SMART BUILDINGS

SPRING EDITION

CONSULTING - SPECIFYING engineer eBOOK

Contents

CONSULTING - SPECIFYING engineer eBOOK

Your questions answered: Pairing VRF with applied HVAC solutions

In this Q&A, learn how Linear Expansion Valve (LEV) Kits help pair VRF with applied HVAC solutions for more flexibility to meet a building's specific load, airflow, and application requirements.

A variable refrigerant flow (VRF) system is an increasingly popular choice as it provides industry-leading comfort, flexibility, high efficiency, and all-electric heating and cooling. Traditionally, VRF systems can be limited in their type and size of indoor equipment, but by using a Linear Expansion Valve (LEV) or Air Handler Expansion kit, air handler options can be expanded and provide engineers more flexibility to meet a building's specific load, air flow, and application requirements.

LEV kits enable the advantages of the VRF outdoor system to be paired with applied equipment to get the benefits of inverter technology resulting in higher efficiency. Additionally, LEV kits can provide higher static pressure, larger capacity, customized products, and dedicated outdoor air system configurations.

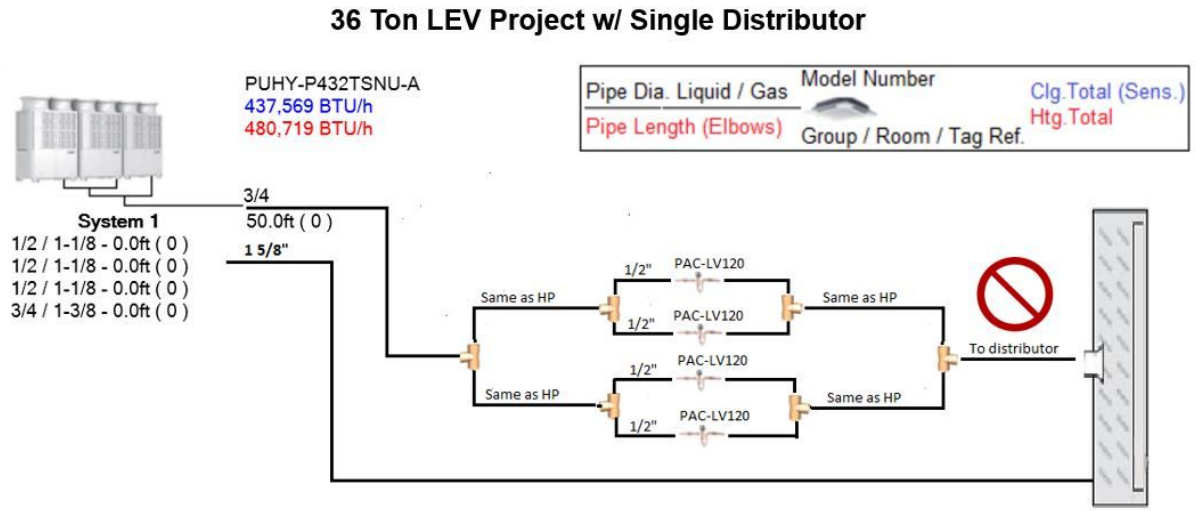
Several questions were left unanswered during the July 27, 2022, webcast: Pairing VRF with applied HVAC solutions Learn more from these experts in this Q&A:

- Aaron Askew, VRF and Ductless Technical Specialist (DTS) for Indiana and central Illinois, Trane
- Evan Eitemiller, VRF and Ductless Sales Specialist for the Pacific Northwest/ Rocky Mountain Region, Trane

Back to TOC

Back to TOC

Diamond System Builder Layout



Courtesy: Trane

What outdoor temperatures are the DSB blue and red heating and cooling capacities based on?

You can set the outdoor conditions specific to your design manually or you can use the ASHRAE standards for the City/State you are designing in.

Any plans for larger capacities above 20 tons?

You can now go greater than 20 Tons as long as you have multiple distributers. You would need to have multiple controllers to go larger than that 20 Tons.

Back to TOC

You have to have a variable speed compressor?

Yes. All VRF ODUs have variable speed compressors.

Can a vrf outdoor be connected with Trane residential indoor units?

Yes, within LEV Kit design guide limits. LEV Kits are not compatible with single phase (i.e., Smart Multi, NV or P-series) ODUs. Typically, LEV kits are not approved for use with residential furnaces.

Can we combine typical VRF evaporators with LEV, non-VRF AHU's?

Yes, within LEV Kit design guide limits.

A failed 4 pipe system have new ahu's, can we retrofit VRF LEV kits to these units?

Yes, within LEV Kit design guide limits.

Is it possible to use LEV kits paired with a commercial AHU to become a split DOAS on a single system?

Yes, within LEV Kit design guide limits.

Recommendations for VAV applications with coil turndown? Use dampers?

Back to TOC

Yes, using bypass dampers is one potential design solution when working with minimum VAV turndown limits.

Will the controller allow control of a multi speed motor?

Yes, there are 3 discrete fan speed signals (H/M/L) that can be sent to the AHU fan controller.

When you say "distributor" does that apply to a single heating/cooling coil?

Yes, some single coils may have multiple distributors.

Having the refrigerant piping being installed correctly and as designed is critical to the performance of VRF systems. Are the piping installation tolerances as critical with LEV systems?

Yes, even more critical.

Can you list actual examples of projects that LEV kit installation?

Yes, contact your local Trane account manager.

For load conditions, can 2 smaller outdoor units be used in lieu of 1 larger one (e.g., two 10-ton vs one 20 ton?

Back to TOC

Yes, but the DX coil is still subject to minimum airflow turndown limitations.

Can this be retrofitted into Blower coil units?

Yes, but may need a new DX coil.

Are these LEV kits compatible with both water-cooled and air-cooled outdoor units?

Yes, but LEV Kits are only compatible with 3ph ODUs. They are not compatible with Smart Multi, nor NV, P-series.

Can LEV kits be used in Multizone VAV air handlers?

Yes, as long as the coil and AHU design fit within all required specifications per the app guide (i.e., minimum fan turndown limits, etc.)

Can an LEV AHU be part of a multi-unit VRF system?

Yes, with both the Heat recovery and standard VRF heat pumps the LEV kits can be used in combination with other VRF indoor units. There are limitations such as nothing bigger than 8 tons on a Heat Recovery system due to Port Max size on the branch controller.

Cold climate, 100% OA ERU, do we need electric reheat coil downstream of the VRF coil for when the ODU goes into defrost? Assuming

Back to TOC

we cannot shut the fan off due to code reasons when the VRF coil is in defrost.

Yes, that would be best practice for when the system goes into defrost or error to prevent huge fluctuations in temperatures.

Can you provide some insight on using cassettes with a VRF and bringing in outside air to accommodate required air changes?

Yes, outside air can be brought into any of the cassettes, they all have a max value depending on size. The air cannot be raw fresh air, minimum return is 59 degrees. The Fresh air has to be forced into the cassette by another piece of equipment (DOAS, ERV, etc..) there is not enough negative pressure to draw in the air.

Can the LEV kit be controlled based on discharge air temperature? Or only space temperature?

Yes, both options are standard with the LEV kits. For discharge Air Control the minimum is a 3 Ton kit for guaranteed outputs.

Does the LEV kit require power connection?

Yes 208/230 Single Phase voltage to each LEV controller.

Will the LEV control to a heating LAT setpoint at all?

Back to TOC

Yes.

Does the "linear" component of the title refer to capacity control of the refrigerant?

Yes.

It seems there are lot of Trane-provided tools available for engineers to do very detailed designs with these refrigerant systems. In the past other VRF suppliers have offered to do the heavy lifting with solutions for designers providing detailed selections, piping diagrams, and performance data that is unique to the project, etc. While Trane offers access these tools to designers, do Trane reps offer similar levels of support with these systems as other manufacturers?

Yes.

Is this system planned to be used with A2L refrigerants in the future?

Yes.

How do you control the system using a wireless thermostat system?

Wireless control options are N/A at this time.

Can you discuss the benefits of using VRF condensing units with LEV

Back to TOC

over traditional condensing units (like the Trane RAUJ/RAUC) in cooling only applications?

When using VRF condensing units you have the full range of the invertor compressor for better part load control, long line length applications with no additional refrigerant specialties needed. With the Y-series VRF used in cooling only you can cool down to -10 degrees ambient with the use of a low ambient cool kit.

When designing a VRF system that is going to serve an area that contains a shell space (not built out), how do we prepare the piping system handle fan coil units in the future? Valve and cap branch selector unit piping?

Using heat recovery VRF is the best way to effectively do a build out. Yes, you would valve and cap unused ports on the branch controller. The limitations to look out for are the 8-ton limit for the LEV kit on heat recovery and also that 50% of the total system capacity will need to be connected to startup the system.

I assume that the LEV kit is compatible with a retrofit of DX cooling. Would a coil for district chilled water be compatible?

Typically, LEV Kits used in retrofit applications require installation of a new DX coil as well as new piping so that contaminants from the old system do not cause premature failure of the new VRF system.

Before use of LEV Kits, how was refrigerant flow to evaporator controlled?

Back to TOC

Traditional VRF IDUs have factory installed LEVs to meter refrigerant flow. Before LEV Kits connection to non-VRF AHUs was not allowed.

When incorporating a non-VRF air handler into as system design – how do we define the applicable characteristics of the coiling coil in DSB [like coil volume]? Or can that be done?

This cannot be done in DSB, which is why it's recommended to use a third party coil selection software.

AHRI treats small VRF systems as mini-spits. How can I explain why a smaller VRF system can be treated as a VRF for purposes of calculating energy savings?

This all depends on the condenser capacity. For systems > 60,000 BTU/h they are tested by AHRI 1230. For systems < 60,000 BTU/h they are tested by AHRI 210/240.

One of the biggest concerns we and the building owners have is the refrigerant leaks. Do you monitor the leaks? What happens if there is a leak. Can we have redundant circuits in order not to lose the entire cooling/heating systems.

There are extensive pressure testing requirements for all VRF installations so there should not be any leaks after startup. The VRF system does not monitor for leaks. If a leak occurs, it must be found and repaired ASAP via soapy water solution applied to piping connections or with a refrigerant detector. You would need to provide redun-

Back to TOC

dant VRF systems in order to keep a system online in the event the other system has a leak.

How far LEV can be from VRF outdoor unit?

There are different piping limitations for if the LEV is being connected to a Heat Pump or a Heat Recovery VRF system and would be specific to the manufacture but as for Trane Mitsubishi on a Heat Pump system furthest actual is 541 actual feet and 623 equivalent feet. For a Heat recovery system single branch controller max length from the Outdoor unit to the branch controller is 360 equivalent feet and from the branch controller to the LEV would be 197 equivalent feet. Always run estimated lengths through the VRF selection software to check for rules and restrictions.

Is it possible to have both a third-party thermostat interface and an MA controller connected to the same LEV kit? It is my understanding that the MA controller is needed for some programming of the LEV kit, and I don't always have a DDC system and need the thermostat interface for some systems.

The MA controller is used and required for initial setup and configurations. It may also be used for standard space temp control. However, you cannot have both the MA controller and a third party t-stat controlling the unit in normal operation. It's one or the other.

What is the advantage of LEV units compared to VRF units?

Back to TOC

The LEV kit allows connection of a non-VRF AHU. Any feature that is required that is not available in a standard VRF IDU (i.e., heat wheel, higher than 1.0 ESP requirement, etc.) could be an advantageous application of an LEV Kit.

What is the advantage of installing LEV units in a typical HVAC unit?

The LEV kit allows connection of a non-VRF AHU. Any feature that is required that is not available in a standard VRF IDU (i.e., heat wheel, higher than 1.0 ESP requirement, etc.) could be an advantageous application of an LEV Kit.

Did we see that a special TEE is not recommended to twin LEV kits? It appears the twinned factory LEV kits (6,8,10T) uses a special TEE NOT a standard bull head TEE

Standard Ts are recommended. Do not use special Y-fittings, Refnet fittings, etc.

What is the most common application you are seeing LEV kits being used on?

Split DOAS applications.

How is auto mode changeover handled in a DAT application? What control inputs are needed to accomplish the change between heating and cooling?

See p. 50 of LEV Kit app guide.

Back to TOC

We have been told minimum airflow at the VAV AHU is 80% of maximum. Why is this? This can create problems with VAV systems. Can airflows be lower but staging the LEV valves using the BAS?

See p. 47 of LEV Kit app guide.

Can the LAD be located in ceiling space below the Rooftop unit and piped up to the unit?

Probably not. The LEV valve and temp sensors have a max 16 ft wire length that cannot be extended.

Can refrigerant press connection copper fittings be used to install the LEV kits (i.e., NIBCO PressACR)?

Press fittings are allowed but not recommended. See this app guide for more detail.

Can a conventional DX AHU with a LEV be used with a VRF to use as a chilled water VAV unit would be used?

Potentially, but with more limited applications. For example, the LEV Kit may not be able to achieve as low of a LAT setpoint as with CHW. The turndown of the VAV fan may be more limited as well.

Are the details in CAD only or are they available for Revit?

Back to TOC

Only REVIT is available.

Mitsubishi / Trane provides air handlers up to 8 tons. Why use an LEV kit for the smaller air handlers?

Only if you needed some feature not available with standard VRF IDUs – i.e., heat wheel, ESP requirement > 1.0 inch etc.

I have a customer who wants a 60-80k high efficiency residential Trane furnace with a 2.5-ton Mitsubishi condenser. Would this be a good application for an LEV kit or is there a guide somewhere to help put this together?

No. LEV Kits are limited to Y and R2-series systems, which start at 6 tons and larger.

Can existing DX coils be reused in a retrofit application? (i.e., RTU with DX cooling and gas heating retrofitted with LEV kit to operate as a heat pump?)

No. A new coil would need to be used. Other systems use different oil types which could potentially contaminate the refrigerant and cause premature failure.

Can you clean the strainers?

No, the strainers are built into the LEV kit.

Back to TOC

Can LEV kit pre-packaged in factory?

No.

What are some best practice solutions for VRF systems to comply with ASHRAE-15 if requested by client?

Limit the total system charge to be less than 26 lbs. R-410a / 1000 cu ft of occupied space. Use permanent opening between adjacent spaces to increase dilution volume of small zones.

Sorry can you clarify that the reheat coil size is maxed at 8tons or the entire lev kit?

LEV Kit applications are limited to 8 tons on a heat recovery application due to capacity limitations of the Branch Controller.

Do I need one wired controller per each LEV control box?

If using Mitsubishi wired remotes, you can group multiple LEV controllers to one Mitsubishi wired controller, similar to grouping of standard VRF IDUs. However, if using third party t-stats or BAS control, you would need one control signal per LEV control board.

On face split do you not get stratification?

Back to TOC

Face split coils can be used for better part load capacity and dehumidification control, but could still be subject to stratification, similar to traditional face split applications.

Are LEV kits applicable to warm/hot environments CA, AZ, NV?

EAT limits for LEV Kit DX coils is 59-75 F WB in cooling and 0-59F DB in heating. The ODU is subject to the same temperature limitations as with standard VRF applications.

Any NEMA rated cabinet options for outdoor AHUs to place controller into? Or do people install inside AHU?

Dimensions of the controller are shown in the submittal. As long as it fits inside, any weather-proof enclosure would work. The controller may be able to be mounted inside the AHU as long as there is available space where it doesn't interfere with other AHU operations. In most cases the controller gets mounted outside of the AHU.

Do you have a ballpark percentage for sensible to latent capacities in the coil?

Depends on the EAT conditions.

Can the LEV kits really go up to 80 ton? It looks like the largest condenser grouping is 40 ton. So, would that be controlled by 2 condenser groups?

Back to TOC

Correct, it would be split between 2 condensing systems most likely 4 distributers and 4 20 Ton LEV kits.

Do they require any special service clearance?

36 inches NEC clearance to high voltage connection on controller.

What is the equivalent length of a typical LEV and is the total refrigerant line length measurement include both the liquid and line piping?

16-24 inches. The pipe length input to DSB includes both pipes.

Is there any way to provide heat below 0°F ambient with these kits?

0°F is minimum EAT to LEV DX coil. Below that temp, pre-heat is required. ODUs are subject to normal temp limits.

Aaron Askew and Evan Eitemiller
Aaron Askew, VRF *and Ductless Technical Specialist (DTS) for Indiana and central Illinois, Trane.* ***Evan Eitemiller, VRF*** *and Ductless Sales Specialist for the Pacific Northwest/Rocky Mountain Region, Trane*

Health care building design model shifts how HVAC is handled

As hospitals and health care facilities evolve, the HVAC systems within them must update to meet air quality and HVAC needs

MEP ROUNDTABLE Q&A

Tanner Burke, PE, Senior Fire Protection Engineer, ACS Group, Austin, Texas; Derek Cornell, Senior Associate, Certus Consulting Engineers, Dallas, Texas; Beth Gorney, PE, Assistant Project Manager, Dewberry, Raleigh, North Carolina; Sierra Spitulski, PE, LEED AP BD+C, Associate Principal/Studio Leader/Mechanical Engineer/Project Manager, P2S Inc., Long Beach, California; Kristie Tiller, PE, LEED AP, Associate, Team Leader, Lockwood Andrews & Newnam Inc. (LAN), Dallas, Texas.

Back to TOC

Back to TOC

How have you and your team addressed the unique air requirements of COVID-19?

Derek Cornell: In hospitals, the approach to HVAC systems in response to COVID-19 has evolved through stages of the pandemic. The additional exhaust and outside air required poses obvious challenges in existing facilities. The more difficult challenge has been designing for flexibility to help ensure prescriptive health care code compliance, maintain environmental conditions and minimize additional energy consumption outside of pandemic surges and state/federal disaster declarations.

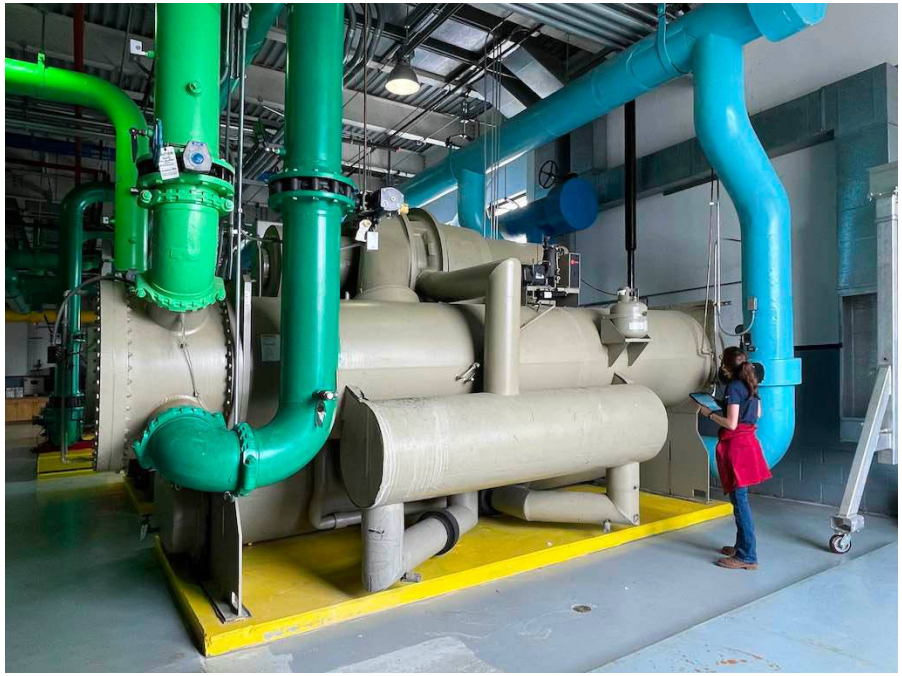
For example, in smaller hospitals with existing systems limited in the ability to handle additional outside air load, strategies such as HEPA fan-filter units ducted back into the return system help to minimize the need for major system upgrades and also provide flexibility in returning to normal pressure relationships outside of a pandemic.

Kristie Tiller: We've had a lot of discussion regarding air cleaning products being installed at the suggestion of the manufacturers. UV lights and Ionizing filters, for example. Some building owners are arbitrarily increasing the amount of outside air in their buildings. The guidelines from the various agencies are still in flux and it's difficult to know which modifications can be made that are both sound investments for health and safety and capital expenditures.

Sierra Spitulski: For one recent project, we were asked to create a pandemic ready pod within the emergency department for highly contagious patients. To protect the staff and nurses working around patients, computational fluid dynamic modeling of air distribution was performed on a typical emergency department scenario. This allowed

Back to TOC

us to design the HVAC distribution in a way that optimized infection control which can help reduce spread of disease and illness.



Mechanical HVAC equipment in a major hospital in Dallas Fort Worth. Courtesy: LAN

How have you worked with HVAC system or equipment design to increase a building's energy efficiency?

Sierra Spitulski: We work with health care providers, builders and designers to create reliable, energy-efficient facilities that safeguard their patient's health and comfort while simultaneously reducing operating costs. Lately, we've been leveraging current code exemptions to decrease airflows in specific areas of the hospital during unoccupied hours through strategic zone level controls, finding creative ways to decarbonize such as rejecting boiler fuel heat to raise the temperatures of the domestic hot and heating hot water systems, in addition to more obvious decarbonization efforts such as heat recovery chillers and electric boilers. Specifically designing the air handlers to be dual duct and dual mixing box has also shown an incredible amount of energy savings in a system.

Back to TOC

What is the most challenging thing when designing HVAC systems in such buildings?

Kristie Tiller: The most challenging HVAC design in health care tends to be renovations in active facilities. Renovations are never simple, especially in older buildings, due to existing structure, utilities and equipment location. In an active health care facility, it is especially important to maintain proper conditions while phasing from the old equipment to the new. As engineers, we must work hand in hand with the contractors to ensure that we maintain the health and safety of the patients while renovating existing systems. This includes proper selection of equipment type and location, the right temporary equipment and careful phasing of construction.

Sierra Spitulski: Challenges are abundant when planning HVAC for hospitals. Equipment that is seismically certified in California comes from a much smaller pool of resources and is not always readily available. Long lead times for this specialty equipment impacts construction schedules, cost and facility cashflow. Infection control protocols and limitations to shut down times require detailed construction procedures. Then, when the new equipment is being installed in a live 24/7 acute care hospital, it's often necessary to have an engineer in the field with the contractors to assist with troubleshooting as the room for error is small–and this is likely happening in the middle of the night.

What systems are you putting in place to combat hospital acquired infections (HAI)?

Derek Cornell: In the aftermath of the pandemic, a cleaner environment for patients and staff is ever-increasing and with that, we have seen a trend in UV technology. The

Back to TOC

use of UVGI (ultraviolet germicidal irradiation) lamps in air streams, while not new technology, are gaining popularity. UVGI lamps in air streams has been pretty popular over the past couple of decades, however, newer technology using UV-C LED lamps is now becoming prevalent in light of recent years. These are replacing the older mercury UV lamps. We are also seeing them applied for more effectiveness using higher watts/square foot irradiation intensity.

Sierra Spitulski: State and federal code regulations and recommendations for hospitals already contain elements aimed at improving air quality and removing airborne pathogens: low-level air exhaust near a patient's head in infection-control spaces to remove exhaled particulates from the airstream, multistage filtration at the air handling unit, negatively pressurized and exhausted dirty spaces and positively pressurized and HEPA-filtered protective spaces for the most vulnerable and immunocompromised patients. Hospitals can opt-in to additional levels of HVAC cleanliness through the use of UV lights in the air handling system to further eradicate airborne pathogens, increased levels of MERV filtration and regular maintenance and cleaning. There are also lots of conversations and constantly evolving research around recommended airflows over and around patients in an operating room environment.

What type of specialty piping, plumbing or other systems have you specified recently?

Sierra Spitulski: Our team is on the cutting edge of today's medical advancements. This includes codes, standards, new technologies and California Department of Health Care Access and Information (previously OSHPD) requirements. There's a new requirement in California that's hitting all hospitals in 2030 that will require all acute care facilities to provide on-site storage for 72-hours or more for domestic water, waste water

Back to TOC

and emergency generator fuel oil. These requirements are aimed at enabling hospitals to maintain functionality in the event of a disaster that renders the city services inoperable for a period of time. This is a massive undertaking, as this means anywhere from 10,000 to 100,000 gallons worth of storage for these resources, which can be an even bigger challenge in landlocked hospitals.

Medical gases are vital for hospitals and medical campuses. Define the project, its goals, the challenges and the design solutions.

Tanner Burke: We provided consulting on the code challenges for medical gas upgrades to a Level 3 imaging room at a medical facility in Northern Nevada medical facility. This involved review of the 2018 Facility Guidelines Institute and NFPA 99: Health Care Facilities Code requirements to determine the required quantity and location of medical gas outlets, as well as the provisions associated with the medical gas zone valve box nurse alarm systems.

Derek Cornell: The need to design medical gas systems for increased ventilator quantities is here to stay. We are currently working on a full evaluation and design of upgrades to a large campus oxygen (O_2) system. At this facility, one of the largest COVID surges occurred simultaneously with extreme winter conditions for the region, resulting in adverse road conditions making increased frequency of deliveries difficult. In the extremely cold weather and very high demand, icing of the vaporizer was also an issue. The proposed design includes a complete replacement of the bulk O_2 system in a new location while keeping the existing hospital operation via connection to multiple emergency oxygen connections.

Offices change, accommodating new work styles

To appeal to various clients and work styles, office building design is shifting

MEP ROUNDTABLE

Miles Brugh, PE, Project Electrical Engineer/Manager, ESD, Chicago–Adrian Gray, C Eng, Eur Ing, Global Director – Commercial and Real Estate Sector, HDR, London–Matt Humphries, Associate Principal, Arup, Toronto–John Yoon, PE, LEED AP, Principal Engineer, McGuire Engineers Inc., Chicago

Back to TOC

Back to TOC

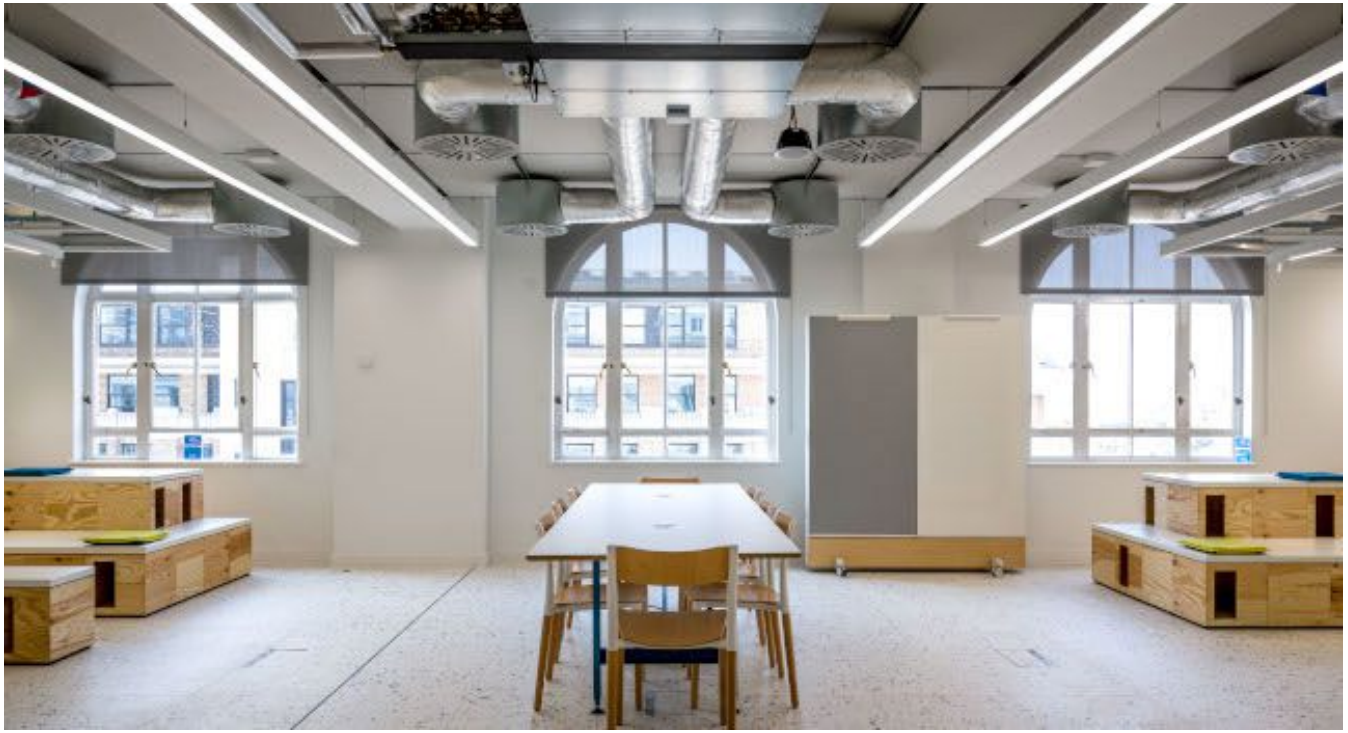
What's the biggest trend you see in office buildings?

Miles Brugh: With people more aware of their time and specifically the time they spend getting to the office, we are seeing employers and buildings allocating more resources to improving their spaces. For employers, we are seeing them provide more flexible and comfortable spaces, increased collaboration space and improved technology, which all support the many changes that companies have seen over the past couple of years. For the buildings themselves, we are starting to see some movement on the building-provided amenity space including lobby improvements and added seating areas to provide users with alternative work locations. For new office buildings under construction, we are seeing these amenity spaces receiving much more time and attentional to provide an improved experience within these buildings.

Adrian Gray: Environmental and net zero carbon legislation. Many U.S. cites are applying legislation to policies that are already in place in Europe, with fines for noncompliance that increase at various gateways. This has been a driver for change in European cites as the road to net zero has been explored for more than two decades. In many cities in Europe for example, the allowable energy criteria have reduced to the extent that the standard practices for air conditioning solutions is no longer permitted. Mixed-mode and natural ventilation are now considered across most city center locations.

Matt Humphries: A key trend for clients is to build for the long term. The goal might be to build a permanent piece of infrastructure to incorporate that isn't thought of with an end date in mind, but as a permanent, ongoing part of their portfolio. Clients have a better appreciation of the full life cycle cost of buildings. As clients they have a view to the long-term for operating costs, but are also mindful of incorporating what we are

Back to TOC



Creative engineering designs at London's Art Deco 80 Strand breathes a new lease of life into an iconic building. The mechanical and electrical services have principally been designed to be fully exposed, creating a striking industrial style workspace and set out to complement the existing original structural grid. Courtesy: Wind & Foster, HDR

finding works well. Geo-exchange, ground-source heating for example and minimizing combustion. In terms of sustainability, the bigger trend is the focus on carbon and future energy costs.

John Yoon: Even a half-full building still needs to be properly conditioned. However, the load profile of most buildings typically doesn't scale linearly with occupancy, resulting in unexpectedly high operational costs. As buildings continue to be half full while most tenants are still "work from home" or hybrid, I expect to see a continued emphasis on design solutions to minimize those operational costs

Back to TOC

— especially in existing buildings. The lowest hanging fruit seems to be retro-commissioning and similar programs that are often incentivized by utility company rebate programs.

What trends do you anticipate in the next year or two as hybrid work remains in flux?

Matt Humphries: The pandemic has created other drivers. A key driver is getting as much fresh air into buildings and keeping the air as clean as possible. Of course, it is true that developing mechanical systems that provide the healthiest air at lower energy costs is a "battle" against two different outcomes. Strategies we used include energy recovery on exhaust and filtration/treatment to reduce pathogen concentration in the airstream.

Miles Brugh: I expect that employers will continue to experiment with their spaces and move and adjust based on user feedback. Flexibility is going to be a larger priority in the decision making for projects so that the space is able to adapt to the changing workforce.

Adrian Gray: Environmental, social and governance, or ESG, requirements of building occupiers is an increasing trend toward new and refurbished buildings to meet the latest sustainability benchmarks. This in turn is driving a program of comprehensive refurbishment of existing buildings as older properties become less desirable. In London all new major development projects have to take account of the embodied carbon required in demolition and construction. At HDR we have developed digital twin modelling tools that can accurately predict the future energy savings of energy reduc-

Back to TOC

tion measures, allowing our client to proceed with renovation with confidence that the targets will be achieved.

John Yoon: The greatest trend is uncertainty. While it hasn't reached the same levels as the Great Recession of 2007-2008, the parallels are uncanny. During the Great Recession, companies disappeared overnight, dramatically driving up vacancy rates and cratering commercial real estate valuations. While the job market has been unusually healthy while recovering from the great pandemic, the explosion of working remotely has caused office workers to disappear from the central business districts in most cities, leaving half-filled office buildings in their wake. It isn't clear when or if those workers will come back.

Uncertainty is bad if you need access to capital from lenders. Engineers often forget that office buildings are bought as investments with an expected rate of return. Traditionally, CRE has been perceived as a safe and stable asset class. However, the valuation of any CRE is dependent on net operating income. NOI is gross rental income less expenses. With many tenants underusing their office suites, requests for rent abatements, delayed payment and/or sub-leases has exploded. With less rental income and relatively static operational costs, the valuation of the building dips. When the valuation of the building dips, the building owners' access to new financing for capital improvements and tenant buildout construction costs also goes away. And without access to financing for construction projects, the ability of the building owner to attract new tenants is diminished. This start a vicious cycle that is difficult to break out of.

Regardless of if a building is fully occupied or not, base building equipment still wears out and will need to be replaced. If traditional financing cannot be secured for these

Back to TOC

types of capital improvement projects, there are innovative financing methods such as property-assessed clean energy loans that may become more attractive.

What types of office building assessment programs are owners adding to ensure tenants are breathing healthy, clean air?

John Yoon: In direct response to COVID concerns, we've seen an increase in ASHRAE Standard 62.1: Ventilation for Acceptable Indoor Air Quality compliance study requests. However, recommendations for increased ventilation often have a downside in increased operational costs.

Adrian Gray: During the COVID-19 pandemic, many building owners invited mechanical, electrical and plumbing engineering consultants to identify upgrades to existing systems to prevent and/or mitigate the spread of the virus amongst building occupants. Many of the recommendations followed industry trends to improve ventilation and increase the amount of fresh air.

Matt Humphries: Overall, they are committed to getting as much fresh air into building and keeping the air clean.

How are engineers designing office facilities to keep costs down while offering appealing features, complying with relevant codes and meeting client needs?

Matt Humphries: The digital twin concept allows engineers to develop a model that you can use to analyze your current situation and adapt the way your building is be-

Back to TOC

ing operated. Efficiency is now especially important. Since the pandemic, offices are not occupied all the time and we can't make the same assumptions as before about the use of space and resources. We need to incorporate ways to know when lights are needed, for example, since knowing when a space is actually occupied can enable you to be more efficient.

John Yoon: Mention the importance of MEP systems to most building occupants, you'll typically be greeted with a blank stare. When construction costs are fixed and they are given the choice between enhanced MEP system functionality and more tangible items, like nice furniture or fancy interior finishes, MEP typically loses. When that happens, the typical direction from the owner is to provide only basic code compliant systems. Conveniently, more stringent requirements associated with new energy conservation codes necessitate greater functionality anyway.

Adrian Gray: New buildings are being designed to reduce and or eliminate greenhouse gas emissions while also complying with local and state building codes. Additional measures may include enhanced building ventilation, energy recovery, airflow segregation and zoning, enhanced filtration measures and implementation of smart building applications. AT HDR we work closely with clients, using technical knowledge and expert modelling, to prioritize their requirements and develop the most economic building engineering services strategies.

What types of products or systems are you importing from the design of other building types, such as outside air, combined heat and power or other technologies?

Back to TOC

Miles Brugh: There is an increased emphasis on electrification; Chicago has mainly had the heating in building driven by natural gas. As we study the electrification options for our designs, we have to factor in larger electrical infrastructure from the utility company and how we distribute throughout the building. On the electrical side, we have to work closely with our mechanical engineering teams on their new strategies and approaches to provide more efficient spaces.

Adrian Gray: The move toward using cleaner electrical power has led to a more extensive use of heat pump systems as a replacement for traditional gas fired heating equipment. The use of clean electrical power is now considered for many new office development and refurbishment projects.

John Yoon: The first thing that comes to mind are dedicated outdoor air systems, known as DOAS. In the past, we've typically only specified DOAS for smaller buildings. It seemed like their use was set to explode with a proposed amendment to the 2024 International Energy Conservation Code requiring commercial buildings to have DOAS, but that was voted down. Regardless of the code, we've been specifying them more frequently on adaptive reuse of existing larger office buildings to maximize ceiling heights. Higher ceilings are another common owner's request.

Consulting-Specifying Engineer

Settling down to ramp up

The advancements in cell and gene therapy solutions and growth of biotech have given rise to hundreds of new startup companies. Companies scaling up and occupying their first facility are hit with a daunting task: how do I go about constructing a facility?

What to look for?
Span and floor to bottom of beam height

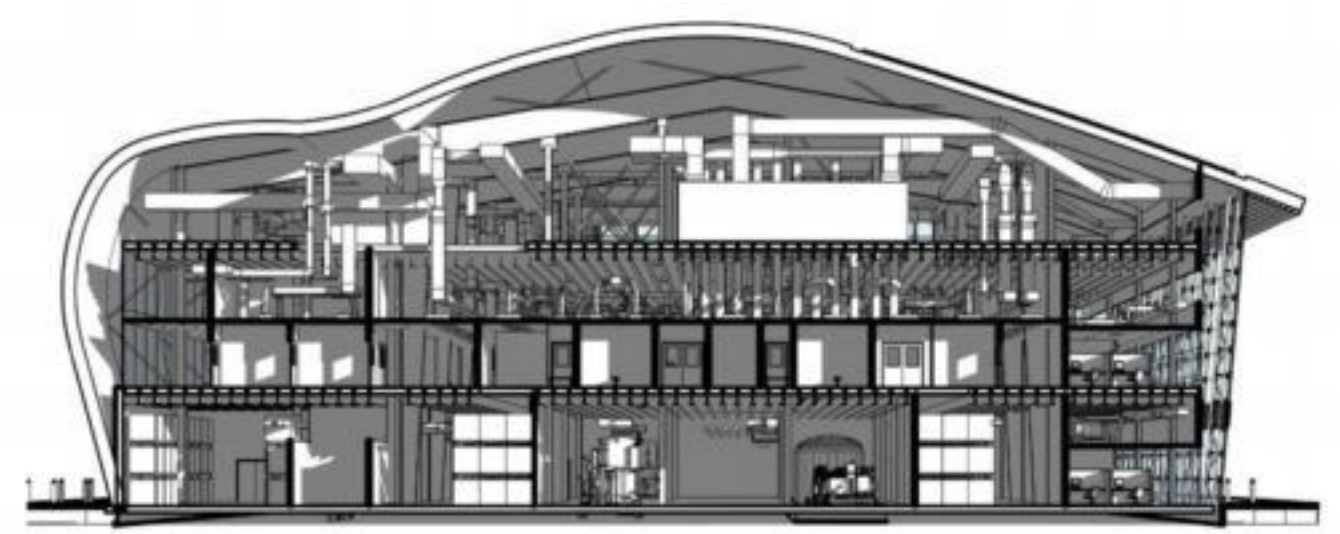
- Having a large span between columns is helpful for space planning and makes future alterations easier. The open plan allows the process to dictate the layout.

- A good floor-to-floor height, or floor to bottom of the beam, is important for classified cleanrooms with walkable ceilings. Take your average manufacturing ceiling height and add 13 feet to the bottom of steel to provide adequate walking clearance under ductwork and utilities. Anything lower typically leads to a difficult to navigate, crawlable ceiling. If you anticipate a large number of high-hat areas, you may want to consider adding 13 feet to those high points if the project can afford it. Otherwise, careful consideration will need to be paid to determine how to gain access to your lights, high-efficiency particulate air (HEPAs), and other items in the ceiling.

- If you're purchasing an existing building, stick to one designed for factory industrial applications. Trying to turn an office building into a manufacturing site will create design challenges, lengthen the project schedule and eliminate the savings you hoped to make by purchasing something cheap. And you'll be left with a building that is harder to manage and less adaptable to change.

Back to TOC

Back to TOC



Recommended span and floor height of office building. Courtesy: IPS

How much square footage do I need?

It depends on what you're manufacturing and many other factors, but here are some ballpark starting points:

- Non-Virtual Research-Based Startup Companies: 1,500 square feet to 15,000 square feet
- Research + Preclinical: 10,000 square feet to 40,000 square feet
- Research + Preclinical + Clinical: 50,000 square feet to 75,000 square feet
- Clinical + Commercial: 90,000 square feet to 150,000 square feet

Back to TOC

New construction vs. existing fit-out

- New construction is typically more expensive. The cost savings experienced when fitting out an existing building translates to reduced flexibility. But if you purchase the right existing building that meets the needs of your project you can benefit from the cost savings without making compromises.

- On your search for an existing site, it is helpful to have a rough design in hand so you know the property can meet your needs. Confirming the square footage needed can avoid regrets and, in most cases, will save you money in the long run.

- Purchasing an existing property that wasn't meant for your specific use can require a large number of upgrades. Do you need to upgrade the electrical service coming into the building? Are drain piping, domestic water service, and fire protection water service diameters large enough or do you need to replace underground piping? If you do need to upgrade, then you'll need to factor in the cost of the trenches or potentially demolishing and replacing the entire slab if it's cost-effective to do so.

- Is there a vapor barrier under the slab? If not, you may have to demo the slab and repour. Otherwise, any water coming through the slab can make bubbles appear in the epoxy flooring in your new cleanrooms.

- Exposing a wall or roof cavity means you need to upgrade it to meet current energy codes. Make sure the contractors are aware of this requirement and they don't open up any walls without the intent to upgrade them.

Back to TOC

Adequate lot size

- Parking – Do a quick parking calculation based on your anticipated building size. Designing a multistory parking structure is very expensive, and a large majority of the footprint will be dedicated to ramps and car circulation. Parking structures should only be used for extremely large facilities in areas where land costs are very high.

- Fire truck access road – Look into access road requirements but plan to have a loop around the building to be on the safe side.

- Truck turning radii – Show the truck turn arounds and turn radii on the plan to ensure adequate space is provided.

- Equipment outside building – Along with sizing the lot to accommodate parking, dedicating space for exterior equipment (transformers, generators, and trash & cardboard compactors) should also be taken into consideration.

Future expansion

- Look for opportunities on the site to expand, whether it's dedicating space on your land, or researching whether a neighboring property is likely to sell.

- Think about how the future expansion can be constructed without affecting existing operations.

Location

- Realize that sites like Boston come at a premium. While other major cities in the

Back to TOC

Example of an adequate lot size for office building construction. Courtesy: IPS

US can potentially be 15% cheaper. Look at Arcadis' Annual International Construction Cost Index to help you site your project.

Pre-engineered buildings

While they are a wonderful product with a variety of great applications and many benefits (such as the large column spans), they also can create some challenges. The root cause of this is they are often designed to meet minimum standards of construction depending on their original intended use.

Roof structure:

Back to TOC

- The steel supporting the roof usually doesn't have enough extra capacity to hang the walkable ceiling you want for your clean rooms. Hanging isn't the only option; you can use deep stud walls and light gauge members to support the ceiling. But if you only planned for 2-inch modular panels in your preliminary design, all these fat walls could present a problem. Also, if your rooms are very large and the spans are too wide for light gauge studs, then you'll need a secondary steel structure to support the walkable ceiling. And new steel means new footings, which means cutting more holes in the existing slab.

Construction worker breaks ground on sloped site. Courtesy: IPS

- Along with not being able to support your walkable ceiling, you might have some trouble supporting ductwork, piping, etc. from the roof structure. You'll need to post down to the level below to support them.

- And if you can't support these items, you can rule out having air handlers or other large equipment on the roof without adding a separate support structure, so

Back to TOC

you'll need to find space inside the building or elsewhere on-site for that equipment.

Exterior walls:

- Many pre-engineered buildings are constructed with flimsy skin with few support points, so modifications down the road could be challenging.
- Try and get extra panels if the vendor still makes them in case you need to infill them in the future.
- You are also less likely to get high-level LEED certification depending on the R-value of the components.

Adding equipment platforms:

- The columns in pre-engineered buildings typically don't have enough capacity to support a new equipment platform, so new columns will likely need to be added.

Slab:

- Some pre-engineered buildings have hairpin rebar on the columns along the perimeter. You cannot touch the slab in these areas, so all your piping needs to be diverted around it or above it.

All of these points translate to more design time to find solutions to problems that wouldn't exist in a wide flange building that has larger tolerances built-in. Weigh the pros and cons of each building before making your decision.

Back to TOC

Sloped site:

- Cut and fill isn't too expensive but removing excess soil off-site can be. Grading the site for parking and truck movement typically involves removing a large amount of soil removal.

Small footprints and multistory manufacturing

- Multistory could lead to a reduction in footsteps with an efficient design. However multistory requires material elevators, typically two: waste and materials & product. Consider the locations if these are existing elevators. The design will either need to be tailored around the elevators, or they may need to be demolished if the location is hindering other key adjacencies. And please remember, there are no truly "clean" elevators. Elevators should be kept within your computer numerical control (CNC) circulation and should not be used in Grade D areas or higher.

Landlord

- Having a landlord requires a lot of back and forth to get approvals. This can be time consuming and could prevent you from meeting your schedule demands. Does your loading dock meet their desired aesthetics? They will ask to see truck schedules and much more information to keep their other tenants happy. Are you allowed to put air handlers on the roof? Are exhaust stacks visible from the street? What screening do they require? Chances are it's not cheap, and you'll need more design hours to do site-line analysis and renderings to present to them. Some of these requirements could make your project unachievable or could kill a future alteration/addition.

Back to TOC

AHJ Requirements

- It would be beneficial to schedule a friendly meeting with the local Authority Having Jurisdiction (AHJ) and review your goals. They can tell you upfront what challenges you'll face. Can a new road to the site be created for truck access? Is there a list of allowable materials that can be seen from the road? For example, some jurisdictions don't allow a chain link fence to be seen from the street.

- If the code says you will need 300 parking spaces, but you'll never have more than 75 people on site, what steps need to be done to prevent you from constructing ~200 unused parking spaces that only contribute to the heat island effect and permeable surface on-site?You shouldn't rely on the AHJ to grant variances, but many AHJs are flexible when it comes to a legitimate hardship.

Environmental study

This is less likely to be an issue for you, but there are many sites that carry restrictions based on environmental protection. It's important to verify if your site has any and how they will affect your project.

- If you have protected wetlands nearby, you should see what restrictions you have and map them on the site to see what your buildable area is and where you're allowed to locate equipment.

- Before you purchase a brownfield site, investigate the costs of removing contaminated soil, abandoned tanks, etc. You can get grants and other assistance from entities like the environmental protection agency (EPA) if you choose to occupy a brownfield, but the benefits should be weighed with the challenges.

Back to TOC

Key takeaway

Every company has lessons learned from prior projects, don't let your startup repeat the same mistakes. Don't buy a building before you know what will go into it. Perform a quick engineering study to ensure your building will be able to meet your needs. This will save you time and money in the long run.

Raymond Szuszkiewicz

Raymond Szuszkiewicz *has 11 years of architectural design experience in the Life Sciences industry. At Integrated Project Services (IPS) Mr. Szuszkiewicz has led the design effort of dozens of Oral Solid Dosage, Biologics, Gene Therapy, Blow Fill Seal, and Aseptic facilities.*

Boosting occupant health through design

National Facilities Services strategy introduces new equipment, improves member experience and security, and decreases operating costs.

If a pandemic has taught us anything, it's the importance of two things: the space we live in and our health. These factors were two driving forces behind the Kaiser Permanente pharmacy renovation project in Washington, D.C.

The project began as part of the National Facilities Services overall strategy to implement an updated pharmacy template that promotes workflow efficiency, introduces new equipment, improves member experience and security, and decreases operating costs.

To allow the pharmacy to remain open during the renovation, we designed the project in phases. It originally began as a six-phase plan, but in the end, we were able to work with the pharmacy management staff and the contractor to simplify it to only four. This meant the renovation was completed in sections:

- Stage 1: Construction staging
- Stage 2: Half of the pharmacy remained operational while the other half was under construction
- Stage 3: Newly constructed half of the pharmacy operates while the previously operational half is under construction

Back to TOC

Back to TOC

- Stage 4: Receiving

Streamlined workstations are adjustable and made with low-maintenance materials, increasing comfort and efficiency for pharmacists. Courtesy: Dewberry

The design itself consisted of two main components: the staff zone and the member zone.

Staff Zone

For the pharmacy staff, we wanted to increase workflow efficiencies, add security features, and use durable and low maintenance materials. We implemented ergonomic features to promote comfort and efficiency throughout the workday. To combat leg fatigue from long hours spent standing, we used cushioned flooring and height-adjustable workstations that could be personalized to each employee's needs.

Back to TOC

POS stations enhanced by new glass dividers and color-changing LED lighting. Courtesy: Dewberry

We implemented Kaiser's prescribed shelving to create clear lines of sight throughout the space, which increased visibility for staff. This project eliminated the need for additional shelving by installing eight IntelliCab lockers for storage and dispensing. The lockers automate the process of storing, retrieving, and returning prescriptions using radio frequency identification (RFID). A dispensing robot was also installed for increased efficiency, and we included necessary infrastructure in the event that Kaiser chooses to add more dispensing robots in the future.

Back to TOC

Organic shapes and materials help to create a welcoming environment in the pharmacy. Courtesy: Dewberry

Finally, security was enhanced through the installation of three separate overhead coiling doors at the points of sale (POS). This allows the front of the pharmacy to be secured and protects employees during late night shifts. It also helped to keep each phase of the project secure as it was completed.

Member Zone

We designed the member zone to create a welcoming atmosphere in the pharmacy and brighten the space. Our design elements emphasize the flow of the space and cre-

Back to TOC

ate directionality towards the POS, eliminating the need for temporary signage. Additionally, color-changing LED lighting are featured at each POS, which can be changed for holidays or special events.

We also used organic elements in the design to enhance the members' experience. Organic-shaped cutouts, natural wood, tree motifs, and light colors all add to a sense of healing. For further comfort, we added privacy glass dividers between each POS and at the consulting station.

This project was one of our favorite transformations to date. As Kaiser continues to serve more members, we are happy to know that we've equipped its staff with an environment that allows them to work efficiently and comfortably. Further, our team is honored to contribute to a space that will make everyone who enters it feel welcomed.

April Vacca and Ellen Augst

Content Archive

2022 Winter Edition

2022 Fall Edition

2022 Summer Edition

2022 Spring Edition

Smart Buildings

Thank you for visiting the Smart Buildings eBook!

If you have any questions or feedback about the contents in this eBook, please contact CFE Media at *customerservice@cfemedia.com*

We would love to hear from you!