APPENDIX

SAFETY OF FIREWALL PENETRATIONS IN HIGH-RISE BUILDING

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Many significant high-rise fires have occurred in years past where the rapid spread of fire and smoke have resulted in numerous fatalities, injuries and property loss. In a number of these fire incidents, the smoke and fire were quickly transported upwards throughout the building by vertical penetrations between floors. Fundamental concepts of fire protection are to prevent such multi-level spread of fire and to contain its spread to the area of fire origin. Examples of some of these historic fires that underscore the tragic results when these fundamental concepts are not achieved with structures include: the MGM Grand Hotel fire on November 21, 1980 (84 dead, 679 injured), the Las Vegas Hilton fire on February 10, 1981 (8 dead, 200 injured), the Dupont Plaza fire on December 31, 1986 (91 dead, 146 injured), and the One Meridian Plaza fire on February 21, 1991 (3 firefighter fatalities, 24 firefighters and 1 civilian injured) and most recently the Chicago high-rise fire last year (6 dead, 13 injured).

In an effort to limit fire and smoke spread, present day building codes attempt to compartmentalize buildings through the use of fire-rated assemblies. Building codes require that all penetrations through these assemblies be fire stopped in such a way that the assembly retains its intended fire rating. Section 1505.2 of the 2003 Uniform Plumbing Code states that, "when penetrating a fire-resistance-rated wall, partition, floor, floor-ceiling assembly, roof-ceiling assembly, or shaft enclosure, the fire resistance rating of the assembly shall be restored to its original rating with a material or product tested to standard(s) referenced in Chapter 14 and at an independent testing agency acceptable to the Authority Having Jurisdiction." Combustible materials (such as plastic pipe) penetrating these fire rated assemblies are of particular concern because when exposed to fire they will burn and decompose or melt, thereby creating a void in the assembly that is capable of spreading fire and combustion products upwards. For example, ASTM E814 "Standard Test Method for Five Tests of Through-Penetration Fire Stops" requires a temperature rise to 1000°F within the first five minutes of the test. Thus, both ABS and PVC pipe are destroyed within the first several minutes of this simulated fire test. In addition, the proximity of the combustible plastic piping to the fire rated assembly is also of concern towards additional fire spread. Section 8.8.6.1 of the 2003 edition of NFPA 5000, *Building Construction and Safety Code*, states that, "where piping penetrates a fire resistance-rated wall or floor assembly, combustible piping shall not connect to noncombustible piping within 36 in. (914 mm) of the firestop system or device unless it can be demonstrated that the transition will not reduce the fire resistance rating." Furthermore, PVC and ABS pipe can be harmful to humans when exposed to fire because their decomposition produces toxic gases.

More specific concerns include the following:

1. The thermal expansion of both PVC and ABS are more than five times as large as cast iron. The current Uniform State Plumbing Code requires expansion joints for PVC but not for ABS. Apparently ABS expansion joints are not available, but if such stress relief is necessary for PVC, it should be necessary for ABS, as well.

2. Although the Plastic Pipe and Fittings Association published a guide in 1997 for the installation of plastic pipe in fire restrictive construction, which guide listed 1,118 assemblies for dealing with protection of penetration in firewalls, a careful review reveals the following:

   a. Of the 1,118 approved penetration assemblies, only 30 apply to PVC Schedule 40 (ASTM F891) and ABS Schedule 40 (ASTM F628). Of these 30, only nine are for use in concrete penetrations.

   b. For PVC there are four 4 inch penetration assemblies, and for ABS there are three 4 inch, one 2 inch, and one 1 1/2 inch penetration assemblies. There are no assemblies for pipe larger than 4 inch. Since buildings higher than ten stories are likely to use DWV piping in sizes larger than 4 inch, there is a serious concern whether the fire rated construction assemblies which are universally required, even exist.

3. In 1998 Underwriters Laboratories published 927 pages of approved fire stop penetration. However, for Schedule 40 PVC and ABS, only 56 assemblies were found, although there were nine assemblies listed for 6-inch pipe.

4. With so many different assemblies, and without a full range of pipe size assemblies available, the designer, contractor and inspector face significant problems specifying the penetration and ensuring that it is installed correctly.

5. It is our understanding that there is a significant level of non-compliance with regard to plastic pipe fire stop penetrations. In addition, improper installation is also a problem noted by the manufacturers of these assemblies.

6. It is not clear that the current Uniform State Plumbing Code requirement in Section 2.06(n) 13 of a 20-inch metal sleeve surrounding the plastic pipe is effective as a fire stop. Once the plastic is gone (within the first few minutes) a hole still remains allowing the fire to communicate with the adjacent compartment.

7. Although the Massachusetts State Building Code Section 707.7.3 requires that penetrations be approved per ASTM 814, no such provision exists in the Uniform State Plumbing Code.

8. The thermal and physical properties of metallic and plastic DWV pipe are substantially different. Cast iron pipes have a much higher heat capacity, thermal conductivity, melting temperature, and strength at elevated temperatures. Cast iron pipe is non-combustible in air. An open vertical metal pipe with flames or hot combustion gases inside will tend to cool or quench the combustion. Under identical circumstances, plastic DWV pipe will melt or burn or both.

Finally, it has been claimed that other jurisdictions allow unrestricted use of plastic DWV pipe. This is not correct. North Carolina, California and Kentucky have restrictions based on height of the building. Other states, such as New York, restrict the use to single or two family residential construction. When New York adopted the International Code, they not only restricted use of plastic pipe but they added an entire chapter on the proper installation and inspection of plastic pipe in fire rated construction.

Thus, containing a fire to the compartment of fire origin is not only fundamental to insuring the life safety of the building's occupants and ensuring continuous operation of business operations, but it is also important to the health and safety of firefighters who respond to the fire incident.

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Professor Eagar received his B.S. and Sc.D. degrees from the Massachusetts Institute of Technology (M.I.T.) in 1972 and 1975, respectively. Following graduation, he worked with the Homer Research Laboratories of Bethlehem Steel Corporation from 1974 to 1976, after which he returned to M.I.T. as a faculty member, where he rose through the ranks to his current position as Thomas Lord Professor of Materials Engineering and Engineering Systems. In 1984 and 1985, he served as a liaison scientist with the Office of Naval Research-Far East in Tokyo, Japan. In 1995, he served for five years as the Head of the Department of Materials Science and Engineering at M.I.T.

Among his many citations, Dr. Eagar has received the Adams Memorial Membership Award of the American Welding Society (AWS) (1979), the Charles H. Jennings Memorial Medal Award of AWS (1983, 1991, 2003), the Champion H. Mathewson Gold Medal of AIME (1987), the Warren F. Savage Award of AWS (1990 and 1996), the William Spraragen Memorial Award of AWS (1990 and 1993), the Silver Quill Award of AWS in 2002, and the Henry Marion Howe Medal of ASM International (1992). He was the Henry Krumb Lecturer of AIME in 1987, and was elected an ASM Fellow in 1989, an AWS Fellow in 1994, and an AAAS Fellow in 2003. He received an Honorary Membership in AWS in 1999. In 1993, he received the William Irrgang Award of AWS. In 1990, he delivered the Houdremont Lecture at the International Institute of Welding, and in 1992 he delivered the AWS Comfort A. Adams Lecture. In 1993, he presented the conference keynote address at the American Society for Nondestructive Testing. He delivered the Nelson W. Taylor Lecture at Penn State University in 1995 and the General Electric Distinguished Lecture at Rensselaer Polytechnic Institute in 2001. In 1997, he was elected a member of the National Academy of Engineering. In June 2003, he testified before Congress on manufacturing employment in the United States.

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Thomas J. Klem is currently the president of a full service fire protection engineering firm, T. J. Klem and Associates, LLC. Mr. Klem holds a Master of Fire Protection Engineering from Worcester Polytechnic Institute, in Worcester MA, and is a certified fire investigator from the International Association of Arson Investigators (IAAI). Before forming his fire protection consulting business Mr. Klem was the Direction of Fire Investigations for the National Fire Protection Association (NFPA). While with NFPA, Mr. Klem conducted fire protection engineering analyses of The Dupont Plaza, One Meridian Plaza, World Trade Center, high-rise building fires (among other major fire incidents), and thus has firsthand experiences and knowledge regarding the fundamental fire protection issues governing adequate prevention of multiple-floor spread of fire and its toxic byproducts in various construction configurations.

Mr. Klem has over thirty years of experience in diverse and practical application of principles of fire protection engineering to various construction and other applications, coupled with his formal education and professional achievements, has brought Mr. Klem to be considered one of the leading experts in the field of fire protection engineering.