OPERATING ROOM HVAC DESIGN

OPTIMIZATION OF THE MODERN O.R.

price | CRITICAL ENVIRONMENTS

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EXECUTIVE SUMMARY

Due to the ever-increasing demand for valuable ceiling space, modern operating room (OR) ceiling and air distribution systems must continuously improve and adapt to meet the demands presented by ceiling mounted medical equipment.

Conventional hospital operating room design utilizes a unidirectional, non-aspirating ventilation system which creates a particulate free zone at, and directly adjacent to, the patient table. This document will provide direction on how to maintain a particulate free zone around the patient and surgical team within the constraints of the complex medical imagery equipment that is an inherent feature of the modern OR.

Figure 1: Traditional Operating Room

Figure 2: Hybrid Operating Room

A traditional OR (*Figure 1*) allows for a large diffuser array directly above the operating table. It is typically easy to meet ASHRAE 170 criteria when designing a ventilation and ceiling system for a traditional OR.

The Hybrid OR (*Figure 2*) utilizes monitors and imaging equipment which consume valuable ceiling space and complicate the design process. Modern operating rooms require an engineered solution, often with custom diffusers and ceiling grids in order to maintain accessibility and cleanability of laminar flow diffusers while meeting FGI guidelines and ASHRAE 170 requirements.

Through our development of innovative HVAC solutions, Price Industries is meeting the challenge of the modern operating room head on. Whether a project requires a fully customized common plenum diffuser system with integrated LED lighting (Ultrasuite) or individually ducted HEPA diffuser modules in a welded ceiling grid (HGWC), Price Industries has a fully customized solution for each challenge. Our design engineers take pride in creating innovative solutions that are aesthetically pleasing and meet your performance requirements.

INTRODUCTION

The modern operating room, including hybrid operating rooms and imaging suites, requires more complex ceiling and HVAC solutions compared to traditional operating rooms. This document will outline what to look for, how to design, and how to optimize a modern OR HVAC design project.

A hybrid operating room, as defined by the FGI Guideline for Design and Construction of Hospitals, is "a room that meets the definition of an operating room and is also equipped to enable diagnostic imaging before, during, and after surgical procedures. Imaging equipment is permanently installed in the room and may include MRI, fixed single-plane and bi-plane tomographic imaging systems, and computed tomography equipment." Whether or not a space is designated as a Hybrid OR, Electrophysiology (EP) Lab, Catheterization (Cath) Lab, or Interventional Radiology (IR) Lab, it typically requires the same considerations to determine feasibility of an engineered integrated ceiling and air distribution system.

A traditional OR layout with 2 ft. x 2 ft. or 2 ft. x 4 ft. diffusers and lights is unlikely to offer the best solution for a modern OR that utilizes imaging equipment and ceiling mounted monitors. Custom sized diffusers are often required to provide enough laminar airflow directly above the operating table while maintaining internal diffuser access and cleanability. Identifying and locating both ceiling level strut channel and imaging equipment support rails below the ceiling is a critical first step when designing a modern OR ceiling layout.

Figure 3: Custom OR ceiling system, featuring the Price Ultrasuite

WHAT TO LOOK FOR

Room Type/Name

The room type/name is typically the first indication that a space will require a custom diffuser layout. The following room types generally require ceiling level strut channel to support tomographic imaging systems, monitors, radiation shields, etc.:

+ Hybrid OR
+ Electrophysiology (EP) Lab
+ Catheterization (Cath) Lab
+ Interventional Radiology (IR) Lab

While plans for the room types mentioned above may not show any medical equipment in their preliminary stages. There is still a very good chance that ceiling level strut channel will be required for these applications and the engineered ceiling system will have to be coordinated around it.

Figure 4: Single plane imaging suite

Single Plane vs. Biplane, & Floor Mounted vs. Ceiling Mounted Imaging Equipment

Not all Hybrid ORs and Imaging Suites utilize ceiling level tomographic equipment or require ceiling level strut channel to support medical equipment. A small portion of Hybrid ORs and Imaging suites, typically single plane, can utilize traditional OR diffuser layouts.

A single plane imaging suite utilizes one C arm which can be floor mounted and can be used without installing equipment support rails from the ceiling which limit diffuser placement. Single plane imaging suites may still utilize ceiling mounted monitors and/or radiation shields which are typically supported from ceiling level strut channel.

A biplane imaging suite utilizes two C arms along with monitors and/or radiation shields and almost always require ceiling level support strut to support the equipment.

Figure 5: Biplane imaging suite

Medical Equipment Manufacturer

There are many medical equipment manufacturers that each require unique ceiling level strut channel layouts to support their equipment. The images below reflect strut channel and equipment layouts for the most common medical imaging equipment suppliers. The uniqueness of each strut channel layout shows the importance of coordinating an engineered HVAC and ceiling system around each specific medical equipment supplier.

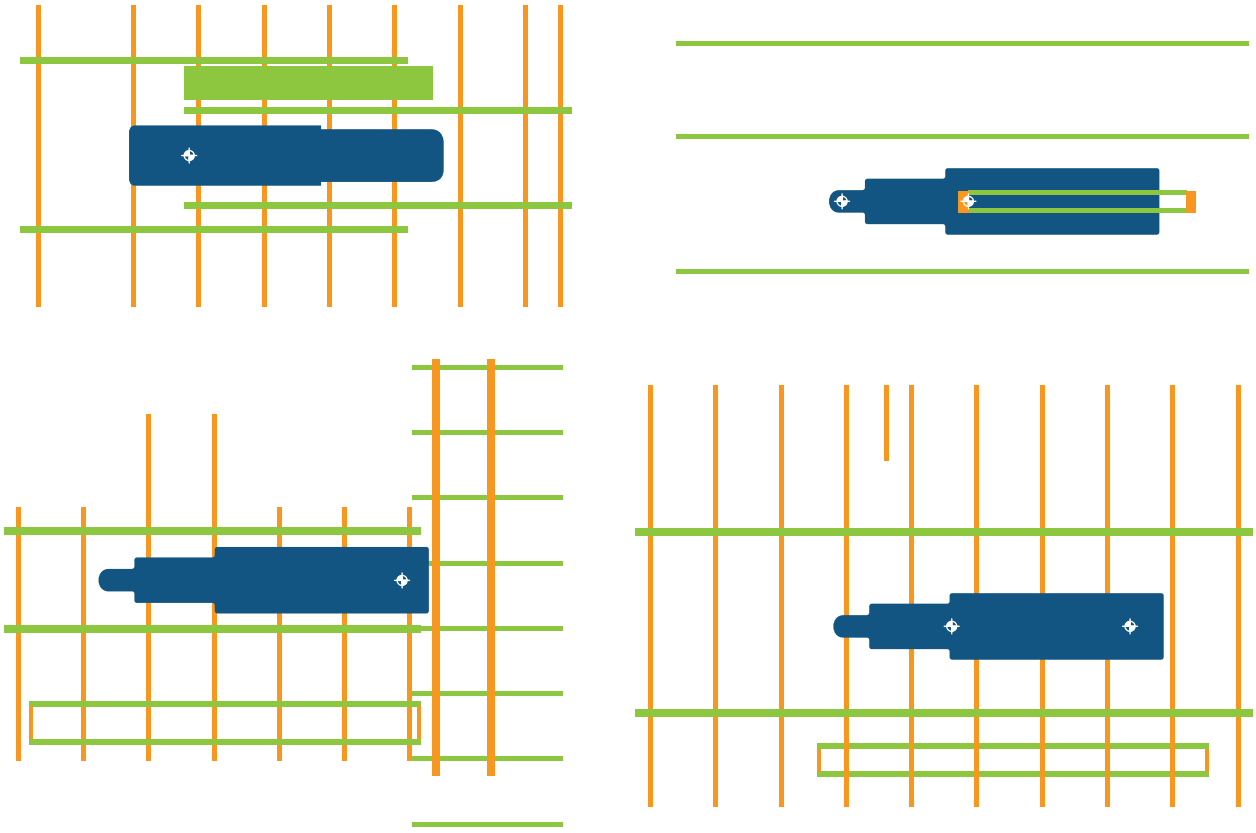

Figure 6: Strut channel layouts for common medical equipment

DESIGN PARAMETERS AND CONSIDERATIONS

Airflow Requirements

As with any OR design, the first step is to identify airflow requirements for the space based on the design criteria set out in *ASHRAE 170-2017 Standard for the Ventilation of Health Care Facilities* and/or applicable local codes. The following considerations should be taken:

+ Design for a positively pressured room with a minimum of 20 total air changes per hour (ACH)
+ Unidirectional downwards MERV 14 (or HEPA) filtered airflow with an average velocity of 25 to 35 cfm/sq.ft.
+ A primary supply diffuser array, of which no more than 30% is used for non diffuser uses, that extends a minimum of 12 in. beyond the footprint of the operating table

Combining these design parameters greatly reduces the risk of infection during medical procedures by creating a sterile field around the patient and medical team.

Strut Channel and Medical Equipment Support Rails

Once the airflow requirements have been specified and the number of diffusers required to meet code has been determined, they must be located and placed within the ceiling level strut channel and medical equipment support rails. Figure 8 is an example of an imaging suite ceiling layout where the vertical rails reflect ceiling level strut channel. Diffusers cannot physically be placed in these locations. Most medical equipment suppliers specify strut channel located on 26" centers which allows standard width diffusers to be used. The horizontal lines reflect medical equipment support rails which install directly below the ceiling. Diffusers can be placed in these locations but the faces cannot be opened for internal access or cleaning once the rails are installed so avoiding these locations is strongly recommended as well.

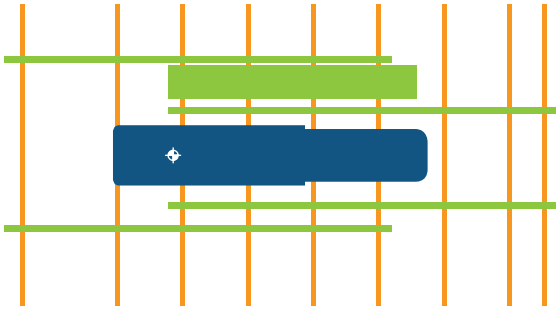

Figure 7: Imaging suite ceiling level strut channel and medical equipment support rail schematic

ASHRAE 170 Table Coverage

The image below illustrates how a central row of custom size laminar flow diffusers can be sized to fit within the medical equipment rails while ensuring that no more than 30% of the 12in. operating table extension is used for non diffuser uses helping to create a sterile field of MERV 14 (or HEPA) filtered air around the surgical area.

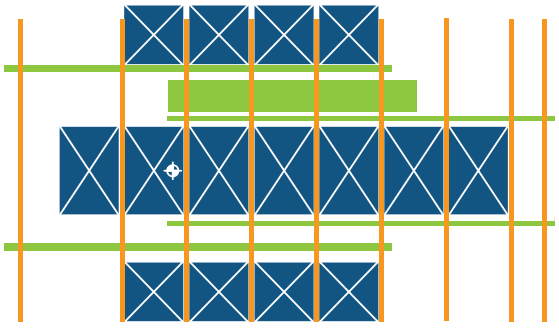

Figure 8: Custom diffuser schematic

Creating the Ideal OR Ceiling System Layout

While a common 2 ft. x 2 ft. or 2 ft. x 4 ft. laminar flow diffuser layout (figure 9) will meet all ASHRAE 170 requirements, the diffusers may not fit into the structural support for the medical imaging equipment. Additionally, diffuser faces may not be removable once the medical equipment rails and equipment is installed which nullifies the functionality of the ¼ hardware and the cleanability of the laminar flow diffuser itself.

Layouts such as figure 10 which account for ceiling level strut channel but not the medical equipment rails will still pose challenges regarding the functionality and cleanability of the laminar flow diffusers.

Creating a custom layout which utilizes job specific sized laminar flow diffusers (figure 11) is the best way to ensure that ASHRAE 170 requirements are met while maintaining all laminar flow diffuser functionality.

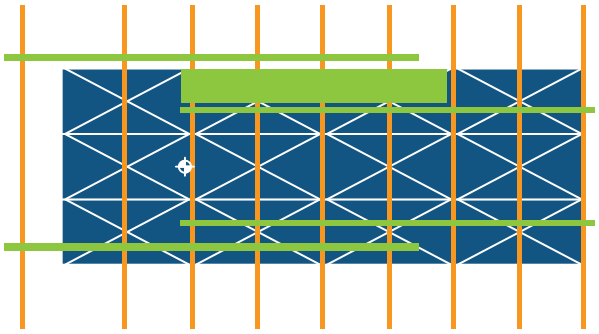

Figure 9: Layout meets ASHRAE 170 requirements but is incompatible with strut channel

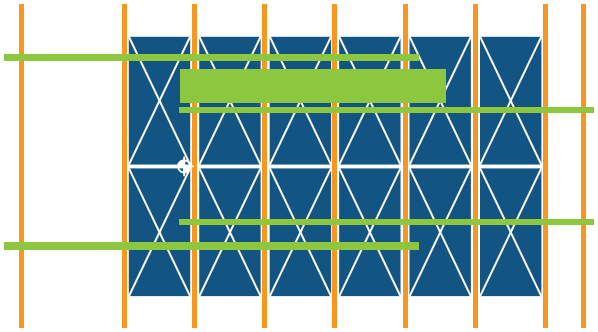

Figure 10: Layout meets ASHRAE 170 requirements but is incompatible with equipment rails

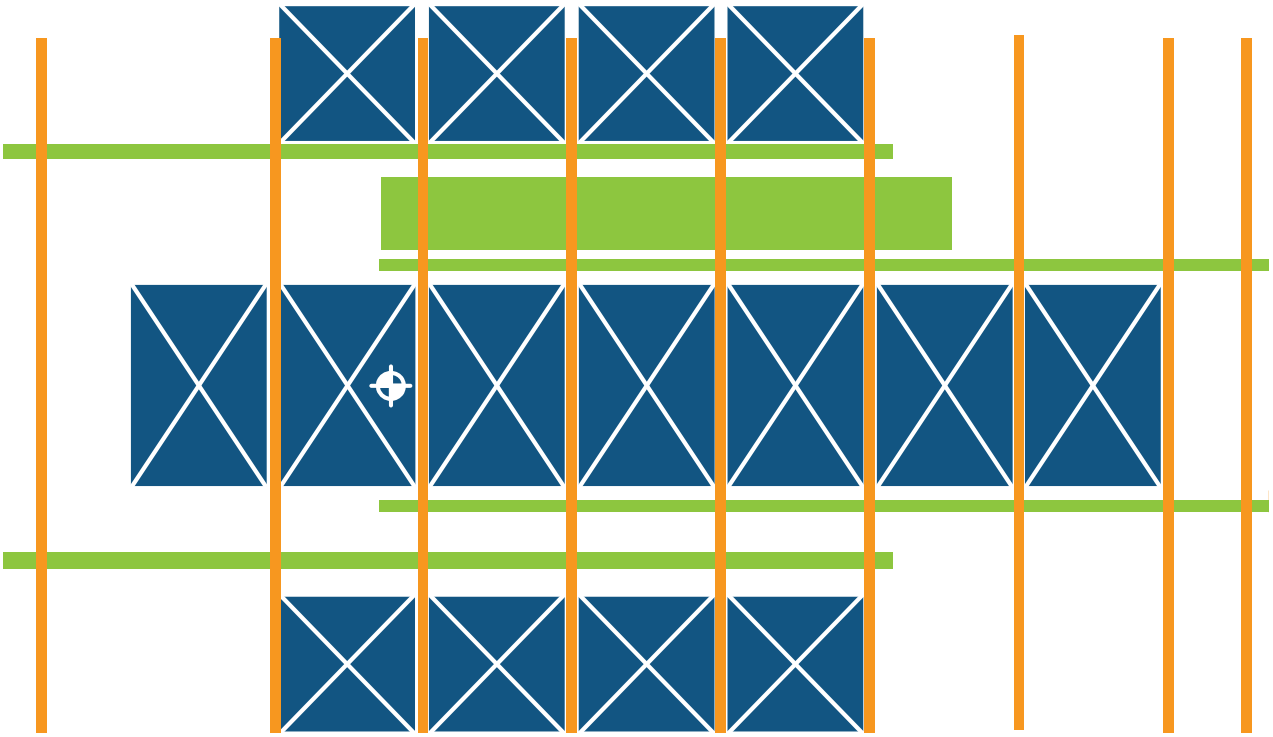

Figure 11: Custom diffuser layout meets ASHRAE 170 standards and coordinates with medical equipment

OPTIMIZATION

Price Industries offers many opportunities to optimize a modern OR ceiling layout.

Engineered Ceiling Grid

Drywall framing around each individual diffuser and light fixture is a common installation method in a standard OR. A Hybrid OR installation has additional challenges in that drywall framing is also required around ceiling level strut channel. A best-case laminar flow layout design in a hybrid operating room typically has 25-30% of the 12” operating table extension used for non-diffuser uses and the added framing required for each diffuser is often enough to push that number over the 30% threshold and eliminate ASHRAE 170 compliance. A Price HGWC welded ceiling grid integrates directly with ceiling level strut channel and ensures maximum coverage of the 12” operating table extension.

Common Plenum System

The additional structure present in a Hybrid OR creates coordination challenges for ductwork. A Price HGP common plenum laminar flow system has all the benefits of a HGWC welded ceiling grid while reducing the overall ductwork requirement to as little as two inlet connections or less for an entire operating suite.

Fully Integrated Common Plenum and LED Lighting System

Further optimization can be found with a Price Ultrasuite common plenum system with integrated LED lighting which provides high quality LED lighting directly over the operating table while providing all of the benefits of a common plenum laminar flow system.

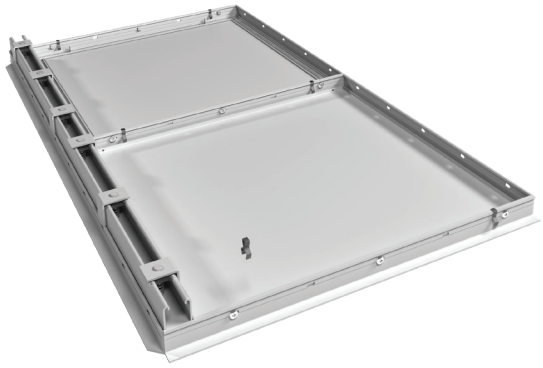

Figure 12: Hospital-Grade Welded Ceiling System (HGWC)

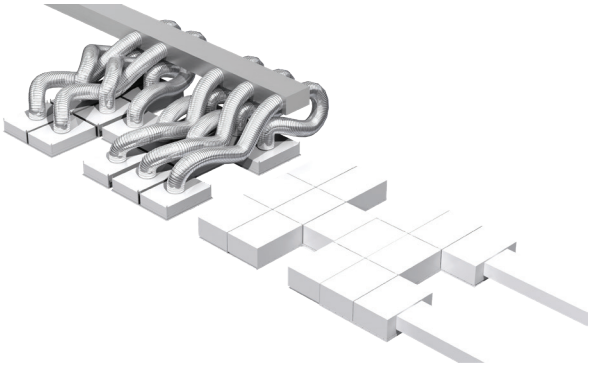

Figure 13: Hospital-Grade Common Plenum (HGP)

Figure 14: OR Diffuser System with Integrated LED Lighting (Ultrasuite)

CONCLUSION

Designing an HVAC system and ceiling grid for a modern operating room presents many challenges. Creating and maintaining a particulate free zone around the surgical area, which is critical in reducing surgical site infections, is further complicated by the imaging and diagnostic equipment that is present. Price Industries has the products and expertise to fit any application and overcome any challenges. Contact our application engineering team at **criticalenvironments@priceindustries.com** for comprehensive layout and design assistance.

Figure 15: Hybrid OR featuring the Price Hospital Grade Common Plenum

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