Operating Room Solutions

Agenda

Operating Room Solutions
- Introduction
- Air Distribution
- Ceiling Systems
- Summary
ASHRAE 170
• Ventilation of Health Care Facilities (2008)
• First release of this standard
• Widely adopted in North America

Facility Guidelines Institute (FGI)
• Supersedes AIA/FGI 2006 Guidelines
• Adopted ASHRAE 170 for all HVAC requirements
Operating Room Solutions
Air Distribution

Air Distribution – O.R. Solutions
Systems

Laminar Flow Systems
Air Curtain Systems
Laminar Flow Systems

- Laminar diffuser array concentrated above surgical zone
- Displace particulates to low-level returns

Benefits

- Widely accepted design
- Supporting research
- Optional integrated filters
Ceiling Space

- Diffusers consuming valuable ceiling space
- 25 to 35 cfm/ft² (fpm) average face velocity (ASHRAE 170 – 2008)

Hybrid O.R. Challenges
Acceleration
- Result of $\Delta T$ between supply and room air
- Archimedes principle
  - ASHRAE RP-1397
Laminar Flow Systems

- Smaller laminar array
- Perimeter slot diffusers
  - 25 to 45 cfm/ft discharge (15° outward from vertical)
- Displace particulates to low-level returns
Air Distribution – O.R. Solutions
ASHRAE 170 Requirements

<table>
<thead>
<tr>
<th>Space Designation (According to Function)</th>
<th>Supply Air Outlet Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>All class A, B, and C surgeries</td>
<td>Primary supply diffusers Group E, non-aspirating additional supply diffusers, Group E</td>
</tr>
</tbody>
</table>

7.4 Surgery Rooms

7.4.1 Class B and C Operating Rooms. Operating rooms shall be maintained at a positive pressure with respect to all adjoining spaces at all times. A pressure differential shall be maintained at a value of at least +0.01 in. wc (2.5 Pa). Operating rooms shall be provided with primary air supply diffusers that are designed as follows:

a. The airflow shall be unidirectional, downward, and the average velocity of the diffusers shall be 25 to 35 cfm ft (127 L/s m² to 178 L/s m²). The diffusers shall be concentrated to provide an airflow pattern over the patient and surgical team. (see Memarzadeh [2002] and Memarzadeh [2004] in Informatie Annex B: Bibliography.)

b. The area of the primary supply diffuser array shall extend a minimum of 12 in. (305 mm) beyond the footprint of the surgical table on each side. No more than 30% of the primary supply diffuser array area shall be used for non-diffuser uses such as lights, gas columns, etc. Additional supply diffusers may be required to provide additional ventilation to the operating room to achieve the environmental requirements of Table 7-1 relating to temperature, humidity, etc.
### 7.4 Surgery Rooms

**7.4.1 Class B and C Operating Rooms.** Operating rooms shall be maintained at a positive pressure with respect to all adjoining spaces at all times. A pressure differential shall be maintained at a value of at least 0.01 in. w.c. (25 Pa). Operating rooms shall be provided with primary supply diffusers that are designed as follows:

a. The airflow shall be unidirectional, downwards, and the average velocity of the diffusers shall be 25 to 35 cfm ft² (117 L/min to 178 L/min). The diffusers shall be concentrated to provide an airflow pattern over the patient and surgical team. (see Memarian et al. [2002] and Memarian et al. [2004] in Informativ Annex D: Bibliography.)

b. The area of the primary supply diffuser array shall extend a minimum of 12 in. (305 mm) beyond the footprint of the surgical table on each side. No more than 30% of the primary supply diffuser array area shall be used for non-diffuser uses such as lights, gas columns, etc. Additional supply diffusers may be required to provide additional ventilation to the operating room to achieve the environmental requirements of Table 7-1 relating to temperature, humidity, etc.
Any vertical discharge diffuser (i.e. Laminar Flow Diffuser or Perimeter Air Curtain Diffusers)

7.4 Surgery Rooms

7.4.1 Class B and C Operating Rooms. Operating rooms shall be maintained at a positive pressure with respect to all adjoining spaces at all times. A pressure differential shall be maintained at a value of at least ≈ 0.01 in. wc (2.5 Pa). Operating rooms shall be provided with primary supply diffusers that are designed as follows:

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- The area of the primary supply diffuser array shall extend a minimum of 12 in. (305 mm) beyond the footprint of the surgical table on each side. No more than 30% of the primary supply diffuser array area shall be used for non-diffuser uses such as lights, gas columns, etc. Additional supply diffusers may be required to provide additional ventilation to the operating room to achieve the environmental requirements of Table 7-1 relating to temperature, humidity, etc.
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System Sizing Example

• 12" offset from surgical table
  (per ASHRAE 170, 2008)

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System Sizing Example

• Laminar flow diffusers only in “Primary Supply Diffuser Array Area”
  (per ASHRAE 170, 2008)
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System Sizing Example

• MAX 30% for non-diffuser equipment
• 25 to 35 cfm/ft² (per ASHRAE 170, 2008)
• 25 cfm/ft² = 600 cfm

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System Sizing Example

• Diffuser layout flexible if minimum coverage satisfied
• Inside perimeter of air curtain diffusers:
  - 2 ft offset from Primary Diffuser Array Area
  - 3 ft offset from surgical table

• Active linear slot ≈ 40 ft

• Air curtain flow (min.)
  - 1600 cfm – 600 cfm = 1000 cfm
  - 1000 cfm / 40 ft = 25 cfm/ft
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System Sizing Example

Air Curtain System

Laminar System

480 ft²
20 ach

600 ft²
20 ach
Air Distribution – O.R. Solutions
System Sizing Example

Air Curtain System  600 ft²  25 ach  Laminar System

Isolation of surgical zone
Why worry about velocity?
- Contamination from surgical team
- Match thermal plume
- Comfort

Draft potential
- Consider the locations of staff in the O.R. (i.e. Anesthesiologist)

Duct configuration
- Ensure laminar flow and perimeter air curtain diffusers are fed from separate duct branches
Air Distribution Strategy Impact on Operating Room Infection Control

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\(^3\)Cannon Design, Grand Island, New York USA
\(^4\)University of Georgia, Athens, Georgin USA

The CFD model results (Figure 3) indicates that the particle path does flow from the clean to less clean area. The positive effect of the linear diffuser concept is clearly indicated. The air curtain has effectively isolated the clean zone, and has also provided an increase in air change rate in the patient zone by inducing air flow away from the clean zone. This results in an increase in the effective air exchange rate within the clean zone from 25 ACH to well above 40 to 50 ACH [2]. It is important to have as little space as possible between the linear diffusers as to reduce the induction of less clean air into the airstream and to avoid stagnant or low velocity areas which will trap contaminants [2]. As noted in the reference to the ASHRAE research studies on this topic [1], this results in a reduced likelihood of patient infection.

The CFD model results (Figure 3) indicates that the particle path does flow from the clean to less clean area. The positive effect of the linear diffuser concept is clearly indicated. The air curtain has effectively isolated the clean zone, and has also provided an increase in air change rate in the patient zone by inducing air flow away from the clean zone. This results in an increase in the effective air exchange rate within the clean zone from 25 ACH to well above 40 to 50 ACH [2]. It is important to have as little space as possible between the linear diffusers as to reduce the induction of less clean air into the airstream and to avoid stagnant or low velocity areas which will trap contaminants [2]. As noted in the reference to the ASHRAE research studies on this topic [1], this results in a reduced likelihood of patient infection.

Operating Room Solutions
Ceiling Systems
Ceiling Systems – O.R. Solutions

Introduction

O.R. Grid Ceiling Systems
- Extruded aluminum profiles
- Variety of finishes
- Closed cell gasket
- Removable panels
- Customizable layout
Advantages of O.R. Ceiling Systems

• Improved aesthetics
• Convenient ceiling plenum access
• Better use of ceiling space
• Reduced construction time / cost

FGI 2010 Guidelines

A2.1-7.2.3.4 (3) Ceilings in restricted areas

a. The central diffuser array, which supplies the ventilation air (e.g., for an operating room) is not considered part of the monolithic ceiling.

b. A central diffuser array consisting of unidirectional flow diffusers and/or architectural fill-in panels should form a single assembly in the ceiling. The array should be gasketed between the diffuser array and the ceiling and also between the system framing and the individual diffusers. Where booms and other equipment are located within the central diffuser array, the array should be provided with fill-in panels cut to accommodate the booms or other equipment. Fill-in panels are to be gasketed at the framing and at the perimeter of any cuts made to accommodate the equipment.
Ceiling Systems – O.R. Solutions
FGI 2010 Guidelines

2.1-7.2.3.4 Ceilings

* (3) Restricted areas

(a) Ceilings in restricted areas (e.g., operating rooms) shall be of monolithic construction.
   Cracks or perforations in these ceilings shall not be permitted.
(b) Ceiling finishes shall be scrubbable and capable of withstanding cleaning and/or disinfecting chemicals.
(c) All access openings in these ceilings shall be gasketed.

APPENDIX

A2.1-7.2.3.4 (3) Ceilings in restricted areas

a. The central diffuser array, which supplies the ventilation air (e.g., for an operating room) is not considered part of the monolithic ceiling.
   b. A central diffuser array consisting of unidirectional flow diffusers and/or architectural fill-in panels shall form a single assembly in the ceiling. The array should be gasketed between the diffuser array and the ceiling and also between the system framing and the individual diffusers. Where beams and other equipment are located within the central diffuser array, the array should be provided with fill-in panels (cut to accommodate the beams or other equipment). Fill-in panels are to be gasketed at the framing and at the perimeter of any cuts made to accommodate the equipment.

Exception for gasketed ceilings
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Finish Options

- Brushed Aluminum
- White Powder Coat
- Clear Anodized

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Ceiling Types

Unistrut® Integration
- Mounting of C-Arm support tracks
- Cath. labs
- Hybrid operating rooms
Integrated Plenum Systems

- Pressurized common plenum reduces duct connection requirements
- Easy balancing
- Custom designs to suit each operating room
# Ceiling Systems – O.R. Solutions

## Cost Comparison

### Surface Mounting
- Number of openings: 38
- Cut, finish, frame openings: $14,700
- Plaster frames (installed cost): $3,100
- Access doors: $1,100
- Estimated Total: $18,900

### Gasketed Grid Ceiling
- 7 penetrations - 90 linear feet

Estimates by installing contractor.
Ceiling Systems – O.R. Solutions
Cost Comparison

Factory Welded Grid System

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of openings</td>
<td>7 (6 can lights)</td>
</tr>
<tr>
<td>Factory Welded Grid</td>
<td>$6,300</td>
</tr>
<tr>
<td>Cut, finish, frame openings</td>
<td>$3,800</td>
</tr>
<tr>
<td>Fill-in panels</td>
<td>$1,300</td>
</tr>
<tr>
<td>Grid/panel installation</td>
<td>$3,500</td>
</tr>
<tr>
<td><strong>Actual Total</strong></td>
<td><strong>$14,900</strong></td>
</tr>
</tbody>
</table>

7 penetrations - 90 linear feet

Ceiling Systems – O.R. Solutions
Cost Comparison

Surface Mounting

$18,900 installed (excluding diffusers)

Gasketed Grid Ceiling

$14,900 installed (excluding diffusers)

> 20% savings over surface mounting
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Summary

• Both air curtain and full laminar flow systems can offer effective protection for the patient if designed correctly.

• Grid ceiling systems offer significant benefits over conventional sheetrock ceilings.
Questions?