Tuesday e-Tech Alert
September 6, 2005

NATIONAL FIRE SPRINKLER ASSOCIATION, INC.

Parking Garage Sprinkler Protection

A recent informal interpretation was issued by the NFSA engineering staff on the subject of sprinkler protection in parking garages:

Q: Where a mechanical car lift would allow the storage of two vehicles stacked one on top of the other within an enclosed parking garage, is it reasonable to provide ceiling-only protection through the use of an increased hazard classification? Any type of in-rack sprinkler arrangement would be difficult since the units do not have specific mechanical stops but are placed at various elevations depending on the individual vehicle heights.

A: The parking garage can be reasonably protected with sprinklers only at the ceiling if the hazard classification is increased to Extra Hazard Group 2. The definition of Extra Hazard Group 2 includes, "occupancies where shielding of combustibles is extensive" (Section 5.4.2 of the 2002 edition of NFPA 13). The basic concept in this section is that hazards that would normally be classified as Ordinary Hazard can be protected with sprinklers only at the ceiling by increasing the density and area of coverage, and by decreasing the sprinkler spacing, in accordance with the Extra Hazard rules. Examples of such situations include factories where manufactured homes are built. During the process of building a manufactured home, sprinkler protection is not extended down inside the manufactured home, but sprinklers at the roof of the factory are expected to control any fire, including one starting inside a home being manufactured. By upgrading the design basis of the sprinkler system to Extra Hazard Group 2 (increasing the density by 167% and increasing the area of operation by 67%) the sprinkler system is expected to handle the additional challenge of a shielded fire (see A.5.4.2 of the 2002 edition), and should be sufficient to handle the fuel load of two cars (one above another), preventing the fire from spreading to the adjacent cars while maintaining acceptable conditions for the structural members within the structure.

The engineering staff response to this question was based on a review of the available literature on sprinkler protection of parking structures. The subject is addressed briefly in NFPA 13 through a reference in the annex (Section A.5.3.1 in the 2002 edition) to "automobile parking and showrooms" among the Ordinary Hazard Group 1 examples. NFPA 13 does not include any extracts from NFPA 88A – *Standard for Parking Structures*, since that document simply references the use of NFPA 13 where sprinkler systems are provided. However, the subject has received a great deal of attention over the past few decades, both in terms of sprinkler requirements and design criteria.

The 2003 edition of the *International Building Code* require sprinkler protection of enclosed parking garages other than those below Group R-3 dwellings as permitted by the *International Residential Code*. Open parking structures are exempt, even those high enough to qualify as high rise buildings if of Type IA construction. For other types of construction, the allowable height is increased if sprinklers are installed. Sprinklers are also required throughout buildings used for the storage of commercial trucks or buses where the fire area exceeds 5,000 sq. ft. The NFPA 101 *Life Safety Code* does not require sprinklers in parking structures, but allows longer travel distance to exits when sprinklers are provided. The NFPA 5000 *Building Construction and Safety Code*, like NFPA 88A, requires sprinklers in basement and underground parking structures and in enclosed parking structures of Type II or IV construction over 50 ft in height, and also in enclosed parking within or immediately below a building used for another occupancy.

The issue of hazard classification has occasionally been raised over the years, with the steel industry promoting the allowance of light hazard classification. One issue of traditional concern, however, is the presence of the gas tanks in these vehicles and the resulting potential for high heat release pool fires, or even explosions if tanks were exposed to prolonged flame.

The issue of garage protection was researched with at least four different sets of fire tests between 1967 and 1977, with the results used to develop fire protection criteria for building codes, fire codes and NFPA 13. Since that time, fire experience within parking structures has been good, calling for little need for revision or reexamination of the issues.

The first test series to look at fuel tanks was conducted in the United Kingdom (Butcher, Thomas, and Bedford, *Fire and the Motor Car, Results of the Tests on the Propagation of Fire in Parked Cars*, Ministry of Technology and Fire Offices' Committee, F.R. Note 678, London, England, 1967). In this test series, a number of fire tests were run with 9 cars (3 rows of 3 cars each) with the middle car ignited. In each test, 5 Imperial Gallons of fuel (6 U.S. gallons) were present in each fuel tank. The distance between the cars varied between 2 ft and 4 ft. With no sprinklers installed in the building, the purpose of the tests was to look at free-burn conditions. The discussion and conclusion of the tests was as follows:

> "One of the major hazards which was considered a possibility was disruption of the petrol tank and the flowing of petroleum under other cars in the vicinity via the sloping concrete ramp. In no case did this occur in spite of the fact that in Test No. 2, the position of the spare wheel and other combustibles which were completely burnt away was situated directly above the tank containing five gallons of fuel. It was observed that the method of burning of the fuel when ignited, was via the filler cap and the connecting pipe which melted and the fuel burnt from this source only. From a knowledge of the disposition of combustible materials adjacent to the fuel tanks, in the three tests, it is considered very unlikely that an explosion or disruption of a petrol tank would take place. A pressure build-up sufficient to cause disruption of the tank could, we feel, not take place as all tanks are provided with a pressure release either in the filler cap or by other means…"
>
> "An outbreak of fire within a single parked vehicle is unlikely to result in uncontrolled fire-spread within the car park or in serious damage to the structure of the building."

The next series of tests was conducted in Scranton, PA by Gage-Babcock and Associates, the Scranton Fire Bureau and Underwriters Laboratories for the American Iron and Steel Institute in 1972 (Cohn, B., *Automobile Burn-Out Test in an Open Air Parking Structure*, Gage-Babcock and Associates, Westchester, IL, 1972). Here, fire tests were carried out in an open parking garage with three cars parked side-by-side with a distance of only 2 ft between the cars. Each car was filled with 10 gallons of gas. There were no sprinklers in the building. During the fire tests, the fire was confined to the car of fire origin with the only spread to an adjacent car being the non-sustained ignition of a plastic taillight. This report concluded:

> "During 48 minutes of uncontrolled burning, fire completely gutted the test car. From front to back essentially all combustible materials have been consumed; nevertheless, about two quarts of gasoline, out of ten gallons at the start of the test, remained in the gas tank. There was no leakage at the seams of the gas tank, and later examination of the tank did not reveal any rupture" (Cohn, 1972, p. 12).

In 1976, fire tests in an underground garage were conducted by the Fire Prevention Service for Industry and Trade in Zurich, Switzerland. An article about the tests written in 1977 for *Fire International* magazine described the tests and conclusions (Bambert, A.E., "Fire protection in underground premises," *Fire International*, Vol. 5 No. 55, pp 35-41, 1977). These tests evaluated the use of fire sprinklers within a garage, and while specific information on the design of the fire sprinkler system used in the tests was not provided, but it is reasonable to believe that it was comparable to an ordinary hazard system because of the discussion earlier in the article of fuel loads in parking structures. Specifically, the article states, "the fire load in such car parks is not very high (according to a British survey, it is approximately 17 kg wood/m2)." The report goes on to conclude:

"Automatic extinguishing systems, e.g. sprinklers, reduce the burning rate and prevent the fire from spreading to nearby vehicles, but do not extinguish a fire in the interior of a car."

In 1977, the American Iron and Steel Institute commissioned a study comparing steel fuel tanks to plastic fuel tanks in cars (Belles, Donald, *Full-Scale Exploratory Fire Tests Involving Steel and Plastic Automotive Fuel Tanks*, Belles and Associates, Madison, TN, 1977). The study consisted of a free-burn of a plastic fuel tank and a full-scale burn of three cars, two of which had been retrofitted with plastic fuel tanks specifically for the test. During the free burn of the plastic tank, the tank was exposed to a spill fire. The tank did ignite and burn:

> "As the tank shell was consumed, the tank wall weakened and the weight of the contents caused failure of the tank, resulting in 'dumping' of the tank contents".

During the full-scale fire tests, one of the cars with the plastic fuel tank was ignited. The fire did involve the fuel in the tank and spread to adjacent cars. It must be stressed that these tests were carried out without any sprinkler protection.

It would be easy to conclude from these tests that, so long as automakers avoid plastic gas tanks, fires in vehicles within parking structures do not spread to adjacent vehicles. However, the potential for fires to spread from vehicle to vehicle even without plastic gas tanks was demonstrated as recently as a July 2001 fire in New South Wales, Australia. A fire that originated in a street level open car park quickly spread from the vehicle of origin to six other vehicles and adjacent combustibles, then through the open sides of the garage to involve seven other garages, also damaging six adjacent residential units.

Upcoming NFSA Technical Tuesday Online Seminar

Topic: Sprinkler Temperature Ratings
Instructor: Kenneth E. Isman, P.E.
Date: September 13, 2005

Although ordinary temperature sprinklers are encouraged in most circumstances, there are a number of locations where higher temperature classification sprinklers are required or where their use would be advantageous to the design of the system. This program will cover the requirements of where higher temperature sprinklers are required and where they can be used to improve the design of the system.

Other Training Opportunities Available from NFSA Engineering

Inspection and Testing NICET Level 2 Review Seminar

November 4-6, 2005 – Warwick, RI
November 29-December 1, 2005 – Dallas/Ft. Worth, TX

Advanced Technician Training Seminar

October 4-6, 2005 – St. Louis, MO

For information and registration for all seminars visit www.nfsa.org.