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**Strategy and Tactics for
Low Rise, Mid Rise, High
Rise and Big Box**

Message from Firefighter Air Coalition President Mike Gagliano

I'm glad you are reading these words, and I'm honored to be taking you on this small journey you're about to enjoy. The training in this supplement reflects the Firefighter Air Coalition's (FAC's) steadfast commitment to the mission of firefighter air. We share the reality that if you have More Air, you have More Time. If you train purposefully and with passion, you can truly Own Your Air. And we continue to proclaim the simple truth that no matter what: It's Your Air, Your Life.

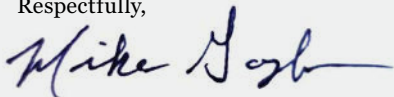
The team at FAC is constantly working to find new and innovative ways to share these messages. You will see our team on social media, in articles, on webcasts, and at conferences, addressing the many aspects of firefighter air that are essential components of successful fire attack and emergency mitigation. Firefighter air remains your permission slip to do your job in hazardous environments of all types.

These articles, and the dynamic authors behind them, were purposely chosen to sharpen your knowledge and skill set in high-priority areas of the mission. Whether you're working on strategy and tactics, hazards, training, policy, or building design, you'll find street-vetted wisdom contained throughout this entire supplement. And every member of your organization will benefit from giving it a thorough read.

I hope you'll use this training as an open door to the many resources available from the FAC. We will be dramatically expanding our training content, continuing our world-class conferences, and standing as a voice for purposeful accomplishment of the mission—a mission that relies on firefighter air to succeed.

God bless you as you tackle 2026 with fire in your heart and purpose in your actions. We'll see you out there and are honored to be at your side.

Respectfully,



MIKE GAGLIANO

PRESIDENT, FIREFIGHTER AIR COALITION
CAPTAIN (RET.), SEATTLE (WA) FIRE DEPARTMENT

YOUR FIRE SERVICE STORY MATTERS!

Sharing your work history can help prevent cancer in the fire service, whether you've been diagnosed with cancer or not.

When you sign up for the National Firefighter Registry (NFR) for Cancer and tell us about yourself and your time in the fire service, you provide critical information that can help improve our understanding of firefighters' risk of cancer and identify occupational factors contributing to that risk. Over time, this information can help pave the way for new health and safety measures to keep future firefighters safe.

Join the more than 20,000 firefighters who have signed up so far! Create your account on NFR.CDC.GOV, sign the consent form, and complete your user profile in just **5 to 10 minutes**. Then tell us your story by filling out the questionnaire. This can be completed over time.

Join the NFR today!



Improving High-Rise Operations: Lessons Learned from the Duke City

BY MATTHEW KLOSTERMAN

MANY CITIES across the United States have high-rise buildings, as mine does. And if your fire department is like mine, you may have never faced a serious high-rise fire. For fire departments with limited high-rise firefighting experience, the challenges of working to improve your department's high-rise response may seem overwhelming. No matter how challenging this task may be, we must proactively maximize our high-rise operational readiness. If your city has high-rises, it is not a matter of if, but when, your department will face a serious high-rise fire. This article describes key lessons learned from Albuquerque (NM) Fire Rescue's (AFR's) initiative to improve our department's high-rise firefighting standard operating guideline (SOG) as well as the equipment we deploy for high-rise fires.

Like many great aspect of the fire service, AFR's high-rise improvement journey started at the kitchen table. Our high-rise firefighting SOG was last updated in 2011, and the need to improve it was discussed by three motivated captains at our downtown high-rise station. These captains would all serve on AFR's High-Rise Working Group, along with me and another well-respected captain from AFR's busiest station. The momentum

from these kitchen table discussions also coincided with the activities of AFR's Pre-Incident Planning Committee, which I have chaired since 2021.

Albuquerque has 50 high-rises, and AFR's Pre-Planning Committee set a goal to create preplans for all of them based on a customized version of the high-rise preplans described by Jerry Tracy, Jack Murphy, and James Murtagh in their book *High-Rise Buildings: Understanding the Vertical Challenges*.¹ Detailed knowledge of our high-rises would prove invaluable to AFR's high-rise improvement initiative.

AFR's High-Rise Working Group operated for more than a year, and the hard work was well worth it; AFR is now in a much better position to combat a high-rise fire than ever before.

The remainder of this article will cover the key factors contributing to our success. Hopefully, the lessons we learned will help your department.

Develop Your High-Rise Team

The first step for most departments will be to develop a team to lead your department's high-rise improvement initiative. Improving high-rise operations will be a sustained effort of a year or more, requiring a significant amount

of research and development as well as coordinating resources across your department. This work is not for the faint of heart, and selecting the members for this team is the most consequential decision your department will make throughout the process.

The members must be credible with your firefighters—those with recognized work ethic, leadership skills, motivation, intelligence, and consistent excellent performance on the fireground. It is important to remember that credibility isn't necessarily about rank or time on the job. Your department probably has highly credible and highly motivated junior members who can make strong contributions to your high-rise improvement team.

Improving high-rise operations is a long-duration effort, and all the credibility in the world won't matter if you can't execute. I cannot overstate the importance of your high-rise team members having a strong work ethic and the ability to get things done. We all know who these firefighters are in our respective departments. They don't just sit around and talk about what needs to change; they do the hard work necessary to make it happen.

Your team members must also be able to check their egos at the door and keep the mission a priority at all times. High-rise operations are very complex, and figuring out what will work for your department will necessarily involve humility, compromise, and thoughtful consideration of multiple viewpoints. There is no room for petty ego battles and easily hurt feelings on your high-rise team.

Setting expectations and coordinating major dates should occur very early in your process. Nothing motivates like a deadline. Major milestones include



1. If your city has high-rises, it is not a matter of if, but when, your department will face a serious high-rise fire. (Photos 1-5 by author.)

completion of research and development, submission of a comprehensive project proposal/budget, and the start of departmentwide training. Setting these dates motivates action while providing an early opportunity to coordinate other stakeholders within your department.

On a more granular level, at least one of your team members must be a competent project manager. This includes unglamorous tasks involved with keeping meetings on track, scheduling, following up on deliverables, etc. This skill set is critically important because the project manager does a lot of necessary tasks to sustain forward momentum for your high-rise improvement initiative.

Additionally, at least one of your members must also have decent writing skills. Since most departments will want to overhaul their high-rise SOG, someone must be capable of turning your team's ideas into a clearly communicated document.

Consider how many members to include on your high-rise improvement team. AFR's High-Rise Working Group had five members; this allowed us to work efficiently but still provided for

excellent discussions and thoughtful decision making. It may be tempting to include a lot of members on your high-rise team, but I caution against this. Large teams experience diminishing returns where free riding (unproductive team members), inability to make decisions, and scheduling nightmares become more common.

Above all else, improving high-rise operations is a team effort. Our success is a direct reflection of the team's many critical contributions throughout AFR's high-rise improvement initiative.

Build Foundational Knowledge

If your department is like ours, your firefighters probably don't have decades of high-rise firefighting experience or may never have faced a significant high-rise fire at all. If you're in this position, the challenge in getting started with improving high-rise operations is that you don't know what you don't know. A good first step will be to learn as much as possible about high-rise firefighting. Fortunately, there are excellent resources such as David McGrail's book, *Firefighting Operations in High-Rise*



3. Your team must learn everything possible about the high-rises in your city. Your SOG must be tailored to your department and your high-rise buildings to be credible and relevant on the fireground.

and *Standpipe-Equipped Buildings*² as well as many online articles from other fire service legends such as Captain Bill Gustin and Captain Jimmy Davis.

Additionally, your department should strongly consider sending your high-rise team to an industry conference on high-rise firefighting. AFR sent our team to the Fire in the Sky Conference, which was a defining moment in AFR's high-rise improvement journey. The investment was worth every penny. Nothing replaces the opportunity to learn from big city pros, and we are forever grateful for what we learned in person from David McGrail, Jimmy Davis, John Norman, Mike Dugan, Mike Gagliano, and other conference instructors.

A key advantage we had was that I was a High-Rise Working Group member and the chair of AFR's Pre-Incident Planning Committee. At the time AFR's High-Rise Working Group was active, the AFR Pre-Incident Planning Committee had completed preplans for the majority of Albuquerque's 50 high-rises. This effort demonstrated that high-rise preplanning is a cornerstone of any high-rise improvement effort. Detailed knowledge of your high-rises will enable your team to create a high-rise SOG that is specific to the challenges your firefighters will face. This point is critical: Your SOG must be tailored to your department and your high-rise buildings to be credible and relevant on the fireground. For example, in Albuquerque, we quickly learned that fire department connection (FDC) vandalism



2. Attending the Fire in the Sky Conference was a defining experience for AFR's high-rise improvement journey. The investment was worth every penny. Here is our high-rise team with Deputy Assistant Chief (Ret.) John Norman, FDNY Special Operations Command (third from right).

is a significant problem; therefore, a major component of our improvement effort was providing new equipment and training for our apparatus operators to handle a wide variety of FDC problems.³

If you think preplanning high-rises is intimidating, you are not alone. The AFR Pre-Planning Committee had little high-rise experience when we started, but we didn't let that stop us. We approached this problem with humility, and we made every effort to learn as much as possible about high-rise buildings. This was a slow but steady process that demonstrated hard work pays off. Over time, we gained the knowledge and competence necessary to translate our site visits into important tactical insights and actionable preplans.

What Works Well and What Needs Improvement?

After working hard to develop foundational knowledge, your team will be well prepared to identify weaknesses in your high-rise operations as well as effective solutions. Give this step the time it deserves; your high-rise team gets one shot to make a good impression with your department, so make every effort to thoroughly vet ideas and equipment. As part of this process, we recommend vetting new ideas and equipment informally with thought leaders in your department. This incorporates more perspectives while helping secure buy-in for your new SOG and equipment. Remember that people are much more likely to support change that they can help shape.

Equipment will likely play a big role in your recommended changes; give it significant consideration throughout your team's research and development effort. This is important because new equipment will be a major expense, and your executive staff will need lead time to appropriately budget for these purchases. Equipment also significantly affects the tactics described in your high-rise SOG, so it is a good idea to figure out exactly what equipment your department will use at a high-rise fire before rewriting your high-rise SOG. Major equipment purchases will likely be determined by significant tactical weaknesses or safety

issues. This may include everything from larger positive pressure ventilation fans to effectively pressurize stairways to an entirely new hoseline and nozzle combination for standpipe firefighting.

Reducing firefighter fatigue should also be a major focus of your team's research and development.⁴ For example, AFR implemented a homegrown solution for carrying self-contained breathing apparatus (SCBA) bottles hands free, which greatly reduces firefighter fatigue during stair climbs. AFR's SCBA bottle carrying strap is very cheap, is extremely effective, and requires minimal training.

Has your department considered how your firefighters will remove an unconscious victim down many flights of stairs during a high-rise fire? This can be a grueling and slow task that you should consider during your high-rise improvement journey. AFR expects to encounter fire victims and, given our mindset, certain AFR units carry patient movers into the building, which are used to move unconscious victims down stairways during a high-rise fire. Patient movers are sold under different brand names but will be constructed of a reinforced tarp with reinforced handles. They are also lightweight and

inexpensive. Our departmentwide high-rise training demonstrated that using patient movers is a highly effective way to carry unconscious victims down many flights of stairs.

Effective solutions may also involve using current equipment in a more functional way. How your firefighters carry hoselines up stairwells significantly impacts fatigue. Simply changing how your department folds and transports hoseline could be a game changer for your firefighters.⁴ Whatever equipment and tactics your team recommends must make sense based on your department's culture, staffing, and capabilities.

Writing a New SOG

A lot of preparation must happen before you rewrite your department's high-rise SOG. Vet ideas and equipment and get budgetary approval. Once your team knows exactly what will change and what will remain the same with your high-rise operations, the rewrite process can begin. We recommend this approach because many sections of your high-rise SOG are interrelated, and having to make changes to one section will require additional changes throughout your document. Forward progress will stall and



4. & 5. Critical improvements don't need to be expensive or complicated. AFR's SCBA bottle carrying strap is simple; just girth hitch the valve stem and clip it to the back frame carrying handle. The straps are sized so the bottle rides next to the back frame and at the firefighter's waist. Carrying equipment hands free is one of the best ways to minimize firefighter fatigue while ascending stairways.

Give Your People the Reins

BY CLINT ANDERSON

IN 2024, I was invited to attend one of the first meetings for the Albuquerque Fire Rescue (AFR) High-Rise Working Group. This group was comprised of veteran fire captains and one driver who possesses unique initiative within our organization. Over the course of almost two decades at AFR, I have had the privilege to work with each of these individuals in field operations. Knowing full well the antiquated nature of AFR's High-Rise SOG, I understood the logic behind this undertaking.

Having worked in the field with these members gave me a particular confidence in the motive for the overhaul and the competence underlying every detail of the project. Of note, the group's organization and adherence to a specific process that they outlined from the start created a robust framework to ensure smooth progress with regular valuable meetings and a finished product with real-world applications suited to our municipality. I was specifically impressed at the ease with which each personality came to the table with the common goal of improving AFR's high-rise operations. Though each member was exceptional and proven, I never saw an ego or stubborn attitude operate as a stumbling block in the process.

As an executive officer, I no longer operate on the front lines with our firefighters. On first promoting to that position, I had to reframe my contribution to the department. In my perspective, this contribution largely includes empowering our personnel and providing the outlet for those with unique initiative to thrive. Everyone has experienced the supervisor who stymied motivation, micromanaged personnel, or did not provide the space to innovate for their people with good ideas born from applicable fireground experience. In an effort to give our people the reins, I maintained a seat in the discussion deliberately from a more distant vantage point, only interjecting as applicable from my point of view while monitoring progress.

I saw myself as a facilitator. As equipment needs would arise, I provided a route to our deputy chief of finance. When the group had rewritten AFR's high-rise SOG, with the fire chief's permission, we made space in our weekly executive meeting for the High-Rise Working Group to give an executive presentation. This forum was advantageous, as it provided an opportunity for each member of the executive staff to ask pertinent questions of the group members who, by this point, had become the subject matter experts. This information session also provided the impetus to set aside funding in collaboration with IAFF Local 244 to send members of the working group to the Fire in the Sky Conference to gain additional knowledge and crucial networking contacts. As the deputy chief overseeing our Training Division, this also allowed an avenue for the group members to begin discussions with AFR's training staff as it related to implementing AFR's new High-Rise SOG within our fire suppression continuing education days. Here once again, it was important for me to step back and

allow the training experts to work with the members of AFR's High-Rise Working Group to create a realistic and digestible training event for the entire department.

I would be remiss if I did not emphasize the importance of the culture at AFR. Our chief believes in bringing the right people into positions where they will flourish in their talents for the benefit of Albuquerque's citizens, the department, and the individual. I would not have been able to operate in my talents were it not for the latitude given by the chief. She has created an atmosphere that fosters innovation and capitalizes on individual initiative within the organization. As the High-Rise Working Group progressed, I would keep the chief and the executive staff updated to elicit feedback and forecast goals.

It is also very important to note that the chief expects the "white shirts" to show up at training and participate. After lugging tools and hose up 13 stories on air, finding, packaging, and bringing our victim manikin down to the base of the training tower, it reminds us all of the rigors that our job demands we perform efficiently and effectively. Moreover, AFR's members benefit when they get to interact and work with the chiefs who can often appear removed and out of touch. I cannot overstate the importance and benefit of chief officers participating in training.

As fire service leaders, we should be concerned when initiative is stalled or professional drive becomes eroded within our organization. This loss of motivation is often derived from a lack of administrative support or failure to grant an audience with the members whose ideas are cultivated in the current firefighting environment of our municipalities. I would challenge leaders to eliminate the idea that "we know best." Counter that mentality with a posture that welcomes these determined individuals and digests their ideas from the baseline that no one knows the challenges of the field better than them. Use your institutional wisdom to provide direction and insight, but do not aim to quell that spirit of innovation. There are times when it is not practical or achievable based on budget or operational constraints. But, in those situations, take the time to explain the circumstances while acknowledging the initiative and encouraging future input. Foster a culture that incentivizes creativity and gives voice to excellent ideas, a platform to explore them, and a means by which to pursue them. The product will justify these efforts. Give your people the reins.

CLINT ANDERSON joined Albuquerque Fire Rescue (AFR) in 2006 and is AFR's deputy chief of strategic planning, policy, and training. He served for nine years as a paramedic driver and a paramedic lieutenant. In 2017, Anderson promoted to captain and served as one of AFR's quality assurance officers, responding to all high-acuity calls in the city. He promoted to battalion chief in 2021, serving as a field battalion chief and as AFR's Special Operations battalion chief. In 2023, Anderson promoted to his current rank. He has a master's degree in public safety leadership administration.

frustrations will rise if major changes are necessary in the middle of the rewrite. First, get everything squared away to ensure a smooth rewrite process.

Give the rewrite process the time and attention it deserves to ensure a quality work product that your firefighters will find credible. We found that keeping our team on the same page during the rewrite process was best accomplished with regular face-to-face meetings. During the most critical phases of our SOG rewrite, we would all sit together and go through our SOG line by line to make sure we didn't miss anything. This is where work ethic is so important; reviewing draft SOGs is tedious work, but your team members must be able to bring a high level of motivation for the less exciting tasks.

Departmentwide Rollout

The final phase will focus on implementing changes to your department's high-rise operations. The venue for implementing changes will be specific to your department. For example, AFR conducts continuing education (CE) programming twice a year, which involves an entire day of training for every AFR firefighter at our Fire Academy. Our new high-rise operations were rolled out at our second round of CEs in 2024. Some key lessons we learned include the following:

- **Developing an outstanding training program will take longer than you think.** Start coordinating with your training cadre early. This includes hands-on drills and any necessary classroom-based training. At this point in the process, it is important to give up some control, which may be hard after a year or more of dedicated effort. AFR is very fortunate to have a truly outstanding training cadre; they contributed critical ideas to make our high-rise training very impactful. The key for us was to take a step back and let our training cadre do what they do best.
- **Lead from the front and finish strong.** At this point in the process, your team will be your department's high-rise experts, but you will also be pretty exhausted. However, it goes a long way when your high-rise team is personally involved with delivering high-rise training to your firefighters.



6. AFR firefighters charging hard during high-rise training. Have a close working relationship with your training cadre. AFR's training cadre contributed critical ideas to make our high-rise training very impactful. (Photo by AFR Lieutenant Charles Bustos.)

Your involvement in training delivery sets a strong tone and provides critical support for your training cadre, especially at the start of training rollout.

- **Make the training realistic and challenging.** Our primary training drill was a multicompany evolution involving a 13-story stair climb in full gear while carrying all high-rise equipment. This stair climb was completed on air in a low-visibility stairway. After reaching the floor below the fire floor, our firefighters had to deploy a charged hoseline while on air and in low visibility. This training evolution also involved victim rescues where members assigned to primary search in the stairway had to locate and remove heavy dummies to the base of our training tower. This may seem excessive until you consider that your firefighters may face a high-rise fire where ascending stairs on air is required, where stairway contamination necessitates deploying a charged hoseline with little visibility, and where multiple victims must be removed for definitive treatment at ground level.

The other point of creating challenging training is to stress test your system. AFR firefighters would rather make

mistakes in training than at 3:00 a.m. when everything is on the line. Realistic and challenging training provides the opportunity to learn tactical nuggets, which translate into improved performance on the fireground. For example, our members figured out different ways to use patient movers to improve the speed and safety of moving an unconscious victim down a stairway.

Pictures are worth a thousand words. The AFR High-Rise Working Group filmed several training videos covering everything from hose deployment to operating sprinkler control valves. Remember that it's the content that matters and not necessarily the production quality. Producing videos also doesn't have to be expensive. We filmed our training videos on a firefighter's relatively inexpensive camera, and we used basic video editing software. Our training videos were used as precoursework material for our CEs and now serve as the foundation for our high-rise training library.

Author's note: I want to acknowledge my outstanding teammates including Battalion Chief Matt Bodle, Battalion Chief Donovan Jacks, Captain Nick Gallagher, and Captain Doug Hearon. Two of my teammates have promoted since AFR's High-Rise Working Group was active. Each one of my teammates was integral to AFR's High-Rise Working Group. ■

ENDNOTES

1. Tracy, Jerry et al. *Highrise Buildings: Understanding the Vertical Challenges*, Fire Engineering Books, 2023, bit.ly/4kq2Agp.
2. McGrail, David. *Firefighting Operations in Highrise and Standpipe-Equipped Buildings*, Fire Engineering Books, 2007, bit.ly/4qAZDLO.
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MATTHEW KLOSTERMAN joined Albuquerque Fire Rescue (AFR) in 2018 and is a driver. He was previously the chair of AFR's Policy Review Committee and currently chairs AFR's Pre-Incident Planning Committee, a position he has held since 2021. Most recently, he served on AFR's High-Rise Working Group. In 2025, he was selected by his peers as AFR Firefighter of the Year. Klosterman has a master's degree in health services administration.

Designing for Survival: Engineering and Tactical Solutions in High-Rise and Underground Firefighting

BY BRENT BROOKS

THE VERTICAL CITYSCAPE of the 21st century presents new challenges. Sky-scrapers, mega-complexes, and subterranean structures reflect engineering innovation and urban ambition, yet they also create some of the most dangerous environments for firefighting. The operational environment is shaped not only by height and depth but by the systems intended to safeguard lives.

Architects and engineers design for compliance, efficiency, and aesthetics, while firefighters (the end users) face the realities of smoke, heat, and human behavior. Bridging this gap requires not only research and training but also foresight in design. If one or all systems fail, how will firefighters operate hoselines and control smoke movement using only their equipment, given the building's layout? Survival is, and must remain, a shared responsibility.

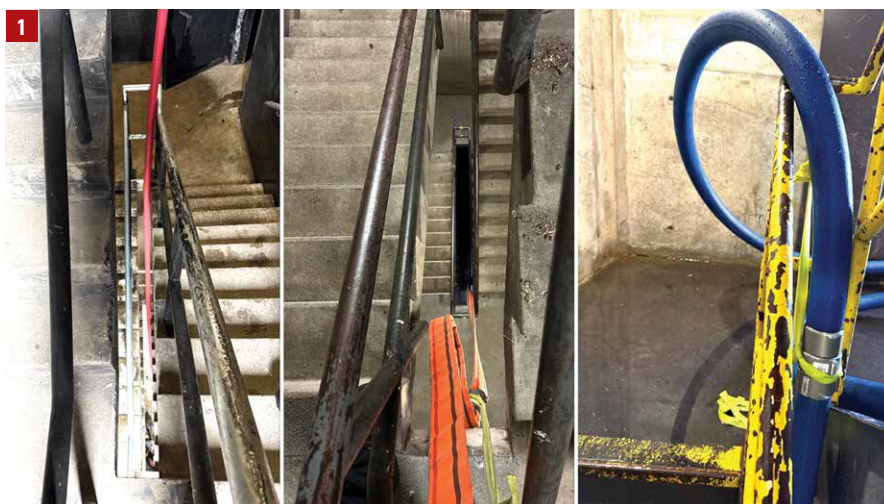
Disconnect Between Design and Firefighting Operations

Fire safety codes often meet regulatory requirements but fall short in actual firefighting situations. Designers might view smoke control and evacuation as theoretical models, while firefighters face disorientation or system compromise under real conditions. Continuous collaboration and feedback are essential to close this gap.

Examples include the following:

- **Stairwell pressurization systems.**

Designed to maintain compartmentalization during evacuation, these systems are quickly compromised once firefighting operations begin. Standard practice involves connecting hoselines from the floor below the fire. With National Fire Protection Association



1. Stretching hoselines from alternative stairwells or creating improvised interior and exterior standpipes connected to fire department pumps. (Photos by author.) **2.** No factor is more decisive than reliable water delivery. Standpipe systems remain the backbone of interior high-rise firefighting, yet they often fail at the most critical times.

(NFPA) 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, flow rates suggesting two hoselines on the fire floor and one on the floor above, at least three stairwell doors will be open simultaneously. This raises serious doubts about whether pressurization can maintain compartmentalization under real fireground conditions. Older buildings without pressurization rely entirely on fire department equipment for stairwell protection.

- **Fire department connections (FDCs) and exit door labeling.**

While signage may meet code requirements, it often provides little practical



guidance to firefighters responsible for pumping the system and protecting stairwells. Critical information should include the cubic feet per minute (cfm) required for stairwell pressurization and the pump discharge pressure

needed to deliver recommended flow rates. Without this, firefighters are left to improvise under intense time pressure.

- **Complex floor layouts.** Responders navigating heavy equipment in full personal protective equipment (PPE), performing hose stretches, and operating in smoke-filled conditions can quickly become disoriented. Simple solutions, such as clear signage directing crews to the nearest stairwell, can drastically improve orientation and reduce response times.
- **The ability to stretch hose when systems fail.** Stairwell well holes provide the simplest solution for deploying hose in the event the building standpipe system fails or

additional tactics are needed. Yet, fewer buildings incorporate this feature, putting firefighters at a considerable disadvantage in hydraulics.

For firefighters, these shortcomings force improvisation at moments when time and safety margins are already minimal. Where design and labeling fall short, prefire planning and quick-reference building summaries become essential tools to bridge the gap.

Firefighter Adaptation and Tactical Realities

History is filled with examples of system failures during fire incidents. Standpipe valves seize, fire pumps go offline for maintenance, fire department connections are vandalized,

and automatic door closures or HVAC systems malfunction.

In these scenarios, firefighters must adapt quickly:

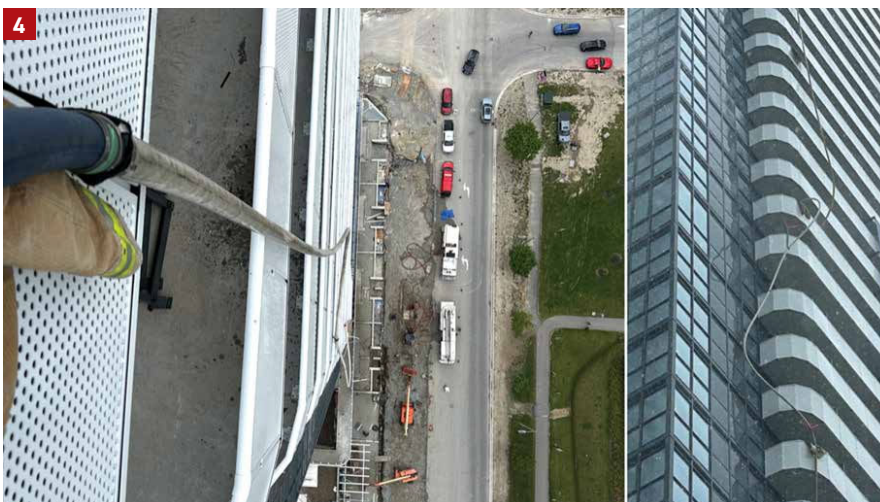
- Stretching hoselines from alternative stairwells or creating improvised interior and exterior standpipes connected to fire department pumps.
- Using gate valves, in-line pressure gauges, and bleed valves to troubleshoot and operate standpipe outlets safely.
- Deploying portable fans to assist or replace compromised pressurization and ventilation systems.
- Using smoke curtains to maintain compartmentalization and protect those sheltering in place.
- Employing communications modules and repeaters to overcome radio dead zones.
- Using evacuation equipment with emphasis on assisting persons with disabilities.

Such adaptations are not simply evidence of ingenuity; they are symptoms of systemic vulnerability. The more robust the building systems and the clearer the interface with responders, the less improvisation is required when lives hang in the balance.

Emerging Hazards in Modern Structures and Firefighter Physiology

Modern high-rise and underground environments present two interlinked categories of hazards: those created by the building itself and those imposed on firefighters who must operate within them.

Building contents and layout hazards. Synthetic furnishings produce higher heat release rates and toxic smoke. Lithium-ion batteries in vehicles, scooters, and devices burn intensely, releasing flammable gases and reigniting unpredictably. Hoarding, subdivided occupancies, and interconnected mixed-use developments complicate suppression and evacuation. Long travel distances require firefighters to move on foot with heavy equipment and SCBA, often exceeding the practical limits of a single air cylinder. Some structures



3. Mitigation requires planning before incidents occur. 4. System reliability can never be assumed. Training must anticipate failure as the baseline.

are simply too deep or complex to allow firefighters to locate, suppress, and exit within one bottle of air.

Underground garages magnify these risks. Vehicle fires, particularly involving electric vehicles, are energy-dense, long-lasting, and difficult to access. These fires require exposure protection with an uninterrupted water supply. Poorly maintained ventilation shafts may spread heat and smoke across levels, endangering evacuation routes and fire crews.

Physiological hazards. While the structural environment has grown more hostile, firefighters themselves face increasing physiological strain. PPE offers essential protection against flames and carcinogens, but it also traps body heat. Fatigue builds rapidly, and exhaustion compounded by heat stress can escalate into life-threatening conditions.

Air supply is finite. Extended travel distances to attack points or refuge areas deplete SCBA air more quickly than expected, often leaving little reserve for egress. This reduces safe working time dramatically and necessitates frequent crew rotations.

Bridging the gap through design. To counter these hazards, building systems must support not only occupant safety but responder endurance. Firefighter Air Replenishment Systems (FARS)—preplumbed interior air lines in stairwells and key interior locations—allow SCBA cylinders to be refilled on site. This sustains operations without retreating to ground level, extending working time and stabilizing rotation cycles.

Adoption of such systems reflects a fundamental principle of “designing for survivability.” Just as sprinklers protect occupants by suppressing flames, FARS protect both occupants and responders by sustaining the firefighters advancing into danger.

Water Supply and System Reliability

No factor is more decisive than reliable water delivery. Standpipe systems remain the backbone of interior high-rise

firefighting, yet too often they fail when they’re needed most. Causes include the following:

- Fraudulent inspections, signed off on without testing.
- Vandalism of valves or outlets.
- Maintenance lapses that leave pumps offline.
- Debris or corrosion blocking pipes and clogging firefighting nozzles.
- Seized clappers and check valves.
- Improperly set pressure-reducing valves (PRVs) and pressure-restricting devices (PRDs).

Operationally, these failures result in delays, complex hose stretches, and elevated risk for both firefighters and occupants. Clear labeling of stairwells, redundancy in risers, and robust maintenance are essential. Firefighters train with standpipe kits (gate valves, in-line gauges, and bleed valves) to troubleshoot these systems, but their effectiveness remains limited by building design and layout.

Bridging the gap through design. Simple engineering provisions can offer critical support:

- Interior wells or shafts (eight inches or larger) for advancing hose in the event of system failure.
- Exterior cleats or anchor points for hoisting hose.

Currently, firefighters can pump water reliably approximately 30 stories and alternate agents to approximately 120 stories. These measures provide responders with redundancy and tactical options when systems fail.

Evacuation and Rescue Realities

Evacuation is not theoretical; it is physical, chaotic, and highly dependent on human behavior. Smoke remains the leading cause of death in high-rise and underground fires, often long before flames reach occupants.

Persistent challenges include the following:

- **Mobility-impaired occupants** requiring refuge areas or assisted evacuation.
- **Counter-flow in stairwells**, where firefighters ascend against descending civilians.



5. Integrating solutions such as FARS gives responders the ability to extend working time, rotate crews effectively, and maintain operations without retreating to ground level.

- **Disorientation under smoke**, when poorly marked or confusing stairwells trap people in dangerous conditions.

Mitigation requires planning before incidents occur. Glow-in-the-dark stairwell markings, tactile signage, and protected refuge floors designed for assisted evacuation can reduce mortality. Building staff play a critical role in initiating evacuations, supported by Personal Emergency Evacuation Plans (PEEPs) for vulnerable occupants.

Prefire Planning and Quick Reference Tools

Preparation is the equalizer between design assumptions and operational reality. Firefighters increasingly rely on “battle plans,” single-page summaries of critical building information. These highlight stairwells, elevators, shut-offs, roof access, fire pump rooms, standpipe type, FDC pressures, and ventilation profiles.

The advantage is consistency. Cities such as Singapore and projects like Malaysia’s Merdeka 118 demonstrate how integrating these tools into building management at the design stage strengthens resilience.

Training for System Failures

System reliability can never be assumed. Training must anticipate failure as the baseline. Exercises that simulate seized valves, smoke control malfunctions, power loss, or disabled elevators force crews to develop contingencies.

Training also fosters dialogue with engineers and designers. By demonstrating how systems fail in practice, firefighters provide vital feedback that informs code development and future projects. This loop of operational research into design helps close the gap between paper compliance and practical survivability.

High-rise and underground fires represent the sharpest collision of engineering and firefighting. Survival depends on collaboration between those who design buildings and those who respond when systems fail.

Architects and engineers must prioritize practical access, equipment deployment, smoke control, redundancy, and physiological realities with firefighter input. This

includes acknowledging the dual nature of PPE, where protection from carcinogens and heat also traps body heat and accelerates exhaustion. Integrating solutions such as FARS or other preplumbed air systems gives responders the ability to extend working time, rotate crews effectively, and maintain operations without retreating to ground level.

Firefighters, for their part, must continue to train for failure, adapt to emerging hazards, and refine tactics through operational research. Engineers and designers must ensure those efforts are supported by infrastructure that recognizes real-world demands.

Bridging this gap is not optional; it is essential. Every improvement in communication, maintenance, and design translates directly into lives saved, both for building occupants and for the firefighters committed to protecting them. Only when buildings are designed with the end user in mind—the firefighter—can we truly say they are “designed for survival.” ■

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Anatomy of a Stretch

BY JAY BONNIFIELD

THROUGHOUT THE past decade plus, the building stock across North America has accelerated the frequency of low-/mid-rise apartments of various kinds; they are the preferred construction type in both urban areas and small towns. For suburban and rural departments, this brings a vertical fire problem that may not have been as present in years past where the bulk of their leadership may have cut their teeth. For urban fire departments, this may bring a combination of density and exterior fire spread potential that can task saturate and challenge already busy companies.

These buildings come in many shapes and sizes: from podium-style builds with commercial spaces below and multiple floors of residential occupancy above to common hallway/interior hallway-type buildings, exterior access/garden-style buildings, courtyard types, townhome/row types, and more.

While these buildings can be fairly straightforward, they offer a chance to fall into a couple of traps: For suburban and rural departments, a common trap is to treat these buildings like a big house fire. For urban departments, a common trap is to underestimate the exterior fire spread potential. Both of these traps are largely because these buildings create a hybrid environment: a multifamily building with high levels of exterior spread potential coupled with urban density and common entrance/exit problems.

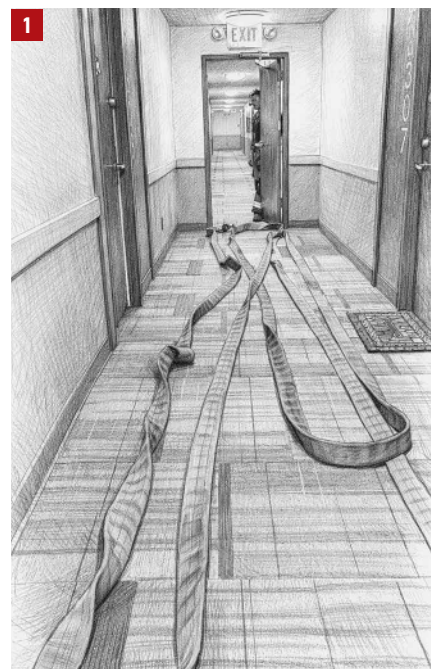
The Stretch

Most rural and suburban engine companies are quite adept at stretching and operating on single-family house fires; a single line or two at most will quickly bring the fire under control. This tempo is well rehearsed and practiced. However, a fire in a wood-frame multifamily building is different. At a house fire, an engine company may predominantly rely on the 150- or 200-foot preconnect without encountering an issue. At an apartment fire, if you do not realize the need to stretch 250 to 400 feet frequently and do not have the ability to do

so, it can be detrimental. While an urban fire department may be used to a particular fire spread rate and path, these buildings can accelerate the timeline and quickly present a dilemma of simultaneous need: confining exterior spread while protecting interior egress pathways. In either case, the ability to rapidly stretch multiple lines in quick succession into multiple floors is often the difference between winning and losing.

Although the importance of the first line cannot be overstated, just as important in these buildings are the confinement lines placed in quick succession. The most important factor in line placement is this: We must protect “the ways” of the building—the stairways, hallways, breezeways, and pathways of ingress/egress for building occupants (photo 1). These are the critical paths of travel for engine companies to access floors and units and also the paths of travel the fire will take to extend once it leaves the unit of origin. If we control the ways, we control the building and can support the searches that are critically needed. This requires that we have a clear understanding of line placement priorities and rules of thumb so that we can place multiple lines in quick succession.

The first rule of thumb is that we want to place the first interior line on the lowest fire floor. Second, we do not want more than two lines operating in a stairwell. Third, as stated above, the priority for protection is the “ways,” but the attic space will also fall into the same category. A fire that gets into the large, common attic spaces can turn a single-unit fire into a disaster if it’s not confined rapidly. While the life threat to occupants may be slightly lower than a fire in a hallway, the potential to burn the top off and impact dozens or hundreds of lives exists if we are not on top of our game. This means an engine company must know how many attack lines they can support from their position or, if later arriving, how to anticipate fire spread and to position and place lines if things progress.



1. Photos by author.

For example, a fire in a four-story garden-style apartment that began on Floor 3 and extended to Floor 4 and the attic may require the following: Engine 1 places a 1¾-inch line to Floor 3; another unit pulls a line off of their engine to the unit above on Floor 4 in the same stairwell. A third line in that stairwell would be detrimental to the first two, so a third and possibly a fourth line will likely be needed to top-floor lateral exposure units, another possibly to a third-floor exposure unit. You can see how quickly the stairwells can get congested along with the need for another engine company to stretch in another stairwell and possibly the need for alternative stretching methods.

Stretch Methods

While there are many valid options, it is important to have an idea of the pros and cons of different methods and to have a hierarchy so that you can quickly recognize and react with intent and reason behind your stretch. Standpipe-equipped buildings may or may not necessitate use, but for the sake of brevity, we

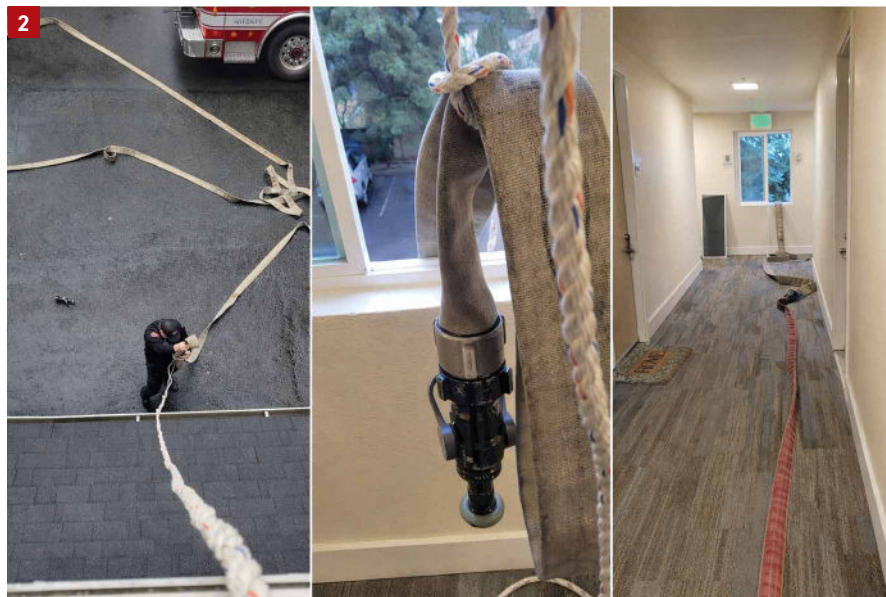
will not discuss them here. Generally speaking, most engine companies prefer to forgo using a standpipe up to the fifth floor or so and to stretch their own line. This may be different for your department or area, but you should have an idea of when you will use your systems and when you will not. The following order is a great framework for stretches from an engine on fires in mid-rise apartment buildings:

Well hole. This is usually plan A for buildings if a well hole is present. It takes our stretch calculation from approximately 50 feet of hose per floor to 10 to 15 feet, shortening and simplifying the stretch. It can be done by shouldering hose or taking just the nozzle and keeping the line in the well hole while you circle up the stairs, or you can drop a coupling from above or hoist a line with a rope in the well hole. This is a great first line option but usually not wise to duplicate with the second line, as you can potentially “candy cane” the second line around the first.

Stretching a line on the stairs/treads. This is an extremely common and simple stretch method. Ordinarily, it is taught to lay hose up the outside track of the stairwell on the ascent, factoring approximately 50 feet of hose per floor. Typically, this will be the plan A on many apartment buildings up to about Floor 5, give or take, depending on staffing and hose load.

Coupling/hose drop from an elevated point. This is an extremely fast method of dropping a coupling from a bundle. This can be done from stairways, walkways, windows, and more. This will commonly be the plan B for a lot of buildings with exterior walkways and access if a well hole stretch or stair tread stretch is too time consuming or not an option. The coupling drop is extremely valuable as an option for successive lines used for confinement because it allows us to bypass clogging the stairwells with lines and offers a simple stretch that gets placed very quickly. The side of the building must allow for the coupling to clear all the way down, so account for this ahead of time. It is also critical that you estimate how much hose you need for the fire area plus the setback to the drop point plus what is needed to make it to the ground. Often a 100-foot bundle will be used, leaving only 50 feet to work with after the coupling is dropped, which may or may not be enough.

Rope stretches (photo 2). Often, this can be the plan B in buildings with interior



stairways/hallways because it allows us to quickly hoist a line into a position and use fire doors and other means to quickly establish a primary or confinement line, bypassing the stairs and going directly to the seat of the fire. On larger buildings with interior hallways, this could look like an engine company bringing 200 feet of 1¾-inch line to the fire floor and laying it out behind a closed fire door while a 2½-inch line is hoisted up from below and brought to the bundles. It could also be hoisting the working length (50 feet) of a 1¾-inch bulk bed to place a line into service or hoisting a preconnect. There are many variations available depending on resources, building stock, and hose loads, but rope stretches offer enormous value in larger apartment buildings not only as an option for the first line but especially for successive confinement lines.

Lines over ladders. Lines over ladders are another valuable option but should rarely be considered as the option for the first line. As stated above, it is critical that our first line is positioned to protect “the ways,” and often taking lines up ground ladders into the building means using windows and balconies to adjacent units. This can leave the common hallways and stairways unprotected and unknown to firefighters. It also can create a choke point for crews if things don’t quite go as planned. When the first lines are positioned in stairways and hallways, they are anchored to an exit that is protected. But when crews use a window or adjacent

unit balcony without another line already in operation on at least part of the fire, they can find themselves in a tight space needing to reposition without the ability to do so quickly. Lines over ladders are extremely valuable as a plan C for confinement lines in a variety of situations: single-room occupancy type buildings with tight stairs that are occluded by the primary line, bypassing stairs in more advanced apartment fires where three or more lines are needed, and so on. It is important that the nozzle firefighter ascends the ladder with no more than 50 feet of hose as a working length and pulls up more as necessary because the transition into the window can be precarious, and the area being entered into can be cluttered.

If your engine companies are well-versed in these techniques of going vertical with hose, you will routinely put yourself in a great position to stay ahead of the mid-rise apartment fire problem.

Running the Treads

When running the treads, stretch the line up the stairwell using the stairs either when there is no well hole option present or when the first line may have used the well hole and you need a second line to a different location. When you stretch up the stairs, there will be significantly more length factored into the stretch as mentioned above (50 feet or so per floor). Because of this, it is often second in the hierarchy of choices, but it is still a very simple and effective way to place a line.

When running the line up the stairs, there are two tweaks in the traditional stretching methods worth considering and practicing to see if they work for your crews and areas: (1) taking the inside track and (2) the supply side lead out.

Inside track (photo 3). Traditionally, we are taught to stretch the first line up the stairs by flaking the line to the outside of the stairwell. Issues we have encountered with hose running the outside track include fleeing occupants opening stairwell doors over the yet-to-be-charged line, causing a catastrophic problem, and also wasted hose causing the first line to come up short potentially. Taking the inside track with the first line keeps the hose away from the doors that swing into the stairwell when opened by fleeing occupants on all floors as you are making the stretch. While we would like to get people to use an evacuation stairwell, the reality of the environment the first line is stretching into is that it is a chaotic influx of occupants trying to flee by any means necessary. These occupants do not realize the catastrophic potential of a door that is opened over the top of an uncharged line being flaked out. The inside track alleviates the potential problem while also ensuring the line is not short stretched by wasting hose in the stairwell. Don't lay the line tight up against the inside, which creates kinks, but take a nice inside line up to the intended destination. Another advantage of this method is that when you place the

first line using the inside track, you can base the stretch calculation of another line on the first line more accurately. If the first line took 250 feet to reach the unit and the second line is going to stretch to the next door exposure, you know the second line will take the outside track in the stairs and need to add a length or two to account for it.

Supply side lead out (photo 4). Also common in stretching is for the nozzle firefighter to shoulder the attack length and be followed by other firefighters on the ascent with hose on their shoulders. The line pays off from the rear firefighter first, followed by everyone else. One of the issues that arises is that false "snags" on corners and obstructions can happen, causing firefighters in the line to prematurely dump hose because they cannot see behind themselves. Supply side lead out means the last firefighter to shoulder line actually leads out and takes the inside track (taking the outside will cause the section of hose between each firefighter to become a trip hazard) up the stairs with everyone else following. This means every firefighter has someone watching their back, tending corners, and keeping hose from sneaking into unwanted places. When a firefighter is done paying hose off his shoulder, he simply becomes extra hands on the stretch or can move ahead if not needed. Supply side lead out leads to much more accurate, much cleaner placement of the first line in both vertical and horizontal stretches with any load that requires shouldering hose.

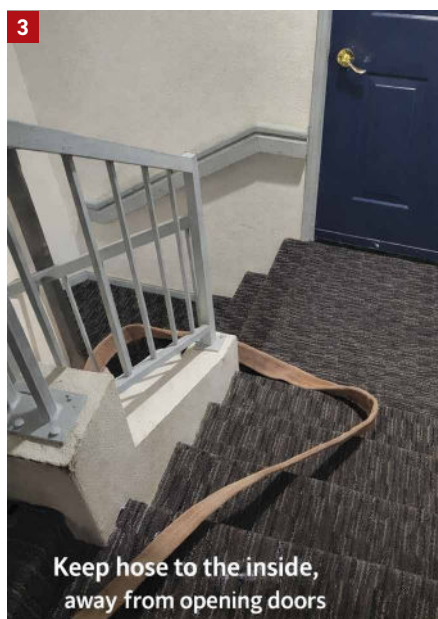


While each one of these stretching methods could become an article in itself, hopefully what is highlighted is that mid-rise apartment buildings of different types necessitate two things:

- Having a clear understanding of a hierarchy of line placement (what options are the best based on building type).
- Having alternative options for stretching multiple successive lines for confinement is critical.

Well holes may not be present or may be of inadequate size, stairways (which should have no more than two lines per) may become overwhelmed, and fire spread may necessitate alternative stretch methods for the second line and beyond. On these buildings, it is not just about placing the first line. Often, what results in a great fire attack is the placement of multiple confinement lines in multiple areas quickly. This is the winning formula on a mid-rise apartment fire. ■

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Energy Hazard Fire Considerations for High-Rise and Large-Scale Buildings

BY CHRIS G. GREENE

THERE IS A GAPING CRACK in our armor. Energy-driven fires involving large buildings can challenge even the most tenured companies. They serve as an unresolved haunting for the fire service. We all know it's there. We all agree that there is a problem, and yet we invest nothing in preparing for these perilous fire events. In fact, most agencies struggle to discern the difference between sound fire tactics and operational tarot cards.

The energy systems present in a large-format building are substantial and diverse. The layering of these systems is intentional. They provide the necessary redundancies that safeguard a building's power platform from being compromised by a single-point failure. As you can imagine, the complexities are inherent. And, when these systems fail, there is real trouble.

That noisy fire alarm and elusive source of smoke production can provide the backdrop for critical mistakes. To the untrained firefighter, these incidents may feel like a "normal" fire response—the building is in alarm, and there are clear signs of smoke but minimal indications of an advanced fire. We press on. Our investigation becomes more frantic and intimate. Something is burning. It doesn't appear to be too big yet, but our fire sense tells us that it is escalating—and we are missing something.

Slow down. Take a moment to consider what you know you have and what the sources may be. Smoke, for example, is a clear indicator that there is an ongoing problem, but we all know that not all smoke is created the same and that we need to appreciate these fundamentals. Both the color and volume can be clues to how advanced a fire may be. However, the odor of that smoke is one of the most straightforward and underappreciated indicators to be assessed during the initial phase of that alarm (see Pro Tip sidebar). And if that routine alarm turns out to be an energy-driven fire event, know this: Without experience and energy hazard training specific to our trade, you are

at a tactical disadvantage and there is no easy way around this.

This article examines several prevalent energy hazards firefighters encounter. The energy systems discussed will be categorized according to their functional purpose and placement within the energy redundancy hierarchy. Additionally, the article will address incidental energy hazards present in contemporary buildings.

Primary Energy Hazards

Vaults and electrical manholes are energy terms we need to understand.

Vaults. Vaults are electrical utility spaces that contain a transformer. These spaces are built and designed to receive high-voltage energy through conduit. They house electrical transformers and provide for electrical energy distribution to buildings and other high-energy spaces. Vaults may be located underground, with access provided through a hatch grate or cover and ladder. Vaults may also be located inside buildings, generally situated in the basement area with access provided by a man door. The walls and door assembly will be rated with a minimum three-hour fire protection.

Electrical manholes. Electrical manholes will be similar in design, location, and function to vault spaces with one exception—they will not contain a transformer. They are part of the energy highway and are commonplace under sidewalks and streets and in buildings.

These spaces are generally located in the basement or lower floors of the building and are entry points for the building's primary

power supply. The energy found in these spaces is extreme, as all of the power needed to support that building will flow through this space. From the outside, it will likely be fed by underground conduit, which is connected to another vault/manhole located under the sidewalk or roadway. That energy highway is how power is moved around a typical metropolitan area—underground, out of sight, with minimal indications of its presence. You must understand this fundamental concept. If there are no overhead powerlines, then they are located underground. This is the preferred standard for most energy grids that support high-rise and large-scale buildings.

Vaults and electrical manholes = nonaccess and nonentry. These spaces contain lethal energy. Your personal protective equipment (PPE), tools, and suppression tactics are no match for the hazards within. You must understand this with absolute certainty. Never enter a vault or electrical manhole that is involved in fire or not functioning normally. This includes opening the door to get a quick look inside. Get that foolishness out of your head. You must address emergency events that involve these spaces defensively until the utility has confirmed this space is fully deenergized. Fires that involve these spaces will likely result in power loss to surrounding buildings and carbon monoxide (CO) creep into adjacent buildings and spaces. Keep in mind that CO can hurt you in a variety of ways—as a toxin and, in high, confined concentrations, it can be explosive (Figure 1).

Informational prefire walk-throughs

Figure 1. Hydrogen Gas vs. Carbon Monoxide Properties

GAS TYPE	INDICATORS	FLAMMABLE RANGE	MINIMAL IGNITION ENERGY (MIE)	MOLECULAR WEIGHT
Hydrogen gas	Colorless, odorless	4%-74%	.017mJ	2.016 g/mol 14 times lighter than air
Carbon monoxide	Colorless, odorless	12%-74%	.3mJ	28.01 g/mol Slightly lighter than air

Hydrogen gas and carbon monoxide have ominous similarities. (Figures courtesy of author.)

of these spaces is important (photo 1). However, this is absolutely at the energy provider's discretion, and you must be accompanied by an energy escort from the utility (photos 2-3).

For more information about vault and manhole fire events, see "Manhole Fire Events: Understanding This Energy Hazard" (*Fire Engineering*, March 2024, bit.ly/4r28Q0z).

Electrical power for the building will move through the vault/manhole and into a switchgear room. Locating these two energy spaces close together is common to the anatomy of a building's energy system.

Switchgear Rooms/ Switching Spaces

Switchgear equipment refers to a collection of devices designed to protect, control, and isolate electrical power. These systems can be basic (confined to one small cabinet) or complex (involving an entire room, as will be the case with any high-rise building). Each component is housed in a metal cabinet/locker. These systems are the brains of the energy distribution system for a building. Inside the switchgear space will be every bit of electrical amperage needed to run that structure and everything in it. These spaces are not open to the public or none-energy trade professionals. Unlike an electrical vault, a building's switchgear room is not generally labeled "High Voltage," as



2. & 3. An energy escort is someone from the utility who is physically present and on scene. This person is trained and qualified to understand the hazards present and authorized by the utility to provide access to the energy space. This role would *not* be filled by a remote representative, security guard, or building engineer. (Photos courtesy of IAFF Energy Hazard Guide, Chris G. Greene.)

voltages within the space do not meet the technical threshold for this term, which is 600 volts or 1,000 volts, depending on the referenced code. Furthermore, signage for these rooms may not even say "Electrical" (photo 4) because in the energy industry, "Switchgear" is understood to be electrical. And when positioned within a building, it generally equates to low voltage-high amperage. We must recognize this as trade language and understand what it means: that the energy hazards within these spaces are lethal.

Emergency responders should not access switchgear rooms that are involved in fire or that are not functioning normally until the space has been deenergized or the cabinet in question has been deenergized and isolated. The energy hazards inside are simply too great. Furthermore, the

implications of an arc fault occurring in proximity to our members can have lethal consequences. Keep in mind that the two primary hazards in this space are electrical shock and extreme thermal in the form of an arc flash. It is understood that your structural firefighting gear provides only limited and passive protection from these hazards.

Temper primary search of these spaces against the lethality of the energy hazards and the potential for someone to be inside the space. Unlike a building vault or electrical manhole, access to these spaces is controlled by the building's engineering staff, which means there is a chance of it being occupied. However, the engineering staff control the access and can confirm if someone is inside. This should be the first question for the building engineer: "Is there anyone inside this space?"

For more information about switchgear emergencies, see "Switchgear: Extreme Energy Hazard" (*Fire Engineering*, January 2026, bit.ly/3MfGCAi).

Reading the Fire Alarm Panel for Energy

Typically, buildings involved in a fire do not experience power loss. This is an important point to recognize. However, if you respond to a fire alarm and notice obvious signs of power loss, either in the area or in the building itself, it's crucial to acknowledge this deviation and consider its impact on the overall hazard profile. This is often your first clue that you have an energy-impacted fire event.

When a building's primary energy source is interrupted, it will be captured



1. A Seattle (WA) Fire Department manhole entry exercise. Note the absence of a transformer and the multitude of conduit openings that function as energy highways connecting manholes and buildings. (Photos by author unless otherwise noted.)



4. A switchgear room label. Note the absence of the term “High Voltage”

or “Electrical.” Switchgear equipment for a nonutility-specific building (high-rise or large commercial) is not likely to be considered high voltage (600 volts or greater). And, for the energy industry, the term switchgear is understood to mean a specific type of electrical protective equipment. We must understand these terms, as the hazards they identify can have significant strategic and tactical implications for your crews.

by the fire alarm panel. There are two principal indicators to look for on that panel. First, the AC Power LED will be off. Second, the screen will read “AC Power Loss” or “Phase Loss” or “AC Power.” There are variations of text that you may see on that screen. Each is intended to notify the reader that the building has experienced a power loss (photos 5-7). Information from the panel can be buttressed by the illumination of egress lighting (photo 8). This is another indicator that the building has experienced power loss. Neither of these energy indicators (panel power loss/egress lighting illumination) should be present during a typical fire alarm—that is, unless the fire involves the primary energy source for that building. This tells you that this incident is driven by energy. Smoke from the basement or subgrade floors is the final puzzle piece settling into position. And the picture is now clear: That basement fire is actually an energy-driven fire. A trained firefighter who is able to connect these energy dots may be able to get ahead of this thing or, at the very least, your crews will understand the perilous nature of this incident and take corrective actions.

Supplemental Energy Hazards

Uninterrupted power supply (UPS) rooms. These are specialized, often fire-rated spaces, which house the backup power safety features and sensitive systems of a building. These rooms necessitate design features that allow for robust ventilation and security from entry. They may be located on any floor above the basement and are generally located on an outside wall to allow for patent and passive ventilation. Today,

most of these rooms are powered using lead acid chemistry batteries, but within the industry there is a heavy push to convert to lithium-ion. Additionally, these rooms will be protected by two separate suppression systems—a clean agent and a traditional water sprinkler system for more advanced fire events. These spaces will be monitored by the building’s fire alarm panel (FAP). Responders should exercise caution when considering entering these spaces because of the elevated energy hazards present and proximity protective features that may not be in place due to the very purpose of this space, which is to power that building.

Fires that are confined to the UPS rooms will not likely cause an interruption of



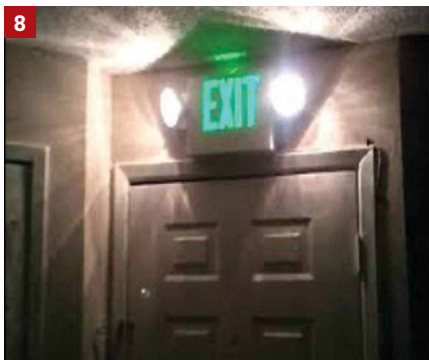
5. The FAP denotes a PHASE LOSS. This means that one of the primary electrical feeds supplying the building has been interrupted. The POWER LED will not be illuminated, serving as an additional indicator of a potential power supply issue within the building. Personnel should remain vigilant for elevators affected by phase loss, as this may result in occupants becoming trapped. Firefighters must be aware of the increased risk of individuals being trapped inside elevator cars under these conditions. **6.** The FAP indicates POWER TROUBLE and the AC POWER LED is not illuminated. Both indicate a problem with the building’s primary energy supply. **7.** The FAP denotes AC POWER-TRBL, and the POWER LED is off. These indicators suggest a power issue within the building. Firefighters may further confirm this by observing illuminated egress lighting.

power to the building. The indications of involvement will be captured by the FAP. Allow the clean agents to do their job, which is to suppress the fire. My point is that we should resist the temptation to push into these spaces with hoselines. Give the system a chance to work. Furthermore, crews should be alert to work being performed in this space, as this may necessitate a rapid primary search. However, this is considered a secure area of any building. People in this space will be trained professionals, and their status will be known. This is not a place where you would expect to find a custodian or random cleaning crew. Search implications in a UPS should be cautious and tempered.

Backup generators. Backup generators for high-rise and large-scale buildings are essential to the stability of critical life safety and exiting features. They can be expected to provide backup power for



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8. Illuminated egress lighting indicates primary AC power loss to a building. This can be a valuable clue about the energy status for a structure.

fire pumps, elevators, emergency lighting systems, and stair/shaft pressurization features. Diesel is by far the most common fuel for these generators, followed closely by natural gas. To ensure continuous operation at full capacity, diesel generators require on-site fuel storage sufficient to supply the building's needs for several hours or even days, depending on the occupancy. These systems may be located on lower floors or rooftops. Fires involving these spaces will initially be captured by the FAP. Furthermore, they will likely be covered by a water-based sprinkler system. Allow the system to do its job and press in with hoselines to supplement if this can be done safely. Remember, what is burning in this space is likely equipment that is damaged beyond repair. These spaces are secured from public entry, so temper a primary search of this space with information from the building engineering staff about the status of their personnel and potential for staff in the space.

Photovoltaic (PV) energy sources.

Anticipate PV on all large-format buildings, including high-rises. The sheer size of the exterior surface is prime real estate for both building integrated photovoltaic (BIPV) systems and building attached photovoltaic (BAPV) systems. The energy credits afforded to those large warehouses with PV systems installed are an irresistible temptation; expect them to be present. Rooftop systems installed under the 2014 NEC or newer can be expected to have rapid shutdown devices (RSD) in place. These safety features can aid in reducing the energy hazards posed by the

PV array. Look for both isolation and RSD on the rooftops and in the electrical room. These will be well-labeled and easy-to-operate systems. When suppressing a rooftop fire that involves the PV system, members should have confidence if they follow these simple rules for water application:

- Maintain a minimum distance of 10 feet between the nozzle and the panels.
- Use a broken pattern nozzle or agitate that smooth bore.
- Cut your foam.
- Avoid standing water.
- Activate RSD if present.
- Do not physically touch damaged PV panels or circuit wiring.

BIPV systems, while not unheard of on warehouse buildings, are much more prevalent on high-rise buildings, specifically façade PV systems. These can run the entire height of a high-rise; more likely, they are mounted intermittently based on light patterns in the region. One of the most concerning challenges for firefighters will be the chimney effect that may result from these façade systems. Fires that become trapped and find fuel between the panels and the building can move vertically at speeds that are difficult to get ahead of. Wind conditions will amplify this problem, so anticipate that too. Unlike rooftop PV systems, façade systems are not required to install RSD. But they will have isolation devices that can aid in reducing the energy hazards to the building itself. Expect to find these isolation features near the building's electrical room or in prefire information specific to the building.

Suppressing these fires should follow the same safety considerations as the aforementioned rooftop systems, minus the RSD activation. Keep in mind that the amount of falling glass and debris may be severe. Recognize the need for a well-defined physical setback distance because of the falling debris hazard potential.

The shock hazard is ongoing. Consider all PV panels and circuit wiring to be energized, regardless of RSD or isolation features. They pose an ongoing and ever-present shock hazard anytime there is light on those panels. Avoiding direct contact with these systems is prudent in any situation, especially if the panels or circuit wires have been damaged.

Incidental Energy Hazards

Lithium-Ion Batteries

The lithium-ion footprint and influence on today's high-rise and large-scale buildings are both frustrating and, at present, unmanageable. These batteries and devices are literally everywhere, and there are very few restrictions placed on them. The fire service will have to learn to deal with them on a case-by-case basis. Recognize that, for our trade, the mission remains unchanged: We save lives. This means conducting a rapid and an aggressive primary search. We are trained and equipped to allow for the relentless pursuit of victims in harm's way. We embrace this tenet with steadfast commitment because it matters. It is the only thing that really matters. And we must not allow this technology to become the distraction that results in prescriptive tactical delays for completing that mission.

Still, there are some strategies and tactics we may employ to better safeguard the public, the building, and our crews when these batteries are involved in fires.

Electric vehicles (EVs) and hybrid electric vehicles (HEVs). These fires are primarily going to occur in parking garages. The absence of smoke detectors in this space means the fire is going to progress, unrestrained, until that building's sprinklers activate. This may result in a stubborn fire and, worse, an escalating and complicated smoke removal problem, which, in turn, will create an entrapment hazard for anyone inside that garage. A word of caution: Triage and resource these events as a building fire rather than a traditional vehicle fire. Furthermore, consider that garage an occupied space; anticipate victims. The fire will go out, but your real problem will be executing a rapid primary search of the garage and surrounding areas.

Rapid, aggressive, and sustained ventilation of these spaces is critical. You cannot allow the fire gases to accumulate, as this creates an increase in a potential deflagration hazard, especially with EVs and HEVs. The battery hazard influencers at play are extreme. The scale and density of cells needed to power an EV, coupled with the confinement of gas, make for an

unusually perilous fire event.

Concerning the vehicle, historically, we could have left that burned-out vehicle inside the garage once it was completely extinguished. The towing and recovery industry was tasked with vehicle removal as time allowed. However, with EVs' and HEVs' capricious rekindle and off-gassing potential, we must address their removal. So, consider this a building fire until the vehicle has been removed from the structure. Resist the temptation to preemptively release units. Because of these same hazards, keep your full structural PPE ensemble in place, including self-contained breathing apparatus (SCBA) and particulate hood.

E-mobility and portable battery devices. These things drive us crazy. They can literally be anywhere in a building. So for fires that involve these battery-operated devices, consider the space they are in. The smaller the enclosure, like a closet or bathroom, the more problematic they will be. However, keep in mind that an electric scooter with 50+/18,650 cells is more than enough to take out a bedroom. Furthermore, the spaces where these devices live are also where people live and work—so expect victims. With an active fire event, a traditional approach continues to be the best strategy for those initial-arriving crews: rapid investigation, aggressive hoseline advancement, and execute a primary search with earnest. Once the primary search is complete and the fire is darkened down, ventilate the space ASAP. Unlike traditional fires, with fires involving e-mobility and portable devices inside a structure, you need to remove the batteries from the building before you can consider the incident to be stable. It is recommended that the batteries be placed in buckets and kept fully submerged in water. Ideally, fire-damaged batteries and devices shouldn't be removed from high-rise buildings using elevators. However, using stairs isn't practical for upper floors. If you must use an elevator, do the following:

- Transport without occupants (ghosting the elevators).
- Send only the batteries in the elevator.
- Have a hoseline ready at the receiving floor (e.g., lobby).

Fireground contaminants. The fire gas hazards and heavy metal contaminants found in a lithium-ion fire can be substantial. And, as with so many fireground contaminants, our profession is no stranger to these hazards. Furthermore, what the fire does not consume is redistributed across the fire scene into our equipment, structural firefighting PPE, and beyond. It can be difficult to appreciate the toxic complexities of a modern fireground.

We have long understood that certain chemicals are better if they are consumed by fire rather than released into the air. Our profession teaches us that one of the most toxic and contaminant-rich environments for firefighters is the instant the fire is extinguished. At that moment, all those invisible, concentrated carcinogens become trapped in that superheated smoke. They settle on our gear and permeate the surrounding surfaces. And, if not properly addressed, these contaminants can result in prolonged skin absorption and unanticipated/unseen inhalation hazards. Third-hand smoke, resulting from improper decontamination processes, can plague our gear for years. Chemicals like benzene, formaldehyde, and hydrogen cyanide, for example, are common to most fire environments. And their concentration can escalate the moment the fire is quenched. Make no mistake, the lithium-ion effect has not made this any better (Figure 2). But these

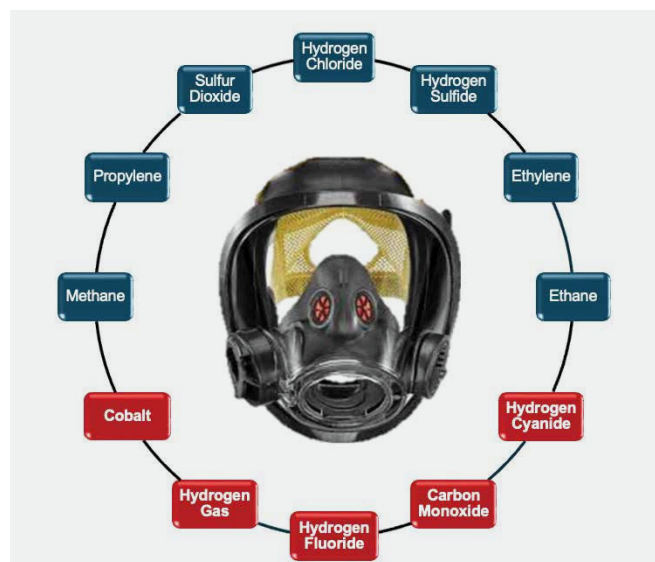
battery failures don't always result in an immediate fire. Sometimes they simply heat up just enough to release a mix of smoke and gas. Lithium iron phosphate battery chemistries are known to do just that—no immediate fire but a whole lot of gas.

Vapor cloud—compounding hazard. Off-gassing from lithium-ion batteries without fire can be unusually problematic. A vapor cloud may form due to a lack of sufficient heat to initiate combustion or a lack of oxidation; hence, the electrolyte solvent will be discharged as a gas. When confined, this situation can result in both hypertoxic and explosive environments. During thermal runaway, for example, the electrolyte can discharge as a vapor cloud. This will certainly result in increased flammability and toxicity hazards in the area immediately around the device. If this type of failure occurs within an enclosure—any enclosure—it must be ventilated in earnest. Confinement of these gases can result and has resulted in deflagration events. In these situations, the principal gases driving deflagration potential will be trapped hydrogen gas and highly concentrated CO. From a toxicity standpoint, one of our biggest concerns is hydrogen fluoride. And in a nonfire, compartmentalized battery failure, that hypertoxic effect can be perilous. As before, the answer is rapid and sustained ventilation.

Protection from the long-term effects of contaminants.

Rigid adherence to the PPE expectations of the fire service has never been so important—full structural firefighting gear, SCBA, and a particulate hood. Consider specialized decontamination for energy fire events. Keep in mind that specialized decontamination can take many forms, from a second wash in an extractor to using a presoaking detergent. If you have the means, consider having the gear cleaned using an independent service provider (ISP) that uses liquid carbon dioxide (CO₂). ISPs are third-party companies that offer verified PPE cleaning. They are often the only access a fire agency has to liquid CO₂ laundering processes.

Figure 2. Lithium-Ion Contaminant Hazards



Some of the most common fireground contaminant hazards associated with lithium-ion failures. Keep in mind that these same hazards may be present in a common house fire.

PRO TIP

Typical fireground odors generally fall into one of five categories/causes:

- 1. Food on the stove (FOS).** This is exactly what it sounds like. A rapid attack will keep this fire confined to the stove or at least the cabinets. A quick and deliberate crew can control this fire using a portable water can.
- 2. Combustibles.** This includes clothing, adornments, and the standard perishables in any apartment room. Like the FOS fire, this too can likely be controlled using a portable can.
- 3. Structure.** Structural components are an indicator of an advanced or advancing fire beyond that of household combustibles. If confined to one apartment unit, a portable water can will likely allow for a quick primary search, but plan on needing a hoseline to truly get this fire under control.
- 4. Electrical/plastics.** They can be an indication of a hidden fire, often trapped in the wall space. Or, worse, they are cues that the real problem is big energy. Odor of electrical when coupled with power loss indicators is a monster clue that this is an energy fire that involves the primary feed or switchgear for that building. However, this can also be an indicator of a vehicle fire in the garage space. Keep in mind that most garages will not have smoke detectors, and sprinklers may not activate until the fire is advanced. I have personally been caught by this anomaly: On a dark and rainy Seattle night, there was a smoke detector activation on Floor 3 of a midrise apartment building. The initial team moved forward to Floor 3 and reported light smoke with an odor of electrical. The source was quickly determined to be coming from the garbage drop on that same floor. Standing at the alarm panel, I watched as the final clue was revealed: a sprinkler activation in the garage. It was a vehicle fire, and we were out of position. I never forgot that incident.
- 5. Decomposing body.** This is exactly what it sounds like.
Investigating companies should report the odor on the radio with earnest. Consider this a tactical report. Example: "Engine 23 on Floor 32, light haze/odor of combustibles." If you were dispatched to a reported FOS, you now have information to the contrary and that needs to get out to command and incoming companies.

Fire contaminants. It's all hazmat/hazardous waste. Today, there is a hyperfocus on lithium-ion battery contamination. I get it. These batteries are definitely adding to the contaminant cocktail our firefighters are facing. But I grow concerned when I hear so many conversations that seem to downplay the dangers of fire toxins and contaminants before the emergence of lithium-ion battery fires—as if any fire without a lithium-ion battery is to be considered prosaic and paltry. It's important to remember that *all* fire environments produce hazardous contaminants that may require specialized decontamination.

For example, when a creosote-soaked dock catches fire, it releases a toxic soup of airborne chemicals that are extremely difficult to remove from firefighting gear. Laundering your gear once in an extractor won't be enough to eliminate these deeply embedded chemicals. In my experience fighting such fires, that pungent odor of creosote often lingers in the gear until it is

retired. The simple truth is that all fire toxins and contaminants are bad for you. Furthermore, they all can meet the definition of a hazardous material. The idea that a fire involving lithium-ion batteries automatically makes for a hazmat incident is absolutely capricious, because it has always been hazmat! Every overhaul operation you've ever engaged in meant you were working with hazmat and hazardous waste material. We need to understand this simple truth of our professional work environment.

For more information about lithium-ion-influenced fires, see "Lithium-Ion-Influenced Fires: Back to Basics" (*Fire Engineering*, December 2025, bit.ly/3O1iwK3).

Energy Hazard Knowledge for Traditionally Resourced Companies

Moving forward, it is imperative that responders be familiar with the diversity of energy systems that may be present in a large-format building. Understanding and recognizing the energy indicators will be key

to safely resolving an energy-influenced fire event before the cascading failures become insurmountable. To do this, we must invest in ourselves. We have much work ahead.

We are a land of traditionally resourced firefighters. They are the very backbone that safeguard this nation. These traditionally resourced companies trust that the training and information needed to safely operate in this space will be provided. Energy hazards are part of our work environment. Yet, the lack of basic prescriptive energy hazard knowledge for our trade persists. This training gap has left us vulnerable in a way that is difficult to appreciate until it is too late.

As a profession, we are going to have to correct this. Furthermore, where we position this knowledge is just as important as the knowledge itself. This means developing firefighter-specific energy hazard training. We need energy acumen, not widgets, gadgets, and bloated specialty teams. Energy hazard knowledge is a fundamental skill that every one of us needs. Locking up critical information and interpretive skill sets within the confines of a specialty team inherently places traditionally resourced fire companies at risk. We must position energy knowledge as close to the emergency as possible—and no one needs it more than the initial-arriving company. They are the tip of the spear, the first and best shot we have to recognize those energy hazard indicators at the outset of the emergency—and that is exactly where we need to position this knowledge. ■

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