By CURT VARONE

Mega-Buildings: High-Rise Rack Storage Warehouses

Fires in These Buildings Pose a Serious Hazard to Firefighters

An engine company arrives at the scene of a large warehouse at 10 P.M. for an automatic alarm. It is a Tuesday and the warehouse appears to be operating with tractor-trailers lined up waiting to be loaded. The firefighters are familiar with the warehouse, occupying 400,000 square feet in a rectangular shape. The construction is Type II unprotected non-combustible, with metal walls and a metal deck roof.

Through inspections and pre-fire data, the firefighters know the warehouse contains 45-foot-tall rack storage that is stocked and maintained by a computer-controlled robotic conveyor system that moves about the facility on tracks that hang from the ceiling. They also know the facility is fully sprinklered.

The crew is met by a warehouse employee who reports smoke in the building and leads them to the enunciator panel in an office area. The panel is indicating the sprinklers have activated. The employee reports everyone has been evacuated from the building and is accounted for.

As additional crews arrive on scene, the engine company crew enters the warehouse, but smoke is banked down to floor level. A ladder company brings in a thermal imaging camera, but the fire cannot be located.

The officers of the engine and ladder confer briefly, and opt to withdraw to await the arrival of the battalion chief and additional units. Conditions remain virtually unchanged since their first arrival, with little smoke visible from the exterior. The chief orders crews to supplement the sprinkler system and conduct an exterior reconnaissance. After approximately an hour, conditions remain unchanged and the chief decides to continue the wait-and-see approach. As daybreak nears, the weary crews have been on scene for over eight hours. Light smoke continues to weep from building and conditions inside remain at near-zero visibility. The fire appears to have neither subsided nor gotten worse.

Courtesy of Frazier Industrial

At 9 A.M., the chief gathers all the officers at the command post to develop a plan. Frustrated at the stalemate, a plan is devised to make entry at 10 A.M., 12 hours after their arrival. Prior to entry, the sprinklers will be shut down and crews will open as many overhead doors as possible to aid in ventilation. An engine and ladder will proceed in to locate the source and complete extinguishment.

At 10 o'clock, the plan is implemented and eight firefighters under the command of a captain enter the warehouse with a charged handline. A rapid intervention crew remains at the entry. The ventilation has succeeded in clearing some of the smoke, but the narrow aisle space between the racks make advancing the hoseline slow.

The crew makes its way to a point approximately 150 feet inside the building where visible fire is observed to be burning about 40 feet above the floor.

The fire, now fed by fresh air and not inhibited by the sprinklers, is picking up in ferocity. The firefighters find it difficult to maneuver their hose stream into a position where it can strike the flames due to the narrow aisles and height of the fire. The captain in command of the crew considers asking for a ground ladder, but quickly realizes it will be impossible to get it inside and raised into a climbing position. Flaming debris begins dropping on the crew from above. Suddenly, one member's low-air warning alarm goes off. Then another. And another. The captain orders the crew to withdraw.

As the last member exits the building, it is obvious that the fire has increased dramatically in intensity. Water flow to the sprinklers is restored, but the fire continues to grow unabated. Exterior operations commence. Fourteen hours after the arrival of the fire department, the warehouse is well involved.

Hazardous Conditions

The above scenario is a fictionalized account of a very real type of fire that is confronting firefighters in the United States. High-rise rack storage warehouses are large warehouse facilities that use high-rise and high-tech rack storage systems, and pose tactical problems that make interior attacks treacherous at best, and perhaps impossible in many cases.

The Fire Protection Research Foundation (FPRF), the research arm of the National Fire Protection Association (NFPA), recently held a strategic planning session in Quincy, MA, to consider the problem. High-rise rack storage facilities are increasing in number, size and complexity, commonly exceeding 45 feet in height, with

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some exceeding 100 feet. Contributing to the firefighting hazards are large undivided floor areas, highly combustible stock such as plastics and synthetics, narrow aisles to maximize usable storage space, and computer-controlled robotic systems to store and retrieve stock.

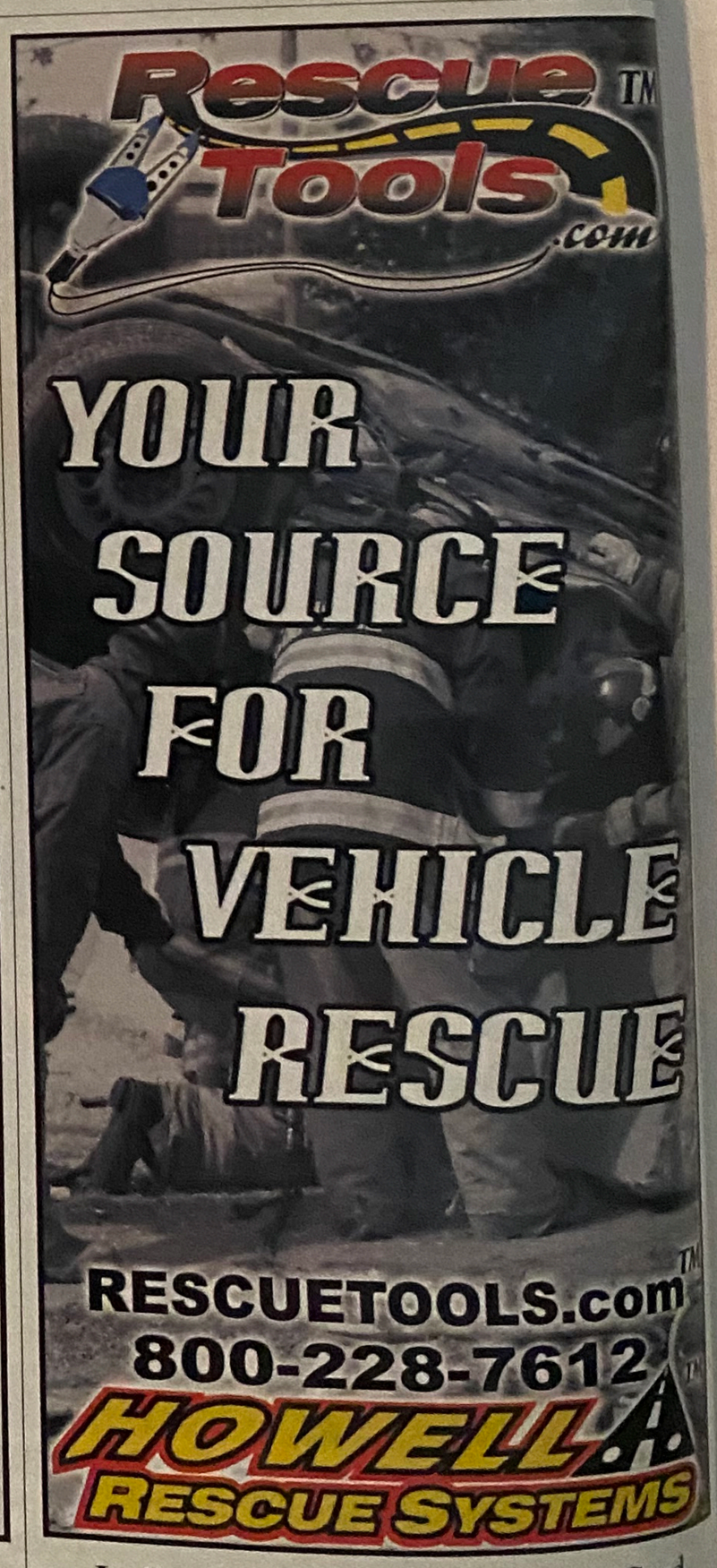
Large buildings with undivided floor areas have always posed a strategic and tactical challenge to the fire service. Typically, the farther into a building firefighters must go to reach the seat of a fire, the greater the risk to them. The more obstructions that personnel encounter as they enter, the greater the risk. The larger the undivided fuel load, the greater the risk.

High-rise rack storage buildings have all of the concerns associated with big-box buildings, and more. Mega-warehouses are proliferating across the country, driven in part by the global supply chains that keep our favorite stores stocked with our favorite supplies. Many times these high-rise rack storage buildings are in rural areas to avoid the congestion associated with urban traffic, but they can be found virtually anywhere.

The rack storage systems in these building are high-tech computerized marvels. One of the goals of the designers of these systems is to maximize usable storage space by minimizing wasted space. As a result, aisle width that is so critical for firefighter access, as well as to serve as a natural barrier to fire spread, is minimized. Some designers have even created track-mounted racks that are movable and can be packed close together when access to their contents is not needed. As a result, accessibility in the event of an emergency can be a serious problem.

The height of these buildings is another big concern. Many rack storage systems are in the 45- to 50-foot range, the equivalent of a four- to five-story building. When one considers the fuel load of the contents of a four- to five-story warehouse with a 400,000-square-foot floor plan, stacked vertically and undivided by floors or walls, the enormity of the fire problem comes into focus. Then consider that some of these rack storage facilities exceed 100 feet in height!

In addition, many of the rack systems



use robotic mechanisms to stock and retrieve items. Automated equipment places the stock in the racks, and in turn picks the stock when needed, delivering it quickly to awaiting delivery vehicles. Some of these systems resemble high-tech robotic fork lifts that are on a track suspended from the ceiling, posing yet another collapse hazard.

Can Sprinklers Solve the Problem?

Virtually all of the warehouse buildings in question are sprinklered and many use in-rack sprinkler systems. However, the basic design premise of most systems is that the sprinklers function to control the fire, but that final extinguishment and overhaul will be carried out by manual firefighting crews who will enter the building.

The obvious problem with that assumption is that the risk profile of these mega-warehouses dictates that firefighters take an extraordinarily cautious (usually defensive) approach. Assuming all occupants have exited the building, there is no life hazard. The large floor areas, narrow aisles and possibly treacherous floor layouts pose a potential trap for firefighters even under good conditions. Under zero-visibility conditions with a fire of unknown intensity potentially impacting the structural stability of the building as well as the rack systems, a slow and deliberate approach is clearly warranted.

Solutions

During the course of the Fire Protection Research Foundation's brainstorming session, it became obvious that the solutions needed to come from a variety of sources. These include sprinkler designers, alarm system designers, warehouse designers, risk managers and firefighters. Among the possible solutions were:

1. Sprinkler systems must be designed to completely extinguish fires in such occupancies. The primary drawback is the high cost of such sprinkler systems. In addition, it may not be feasible to redesign existing facilities, so that improved sprinkler systems may only be viable as an option on a going-forward basis for new construction.

2. The incident commander (IC) responding to an alarm in such a building needs better information on fire conditions so that better tactical decisions can be considered. Through more advanced detection and alarm systems, the IC would benefit from knowing how many sprinkler heads had activated (to help determine the extent of the fire), which heads have activated (to help determine the location of the fire) and the ceiling temperature (to help determine if the structural stability of the roof was in question). The primary drawback of this solution is the same as suggestion 1 above.

3. Develop robotic extinguishing systems that use the same technology and equipment used to manage inventory to deliver extinguishing agent directly to the seat of the fire. Technological issues must be overcome for such a solution to be viable, not the least of which is whether the system can function despite being damaged by the fire it is intended to extinguish.

4. Make mega-warehouses more firefighter friendly by providing: wider aisles for better and safer accessibility; pre-positioned equipment (such as fixed deluge guns with enough capacity to complete extinguishment); sufficient access points so that firefighting crews can access any portion of the building without having to go in more than 50 to 75 feet from an exterior exit; and built-in ventilation systems that firefighters can control as needed.

5. Develop realistic entry parameters – conditions under which firefighters can safely enter and operate in these structures. These parameters would help ICs determine when an entry can be attempted and when it should not, as well as help building designers create buildings and rack systems that are based on a realistic assumption about fire department capabilities. Examples of the entry parameters needed are: the maximum rack height that firefighters can realistically be expected to overhaul and extinguish; the maximum distance of any point in the warehouse from an exterior exit, and minimum aisle width to allow safe entry, egress and operations.

6. Train firefighters to identify such structures, develop safe operational plans and use safe tactics while operating.

Conclusion

Fires in high-rise rack storage buildings pose a serious hazard to firefighters. These buildings are proliferating throughout the country. The NFPA and the FPRF are working to help understand and address this issue. Additional research is being proposed to help better understand and define the problem, as well as investigate the feasibility of some of the solutions. We encourage you to help us with your ideas and comments. The Public Fire Protection Division at the NFPA will post periodic updates on the high-rise rack storage building problem at www.fireservicetoday.org and the blog at http://nfpa.typepad.com/fireservicetoday/.