Cleanroom ceiling systems

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Abstract

There are many considerations when designing a cleanroom ceiling system and this article sets out to list and explain the most important. Ceilings can be modular or stick-built and assembled onsite or offsite. They need to take into account access to components such as filters and lighting, whether this access will be from below or above, whether the ceiling needs to be walkable and what types of loads need to be supported from the ceiling grid. How these components, as well as utilities, are integrated into the ceiling without compromising the performance of the cleanroom is important. Designers should also take into account whether it is necessary to allow for possible future expansion of the cleanroom. The use of BIM (building information modeling) will help achieve a coordinated project and the eventual cost will depend on choices made in all these considerations.

Introduction

Designing a cleanroom ceiling system is a critical aspect of creating a controlled environment that meets specific cleanliness and safety standards. The ceiling system plays a significant role in maintaining cleanliness, controlling airflow, and ensuring the overall functionality of the cleanroom with construction requirements that minimize cost and allow ease and speed of installation.

Here are the main considerations in any cleanroom system design, for cleanroom end-users, architectural engineers, and general contractors.

Types of ceiling system

There are various types of cleanroom ceiling systems to choose from to best fit the requirements including space. The main types are modular and stick-built systems. When selecting the appropriate ceiling grid for the space in question, factors such as ease of maintenance, installation flexibility and long-term adaptability need to be considered. With a modular grid, the ceilings are pre-built and integrated with wiring, lighting, and fire protection ready to be lifted into place. In instances where retrofitting is needed, a stick-built solution can provide more flexibility and adaptability to existing spaces. All stick-built solutions are not the same and depend on installation requirements and the support structure required for hanging. For example, having less hangers means a quicker, less labor-intensive installation. For examples of the different systems see Figures 1. to 4.

Onsite assembly or offsite manufacturing

Depending on whether the cleanroom is a new space or being retrofitted into an existing space, and what other construction is taking place at the same time, there may not be space or time for onsite assembly. A suitable partner for ceiling systems will have flexibility for installation. A partner with a hybrid construction model should be able to deliver the ceiling grid completely built, semi-built, or ready to be built on site.

Structural capabilities of the ceiling grid

There are three primary structural components to consider for a ceiling grid:

1. What structure is above the cleanroom that needs to be supported?
2. What hangs below the ceiling – automatic material handling system (AMHS load)?
3. Does the ceiling grid need to be walkable?

Regular maintenance, inspections, and housing air handlers and fall protection require easy access to the ceiling plenum. The ceiling system's design can make access more convenient and reduce downtime during maintenance activities. Not only is walkability of a ceiling grid important, but an understanding of the different available walkable components such as blanks, return air grills, light troffers, and fan filter units is important to the performance of the ceiling grid.

For the semi-conductor industry, ceilings often need to integrate the load requirements of automated material handling systems (AMHS). Identifying these requirements and verifying the

Figure 1: Modular flush ceiling with integrated lighting

Figure 2. T Grid stick-built assembly with amber LED track lighting

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capability of the cleanroom partner to provide solutions will ensure that the ceiling is designed to support all essential elements.

Integration of lighting and utilities

Cleanroom ceiling systems often need to accommodate lighting, HEPA filters, sprinklers, and other utilities. The partner will need to answer how the ceiling system will integrate these components, while maintaining the required level of cleanliness. Proper integration is essential to avoid compromising the cleanroom's functionality or contaminating the environment.

As the industry continues to shift to LED lighting, the lighting options should be explored as well as the spectrum of light. For instance, areas in semi-conductor cleanrooms may require amber lighting for the process. A simple shift to LED options will not only meet regulatory demands, but will also provide energy efficiency opportunities.

Placement of lighting and wiring in the ceiling grid can also impact the performance of the cleanroom. Flush mounting the lights is beneficial but a small change in mounting can have a big impact in a unidirectional airflow cleanroom with high filter coverage requirements, reducing turbulence and creating a smoother airflow.

Suitability of materials

Ceiling system materials vary in terms of durability, chemical resistance, and cleanability. The materials selected for the ceiling panels, grid structure, and any additional components should be suitable for the process to be carried out, especially for cleanrooms in the semi-conductor and biopharmaceutical industries. Powder coated aluminum is usually a safe choice as it not only increases durability but also prevents off-gassing which can impact the process that is taking place in the cleanroom.

Adaptabilty to future changes

As demand for cleanroom production continues to increase, future expansion of an existing cleanroom may be required. The chosen ceiling system should be capable of adapting to these changes, without requiring extensive modifications or replacements.

In instances of expansion or retrofitting, a stick-built ceiling grid can integrate with the existing structure, even if it is a modular ceiling. Not all partners have the knowledge to connect the varying ceiling grid structures together so it is important to select a partner who not only manufactures both types of ceiling grid but also has the expertise.

Building information modeling (BIM)

BIM is an important tool in cleanroom design. Architects commonly use a BIM platform called Revit. Collaboration between the cleanroom designer, architect and mechanical and electrical disciplines ensures that the space is utilized efficiently with no clashes or access problems. A cleanroom manufacturer who has the capability to draw the ceiling system in the BIM platform, will produce more refined designs that integrate into the space seamlessly. This can be critical to keeping projects on time and to budgets.

Cost

A key starting point is the cost of design services such as BIM to coordinate the design work. Within the design, evaluation of loading requirements is important to determine the type of ceiling system needed (pre-assembled modules or stick-built ceiling pieces). Based on the ceiling type, labor costs will vary. For example, ceiling modules are commonly pre-assembled offsite, ready to lift in place, and often have

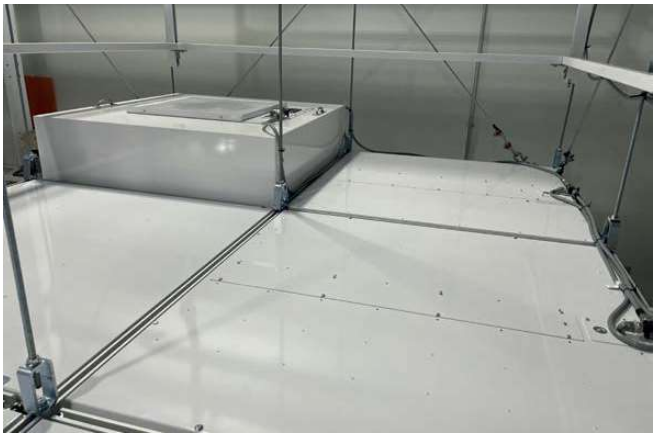

Figure 3: T Grid stick built assemble, walkable top-side with 4x4 FFU (fan filter unit) installed

Figure 4: Walkable modular flush ceiling with plenum, recirculating AHU, sprinkler main and FFU
All photos courtesy of Nortek Air Solutions CleanSpace.

components like lighting and fire protection already integrated. Whereas stick-built ceilings will be partially or completely assembled onsite and then accessories are added. While ceiling cost per square foot will vary in this comparison, they are also affected by the local cost of labor as well as schedule timing.

For any ceiling system, materials of construction will affect cost. Steel, stainless steel, and aluminum are the most commonly used materials. Material selection is determined by the application and level of sanitary requirements. Once installed, cleanroom ceiling systems play a critical ongoing role in proper air delivery, air quality and process control. The right products can help ensure a return on investment with decreased operation costs, increased productivity, and reliability.

Conclusion

Designing a cleanroom ceiling system involves a complex balance of technical considerations to ensure optimal cleanliness, functionality, and compliance with industry standards. By taking into account the considerations covered in this article and collaborating closely with carefully selected cleanroom design experts, the result will be a ceiling system that aligns with the cleanroom's classification requirements, contributes to effective contamination control, and maintains a controlled environment for the specific application.

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