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Rainscreen Wall Assemblies

Introduction

All exterior wall assemblies are designed to control water infiltration and provide insulation. A conventional envelope system involves installing an outer weather-resistant barrier directly on an inner insulated layer, creating a dual-purpose outer skin. This type of system can be effective but is highly dependent on the integrity of the outer barrier. Failures can occur if components of the barrier are damaged or degrade and pressure-driven water becomes trapped behind the barrier, which can lead to mold, reduced insulation values, and other issues.

Rainscreen wall assemblies solve this problem by separating the weather-resistant barrier from the insulated wall with a ventilated air space. The air space equalizes the pressure on the weather-resistant barrier, greatly reducing pressure-driven water and minimizing infiltration. Any water that passes through the barrier is captured in the air space, where it can drain and evaporate.

Rainscreen Function

A rainscreen must be designed to resist numerous forces which naturally drive water to the interior of a wall assembly, including:

- **Kinetic Energy,** in the form of wind, which creates differential pressure that can drive water into a wall. The wall must be detailed so that the exterior surface is pressure equalized in order to negate this effect.
- **Gravity,** which pulls water down the face of a wall. The wall must be detailed so that water traveling down the exterior face remains on the exterior and is continually directed outward.
- **Capillary Action,** which allows a liquid to flow in narrow spaces in opposition to gravity. The wall must be detailed so that joints are either large enough or provided with gaps or breaks so that water does not flow into the interior.
- **Surface Tension,** which allows water to cling to the underside of a horizontal surface. The wall must be detailed so that horizontal surfaces have drip edges to interrupt the migration of water to the interior.

A functional rainscreen assembly requires the following components, from exterior to interior (see Figure 1):

1. **Rainscreen cladding** composed of a weather-resistant material and detailed to minimize water infiltration through gravity, capillary action, and surface tension. The cladding must also be detailed with openings to promote ventilation, which can be at the top and bottom or in gaps between the cladding members.

Figure 1:
Rainscreen Components

2. **Air space** between the cladding and the insulated wall that is large enough to promote air circulation for ventilation, equalize air pressure, and allows water in the air space to drain and evaporate.

3. **Water-resistant barrier** on the interior of the air space that provides a second line of defense against water as well as a drainage plane and allows the wall to breathe. Characteristics of the barrier are determined by the climate and the dynamics of the wall performance. The barrier must be flashed and sealed at the top, bottom, and at all penetrations.

Conclusion

Properly detailed rainscreen assemblies solve many issues common in conventional envelope systems. By equalizing the pressure on the weather-resistant cladding, the rainscreen reduces water infiltration and eliminates trapped water in a wall system.

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ANSI/NEMA LED Binning Standard

Introduction

Daylighting, Lighting-class LEDs are driven by application requirements and industry standards. In 2008, ANSI and NEMA collaborated to establish a binning standard for LED manufacturers called ANSI/NEMA C78 377A, also known as "Specifications for the Chromaticity of Solid-State Lighting Products."

This Technical Bulletin briefly explains the binning process, which is the focus of ANSI/NEMA C78 377A and illustrates why this standard should be important to both manufacturers and lighting engineers.

Definitions

The technique that manufacturers have developed to classify their LEDs is called LED binning. LEDs are placed into similar categories, or bins, with each category defined by similarity in lumens, colors, and forward biased voltages. LED binning according to colors is based on the CIE 1931 Chromaticity Diagram (from the International Commission on Illumination) and a series of quadrilaterals that are imposed upon the Chromaticity Diagram (see Figure 1). Those quadrilaterals identify regions of noticeable differences in color. Within each of these individual quadrilaterals, the human eye cannot perceive any color difference. Therefore, LED manufacturers indicate the coordinates of their LED on the chromaticity diagram, and end-users can reliably use this information to select the correct color light for specific applications.

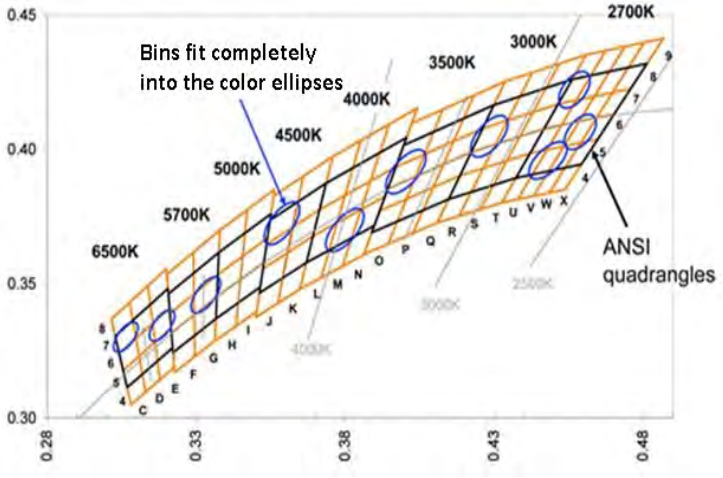

Figure 1: Chromaticity Diagram

LED Production

To understand binning, it is helpful to review the production of LEDs. Manufacturers receive LED chips known as blue chips, which are groups of similar LED chips packed and glued to blue discs. LEDs are first unpacked manually, then picked and placed automatically onto plastic packages. After alignment, a gold wire is attached between every chip, at which point phosphor is applied on top of the LED chips to convert the blue light emitted from the chip to white light. Each LED is then scanned and verified for the appropriate color temperature, and phosphor is manually added or removed as needed so that the color matches the specification. Protective polycarbonate casing is then attached on top of the underlying chips. The product is tested for air voids, and silicon will be manually added to fill these voids as necessary. Finally, heat is applied to cure the silicon material within the LED. When the quality control is finished, the binning process begins.

Binning Process

LEDs are first introduced into the hopper of a sorting machine and then lined up to enter into a spectral radiometer. Each LED product is then individually measured and sorted by lumen output and color into prescribed ranges. LED suppliers create their own standard sets of lumen bins and provide clear information on the expected lumen performance of each of their bin ranges. This way, luminaire manufacturers can easily select the bin (or set of bins) that best meets their needs using the lumen coordinates based on the Chromaticity Diagram. Smaller bin sizes maintain a tighter control of color variation and are consequently more desirable.

Conclusion

Binning is important for luminaire manufacturers to specify and control LED color output, since these factors have significant impact on performance, cost, and lead-time. Lighting engineers and designers are also encouraged to familiarize themselves with the manufacturer's binning process and applicable engineering standards like ANSI/NEMA C78 377A to ensure quality LED products are installed.

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Daylighting – European Standard EN 17037

Introduction

Daylighting, a practice involving the access to and illumination of interior spaces by natural light, is an established component of good building design and has been linked to the improved health and performance of building occupants. Natural light and views are important design elements that are addressed in LEED and other building design assessment programs, and requirements continue to evolve to reflect their value. For insight into the potential future of daylighting requirements, it is valuable to understand the European Union standard for daylighting.

Due to factors such as population density, high energy cost, and environmental awareness, Europe has focused on healthy and sustainable building design, and therefore leads the world in many emerging building technologies, including green roofs, rain screen wall systems, and natural ventilation. Because of the industry's focus on healthy design, the practice of daylighting has become more mainstream, and EN 17037 was created to outline standardized daylighting requirements.

EN 17037 was published in 2018 and is the first European standard to provide requirements for daylight in buildings. It defines the quantity and quality of daylight building occupants should experience. This standard is applicable to all rooms occupied on a regular basis, except for rooms with functions that are incompatible with daylight. Its provisions have the potential to influence the depth of floorplates, the size, configuration, and orientation of windows, the use of skylights, the height of ceilings, and other key architectural elements.

Levels of Performance

EN 17037 sets standards for individual spaces within a building and recognizes that optimal daylighting varies by room type. Performance levels are established for each of four daylighting design criteria: daylighting, views, access, and glare. These criteria establish a minimum acceptable daylighting environment for building occupants and address health, comfort, and productivity.

Daylighting: The daylighting provision require that adequate natural lighting, defined as 300 lux of natural light, should be present for building occupants to be able to perform regular tasks. A space is deemed compliant if it is calculated to achieve a minimum of 300 lux over 50% of the space for more than half the daylight hours in the year without artificial lighting. Calculations can be validated by software or by specified procedures.

Views: The views provision requires that building occupants have exterior views which are clear, unobstructed, and naturally colored. Building users should have an acceptably large, clear view of the outside. Designers should consider factors such as width, distance, and features (sky, landscape, and ground).

Access: The access provision addresses exposure to direct sunlight, which is a comfort and health factor for residential, clinical, and childcare facilities, among other building types. Daily sunlight exposure calculations can be validated by software or by table values provided.

Glare. The glare provision addresses the negative impact glare has on building occupants' comfort and productivity. The daylight glare probability (DGP) is calculated and used to determine whether anti-glare provisions are required. Rooms where people read from paper or computer screens are of particular concern, and shading, low transmission glazing, or electrochromic glazing may be required.

Conclusion

Daylighting has proven to be beneficial for the health and wellbeing of building occupants. Europe's increased focus on healthy design practices mean that daylighting has become a more standard practice, leading the EU to develop EN 17037. As a European standard, EN17037 only applies to countries in the European Union, but with the increased awareness of healthy design in the US, similar requirements may be adopted here in the future. Reviewing this standard may therefore be a good indication of what the US can expect.

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APF Pressurization Part II

Introduction

APF (Aseptic Processing Facilities) room differential pressurization (dP) is critical for controlling the migration of contaminants. The HVAC control system must be designed to attain dP stability during normal operation, recover fully and within the desired pressure range after an upset event (such as a generator testing), and minimize potential for pressure reversal during failure conditions. Pressure sensors must remain calibrated over the period of operation, as sensors drift over time.

Room Pressure Control

Space pressure differential is actively controlled through the Building Automation System (BAS). In APFs, passive cascading flow tracking (fixed offset) pressurization with limited pressure reset control is the most commonly used method. On the other hand, direct pressure measurement-based active pressurization control is not allowed in APFs.

Supply and exhaust air terminals are provided with fast-acting actuators and airflow monitors. For positive pressure rooms, the actuator on a supply air terminal controls airflow to its setpoint. The actuator on an exhaust valve then modulates to maintain a volumetric offset between the measured supply and exhaust air volumes, thereby maintaining directional airflow control. If the measured room dP is less than the lower alert pressure limit, the offset airflow setpoint value is increased by a small amount of airflow per minute. If the measured room dP is greater than upper alert pressure limit, the reverse occurs, and if the measured room dP is between the alert limits, the offset airflow setpoint shall remain fixed. The total offset airflow setpoint value shall also be restricted to the selected range. With negative pressure rooms, the reverse of this process occurs.

Pressure Stability

To the extent possible, dP between rooms is achieved using gaps around doors and door undercuts to control differential airflow between spaces, thereby controlling the differential pressure. Where inaccuracies in airflow measurement exceed the amount of air that can be passed around door gaps, an adjustable transfer louver may be installed between adjacent rooms to allow greater transfer of air in order to achieve pressure stability.

Loss of Pressurization

The potential for loss of pressure control due to power loss, emergency generator testing, or controller failure is a concern in APFs. According to DRM section 13.9.8, fail positions (fail in last position or total shut-off) of the air terminal "shall be such that classified space pressurization is maintained to the extent possible." Upon main system failures (such as loss of an AHU or exhaust fan), DRM 13.9.9 states that a cross-limiting loop sequence shall be provided in order to "restrict the leading system from exceeding the lagging system [and]… prohibit excessive door-opening forces" or reverse pressurization. Cross-limiting loops shall not apply to biological safety cabinets (BSCs) or other safety equipment.

Alarm/Data Capture Requirements

Time delays are provided to minimize nuisance alarms whenever a door is opened. DRM 13.9.5 says that "The duration of the time delay should be sufficient (not less than 120 seconds) to permit the normal passage through an open door and for the system to recover." Differential pressure data is typically collected at 1-minute intervals or every Change of Value (COV), whichever is less.

Calibration

Calibration is required initially during start-up of the facility and then periodically (12 months or as indicated in the SOP) as sensors drift over time. Calibration must be traceable to NIST or equivalent standards. The accuracy of the dP electronic pressure transducers will be ±1.25 Pa (±0.005 in. w.g.). Field calibration for critical differential pressure sensors shall be performed using a 3-point calibration procedure at minimum, and EMS and BAS sensors should be recalibrated contemporaneously.

Conclusion

The combination of design elements (described in Part 1) and HVAC controls help maintain desired pressurization and stability in APFs. These elements are critical for APF facilities to maintain proper functionality and meet design and operation requirements.

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APF Pressurization Part I

Introduction

Aseptic Processing Facility (APF) room differential pressurization (dP) is critical for controlling the migration of contaminants. The air distribution systems in these facilities must be designed to attain a desirable pressure level within each room relative to all adjacent areas. Airlocks are a key factor in maintaining pressure differentials and the integrity of controlled spaces during entry and exit.

Space Layout

ISO 7 cleanrooms are designed with airlocks that help buffer the room from external pressures and control the migration of contaminants. If there is no airlock, room dP will drop to near zero when the door is opened.

There are three kinds of airlocks: cascading type (where air flows from high pressure spaces to lower pressure), bubble type (where air flows out to adjoining rooms) and sink type (where air flows in from adjacent areas). Cascading airlocks are used for entry to sterile non-hazardous rooms. Bubble type airlocks are used for entry to sterile hazardous rooms, or in biological processing rooms where viral vector manipulation is performed. Sink type airlocks are almost always used for exits from unidirectional sterile hazardous rooms.

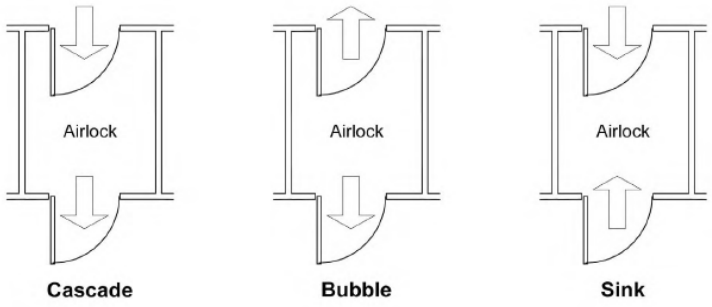

Figure 1: Airlock types

In a bidirectional layout arrangement (where entry and exit occur through a common anteroom), the airlock can be either cascading or bubble type, depending on the type of product – a facility handling hazardous products will use a bubble airlock, while one that handles non-hazardous products will use a cascading airlock.

Architectural Features

Architectural features also play a critical role when designing to maintain room pressurization and control the migration of contaminants. Wall and ceiling materials, door types, door gaskets, access doors, door gaps, and pass throughs all factor into the design of the pressurization system. There should be very minimal leakage from the walls, ceiling, and fixtures in ISO classified rooms, so all the air is transferred via door gaps. This helps control the amount and direction of air needed to maintain differential pressure.

Air Distribution Requirements

Each pressure control zone is provided with both pressure-independent supply air served from 100% outside air handlers and exhaust air terminal units connected to exhaust fans. This helps to maintain constant airflow at the terminals regardless of airflow or pressure changes in other spaces.

Differential Pressure Monitor (DPM)

Each classified space is required to have a DPM. The DPM can be mounted outside the entrance door to the room being monitored or placed in a central panel, so long as the panel location is in line of sight of the rooms being monitored.

The DPM also provides local and remote alarms when the pressure goes beyond adjustable thresholds and time durations. It is preferred that DPMs display the Environmental Monitoring System (EMS) pressure value, as the EMS is the validated system of record.

This article will continue next month with a further review of the control requirements to successfully maintain room pressure in APF facilities.

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Predictive Maintenance

Introduction

The goal of predictive maintenance is to reduce unscheduled outages created by equipment failures and to improve the overall availability of an operating plant. Traditional maintenance programs rely on routine equipment servicing to reduce plant outages, but predictive maintenance programs schedule specific maintenance tasks as they are actually required based on equipment operating conditions. Predictive maintenance is not a substitute for traditional maintenance programs, but if executed properly it can significantly increase plant availability. Comprehensive predictive maintenance programs shall include monitoring and diagnostic techniques such as vibration monitoring, thermography, tribology, ultrasonic and other nondestructive testing techniques.

Vibration Monitoring

Vibration monitoring is the most critical predictive maintenance tool as most plants have a large number of electromechanical equipment. Many of the vibration monitoring systems employed today collect single channel, steady state data that are only suitable for simple machines operating at a relatively constant speed. Therefore, frequency domain vibration monitoring tools as well as analytical tools are required to accurately predict machine failure. Furthermore, vibration monitoring systems must be used for all critical systems, not only simple rotating systems, to increase plant availability.

Thermography

Thermal imaging tools can be used to monitor the conditions of machinery, structures, and plant systems. These tools detect infrared energy emitted by equipment in order to identify thermal anomaly i.e. areas that are hotter or colder than the normal operating condition. Thermal image analysis can locate a multitude of incipient problems within the plant. Because there is a wide selection of thermal imaging equipment available, proper equipment selection is critical for predictive maintenance applications. Thermal imaging systems can also be valuable for monitoring the thermal efficiency of critical processes that rely on heat transfer or retention, electrical equipment, and other process parameters.

Tribology

Tribology refers to the analysis of surfaces in relative motion and studies how wear, friction and lubrication, and other tribo-elements behave in relative motion in natural and artificial systems. Two of the most important tribology techniques used for predictive maintenance are lubricating oil analysis and wear particle analysis. Lubrication analysis can only be used to schedule oil change intervals based on the actual condition of the oil and to analyze effectiveness of the oil in lubricating the equipment. Lubrication analysis can't be effectively used to determine the operating condition of equipment or detect potential equipment failures. Wear particle analysis, on the other hand, provides wear conditions of equipment. Wear particle size, shape, composition, and quantity can be used to predict potential equipment failures. Wear particle analysis can also be useful for understanding the root cause of catastrophic equipment failures. To effectively employ wear particle analysis in predictive maintenance programs, sampling frequency must be chosen based on the equipment mean time between failures (MTBF).

Ultrasonic

Like vibration analysis, ultrasonic is a subset of noise analysis. The only difference between the two measurements is the frequency of interest. Ultrasonic measures noise frequencies above 30 KHz, whereas vibration analysis measures frequencies between 1 Hz to 30 KHz. Ultrasonic measurement is useful for detecting leaks that generally create high frequency noise because of the expansion or compression of air, gases, or liquids as they flow through an orifice or leak in either pressure or vacuum vessels.

Visual Inspection

Visual inspection is one of the most critical components of predictive maintenance. Daily walk-throughs and check routines are vital for identifying potential failures or maintenance issues that can impact plant availability. Visual inspection shall be included in any effective predictive maintenance program.

Electrical Testing

Periodic electrical testing shall be used in predictive maintenance programs along with the aforementioned techniques to increase plant availability. These electrical tests should include: resistance testing, megger testing, HiPot testing, impedance testing, transformer oil sampling, etc.

Conclusion

Predictive maintenance programs can significantly improve plant availability by reducing unplanned outages. Predictive maintenance tools can be used for maintenance management, plant optimization, and reliability improvement. Predictive maintenance programs have been proven to lead to significant performance gains. Successful implementation of a predictive maintenance program must start with proper identification of the program objective, proper selection of technologies, successful implementation, and continuous improvement plans.

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APF Plumbing Fixtures Part II

Introduction

April's Technical Bulletin discussed the issues associated with tying potable water systems, drain waste, and vent plumbing systems to Aseptic Production Facilities (APF). These types of connections create challenging environmental design issues for APF spaces, and the article reviewed multiple strategies to address these inherent issues. This month's article reviews two more specific applications common to most APF spaces, hand washing sinks and emergency fixtures like eyewash, facewash stations, and emergency showers. All plumbing fixtures and drains should have a regular cleaning and maintenance program designed to suppress microbiological activity. Fixtures and water should be regularly monitored by an Environmental Monitoring (EM) program to detect uncontrolled grown and profusion of microbiological activity.

Hand Sinks

Hand sinks are an essential component of hygiene in the gown-in process, requiring both a supply of potable water and a drain; after Personal Protective Equipment (PPE), they may also serve as the next line of defense after accidental exposure to a hazardous sustenance.

APF hand sink

Within an APF, a hand sink typically consists of a deep basin surgical hand sink with a self-draining deck; a stainless-steel apron and access panel which fully covers the associated plumbing and wiring; and a tall gooseneck spout faucet with laminar flow head and hands-free, non-mechanical activation sensor. The depth of the sink and discharge point of the faucet should be coordinated to minimize splashing and aerosolization of the potable water as it flows.

The sink's design should provide the fewest practicable number of seams and crevices, which are hard to keep clean and dry. Other fixtures/components associated with the hand sink include an adjustable thermostatic mixing valve; a digital scrub timer; an exhaust grill to establish an airflow in the area (generally towards the sink area in order to reduce the migration of aerosolized particles); and containers for soap/scrub packs and appropriate gloves. Knee-operated and floor pedal-activated controls should be avoided because they are difficult to keep clean.

Eyewash/Facewash Stations and Emergency Showers

As with all other water and drain source fixtures in APF spaces, there are certain design strategies intended to reduce the potential impact of installing emergency fixtures. It's important to note that these fixtures require routine testing and tend to discharge water over a large area, even when using containment devices intended to mitigate spills. Because of this, the number of emergency fixtures within classified spaces should be reduced or eliminated to the extent practicable, and every effort should be made to have one or more doors between emergency fixtures and any Primary Engineering Controls (PECs).

A fully plumbed emergency fixture station should instead be provided as close as possible to classified spaces, and supplementation with sealed-sterile dual bottle secondary stations should be considered following consultation with a safety officer. The duplex bottle station should be made of materials compatible with the cleaning program and should be sealed to the wall with 100% silicone sealant or other approved means to eliminate cracks and crevices.

Conclusion

Using the strategies noted above in combination with those discussed in April's Technical Bulletin, can aid in reducing environmental risk to APF spaces where water and drain connections are unavoidable. Safety Officers need to be involved in the design process, as the layout of emergency fixtures and devices is part of a comprehensive safety plan. The overall design must be carefully coordinated with end users to confirm that it works closely with the user's standard operating procedures for the space.

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Biophilic Design

Introduction

Biophilic design is the emphasis on maintaining a connection with nature in built environments with the intent to achieve benefits that span from merely aesthetic into the realm of restorative. Research on biophilic design has increased over the 20th century within healthcare and office settings; evidence of its effectiveness includes reductions in stress, lower systolic and diastolic blood pressure, and enhanced mental well-being. [1, 2, 3]

Healthcare

Studies have proven the way biophilic design benefits patient outcomes. Biophilic design can reduce stress via enhanced feelings of calm, which are associated with measurable decreases in blood pressure and heart rate. When patient rooms have views of nature, postoperative stays are generally shorter, less pain medication is dispensed, and healing accelerates.[5] Windowless ICU settings, on the other hand, double the chance of hallucinations in patients.[5]

Biophilic design is also beneficial for managing staff stress levels.[4] Examples of this design style in include break areas with direct access to the outdoors and patient care rooms with wall of glass with natural views.[4] Thoughtfully designed connections with the natural environment can increase staff job satisfaction, reduce stress, and improve patient care.[5]

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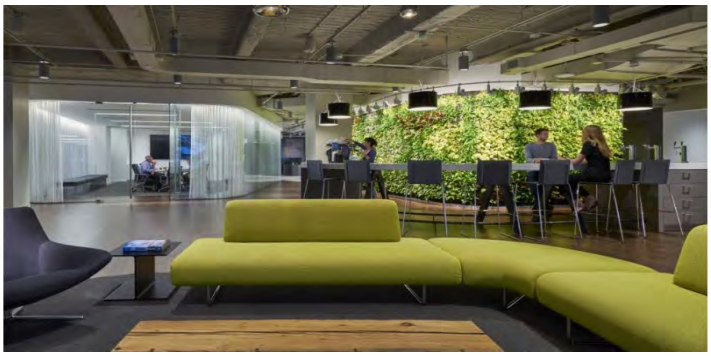
Healing Gardens

Gardens have been traditionally used worldwide to assist in healing since the Middle Ages.[5] Studies have shown that as little as 5 to 10 minutes spent in nature or with a view of nature can reduce stress.[5]

Gardens can be designed for specific patient trauma groups. For instance, cancer or burn patients may prefer small amounts of direct sunlight.[5] Patients using medications with photosensitizers may prefer trees and shaded areas. Developing gardens for their specific climates is also ideal; in humid and hot climates, shading is essential, or an interior garden may be a great alternative to an outdoor one.[5]

Office Spaces

The cost of biophilic design is always a concern, but overall worker wellbeing appears to increase based on a thoughtfully designed office environment. When they are implemented, biophilic environments lead to increased productivity, lower employee turnover, reduced employee absenteeism, higher retention, and lower error rates.[6] Design strategies can include the use of earth tone colors, organic shapes, and material choices such as wood and woolen fabrics to help occupants indirectly experience nature if a direct experience is not possible.[1]



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Conclusion

For most of us, the greater portions of our lives are spent working indoors, so designers and planning professionals can enhance general wellbeing by incorporating biophilic design. This is particularly true of healthcare settings, where stress levels are a concern for both the patients, staff and visitors who are collaboratively needed for the patient's recovery.

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APF Plumbing Fixtures Part I

Introduction

Aseptic Production Facilities (APF) are a challenging environment for the design, operation, and maintenance of water sources and drains. A sanitary drain with a P-trap, for instance, is an open-air connection to a constantly dark, moist area where biological activity can occur, including the formation of biofilms and the growth of molds, fungi, and bacteria. A less obvious source of contamination is the potable water supply serving handwashing sinks and emergency plumbing fixtures (eyewashes, etc.); while far cleaner than drain/waste/vent (DWV) systems, these fixtures are still a possible source of microbiological flora.

All connections to the plumbing system are persistent – and potentially potent – sources of contamination in the aseptic environment. Risk mitigation should be incorporated where fixtures are necessary, including measures like:

- The number of fixtures should be reduced to the extent practicable.
- Fixtures should be placed in areas of the lowest classification possible, and are prohibited from areas with a classification of ISO-7 or better.
- Fixtures should be located as remotely as practicable from the areas of greatest risk for product contamination.
- Airflow and differential pressure should be considered to prevent the migration of aerosolized potable water droplets and aspirated/aerosolized DWV products towards higher classified areas.
- A low side wall exhaust or HEPA-filtered return grill should be placed in proximity to fixtures with the intent to efficiently capture fugitive aerosolized particles.
- Fixtures should be selected for cleanability and resistance to degradation from APF cleaning chemicals.
- Fixtures and components should be selected that produce the smallest amount of aerosolized particles, possible (i.e. laminar flow heads in lieu of aerators, etc.)
- All plumbing fixtures and drains should be enrolled in a regular cleaning and maintenance program designed to suppress microbiological activity.
- Fixtures and water should be regularly surveilled by an Environmental Monitoring (EM) program to detect uncontrolled grown and profusion of microbiological activity.

Potable Water Supply Plumbing System

When tying an APF into existing domestic cold water and domestic hot water (DCW/DHW) systems, careful consideration should be given to disinfection beyond the code required minimum for new piping work. Factors worth considering include the persistence of established biofilms and the value of prophylactic measures in reducing the risk of recolonization. Consideration should also be given to monitoring residual system disinfectant. Injecting additional disinfectant to maintain residual disinfectant levels should generally be avoided, as it requires additional labor, adds to system complexity, and has the potential for unintended consequences. DCW/DHW systems should be designed to eliminate dead-legs. The use of automated flushing to ensure water turn-over to maintain residual disinfectant levels should be evaluated on a case-by-case basis.

After risk assessment and engineering analysis, a duplex potable water filter which achieves not less than 0.2 microns can be installed on the DCW/DHW supplies. Filters should be placed in a remote yet accessible location outside of the APF. It should be noted that water filters require regular maintenance, including replacement, to reduce the likelihood that they become sources of microbial contamination.

Drain/Waste/Vent Plumbing System

Specific drain/trap maintenance (i.e. cleaning) requirements should be included in a formal, change-controlled SOP. During regular facility cleaning, the strainer, tail piece, and p-trap (deep p-trap for higher Differential Pressure (DP) locations, as required) should be treated per the cleaning SOP throughout classified areas to suppress biological activity within exposed areas of the DWV system.

Next month, this article will continue with a specific discussion of hand sinks and emergency fixtures in classified APF environments.

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Access Panels in Laboratories

Introduction

Laboratory buildings have a variety of utility systems with piping, valves, dampers, air terminals, and other components that require routine inspection, service, and maintenance. Utility systems shall be configured so that these items are located in accessible areas outside of the laboratory perimeter to the greatest possible extent; this is in order to minimize maintenance activities in laboratories, especially in containment laboratories and animal research facilities (ARFs). Access panels must be provided in the laboratory if this is not possible.

A number of functional considerations must be addressed when selecting and detailing access panels, including finish and detailing, size, and other potential factors, including fire rating.

Finish and Detailing

All laboratory walls and ceilings must be non-porous, durable, and chemical resistant. As integral parts of the walls and ceilings, access panels must meet the same functional requirements of the particular lab in which they are installed.

BSL-2 labs: Access panels must be resistant to water and the cleaning and disinfection products which will be used. Generally, they may be cold rolled steel with a baked enamel, powder coated, or field-applied painted finish, and must be gasketed to prevent air leakage.

BSL-3 labs: Access panels must be resistant to harsh decontamination agents and are generally made from stainless steel, fiber reinforced plastic (FRP), or another highly chemical resistant material. Access panels must be fully gasketed and secured by compression latches to ensure a gas-tight seal to maintain containment.

ARFs: Access panels are generally stainless steel and must be impact resistant and resistant to wash-down and harsh cleaning chemicals. Access panels must be fully gasketed and secured by compression latches to ensure a gas-tight seal.

Aseptic Production Facilities: Access panels in classified areas are typically not permitted.

Size

Access panels shall be sized to allow for unconstrained access to components and the unencumbered performance of maintenance operations. Either 'hand access' or 'person access' can be provided, depending on the nature of the component served and the service to be performed. Hand access panels, used for valves and other small components immediately inside of the panels, typically range from 6" x 6" (152 mm x 152 mm) to 12" x 12" (305 mm x 305 mm). Person access panels are used for larger components and less accessible locations, which requires the comfortable, unrestricted passage of a person's upper body. The minimum allowed size for a person access panel according to the Design Requirements Manual (DRM) is 24" x 24" (610 mm x 610 mm). Laboratory design should be reviewed by maintenance personnel to ensure adequate access panel size, number, and location.

Ceiling Access Panel

Fire Rating and Other Considerations

Because access panels are an integral component of a laboratory's perimeter enclosure, it's important to consider other functional aspects, including:

- Access panels in fire rated assemblies shall be appropriately UL rated.
- Access panels should be located in places unobstructed by fixed casework, equipment, or furnishings. Sufficient space shall be provided adjacent to access panels to allow for full access to service components.
- Latching mechanisms are preferred over screws for securing the access panel cover for ease of use, durability, and maintenance of a positive seal.
- Panel covers should be labeled to identify the type of utility they access.

Conclusion

Access panels are a laboratory design element that should be considered throughout the planning and design process. Utility systems should be configured specifically to place components requiring access outside of critical areas, but sometimes the need for access panels is unavoidable. These necessary access panels should be properly detailed, sized and located to promote required service, inspection, and maintenance.

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APF Temperature and Humidity, Chilled Water and Supplementary Chiller Requirements

Introduction

APF (Aseptic Processing Facilities) must be appropriately designed to maintain space temperature at lower conditions than laboratories and animal facilities and humidity must not exceed a certain lower value in summer. The chilled water coils must also be appropriately sized to achieve these conditions. The following is an elaboration of APF requirements from Chapter 13.8 of the DRM.

Temperature and Humidity

According to DRM section 13.8.3, "APF room temperature and humidity requirements depend on process, equipment, material and product requirements, and operator comfort. Personnel in the space produce fewer particles when comfortable. Also, high humidity increases microbial and mold growth on surfaces." Lower temperature and moderate humidity levels also reduce sweating and help in drying out the top layer of skin.

The DRM states that "The compounding pharmacy USP (US Pharmacopeia) regulations, require room temperature to not exceed 20°C (68°F) and room humidity to not exceed 60% RH." There is no such prescriptive requirement for GMP facilities, but significant gowning requirements and the concern for mold growth dictate cooler conditions and low humidity (in summer) in these rooms. There is no such concern for humidity during winter except as required for human comfort; the minimum humidity is typically 25% RH.

At NIH, the DRM specifies that APFs shall be designed to 19°C (66°F) for classified rooms with room temperature not to exceed 20°C [68°F]), which is also the temperature alarm limit for all APFs. It also specifies that room humidity shall be designed to 55% RH for the classified areas during summer months, so room humidity does not exceed 60% RH, which is the humidity alarm limit for all APFs.

Chilled Water and Primary Cooling Coil Row Depth

Chilled water to APF AHUs shall be provided from central utility plant (CUP). In DRM section 13.8.14, the specification is that "The main AHU's chilled water coil dew point temperature shall be designed at a maximum of 8.9 °C (48°F), to allow the necessary dehumidification and cooling needed to maintain these room conditions." The minimum number of rows for the primary cooling coil shall be 10-rows to improve such coil performance.

Supplemental Chiller

DRM section 13.8.18 states that "To help mitigate discharge air temperature and dew point fluctuations of AHUs due to varying chilled water temperatures from the CUP and extreme outdoor air conditions, supplemental air-cooled chiller shall be provided. N+1 redundancy of this supplemental chiller is not required; however, pumps shall be redundant. Typically, designs provide supplemental chiller and AHU trim coil to allow the supplemental chilled water system to respond quickly to sudden changes in CUP supply chilled water temperature. The supplemental chiller design shall be based on CUP supply temperature rising 2°F (from 44°F to 46°F) and extreme outdoor conditions of 97°F DB/84°F WB. The chiller shall be piped to the AHU trim coil. AHU trim coils may also be piped to the plant chilled water loop but would remain isolated closed during normal operation when the supplemental chiller is operational."

The supplementary chiller is generally air-cooled (See Figure 1) but may also be water-cooled if there is adequate plant chilled water available in close proximity. Either the CUP supply or return chilled water may be used on the heat rejection side of the heat exchanger for the water-cooled chiller. Water cooled chillers are compact in size but require indoor space. If an air-cooled chiller is used the fluid medium is glycol for freeze protection.

Figure 1 – Air Cooled Chiller

Section 13.8.18 also states that "For small APFs such as modular trailers where CUP chilled water is not available in proximity, N+1 redundant air-cooled chiller shall be provided."

Where existing base building AHUs are being utilized as the main source of air, booster coils in the supply duct serving the APF spaces are required to lower the dewpoint temperature of the supply air from the base building AHUs to 8.9 °C (48°F). The booster coil may use plant chilled water or even a trim chiller. If a trim chiller is used, the chiller would need to have N+1 redundancy, since the chillers would be expected to run a lot longer.

The two-cooling coil in series with the supplementary chiller shall be controlled to maintain design of maximum 8.9 °C (48°F) dewpoint temperature of the secondary coil. If the primary coil cannot maintain this temperature, the secondary coil and the chiller will be activated.

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The Freeze-Thaw Cycle in Concrete and Brick Assemblies

Introduction

The freeze-thaw cycle is a major cause of damage to construction materials such as concrete and brick assemblies. Freeze-thaw damage occurs when water fills the voids of a rigid, porous material and then freezes and expands. The volume of frozen water is 9% greater than liquid water, so when water freezes pressure is exerted on the surrounding material, and when the pressure exceeds the tensile strength of the material, cracks will result. During this process, the voids are enlarged, enabling the accumulation of additional water during the next thaw; this results in additional cracking during the next freeze. Substantial damage can occur over subsequent freeze-thaw cycles.

The NIH Bethesda campus, like many parts of the US, is in an area prone to freeze-thaw damage. The average high and low temperatures in January are 44° and 29°F, so freezing and thawing can occur frequently. This kind of recurrence makes the cycle more destructive than in colder climates, which remain below freezing for much of the winter and therefore experience the freeze-thaw cycle less frequently.

Freeze-Thaw Damage

Freeze-thaw damage is caused by excessive water on the surface of or within assemblies. The two types of damage are surface spalling and internal cracking.

Surface spalling is a result of recurring accumulation of water or snow on surfaces, both horizontal and vertical, causing them to remain wet for extended periods to time. During freezing, the external layer of material fractures to the depth of water penetration and falls off. Concrete surface spalling results in the exposure of underlying aggregate; repeated spalling can expose reinforcing bars, leading to further deterioration. Brick surface spalling results in the flaking of the outer layer of brick, exposing the inner layers which are typically softer, more porous, and more susceptible to further freeze-thaw damage.

Internal cracking occurs when internal cracks and voids are filled with water and subject to freezing. Unlike surface spalling, the cracking starts on the interior, which may not be evident to visual inspection. Upon further freeze-thaw cycles, the damage may propagate to the surface.

Prevention of Freeze-Thaw Damage

Both surface spalling and internal cracking are progressive, with damage that will increase in severity if not corrected, making them issues that are better handled proactively than reactively. There are numerous strategies for preventing damage, including the following:

Control rain, ice, and snow penetration. One way to prevent freeze damage is controlling environmental water. Properly detailed parapets, copings, roof edges, and other critical connection points prevent water penetration in assemblies. Overhangs, drip edges, and other details prevent water from saturating wall suraces. Details by SMACNA (Sheet Metal and Air Conditioning Contractors National Association) or other recognized industry sources that are not overly reliant on sealant or maintenance should be used.

Control groundwater. Eliminate capillary action from damp ground. Earth should be well drained and slope away from the structure, and assemblies should have flashing or other methods of reducing water from being drawn up into wall assemblies.

Use water-resistant brick. Use bricks appropriately graded for resistance to freezing damage. Grade SW (severe weathering) brick is intended for use where high and uniform resistance to cyclic freezing is desired and where the brick may be frozen when saturated with water. Grade MW (moderate weathering) brick is intended for use where moderate resistance to cyclic freezing damage is permissible or where the brick may be damp but not saturated with water when freezing occurs.[2]

Use appropriately designed concrete. Concrete should be designed with characteristics that will minimize freeze-thaw damage. A low water to cement ratio reduces permeability, which will in turn reduce both surface and internal water absorption. High strength concrete (6,000 psi or greater) has increased tensile strength and will withstand increased internal pressures caused by freezing. Air-entrained concrete (4% or more of concrete volume) contains microscopic bubbles which allow the concrete to expand with less likelihood of cracking. Smaller aggregate is less likely to have internal voids than large aggregate.

Conclusion

The freeze-thaw cycle is a concern in most climates and should be addressed during design. With proper detailing and specification freeze-thaw damage to assemblies can be reduced or eliminated.

References
[1]ASTM C216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)

[2]Brick Industry Association, Technical Notes 9A, Specification for and Classification of Brick