HOSPITAL ISOLATION ROOM HVAC SYSTEM DESIGN

Presented to:

ASHRAE YEA Illinois Chapter
Specialty Environment Design Conference
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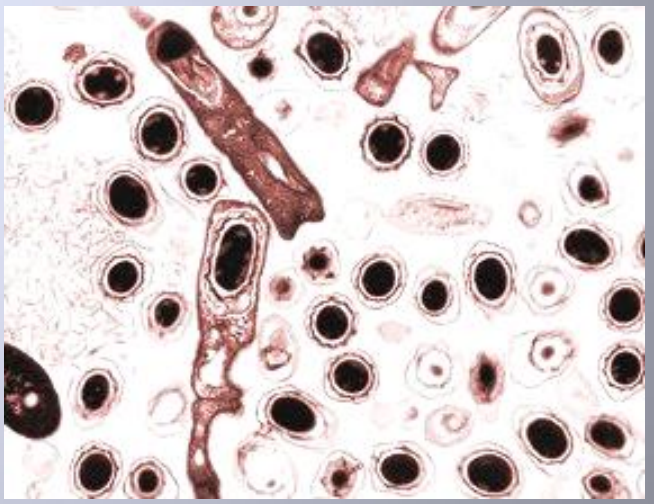

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Hospital Isolation Room HVAC System Design

- Types of Isolation Rooms
- Codes/Standards/References
- Design Criteria
- Design Considerations
- Design Examples

Types of Isolation Rooms

Airborne Infection Isolation (AII) Rooms	• Used to reduce the spread of airborne infectious diseases (TB) from the patient in the AII Room to the rest of the hospital. • Most common type seen in hospitals
Protective Isolation/Environment Rooms	• Used to protect the patient (typically an immune suppressed patient) in the protective environment from common environmental airborne infectious microbes. • Less common than AII
Convertible Isolation Rooms	• Rooms that can be converted from an AII Room (negative) to a Protective Environment Room (positive) • Out of date concept - not allowed by ASHRAE Standard 170
Combination AII/PE Rooms	• Used for an immune suppressed patient who has an infectious disease. • Protects both patient and rest of hospital.

Codes/Standards/References

- "Guidelines for Environmental Infection Control in Health-Care Facilities", Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC), 2003
- Codes:
  - Illinois Administrative Code – will refer to as IDPH
    - Title 77: Public Health
      Chapter I: Department Of Public Health
      Subchapter B: Hospitals And Ambulatory Care Facilities
      Part 250 Hospital Licensing Requirements
    - For HVAC: refer to Section 250.2480 Mechanical
  - International Mechanical Code (IMC) - applicable to most suburbs
  - City of Chicago Building Code
- Standard:
  - ANSI/ASHRAE/ASHE Standard 170 – Ventilation of Health Care Facilities (2013)
  - NFPA 101
- Guidelines
  - Facility Guidelines Institute (FGI) Guidelines (2014) – for ventilation refers to ASHRAE Standard 170 - 2013

Airborne Infectious Isolation Room Design Step 1: Develop HVAC Design Criteria

Temperature, humidity, airflow and pressurization requirements

CDC	IDPH	ASHRAE Standard 170-2013 (incorporates CDC)
• Temp/humidity – not addressed • Min 12 ach exhaust for rooms constructed since 2001 • Min 0.001″H_2O pressure differential to achieve airflow into room (this is too low – need 0.01″ wg)	• 75F • 30% rh winter min, 60% rh summer max • 15 cfm per bed / 10 cfm per bed OA • All air exhausted to outdoors • Airflow into room	• 70F-75F – ability to maintain at all times • 60%rh • 12 ach minimum total airflow/2 ach outside air • All air exhausted to outside • Negative pressure relative to adjacent spaces

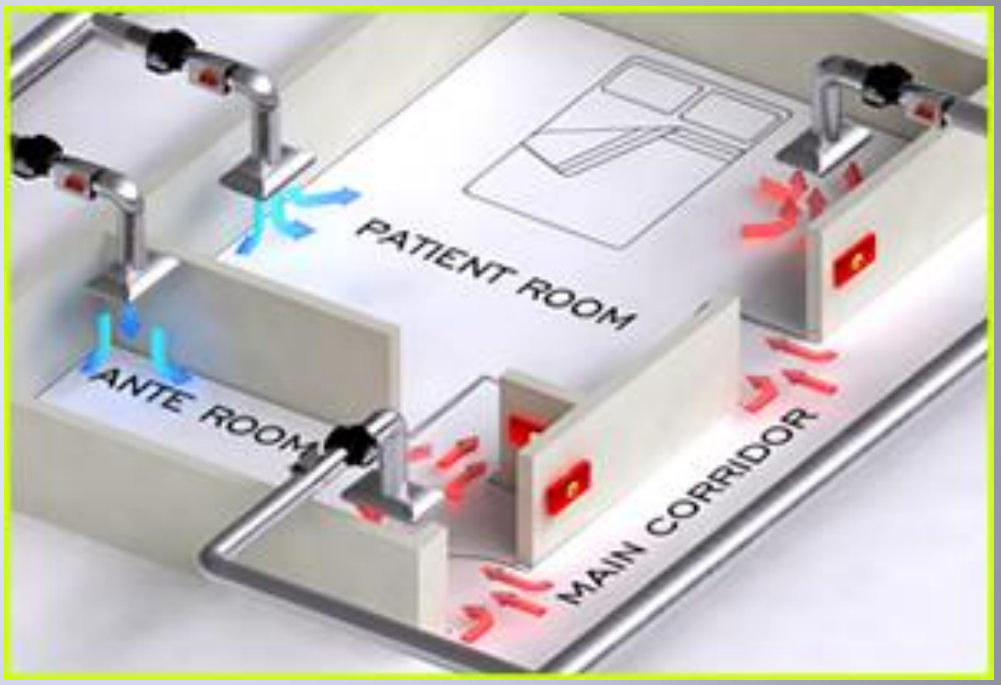
Airborne Infectious Isolation Room
Design Step 1:
Develop HVAC Design Criteria

Use most stringent of IDPH/ASHRAE Standard 170

Temperature:	70F to 75F
Humidity:	30% rh winter min, 60% rh summer max
Airflow:	12 ach total/ 2 ach OA
Pressure:	Negative to adjacent areas

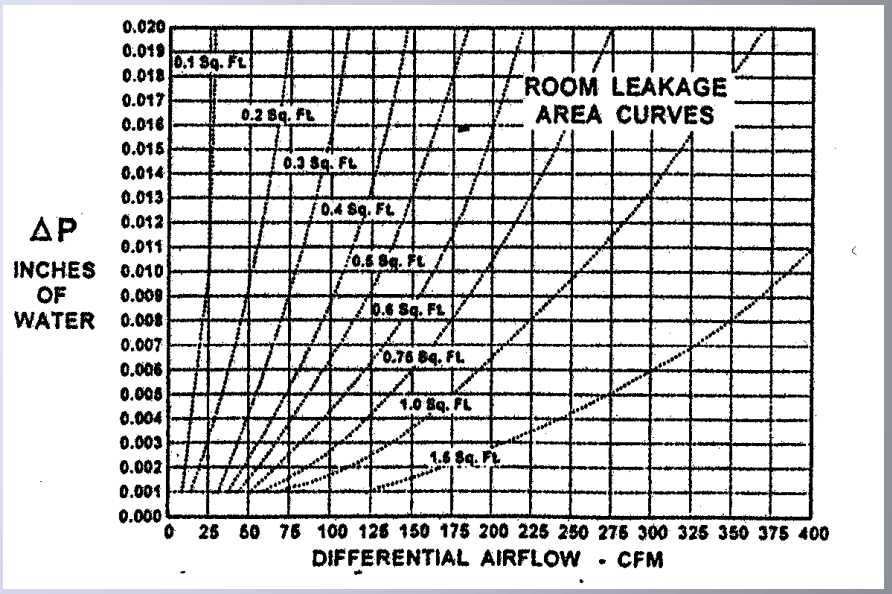
Airborne Infectious Isolation Room Architectural Design Considerations

- Ante room with hand wash sink (IDPH Section 250-2440)
  - Note not required by FGI or ASHRAE
- One toilet room per AII room



Airborne Infectious Isolation Room Architectural Design Considerations

- AII room constructed to minimize leakage areas and allow for room pressurization
  - Walls – slab-to-slab
  - Ceilings – plaster or drywall
  - Self-closing doors (swing out for negatively pressurized spaces; swing in for positively pressurized spaces) with door sweeps
  - Sliding doors preferred
  - Finishes should be smooth and cleanable
  - Label room use (signage)
  - Seal all penetrations



Airborne Infectious Isolation Room Pressurization Design Considerations

AII room negative to ante room/ante room negative to corridor (ASHRAE)

Min ΔP between AII room and adjacent rooms/corridor -0.01″ wg (ASHRAE)

Min of 10% more EA than SA but no less than 50 cfm

- New tight construction - 200cfm to 300 cfm differential
- Poorly constructed - 300 cfm to 500 cfm

Permanently installed ΔP monitoring device (ASHRAE)

Provide provisions to change HVAC for normal patient care room use (IDPH only/different than ASHRAE)

Airborne Infectious Isolation Room
Room Supply and Exhaust Design Considerations

- Ante room airflow: 10 ach (ASHRAE)
- Location of supply diffusers and exhaust grilles - CDC 2003 and ASHRAE Standard 170 disagree
  - CDC 2003: Supply above patient, exhaust low on wall
  - ASHRAE Standard 170 2008/2013: "Exhaust grilles or registers … shall be located directly above the patient bed on the ceiling or on the wall near the head of the bed…"
  - Designer may consider discussing discrepancy with hospital infection control.
  - If chose to supply above patient use non-aspirating laminar flow type diffusers

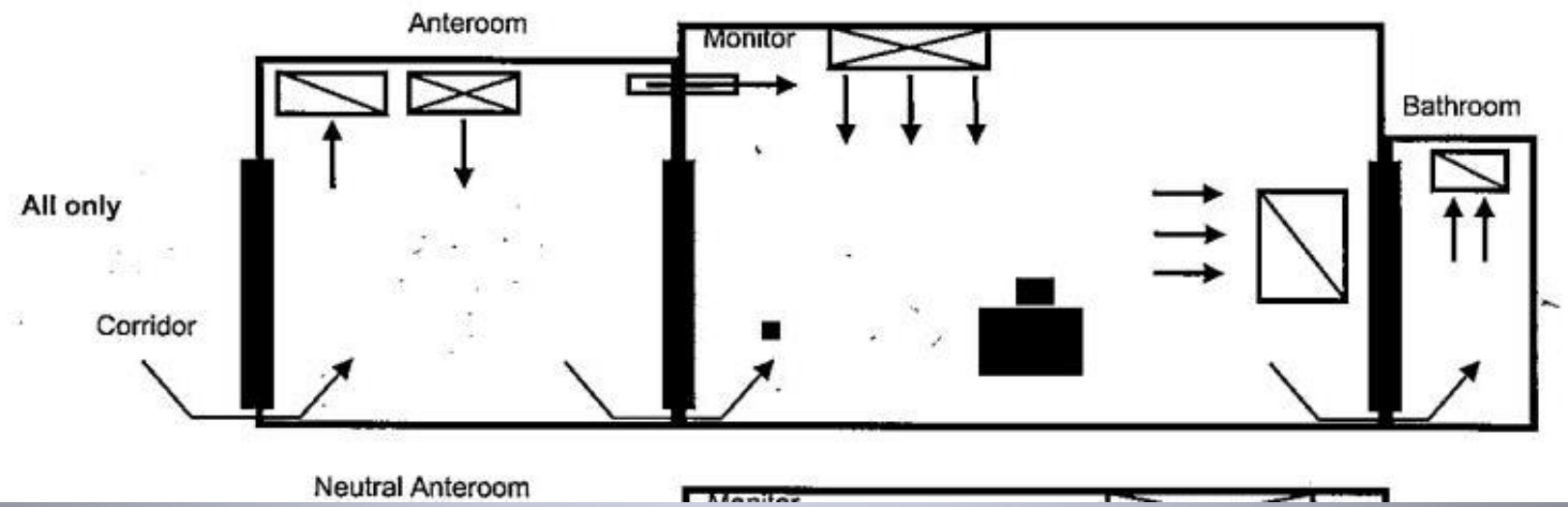
Airborne Infectious Isolation Room
Other Design Considerations

- SA must be from AHU that has code-required filtration:
  - Min MERV 7 prefilters and MERV 14 final filters (IDPH/ASHRAE)
- Exhaust air from AII/ante room/toilet room shall not mix with non-AII room exhaust (ASHRAE)
- Induction units and baseboard heaters should be avoided – surfaces must be cleanable. Use radiant panels of perimeter heat is required

Airborne Infectious Isolation Room Airflow Diagram

Diagram from CDC Guidelines

Figure 4. Example of airborne infection isolation (AII) room with anteroom and neutral anteroom* + §



Airborne Infectious Isolation Room Room HVAC Design Example

Exhaust system:

- EA from AHII to maintain 12 ach: 1,500 cfm
- Toilet exhaust: 100 cfm
- EA from ante room to maintain 10 ach: 250 cfm
- Constant volume exhaust box to maintain EA / Total EA = 1,400 cfm + 100 cfm + 250 cfm = 1,750 cfm

Transfer air from corridor to ante room and ante room to AII room

- Assume mid range in tightness – use 300 cfm transfer air (TA)

Supply system:

- AII SA = EA–TA from ante room + TA to toilet /AII SA = 1,400 cfm – 300 cfm + 100 cfm = 1,200 cfm
- Constant volume box to maintain total SA / Total SA = 1,200 cfm + 250 cfm = 1,450 cfm
- SA to ante room: 250 cfm (Ante room neutral)
- Reheat coil to provide space temperature control

Airborne Infectious Isolation Room Room HVAC Design Example

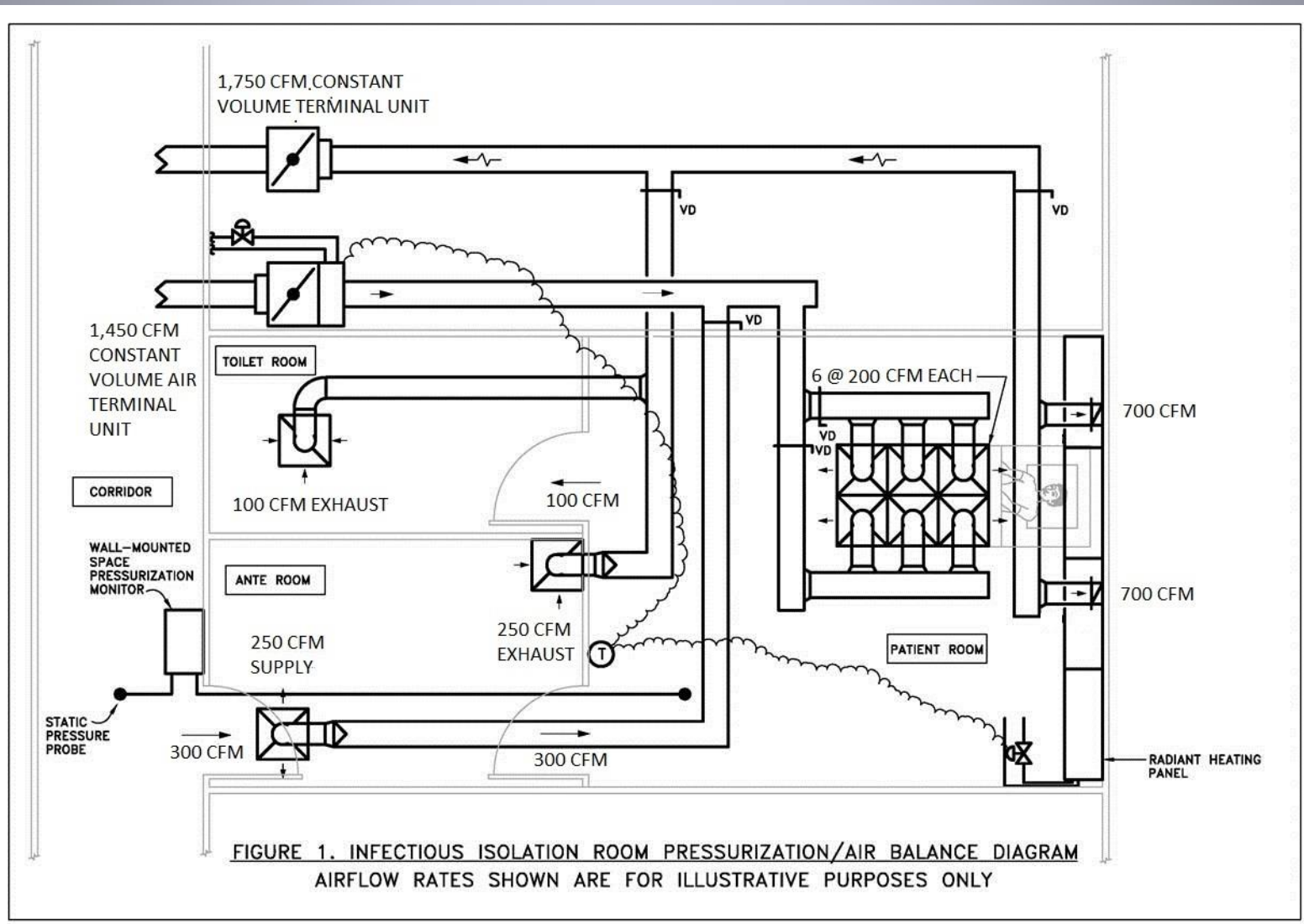


FIGURE 1. INFECTIOUS ISOLATION ROOM PRESSURIZATION/AIR BALANCE DIAGRAM
AIRFLOW RATES SHOWN ARE FOR ILLUSTRATIVE PURPOSES ONLY

Airborne Infectious Isolation Room Room HVAC Design Example

- Example of a AII Ventilation Schedule (numbers do not match example

IDPH VENTILATION SCHEDULE - LEVEL TWO - CONTINUED

ROOM NUMBER	ROOM NAME	ROOM FUNCTION	ROOM DATA				IDPH CODE REQUIREMENTS				
			AREA (SQ.FT.)	CEILING HEIGHT (FT.)	VOLUME (CU. FT.)	NUMBER OF OCCUP.	AIRFLOW			AIR CHANGES PER HOUR (ACH)	SPACE PRESSURIZATION (+, -, N)
							SUPPLY (CFM)	RETURN (CFM)	EXHAUST (CFM)		
2-122	PED ISOL 122	INFECTIOUS ISOLATION ROOM	382	9	3,247	5	541	NR	649	12	(-)
2-122A	TOILET 122	TOILET ROOM	51	8	408	1	NR	NR	68	10	(-)
2-122B	ANTE	ISOLATION ROOM ANTEROOM	56	9	476	0	79	NR	NR	10	(+) or (-)

DESIGN							SERVED BY SYSTEM			REMARKS
AIRFLOW			% OF IDPH CODE REQ. SUPPLY AIRFLOW	% OF IDPH CODE REQ. EXHAUST AIRFLOW	AIR CHANGES PER HOUR (ACH)	SPACE PRESSURIZATION (+, -, N)	SUPPLY	RETURN	EXHAUST	
SUPPLY (CFM)	RETURN (CFM)	EXHAUST (CFM)								
625	0	700	115%	108%	13	(-)	AHU-30&31	-	IE-1	
0	0	125	NR	184%	18	(-)	-	-	IE-1	
150	0	100	189%	NR	19	(+)	AHU-30&31	-	IE-1	

Airborne Infectious Isolation Room Room HVAC Design Example

Example simplified AII room sequence of operation, including IDPH required switch to neutral:

- Modulate supply CAV air terminal unit damper to maintain supply airflow setpoint.
- Modulate exhaust air terminal unit damper to maintain exhaust airflow setpoint.
- Modulate reheat valve and radiation valve to maintain temperature setpoint.
- Coordinate with users to setup time delay to allow entrance/exit to the pressurized space without audible alarm.
- If an exhaust fan failure alarm is received at the front end, close the supply air terminal damper operator.
- When room pressurization state is set to neutral:
  - The BAS shall change CV air terminal unit setpoint such that the AII exhaust airflow is equal to the supply airflow – accounting for TE
  - SA = 1,200 cfm
  - EA=SA-TA to toilet=1,100 cfm

Airborne Infectious Isolation Room with IDPH Required Neutral State

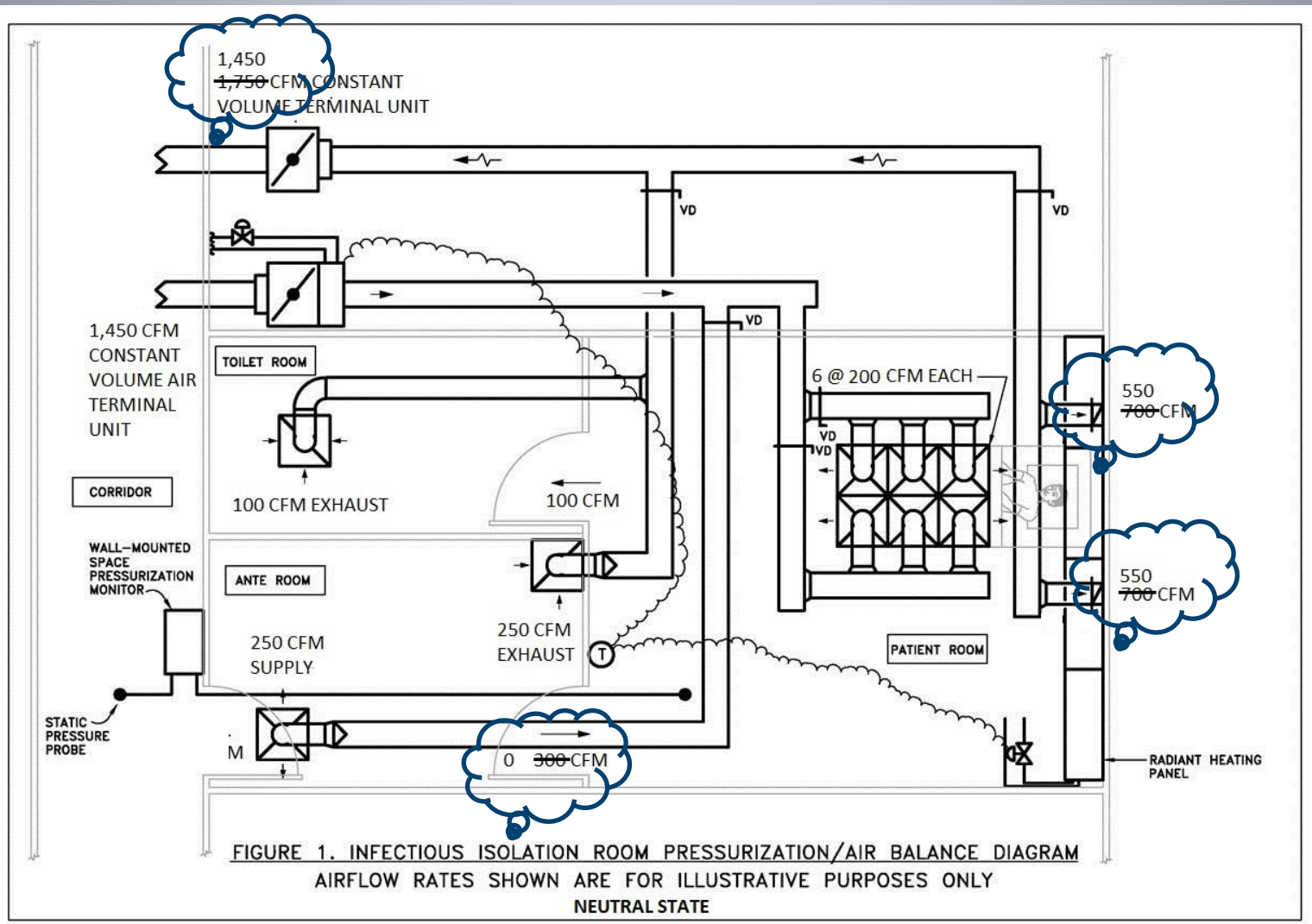


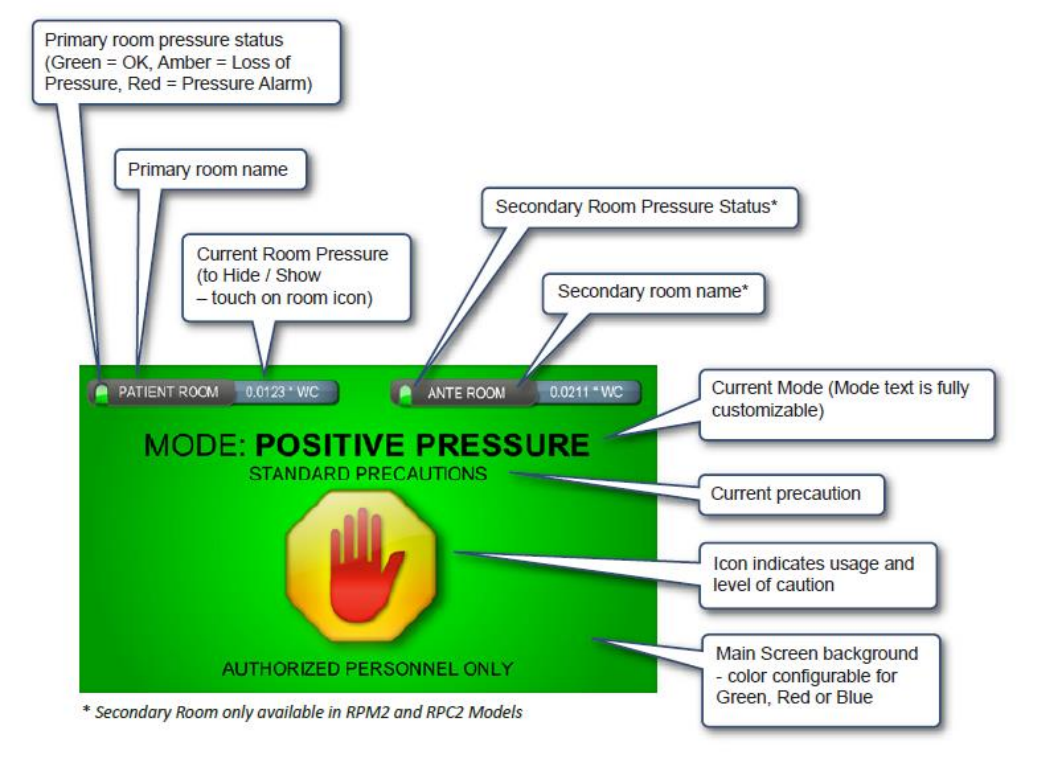
FIGURE 1. INFECTIOUS ISOLATION ROOM PRESSURIZATION/AIR BALANCE DIAGRAM
AIRFLOW RATES SHOWN ARE FOR ILLUSTRATIVE PURPOSES ONLY
NEUTRAL STATE

Airborne Infectious Isolation Room Room Pressure Monitors

- Locate outside of ante room door in corridor
- Alarms visually and audibly if negative pressure is not maintained.
- Tie-in alarm to building automation system
- To avoid nuisance alarms, control to a higher point ΔP than to the ΔP at which the alarm is set
  - Control to 0.03” and alarm at 0.01”.

Airborne Infectious Isolation Room Room Pressure Monitors

- Look for monitors that are easy for nursing staff to read and understand.



Airborne Infectious Isolation Room Central System Design

- Exhaust System
  - Locate exhaust fan outside, if possible
  - If exhaust fan is inside, use welded duct construction downstream of fan
  - Bag in/bag out prefilter/HEPA filter upstream of the exhaust fan
  - VFDs for the exhaust fan to adjust fan speed as filters load up
  - Locate fan discharge away from all intakes and above roof, if possible
  - Consider large exhaust system to serve multiple rooms instead of multiple smaller exhaust systems
  - Provide emergency power for fans

Airborne Infectious Isolation Room Central System Design

- Supply System
  - Can supply from same AHU system that serves adjacent patient rooms
  - Must have Min MERV 7 prefilters and MERV 14 final filters (IDPH/ASHRAE)
  - Must be able to humidify to IDPH required 30% rh

Protective Isolation Room
Design Step 1:
Develop HVAC Design Criteria

Use most stringent of IDPH/ASHRAE Standard 170

Temperature:	70F to 75F
Humidity:	30% rh winter min, 60% rh summer max
Airflow:	12 ach total/ 2 ach OA
Pressure:	Positive to adjacent areas

Protective Environment Room Pressurization Design Considerations

PE room positive to ante room/ante room positive to corridor (ASHRAE)

Min ΔP between PE room and adjacent rooms/corridor +0.01" wg (ASHRAE)

Min of 10% more SA than EA but no less than 50 cfm

- New tight construction - 200cfm to 300 cfm differential
- Poorly constructed - 300 cfm to 500 cfm

Permanently installed ΔP monitoring device (ASHRAE)

Provide provisions to change HVAC for normal patient care room use (IDPH only/different than ASHRAE)

Protective Isolation Room
Room Supply and Exhaust Design Considerations

- Same requirements as All room except:
  - Location of supply diffusers and exhaust grilles
    - ASHRAE Standard 170 “Supply diffusers shall be above the patient bed… Diffuser design shall limit air velocity at patient bed to reduce patient discomfort
    - ASHRAE Standard 170 “Return/exhaust grilled shall be locate near the patient door.”
  - SA must be from AHU that has code-required filtration:
    - Min MERV 7 prefilters and HEPA final filters (ASHRAE) or
    - MERV 14 final filters with terminal HEPA filter

Airborne Infectious Isolation Room Room HVAC Design Example

Supply system:

- SA from PE to maintain 12 ach: 1,400 cfm
- SA to ante room: 250 cfm
- Constant volume box to maintain total SA / Total SA = 1,400 cfm + 250 cfm = 1,650 cfm
- Reheat coil to provide space temperature control

Transfer air from PE room to ante room and ante room to corridor

- Assume mid range in tightness – use 300 cfm transfer air (TA)

Return/Exhaust system:

- Air from ante room and PE room may be returned to AHU / RA from Ante Room: 250 cfm
- Toilet exhaust must be exhausted to outside / TE: 100 cfm
- PE room RA = PE room SA – TA to ante room – TA to toilet = 1,400 cfm - 300 cfm - 100 cfm = 1,000 cfm
- Constant volume box to maintain total RA
- Total RA = RA from PE room + RA from ante room = 1,000 cfm + 250 cfm = 1,250 cfm

Protective Environment Room
Room HVAC Design Example

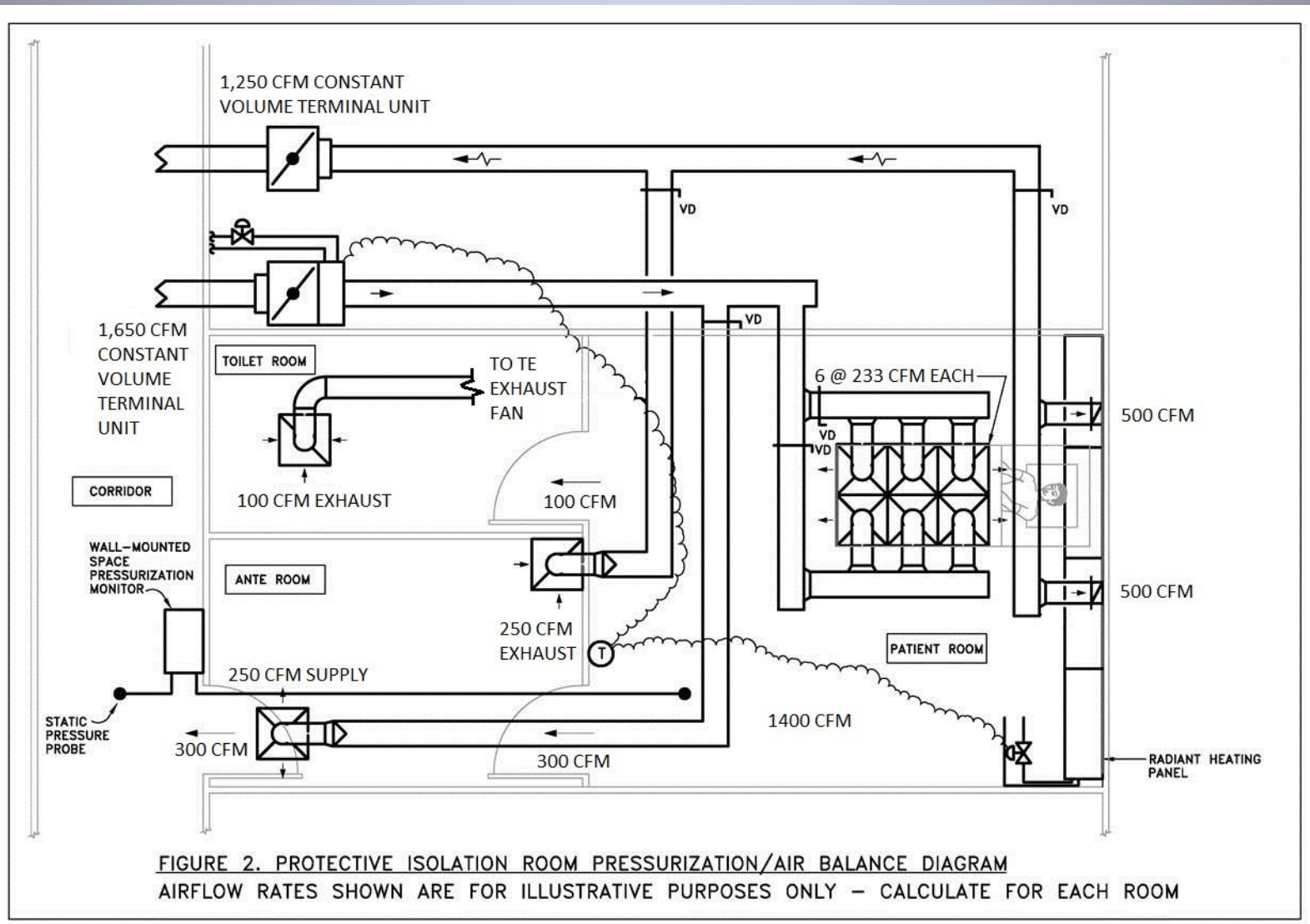
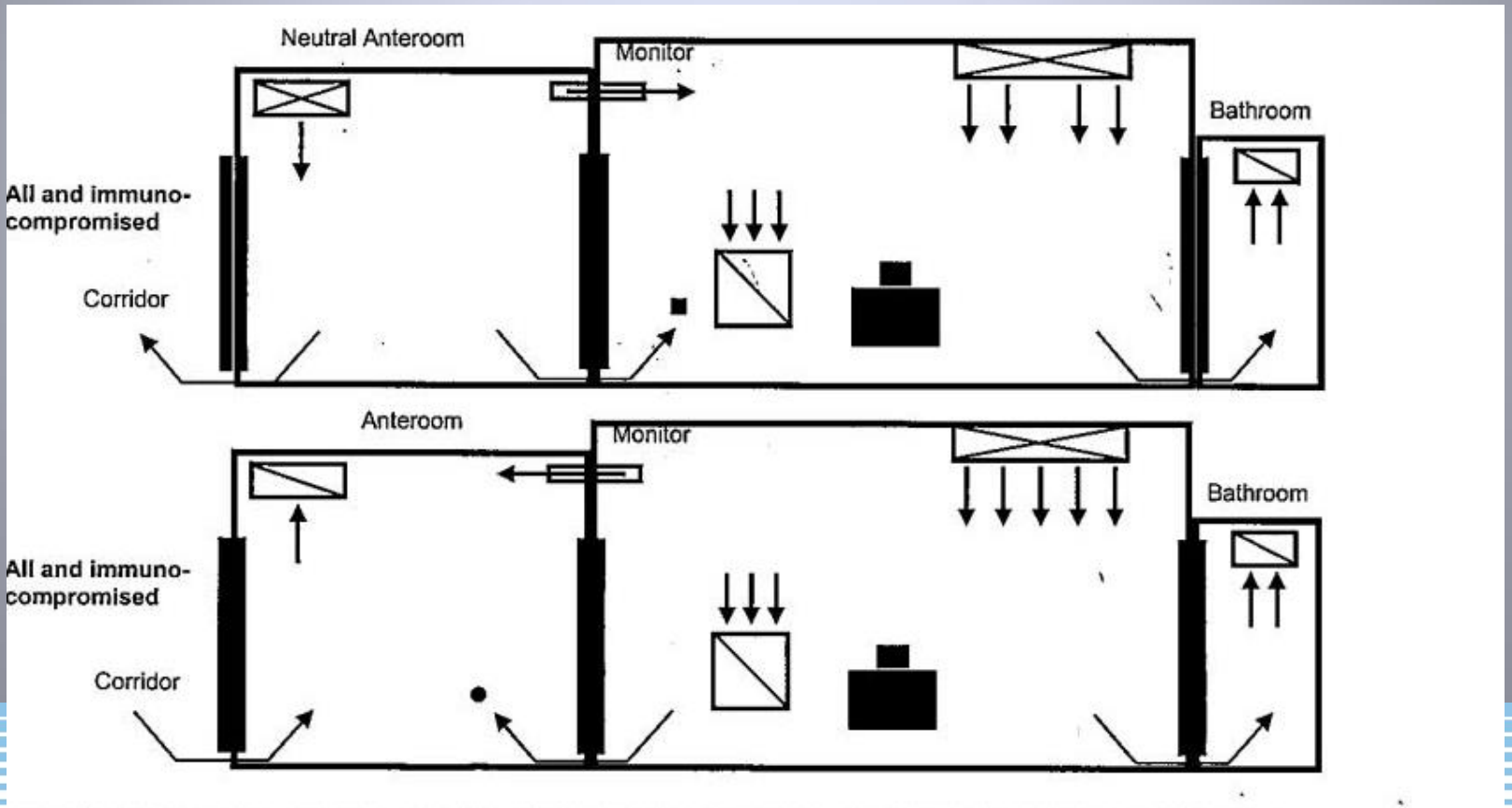


FIGURE 2. PROTECTIVE ISOLATION ROOM PRESSURIZATION/AIR BALANCE DIAGRAM
AIRFLOW RATES SHOWN ARE FOR ILLUSTRATIVE PURPOSES ONLY – CALCULATE FOR EACH ROOM

Combination Airborne Infectious Isolation/Protective Environment Rooms

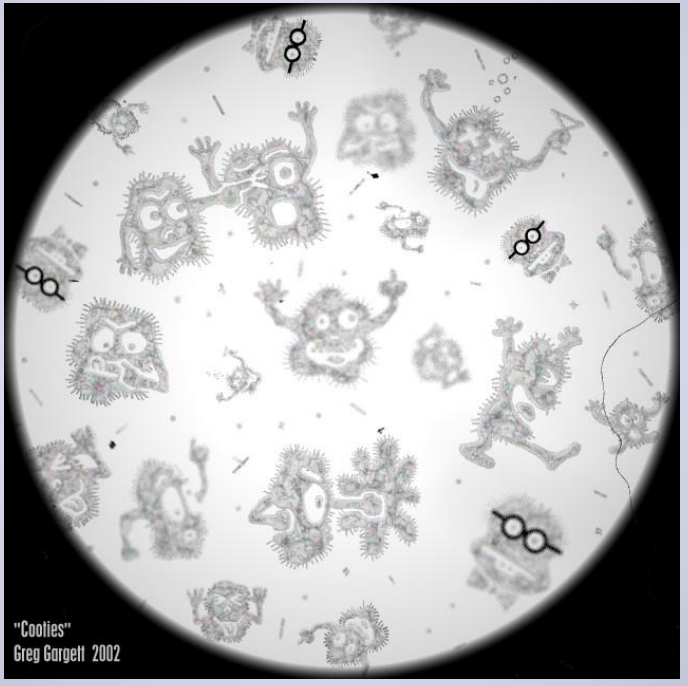
- For immune suppressed patients with a airborne infectious disease
- CDC and ASHRAE 170 allow two options: positive or negative ante room



Combination Airborne Infectious Isolation/Protective Environment Rooms

- PE requirements govern supply diffuser and exhaust grille locations:
  - ASHRAE Standard 170 “Supply diffusers shall be above the patient bed.
  - ASHRAE Standard 170 “Return/exhaust grilled shall be locate near the patient door.”
- Two permanently installed monitoring devices are required
  - One between the AII/PE room and the ante room
  - One between the ante room and the corridor

Thank You



Questions?