Hospital Critical Environments
Operating Rooms, Pharmacies
Pressurization, Night setbacks & Energy Savings

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Session Learning Objectives

Commissioning Hospitals

At the end of this session participants will be able to:

1. Identify and use unique systems approaches when undertaking an energy optimization project
2. Leverage energy savings approaches specific to in healthcare EBCx
3. Apply the latest OR pressurization codes and standards for occupied and unoccupied modes
4. Test, commission and optimize pressure dependent spaces

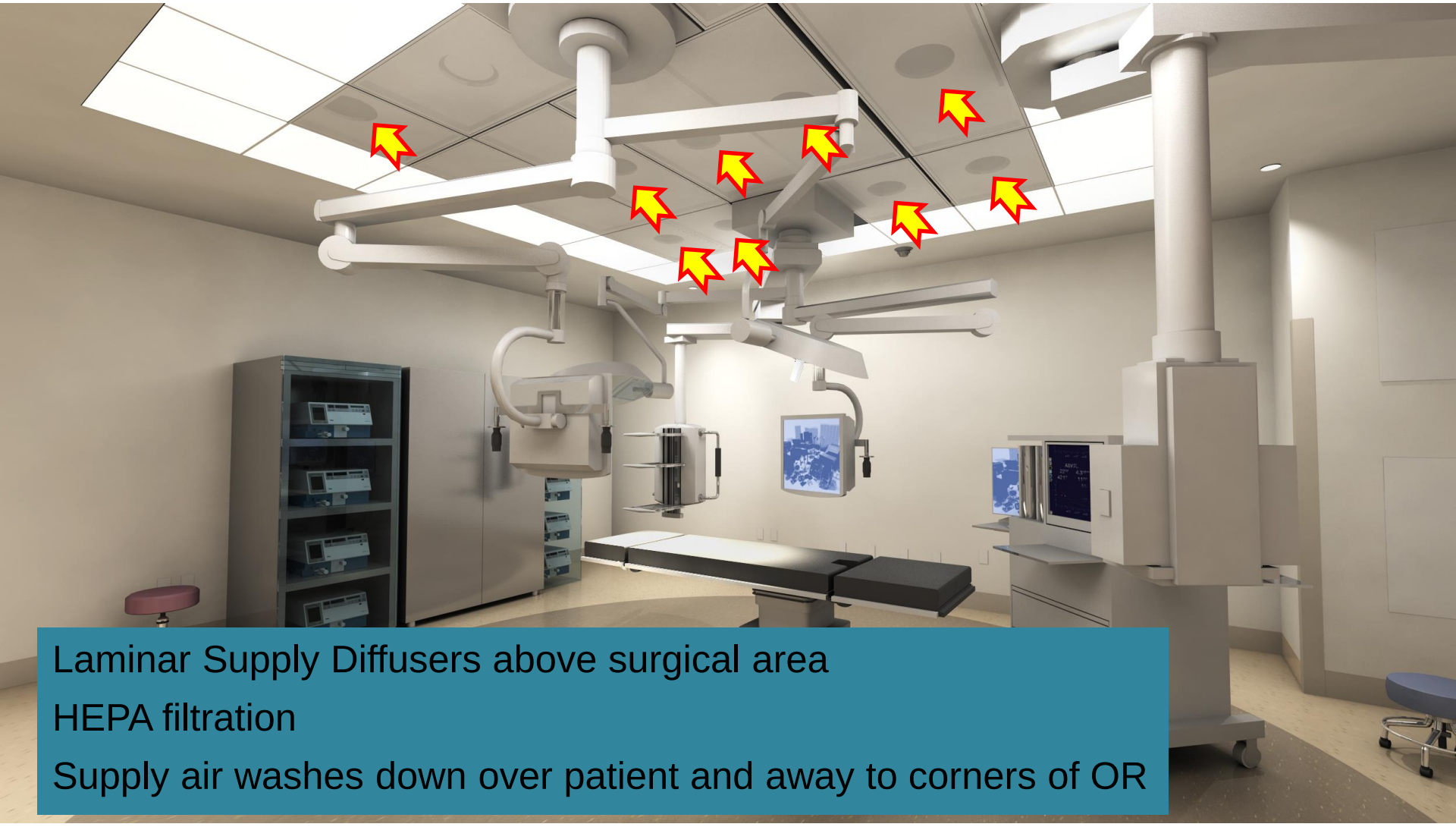
Presentation Learning Objectives

At the end of this presentation participants will be able to:

- Understand the general design approach, pressurization relationships and codes pertaining to operating rooms
- Understand various approaches to setting back operating rooms during unoccupied hours and the associated codes
- Review energy savings potential from operating room setback
- Understand building pressurization, and sequences or operations (fan tracking) to achieve pressurized buildings

Design, Codes, and Air Changes per Hour (ACH)

General Design – Supply Air

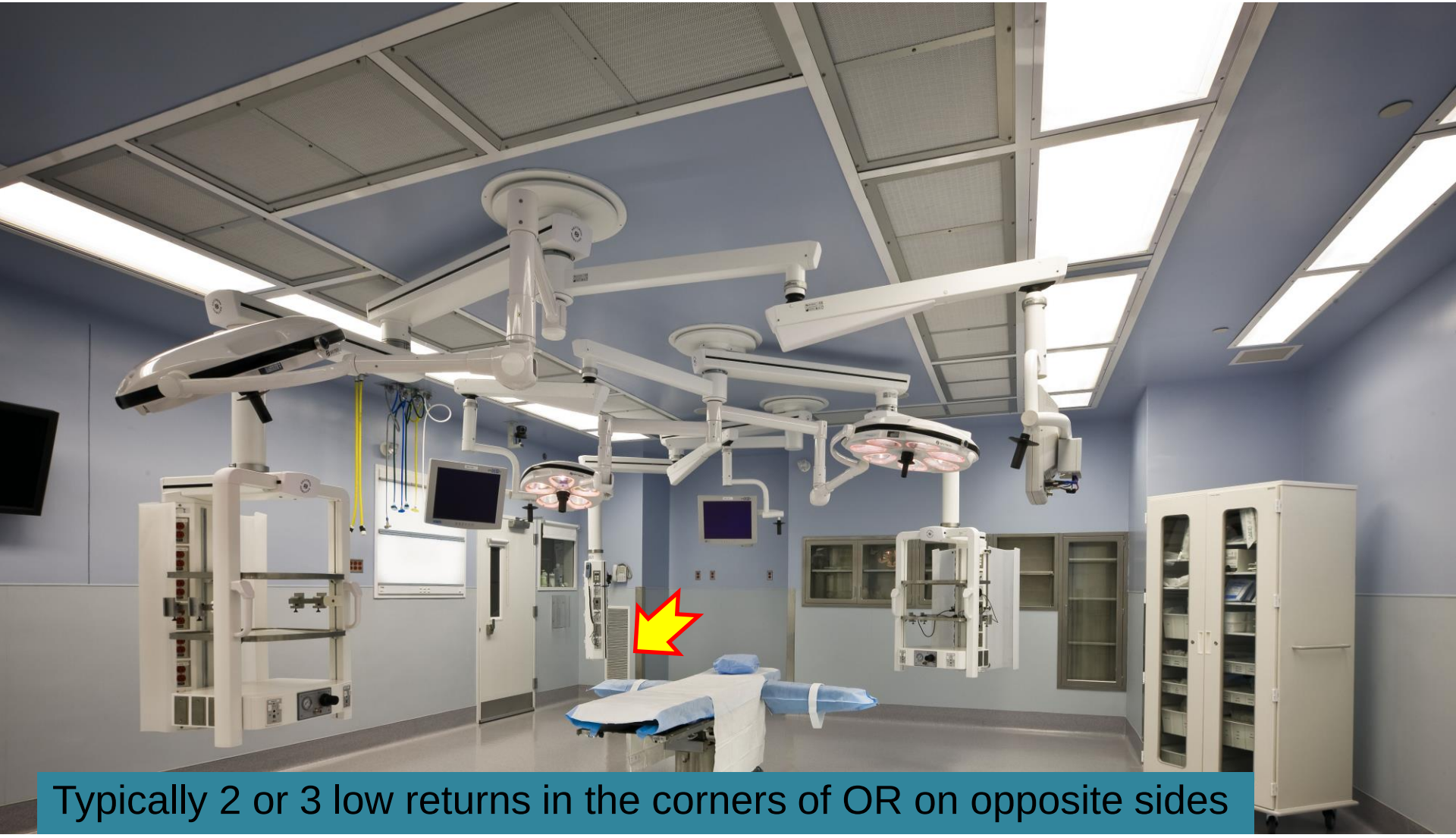


Laminar Supply Diffusers above surgical area

HEPA filtration

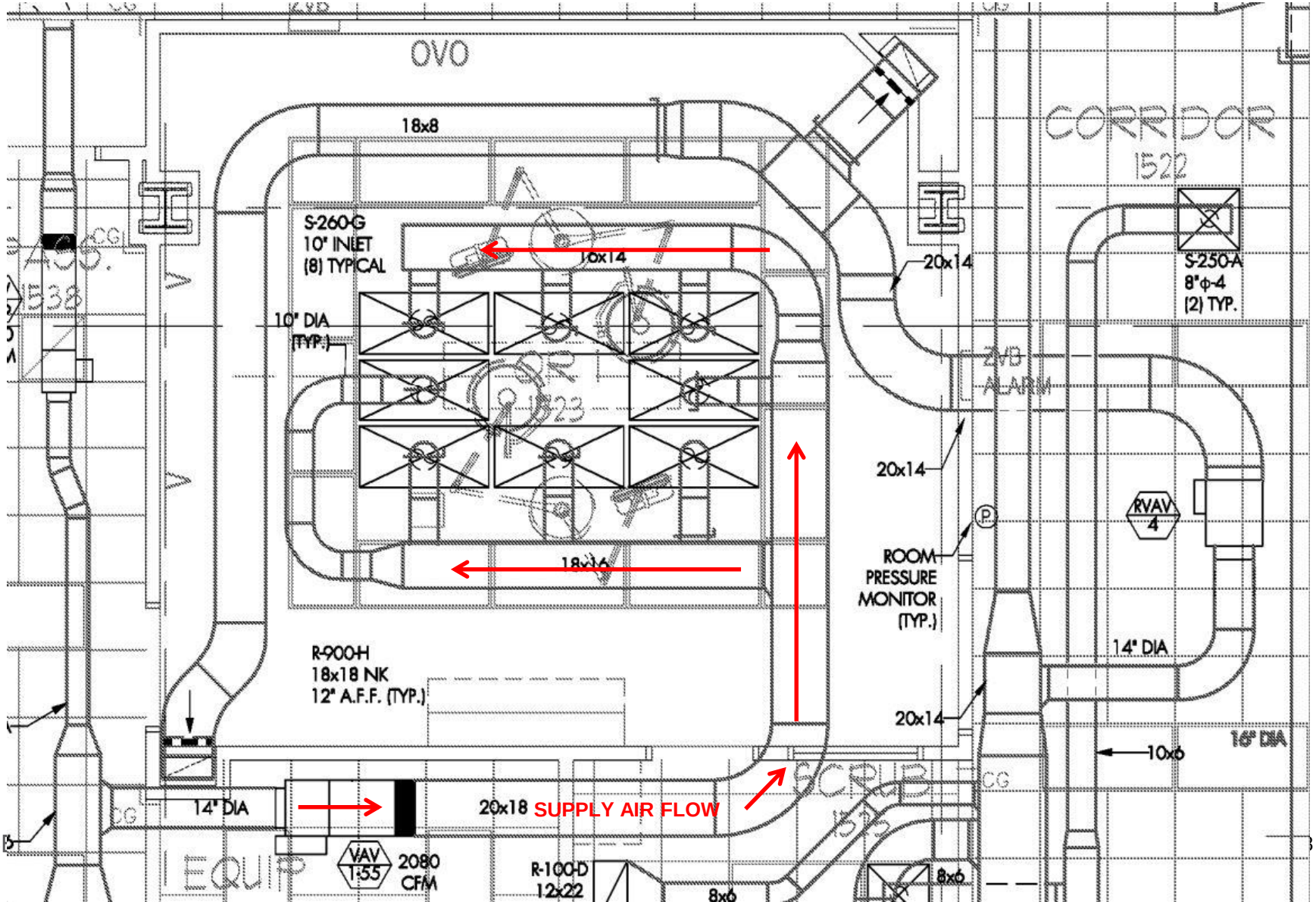
Supply air washes down over patient and away to corners of OR

General Design – Return Air

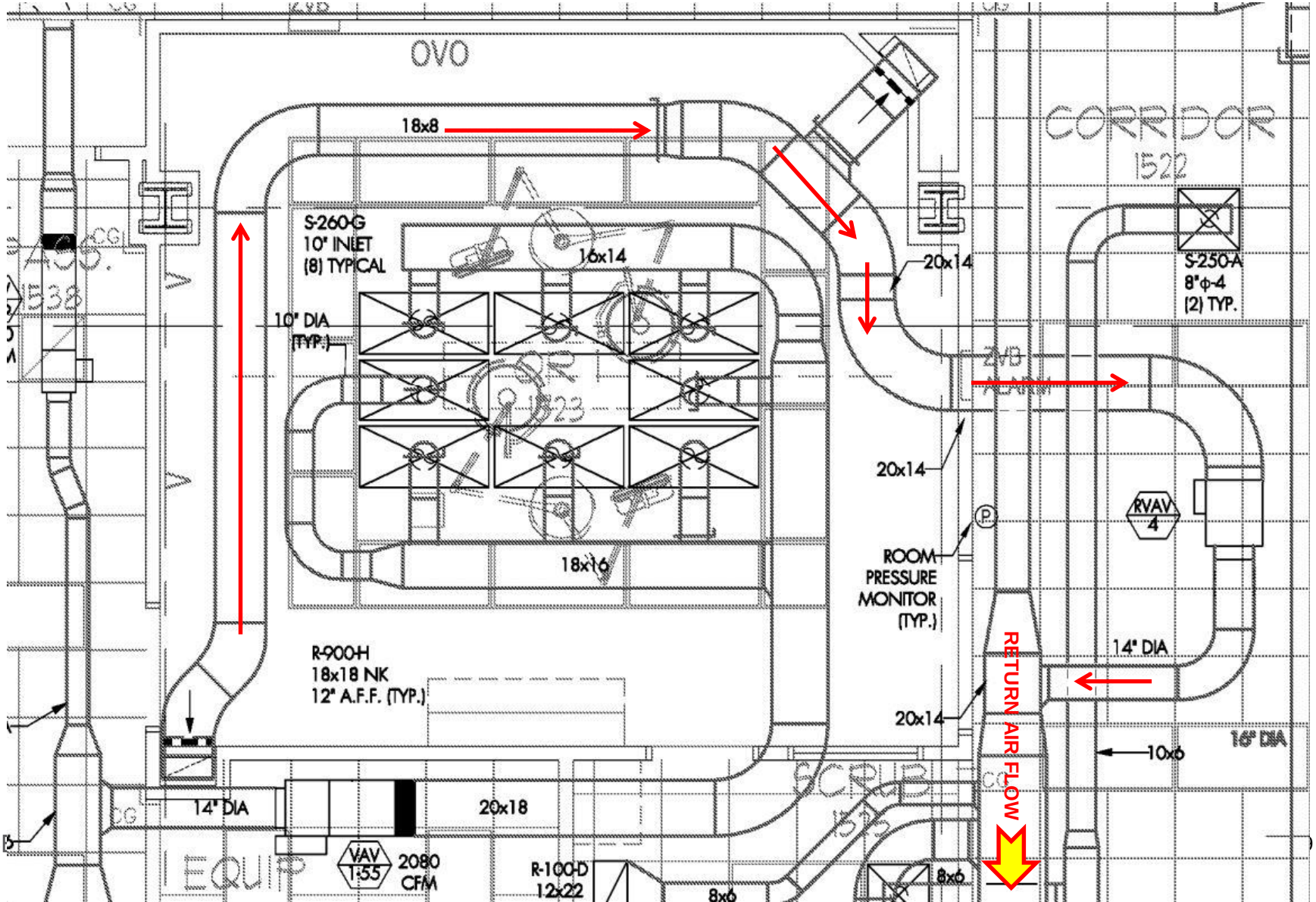


Typically 2 or 3 low returns in the corners of OR on opposite sides

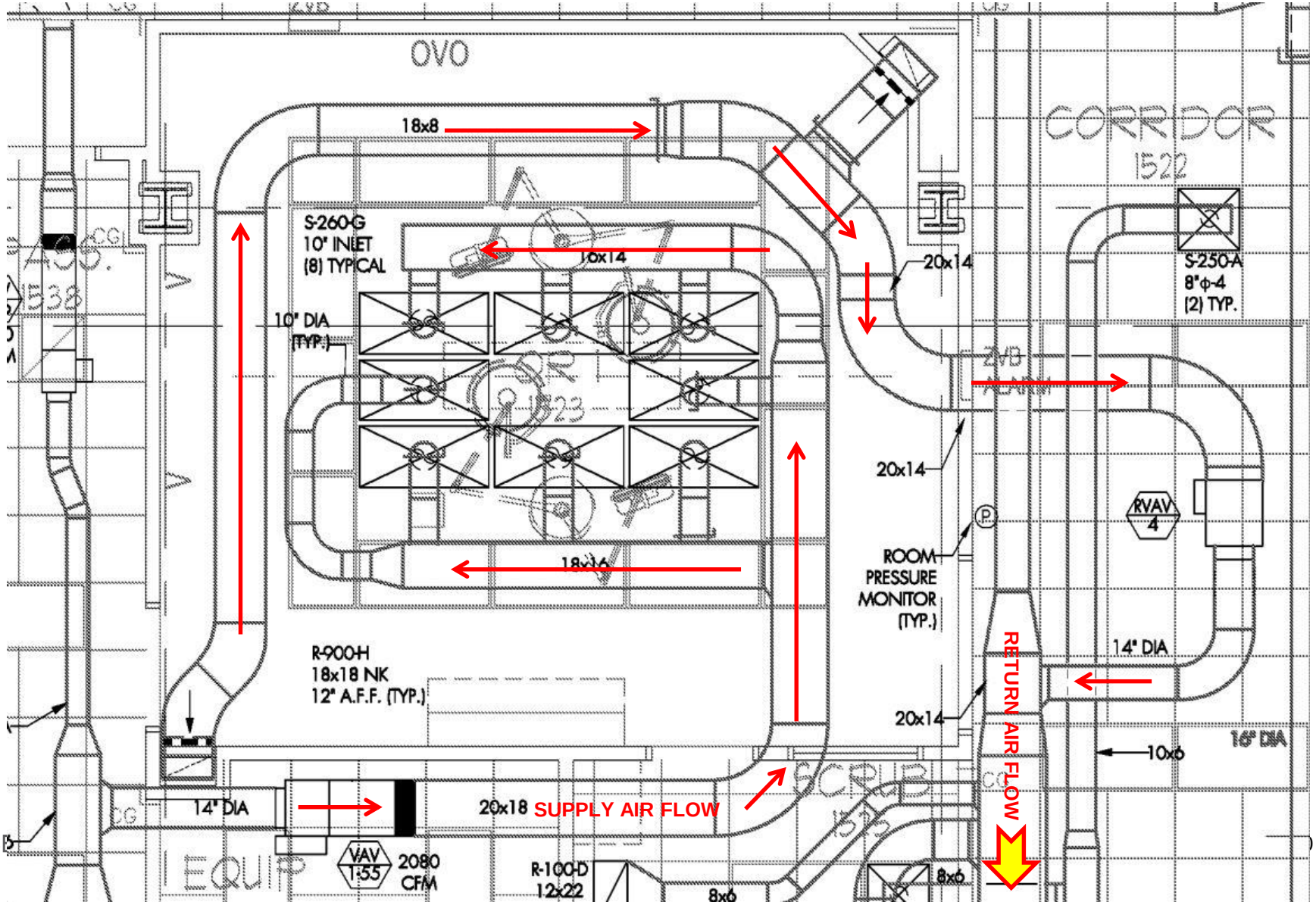
General Design – Supply Air



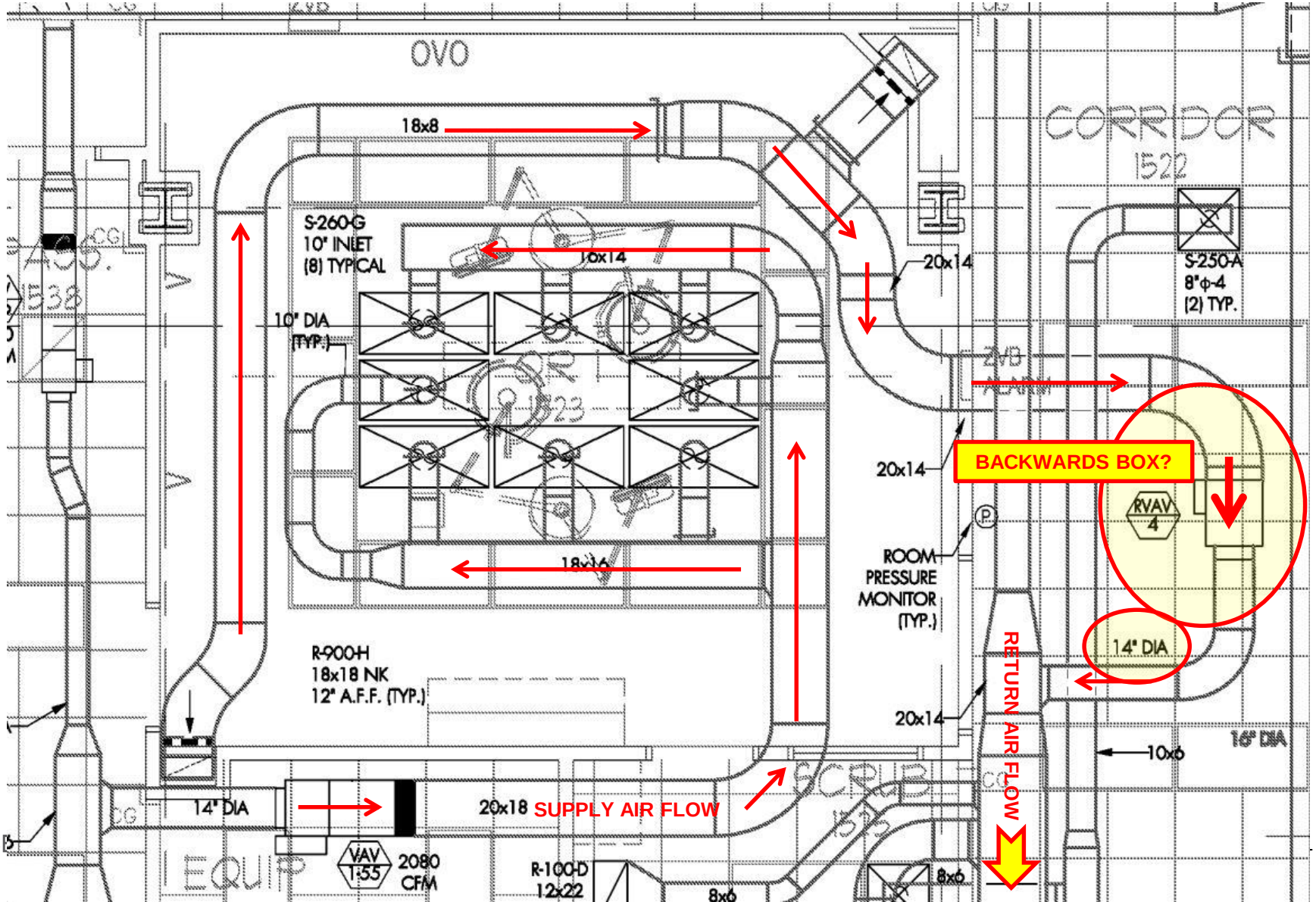
General Design – Return Air



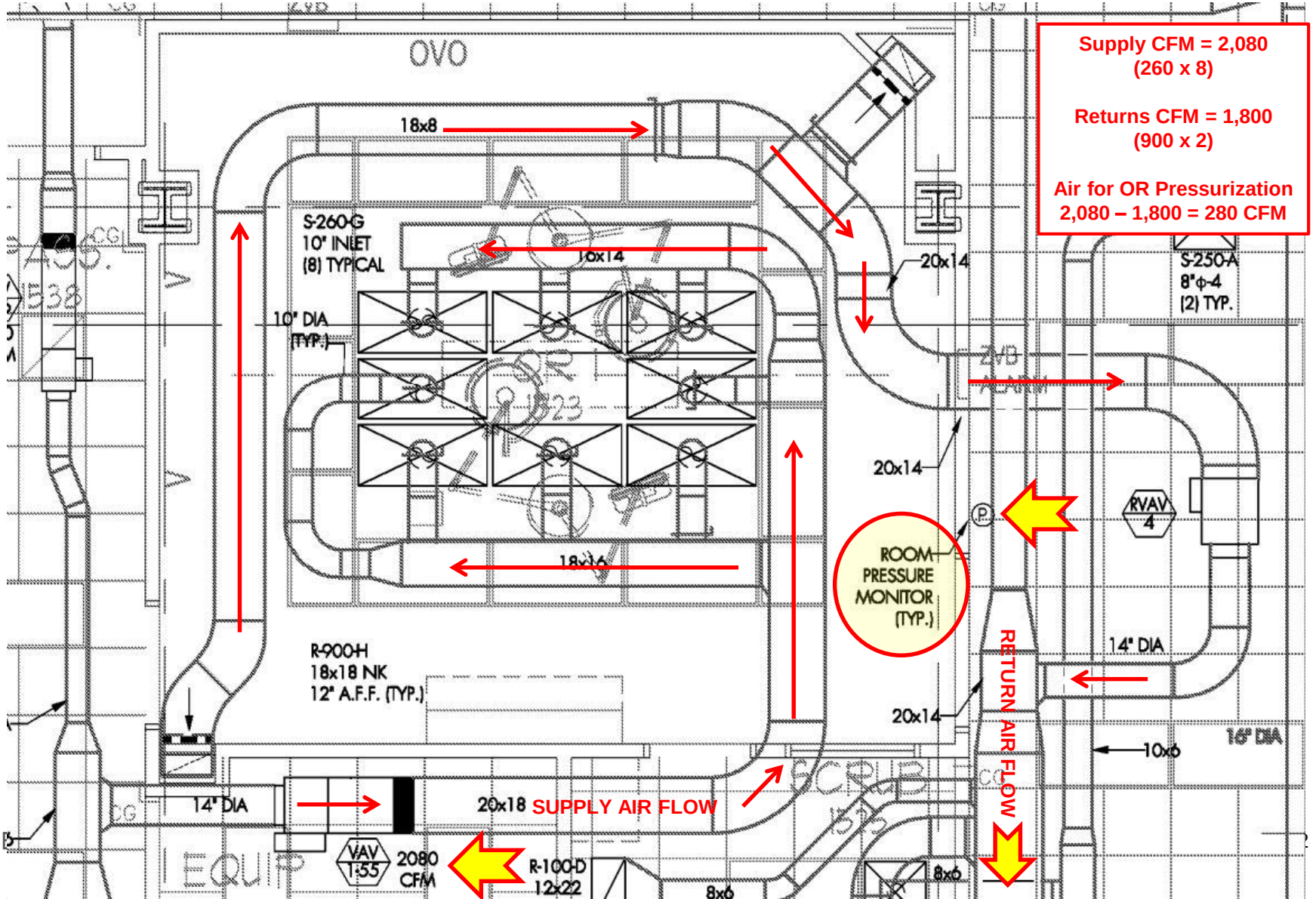
General Design – Supply and Return Airflow



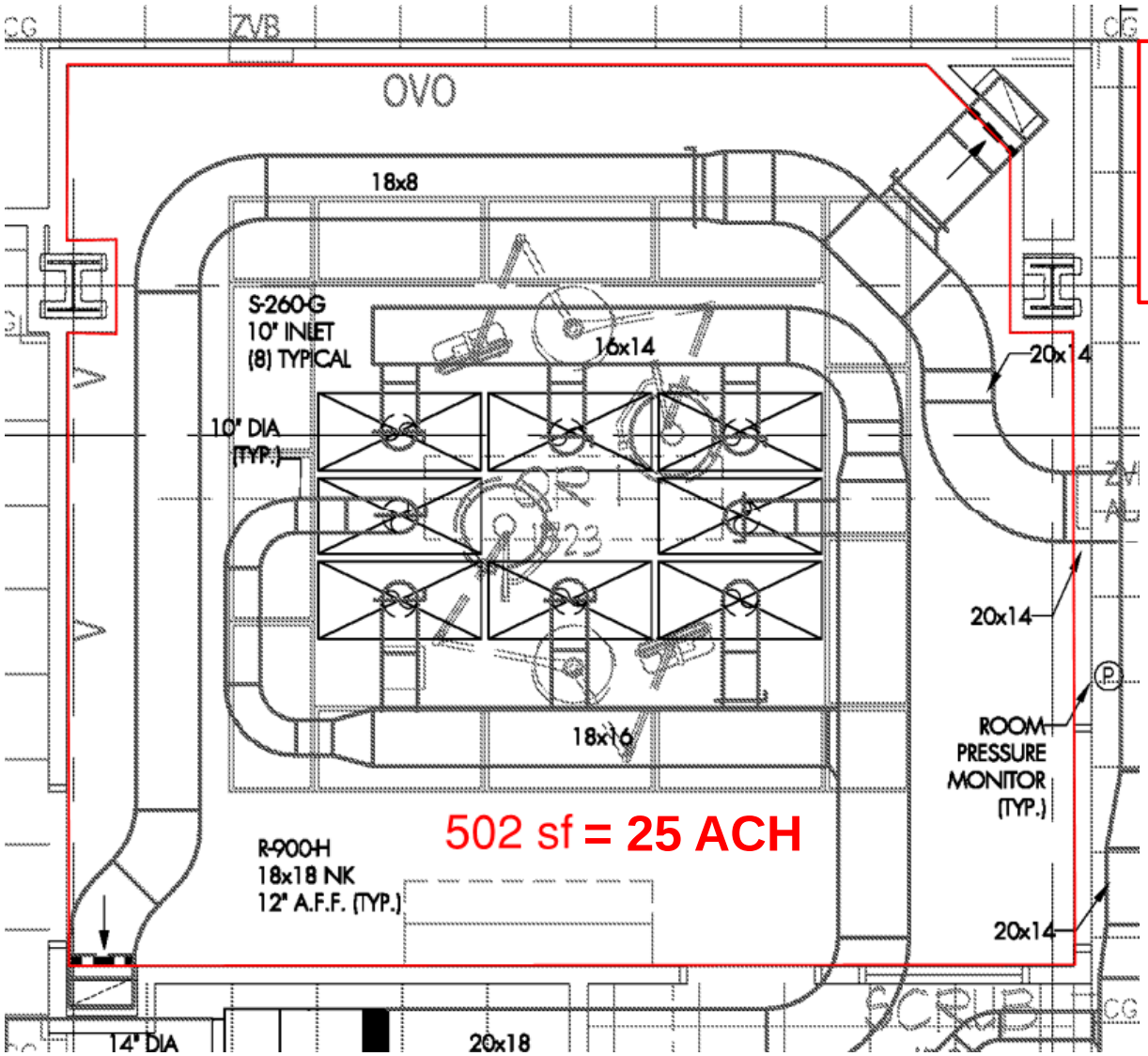
What's Wrong with this Picture?



General Design – Supply and Return



General Design – Air Changes per Hour



OR = 502 Sq.Ft.
10' Ceilings = 5,020 FT^3

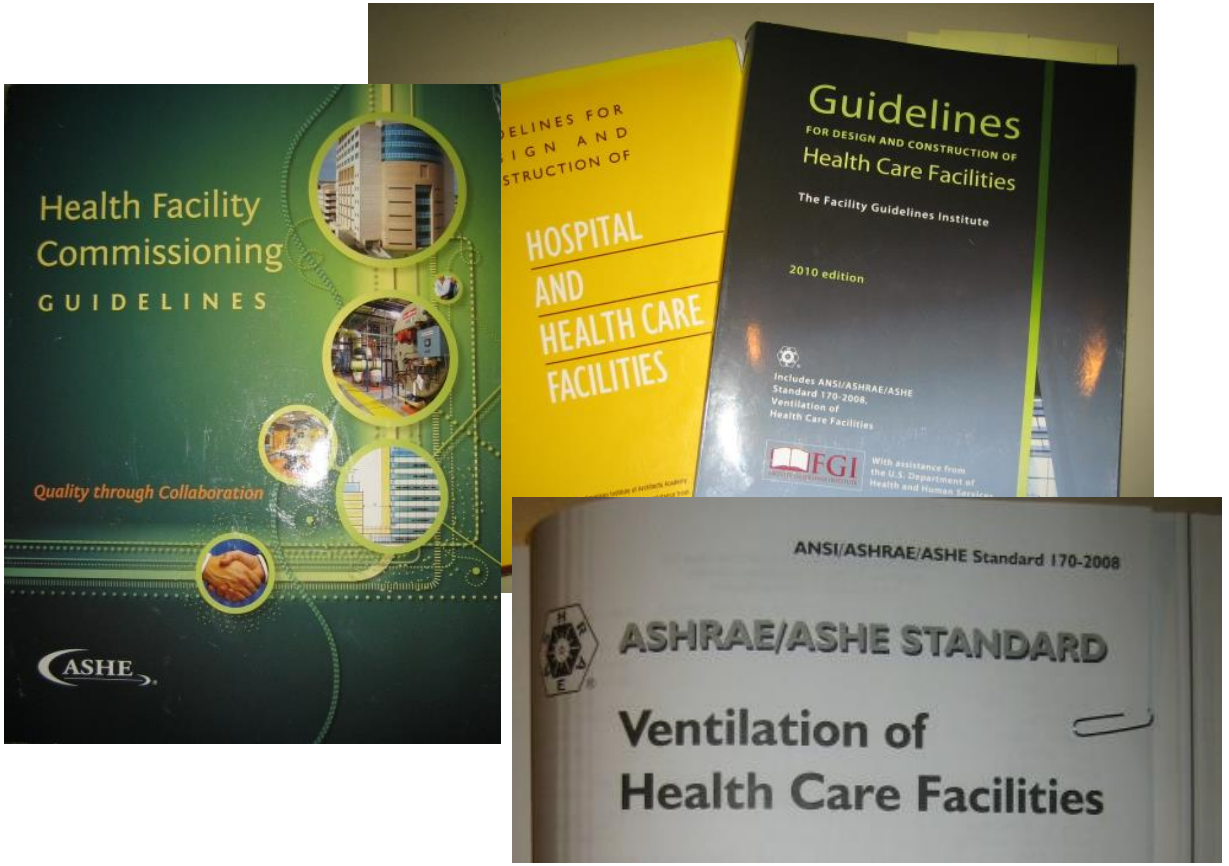
Supply CFM = 2,080

Air Changes per Hour (ACH) =
2,080 CFM x 60 (min/Hr) / 5,020 FT^3
= 25 ACH

Codes – *KEEP CHANGING* . . .

To conduct commissioning in the healthcare field, the provider needs to be intimately familiar with the related codes and standards

- State Codes
- IBC
- IECC
- ASHRAE
- AIA
- ASHE
- CDC
- NFPA
- NEC



ASHRAE – *Then and Now . . .*

1999
JDV
From JCM

Table 3 General Pressure Relationships and Ventilation of Certain Hospital Areas

Function Space	Pressure Relationship to Adjacent Areas[a]	Minimum Air Changes of Outdoor Air per Hour[b]	Minimum Total Air Changes per Hour[c]	All Air Exhausted Directly to Outdoors	Air Recirculated Within Room Units[d]
SURGERY AND CRITICAL CARE					
Operating room (all outdoor air system)	P	15[e]	15	Yes	No
Operating room (recirculating air system)	P	5	25	Optional	No
Delivery room (all outdoor air system)	P	15	15	Optional	No
Delivery room (recirculating air system)	P	5	25	Optional	No
Recovery room	E	2	6	Optional	No
Nursery suite	P	5	12	Optional	No
Trauma room[f]	P	5	12	Optional	No
Anesthesia storage (see code requirements)	±	Optional	8	Yes	No

Table 3 Ventilation Requirements for Areas Affecting Patient Care in Hospitals and Outpatient Facilities

Function Space	Pressure Relationship to Adjacent Areas[a]	Minimum Air Changes of Outside Air per Hour[b]	Minimum Total Air Changes per Hour[c]	All Air Exhausted Directly to Outside[m]	Air Recirculated Within Room Units[d]	Relative Humidity,[n] %	Design Temperature,[o] °F
Surgery and Critical Care							
Operating room (recirculating air system)	Positive	5	25	—	No	45 to 55	62 to 80
Operating/surgical cystoscopic rooms[e, p, q]	Positive	5	25	—	No	45 to 55	68 to 73[r]

ASHRAE – *Then and Now* . . .

Table 3 Ventilation Requirements for Areas Affecting Patient Care in Hospitals and Outpatient Facilities

Function Space	Pressure Relationship to Adjacent Areas[a]	Minimum Air Changes of Outside Air per Hour[b]	Minimum Total Air Changes per Hour[c]	All Air Exhausted Directly to Outside[m]	Air Recirculated Within Room Units[d]	Relative Humidity,[n] %	Design Temperature,[o] °F
Surgery and Critical Care							
Operating room (class B and positive C surgical)	Positive	4	20	—	No	30 to 60	62 to 80
Operating/surgical cystoscopic rooms[e, p, q]	Positive	4	20	—	No	30 to 60	68 to 73[r]

Table 3 Design Parameters for Areas Affecting Patient Care in Hospitals and Outpatient Facilities

Space Function	Pressure Relation-ship 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]	Relative Humidity[k] %	Design Temp-erature,[l] °F
Surgery and Critical Care							
Classes B and C operating rooms[m,n,o]	Positive	4	20	N/R	No	30 to 60	68 to 75
Operating/surgical cystoscopic rooms[m,n,o]	Positive	4	20	N/R	No	30 to 60	68 to 75

ASHRAE – *Then and Now* . . .

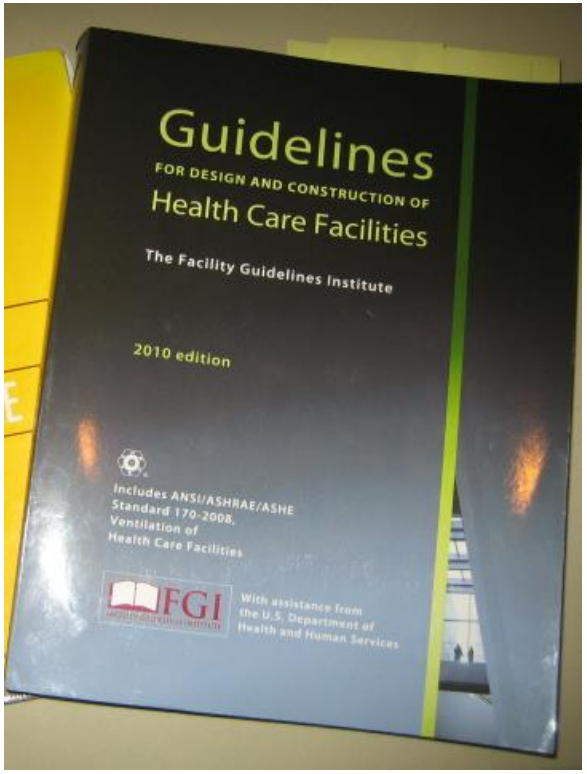
2.1-8 Building Systems

2.1-8.1 Reserved

2.1-8.2 Heating, Ventilation, and Air-Conditioning (HVAC) Systems

***2.1-8.2.1 General**

Basic HVAC system requirements are defined in Part 4 (ANSI/ASHRAE/ASHE Standard 170: *Ventilation of Health Care Facilities*). This section of the *Guidelines* includes additional requirements.



ANSI/ASHRAE/ASHE Standard 170-2013

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

Current Applicable Codes and Standards

ASHRAE/ASHE Standard for Ventilation of Health Care Facilities:

- Class B and C Operating Rooms: minimum 20 ach, minimum 4 ach outside air, positive
- Per Paragraph 7.1.1.c: “For spaces that required positive or negative pressure relationships, **the number of air changers 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 reestablished anytime the space becomes occupied.”

State Codes can differ from Standards/Guidelines

Illinois Department of Public Health (IDPH)

IDPH Part 205 for Ambulatory Surgical Treatment Centers:

- Procedure Room: minimum 15 ach, positive

IDPH Part 250 for Hospitals and Ambulatory Care Facilities

- Surgical Suite – Operating Rooms: minimum 15 ach, minimum 20% outside air, positive

Other considerations

- IDPH and ASHRAE specified ach are minimums, actual occupied ach can be higher if needed for cooling. **Many ORs get up to 30 ach**.

Case Study 1 - Occupied OR Testing and Cx

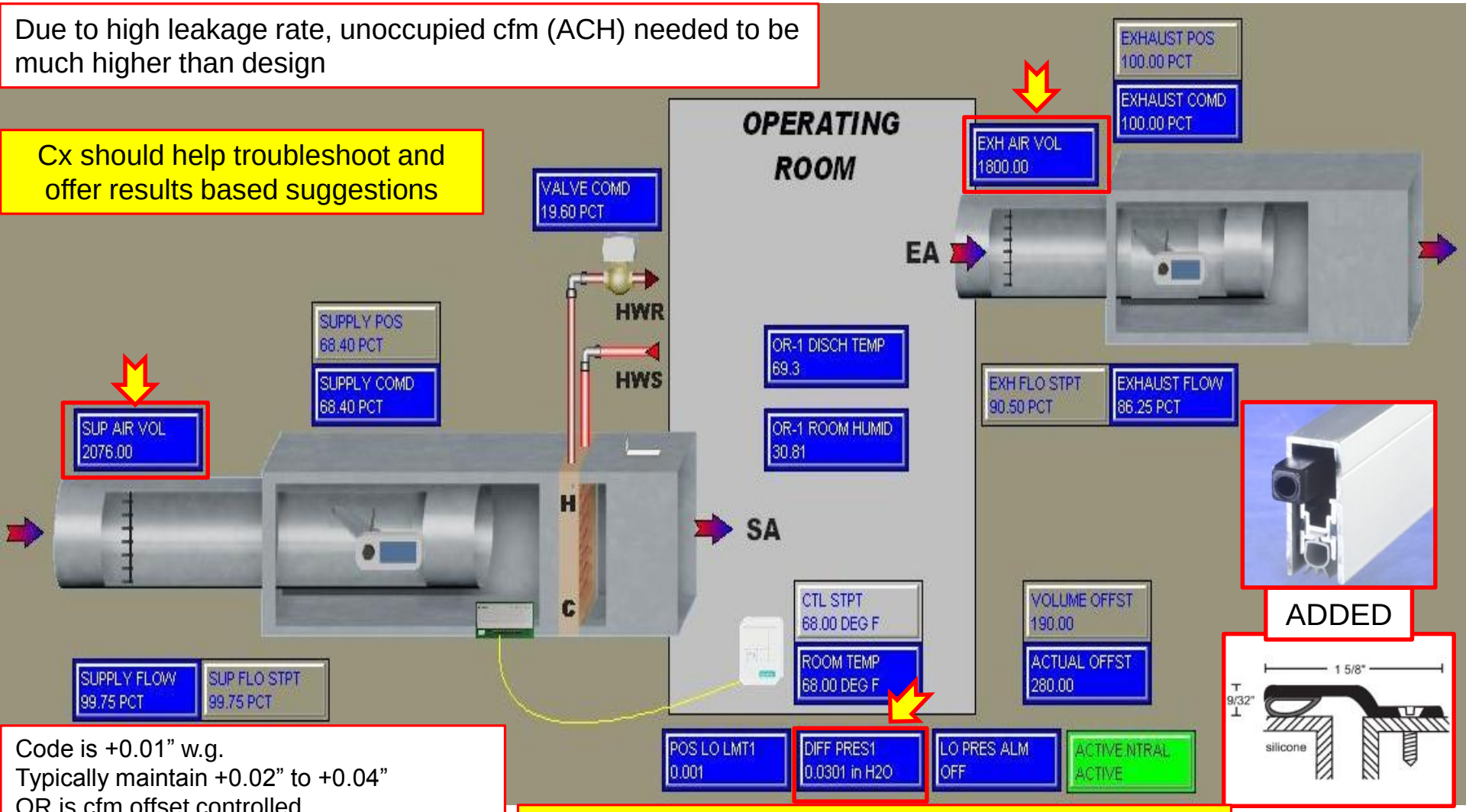
- First tested ORs and found we could NOT meet pressurization setpoint of 0.02” w.g. across OR door to sterile corridor
- Increased OR cfm offset
- OR’s started with over 700 cfm offset due to no door sweeps or astragals and incomplete construction such as the med gas column

Used painters tape to test tightening the OR at the doors

Case Study 1 - Occupied OR Testing and Cx

Due to high leakage rate, unoccupied cfm (ACH) needed to be much higher than design

Cx should help troubleshoot and offer results based suggestions



Code is +0.01” w.g.
Typically maintain +0.02” to +0.04”
OR is cfm offset controlled

End result – great pressurization and on design offset

Unoccupied Mode – What is minimum ACH?

Other considerations

- IDPH has stated to G/BA that “it is acceptable to reduce OR air change rates lower than 15 ach when the rooms are unoccupied, provided that the positive pressurization is maintain, and the air changes per hour is 15 ach when the room is occupied again.”
- California – Unoccupied 6 ach minimum

Unoccupied Mode – What is minimum ACH?

G/BA data:

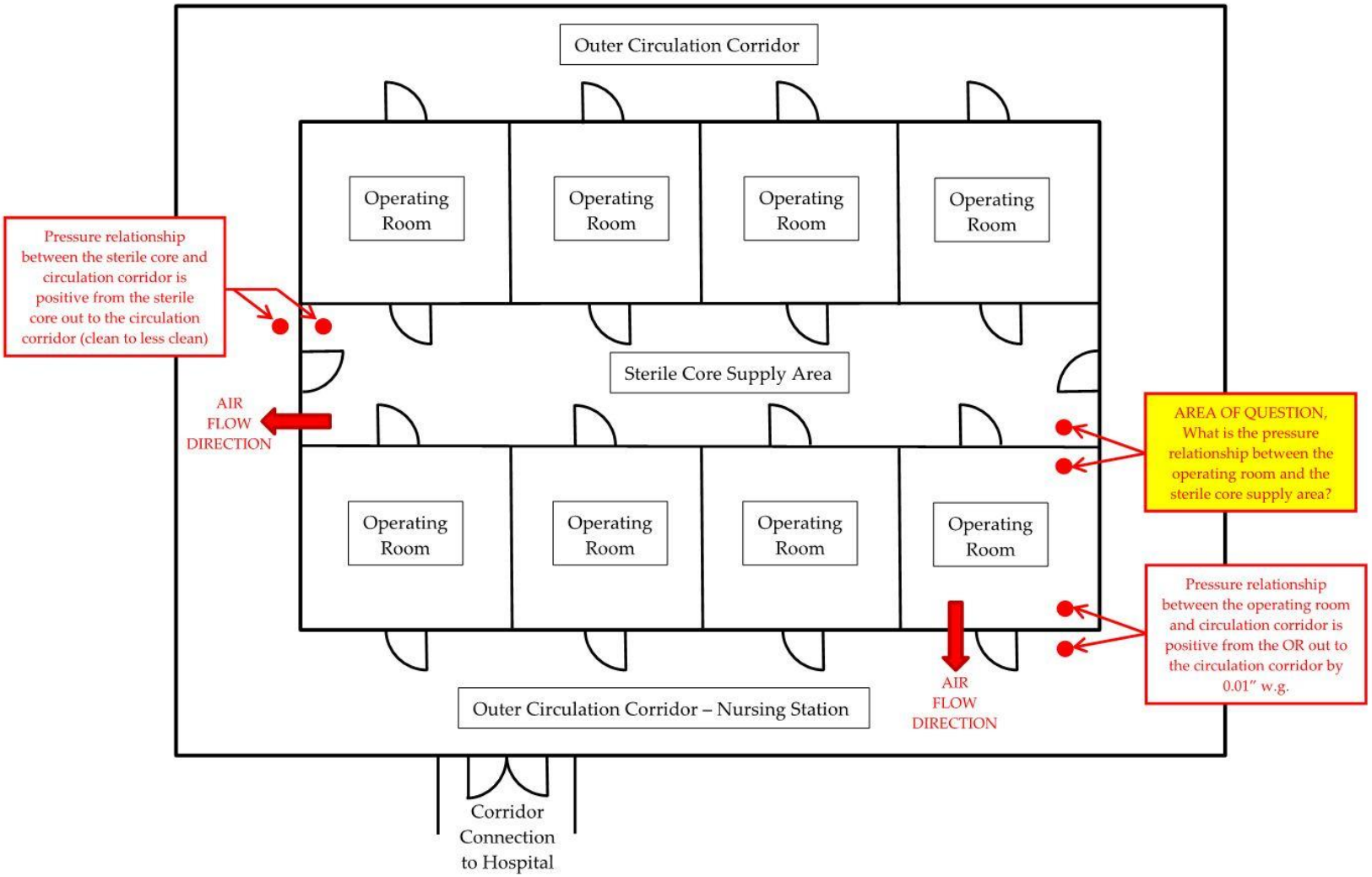
- RCx on 164 OR's, 8 hybrid and 12 hybrid ORs

Findings from this data:

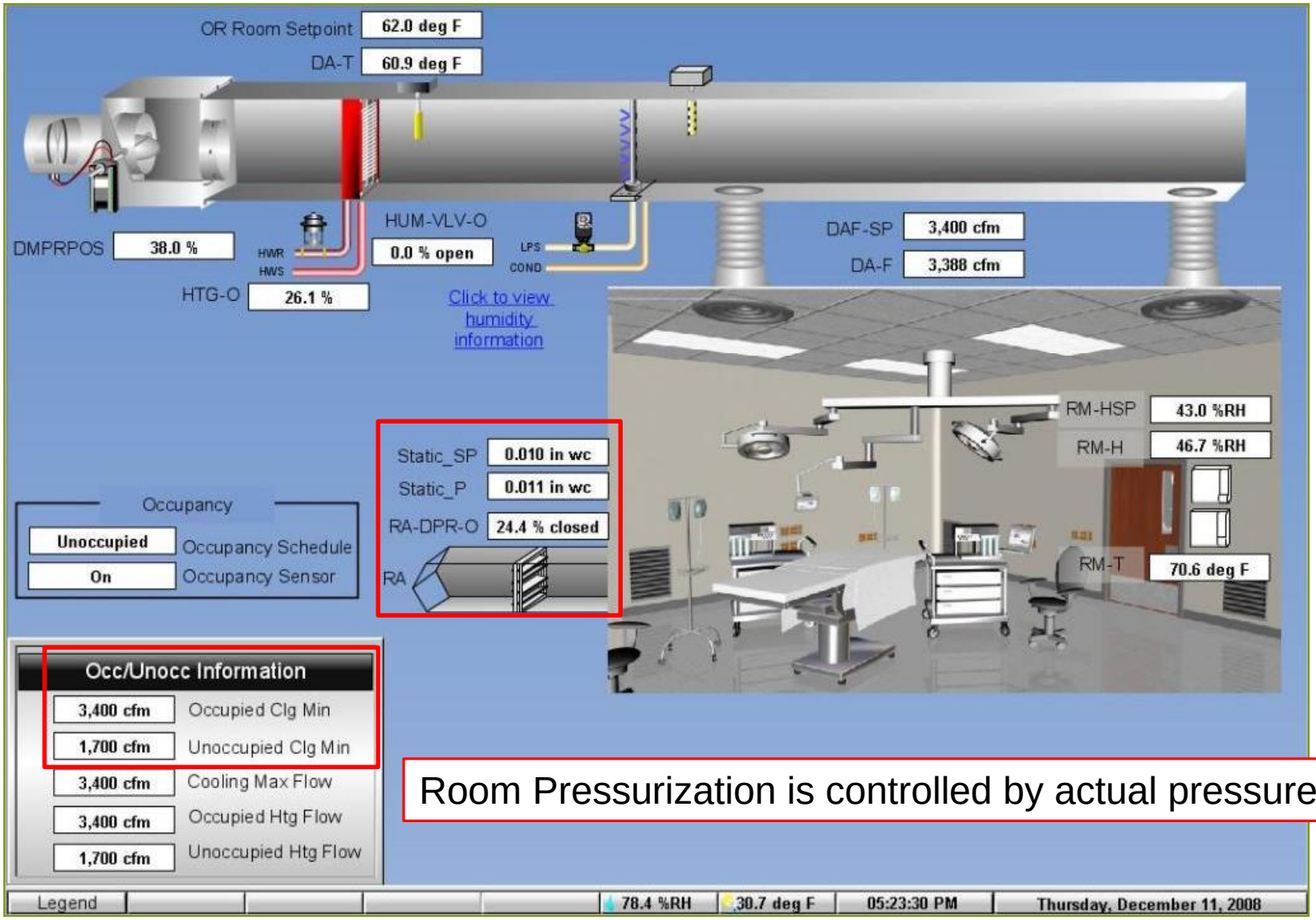
- Most existing OR's can remain positive with 6 ACH, however, will be just at code minimum of +0.01" w.g. (Note: not *ALL*)
- Normal stable unoccupied control can be found with 8 ACH, which is now our starting point for RCx projects
- Calibration, Testing and trending MUST be done to confirm stabile operation
- MUST consult with the Medical Staff and Infection Control Group within the hospital
- Must provide means of switching back from unoccupied to occupied modes

Pressure Relationships

ORs must remain positive to adjacent spaces

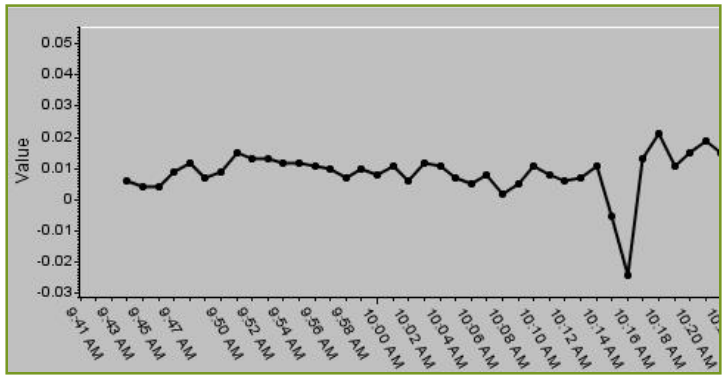


Case Study 2



Room Pressurization is controlled by actual pressure

Case Study 2



Negative OR Pressurization

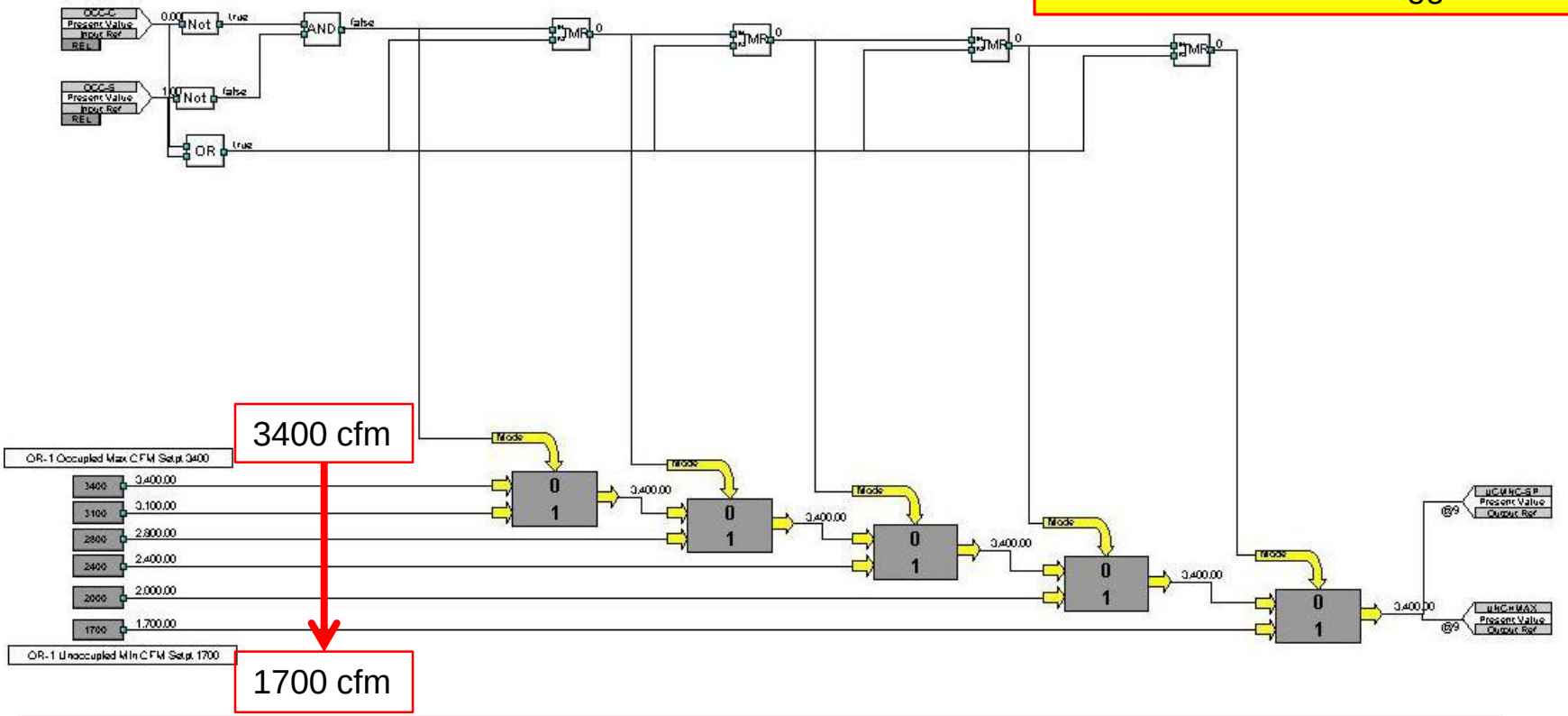
Neutral OR Pressurization

Trending showed this happening 3 to 4 times per night per OR

Time	OR1_VAV Discharge Air Flow (cfm)	OR1_VAV Room Static Pressure (in wc)	OR1_VAV Return Air Damper Position (% closed)	OR1_VAV Supply Damper Position (% Open)	OR1 Occupied Unoccupied Mode
3/11/09 10:27:00 PM CDT	3,373	0.023	0.5%	37.1%	Occupied
3/11/09 10:28:00 PM CDT	3,373	0.022	0.5%	37.1%	Occupied
3/11/09 10:29:00 PM CDT	3,354	0.022	0.5%	37.1%	Occupied
3/11/09 10:30:00 PM CDT	3,379	0.023	0.5%	37.1%	Occupied
3/11/09 10:31:00 PM CDT	3,382	0.021	0.5%	37.1%	Occupied
3/11/09 10:32:00 PM CDT	3,377	0.022	0.5%	37.1%	Occupied
3/11/09 10:33:00 PM CDT	1,608	0.014	1.0%	37.1%	Unoccupied
3/11/09 10:34:00 PM CDT	1,602	-0.028	6.5%	15.0%	Unoccupied
3/11/09 10:35:00 PM CDT	1,683	-0.028	10.0%	15.0%	Unoccupied
3/11/09 10:36:00 PM CDT	1,685	-0.025	14.9%	15.0%	Unoccupied
3/11/09 10:37:00 PM CDT	1,675	-0.023	18.7%	15.0%	Unoccupied
3/11/09 10:38:00 PM CDT	1,692	-0.021	22.8%	15.0%	Unoccupied
3/11/09 10:39:00 PM CDT	1,683	-0.018	25.0%	15.0%	Unoccupied
3/11/09 10:40:00 PM CDT	1,680	-0.016	28.4%	15.0%	Unoccupied
3/11/09 10:41:00 PM CDT	1,657	-0.014	31.2%	15.0%	Unoccupied
3/11/09 10:42:00 PM CDT	1,651	-0.014	32.7%	15.0%	Unoccupied
3/11/09 10:43:00 PM CDT	1,681	-0.010	35.9%	15.0%	Unoccupied
3/11/09 10:44:00 PM CDT	1,670	-0.009	38.4%	15.0%	Unoccupied
3/11/09 10:45:00 PM CDT	1,689	-0.007	39.5%	15.0%	Unoccupied
3/11/09 10:46:00 PM CDT	1,678	-0.006	40.9%	15.0%	Unoccupied
3/11/09 10:47:00 PM CDT	1,700	-0.003	42.9%	15.0%	Unoccupied
3/11/09 10:48:00 PM CDT	1,674	-0.003	44.2%	15.0%	Unoccupied
3/11/09 10:49:00 PM CDT	1,702	-0.002	45.4%	15.0%	Unoccupied
3/11/09 10:50:00 PM CDT	1,714	-0.001	46.5%	15.0%	Unoccupied
3/11/09 10:51:00 PM CDT	1,686	-0.001	47.7%	15.0%	Unoccupied
3/11/09 10:52:00 PM CDT	1,677	0.001	48.7%	15.0%	Unoccupied
3/11/09 10:53:00 PM CDT	1,699	0.001	49.4%	15.0%	Unoccupied
3/11/09 10:54:00 PM CDT	1,680	0.002	50.5%	15.0%	Unoccupied
3/11/09 10:55:00 PM CDT	1,685	0.003	51.0%	15.0%	Unoccupied
3/11/09 10:56:00 PM CDT	1,700	0.001	52.3%	15.0%	Unoccupied
3/11/09 10:57:00 PM CDT	1,724	0.012	52.3%	15.0%	Unoccupied
3/11/09 10:58:00 PM CDT	1,693	0.006	53.0%	15.0%	Unoccupied
3/11/09 10:59:00 PM CDT	1,719	0.011	53.0%	15.0%	Unoccupied

Case Study 2

Cx should help troubleshoot and offer results based suggestions



Added a stepped control loop to go from occupied to unoccupied mode in 300 cfm increments every 5 minutes

Energy Savings Opportunities

Estimated annual energy dollars saved for implementing off-hours airflow reduction in one OR based on:

- Chicago weather; $0.11/kWh for electricity and $0.65/therm for gas
- 13 unoccupied hours per day
- Recirculating air handling unit

≈10 ORs – annual savings is $20,000 to $32,000

		Occupied ACH		
		30	20	15
Unoccupied ACH	20	$2,023	-	-
	15	$2,846	$2,027	-
	6	$3,260	$,2597	$2,378

Energy Savings Opportunities

IF OR is served by a 100% outside air unit, savings increase.

- Chicago weather; $0.11/kWh for electricity and $0.65/therm for gas
- 13 unoccupied hours per day
- 100% OA air handling unit

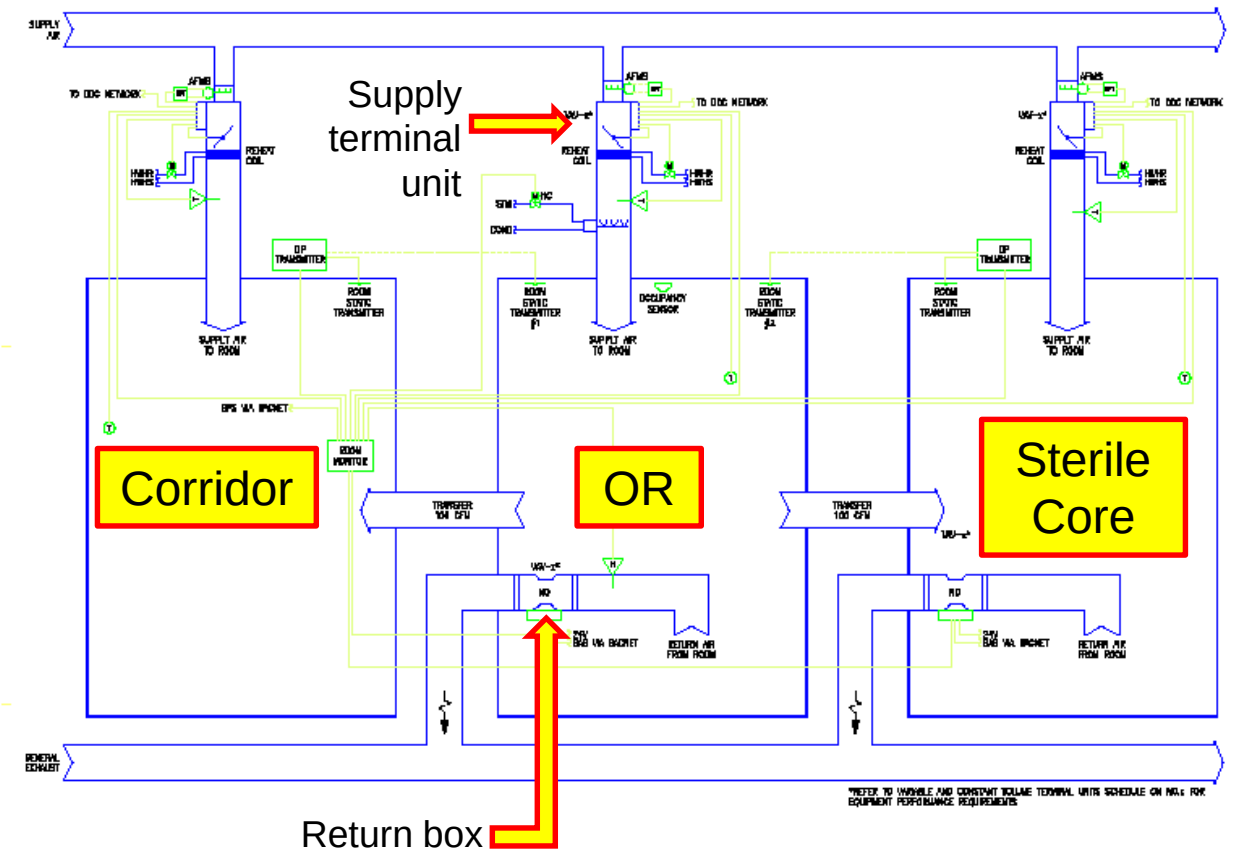
≈10 ORs – annual savings is $27,000 to $57,000

		Occupied ACH		
		30	20	15
Unoccupied ACH	20	$2,780	-	-
	15	$4,010	$2,027	-
	6	$5,740	$4,150	$3,555

General Design Approach

Terminal unit and reheat coil on supply

- Supply box maintains constant required airflow
- Reheat coil valve modulates to control temperature
- Return box maintains pressurization



Case Studies

All of these examples have ROBUST building automation systems. This is a must have before attempting implementing an unoccupied mode for OR's

SIEMENS

Johnson Controls

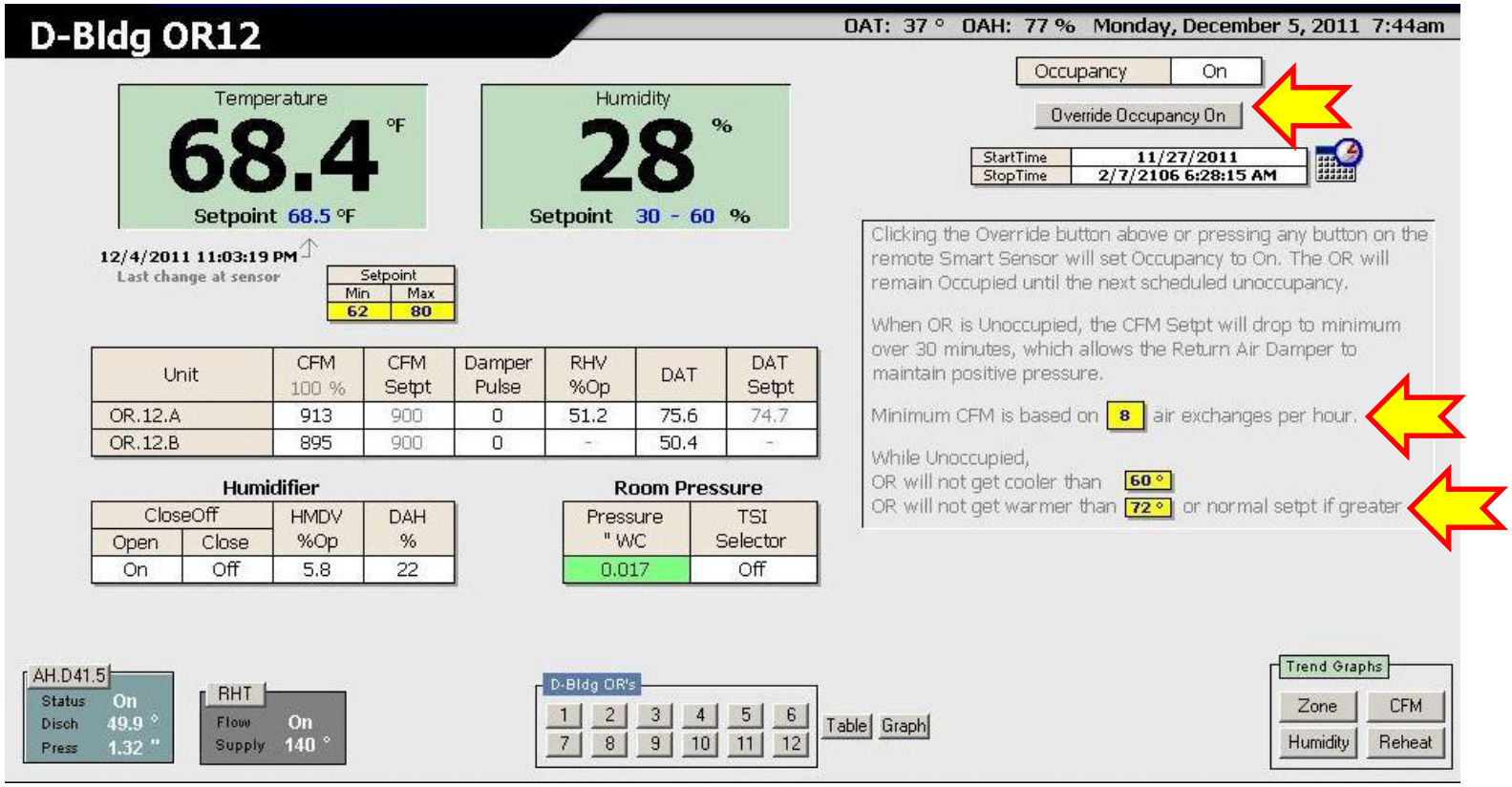
AUTOMATEDLOGIC

Schneider Electric

ORs MUST be positively pressurized at ALL times!!

Case Study #3 –4 OR AHUs serving 12 ORs each AHU has supply and return fan VFDs

Case Study #3 – Unoccupied Mode for 12 ORs



Most OR's can be positively pressurized with 8 air changes per hour,
Let temperature "float" during unoccupied mode with deadband

Case Study #3 – Unoccupied Mode for OR's 1 – 6

Date/Time	OR1.AirX	OR2.AirX	OR3.AirX	OR4.AirX	OR5.AirX	OR6.AirX
12/6/2011 2:44:00 P	-	-	-	-	-	-
12/6/2011 1:44:00 P	25.1	24.7	25.2	25.2	31.7	25.2
12/6/2011 12:44:00	25.2	24.8	25.4	25.3	31.7	25.3
12/6/2011 11:44:00	25.2	24.7	25.2	25.2	31.6	25.2
12/6/2011 10:44:00	25.0	24.8	25.4	25.2	31.8	25.0
12/6/2011 9:44:00 A	25.2	24.8	25.1	25.1	31.8	25.1
12/6/2011 8:44:00 A	25.2	24.9	25.3	25.2	31.8	25.2
12/6/2011 7:44:00 A	25.0	24.7	25.2	25.2	31.7	24.7
12/6/2011 6:44:00 A	25.0	25.0	23.3	18.7	32.0	8.3
12/6/2011 5:44:00 A	25.0	24.8	7.6	7.8	9.5	8.4
12/6/2011 4:44:00 A	25.3	24.7	7.6	7.7	7.7	8.4
12/6/2011 3:44:00 A	25.2	24.8	7.6	7.8	7.8	8.4
12/6/2011 2:44:00 A	25.0	24.8	7.6	7.8	7.9	8.3
12/6/2011 1:44:00 A	25.1	24.7	7.6	7.8	8.0	8.3
12/6/2011 12:44:00	25.4	24.7	12.2	12.4	14.3	12.8
12/5/2011 11:44:00	25.0	24.8	25.1	25.2	31.6	25.2
12/5/2011 10:44:00	25.1	24.8	25.2	25.3	31.6	25.2
12/5/2011 9:44:00 P	25.0	24.6	25.1	25.3	31.5	25.1
12/5/2011 8:44:00 P	25.1	24.7	25.1	25.1	31.8	25.2
12/5/2011 7:44:00 P	25.0	24.7	25.3	25.3	31.9	25.1
12/5/2011 6:44:00 P	24.9	24.7	25.3	25.2	31.9	25.3
12/5/2011 5:44:00 P	25.1	24.9	25.3	25.3	31.8	25.2
12/5/2011 4:44:00 P	25.1	24.9	25.4	25.2	31.8	25.4
12/5/2011 3:44:00 P	25.1	24.9	25.3	25.4	31.9	25.4
12/5/2011 2:44:00 P	25.1	24.8	25.2	25.2	31.8	25.2

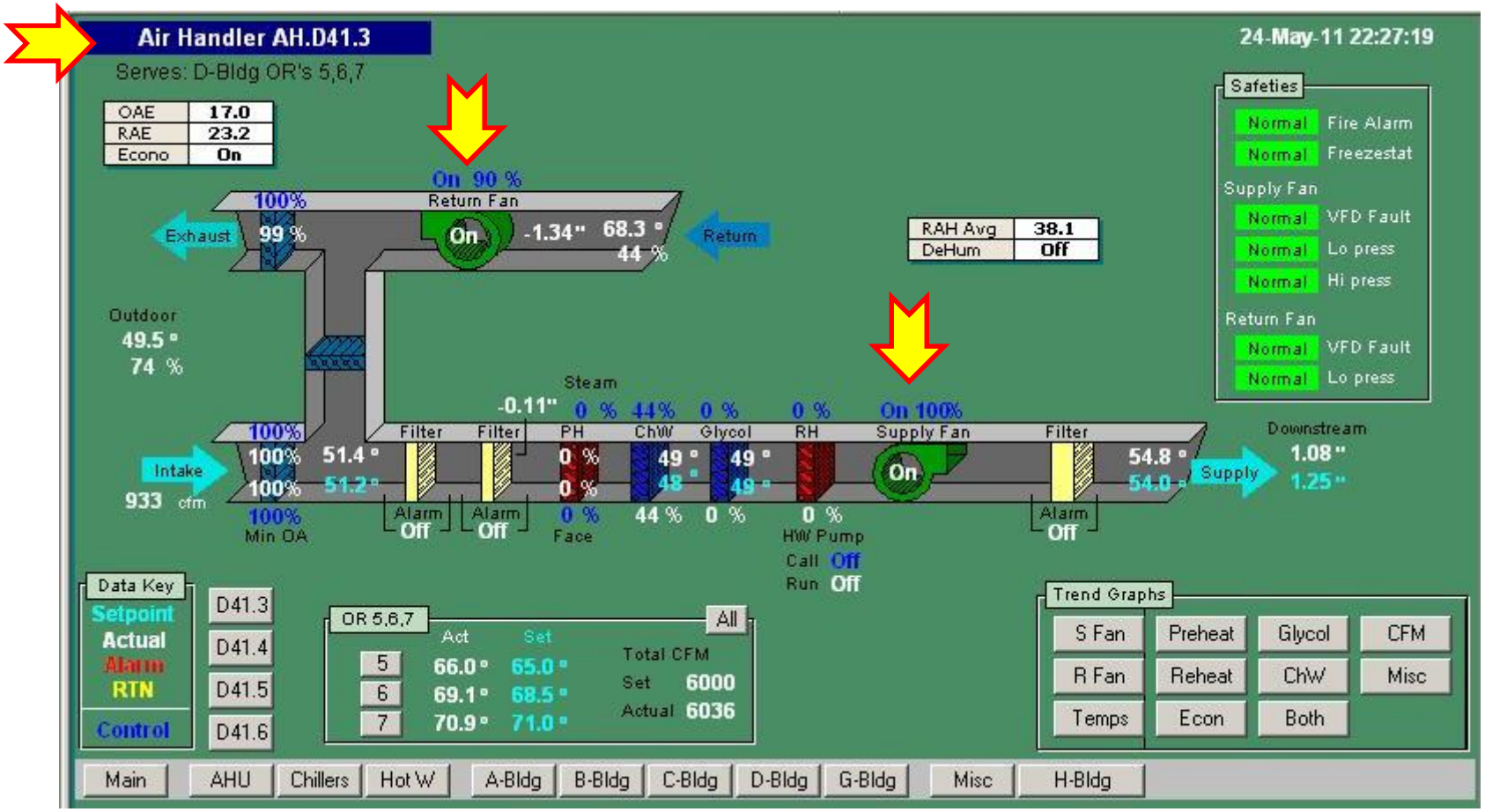
Hospital with Level 1 Trauma Center, 4 ORs were decided to be left occupied all the time, ORs 1,2, 11 and 12 (also the biggest)

Case Study #3 – Unoccupied Mode for OR's 7 – 12

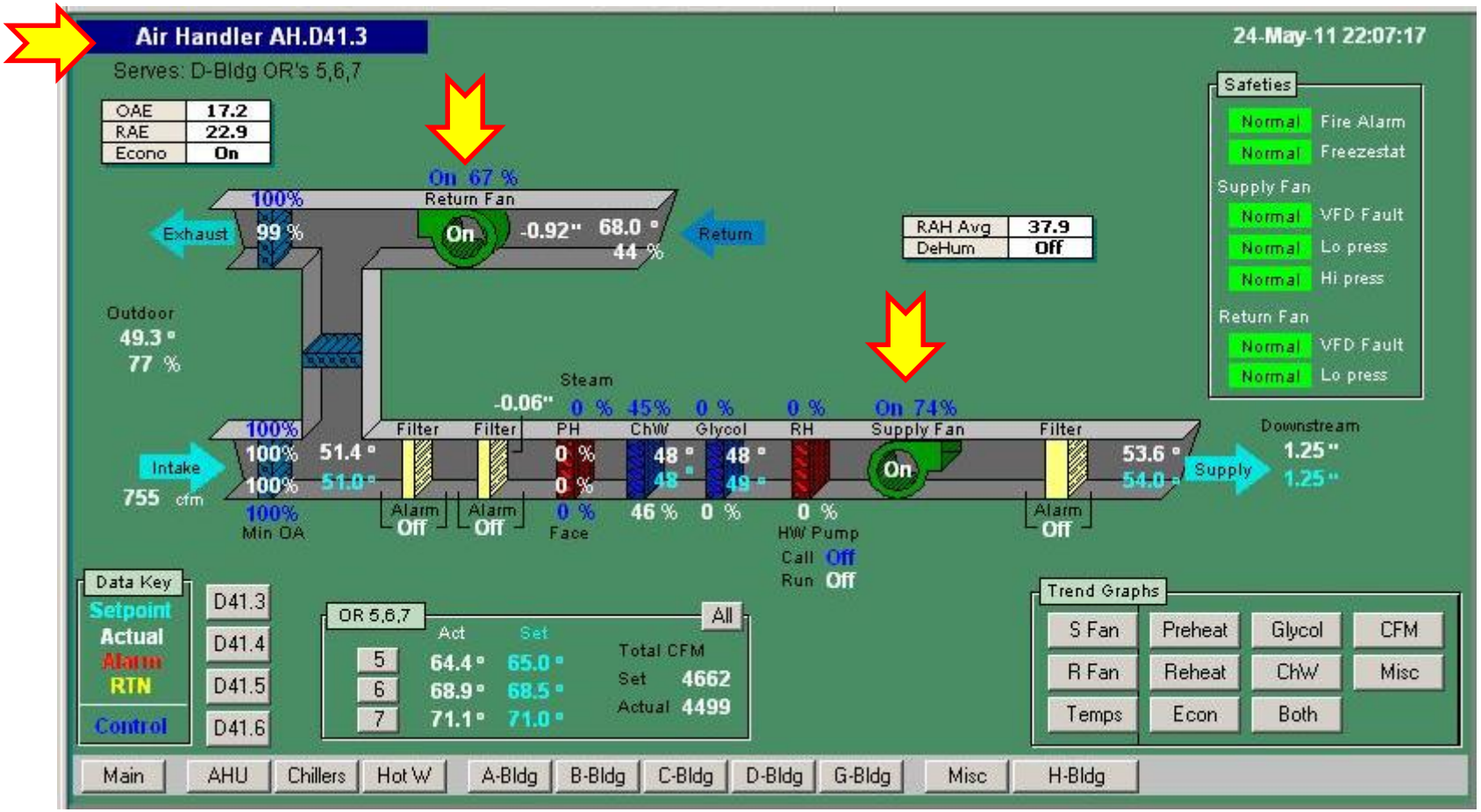
Date/Time	OR7.AirX	OR8.AirX	OR9.AirX	OR10.AirX	OR11.AirX	OR12.AirX
12/6/2011 2:45:00 P	-	-	-	-	-	-
12/6/2011 1:45:00 P	25.2	25.4	25.3	25.2	25.3	25.1
12/6/2011 12:45:00	25.2	25.3	25.3	25.2	25.3	25.1
12/6/2011 11:45:00	25.2	25.2	25.2	25.3	25.3	25.1
12/6/2011 10:45:00	25.1	25.2	25.2	25.1	25.3	25.1
12/6/2011 9:45:00 A	25.2	25.2	25.4	25.2	25.4	25.2
12/6/2011 8:45:00 A	25.1	25.3	25.3	25.1	25.4	25.1
12/6/2011 7:45:00 A	24.8	24.8	25.0	25.2	25.3	25.0
12/6/2011 6:45:00 A	12.0	6.8	8.2	25.1	25.3	25.1
12/6/2011 5:45:00 A	11.7	6.8	8.2	25.2	25.2	25.1
12/6/2011 4:45:00 A	11.8	6.8	8.2	25.1	25.3	25.1
12/6/2011 3:45:00 A	11.8	6.8	8.3	25.2	25.4	25.2
12/6/2011 2:45:00 A	11.8	6.8	8.3	8.0	25.3	25.0
12/6/2011 1:45:00 A	11.8	6.8	8.2	7.7	25.3	25.1
12/6/2011 12:45:00	14.9	11.7	12.7	12.5	25.5	25.2
12/5/2011 11:45:00	25.2	25.1	25.3	25.1	25.4	25.1
12/5/2011 10:45:00	25.2	25.2	25.4	25.1	25.4	25.1
12/5/2011 9:45:00 P	25.1	25.0	25.2	25.1	25.2	25.0
12/5/2011 8:45:00 P	24.9	25.3	25.3	25.1	25.4	25.1
12/5/2011 7:45:00 P	24.9	25.2	25.2	25.1	25.2	25.1
12/5/2011 6:45:00 P	25.1	25.2	25.3	25.2	25.2	25.1
12/5/2011 5:45:00 P	25.1	25.3	25.3	25.2	25.4	25.1
12/5/2011 4:45:00 P	25.0	25.3	25.3	25.3	25.3	25.1
12/5/2011 3:45:00 P	25.1	25.2	25.3	25.2	25.5	25.1
12/5/2011 2:45:00 P	25.2	25.2	25.3	25.2	25.3	25.1

California Mechanical Code allows a *MINIMUM* of 6 ACH, it is not recommended or typically feasible to go below this

Case Study #3 – Unoccupied Mode Before Changes



Case Study #3 – Unoccupied Mode AFTER Changes



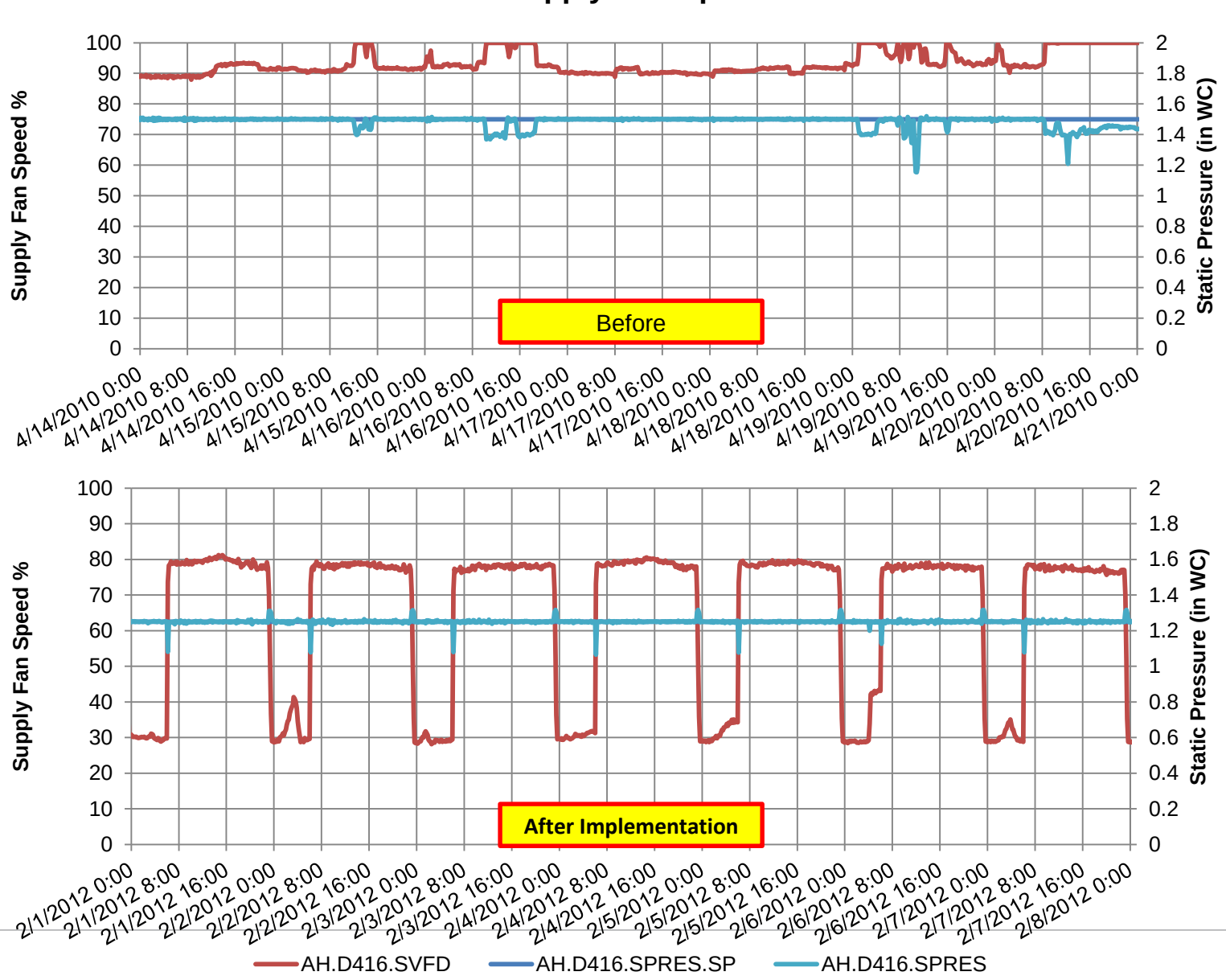
Case Study #3 – Unoccupied Mode AFTER Changes

Date/Time	AH.D416.SPRES.SP Static Pressure Setpoint "w.g.	AH.D416.SPRES Actual Static Pressure "w.g.	AH.D416.SVFD Supply Fan VFD % Speed
2/8/2012 7:00	1.25	1.25	77
2/8/2012 6:30	1.25	1.26	77
2/8/2012 6:00	1.25	1.24	29
2/8/2012 5:30	1.25	1.25	29
2/8/2012 5:00	1.25	1.25	29
2/8/2012 4:30	1.25	1.26	29
2/8/2012 4:00	1.25	1.25	29
2/8/2012 3:30	1.25	1.25	29
2/8/2012 3:00	1.25	1.25	29
2/8/2012 2:30	1.25	1.25	29
2/8/2012 2:00	1.25	1.25	29
2/8/2012 1:30	1.25	1.26	29
2/8/2012 1:00	1.25	1.25	29
2/8/2012 0:30	1.25	1.25	29
2/8/2012	1.25	1.25	29
2/7/2012 23:30	1.25	1.30	35
2/7/2012 23:00	1.25	1.25	77

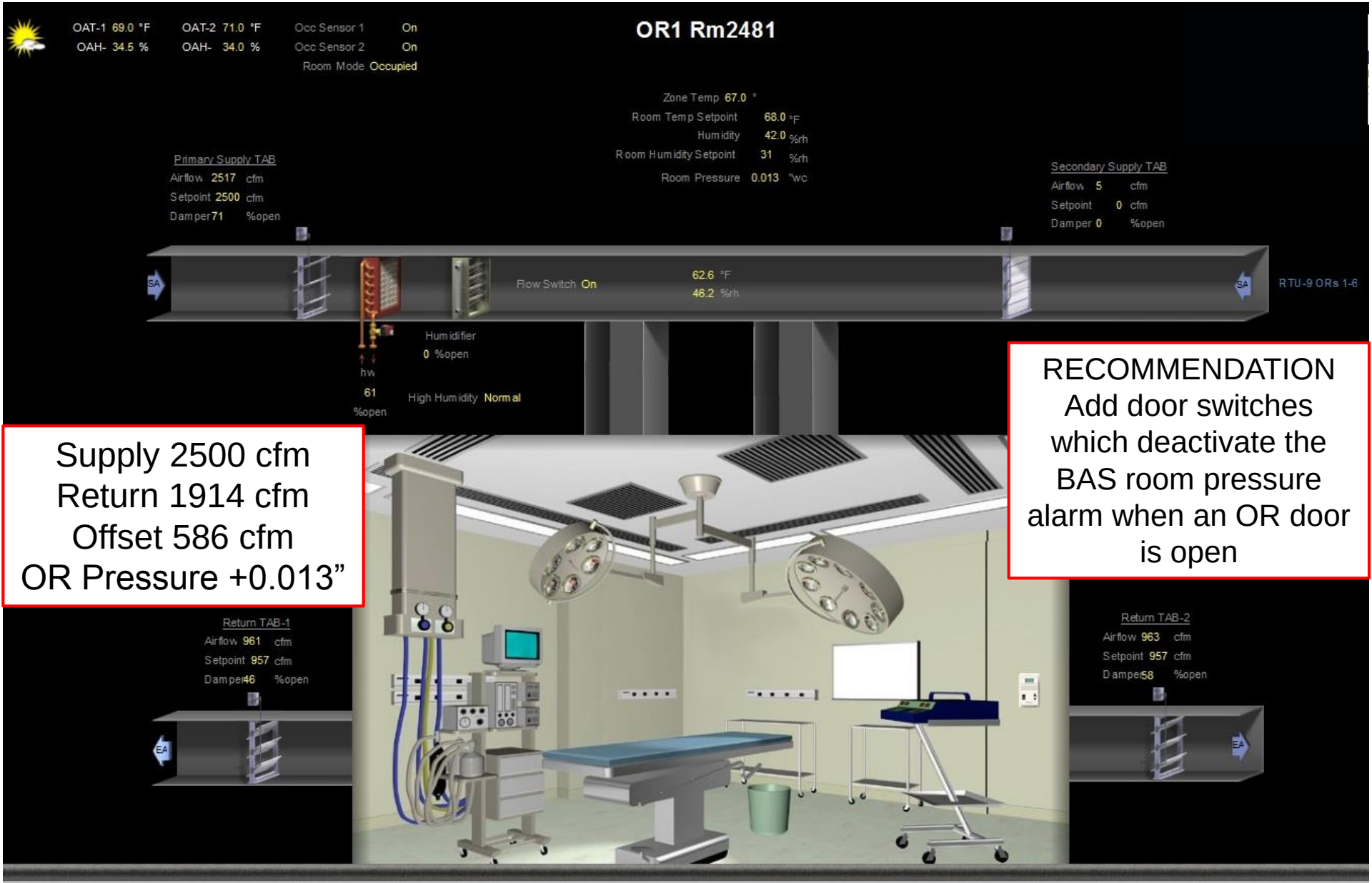
UNOCCUPIED TIME PERIOD

Different fan than previous screen shots

Case Study #3 – Unoccupied Mode AFTER Changes



Case Study #4 – Dual Supply & Return Boxes



Supply 2500 cfm
Return 1914 cfm
Offset 586 cfm
OR Pressure +0.013”

RECOMMENDATION
Add door switches which deactivate the BAS room pressure alarm when an OR door is open

Occupied / Unoccupied Schedule

SAMPLE HOSPITAL – OPERATING ROOM OCCUPANCY INSTRUCTIONS

These instructions are meant to detail the changes made to the occupancy controls for the twelve operating rooms (ORs) at SAMPLE HOSPITAL. The table below details the occupancy schedule that has been coordinated with operating room staff and put in place.

Day of Week	Time of Day	# of Occupied ORs	Occupied OR Tags
Mon-Fri	6am-11pm	ALL	ALL
	11pm-6am	4	1,2,11,12
Saturday	6am-11pm	4	1,2,11,12
	11pm-6am	4	1,2,11,12
Sunday	6am-11pm	4	1,2,11,12
	11pm-6am	4	1,2,11,12

Occupied Mode

The ORs are in an occupied mode as detailed in the table above. This means that the OR is operating with the necessary air changes and positive pressurization required by the code and is available for surgery.

Unoccupied Mode

ORs not listed during a particular schedule period above are in an unoccupied state. The airflow to the OR has been reduced yet it is still maintaining the positive pressurization required by code. The ORs will automatically switch to occupied mode based on the schedule above. During unoccupied mode, the OR temperatures will be maintained between 60 and 72 degrees.

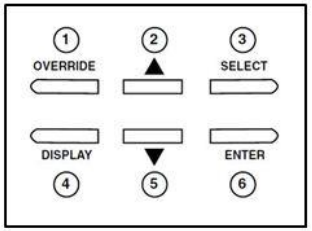
General Instructions for RE-activating an OR Overriding Unoccupied Mode

Instructions for Overriding Unoccupied Mode

Below are the instructions for overriding an OR when it is in an unoccupied mode. This would essentially need to be done for all ORs EXCEPT 1, 2, 11, or 12 when it is after 11pm (or before 6 am) Monday through Friday or any time on the weekend.

1. Locate the thermostat in the operating room. See picture below.

2. Hit ANY button on the thermostat. See picture below.



When an OR is taken out of override by depressing any button, the room will automatically go back into an occupied status until the next scheduled unoccupied time period (next day). This process only takes several minutes and no further action is required by the medical staff. If there are any questions with the operation of the ORs, please contact the hospital engineering staff.

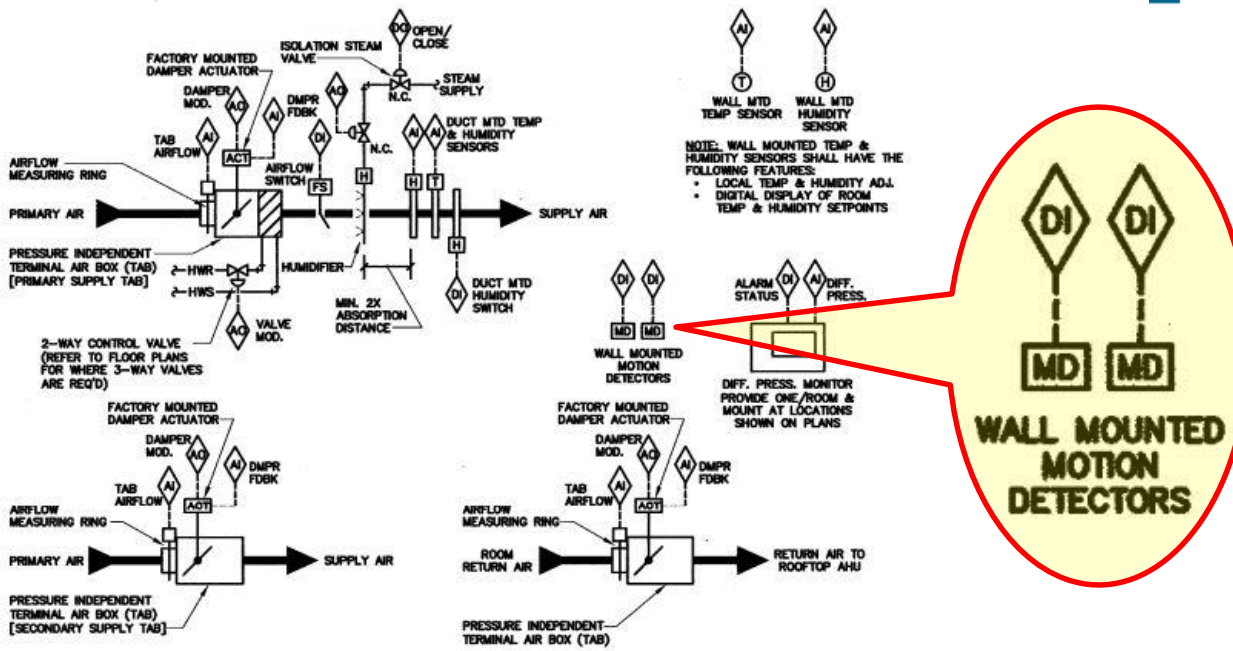
Provide in-service training to the clinical staff

General Design: Return Damper vs. VAV Box
IT MAKES A DIFFERENCE

Return dampers don’t provide tight control over space pressure

Design Example

Good start to the sequence in design is important. This sequence does not include a time of day schedule, so the OR could go unoccupied in the middle of the day if there is no motion for 15 minutes, probably not desired



SEQUENCE OF OPERATION:

WHEN ANY ROOM OCCUPANCY SENSOR DETECTS MOTION FMCS SHALL ENABLE OCCUPIED MODE AND THE FOLLOWING SHALL OCCUR:

- PRIMARY SUPPLY TAB SHALL SUPPLY MAX. SCHEDULED AIRFLOW PER TAB SCHEDULE.
- LOCAL TEMP SETPOINT ADJUSTMENT SHALL BE ENABLED ALLOWING TEMP SETTINGS 60°F – 80°F (ADJ.).
- SECONDARY SUPPLY TAB DAMPER SHALL REMAIN FULLY CLOSED. (DOES NOT APPLY TO TREATMENT)
- FMCS SHALL MODULATE RETURN TAB DAMPERS AS REQUIRED TO MAINTAIN THE ROOM AT MIN. +0.010 INCHES W.G. RELATIVE TO ADJACENT CORRIDOR.
- FMCS SHALL MODULATE REHEAT COIL HW CONTROL VALVE AS REQUIRED TO MAINTAIN SPACE TEMP SETPOINT (68°F).

IN THE EVENT REHEAT COIL HW CONTROL VALVE IS FULLY CLOSED AND ADDITIONAL COOLING IS REQUIRED, FMCS SHALL MODULATE THE SECONDARY SUPPLY TAB DAMPER AS REQUIRED TO MAINTAIN SPACE TEMP SETPOINT. (DOES NOT APPLY TO TREATMENT)

WHEN BOTH ROOM OCCUPANCY SENSORS DO NOT DETECT MOTION FOR 15 MINUTES (ADJ.), FMCS SHALL ENABLE UNOCCUPIED MODE AND THE FOLLOWING SHALL OCCUR:

- PRIMARY SUPPLY TAB SHALL SUPPLY MIN. SCHEDULED AIRFLOW PER TAB SCHEDULE.
- PRIMARY SUPPLY TAB DAMPER SHALL MODULATE OPEN TO MAINTIAN ROOM SETPOINT.
- LOCAL TEMP SETPOINT ADJUSTMENT SHALL BE DISABLED AND ROOM TEMP SETPOINT SHALL BE 68°F (ADJ.).
- SECONDARY SUPPLY TAB DAMPER SHALL FULLY CLOSE. (DOES NOT APPLY TO TREATMENT)
- FMCS SHALL MODULATE RETURN TAB DAMPERS AS REQUIRED TO MAINTAIN THE ROOM AT MIN. +0.010 INCHES W.G. RELATIVE TO ADJACENT CORRIDOR.
- FMCS SHALL MODULATE REHEAT COIL HW CONTROL VALVE (WITH TAB DAMPER IN MINIMUM POSITION) AS REQUIRED TO MAINTAIN SPACE TEMP SETPOINT.

GRAPHICAL SCREEN AT THE OPERATOR WORKSTATION.

THE FMCS SHALL UTILIZE OUTPUT FROM ALL TERMINAL AIR BOX POSITION TO RESET THE SUPPLY AND RETURN DUCT DIFFERENTIAL STATIC PRESSURE.

SEQUENCE OF OPERATION (CONT.):

HUMIDIFIER OPERATION:

FMCS SHALL ENABLE HUMIDIFIER CONTROLS WHEN OA DEWPOINT DROPS BELOW 38°F (ADJ.) AND SHALL FULLY OPEN STEAM ISOLATION VALVE. FMCS SHALL MODULATE HUMIDIFIER STEAM VALVE AS REQUIRED TO MAINTAIN ROOM HUMIDITY SETPOINT (40% RH, ADJ.). FMCS SHALL LIMIT STEAM VALVE OPERATION TO PREVENT DUCT MOUNTED HUMIDITY LEVELS FROM EXCEEDING 70% RH (ADJ.) AT DUCT MOUNTED HUMIDITY TRANSMITTER.

HUMIDIFIER STEAM VALVE SHALL NOT BE ENABLED UNLESS AIRFLOW IN SUPPLY DUCT IS PROVEN BY AN AIRFLOW SWITCH.

FMCS SHALL DISABLE HUMIDIFIER CONTROLS AND ALARMS WHEN OA DEWPOINT RISES ABOVE 40°F (ADJ.) AND SHALL FULLY CLOSE STEAM ISOLATION VALVE.

SMOKE EVACUATION MODE:

ELECTRICAL CONTRACTOR SHALL INSTALL SMOKE DETECTOR. UPON DETECTION OF SMOKE, THE OPERATING ROOM SHALL ENTER PURGE MODE

- THE COOLING ONLY TAB SHALL CLOSE. IN EACH OR ROOM CONNECTED TO THE AHU IN PURGE MODE. (DOES NOT APPLY TO TREATMENT)
- THE REHEAT TAB SHALL BE OPEN IF ROOM IS OCCUPIED OR CLOSED IF ROOM IS UNOCCUPIED.
- THE RETURN TAB SHALL MODULATE TO MAXIMUM CFM.
- THE AIR HANDLING UNIT SHALL ENTER 100% OA.
- OCCUPIED LOCAL SETPOINT ADJUSTMENT SHALL BE 70°F – 80°F (ADJ.)
- ALL OTHER ROOMS SHALL REMAIN IN NORMAL OPERATION.

INTERCONNECTED MODE:

- WHEN SUPPLY AIR HUMIDITY EXCEEDS 80% RH A SEPARATE DUCT MOUNTED HUMIDITY SWITCH (MANUAL RESET) SHALL DISABLE HUMIDIFIER CONTROLS AND SHALL FULLY CLOSE STEAM ISOLATION VALVE. AN IDENTIFIABLE ALARM CONDITION SHALL BE DISPLAYED AT THE OPERATOR WORKSTATION.
- ROOM POSITIVE PRESSURE (RELATIVE TO ADJACENT CORRIDOR) DROPS BELOW 0.01 INCHES W.G. (ADJ.) FOR MORE THAN 45 SECONDS (ADJ.) AS MEASURED BY ROOM DIFFERENTIAL PRESSURE MONITOR (AUTO RESET).

WHEN BOTH ROOM OCCUPANCY SENSORS DO NOT DETECT MOTION FOR 15 MINUTES (ADJ.), FMCS SHALL ENABLE UNOCCUPIED MODE AND THE FOLLOWING SHALL OCCUR:

5 TAB OPERATING ROOM CONTROL: TAB-E
NO SCALE

Mode Control Methodology
How and when to use occupancy sensors and the downfall . .

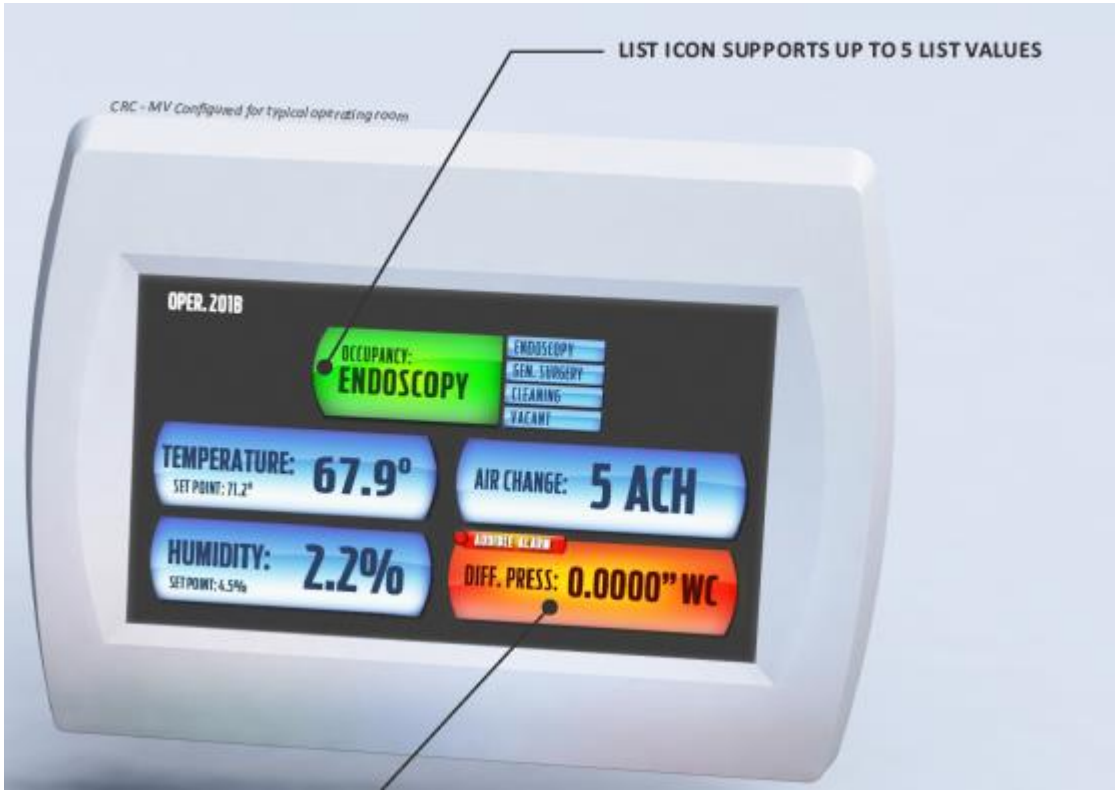
Does Motion Detector have "Pass Through Mode"?

The CI-24 occupancy sensor for lighting applications, specifically designed to interface with Building Automation Systems, BAS, through an internal isolated relay. The ceiling-mount passive infrared occupancy sensor has a user-adjustable time delay (30 seconds to 30 minutes). It may be programmed through DIP switches to prevent unnecessary cycling. The CI-24 includes a built-in override switch. Two levels of sensitivity are also selectable through DIP switches. The four-level patented Fresnel lens allows the CI-24 to cover up to 1200 ft2 (111.48 m2).

Problem, if occupancy sensors are used to trigger the room to go back occupied, they can and will have false activation for OR cleaning, resupply of sterile instruments, general preparation, and CUT THROUGH

Mode Control Methodology
Ideal Solution for ORs – Inside OR

Day of Week	Time of Day
Mon-Fri	6am-11pm
	11pm-6am
Saturday	6am-11pm
	11pm-6am
Sunday	6am-11pm
	11pm-6am



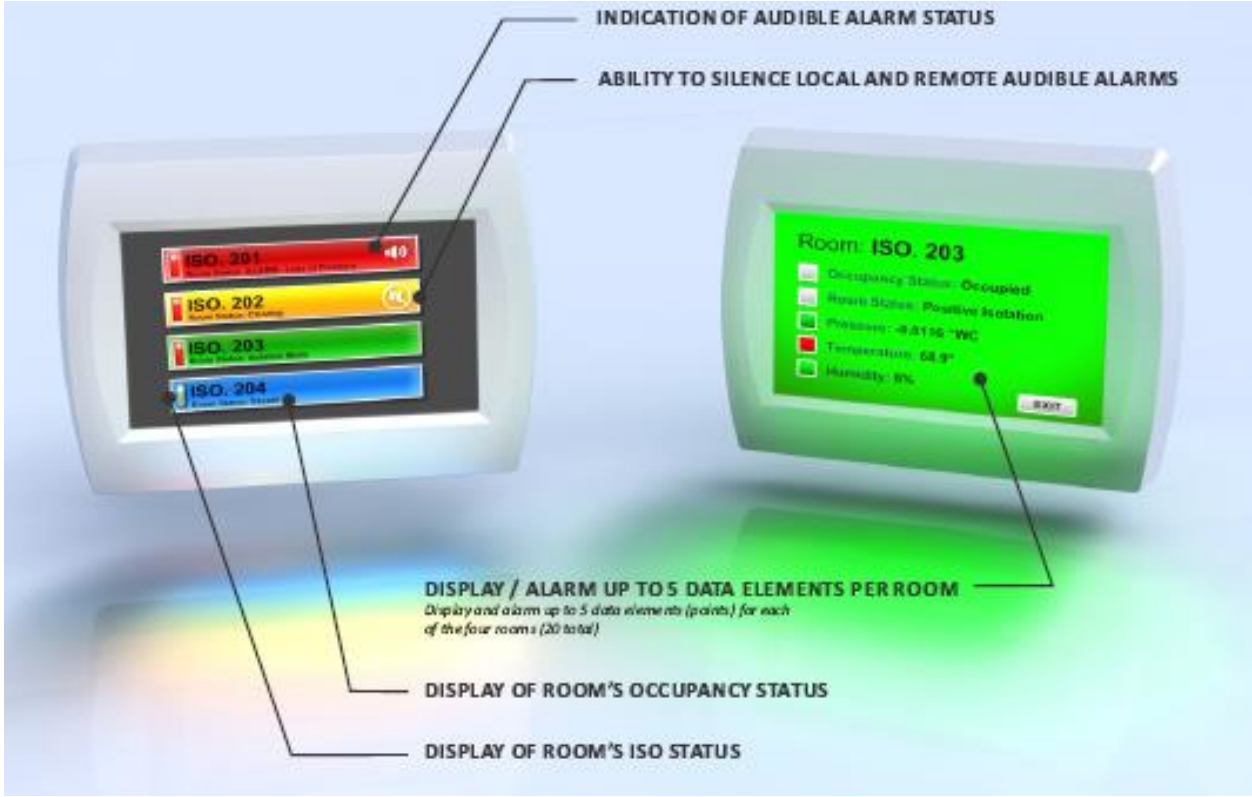
Motion Detector is ONLY used to provide the BAS an unoccupied signal after the schedule has dictated the OR can go unoccupied. The MD prevents OR from going unoccupied if the room is in use.
Display inside OR provides critical information to staff

Mode Control Methodology
Ideal Solution for ORs – Outside OR

MANUAL intervention is required by the CLINICAL staff to force an OR back into occupied mode during the unoccupied time period

OR Monitor OUTSIDE the OR indicates what state the room is in OCCUPIED or UNOCCUPIED and can be used to activate an OR

Ideal Solution for OR's
Occupied/Unoccupied Mode – Nurse's Station



Recommended to provide the Nurse's Station with a way to view status of OR's **IF** they will be changing state

Ideal Solution for OR's Occupied/Unoccupied Mode – Nurse's Station

New products provide capability to monitor, schedule and change the status of an OR remotely from the Nurse's Station

Building Pressurization

International Energy Conservation Code

Chapter 4 – Commercial Energy Efficiency

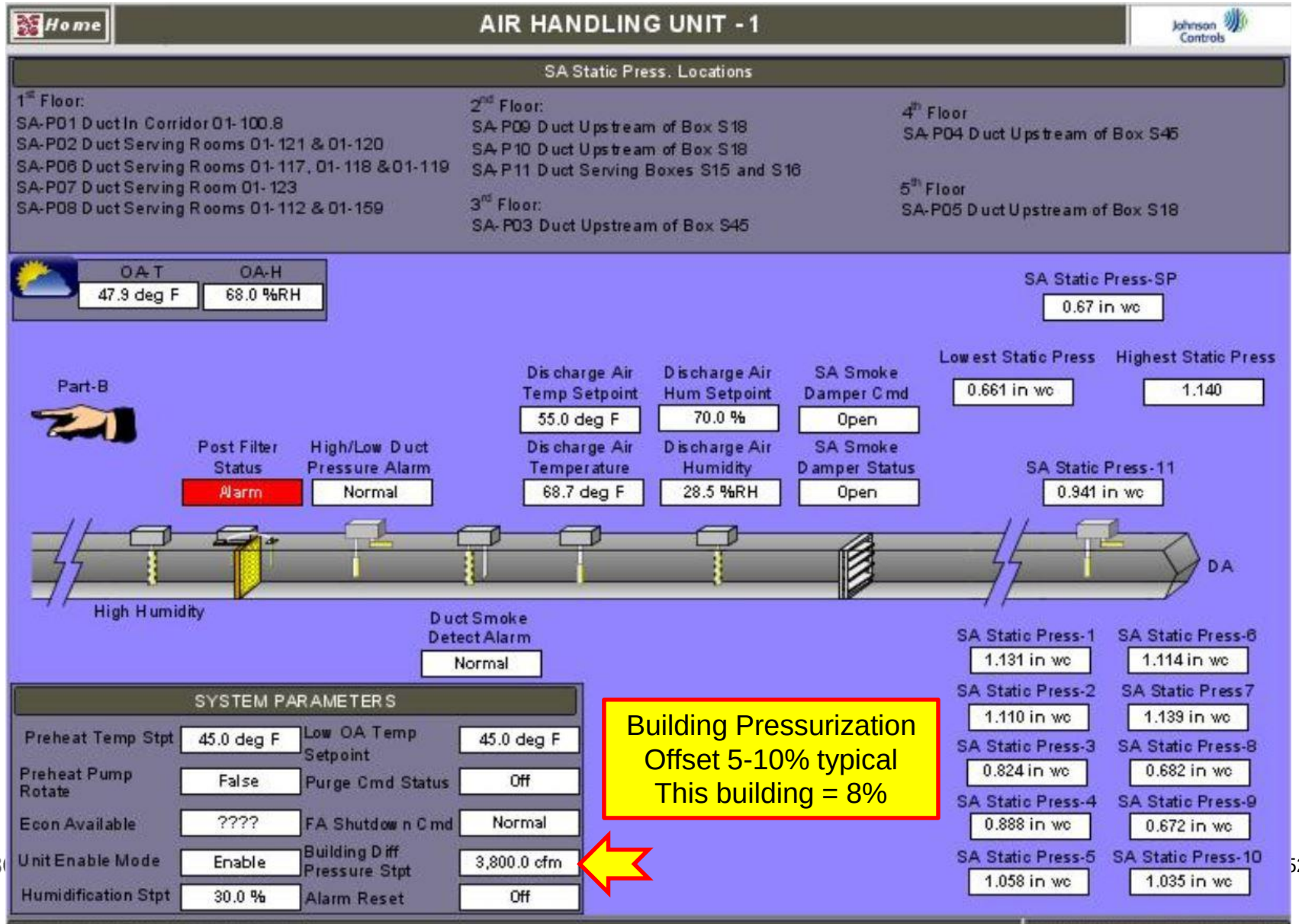
Section C402 – Building Envelope Requirements

C402.4.1.2.3 Building Test. The completed building shall be tested and the air leakage rate of the building envelope shall not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3 inches water gauge (2.0 L/s – m^2 at 75 Pa) in accordance with ASTM E 779 or an equivalent method approved by the code official.

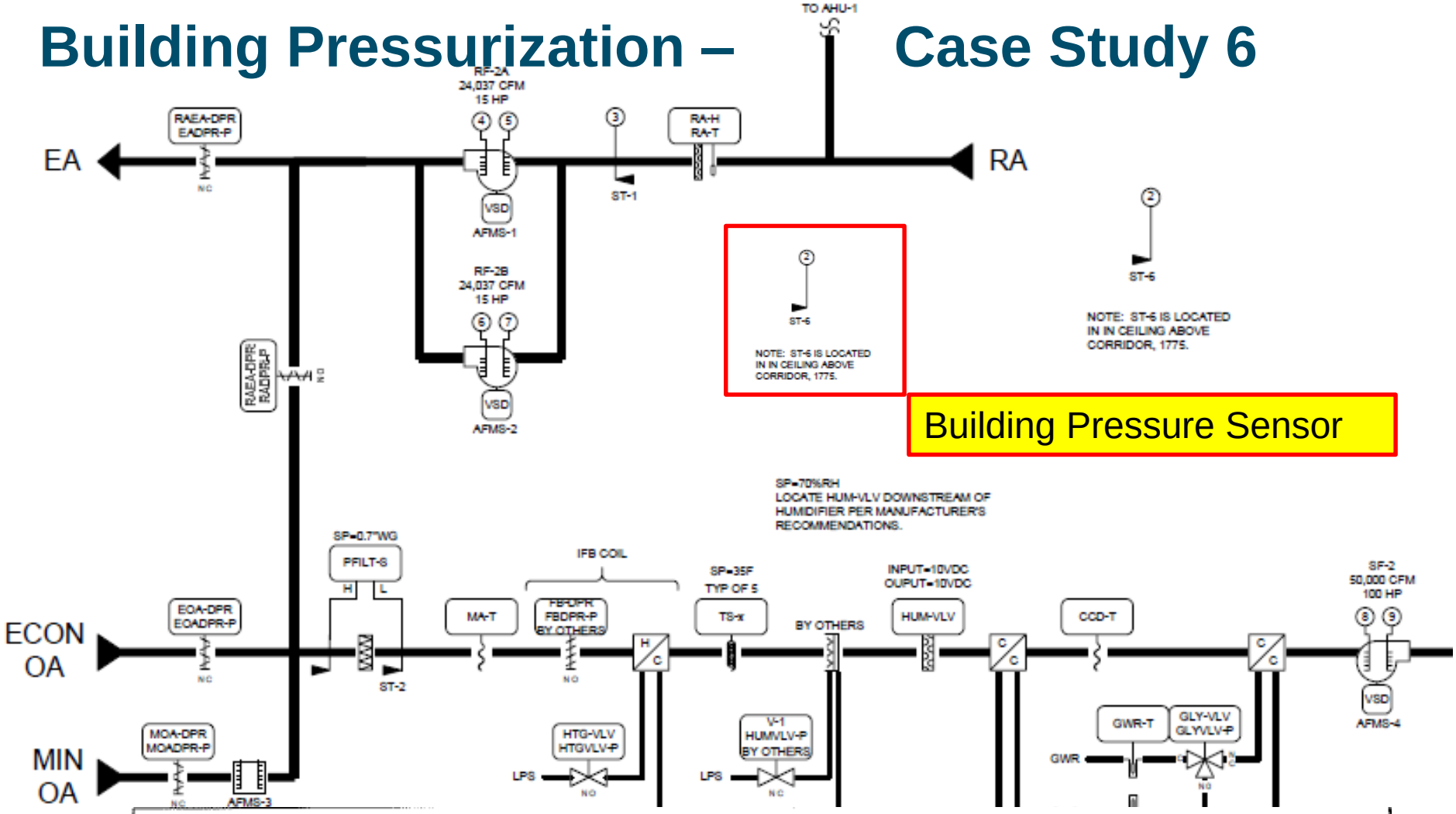
Building Pressurization – Case Study 5

Tested and found much better than code 0.14 CFM/Sq.Ft.

Building Pressurization – Case Study 5



Building Pressurization – Case Study 6



MIN

AHU-2 BLANCING MATRIX

UNIT OPERATION	SUPPLY FAN CFM	EXHAUST FAN CFM	O.A. DAMPER CFM	RETURN FAN CFM	RELIEF DAMPER CFM	RETURN DAMPER CFM	REMARKS
MAXIMUM UNIT CAPACITY	50000	1925	12500	48075	10575	37500	SIZED FOR REDUNDANCY OF AHU-2
VAV BOXES AT MAX COOLING	30300	910	7575	29390	6665	22725	
VAV BOXES AT MAX HEATING	18310	910	4578	17400	3668	13733	
VAV BOX MINIMUMS	14860	910	3715	13950	2805	11145	

Building Pressurization

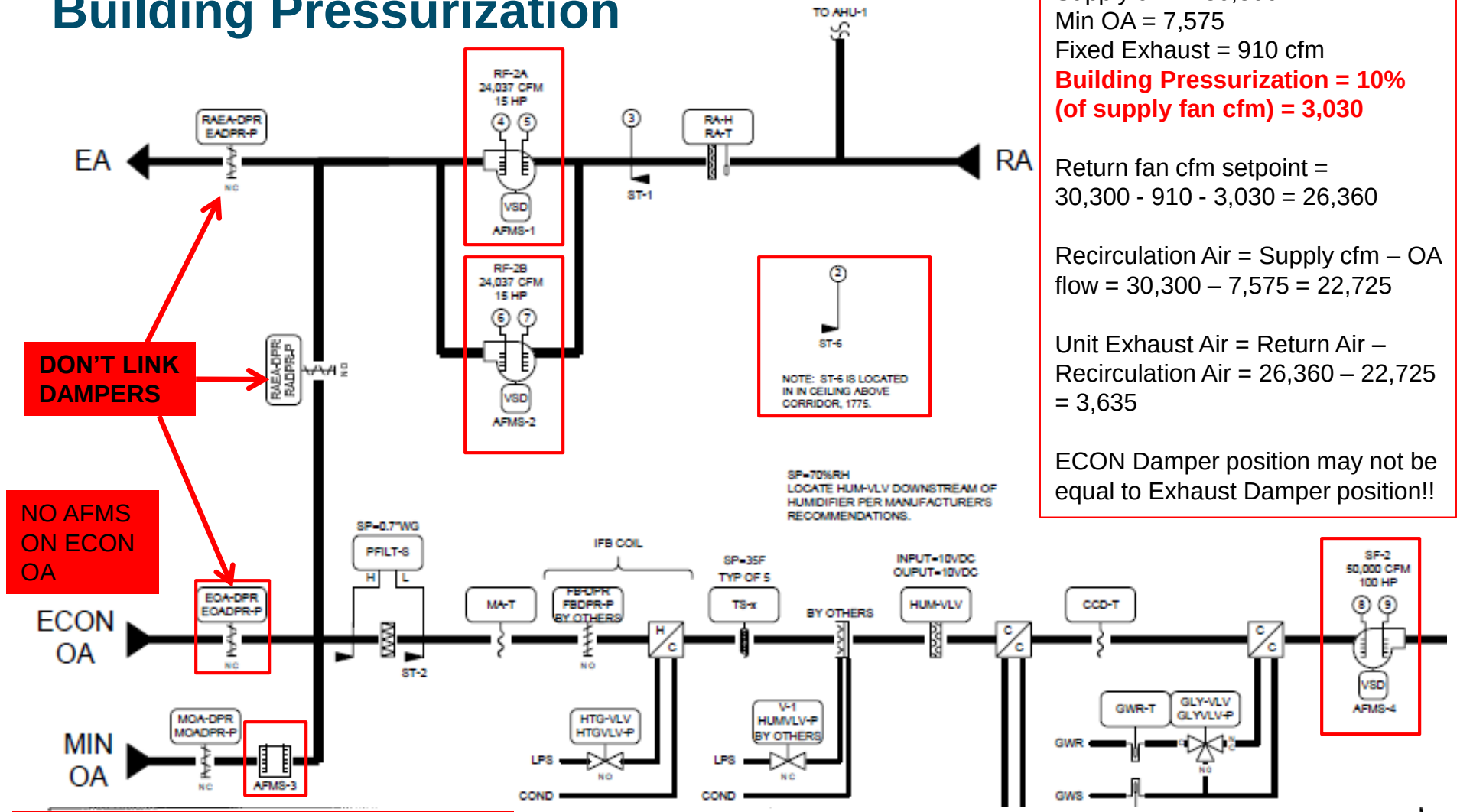
Supply cfm = 30,300
Min OA = 7,575
Fixed Exhaust = 910 cfm
Building Pressurization = 10% (of supply fan cfm) = 3,030

Return fan cfm setpoint = 30,300 - 910 - 3,030 = 26,360

Recirculation Air = Supply cfm – OA flow = 30,300 – 7,575 = 22,725

Unit Exhaust Air = Return Air – Recirculation Air = 26,360 – 22,725 = 3,635

ECON Damper position may not be equal to Exhaust Damper position!!



PROBLEM – NOT ALL OA IS MEASURED

AHU-2 BLANCING MATRIX

UNIT OPERATION	SUPPLY FAN CFM	EXHAUST FAN CFM	O.A. DAMPER CFM	RETURN FAN CFM	RELIEF DAMPER CFM	RETURN DAMPER CFM
MAXIMUM UNIT CAPACITY	50000	1925	12500	48075	10575	37500
VAV BOXES AT MAX COOLING	30300	910	7575	29390	6665	22725
VAV BOXES AT MAX HEATING	18310	910	4578	17400	3668	13733
VAV BOX MINIMUMS	14860	910	3715	13950	2805	11145

PROBLEM – BALANCING MATRIX DID NOT LEAVE ANY AIR FOR BUILDING PRESSURIZATION

Summary – Codes and ACH's

- ORs are allowed to have an unoccupied mode PROVIDED they remain positively pressurized
- OR Room Pressure
  - Minimum +0.01" wg
  - Typically control to +0.02" or greater
- Air Changes per Hour
  - 15 per IDPH
  - 20 per ASHRAE
  - 30 typical at many facilities
  - 8 ACH in unoccupied mode (6 ACH Minimum) (verify this holds room positively pressurized)

Summary – Design Approach

- Design
  - Include supply and return terminal boxes, not just dampers
  - Include occupancy sensors with multiple technology, and pass through mode capability
  - Include door switches
  - Provide clear indication of room conditions and occupied/unoccupied mode status both inside and outside of OR
  - Provide remote monitoring and control from Nurse's station

Summary – Sequence of Operations

- Best Sequence
  - Uses a schedule PLUS occupancy sensors to initiate unoccupied mode
  - Uses manual intervention to re-occupy if an OR is needed during unoccupied time
- Temperature and Humidity
  - Allow “float” (deadband) in the OR temperature during unoccupied mode
  - Maintain OR humidity
- Testing and Trending!
  - Test/calibrate all BAS sensors and verify room pressure
  - Trend ORs, room pressure and mode

AND don’t forget to look at your OR fans once and a while

Don’t forget why we are doing this . . .

Getting this wrong is NOT an option!!

2014 NCBC

John D. Villani, Vice President

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Energy Efficiency Consultants and Sustainable Design Engineers

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