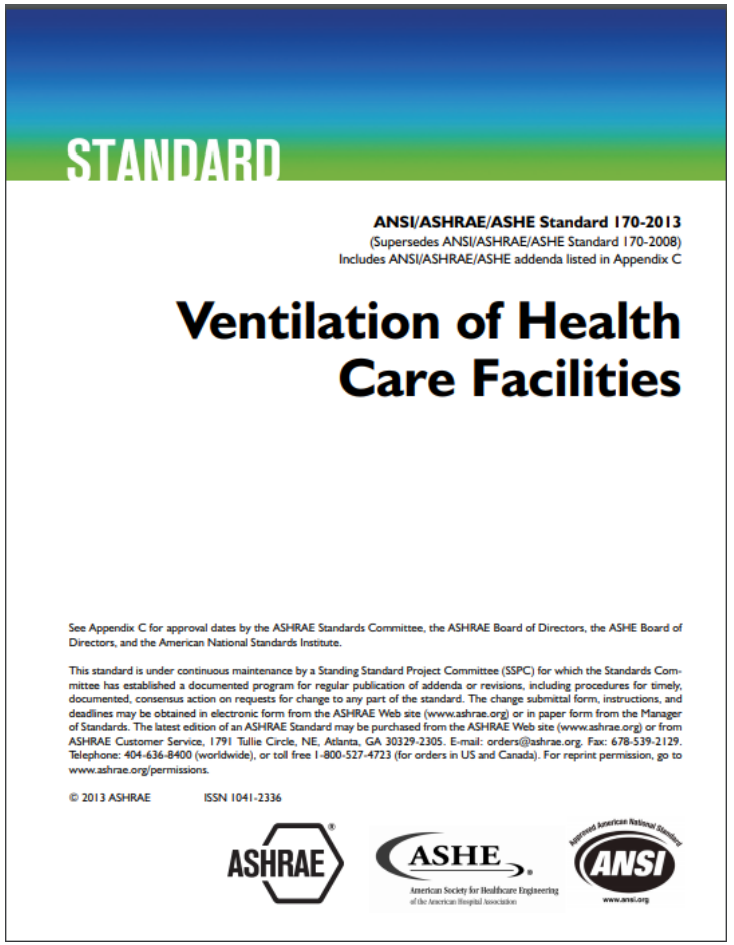


Image Source: Facilities Guidelines Institute (FGI)

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?



STANDARD

ANSI/ASHRAE/ASHE Standard 170-2013
(Supersedes ANSI/ASHRAE/ASHE Standard 170-2008)
Includes ANSI/ASHRAE/ASHE addenda listed in Appendix C

Ventilation of Health Care Facilities

See Appendix C for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the ASHE Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site (www.ashrae.org) or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE Web site (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1041-2336

ASHRAE ASHE American Society for Healthcare Engineering of the American Hospital Association ANSI www.ansi.org

Image Source: ASHRAE

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

ASHRAE 170-2013 Space Design Parameters Table 7.1:

TABLE 7.1 Design Parameters

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							
Operating room (Class B and C) (m), (n), (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Operating/surgical cystoscopic rooms, (m), (n) (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Delivery room (Caesarean) (m), (n), (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Substerile service area	NR	2	6	NR	No	NR	NR
Recovery room	NR	2	6	NR	No	20–60	70–75/21–24
Critical and intensive care	NR	2	6	NR	No	30–60	70–75/21–24
Intermediate care (s)	NR	2	6	NR	NR	max 60	70–75/21–24
Wound intensive care (burn unit)	NR	2	6	NR	No	40–60	70–75/21–24
Newborn intensive care	Positive	2	6	NR	No	30–60	72–78/22–26
Treatment room (p)	NR	2	6	NR	NR	20–60	70–75/21–24
Trauma room (crisis or shock) (c)	Positive	3	15	NR	No	20–60	70–75/21–24
Medical/anesthesia gas storage (r)	Negative	NR	8	Yes	NR	NR	NR

Image Source: ASHRAE 170-2013

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

ASHRAE 170-2013 Design Parameters for OR's:

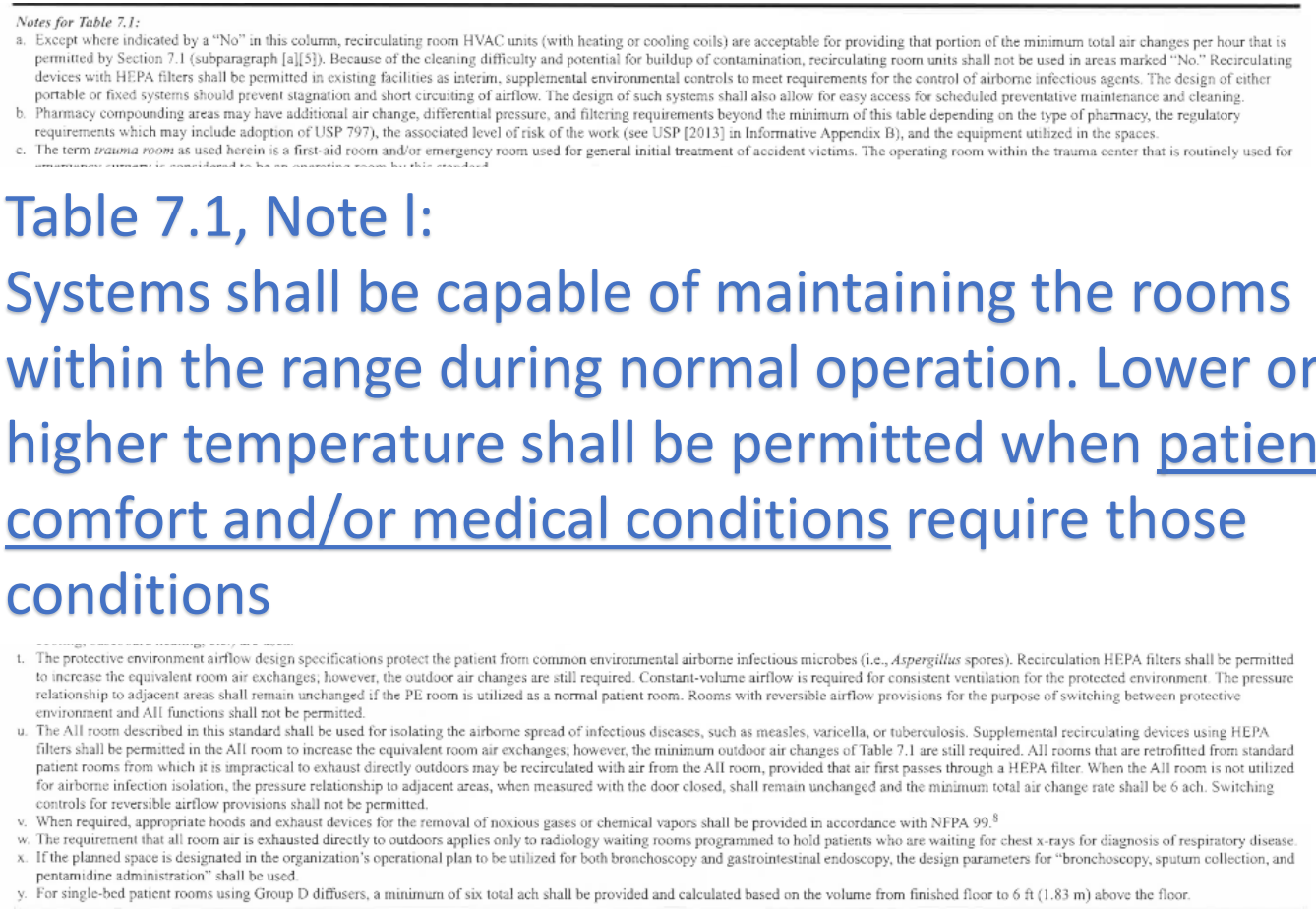
68°F - 75°F

20% - 60% RH

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

ASHRAE 170-2013 Space Design Parameters Table 7.1:



Notes for Table 7.1:

a. Except where indicated by a "No" in this column, recirculating room HVAC units (with heating or cooling coils) are acceptable for providing that portion of the minimum total air changes per hour that is permitted by Section 7.1 (subparagraph [a][5]). Because of the cleaning difficulty and potential for buildup of contamination, recirculating room units shall not be used in areas marked "No." Recirculating devices with HEPA filters shall be permitted in existing facilities as interim, supplemental environmental controls to meet requirements for the control of airborne infectious agents. The design of either portable or fixed systems should prevent stagnation and short circuiting of airflow. The design of such systems shall also allow for easy access for scheduled preventative maintenance and cleaning.

b. Pharmacy compounding areas may have additional air change, differential pressure, and filtering requirements beyond the minimum of this table depending on the type of pharmacy, the regulatory requirements which may include adoption of USP 797), the associated level of risk of the work (see USP [2013] in Informative Appendix B), and the equipment utilized in the spaces.

c. The term *trauma room* as used herein is a first-aid room and/or emergency room used for general initial treatment of accident victims. The operating room within the trauma center that is routinely used for

t. The protective environment airflow design specifications protect the patient from common environmental airborne infectious microbes (i.e., *Aspergillus* spores). Recirculation HEPA filters shall be permitted to increase the equivalent room air exchanges; however, the outdoor air changes are still required. Constant-volume airflow is required for consistent ventilation for the protected environment. The pressure relationship to adjacent areas shall remain unchanged if the PE room is utilized as a normal patient room. Rooms with reversible airflow provisions for the purpose of switching between protective environment and AII functions shall not be permitted.

u. The AII room described in this standard shall be used for isolating the airborne spread of infectious diseases, such as measles, varicella, or tuberculosis. Supplemental recirculating devices using HEPA filters shall be permitted in the AII room to increase the equivalent room air exchanges; however, the minimum outdoor air changes of Table 7.1 are still required. All rooms that are retrofitted from standard patient rooms from which it is impractical to exhaust directly outdoors may be recirculated with air from the AII room, provided that air first passes through a HEPA filter. When the AII room is not utilized for airborne infection isolation, the pressure relationship to adjacent areas, when measured with the door closed, shall remain unchanged and the minimum total air change rate shall be 6 ach. Switching controls for reversible airflow provisions shall not be permitted.

v. When required, appropriate hoods and exhaust devices for the removal of noxious gases or chemical vapors shall be provided in accordance with NFPA 99.[8]

w. The requirement that all room air is exhausted directly to outdoors applies only to radiology waiting rooms programmed to hold patients who are waiting for chest x-rays for diagnosis of respiratory disease.

x. If the planned space is designated in the organization's operational plan to be utilized for both bronchoscopy and gastrointestinal endoscopy, the design parameters for "bronchoscopy, sputum collection, and pentamidine administration" shall be used.

y. For single-bed patient rooms using Group D diffusers, a minimum of six total ach shall be provided and calculated based on the volume from finished floor to 6 ft (1.83 m) above the floor.

Table 7.1, Note l:

Systems shall be capable of maintaining the rooms within the range during normal operation. Lower or higher temperature shall be permitted when patient comfort and/or medical conditions require those conditions

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

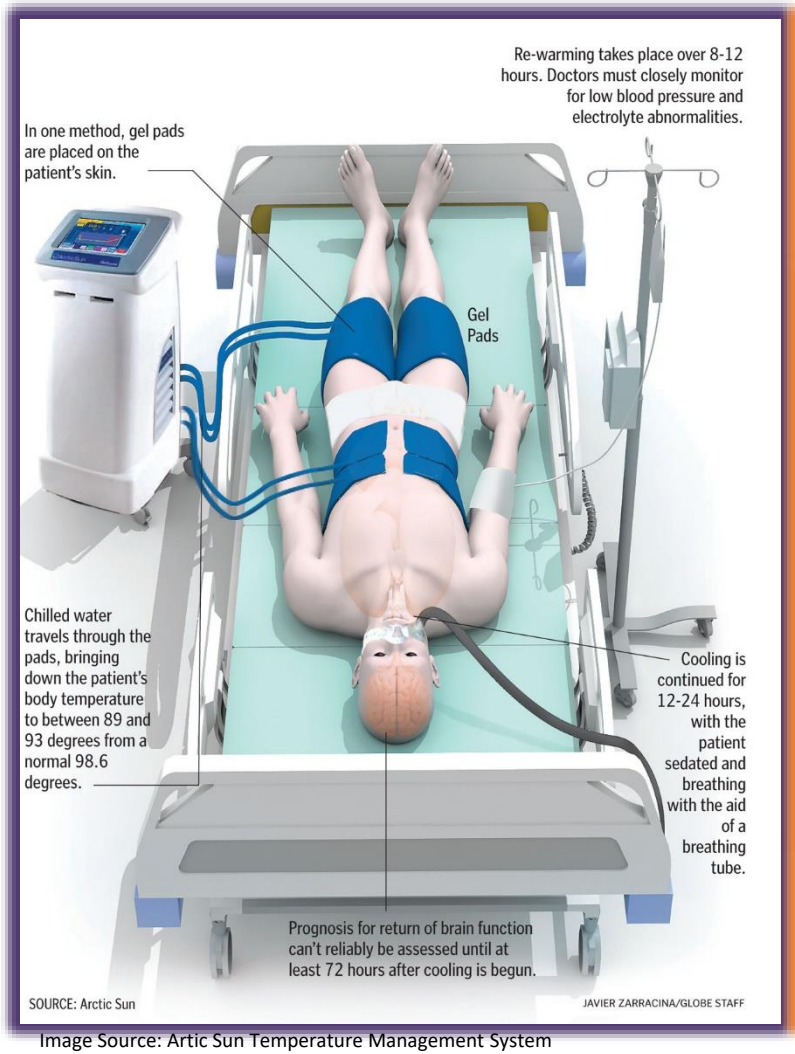


Image Source: Artic Sun Temperature Management System

Image Source: IOB Medical

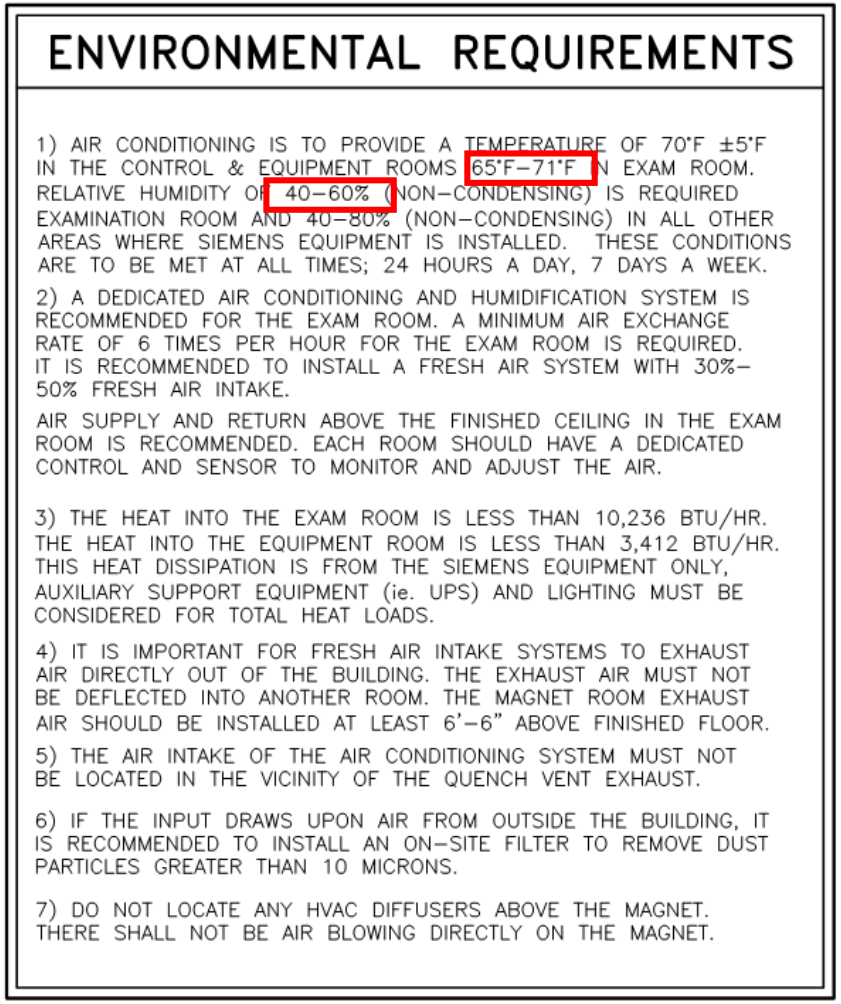
- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

Image Source: Affiliated Engineers, Inc.

- Code Requirements
- Surgical Procedure Requirements
- **Equipment Requirements**
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?



ENVIRONMENTAL REQUIREMENTS

1) AIR CONDITIONING IS TO PROVIDE A TEMPERATURE OF 70°F ±5°F IN THE CONTROL & EQUIPMENT ROOMS 65°F–71°F IN EXAM ROOM. RELATIVE HUMIDITY OF 40–60% (NON–CONDENSING) IS REQUIRED EXAMINATION ROOM AND 40–80% (NON–CONDENSING) IN ALL OTHER AREAS WHERE SIEMENS EQUIPMENT IS INSTALLED. THESE CONDITIONS ARE TO BE MET AT ALL TIMES; 24 HOURS A DAY, 7 DAYS A WEEK.

2) A DEDICATED AIR CONDITIONING AND HUMIDIFICATION SYSTEM IS RECOMMENDED FOR THE EXAM ROOM. A MINIMUM AIR EXCHANGE RATE OF 6 TIMES PER HOUR FOR THE EXAM ROOM IS REQUIRED. IT IS RECOMMENDED TO INSTALL A FRESH AIR SYSTEM WITH 30%–50% FRESH AIR INTAKE.

AIR SUPPLY AND RETURN ABOVE THE FINISHED CEILING IN THE EXAM ROOM IS RECOMMENDED. EACH ROOM SHOULD HAVE A DEDICATED CONTROL AND SENSOR TO MONITOR AND ADJUST THE AIR.

3) THE HEAT INTO THE EXAM ROOM IS LESS THAN 10,236 BTU/HR. THE HEAT INTO THE EQUIPMENT ROOM IS LESS THAN 3,412 BTU/HR. THIS HEAT DISSIPATION IS FROM THE SIEMENS EQUIPMENT ONLY, AUXILIARY SUPPORT EQUIPMENT (ie. UPS) AND LIGHTING MUST BE CONSIDERED FOR TOTAL HEAT LOADS.

4) IT IS IMPORTANT FOR FRESH AIR INTAKE SYSTEMS TO EXHAUST AIR DIRECTLY OUT OF THE BUILDING. THE EXHAUST AIR MUST NOT BE DEFLECTED INTO ANOTHER ROOM. THE MAGNET ROOM EXHAUST AIR SHOULD BE INSTALLED AT LEAST 6'–6" ABOVE FINISHED FLOOR.

5) THE AIR INTAKE OF THE AIR CONDITIONING SYSTEM MUST NOT BE LOCATED IN THE VICINITY OF THE QUENCH VENT EXHAUST.

6) IF THE INPUT DRAWS UPON AIR FROM OUTSIDE THE BUILDING, IT IS RECOMMENDED TO INSTALL AN ON–SITE FILTER TO REMOVE DUST PARTICLES GREATER THAN 10 MICRONS.

7) DO NOT LOCATE ANY HVAC DIFFUSERS ABOVE THE MAGNET. THERE SHALL NOT BE AIR BLOWING DIRECTLY ON THE MAGNET.

Image Source: Siemens Healthcare

Equipment Requirements:

65°F - 71°F

40% - 60% RH

ASHRAE 170 Requirements:

68°F - 75°F

20% - 60% RH

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

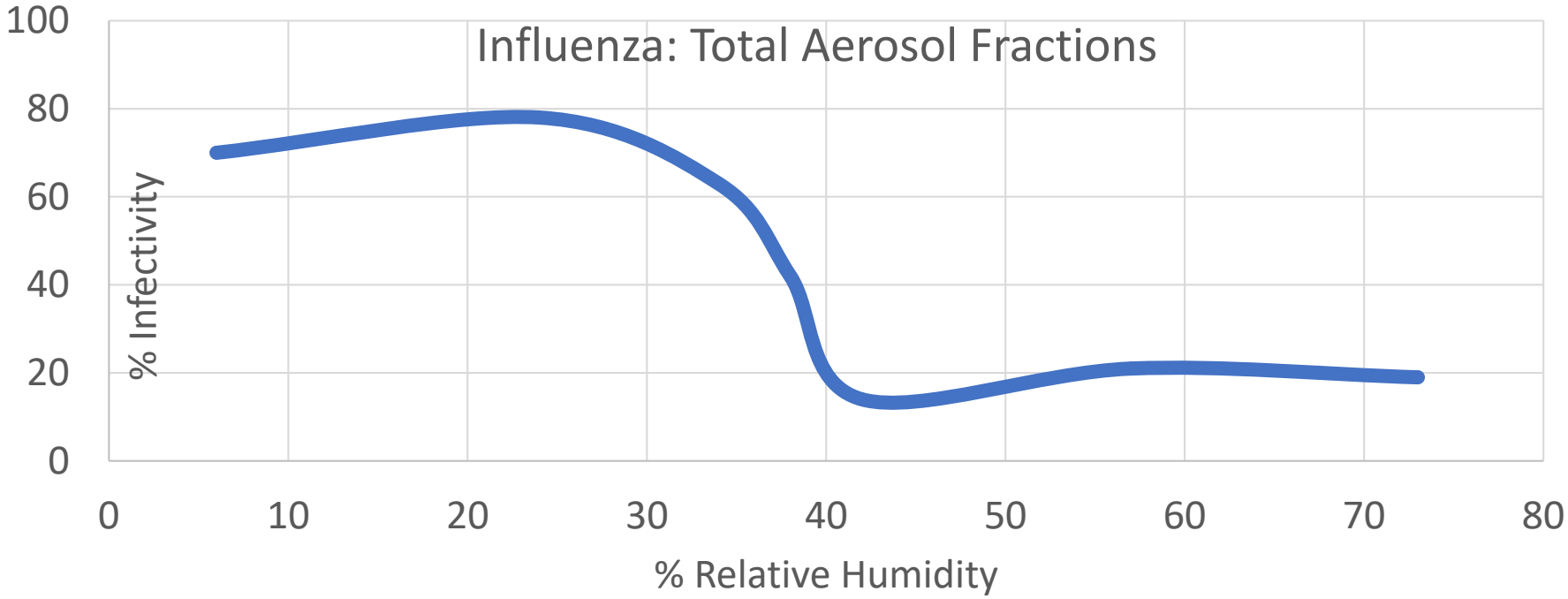
- Most common type of HAI: Pneumonia and surgical site infection (SSI)

Major Site of Infection	Estimated No.
Pneumonia	157,500
Gastrointestinal Illness	123,100
Urinary Tract Infections	93,300
Primary Bloodstream Infections	71,900
Surgical site infections from any inpatient surgery	157,500
Other types of infections	118,500
Estimated total number of infections in hospitals	**721,800**

- Direct costs associated with HAI: $28.4-$45 Billion (Scott, CDC Paper, 2012)

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?



SOURCE: NOTI J, ET AL. HIGH HUMIDITY LEADS TO LOSS OF INFECTIOUS INFLUENZA VIRUS FROM SIMULATED COUGHS

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

- Surgeon discomfort is an infection risk
  - Sweating
  - Exasperation
  - Concentration

Illustration © Affiliated Engineers, Inc.

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

Why do we care about OR temperature and humidity control?

Illustration © Affiliated Engineers, Inc.

Per ASHRAE 170, Table 7.1, note (o):

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

- Code Requirements
- Surgical Procedure Requirements
- Equipment Requirements
- Infection Control
- Surgeon Comfort

How do we meet OR temperature and humidity requirements?

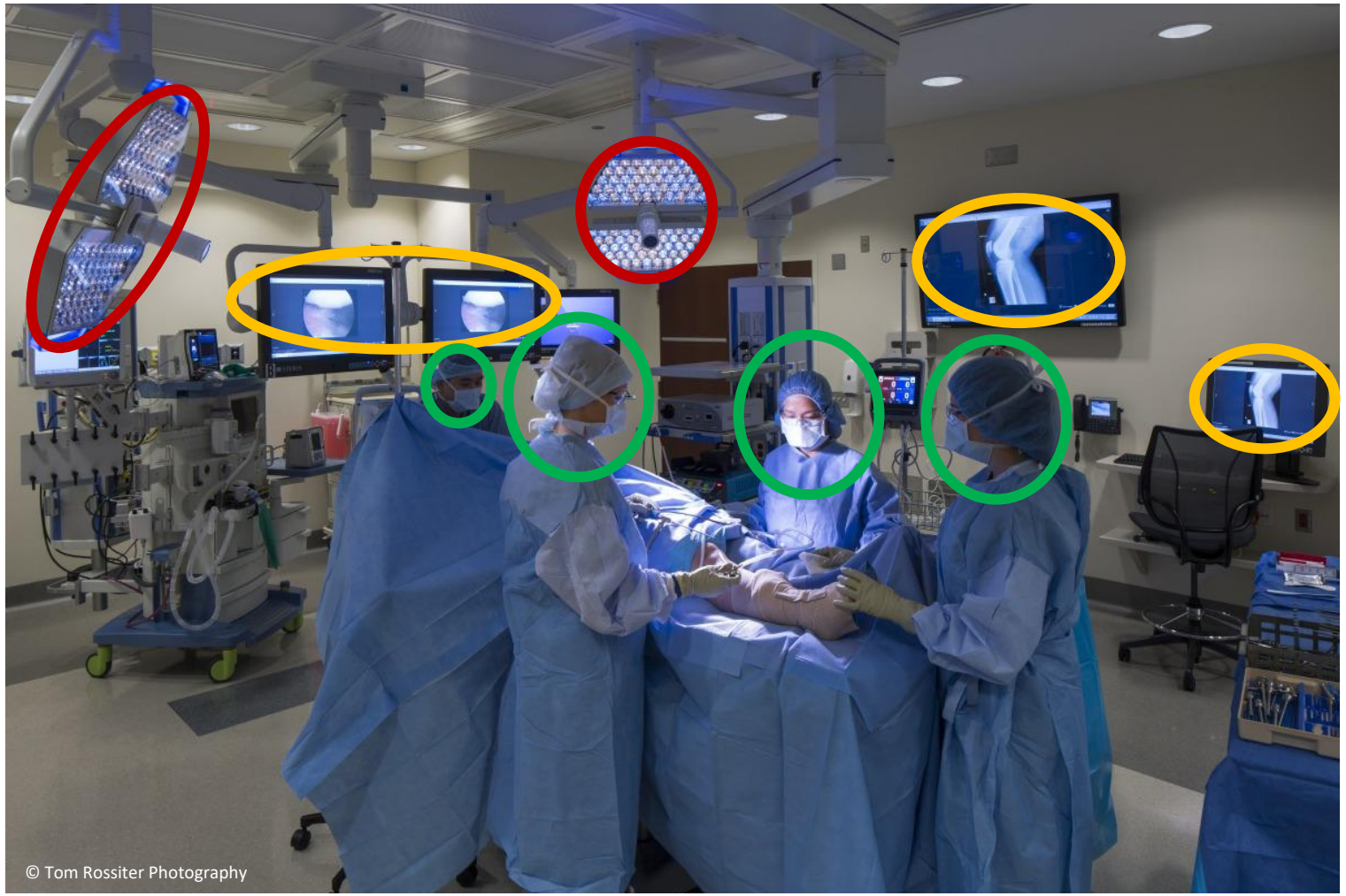
How do we meet OR temperature and humidity requirements?

Sources of Heat

- Occupants
- Lights
- Equipment

Sources of Humidity

- Occupants



Example Hospital

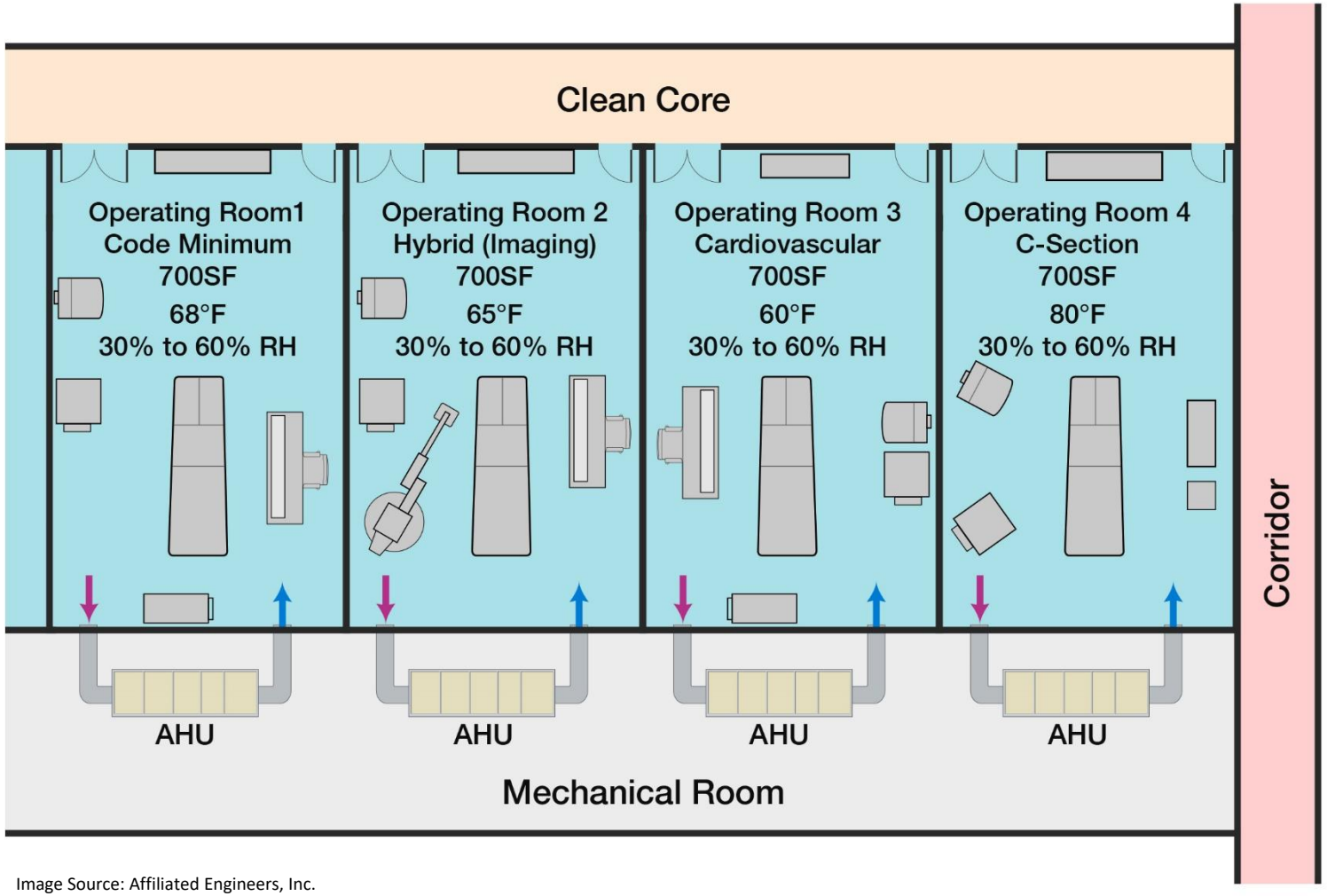


Image Source: Affiliated Engineers, Inc.

10’-0” Ceilings

10 People

2 W/SF Lighting

12 W/SF Equipment

42°F Chilled Water

10 psi Low Pressure Steam

160°F Heating Hot Water

Standard Operating Room

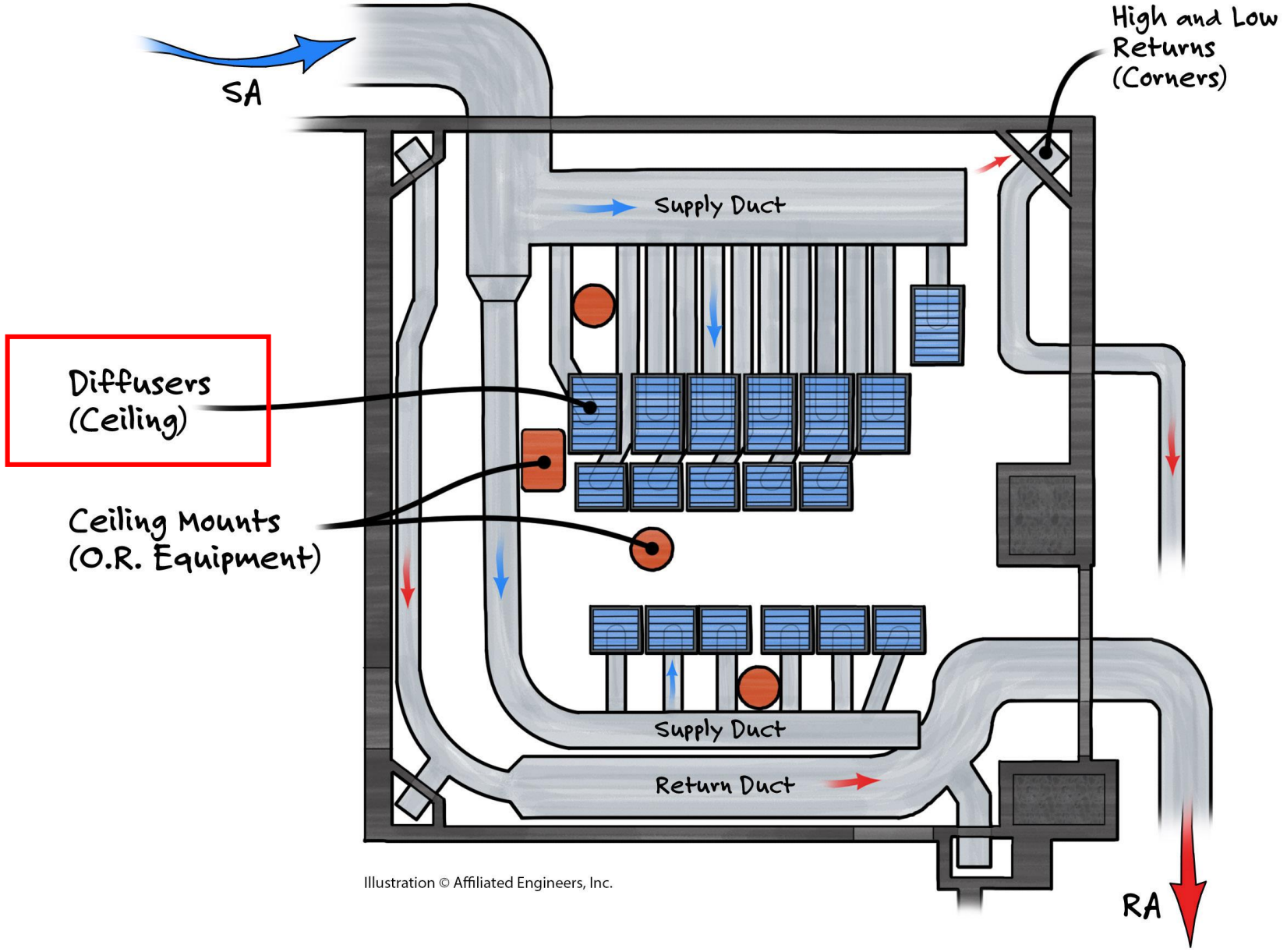
68°F and 30% to 60%RH

Standard OR
University of Colorado Health, Longs Peak Hospital

Image Source: Affiliated Engineers, Inc.

What is your primary means of maintaining temperature in an operating room?

Typical OR Ceiling



Standard Operating Room 68°F, 30%-60% RH

- Cooling Airflow Required:
  - Sensible load: 31,500 BTU/H
  - Load=1.085xCFMx(68°F– 55°F) [50°F Leaving the Cooling Coil + Fan Heat]
  - Room Airflow=2,200 CFM → Does not meet FGI requirements!

TABLE 7-1 Design Parameters

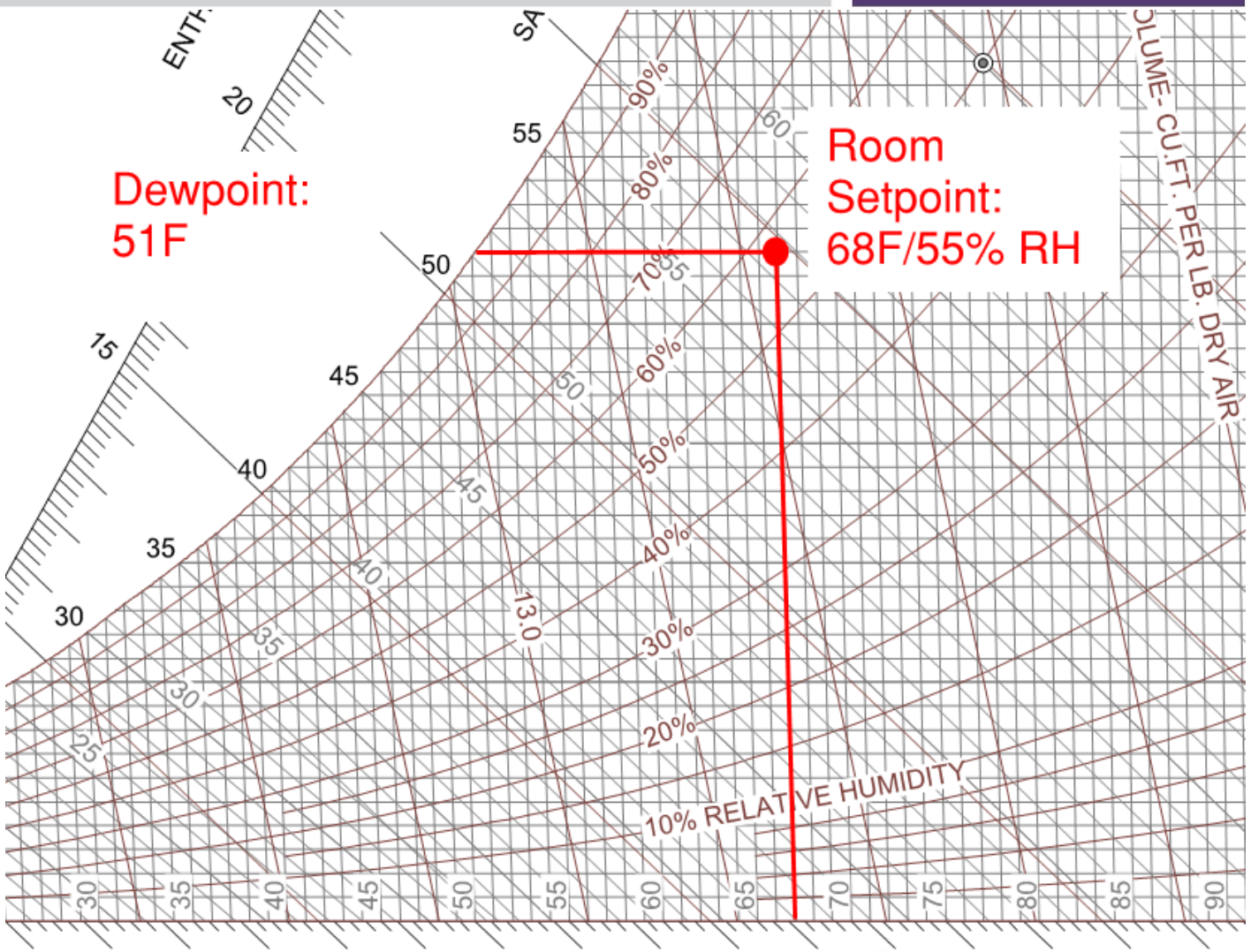
Function of Space	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	RH (k), %	Design Temperature (l), °F/°C
SURGERY AND CRITICAL CARE							
Classes B and C operating rooms, (m), (n), (o)	Positive	4	20	N/R	No	30–60	68–75/20–24

- Code Required Airflow:
  - 700x10x20/60 = 2,400 CFM

- Sources of Heat and Humidity
- Standard OR
- Hybrid Imaging OR
- Cardiovascular OR
- C-Section OR

Standard Operating Room - Psychrometrics

- Cooling coil leaving air dewpoint must be less than 51°F



Hybrid (Imaging) Operating Room

65°F and 30% to 60%RH

Hybrid OR
Houston Methodist Hospital, Walter Tower

Image Source: Affiliated Engineers, Inc.

Hybrid Imaging OR

65°F, 30%-60% RH

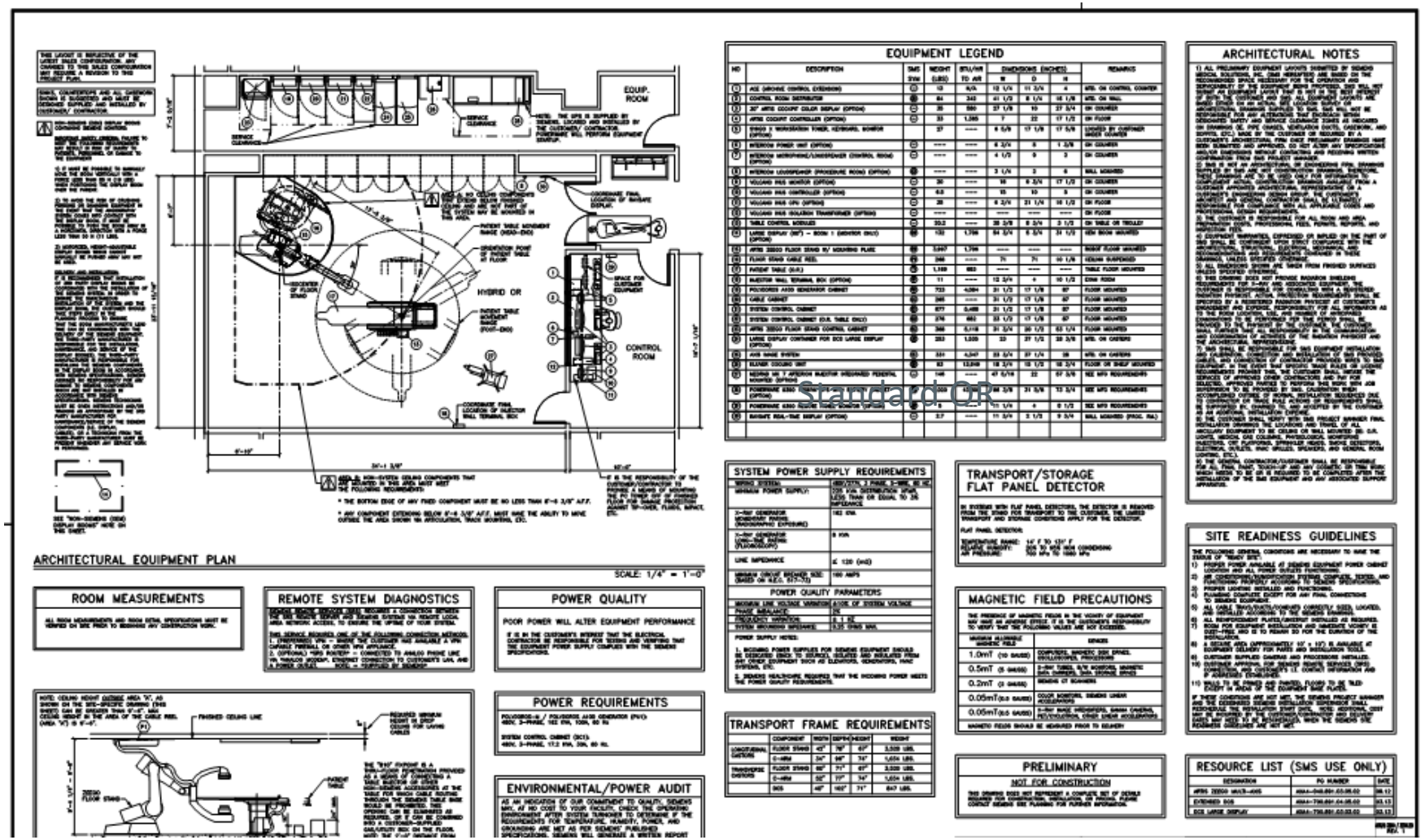


Image Source: Siemens Hybrid OR

- Sources of Heat and Humidity
- Standard OR
- Hybrid Imaging OR
- Cardiovascular OR
- C-Section OR

EQUIPMENT LEGEND

NO	DESCRIPTION	SMS SYM	WEIGHT (LBS)	BTU/HR TO AIR	DIMENSIONS (INCHES) W	D	H	REMARKS
1	ACE (ARCHIVE CONTROL EXTENSION)		13	N/A	12 1/4	11 3/4	4	MTD. ON CONTROL COUNTER
2	CONTROL ROOM DISTRIBUTOR	CR	64	342	41 1/2	8 1/4	16 1/8	MTD. ON WALL
3	30" ARTIS COCKPIT COLOR DISPLAY (OPTION)		35	580	27 1/8	10	27 3/4	ON COUNTER
4	ARTIS COCKPIT CONTROLLER (OPTION)		33	1,365	7	22	17 1/2	ON FLOOR
5	SYNGO X WORKSTATION TOWER, KEYBOARD, MONITOR (OPTION)		27	---	6 5/8	17 1/8	17 5/8	LOCATED BY CUSTOMER UNDER COUNTER
6	INTERCOM POWER UNIT (OPTION)		---	---	6 3/4	5	1 3/8	ON COUNTER
7	INTERCOM MICROPHONE/LOUDSPEAKER (CONTROL ROOM) (OPTION)		---	---	4 1/2	9	2	ON COUNTER
8	INTERCOM LOUDSPEAKER (PROCEDURE ROOM) (OPTION)	PZ	---	---	3 1/4	2	6	WALL MOUNTED
9	VOLCANO IVUS MONITOR (OPTION)		20	---	16	9 3/4	17 1/2	ON COUNTER
10	VOLCANO IVUS CONTROLLER (OPTION)		6.5	---	15	10	5	ON COUNTER
11	VOLCANO IVUS CPU (OPTION)		35	---	6 3/4	21 1/4	16 1/2	ON FLOOR
12	VOLCANO IVUS ISOLATION TRANSFORMER (OPTION)		---	---	---	---	---	ON FLOOR
13	TABLE CONTROL MODULES		20.2	---	35 3/8	8 3/4	3 1/2	ON TABLE OR TROLLEY
14	LARGE DISPLAY (60") – BOOM 1 (MONITOR ONLY) (OPTION)	D1	132	1,706	54 3/4	5 3/4	31 1/2	OEM BOOM MOUNTED
15	ARTIS ZEEGO FLOOR STAND W/ MOUNTING PLATE	R1	3,997	1,706	---	---	---	ROBOT FLOOR MOUNTED
16	FLOOR STAND CABLE REEL	P1	268	---	71	71	10 1/8	CEILING SUSPENDED
17	PATIENT TABLE (O.R.)	T1	1,169	683	---	---	---	TABLE FLOOR MOUNTED
18	INJECTOR WALL TERMINAL BOX (OPTION)	IW	11	---	12 3/4	4	10 1/2	EXAM ROOM
19	POLYDOROS A100 GENERATOR CABINET	PU	723	4,094	31 1/2	17 1/8	87	FLOOR MOUNTED
20	CABLE CABINET	CC	265	---	31 1/2	17 1/8	87	FLOOR MOUNTED
21	SYSTEM CONTROL CABINET	SC1	677	5,460	31 1/2	17 1/8	87	FLOOR MOUNTED
22	SYSTEM CONTROL CABINET (O.R. TABLE ONLY)	SC2	276	682	23 1/2	17 1/8	87	FLOOR MOUNTED
23	ARTIS ZEEGO FLOOR STAND CONTROL CABINET	RC	368	5,118	31 3/4	20 1/2	53 1/4	FLOOR MOUNTED
24	LARGE DISPLAY CONTAINER FOR DCS LARGE DISPLAY (OPTION)	DC	253	1,535	23	37 1/2	28 3/8	MTD. ON CASTERS
25	AXIS IMAGE SYSTEM	S	331	4,347	23 3/4	37 1/4	28	MTD. ON CASTERS
26	KLUVER COOLING UNIT	CU	93	13,649	18 3/4	15 1/2	18 3/4	FLOOR OR SHELF MOUNTED
27	MEDRAD MK 7 ARTERION INJECTOR INTEGRATED PEDESTAL MOUNTED (OPTION)		146	---	47 5/16	22	57 3/8	SEE MFG REQUIREMENTS
28	POWERWARE 9390 160KVA UPS WITH BATTERY CABINET (OPTION)	UPS	5,020	43,800	86 3/8	31 5/8	73 3/4	SEE MFG REQUIREMENTS
29	POWERWARE 9390 REMOTE PANEL MONITOR (OPTION)	RP	5	---	11 1/4	4	8 1/2	SEE MFG REQUIREMENTS
30	RAYSAFE REAL-TIME DISPLAY (OPTION)		2.7	---	11 3/4	2 1/2	9 3/4	WALL MOUNTED (PROC. RM.)

Image Source: Siemens Hybrid OR

- Sources of Heat and Humidity
- Standard OR
- Hybrid Imaging OR
- Cardiovascular OR
- C-Section OR

Hybrid Imaging OR

65°F, 30%-60% RH

- Cooling Airflow Required:
  - Sensible load: 50,000 BTU/H
  - Load=1.085xCFMx(65°F– 52°F) [47°F Leaving the Cooling Coil + Fan Heat]
  - Room Airflow=3,600 CFM → 25 ACH → More than FGI requirements!

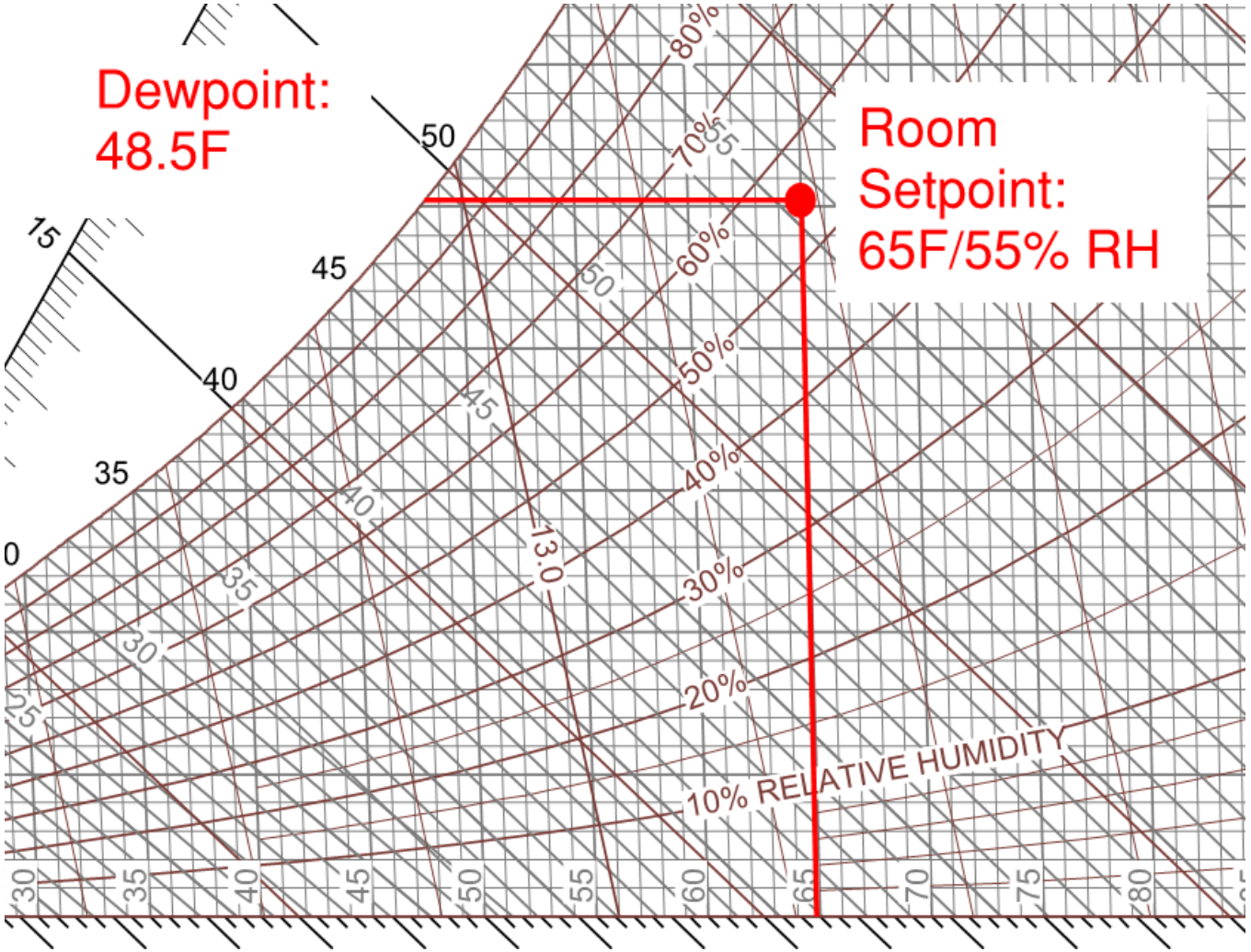
TABLE 7-1 Design Parameters

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)	RH (k), %	Design Temperature (l), °F/°C
SURGERY AND CRITICAL CARE							
Classes B and C operating rooms, (m), (n), (o)	Positive	4	20	N/R	No	30–60	68–75/20–24

- Code Required Airflow:
  - 700x10x20/60 = 2,400 CFM

Hybrid Imaging OR

- Cooling coil leaving air dewpoint must be less than 48°F



Cardiovascular (Low Temperature) Operating Room

60°F and 30% to 60%RH

Cardio OR
Houston Methodist Hospital, Walter Tower

Image Source: Affiliated Engineers, Inc.

Cardiovascular OR

60°F, 30%-60% RH

- Cooling Airflow Required:
  - Sensible load: 45,000 BTU/H
  - Load=1.085xCFMx(60°F– 48°F)[37°F Leaving Cooling Coil +Reheat+ Fan Heat]
  - Room Airflow=3,400 CFM → 25 ACH → More than FGI requirements!
- Requires low temperature chilled water to hit space dew point condition

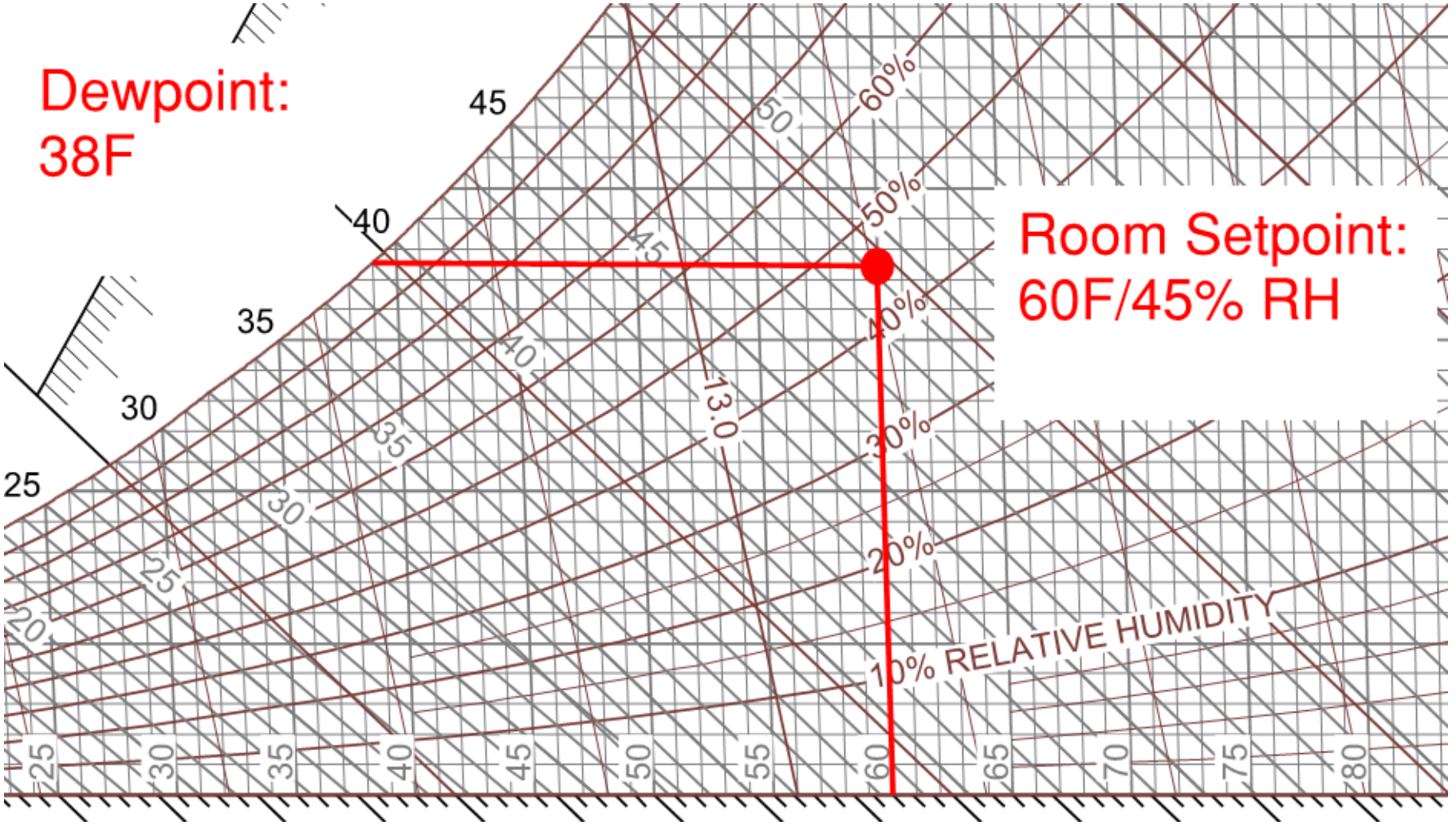
TABLE 7-1 Design Parameters

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)	RH (k), %	Design Temperature (l), °F/°C
SURGERY AND CRITICAL CARE							
Classes B and C operating rooms, (m), (n), (o)	Positive	4	20	N/R	No	30–60	68–75/20–24

- Code Required Airflow:
  - 700x10x20/60 = 2,400 CFM

Cardiovascular OR

- Cooling coil leaving air dewpoint must be less than 38°F



Cardiovascular OR

60°F, 30%-60% RH

Methods to address the strict dehumidification requirement will be addressed in the next section of the presentation

- Sources of Heat and Humidity
- Standard OR
- Hybrid Imaging OR
- Cardiovascular OR
- C-Section OR

C-Section Operating Room

80°F and 30% to 60%RH

C-Section OR
UnityPoint Health-Meriter

C-Section OR

80°F, 30%-60% RH

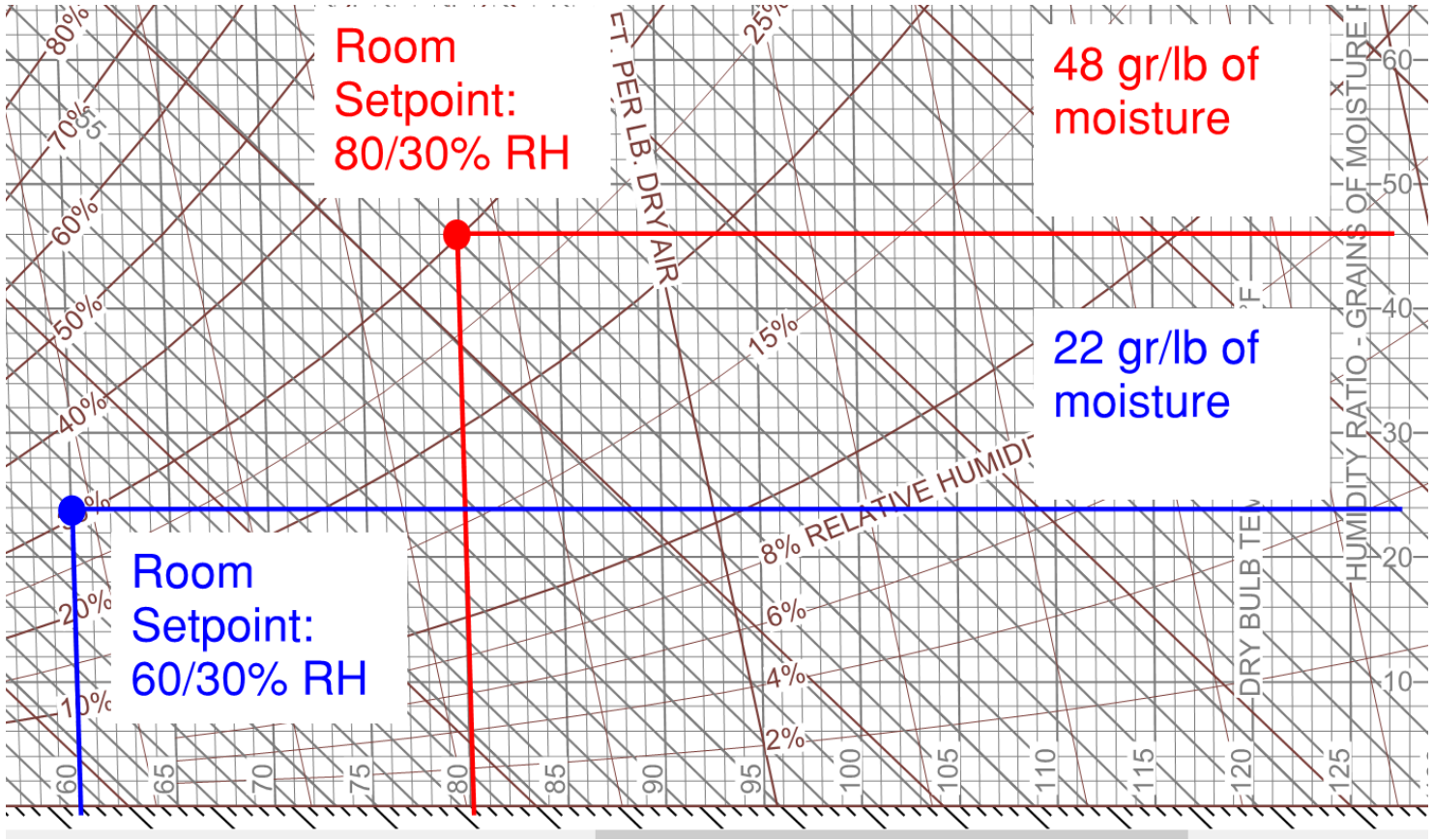
Design Considerations in a C-Section (High Temperature) OR:

- Heating Setpoint
- Response time in heating the OR
- Steam heating coils vs. hot water coils
- Humidification

C-Section OR

80°F, 30%-60% RH

Rooms at higher setpoints will require more humidified air delivered to the space:



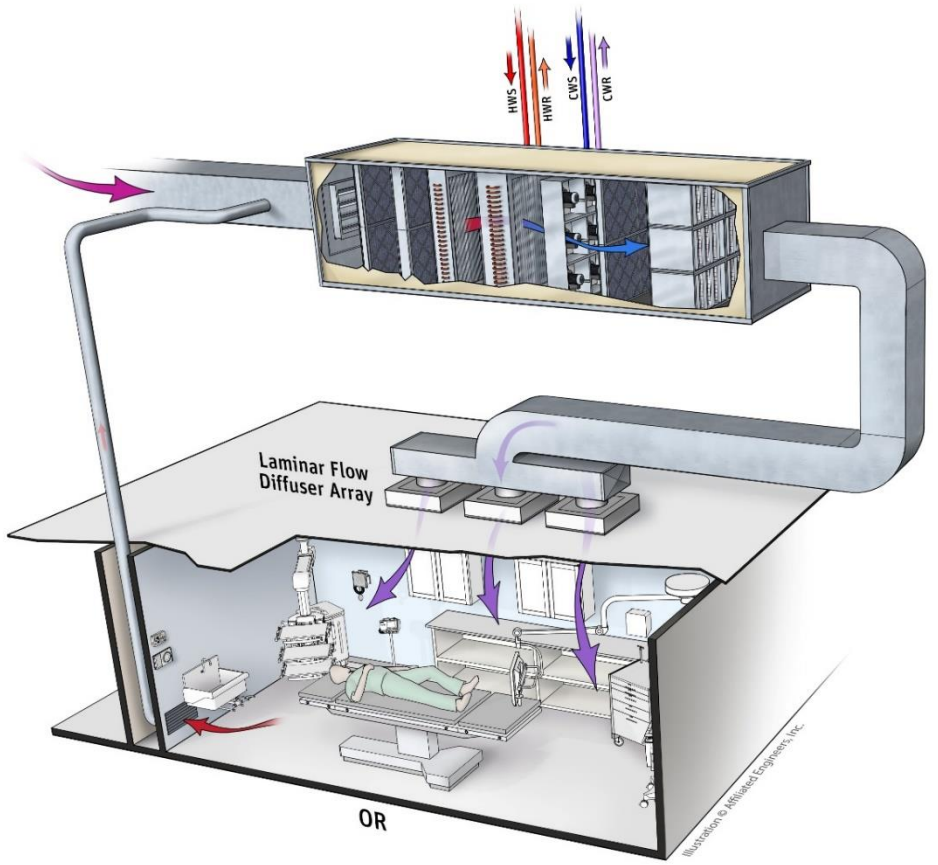
- Sources of Heat and humidity
- Standard OR
- Hybrid Imaging OR
- Cardiovascular OR
- C-Section OR

How do we control OR temperature and humidity?

Single Zone Operating Room Temperature Control

- One AHU per OR
- Temperature Control/Dehumidification/ Humidity Control all occur at the Air Handling Unit
- Airflow to the OR is directly controlled by AHU fans
- System is Pressure Dependent

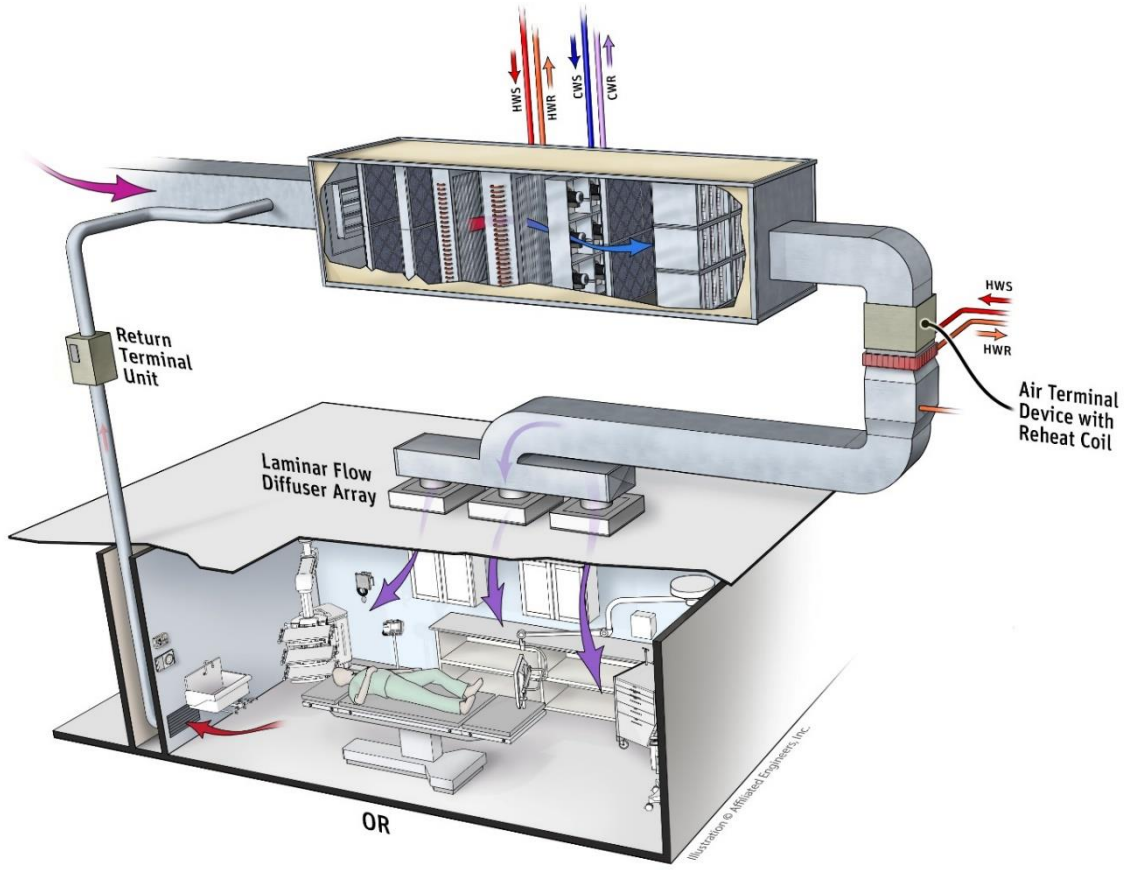
Single Zone OR without Terminal Devices



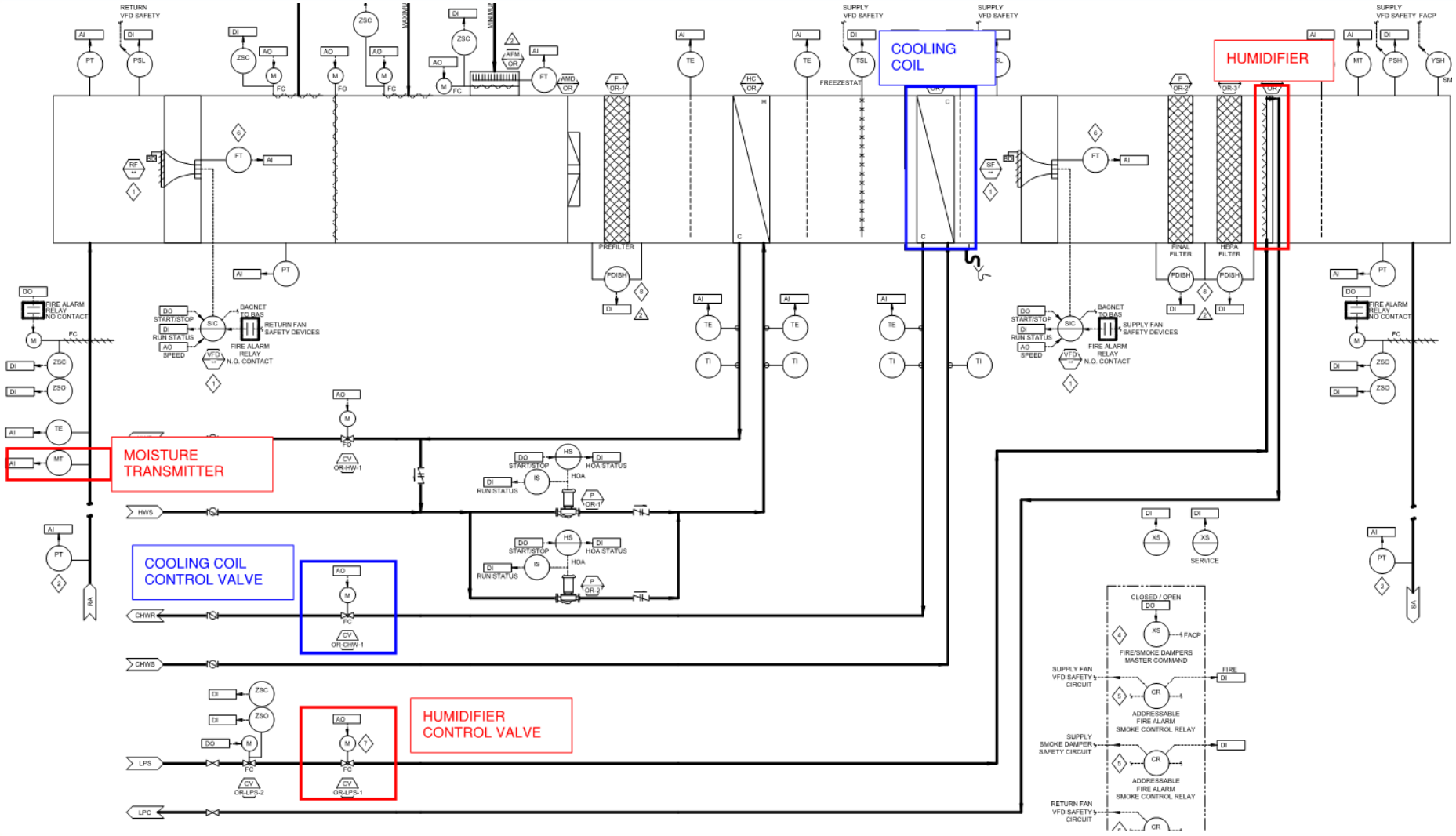
Single Zone Operating Room Temperature Control

- One AHU per OR with Supply and Return Terminal Units
- Constant Discharge Temperature from the AHU and the Terminal Unit modulates to maintain OR temperature/airflow
- Humidity Control is through AHU humidifier
- Dehumidification is through AHU cooling coil
- Airflow to the OR is controlled by the respective Terminal Units
- System is Pressure Independent

Single Zone OR with Terminal Devices



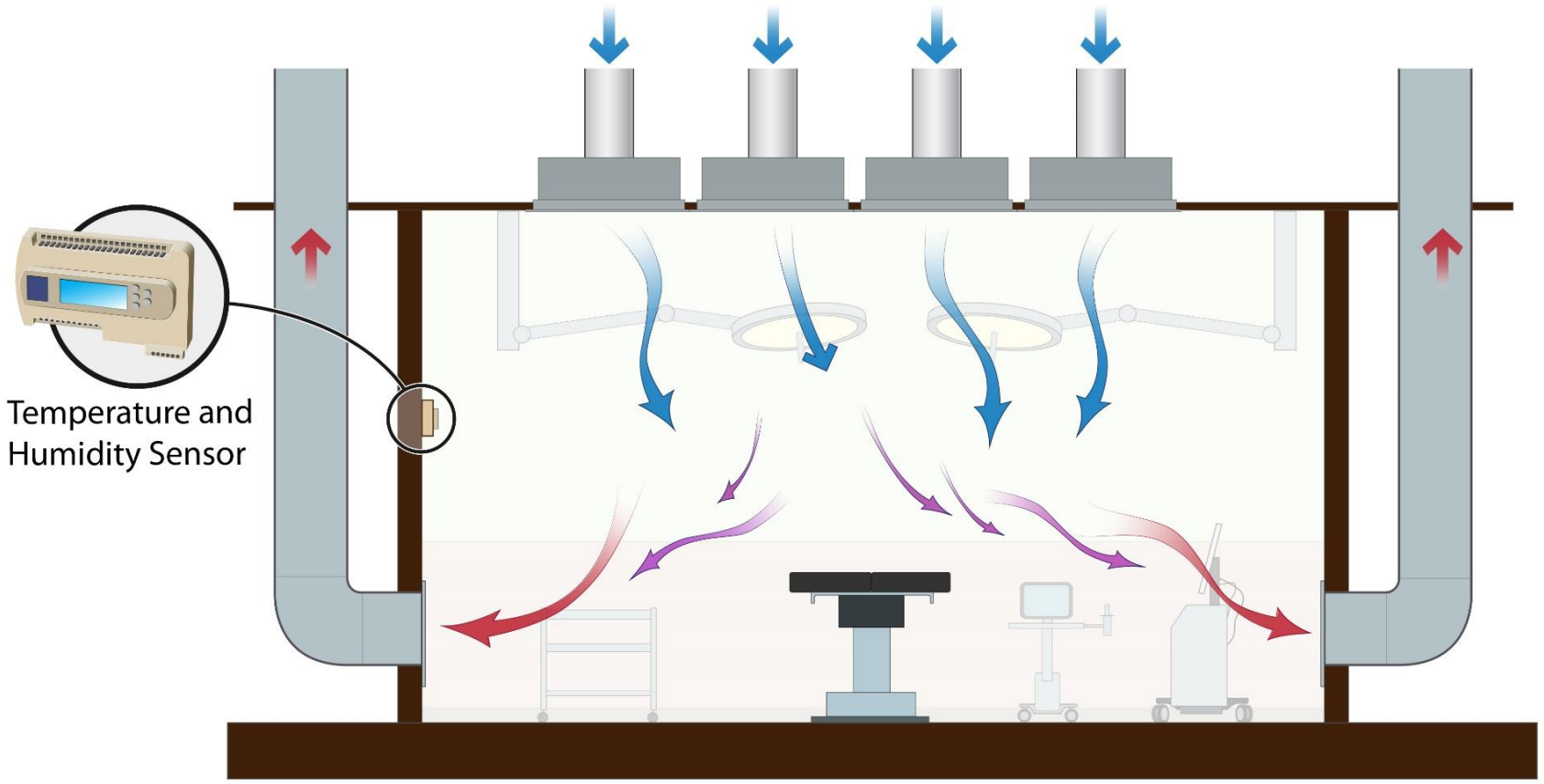
Air Handling Unit – Control Drawing



Temperature Control

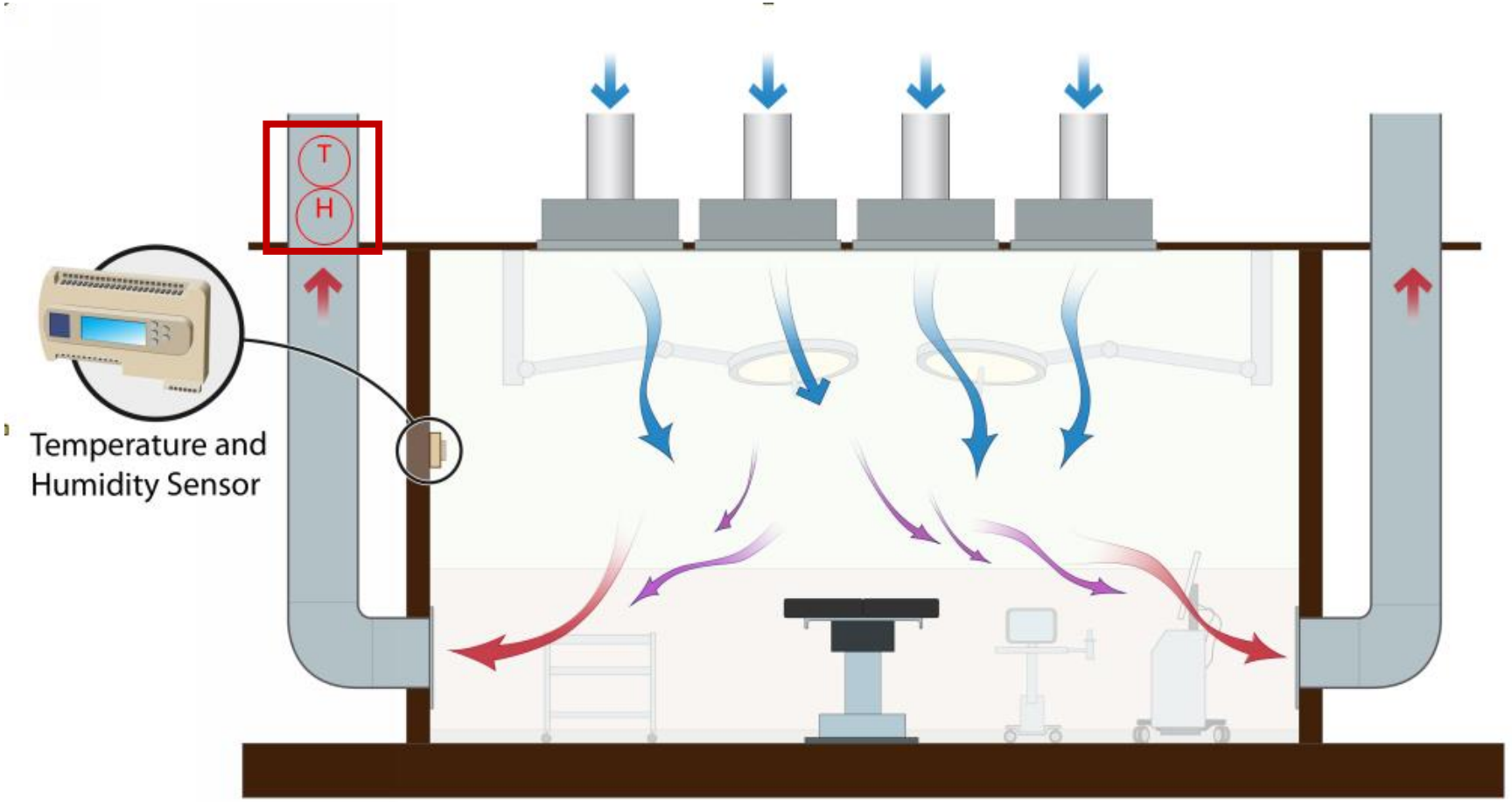
Humidification Control

Operating Room Sensor Location



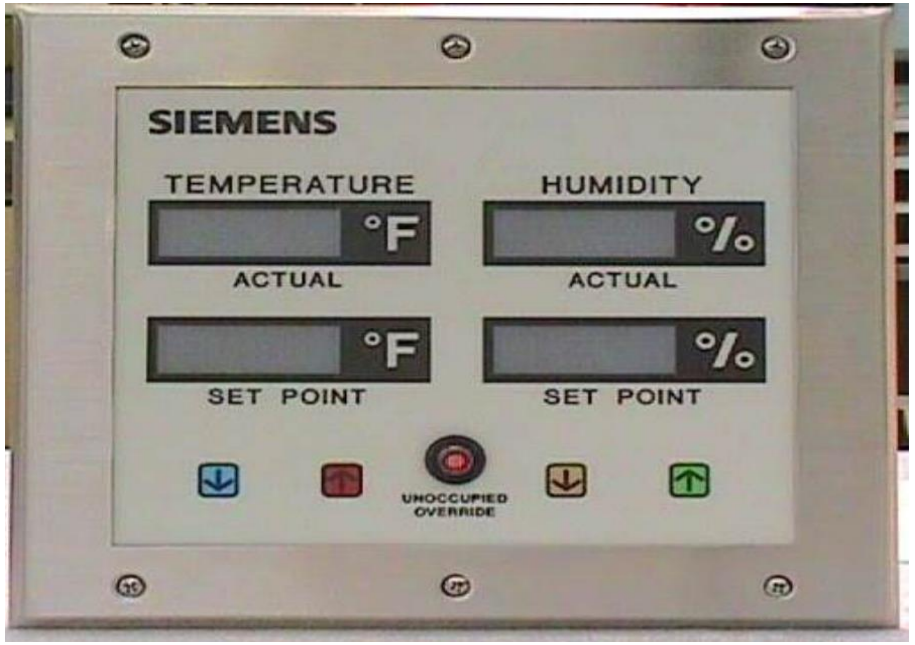
Location of Temperature/Humidity sensor is critical in maintaining precise OR space conditions

Operating Room Sensor - Recommended Location

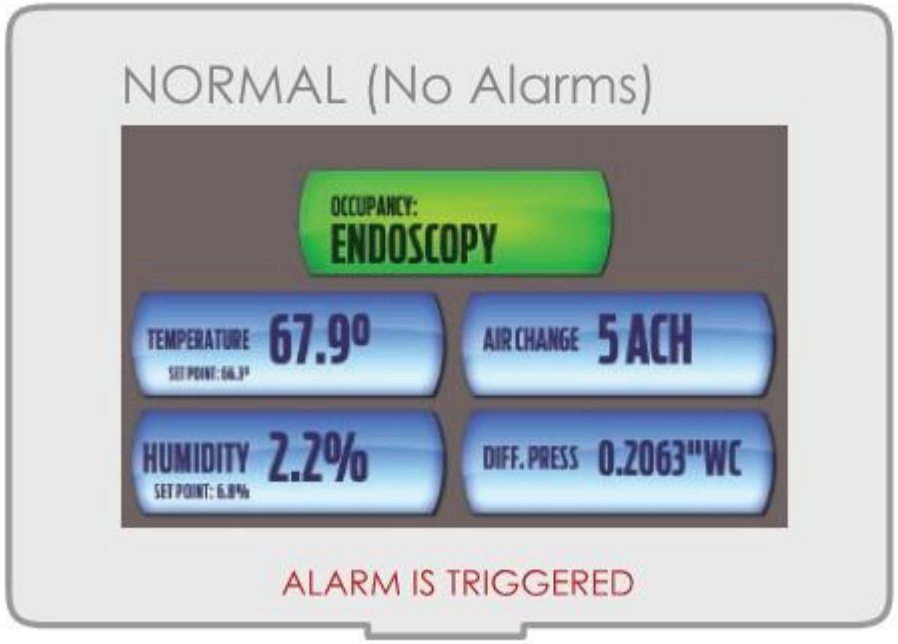


Location of Temperature/Humidity sensor is critical in maintaining precise OR space conditions

Operating Room Control Panel

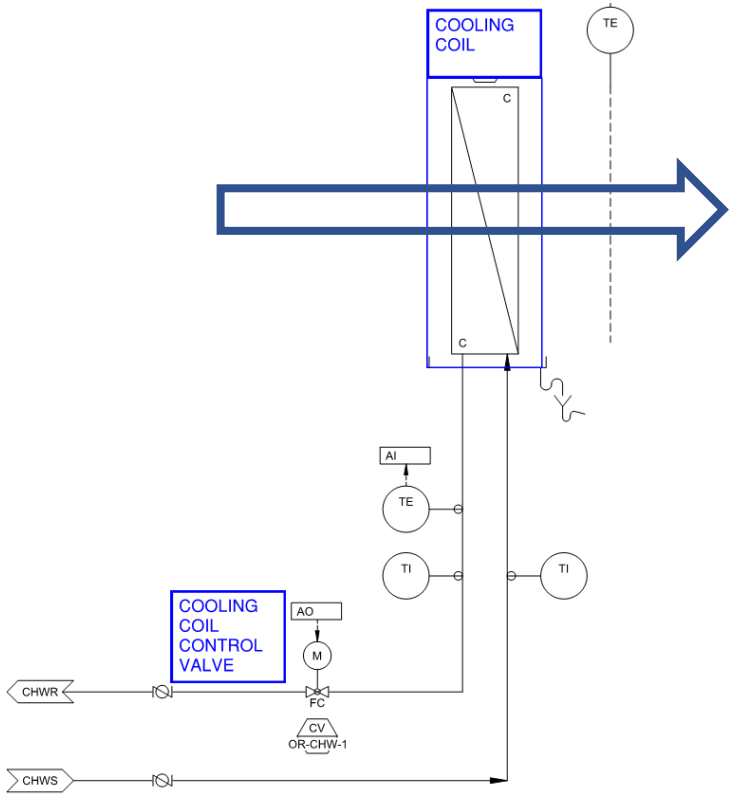


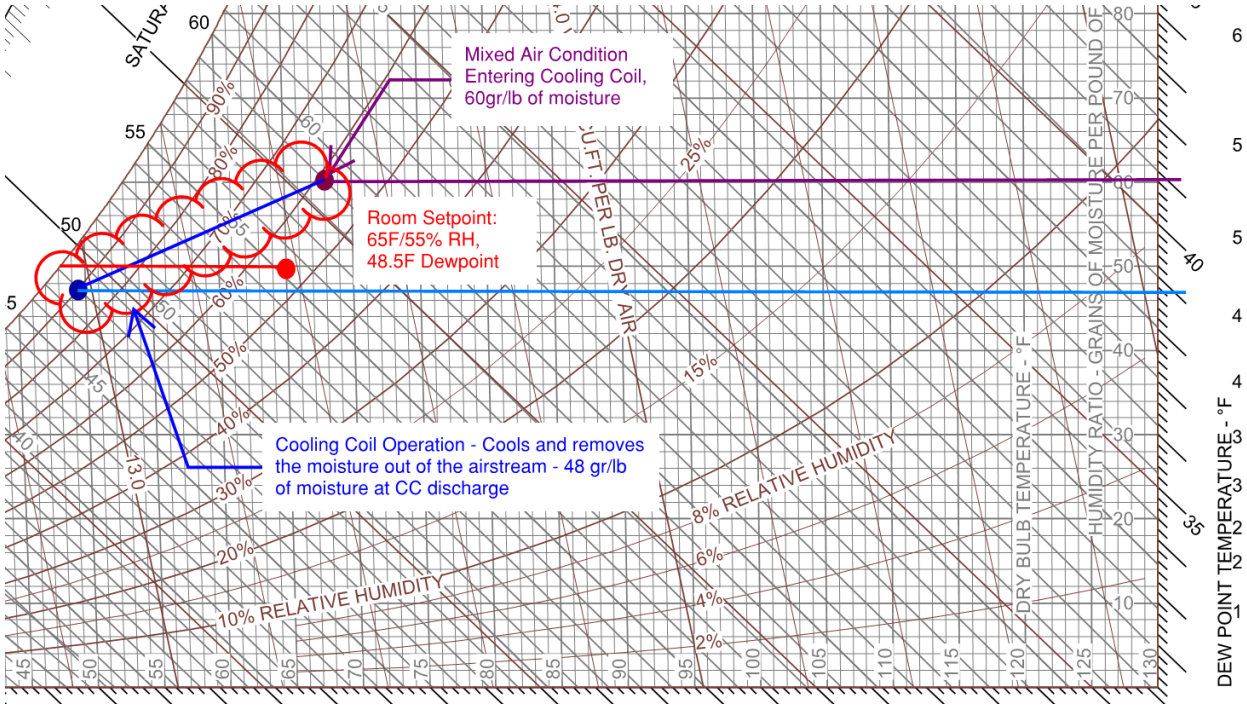
Example: Siemens OR Control Panel



Example: CRC OR Control Panel

Single Zone Operating Room Temperature Control



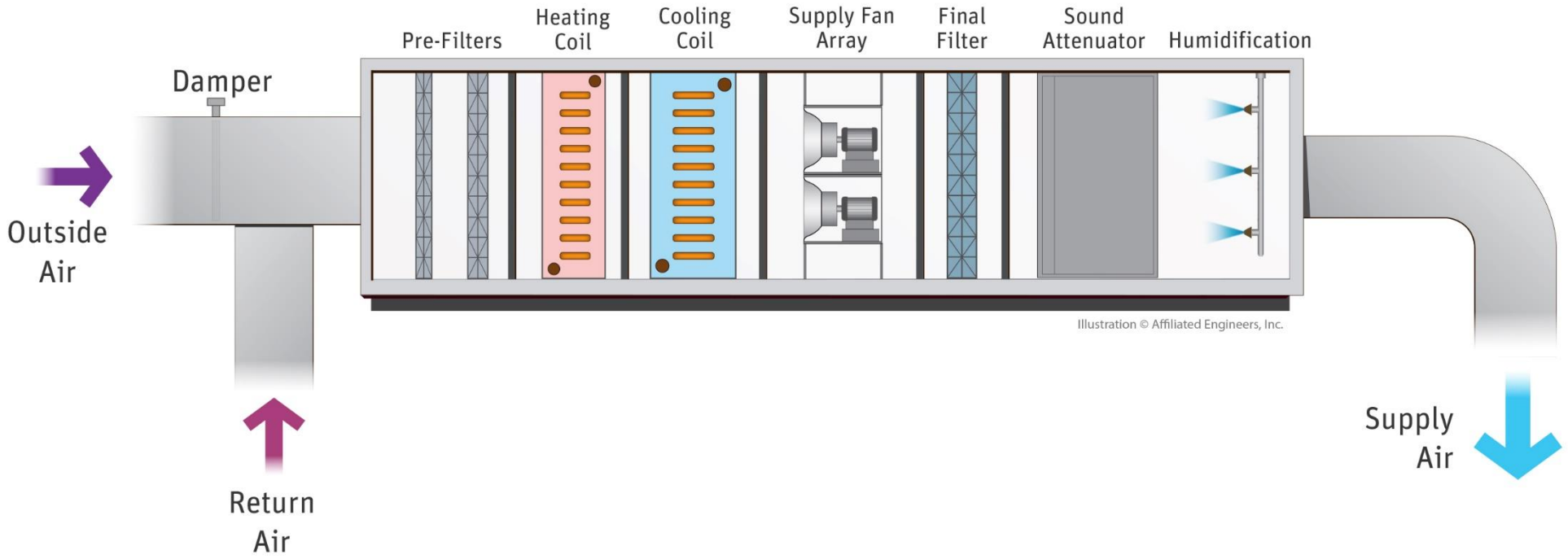


Cooling Coil Control Operation

- Cooling Coil Control valve modulates flow to maintain a certain discharge air temperature leaving the Coil
- Cooling Coil is the “primary” means of dehumidification

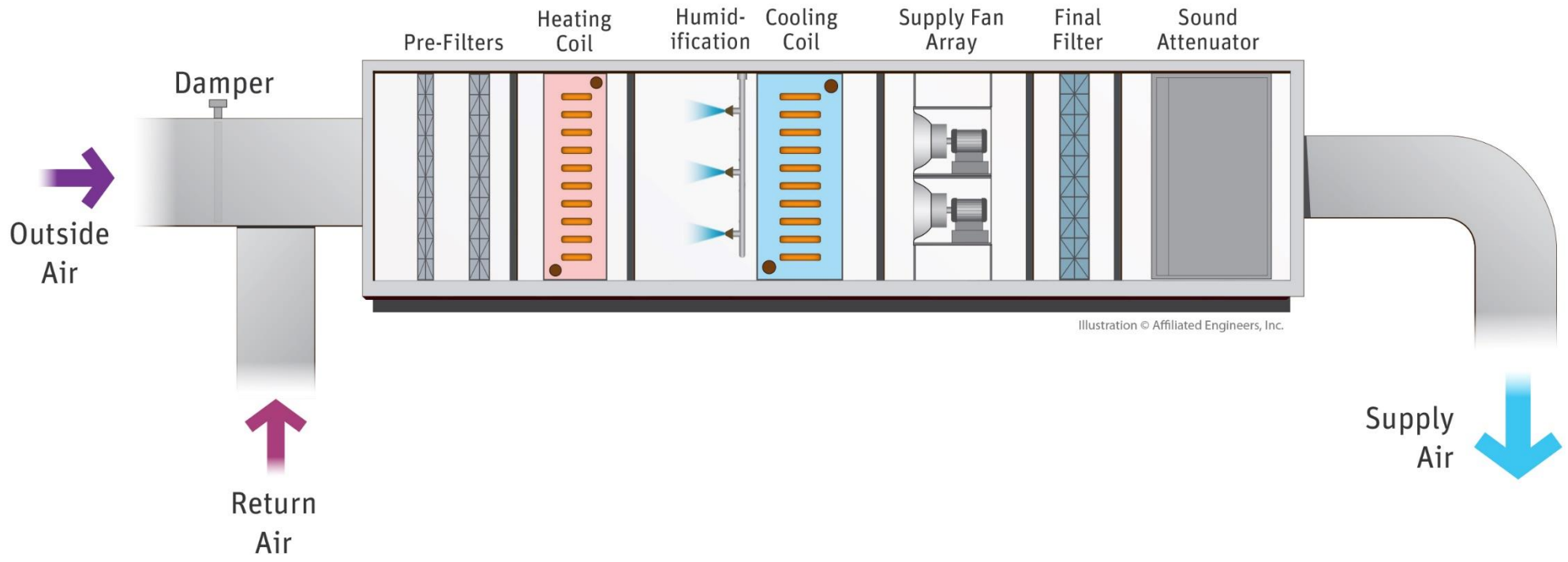
Air Handling Unit – Humidifier Location

- Humidity Control – Humidifier Downstream of Final Filter



Air Handling Unit – Humidifier Location

- Humidity Control – Humidifier Upstream of Cooling Coil

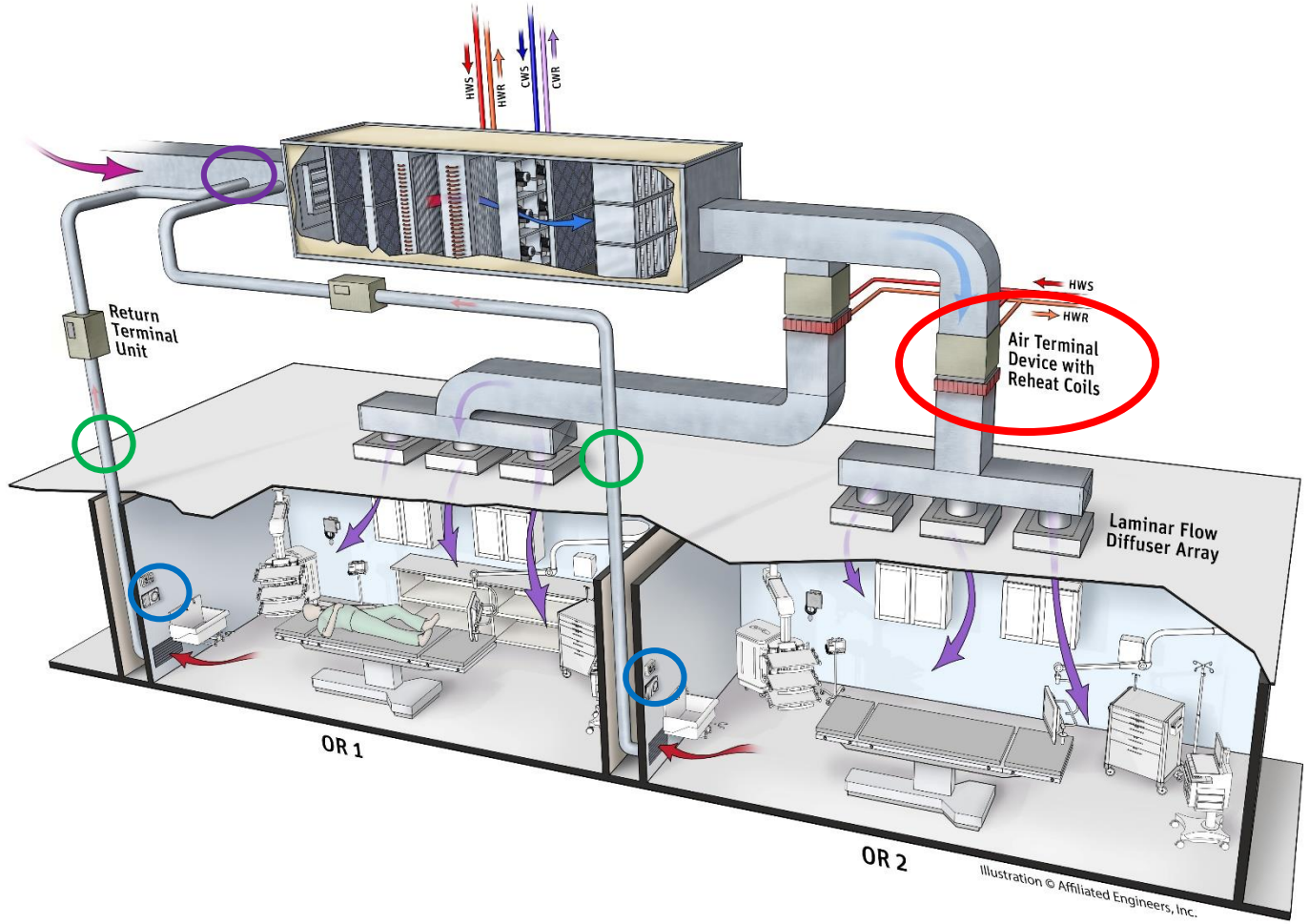


Multiple Operating Room Air System Control

Multizone Air Handling Unit System:

- A single air handling unit serving multiple operating rooms
- ASHRAE 170 requires each operating room to have individual temperature control

Multiple Operating Room Air System Temperature Control



Air Terminal and Reheat Coil

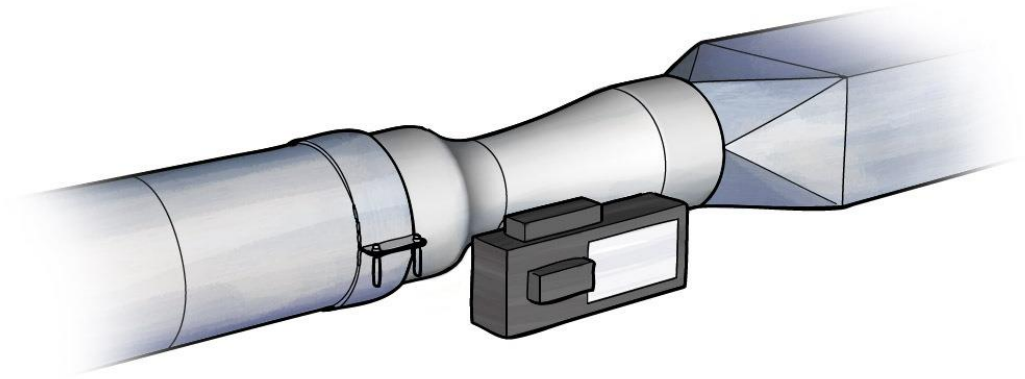
Temperature and Humidity Sensor Locations

OR Control Panel Location

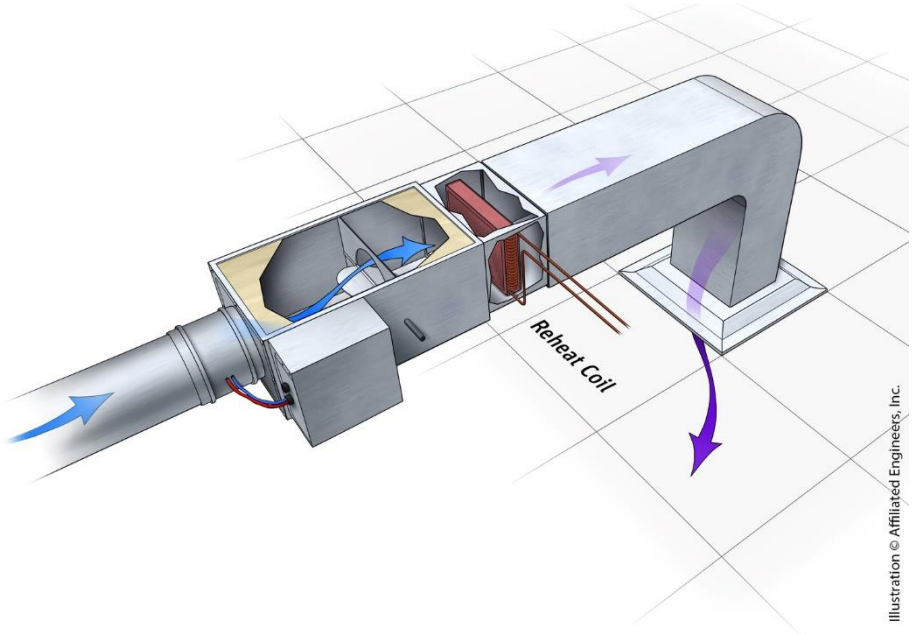
Averaging Type Humidity Sensor Location in Common Return Duct

Multiple Operating Room Air System Temperature Control

- Multizone Zone AHU – Temperature Control – Air Volume Control
  - VAV boxes / Venturi valves

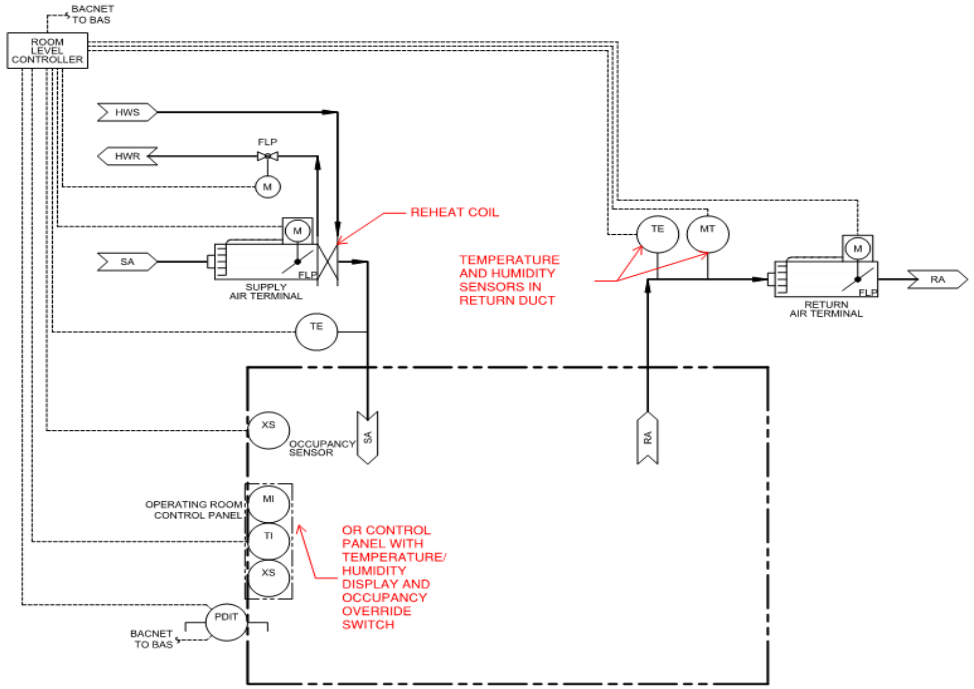


Venturi valve

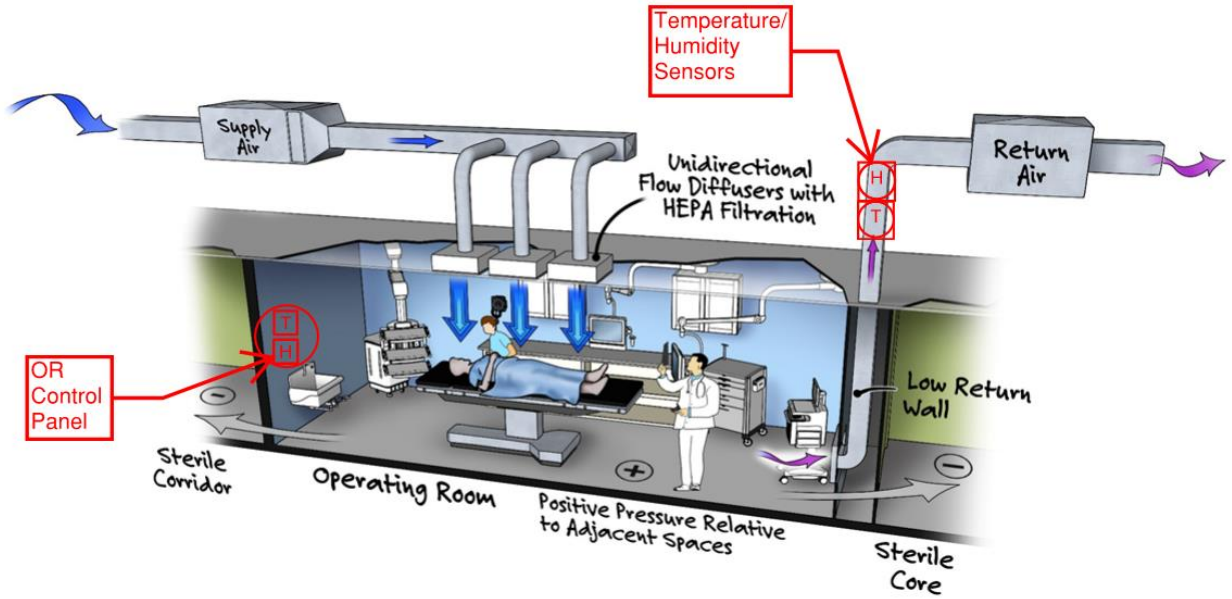


VAV box

Room Level Control Drawing



4 **VARIABLE VOLUME SUPPLY WITH REHEAT, SUPPLY/RETURN TRACKING, OCCUPANCY, ROOM PRESSURE MONITOR - OPERATING ROOM**
SCALE: NONE



Constant Volume vs. Variable Volume Control Sequence

Constant Volume Supply Terminal with Reheat and Return Terminal

- Airflow Control
  - Supply Air Terminal is balanced to the scheduled airflow, airflow sensor in the Supply Air Terminal measures the supply flow rate continuously
  - Return Air Terminal is balanced to scheduled airflow and Terminal Controller calculates the required Return airflow rate to maintain predetermined offset and positive pressure in the OR. Return Air Terminal Actuator modulates to maintain offset.
- Temperature Control
  - Temperature Sensor in Return duct measures OR space temperature and modulates reheat coil valve through the Air Terminal Controller. If the space temperature drops below setpoint, the reheat coil valve modulates open and If the space temperature rises above setpoint, the reheat coil valve modulates closed

Variable Volume Supply Terminal with Reheat and Return Terminal

- Airflow Control
  - Supply Air Terminal is balanced to the scheduled airflow, airflow sensor in the Supply Air Terminal measures the supply flow rate continuously. Supply Air Terminal Damper modulates between maximum and minimum to maintain space temperature and code required air changes.
  - Return Air Terminal is balanced to scheduled airflow and Terminal Controller calculates the required Return airflow rate to maintain predetermined offset and positive pressure in the OR. Return Air Terminal Damper modulates in sync with the Supply Terminal Damper to maintain predetermined offset.
- Temperature Control
  - Temperature Sensor in Return duct measures OR space temperature and modulates Supply Terminal Damper and reheat coil valve through the Air Terminal Controller. If the space temperature drops below setpoint - first the Supply Terminal damper is modulated to minimum position, and if the space temperature continues to drop then the reheat coil valve modulates open. If the space temperature rises above setpoint, the reheat coil valve modulates closed first, and if the space temperature continues rising the Supply Damper modulates from minimum to maximum position.

Variable Volume Airflow Control

Varying Airflow Pros:

- Saves energy – close to 30% reduction in CFM

Varying Airflow Cons:

- May result in uneven temperature profile
- May cause disruption in airflow pattern
- Room pressurization control needs to be designed carefully

Varying Airflow – CFM reduction:

- Can vary from cooling airflow down to code required airflow

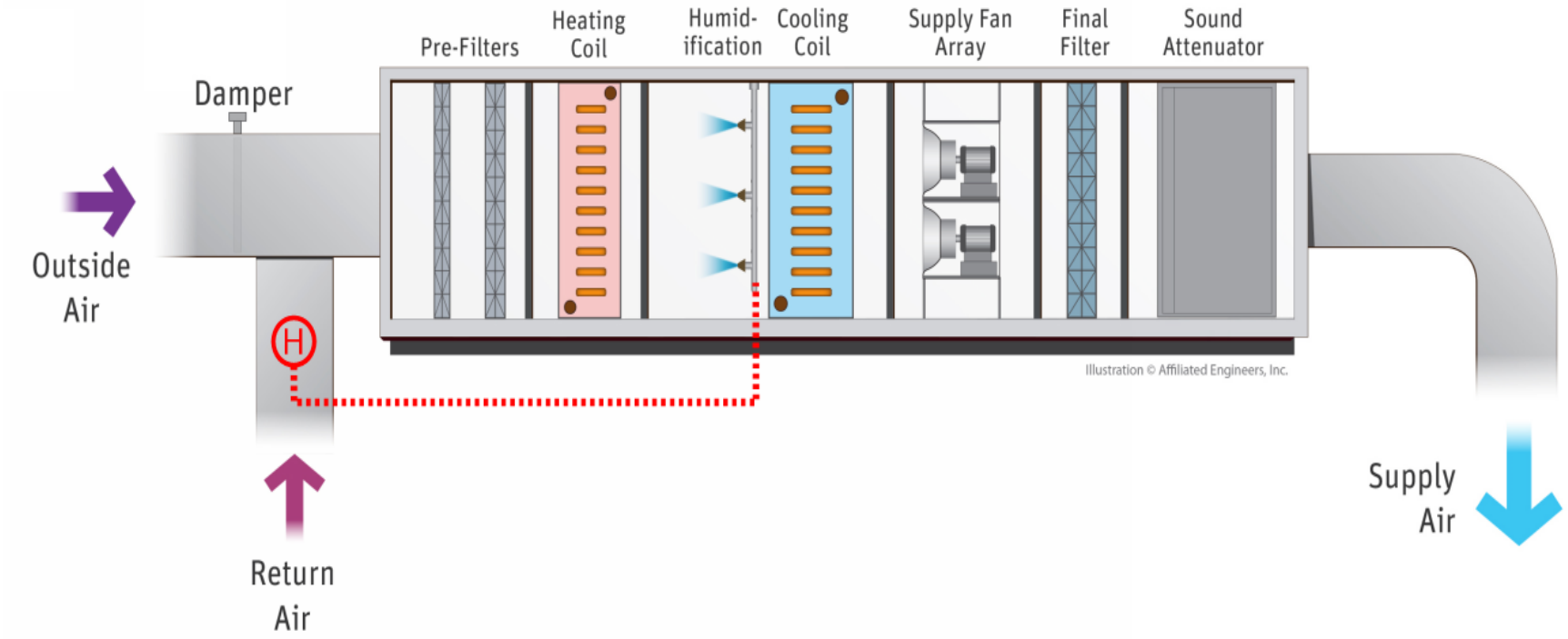
OR Type	Cooling CFM	Design ACH	Code Required CFM	Code ACH	CFM Delta
Standard OR	2400	20	2400	20	0
Hybrid OR	3600	25	2400	20	1200
Cardio OR	3400	24	2400	20	1000

Multiple Operating Room Air System Humidity Control

- Multizone Zone AHU – Humidification Control
  - Humidifier at AHU
  - Individual Room Humidifiers

Humidifier at AHU

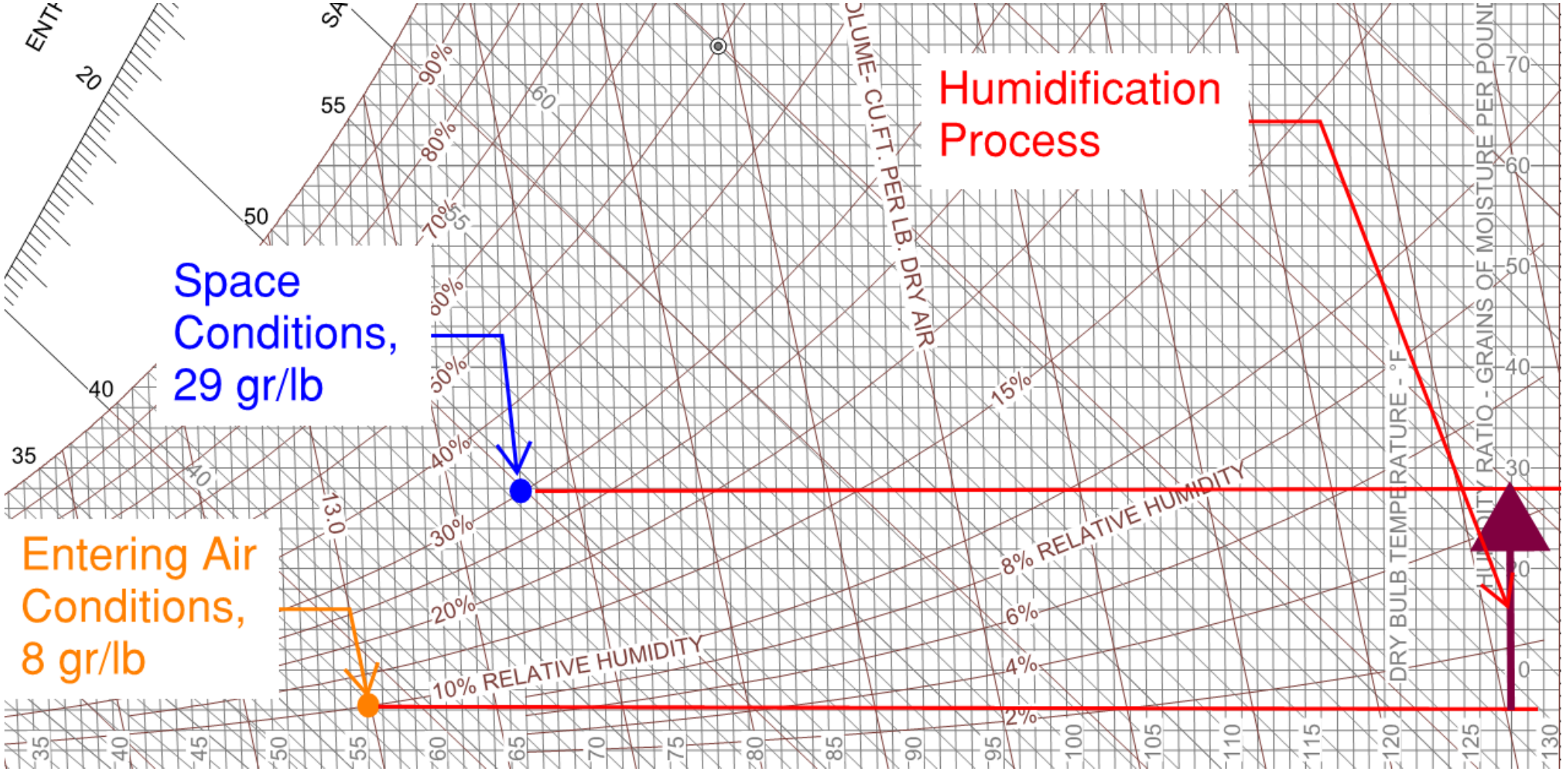
- Humidity Control – Humidity Sensor Location



Humidifier Control:

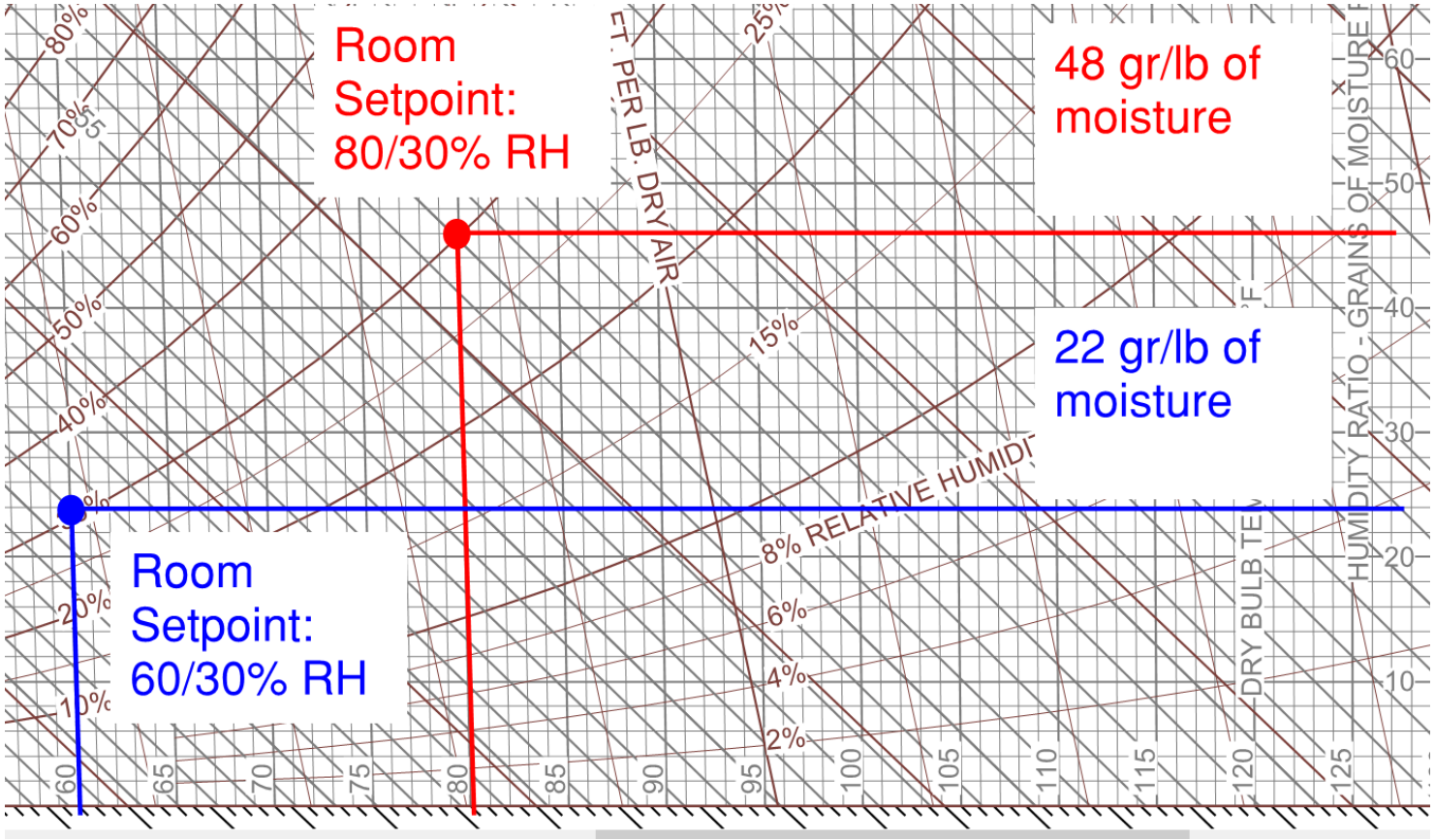
- Steam Control Valve modulates to maintain return humidity setpoint
- As RH falls below setpoint, steam valve opens. If RH starts going above setpoint, steam valve closes

Humidity Control - Psychrometrics



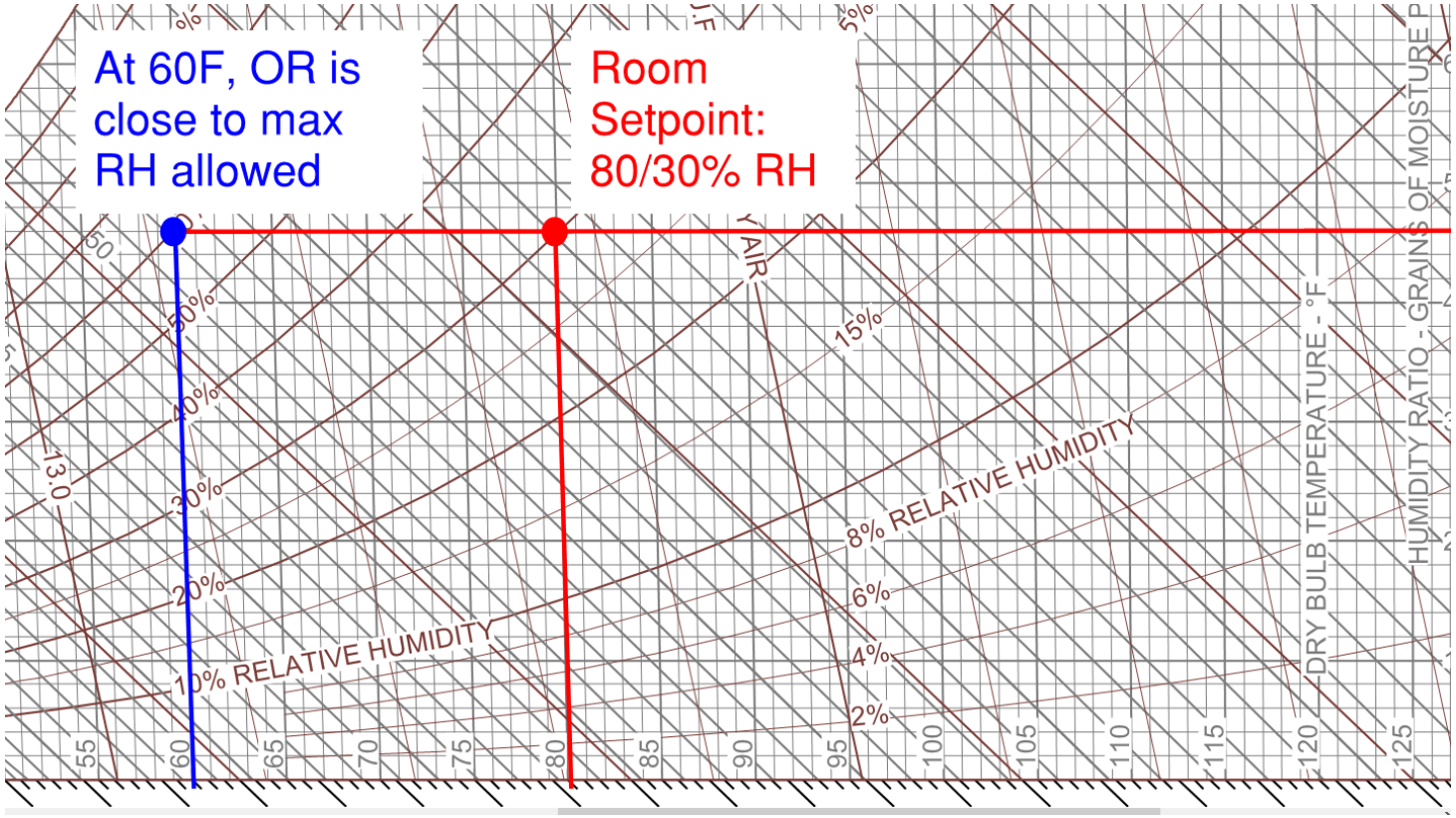
Multiple Operating Room Air System Humidity Control

Different Operating Rooms may have different humidity requirements, but…

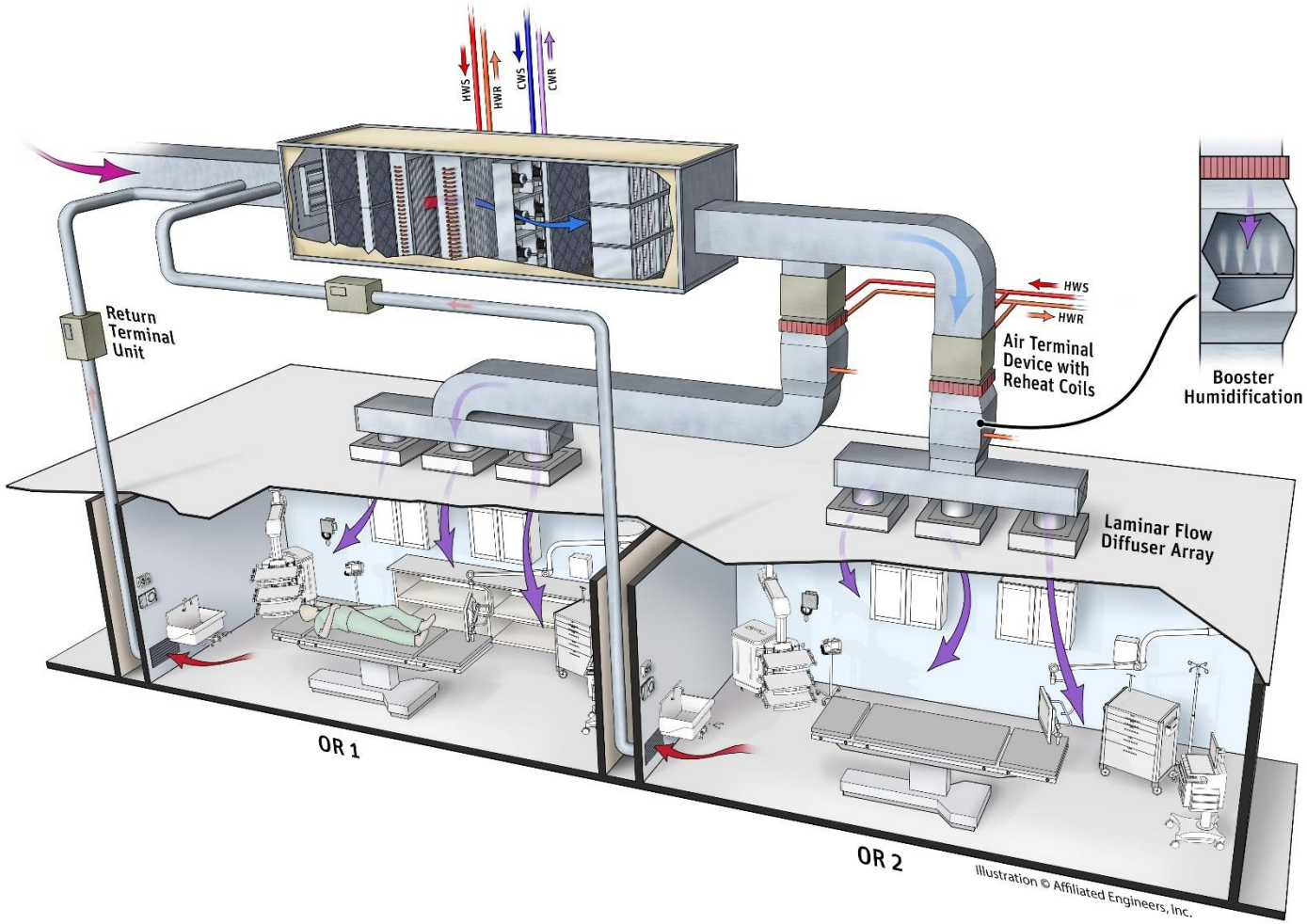


Multiple Operating Room Air System Humidity Control

…a single, central humidifier can only control to one humidity level



Multiple Operating Room Air System Humidity Control

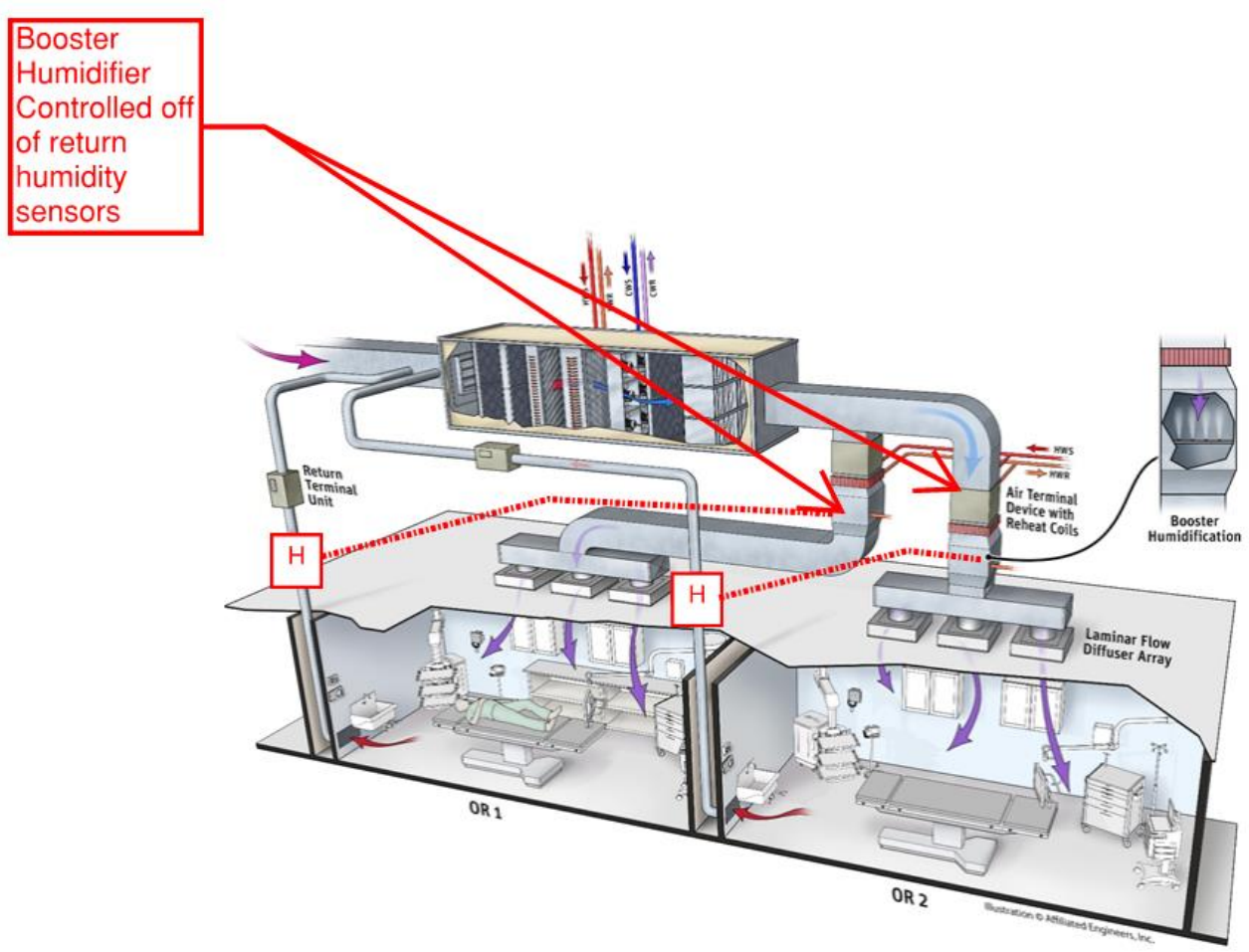


Multizone Zone AHU – Duct Mounted Humidifier

Each OR can control humidity individually

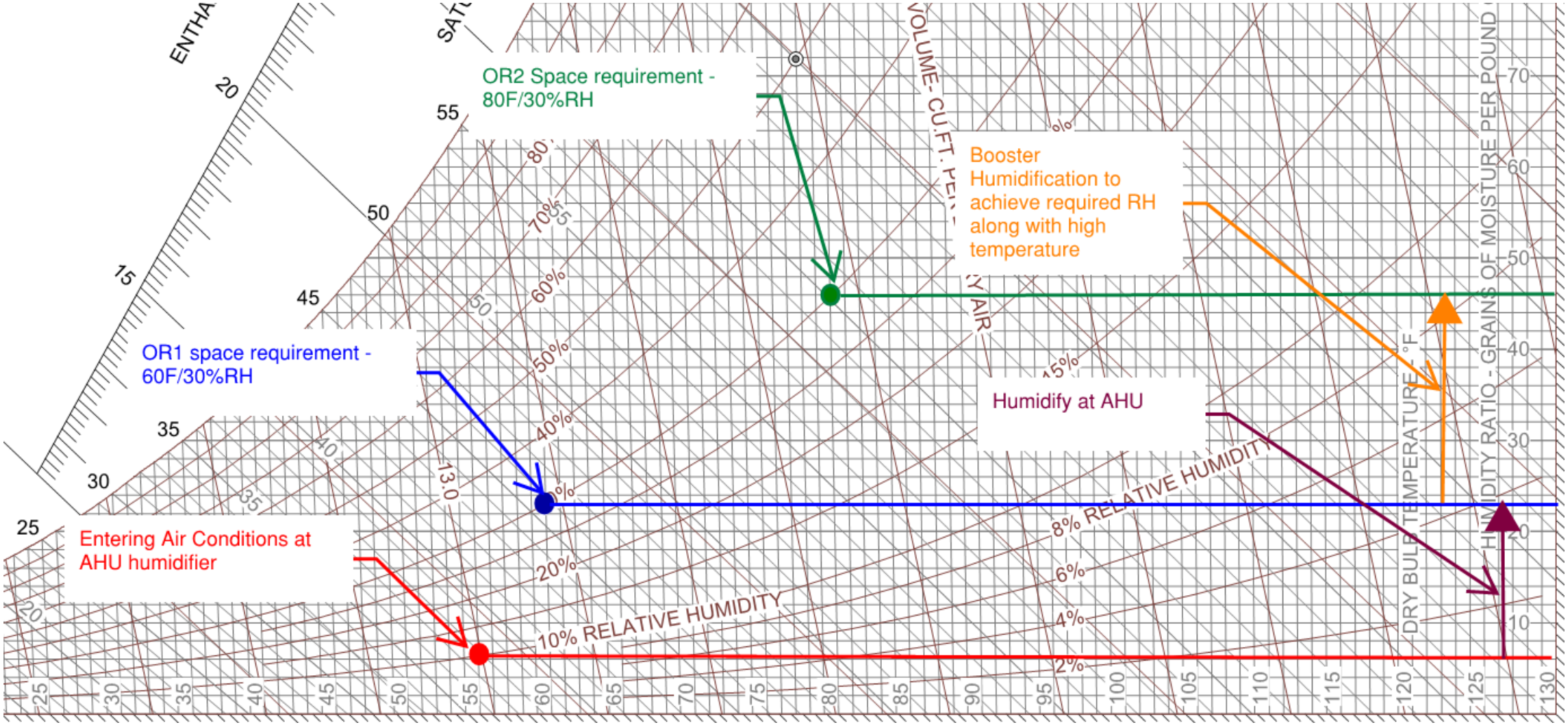
AHU Humidifier humidifies to a standard RH – say 20% and the dedicated booster humidifier can add additional humidity based on requirements

Multiple Operating Room Air System Humidity Control



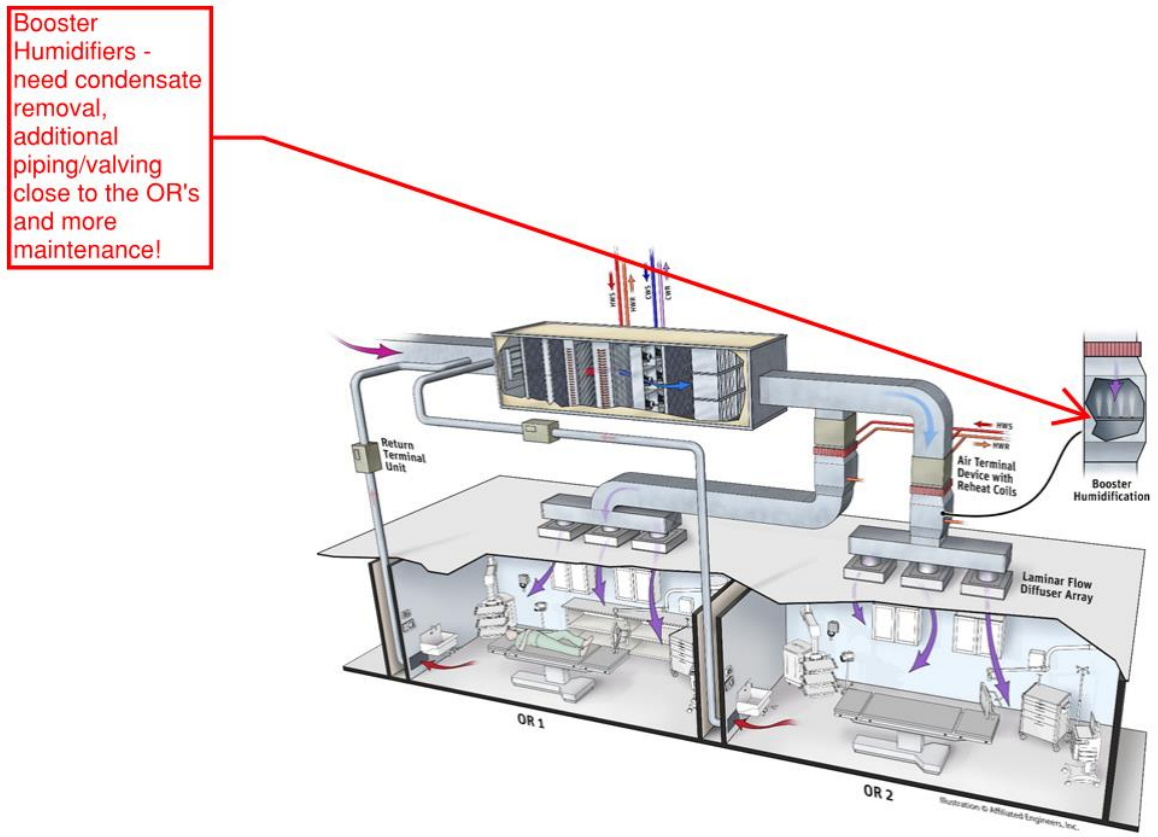
Booster Humidifiers are controlled off of return humidity sensors in each return duct giving each OR the ability to control the RH

Booster Humidifier - Psychrometrics



Multiple Operating Room Air System Humidity Control

Having one humidifier per room allows for each room to be controlled to their own humidity level, but:

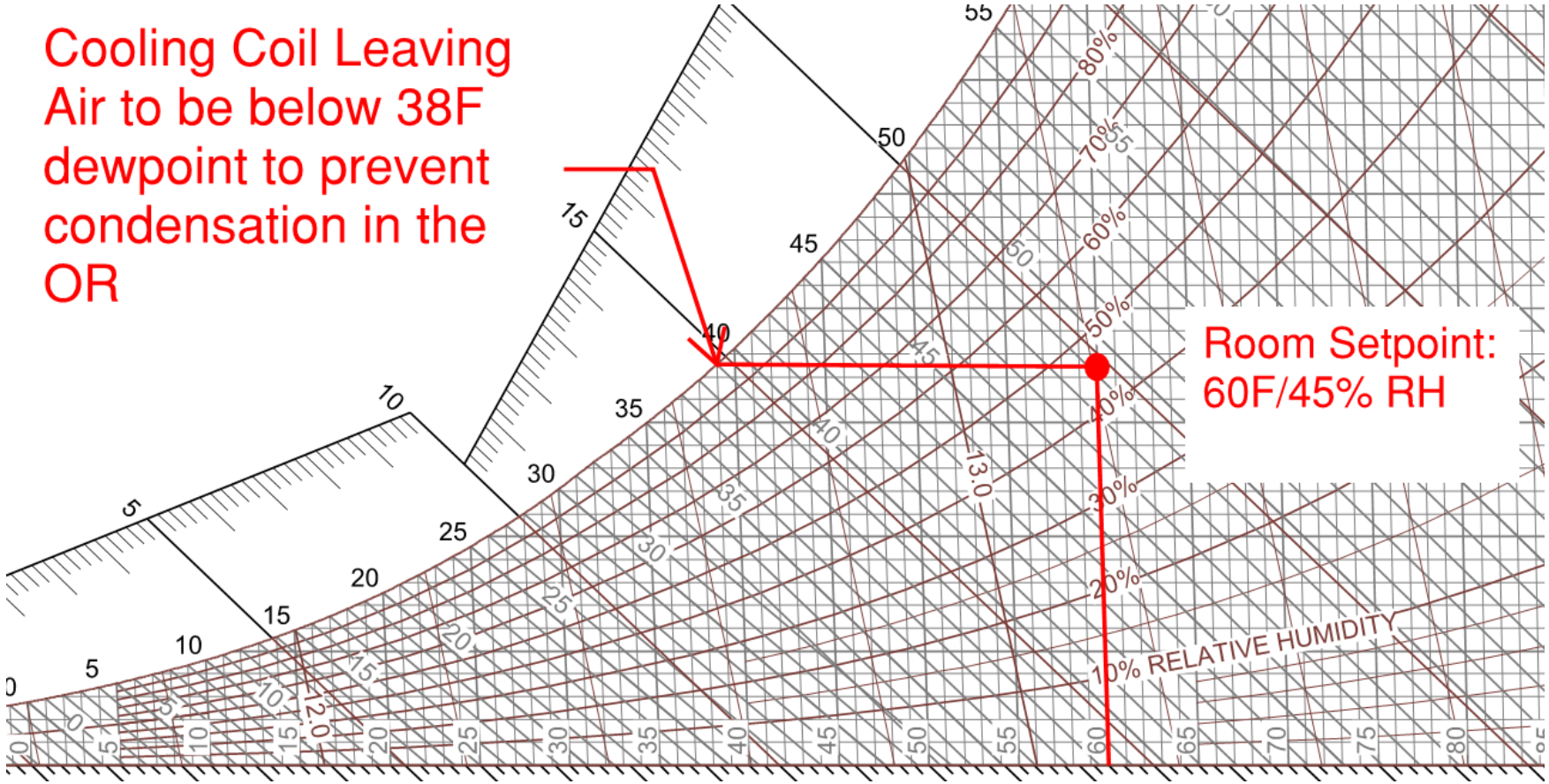


…more steam piping, condensate removal, and maintenance required.

Operating Room Low Temperature Control

To reach low temperature setpoints (60°F) in operating room we need to cool the supply air down significantly for cooling and dehumidification:

Low Temperature OR – Psychrometrics



Operating Room Low Temperature Control

Low Temperature Chilled Water System

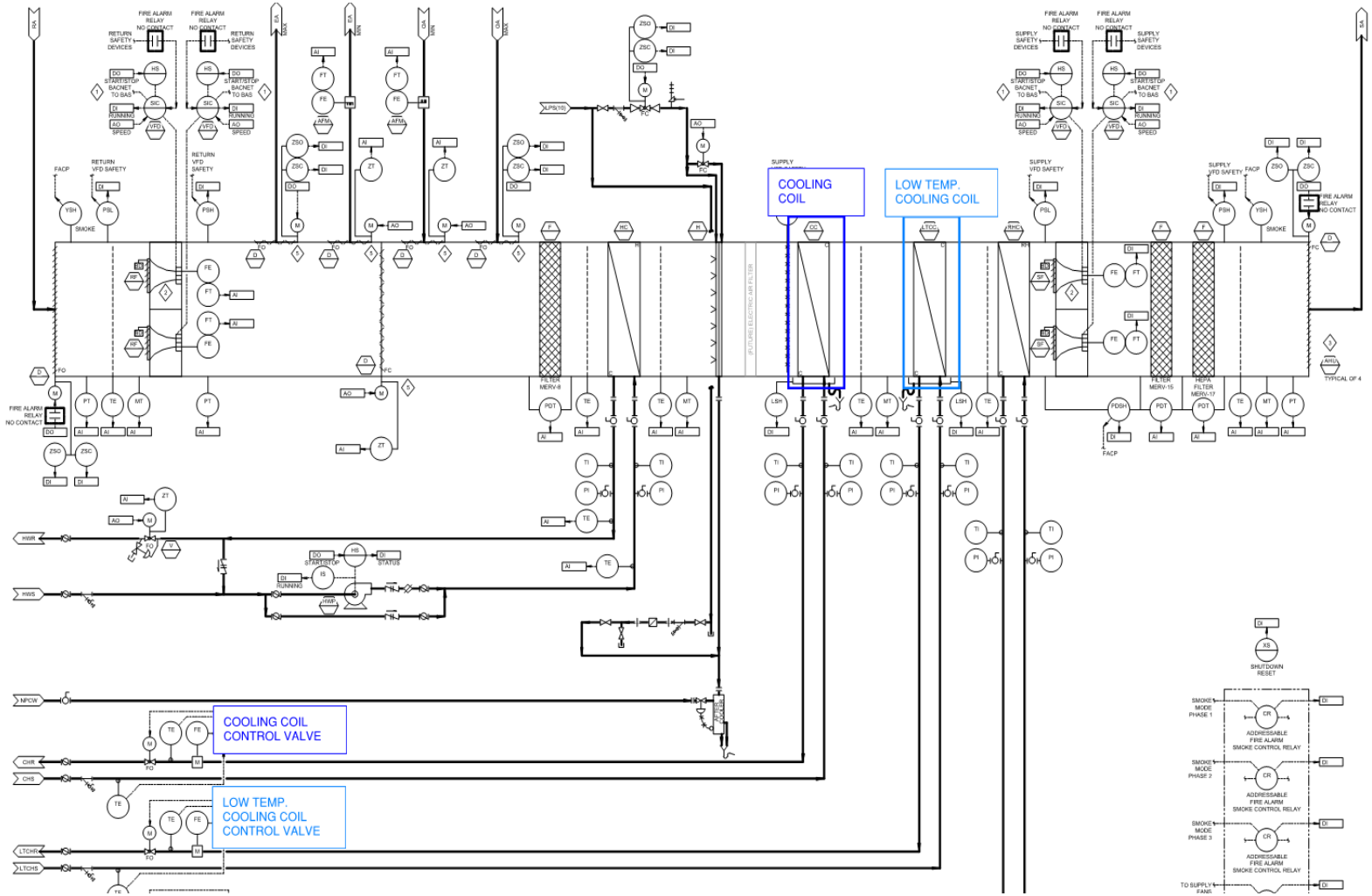
- Cool air to required dewpoint (38°F) for dehumidification
- Reheat air to 45°F to 48°F for comfortable discharge air temperature, avoid ductwork condensation, and increased insulation requirements

Operating Room Low Temperature Control

Low Temperature Chilled Water System

- Lower Chilled water supply temperature between 30°F to 39°F
- Lower temperatures run risk of freezing coils.
- Glycol may be required for water temperatures less than 34°F
- Results in use of Low Temperature Chillers.

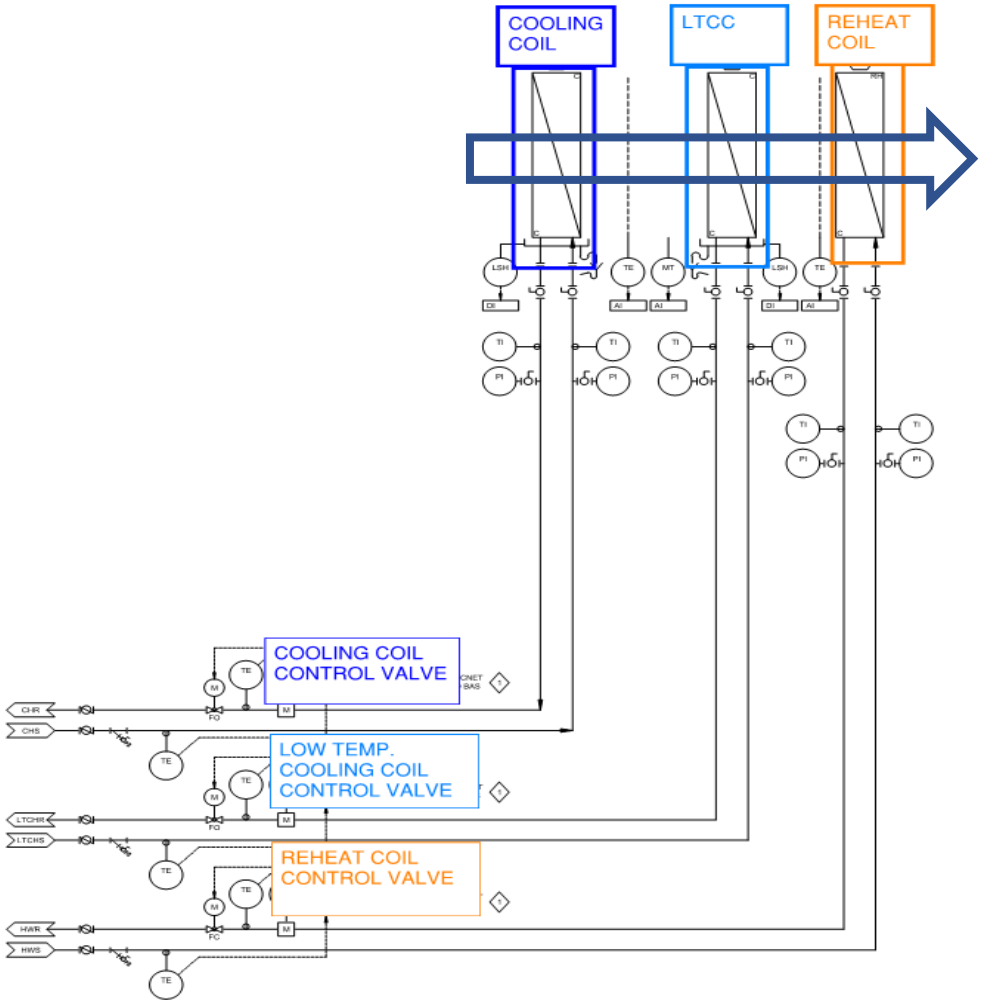
OR AHU with Low Temperature Coil – Control Drawing



Primary Cooling Coil

Low Temperature Cooling

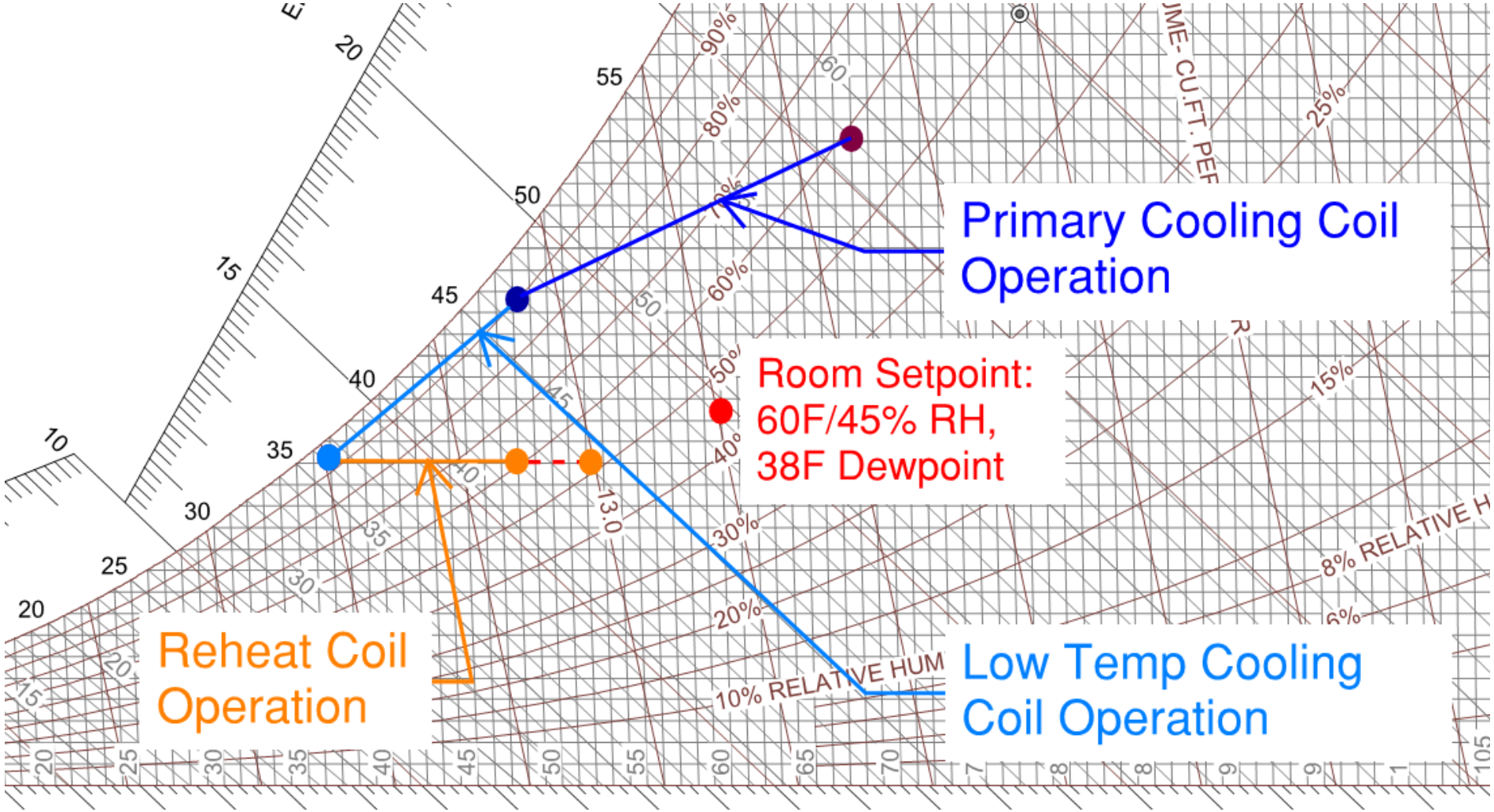
Operating Room Low Temperature Control



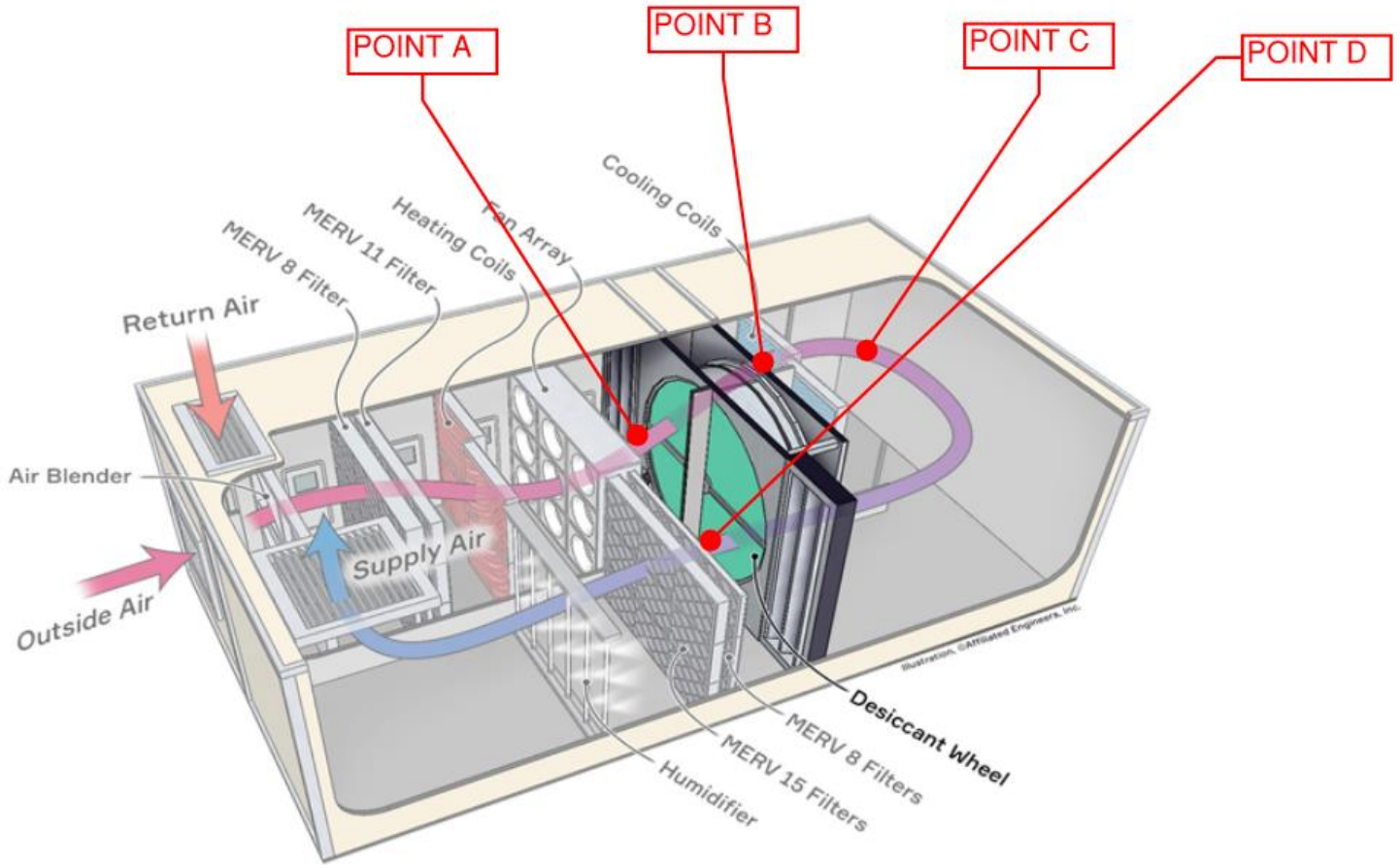
Low Temperature Cooling Coil Option

- Primary Cooling Coil cools and removes moisture from the airstream,
- Low Temperature Cooling Coil is needed to further “dehumidify” the air to meet space conditions
- Since the Air Leaving the Low Temperature Cooling Coil is too cold, it needs to be heated up to a reasonable AHU discharge temperature

Operating Room Low Temperature Control – Psychrometric Analysis



Desiccant Wheel Option



Desiccant Wheel Operation:

- Point A: Mixed Air at a Lower RH enters the desiccant wheel
- Point B: Mixed Air absorbs vapor and leaves the wheel at a higher RH
- Point C: Higher RH Mixed Air condenses on the cooling coil, reducing Leaving Air Temperature and reducing moisture (grains)
- Point D: Desiccant Wheel through an adsorption process further dries the air out to satisfy required space conditions
- An additional trim cooling coil may be considered if colder air is required at the AHU discharge

How can we save energy and operational costs while maintaining OR temperature and humidity?

How can we save energy and operational costs while maintaining OR temperature and humidity?

HVAC systems are often the single most energy-intensive component in hospital

Reasons it hard to save energy in operating rooms:

- Surgeries are performed often and at any time
- Required air changes use large amounts of fan energy
- High equipment and lighting loads consume cooling energy
- Often require simultaneous heating and cooling as equipment loads vary
- Sometimes require extreme temperature setpoints

How can we save energy and operational costs while maintaining OR temperature and humidity?

- First goal is to educate users on energy requirements for cooling OR's to 60 degrees

- Cooling Airflow Required: 3,400 CFM → 25 ACH

- Code Required Airflow: 2,400 CFM → 20 ACH

How can we save energy and operational costs while maintaining OR temperature and humidity?

- Since surgeon comfort and surgical procedures often require the lower temperature, what else can we do?

Operating Room Airflow Setback

Operating Room Airflow Setback

ASHRAE 170 7.1, a, 3:

….For spaces that require a positive or negative relationship, the **number of air changes can be reduced when the space is unoccupied**, provided that the required pressure relationship to adjoining spaces is maintained while the space is unoccupied and that the minimum number of air changes indicated is re-established anytime the space becomes occupied…

Operating Room Airflow Setback

- Operating Room Setback
  - Reduce air changes when room is unoccupied
  - Increase air changes to code required air changes when room is occupied
  - Maintain pressurization at all times
  - Maintain same temperature and humidity at all times
  - Keep one or two OR’s ready at all times for emergencies

Operating Room Airflow Setback

- What airflow do we setback to?

10 Air Changes

Example 700 SF Operating Room  **1200 CFM**

Operating Room Airflow Setback

How to determine if room is occupied or unoccupied:

Operating Room Airflow Setback

How to determine if room is occupied or unoccupied:

- Operating Room Schedule set at BAS

Operating Room Airflow Setback

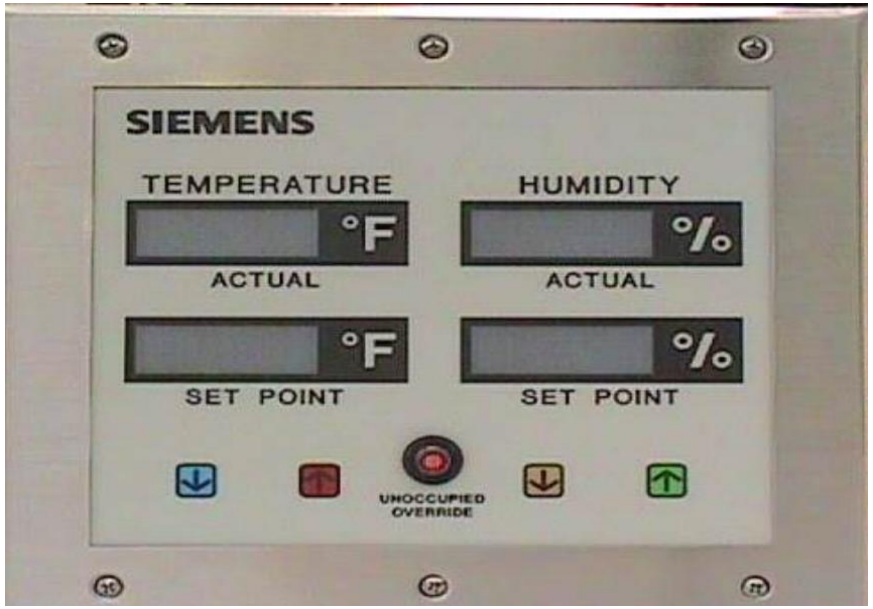
How to determine if room is occupied or unoccupied:

- Operating Room Schedule
- Integration with the Nurse Scheduling Software

Operating Room Airflow Setback

How to determine if room is occupied or unoccupied:

- Operating Room Schedule
- Integration with the Nurse Scheduling Software
- Manual Occupancy Override Button in Operating Room



Operating Room Airflow Setback

How to determine if room is occupied or unoccupied:

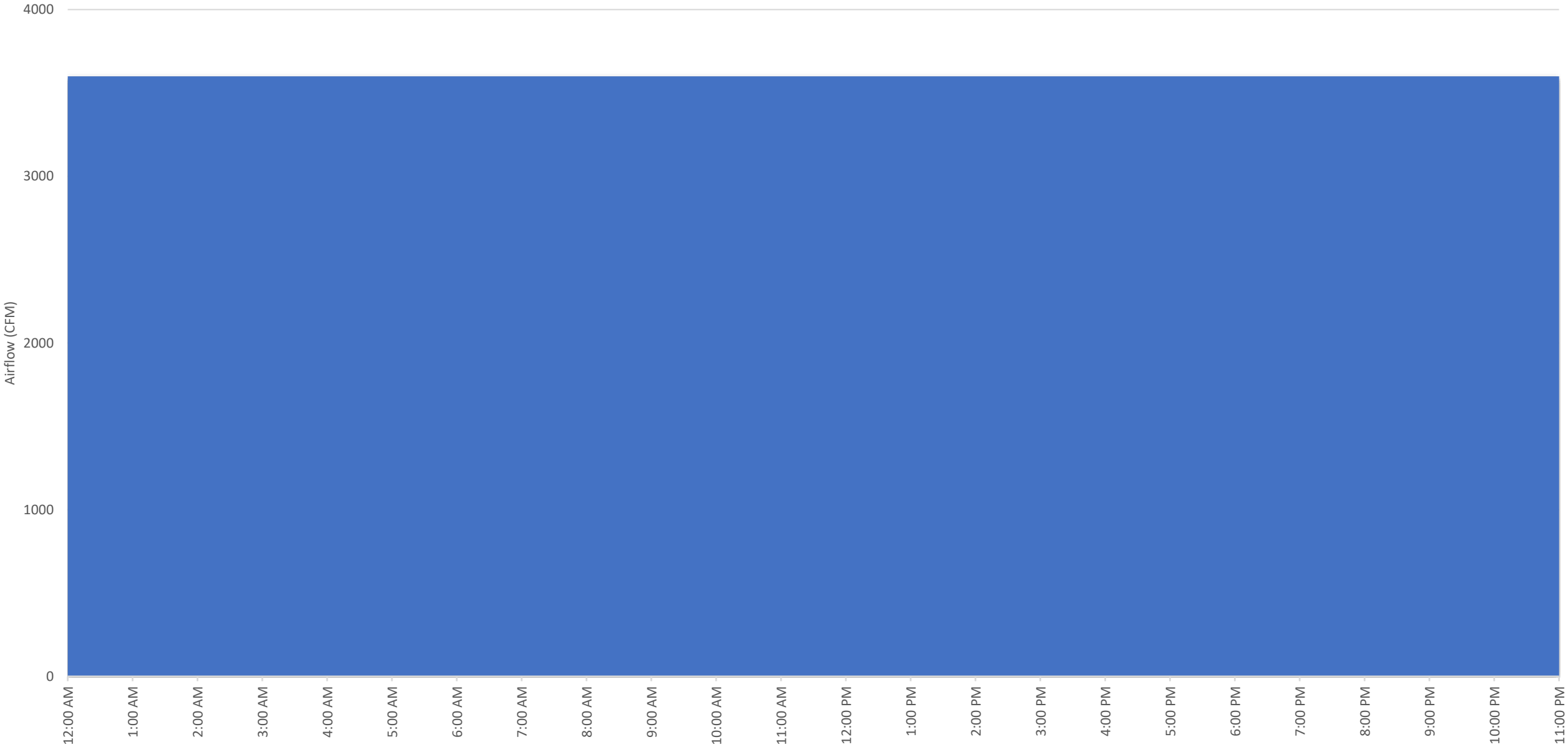
- Operating Room Schedule
- Integration with the Nurse Scheduling Software
- Manual Occupancy Override Button in Operating Room
- Occupancy Sensors

Operating Room Airflow Setback

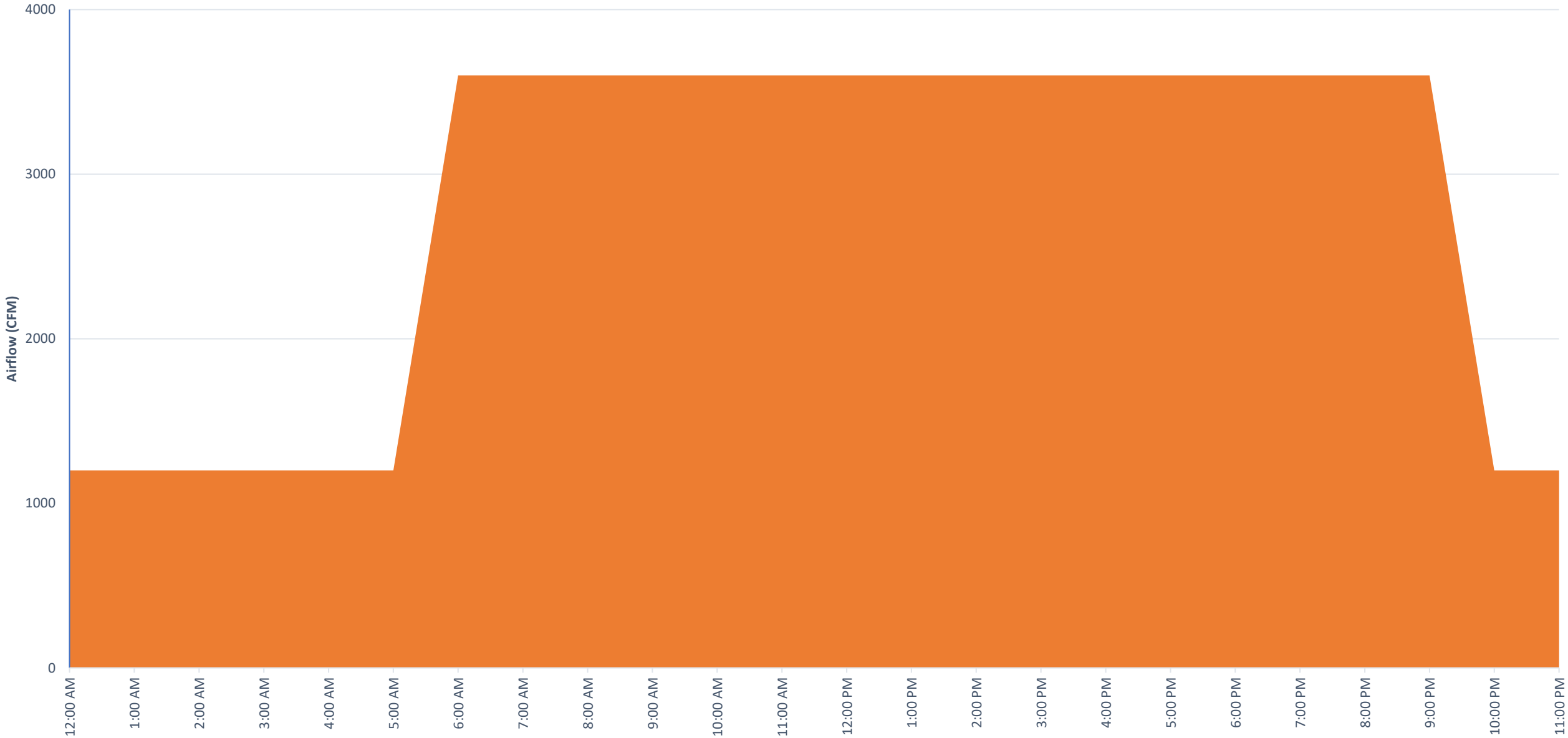
There are two types of operating room airflow setback sequences

- Two-Position Constant Volume Setback Control
- Variable Volume Setback Control

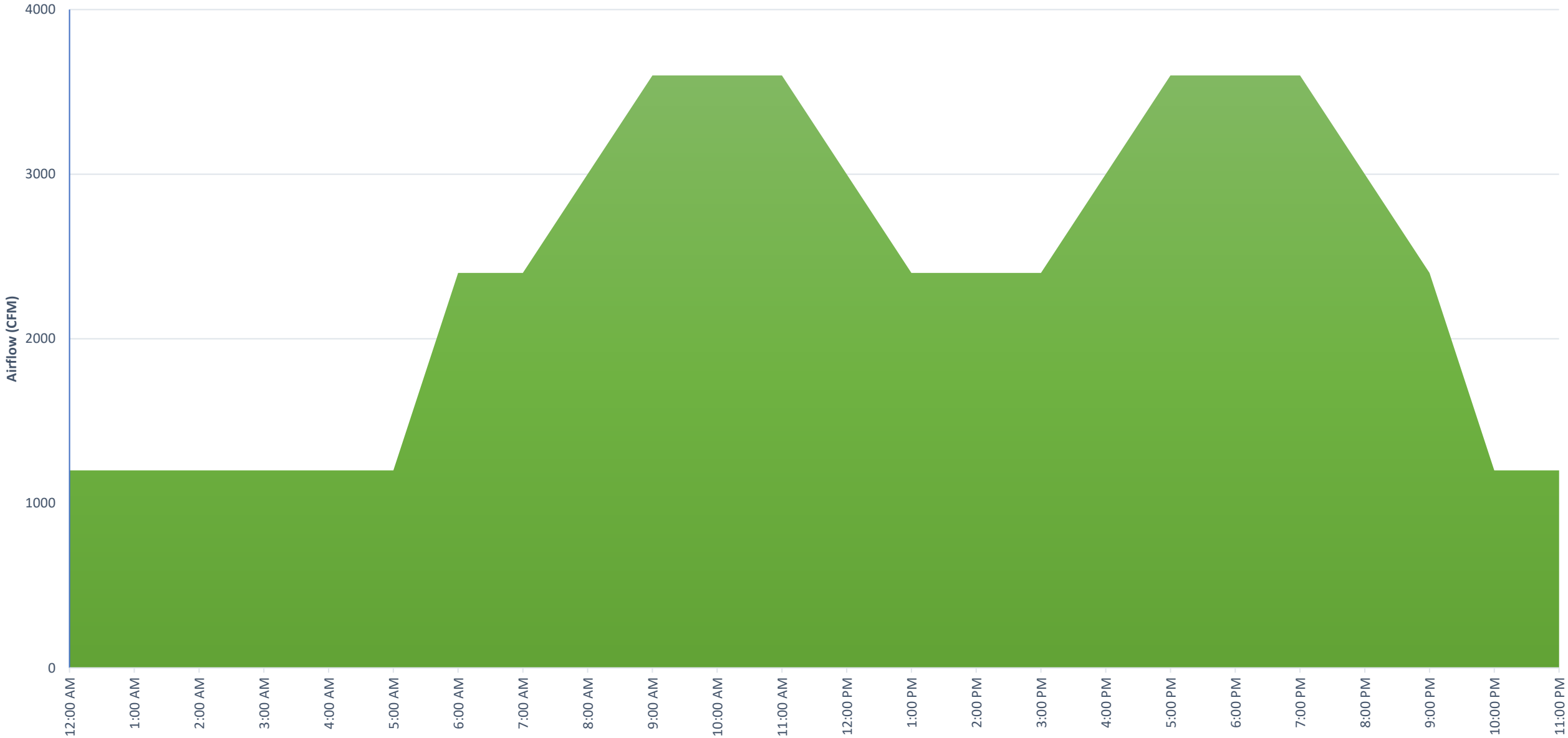
Constant Volume Airflow CFM



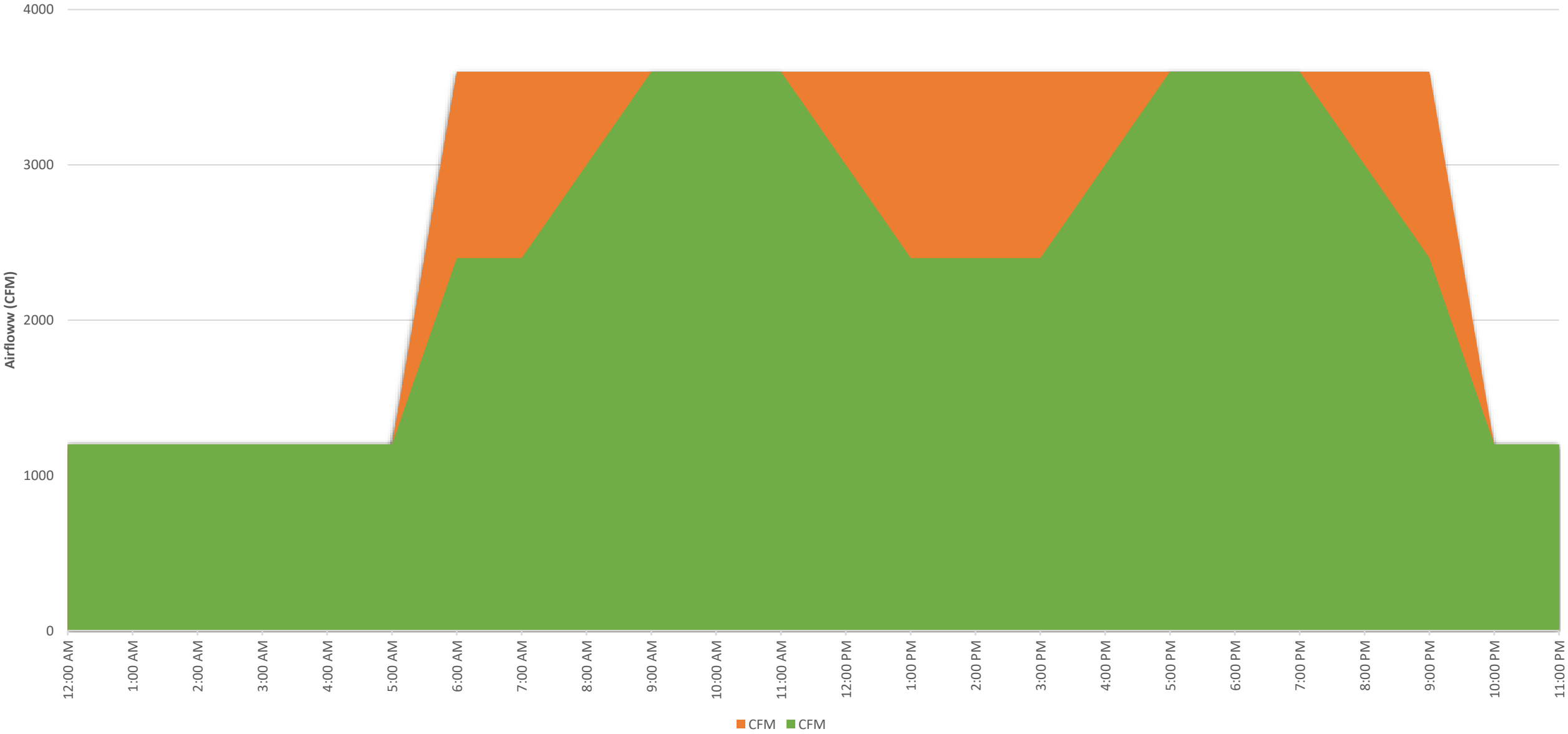
Two-Position Constant Volume Setback Control



Variable Volume Occupied with Unoccupied Setback Control



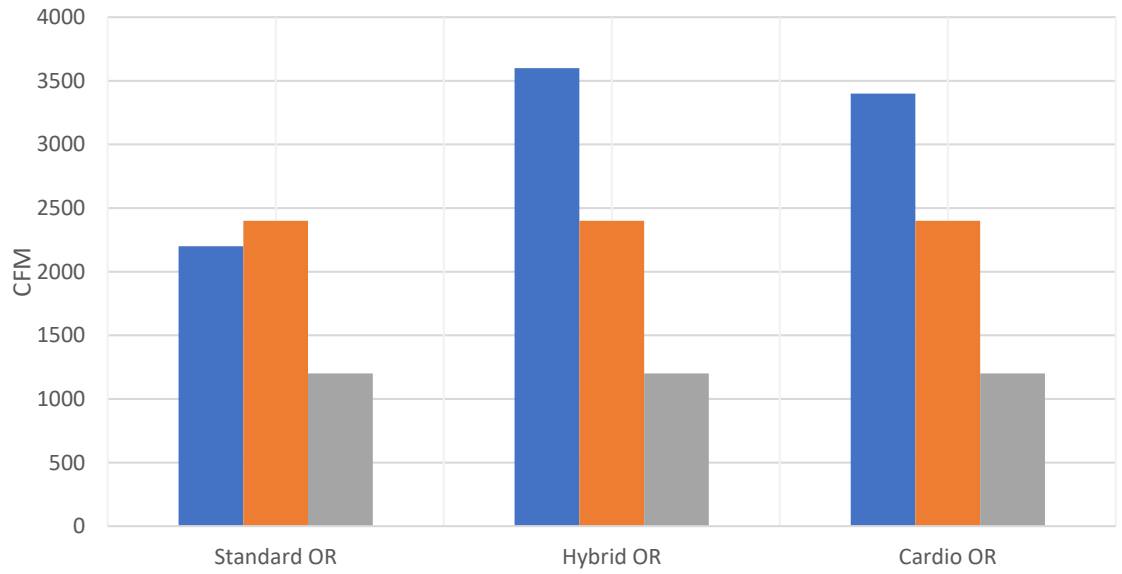
2-Position Setback Control vs. Variable Volume Setback Control



Operating Room Airflow Setback

Two Position Constant Volume Setback

- Simpler Controls
- Higher energy consumption



Variable Volume Occupied with Unoccupied Setback

- Saves fan energy and reheat energy
- More constant supply temperature

	Standard OR	Hybrid OR	Cardio OR
Cooling CFM	2200	3600	3400
Code Required CFM	2400	2400	2400
Unoccupied CFM	1200	1200	1200

Operating Room Airflow Setback

Occupied-Standby-Unoccupied Mode:

a. Space shall have occupied-standby-unoccupied modes which shall be controlled by occupancy schedule and occupancy sensor.

b. When space is scheduled as occupied, air terminal units shall be indexed to operate at maximum airflow setpoint to maintain required airflow offset and at space temperature setpoint. When space is scheduled unoccupied (per BAS Schedule), air terminal units shall be indexed to operate at minimum airflow setpoint with setpoint dead bands in effect for energy savings.

c. Occupancy sensor shall be provided to automatically index to standby mode (unoccupied airflow rate) for reduced ACHs while maintaining space temperature at occupied setpoint for energy savings during scheduled occupancy (per BAS Schedule). Occupancy sensor shall also serve to override scheduled unoccupied mode (per BAS Schedule) and index the space to full occupied mode upon occupancy detection during scheduled unoccupied operation.

d. Manual override switch shall be included in each OR at OR control panel for indexing space to full occupied mode from either scheduled unoccupied mode or standby mode.
   1) Any time the occupancy override switch is pressed, the space shall be indexed to full occupancy mode (maximum ACH and occupied space temperature setpoint) for 120 minutes (FA).

e. Scheduled Occupied Mode (BAS Schedule):
   1) Initial schedule shall be programmed for occupancy between 6:00 am and 6:00 pm Monday through Friday. All other times including weekends and holidays shall be scheduled unoccupied.
   2) Local occupancy sensor places the room in standby mode when occupancy sensor detects no occupancy for 60 minutes (FA) during the occupied scheduled mode.
   3) Local occupancy sensor places the room in occupied mode for 60 minutes (FA) when occupancy sensor detects occupancy during the unoccupied scheduled mode.

f. Scheduled Unoccupied Mode (BAS Schedule):
   1) When schedule reverts to unoccupied mode, air terminal units shall be indexed to minimum flow (minimum ACH), and setpoint dead bands as described in air terminal General section above shall be in effect.
   2) Local occupancy sensor shall index the space from unoccupied operation to full occupied operation for 30 minutes (FA) during scheduled unoccupied mode when occupancy sensor detects occupancy.

Operating Room Airflow Setback

ASHRAE 170 7.1, a, 3:

….For spaces that require a positive or negative relationship, the **number of air changes can be reduced when the space is unoccupied**, provided that the required pressure relationship to adjoining spaces is maintained while the space is unoccupied and that the minimum number of air changes indicated is re-established anytime the space becomes occupied…

OR Type	Occupied CFM	Occupied ACH	Unoccupied CFM	Unoccupied ACH	CFM Delta
Standard OR	2400	20	1167	10	1233
Hybrid OR	3600	25	1167	10	2433
Cardio OR	3400	24	1167	10	2233

Reduction in airflow during scheduled setback or unoccupied mode can save close to 50% airflow, resulting in significant fan energy savings

Based on the “2016 Practice Greenhealth Sustainability Report” :

- HVAC setback in an OR can save close to $3,000 per OR.
- Close to 40% of Healthcare facilities have the OR unoccupied mode programmed as of 2017.

Summary

- ✓ **Why do we care about OR temperature and humidity control?**
- ✓ **How do we meet OR temperature and humidity requirements?**
- ✓ **How do we control OR temperature and humidity?**
- ✓ **How can we save energy and operational costs while maintaining OR temperature and humidity?**

WISCONSIN HEALTHCARE ENGINEERING ASSOCIATION (WHEA)

Operating Room Temperature and Humidity Control

Webinar: July 12, 2018

Affiliated Engineers