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INSIDE:

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- Sleep at the Station

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Vehicle exhaust in the apparatus bay can be mitigated by whole-house, filter and tailpipe extraction systems.
Photo courtesy RRM Design Group

Ramsey Fire Station #2—designed by BKV Group for the City of Ramsey, MN—is an energy-efficient facility with three drive-through apparatus bays. It occupies a prominent corner lot in a residential neighborhood of this growing suburban community, and it serves a paid on-call staff of 24 firefighters.
Photo courtesy BKV Group

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For news related to fire stations around the country as well as original content related to station design tips and trends, visit firehouse.com/stations.

By Mike Scott

Response from the front apron should enter a safe and controlled roadway. *Photos courtesy RRM Public Safety*

Planning Pitfalls

Avoid these common mistakes when planning a new station

Proper planning up front can save thousands of dollars down the road. With this in mind, here we'll review some of the most common pitfalls encountered during the planning of a new station, divided into five categories: site, decontamination, space programming, layout, and material selection.

Site pitfalls

The overall site layout is a critical part of fire station design, so it's important to keep several factors in mind.

Circulation options: Site layout is driven primarily by the circulation of the apparatus, so stay open to all circulation possibilities to ensure that the site is large enough to accommodate circulation for a full drive-through station.

Utility access: Make sure all utilities—sewer, water, gas, electric, communications—are within workable distance to the project site. You do not want to be significantly into the planning of the project before finding out that a main utility line is hundreds of feet away.

Front apron: Response from the front apron should enter a safe and controlled roadway. Signalization can help, but proper location of egress is the first design consideration. Line of sight from adjacent corners and drives must be considered. Make sure that equipment is not exiting onto a busy street.

Environmental impacts: It's important to understand how potential environmental impacts, such as avoiding waterways and biological habitats, could impact the project timeline. Not only can these environmental issues limit site availability, but studies for certain species can only be done at certain times of the year, and can easily add a year to your project schedule. Complete environmental investigations early to avoid timeline problems.

Terrain considerations: Beware of excessive slopes on sites. They can be mitigated, but often at great cost.

Soils: Understanding the soils in the area can help avoid excessively large foundation systems. In a recent example, a fire station built on fill necessitated multiple 25-feet-deep concrete caissons, increasing the construction costs greatly.

Decontamination pitfalls

According to a 2010 NIOSH research paper, firefighters have a significantly higher rate of developing cancer.[1] There are several key considerations related to this issue that can help protect firefighters.

Protection from exhaust: Vehicle exhaust in the apparatus bay can be mitigated by whole-house, filter, and tailpipe extraction systems. In addition, a positive-pressure vestibule airlock with two doors stops any airflow from the apparatus bay to the fire station house.

Separation from contaminants: Turnouts should be stored as far from the living quarters as possible to protect firefighters from off-gassing of harmful contaminants. Separate washing facilities for contaminated tools and materials should be located as far as possible from the living area. An example would be separate washers/dryers for contaminated rags from truck washing.

Turnout decontamination: This process of decontaminating equipment and turnout gear starts at the rear apron before entering the station, and uses a special decontamination room entered from the exterior as the entry to the turnout cleaning area of the station.

Protective materials: Materials like carpet have been eliminated from recently designed firehouses, as they tend to trap contaminants tracked in by boots. Hard, cleanable surfaces have replaced these to maintain health and safety in the living quarters of the station.

At-incident decontamination process: Although this is not specific to building design, a fire department's procedure of decontamination at the site prior to entering the apparatus for the return back to the station is the first line of defense.

Turnouts should be stored as far from the living quarters as possible to protect firefighters from off-gassing of harmful contaminants.

Space programming pitfalls

A fire station is truly unique, as there are special spaces needed for fire operations that will rarely be found in other structures, and these merit special consideration.

Apparatus location: Design of a fire station should be centered on the circulation of the apparatus into and out of the apparatus bay. Layout of the apparatus within the bay determines first-out vehicles, drive-through capability, and ability for vehicle-stacking in support bays. Safety of response and support needs of the fire apparatus should guide apparatus bay location and considerations. Vehicle exhaust extraction methods are a primary consideration, and should be decided early.

Extractor location: Washer extractors for cleaning should be located near the PPE storage area. Accommodations should be made for rear maintenance access and trough drains to extractor functioning. Proximity to exterior access may be a consideration if other stations use this extractor.

SCBA filling station location: Some stations house an SCBA filling station system, while other stations may only store bottles that were filled elsewhere. The SCBA system should be in a ventilated room away from the apparatus bay with enough clearance to maintenance access panels and adequate bottle storage. If other stations use this system, additional bottle storage—and access—may be required. The compressor should be placed away from the living quarters to avoid noise transmittance.

Sleeping quarters and restroom privacy: Fire stations have traditionally had large open dormitory areas with shared restroom facilities. However, today's fire departments require a higher level of privacy, as more women are becoming firefighters. A proven configuration to provide privacy for sleeping and private restrooms is to design multiple single-accommodation sleeping rooms off of a private hallway. This hallway should also contain multiple single-accommodation shower/restroom facilities. If these restrooms are directly off the private hallway, a modesty policy for that hallway should be in place for firefighter attire, and the restrooms may be placed one for every two bunks.

Future expansion needs: Station layouts may be designed in such a way to allow a station to grow from one company to multiple companies. When this is anticipated, bunkrooms and private hallways should be arranged to either be extended or duplicated extending from the living area. Placement of the apparatus support areas and structural accommodations to the apparatus bays can allow future added apparatus bays. Site area around the fire station should be planned at the conceptual level to allow this to occur, as this will result in cost savings once expansion has begun.

Layout pitfalls

Time and safety are the most important elements when considering the layout of a fire station. How can you design a facility that will allow firefighters to be as responsive as possible, in an environment that allows for the privacy of each of the firefighters, all the while maximizing the safety and protection of firefighters and the community?

Response time: The layout of a fire station should be set up such that firefighters have a minimal distance to travel to the front of the apparatus bay where the first engines are located from both the sleeping quarters and the kitchen/dining/dayroom area.

Public-to-private separation: A fire station should be organized with a progressive transition from public areas to semi-private areas to private areas. This can be accomplished by placing the administrative office near the lobby with a secured door. As visitors enter the station from the lobby, they should first encounter the living areas as transitional semi-private space, allowing the sleeping quarters to be the most private and farthest from public areas.

Visibility protection of living area: Visibility to the kitchen/dining/dayroom should be screened from the exterior front of the station. The community should see firefighters in action in the apparatus bay, not during off-duty time.

Layout of the apparatus within the bay determines first-out vehicles, drive-through capability, and ability for vehicle-stacking in support bays.

Noise protection: Great consideration should be given to firefighters' sleeping quarters. Avoiding immediate adjacency to the kitchen/dayroom/exercise room will help minimize interior disruptions of firefighters while sleeping. Bunkrooms should also avoid immediate proximity to busy roads.

Exercise area: Exercise areas should be located on the house side of the fire station whenever possible to avoid the need to cross potential areas of contamination, such as the apparatus bay. To allow firefighters good ventilation and additional space for exercise, several doors or roll-up doors should be provided to an exterior exercise patio.

Decon process: It is optimal to have an exterior door from the rear apron allowing firefighters to enter the decontamination room to perform the cleaning process prior to entering the apparatus bay. PPE washing should be immediately adjacent to the decontamination room prior to entering the PPE storage area or the apparatus bay. This provides a progression in the decontamination process as the station is being entered.

Vestibule placement: The apparatus bay and support areas are considered a "hot zone" (aka red zone) for contaminants.

To allow firefighters good ventilation and additional space for exercise, double doors or roll-up doors should be provided to an exterior exercise patio.

The living and sleeping quarters is the green/safe zone that is to be protected from those contaminants. A vestibule should be placed between the red zone and the green/safe zone. It is recommended that this vestibule have two doors and the mechanical system for the station be designed to maintain a positive air pressure flow from the green/safe zone through the transitional zone vestibule toward the red zone. Before entering the vestibule from the apparatus bay, a hand-washing sink should be located next to each door. Additional boot-washing stations or boot-changing areas are recommended to be part of this vestibule.

Material selection pitfalls

Fire stations are 24-hour facilities, and the materials selected need to be able to withstand constant use. Durability, ease of use, cleanability and longevity are key factors when selecting materials.

Durable kitchen finishes: Kitchen spaces require finishes to be significantly more durable and cleanable than a typical residence or commercial facility. While cleanable laminate or formed surfaces work on the cabinetry, countertops take a heavier amount of abuse from the cooking process due to interactions with pots, pans and cooking utensils. Recommended surfaces for countertops include quartz, stainless steel or solid phenolics, such as Corian. These surfaces that are on the countertops should extend from the splash to the bottom of upper cabinets and the sill of any windows that may be present

Kitchen spaces require finishes to be significantly more durable and cleanable than a typical residence or commercial facility.

near the kitchen sink. Joinery of these surfaces near corners and edges should be detailed carefully for durability and easy sanitation. A marine edge is best near the edges of the counters to stop water from running over the edge. Sinks should always be undermount or preferably integral to the counter surface, again minimizing edges that are difficult to clean or that would collect particles.

Durable restroom finishes: Restroom facility walls that are not covered by shower enclosure material or casework should be covered in a cleanable surface. Tile is often used to at least a 4-foot height to achieve this coverage. Tile is also commonly used for showers surrounds, but solid phenolic is another very good option with the benefit of reducing grout lines to clean. This type of solid surface for a surround comes in a variety of thicknesses; 3/16-inch or greater is recommended when using a solid surface for long-term durability. Floor surfaces in restroom areas are often tile, but polished or stained concrete has also proven to be a durable and low-maintenance solution. Careful specifications for slip resistance should be maintained regardless of the floor surfaces. Like kitchen casework, solid phenolic or quartz has been successful in providing the moisture resistance necessary for long-term durability.

Water-resistance: In addition to the kitchen and restroom facilities, a fire station has many rooms that are considered "wet rooms," such as the apparatus bay, the cleanup or decontamination room, turnout or PPE storage rooms, and laundry/utility rooms. All these rooms should have a raised concrete curb from 4–6 inches off the floor to keep water from causing

moisture problems at the wall. In an ideal situation, these wet rooms are constructed out of a moisture-resistant material, such as concrete block. Due to cost, however, many times these rooms are stud-framed. When this occurs, it is recommended that moisture- and impact-resistant gypsum board, along with epoxy paint or a protective surface, be used to cover the walls. This protective surface can be tile or a solid surface such as solid phenolic, or in areas that see little use and are considered more back-of-house maintenance spaces, fiberglass reinforced panels (FRP) would suffice. Any area considered to be a wet area should include a floor drain and either a concrete or tiled floor.

Finishes to avoid: These same durable finishes provided in the wet areas are also very effective for cleanability due to their ability to resist trapping contaminants. Recommended flooring material options include tile, terrazzo, polished concrete and stained concrete. These have proven to be effective at being both durable and cleanable. Sheet flooring goods have also been commonly used, especially on upper-floor levels. Firefighter boots entering the fire station can track in contaminants that more easily adhere to carpet than smooth cleanable surfaces. Therefore, today's fire stations have little to no carpeted floor surfaces where boots are worn. Some departments are using mats or area rugs that can be taken out and cleaned or replaced regularly in place of carpet. The important consideration is that all surfaces within a station built-in or furnished should consider the adherence of potential contaminants brought in by a firefighter returning from a call.

Long-lasting material: Fire stations should be considered 50-year buildings and are often asked to last 60–70 years. Frequently, casework in wet areas does not outlast the life of a fire station. Typical residential casework construction has often been used in the past and has been found to have moisture problems and cause delamination of the exterior finish. High-grade plywood or medium density fiberboard (MDF) have been solutions to combat this moisture issue for casework, especially at base cabinets that are near the floor or below wet counters.

In sum

Focusing on these pitfalls commonly associated with fire station site, decontamination, space programming, layout, and material selection can help keep your project on track and help the facility stand the test of time. ■

References

1. CDC: Findings from a Study of Cancer among U.S. Fire Fighters. 2016. www.cdc.gov/niosh/pgms/worknotify/pdfs/ff-cancer-factsheet-final.pdf.

Mike Scott, LEED AP, is the director of RRM's Public Safety Studio. He earned his bachelor's degree in architecture from California Polytechnic State University. Scott has spent much of his 18 years at RRM specializing in public safety projects, including the planning and design of fire stations, combined fire and police station facilities, and fire training facilities, including building and site training scenarios.

By Raegan Porter

Commercial Furniture 101

A designer can help select furnishings and finishes that are more about durability and how they will function in the space. *Photos courtesy FGM Architects*

Key factors for researching and procuring commercial furniture

It is a unique opportunity for a chief to oversee building a new fire station, which generally involves a designer to help outfit the station with new furniture. There are several important factors to consider before purchasing furniture, perhaps the most important being the difference between residential and commercial furniture (aka contract furniture). Fortunately, whether the furniture is for a new station, renovation or a single room, the process is the same. When ordering commercial furniture, you will have to specify the parts and pieces. This specification process will help ensure that you are getting durable furniture that will stand the test of time. Let's review a series of questions to explore the ins and outs of commercial furniture.

What is the difference between residential furniture and commercial furniture?

Research shows that the average American spends more time at their job then eating, sleeping or with their families. Because of the sheer volume of time spent in the "office," commercial furniture has to be built to a much higher standard than the furniture we put in our homes. As such, commercial furniture is what belongs in the workplace. Unfortunately, a common pitfall I see is purchasing residential furniture over commercial furniture because of the cost savings. But there is a big difference between residential and commercial furniture, and facilities that operate on a 24/7, three-shift schedule require commercial furniture.

It is vital to know where to find commercial furniture, as only a few companies sell both residential and commercial furniture. The designer will choose the appropriate company because each business identifies itself differently. The name of the business will not always indicate the type of furniture it sells. For example, there are the West Elm retail stores, but there are also West Elm Workspace stores, which have commercial or contract furniture. Another example would be La-Z-Boy, which also has a commercial furniture line called La-Z-Boy contract furniture or KNU Contract.

The commercial furniture industry has a "governing" body called the Business and Institutional Furniture Manufacturer Association (BIFMA). It is a not-for-profit organization that has been around since 1973. They assess the comfort, safety and durability of commercial furniture. Residential furniture companies do not have their furniture tested to meet the BIFMA standards. The American National Standard Institute (ANSI) provides the accreditation for BIFMA. This organization comes up with the testing standards for products to protect the public.

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Because of the sheer volume of time spent in the "office," commercial furniture has to be built to a much higher standard than the furniture we put in our homes.

What are the different ways to procure commercial furniture?

There are a few different ways to purchase commercial furniture. One easy way is off of state and government purchasing agreements. Agreements such as General Services Administration (GSA), National Joint Powers Alliance (NJPA) or The Cooperative Purchasing Network (TCPN) are a good place to start for commercial furniture purchases. These agreements have been pre-bid to allow government agencies the ability to buy off of and receive competitively priced furniture. The only wildcard is installation, which is easily bid out.

The second way to purchase commercial furniture is by bidding it out. Bidding out is a very time-consuming process, and it does not allow you as much control as buying off of an agreement. You also need to keep in mind that you might be dealing with multiple dealers in the end, so if something were to break or you need maintenance on something, you will need to reach out to the correct dealer.

How do I know if I am getting something that is durable?

Commercial furniture must be purchased through a furniture dealer or manufacturer's rep. Do not purchase commercial furniture off the Internet. The industry has been set up this way for many years. However, reading and understanding the

warranties is always important when buying furniture, especially for a 24/7 facility. It is important to know that even though a company and/or product may be commercial or for contract use, it still might not have a warranty that covers a 24/7, multiple-shift facility. So it is important to read or ask for products that have a warranty to cover the heavy use that a multiple-shift facility will endure. It is also important to understand that the warranty does not always cover the whole chair; it may only cover the parts and pieces. The fabric will then have a different warranty. Warranties do not cover abuse or misuse of the product, or failure from normal wear and tear.

How do I narrow my search?

Some key things to look for to narrow down the search:

- At least 300-lb. weight capacity
- Meets or exceeds ANSI/BIFMA standards
- Warranty coverage for multi-shift (24/7) applications
- Fabric should meet CAL 133 (flammable retardant/resistance)
- Wyzenbeck fabric durability test (look for 100,000 double rubs or more)

Why are there so many selections for one piece of furniture?

The number of selections for a simple task chair can be overwhelming, let alone a whole room of furniture. However, it is no different from buying a car and making the choice that works for you. Commercial furniture is not something that manufacturers have in stock; it is all made to order.

Let's take the task chair as an example and say we have found a chair that meets all the above requirements. Now, I need to make several choices:

- *Mesh back vs. upholstered back:* The type of backing is an aesthetic and personal preference. With a mesh back, it tends to be cooler while sitting in a chair for an extended period. The key is to make sure that there is lumbar support.
- *High back vs. mid-back*: This is an aesthetic and personal preference. Consider the height of those who may be sitting in the chairs. If they are 6 feet tall and above, the high back may be best.
- *Fixed arms vs. adjustable arms or no arms*: We are all different sizes, so to have this flexibility for ergonomics is critical. Having this adjustability also helps with the longevity of the furniture. When someone first sits in their task chair, they adjust the height to fit their body. It is helpful to have the ability to change the arms to fit their body so that when pushing in the chair, the arms do not hit the desk or table and damage the edges. Depending on how often you need to move around or how you wear your radios, it may be helpful to have no arms.
- *Seat depth adjustment or none*: Again, with everyone being different heights, it is imperative that the ability to adjust

the depth of the seat, so that the edge of the seat hits just behind the knee joint with your thighs parallel to the floor.

- *Hard casters or soft casters*: Casters are all about the ease in how the chairs move. Different flooring surfaces require different caster types. If the chair will be on carpet, it is important to have hard casters for the ease of movement. If the chair will be on a hard flooring surface, it is important to have soft casters so that there is a more controlled movement with the chair.

What are the health factors to consider?

Basic ergonomics in a task chair is a given today. However, adding a sit-to-stand desk, walking station or a bike station goes a long way in the health of your employees.

Of course, there are many different—and deeper—layers to health in the workplace today. The Well Building Standard is a system to help guide the design, uses and behaviors within the work environment to improve the health and well-being of its occupants. It looks at air quality and levels of volatile organic compounds (VOCs), which are linked to cancer and other health issues. VOCs affect our cardiovascular system, nervous system, respiratory and immune system. This evaluation is important because VOC levels can be five times higher indoors than outdoors. Designers will look at several station elements for these reductions, including interior paints and coatings, interior adhesives and sealants, flooring, insulation, and furniture and furnishings.

Most commercial furniture is held to the higher testing standards below, and should be tested by these standards:

- ANSI/BIFMA e3-2011 Furniture Sustainability Standard (Sections 7.6.1 and 7.6.2), tested by ANSI/BIFMA Standard Method M7.1-2011
- California Department of Public Health (CDPH) Standard Method v1.1-2010

The Well Building Standard also looks at how environments affect our mental wellbeing. One simple but notable example is when outfitting workstations for an office, make sure that the employee's back isn't to the door or walkway. As humans, we feel most in control and safe when our backs are up against a wall, allowing us to see what is coming. You can trace this over thousands of years with human behavior.

When outfitting workstations for an office, make sure employees are positioned to face the door or walkway, as people feel more comfortable when they can see what's coming.

It is also important to research the manufacturer whose products you wish to purchase. What type of materials do they use? How much off-gassing will the products have? Are the surfaces antimicrobial? Are they easy to clean? Material quality is a small part of a broader topic, but each manufacturer will have answers to these questions.

Is there an added benefit of having a designer help?

There are many benefits to having a designer assist on furniture projects. First, they know all the details, yet are looking at the overall larger picture. One example of this is the designer will coordinate the electrical with the furniture, and make sure the overall design and finishes are functional for the application. Finishes are not just about the "look"; they are really about the durability and how it will function in a space. For example, stainless steel sounds like great material for durability, but it is loud. Designers can help with layouts and space planning while explaining how it will impact your operations. They can also bring samples out or take you to a nearby showroom.

In sum

As you can see, there is a lot of testing and standards that go into contract furniture. These tests and standards help protect the health and well-being of people in the workplace. Commercial furniture is costlier than what you might buy from a website or a residential manufacturer; however, the added value that you receive in durability, longevity and safety is well worth it, just like the old saying "you get what you pay for." It is also important to keep in mind that furniture can truly influence the culture and operations of the station. Often there is a furniture solution that can influence a culture shift that will help solve the issue.

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By Philip Wright

HVAC Design to Support Hot Zone Design

Air flow is key in controlling firehouse contaminants

Published research on cancer rates in fire station staff has given rise to a new design philosophy among fire station architects.[1] Hot Zone Design was developed to prevent the entrainment of contaminants from areas inside the station that are identified as sources (apparatus bays, decontamination areas, etc.) into the living quarters.[2] Now, simultaneous modifications to the heating, ventilation and air conditioning (HVAC) design can complement and support hot zone design.

The contaminants identified as cancer-causing include benzene, formaldehyde, butadiene, toluene, acrylonitrile and isocyanates, among others. These chemicals are emitted as gases and soot during a fire, and contaminate exposed gear, vehicles and tools.

When firefighters return to the station with contaminated equipment, they follow industry-standard practices for decontamination, which take place in specific locations within the building. These immediate and essential steps to control contaminants include washing vehicles, apparatus and gear. Depending on the location of the contaminated equipment, wash locations, and the route of travel between the spaces housing the equipment and the living quarters, contaminants may have a direct path of transmission into the living quarters. Transmission routes haven't been studied in detail, but may take place physically on people and clothing, and potentially through the transfer of air. HVAC design can help address the latter.

Hot zone design

Areas of the station where the exposed equipment is stored and washed are identified as hot zones. Areas that are required to be contaminant free are named cold zones, and the spaces between are transition zones. Architectural hot-zone programming consolidates the spaces within each of the hot and cold zones, and provides controlled transitions between the zones. Hot zone design philosophy complements the fundamental fire station design practices of providing the most direct path to respond to an emergency call and grouping similar usage areas.

HVAC systems must support the objective of hot zone design by limiting transmission of contaminants from the hot zone, through the warm (transition) zone, and into the cold zone. To achieve this goal, the HVAC engineer should view the mechanical systems not as individual components, but as a unified configuration that integrates all aspects of the required building operations.

Contaminant transfer is inhibited and limited by HVAC systems through several means (each may be employed individually or in some combination):

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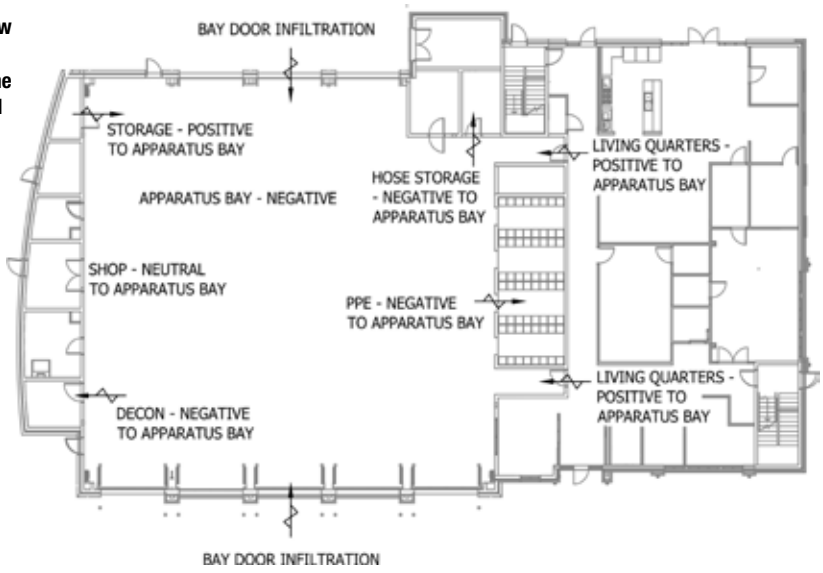
- Positive space pressure control to prevent contaminated air from entering a space. A room can be put into positive pressure by supplying more air than is exhausted. A positive space will move air out of the room, either under the door when the door is closed, or through the doorway when the door is opened. Positive pressure control is typically utilized in cold zones.
- Negative space pressure control to contain contaminated air and prevent transfer to other spaces. A room can be put into negative pressure by exhausting more air than is supplied. A negative space will draw air in from surrounding spaces to make up the differential between the exhaust and supply. The air to make up the exhaust can be transferred under the door, when the door is opened, or through overhead transfer ducts and grilles that connect positive and negative spaces. Negative pressure control is utilized throughout hot zones.
- The 100 percent outdoor air equipment provides a single pass-through of outdoor air that is exhausted without being mixed and returned to the space. This system and equipment type is typically used in all hot zones to remove contaminants. The equipment will be balanced to provide more exhaust than supply so that the space served is under negative pressure.
- Exhaust air from equipment serving hot zones must not be re-entrained into the outdoor air intakes of equipment serving cold zones. This will often require exhaust and intakes to be more than the code minimum distances apart. A good practice is to evaluate local wind direction data.

Common to both positive and negative space pressure control is the requirement for the differential between supply and exhaust airflows to be sufficient enough to move air through doorways, but not impact the operation of the door. A common target is to develop between 0.04-inch water gauge (w.g.) and 0.07-inch w.g. As a reference, NFPA 92 smoke control stairwell pressurization must generate a minimum of 0.1-inch w.g. across the stairwell door.

HVAC design criteria

To realize a fully integrated HVAC design that addresses hot zone design, it is necessary to identify the design criteria on two increasingly complex levels and perform a final system integration analysis. This work should be performed during the schematic design phase in conjunction with the architect and continue through the development of the 100 percent construction documents. Starting work during the schematic and programming phase will permit the engineer to identify any potential issues with the initial layout. Issues may be as basic as not having sufficient space for the equipment to service the rooms and zones properly, or could be more complex and involve relocations of rooms and doors.



A sample airflow diagram sketched upon the first review of the proposed program demonstrates how basic the initial step is, but also how it immediately conveys to the architectural team and owner how the HVAC design will be developed.

Stages of design for hot zone HVAC design: 1) Room Criteria, 2) Zone Criteria and 3) System Integration Analysis.

1. Room criteria

Room criteria are often well-documented as part of the design narrative generated by the engineer during the schematic design phase. The basic needs of each room are identified and the conditions are frequently tabled. The engineer will identify the living-quarter occupied spaces, such as bunk rooms, dayrooms, kitchens and offices. The support spaces will also be identified and include the apparatus bay, decontamination rooms, gear storage rooms, laundry, shop tool rooms, etc. Each room's designed heating and cooling temperature set points are noted, along with any upper and lower humidity requirements. Occupancy rates are documented with code-required ventilation rates.

Critical to hot zone design is to include relative air pressurization in the room criteria. The room must be noted as either being under positive, neutral or negative pressure relative to the adjacent space. A space airflow diagram is often a great help in showing how each space pressure relates to adjacent spaces and showing airflow paths.

2. Zone criteria

Zone criteria tend not to be clearly documented on the design documents and may not be immediately obvious to the end user or owner, although they may be implicitly addressed in the design. Groups of rooms must now be identified and zoned. The zones should be labeled with their potential contaminant level as either hot, warm (transitional) or cold.

The zones and groups will then have specific systems and HVAC equipment associated with them. Decisions as to what type of system is most appropriate for each zone will be influenced by many factors: ability to maintain space temperature and humidity set points, life-cycle cost analysis, availability of utilities, space constraints, energy efficiency, maintenance requirements, etc. Hot zone design adds additional factors that must be considered—airflow and space pressure control.

A return fan with airflow monitoring station ensures return airflow controls to the design value and will maintain the design space pressurization.

A typical fire station will likely have several zones with individual HVAC equipment and systems, divided among cold zones (bunk rooms, offices, training/multipurpose rooms, other rooms open to the public, kitchen and dayrooms, exercise rooms, and telecom/data rooms) and hot zones (apparatus bay, PPE storage room, SCBA storage room, PPE laundry room, decontamination room, and hose storage).

3. System integration analysis

After selecting the HVAC systems and equipment for each of the cold and hot zones and verifying that they address all the room criteria, the engineer must now focus on the final task of ensuring that each part of the HVAC system is fully integrated with the building hot zone design and functions to hinder the transmission of contaminants between zones and rooms.

Each system and piece of HVAC equipment must be reviewed in context with the other systems in the fire station. Proper maintenance of space pressurization between zones must be confirmed. For example, this may include:

- Apparatus bay ventilation/exhaust systems relative to the living quarters space conditioning system
- Apparatus bay ventilation/exhaust systems relative to public space conditioning system
- PPE storage room ventilation/exhaust system relative to the apparatus bay ventilation/exhaust
- PPE laundry ventilation/exhaust system relative to the apparatus bay ventilation/exhaust

As an illustration of the complexity involved in ensuring complete integration, the first example noted above would require that the engineer do the following:

- Determine that the apparatus bay system is continuously under negative pressure. Continuous exhaust is a code requirement, but intermittent high-volume vehicle exhaust or additional summer ventilation will affect pressure and should be considered in every scenario examined.
- Ensure the living quarters HVAC system provides continuous positive pressure relative to the apparatus bay. In a 24/7 facility in which equipment operates with a fixed quantity of outdoor air, this shouldn't be problematic.

Complications arise when the system has unoccupied sequences or the outdoor air intake varies based on demand control ventilation. Again, the engineer should assess the system under each of the operating conditions.

- Continue the analysis of other zone equipment, sequences, and airflow variables if the living quarters are adjacent to other negative spaces such as the PPE room.
- Quantify the volume of air being exhausted from the apparatus bay and determine from where the make-up-air is being drawn. Make-up-air will be drawn not only from the living quarters, but from other adjacent spaces as well, as infiltration from doors and windows.
- Calculate the volume of air necessary to maintain target pressure levels across the doors between the living quarters and the apparatus bay. Perform this calculation for every combination of sequences for the HVAC systems involved.
- Verify the worst-case scenario is identified, accommodated by the equipment, and ensure operations in the other scenarios don't create pressurization issues. Being too positive prevents doors from latching closed, and a very negative space may make it difficult to open doors.
- Finally, update the airflow diagram with the design airflow values calculated for the worst-case scenario and update HVAC equipment selections with revised outdoor air or exhaust values.

In sum

Hot zone design is gaining traction in fire station architectural design, and the HVAC engineer can support this design objective through equipment selection, equipment location, airflow control and space pressurization. A fundamental understanding of each space, its associated zone type, and all the room condition criteria are required at project commencement. After establishing individual room criteria, the engineer must continue the development of the design through the grouping of rooms to create zone criteria and the subsequent selection of equipment. HVAC design is only complete once the final system integration analysis is performed. This final complex task is critical to ensuring that the HVAC equipment will perform as an integrated system in support of hot zones design.

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By Craig Carter

There are many alterations that can be made to the physical space that will allow you and your crew to get better sleep on nights when the calls slow down. *Photos courtesy BKV Group*

Better Sleep at the Station

How to alter your existing fire station to reduce sleep deprivation

Sleep deprivation, fatigue and decreased alertness among first responders are problems receiving significant attention in the fire service media, and rightly so. Studies have identified some of the key implications of sleep deprivation and sleep disorders, and they are sobering.

Sleep stats

According to a recent study, 37 percent of firefighters show signs of a sleep disorder, the majority of which are undiagnosed and untreated.[1] Furthermore, firefighters face increased risks of chronic health issues, and sleep deprivation compounds the issue. Firefighters with sleep disorders are 2.4 times more likely to have cardiovascular disease, 1.9 times more likely to have diabetes, and 3 times more likely to have depression or anxiety disorders.[1] More broadly, sleep loss associated with shift work has been shown to significantly increase relative risks for cancer and stroke.[2]

Mental functioning is severely diminished without proper sleep. Only getting 5 hours of sleep for four consecutive days, instead of the recommended 7–9 hours, has cognitive effects similar to a blood-alcohol concentration of .06 percent.[3] Fireground injuries are more likely to occur between 12 a.m. and 6 a.m. than at any other time of day.[4] Firefighters diagnosed with sleep deprivation are twice as likely to be involved in a motor vehicle accident.[1] Additionally, sleep deprivation has been linked to theft or destruction of employer property,[5] verbal abuse of co-workers,[6] susceptibility to unethical suggestions,[7] impulsive behavior,[8] and a general lack of emotional restraint.[6]

The myriad impacts of poor sleep amount to a serious safety concern, but is also a significant area of liability for departments whose firefighters are experiencing these symptoms. We know that there is no simple solution to sleep disorders, even as widespread as they are. Part of the solution is policy related, but another is directly attributable to the built environment.

The way your firehouse is designed and constructed plays a significant role in the quality of sleep firefighters can hope to achieve. Most fire stations are old, small and designed for an era with fewer calls, and unless they were forward-thinking, they were not designed

to promote good sleep. Fortunately, there are many alterations that can be made to the physical space that will allow you and your crew to get better sleep on nights when the calls slow down. Let's review several contributing factors to poor sleep and some solutions for each.

Light

The brightness and color profile of light has a direct impact on our internal clock. Various hormones rise and fall in response to these cues, so lighting can be used to communicate to our bodies that it is time for sleep.

An ambitious alteration project might replace light fixtures in portions of the station with cutting-edge LED technology that can echo the subtle color variations that natural sunlight goes through each day, from cool tones in the morning to softer reddish tones late in the day. These color-adaptive fixtures, now gaining popularity in residential settings, provide extra environmental cues to wind the body's hormones toward a restful night. Providing better access to daylight during the day also serves to align your body's internal clock, so installing skylights and light tubes or cutting in additional windows throughout the station can notably improve sleep.

Control of the light levels in your sleeping area is important. The best-case scenario would provide each firefighter with a separate room and a dimming switch for precise light level controls, and in some large stations, this may be a feasible retrofit. In a group dormitory arrangement or a room without full-height walls between bunks, each sleeping space should be provided a small LED task light to allow reading or getting ready for bed without turning on the overhead lights and disturbing the entire room. Similarly, it is a common practice to install step lights in fire station corridors to provide enough light to reach the restroom without the bright overhead fixtures jolting you back to full alertness. These fixtures are an easy addition to a building, with battery-powered options available. Light levels in restrooms should be on dimmer controls, with an occupancy sensor controlling a low-level fixture and manual control for more light if desired.

Rolling blackout shades are a critical and inexpensive amenity for sleeping areas. Even stations that are not bothered by car headlights, streetlights or building security lighting can benefit from this alteration if firefighters occasionally sleep late after a call the night before. Any frequent visitor to fire stations has seen ad hoc solutions to this problem that may or may not be building code compliant. Properly installed blackout shades are opaque even in bright sunlight, and run in tracks or channels at the window jambs, preventing light spillage around the edges.

Another option is to alter your alerting system to only turn on lights specific to the crews that are responding to the call instead of for the entire station. If your existing system doesn't allow that, consider tying the system into a dedicated light fixture with a red filter. This way, blue wavelengths don't confuse your body into thinking it is time to be awake.

Sound

Loud noises create an instant adrenaline response, but even consistent low-level noise can be sufficient to prevent sleep. In an ideal scenario, each firefighter will have independent control of the sound level in their sleeping space to suit their needs, such as using a white noise machine or resting in complete silence.

Physical distance from the source of noise is the most foolproof way to reduce decibel levels, but a barrier with sufficient mass can also dampen sound transmission. However, sound travels well through even the smallest holes, so partial-height separations will have almost no effect on the transfer of sound between bunks (although they are beneficial for other reasons). Even full-height walls are imperfect if they are not caulked at the perimeter with acoustic sealant or if they don't have a door with perimeter gasketing.

In large dormitory-style bunk rooms, or even a single-user room where a firefighter occasionally snores himself awake, sound absorption can be an effective strategy. Absorptive ceiling tiles are inexpensive and can be very effective if they are maintained properly. Window

curtains will also contribute to sound absorption, but are slightly less effective at mitigating sound transfer through the window than the same blackout shades with perimeter channels mentioned above. In group sleeping rooms, white noise at a reasonable level (no more than 65 decibels, according to some experts) can sufficiently mask noise to keep the tossing and turning of coworkers well below the level of notice.

At the least, frequent sources of loud noises should be minimized. All the doors near the sleeping spaces should be fitted with jamb silencers to prevent slamming. Lockers located near the sleeping areas should have silencers as well. If possible, the alerting system should notify only the rooms occupied by the crew leaving on the call, leaving other firefighters blissfully asleep.

If space and budget allow, individual murphy beds for each shift provides the peace of mind that comes from not sharing a mattress.

Even vibration from industrial work, nearby highways or somebody dropping weights in the physical conditioning room down the hall can disturb sleep. Different strategies are appropriate for mitigating different types of vibration, but beds are less likely to transmit vibration than built-in platforms that are securely attached to walls and floors.

Thermal comfort

It is documented in other areas of human comfort research that differences in biology, metabolism, clothing and physical size result in massive changes to perception of thermal comfort, and this remains true while people are asleep. While science shows that cool air temperatures are ideal, feeling too cold can cause poor sleep. Providing individual temperature controls within individual bunk rooms is unrealistic on most budgets, but wall diffusers with integral re-heating coils are readily available, and a simple alteration could simply be providing individual electrical circuits for each bunk space to provide capacity for small space heaters.

Air movement is a key thermal comfort variable, so installing a ceiling fan for each bunk space allows control of air speed without freezing out the next bed over. The effects of radiant heat and drafts due to insufficient insulation in the

exterior walls or poorly performing windows are important to consider, as they frequently cause an uncomfortable temperature gradient from one side of the body to the other. This may require additional insulation on the interior side of the wall or, if a window is the issue, your blackout shade with guide tracks can provide an extra barrier to heat transfer.

Humidity is another factor in perceived temperature, and proper control of humidity can be a major factor in promoting good sleep. Insufficient humidity can be addressed by adding humidifiers onto the mechanical system and providing the necessary maintenance. Most excess humidity issues are the result of poor ventilation in shower areas, which can be resolved with a more powerful exhaust fan, or caused by holes in the building envelope allowing humidity to infiltrate the enclosure. The latter is a more difficult problem to fix, but it can be tackled with a caulk gun and a thermal imaging camera and will provide savings in your energy bills as well.

Texture and posture

While not traditionally considered a dominant sense, when in a quiet room with eyes closed, a person's touch receptors occupy a large portion of the brain's attention. Finding the right bedding ensemble that allows those receptors to rest peacefully is essential to sleep. Many full-time departments issue blankets, sheets and pillows to their staff for sleeping and most provide mattresses, all of which guarantee that no one is completely happy. Mattresses should be sized appropriately to the firefighter, be adjustable from firm to soft, or be constructed of supportive foam designed by a chiropractic or sleep professional. Providing separate murphy beds for each shift so each firefighter can select their individual mattress is another option. Providing a bed cover for consistent appearance during waking hours is fine, but firefighters should supply their own pillow, sheets and blankets that provide the softness or stiffness, silkiness or scratchiness, heaviness or lightness that they prefer. Sleeping wedges to elevate the back and body pillows for side sleeping support may require more storage space than traditional lockers accommodate, but if they improve sleep outcomes for firefighters who use them, they are well worth the cost of a second locker.

Peace of mind

Departments cannot eliminate mental stress from their employees, but they can provide space that satisfies our innate desire for physical protection, giving us one less thing to worry about when we sleep. Most people need more personal space when sleeping than when awake, and defining the boundaries of that space and providing a wall at your back is a simple strategy. If full-height walls are cost prohibitive or not feasible for other reasons, try using wardrobe cabinets, lockers, furniture or short walls to provide individual cubbies for each firefighter on shift. Doors that separate the cubbies from common areas are best practice, but even a curtain is better than leaving the entry completely open. Sleep experts recommend personalization of your sleeping space to create an environment that is visually associated specifically with sleep and security, so encourage firefighters to fill the walls with posters and provide shelves for memorabilia.

Another key to reducing mental stress is a clean sleeping room. To put it delicately, we all have different internal thresholds of what constitutes appropriate personal hygiene. These individual differences are a frequent source of conflict, so a space that is easy to effectively clean each morning becomes essential. Ideally the floor should be a hard surface that can be swept and mopped, potentially with some small rugs that can fit into the washing machine. Even if it is accomplished through off-the-shelf HEPA air purifiers, the room should be well-ventilated to remove unpleasant smells and allergens. If the windows are operable, check the seals to make sure dust and dirt aren't making their way in. If space and budget allow, individual murphy beds for each shift provides the peace of mind that comes from not sharing a mattress. And of course, the sleeping areas should

Doors that separate the cubbies from common areas are best practice, but even a curtain is better than leaving the entry completely open.

be physically removed from the apparatus bays and any potential cross-contamination should be prevented with an air lock and appropriate exhaust air balancing.

In sum

Many of the approaches discussed above can be achieved as a small improvement project with materials purchased via discretionary funds and installed by staff. Others are more appropriate as part of a comprehensive station renovation, designed by an architect who has studied sleep hygiene and the relevant research and bid out to a contractor. But whether the project is large or small, the benefits to your firefighters and to the citizens you protect will be real. While more research remains to be done and a broader industry-wide strategy has not yet been defined, we can immediately implement incremental changes with the confidence that we are helping our firefighters sleep better, thereby helping them to serve the citizens they are charged with protecting.

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