FIRE PROTECTION FOR MECHANICAL PARKING FACILITIES
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SUMMARY

The use of mechanical parking is growing as development density increases and society finds new ways to address urban growth complications. This article discusses mechanical parking from a fire protection perspective and provides a summary of the mechanical parking provisions of the 2009 International Building Code (IBC) and the 2009 International Fire Code (IFC). While the International Code Council has incorporated mechanical parking into the International Codes, fire protection measures for these systems and facilities have only begun to be codified within the model codes. Therefore, this article also provides a review of the requirements of NFPA 88A Standard for Parking Structures, which addresses mechanical parking structure requirements.

It is important to note that the IBC and IFC do not fully address mechanical parking. This article and analysis is intended to provide concepts for fire protection based on sound engineering principles and a rational application of Building and Fire Code provisions. This article also proposes an approach to address firefighter operation hazards associated with mechanical parking. Engineering analysis and proposals are integral to addressing design elements that are not clearly addressed by the IBC and the IFC.

MECHANICAL PARKING CONCEPTS

In mechanical parking facilities, vehicles are typically stored on parking units that are part of the overall mechanical parking system. Most parking surfaces are a skid or pallet that is used to maneuver vehicles through the structure. These parking units can be solid structural steel or an open, grated assembly designed to fit and support the range of vehicles anticipated. Once parked by the operator on a parking unit in a designated drop-off zone, automated machinery is used to store the car until retrieved by the operator. Cars are mechanically parked in storage bays, similar to open-rack systems. Vehicles are stored with minimal spacing between cars, vertically and horizontally, to maximize efficiency. Mechanical parking equipment ranges from a centralized machine moving along tracks and belts or multiple pieces of machinery transferring vehicles through the storage system. The equipment can be electrical, hydraulic or a combination of operating technologies. The mechanical assembly moves the cars from the drop-off point, through the facility and into a parking bay. The systems are complicated and use digital control equipment that can be programmed to store vehicles in different arrangements for partial capacity. For instance the system can be programmed to keep vehicles as close to the loading area as possible, to achieve short response times, or to load vehicles in upper tiers first if there is a concern for fire sprinkler responsiveness.
INTERNATIONAL BUILDING CODE REQUIREMENTS AND DISCUSSION

The following analysis of the IBC documents the code minimum fire and life safety requirements for mechanical parking:

**Occupancy Classification**

Based on Section 311.3, low-hazard Group S-2 storage includes buildings used as enclosed or unenclosed parking garages. Section 406 provides the requirements for motor-vehicle related occupancies.

The IBC defines an occupiable space as a room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes, or in which occupants are engaged in labor and which is equipped with means of egress, light and ventilation facilities meeting the requirements of the IBC. Based on this definition, the area of the automated parking structure in which cars are parked is not considered an occupiable space.

As a Group S-2 Occupancy, mechanical parking areas are required to be separated from adjacent occupancies by an occupancy separation.

**Building Height and Area/Construction Type**

Section 406.3 includes provisions for open parking garage height and area (including code allowed height and area increases) and contains specific requirements for mechanical access parking garages, which can be used if public occupancy is prohibited above the street level. For enclosed parking facilities, Section 406.4 states that the height and area be limited to the allowable heights and areas found in Table 503 as modified by Sections 504, 506 and 507. There are no specific height and area provisions for enclosed mechanical parking facilities.

Typically mechanical parking structures are of a height and/or area that require a non-combustible structure. Because the mechanical parking assemblies are often supported by structure that is separate from the building, they can be installed in any type of structure with minimal impact on the parking system design.

**Horizontal Assemblies and Floor Openings**

Multi-tier parking structures are typically classified as multi-story but the function of the mechanical parking system requires vertical openness, similar to ramps in parking garages. Based on IBC Section 708.2 Exceptions 8, 14 and 15, shaft enclosures are not required for automobile ramps, elevators or mechanical systems in open and enclosed parking garages. This allowance is typically applied to mechanical parking facilities. Often horizontal floor assemblies are provided between groups of
mechanical parking tiers in structures that are more than 40 feet in height. This provides for structural stability but can also be included in the fire protection approach.

**Fire Suppression**

Typically, mechanical parking facilities are relatively large buildings, requiring automatic fire sprinkler protection throughout as well as standpipe systems.

**Fire Alarm**

Section 907 of the IBC provides requirements for fire alarm systems. Because mechanical parking is a Group S-2 parking structure and is non-occupiable, with the exception of drop-off areas, they are not required to be provided with a fire alarm/detection system. However, other portions of a mixed-use facility may require a fire alarm system. If the parking facility is located adjacent to other occupancies in a mixed-use building, the overall fire alarm system should include occupant notification based upon an incident within the parking structure.

**Mechanical ventilation**

Section 406.4.2 of the IBC requires that a mechanical ventilation system be provided in accordance with the International Mechanical Code. This mechanical ventilation system is intended for the ventilation of parking structures and fumes associated with automobiles. This code required ventilation system is not related to smoke exhaust or smoke control.

**Smoke/Heat Venting, Manual Exhaust and Smoke Control**

Section 910.2.1 of the IFC states that Group S-1 or F-1 buildings that have an undivided area greater than 50,000 square feet must be provided with smoke and heat vents. Parking garages are classified as Group S-2 based on the IBC, and do not require smoke and heat venting. No smoke or heat venting, manual exhaust or smoke control systems are specifically required for mechanical parking or Group S-2 functions.

**Means of Egress and Fire Department Access**

Chapter 10 of the IBC provides the requirements for means of egress from buildings and structures. Section 1021.1.2 states that for parking structures where vehicles are mechanically parked, only one means of egress is required from each tier. Fire department access is not specifically addressed for mechanical parking structures by the IBC.

**Other Emergency Systems**

Emergency power is not specifically required for mechanical parking facilities. However, if an overall project requires emergency power, any emergency systems serving the mechanical parking will require
emergency power connections. The IBC does require emergency lighting for parking structures in general. This requirement can be negotiated for mechanical parking structures, given their non-occupiable nature.

NFPA 88A (2011 EDITION) COMPLIANCE

NFPA 88A Standard for Parking Structures 2011 Edition contains additional requirements for mechanical parking areas. NFPA 88A is not necessarily adopted in all areas; however, because the IBC does not fully address mechanical or automated parking structures, it is appropriate to review the requirements of the NFPA standard in order to provide perspective to the requirements of the IBC. This standard helps to establish the expected standard of care for these types of structures.

NFPA 88A includes the following sections, which apply to automated or mechanical parking structures.

- Section 9.2.1 states that means of egress based on Chapter 4 of NFPA 88A are not required in mechanical or automated parking structures. Means of egress are not required because the automated/robotic parking areas are considered as non-occupiable.

- Section 9.2.2.1 requires that access be provided to fire service and maintenance personnel in accordance with Table 40.2.5.6 of NFPA 101, except that the minimum dimensional criteria shall be 36 inches. NFPA 101 Table 40.2.5.6 requires that access be provided to industrial equipment via walkways, platforms and/or stairs.

- Section 9.2.2.2 requires that horizontal walkways for access be provided at intervals not to exceed 19.5 feet vertically and 98.5 feet horizontally.

- Section 9.2.2.3 requires that travel distance to the exterior or to an enclosed stair be provided in accordance with the distance criteria for “Special Industrial Occupancies” based on Table 40.2.6 of NFPA 101. Section 40.2.6 requires that travel distance be limited to 200 feet (250 feet if the building is fully sprinklered).

- Section 9.2.2.4 requires that one exterior door be provided at grade for every stair.

- Section 9.2.3 requires that the structure be provided with a ventilation system capable of continuously providing two air changes per hour.

- Section 9.2.4 states that an automatic sprinkler system be installed in accordance with NFPA 13; however, standpipes and fire alarm systems are not required.

The appendix to NFPA 88A recognizes that NFPA 13 does not currently provide an approach for protection of automated-type parking structures. The NFPA 88A Technical Committee has
acknowledged the need to further review the issue and has deferred to the NFPA 13 Technical Committee for direction.

Because NFPA 88A and NFPA 13 do not clearly address the approach for sprinkler protection for the storage configuration of automatic parking structures, an engineered solution is required.

**FIRE PROTECTION APPROACH**

This section details a fire protection approach that RJA has applied for mechanical parking facilities.

**Occupancy Classification**

Although the storage configuration for mechanical parking systems is unique and not addressed by the IBC, it is not anticipated that the storage configuration will result in a significantly increased hazard, if the parking structure is provided with appropriately designed fire suppression systems.

The parking tiers/decks are not intended to be occupied. The parking structure, with the exception of the vehicle drop-off area, is classified as non-occupiable. Essentially, the occupancy is similar to that of an automated storage facility.

**Clear ceiling height**

The requirement for a floor to ceiling clearance of seven feet in vehicle and pedestrian traffic areas is specified by the IBC for several reasons. Based on a review of the 2006 *International Building Code Commentary*, one of the reasons for a minimum ceiling height is to allow smoke and hot gases to accumulate above building occupants. Because there will be no occupants in the parking structure, this clear height could be reduced. However, fire fighter access and operations need to be considered and addressed.

**Mechanical Ventilation**

The mechanical ventilation system for general parking areas is required by the IBC and must be provided. The International Mechanical Code provides a means for determination of a required exhaust rate. NFPA 88A provides direction that two air changes per hour is appropriate based on the non-occupiable nature of the space, which is a relatively low rate of ventilation. The mechanical engineer should also provide recommendations for normal ventilation/exhaust of the space.

**Smoke Exhaust**

Based on the vertical interconnection of levels and potential for incorporation into a mixed-use or high-rise project, a smoke exhaust system may be required or provided for a large mechanical parking facility. A smoke exhaust system within the mechanical parking area can address the potential for smoke spread...
to adjacent areas or to provide for heat removal and smoke clearing in the event of a fire within the parking facility. These systems are not typically life safety systems for the garage, since it is a non-occupiable occupancy, but may protect adjacent occupied areas from exposure.

Parking garage smoke exhaust systems typically make use of the same make-up air locations used for the normal ventilation system and provide mechanical exhaust via shared or dedicated mechanical equipment. The layout of the mechanical ventilation system needs to be understood by the smoke exhaust designer because the objectives of normal ventilation and/or carbon monoxide exhaust are different from the objectives of smoke exhaust. In many cases, additional ductwork or mechanical equipment is necessary to achieve smoke exhaust.

The sizing of the smoke exhaust fans is completed assuming a reasonable design fire, typically including the assumption that sprinklers will respond. The design fire analysis should take into consideration the location, installation and responsiveness of the sprinkler system as well as the shielded nature of most vehicle interior fires. Detailed car fire research reports are available, such as those from the British Automatic Fire Sprinkler Association or a database of full-scale calorimeter tests of motor vehicle burns prepared by the Southwest Research Institute in 2008. Once the design fire and building geometry have been determined, the smoke control correlations of IBC Section 909 are used to evaluate the required exhaust. Computer modeling can also be used to develop and analyze the smoke control system in more detail. A critical factor in managing the extent and complexity of the systems is to develop performance criteria that are reasonable for the occupancy.

If provided, the smoke exhaust system should be initiated by a building sprinkler workflow alarm. In large parking facilities, sprinkler systems should be zoned to serve only the mechanical parking areas so that the smoke exhaust system is not initiated for sprinkler operation in another portion of a mixed-use facility. Since mechanical parking facilities are usually open to the exterior, smoke detection is not normally provided. If smoke exhaust is provided, manual controls are also provided to allow fire fighters the ability to activate or deactivate the system during their operations.

**Fire Suppression**

The IBC requires an automatic fire sprinkler system throughout the building. Although there is a lack of fire test and fire history data for mechanical parking facilities, it is expected that a fire event would spread horizontally and vertically within the mechanical parking area if an automatic suppression system were not provided. While other types of suppression systems could be used, traditional sprinkler protection is appropriate.

The location and activation of sprinklers needs to be considered to ensure effective response and maximum effectiveness of the sprinkler system. Additionally, an appropriate design density needs to be identified.

Based on review of the fire history data and fire test data associated with automobiles parked side-by-
side the ability of automatic fire sprinklers in suppressing fires within automobiles is limited. However, automatic fire sprinklers are effective at containing the fire to the vehicle of origin. The automatic fire sprinklers prevent tires and exterior trim from igniting, but do not suppress or extinguish fires within the engine or passenger compartments; automatic sprinkler systems would also likely prove ineffective for shielded pool fires underneath parked automobiles but would limit the ability of the fire to spread prior to firefighter response or burn-out.

**Standpipe system**

It is appropriate that the building be provided with a standpipe system for fire fighter use, with outlets provided at each tier of the mechanical parking area.

**Fire Alarm**

Section 907 does not require parking garages to be provided with a fire alarm or detection system. Because mechanical parking smoke exhaust systems are not life safety systems early detection is not necessary. In a mixed-use facility that is required to include a fire alarm system, basic fire alarm notification should be provided within the mechanical parking and adjacent areas, as appropriate, based on sprinkler water flow.

When a fire is detected within the mechanical parking area it is recommended that the mechanical parking system cease operation and return to the loading area (similar to elevator recall). It may be advantageous to recall the loading platform to an alternate location; the need for this capability is dependent on the physical configuration of the parking structure and mechanical ventilation system design. It is the intent that any parking equipment sequencing would take place prior to Fire Department arrival. At a minimum, basic manual shutdown control should be provided at the fire department response location.

**Fire Department Access**

Although not required by the IBC, depending on the configuration of the building it may be appropriate to provide for exterior access to each parking tier or provide a protected interior means of accessing each tier. Additionally, it is appropriate to account for access to each portion of the interior tiers utilizing catwalks or similar access elements. These access points can be combined with maintenance access. Each point of access, especially where limited, should include standpipe outlets at each parking level. Access to the roof should also be provided by an enclosed stair.

It is not intended that mechanical parking vertical access elements serve as code compliant egress stairs or accessible stairs. The ladders and stairs typically serve as mechanical equipment access and fire department access only.

**CONCLUSION**
The concepts and provisions discussed in this article result in a level of protection for automated parking structures that meets or exceeds the requirements of the IBC and IFC. The fire safety provisions also provide a reasonable level of fire and life safety for elements of the design which are not directly addressed by the IBC and IFC. These proposals are based on a review of the available fire loss data for standard parking structures, full scale fire tests for cars parked side-by-side and other mechanical parking requirements. An engineering analysis should be completed to assess the specific hazards of individual mechanical parking facilities prior to completion of design.