FIRE TEST PROTOCOL FOR TESTING POLYMER PIPE IN FIRE RATED
FLOOR, FLOOR/CEILING AND WALL ASSEMBLIES

Client
Polymer Piping Council of Canada
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FIRE TEST PROTOCOL FOR TESTING POLYMER PIPE IN FIRE RATED FLOOR, FLOOR/CEILING AND WALL ASSEMBLIES

SECTION – A. GENERAL

1. SCOPE

The purpose of this fire-test protocol is to define requirements for laboratories accredited by the Standards Council of Canada (SCC) to evaluate and certify polymer pipes as part of fire-rated floor, floor/ceiling and wall assemblies, evaluated in accordance with CAN/ULC-S101, Standard Methods of Fire Endurance Tests of Building Construction and Materials, as prescribed in subsection 3.1.7 of the 1995 edition of National Building Code of Canada.

2. DEFINITION OF TERMS

Combustible – A material that fails to meet the acceptance criteria of CAN4-S114, “Standard Method of Test for Determination of Non-Combustibility in Building Materials”.

Degree of Combustibility – A classification system involving several parameters related to heat release rate, supplemented by parameters related to smoke release. At the time of writing this protocol, building code authorities are evaluating setting quantitative values which will establish boundaries between different classes of combustible material. (For the purpose of this protocol heat release rate shall be the measure for determining, degrees of combustibility).

Fire Endurance – A measure of elapsed time during which a building element continues to exhibit fire resistance under specified condition of test and performance. As applied to elements of building, it is measured by the methods and to the criteria defined in CAN/ULC-S101, Standard Methods of Fire Endurance Tests of Building Construction and Materials.

Fire Resistance Period – The time assigned in hours or fraction thereof (normally 45 minutes, 1, 1.5, 2, 3 and 4 hours) that a building element shall withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria as set out in CAN/ULC-S101, Standard Methods of Fire Endurance Tests of Building Construction and Materials, or as determined by extension or interpretation of information derived therein.

Floor/Ceiling Plenum – The space between the soffit of the floor deck and the ceiling below.

Heat Release Rate – The heat evolved from the specimen, per unit of time, when tested in accordance with CAN/ULC-S135, Standard Method of Test For Determination of Degrees of Combustibility of Building Materials Using an Oxygen Consumption Calorimeter (Cone Calorimeter).

Listed Assembly – Assembly of building elements evaluated by an accredited certification organization where the components used for the manufacturing of the assembly are manufactured under an agreement between the certification organisation and the component manufacturer.
3. **INTRODUCTION**

Polymer pipes are manufactured in various types. This fire test protocol is applicable to the generic polymer pipe installed in fire-rated floor, floor/ceiling and wall assemblies. Polymer pipes types; PEX (Cross-linked polyethylene), PEX-AL-PEX (Cross-linked polyethylene/aluminum/cross-linked polyethylene) and PE-AL-PE are the commonly used polymer pipes for radiant floor heating, hydronic systems, and for conveying potable water. Sections B, C and D respectively, of this fire test protocol relate to the evaluation of PEX, PEX-AL-PEX pipes and PE-AL-PE, as part of fire-rated assemblies.

Since polymer pipe is combustible, the presence of polymer pipe in the cavities of fire rated floor/ceiling and wall assemblies add a fuel load that may effect the fire endurance properties of the assemblies. Polymer pipe installed in concrete floors create voids that affect heat transmission through the concrete that in turn may adversely affect the fire endurance of concrete floors.

The following properties of polymer pipes would influence the fire rating of the assemblies that the polymer pipes are installed in:

A. Ignition Temperature – Floor/ceiling plenum and cavities in walls in a fire test would be subject to elevated temperatures. Since the fuel load of polymer pipe is of concern after the pipe has ignited, the ignition temperature would provide information about the approximate time in a fire test the fuel load of the polymer pipe would impact the fire resistance of the assembly;

B. Heat Release Rate – polymer pipe installed in floor/ceiling plenum and cavities in walls in a fire test would be subject to elevated temperatures. During a fire the polymer pipe may ignite. Information about the heat release rate would provide an indication about the polymer pipes that contribute the most fuel during the fire test. In Canada, the current building code evaluates materials as being combustible or non-combustible. However the building codes are being reviewed to classify products in accordance with their degree of combustibility. The cone calorimeter is an essential test required to classify degree of combustibility of polymer pipe; and

C. Sag Properties of Pipes at Elevated Temperatures - polymer pipe installed in floor/ceiling plenum and cavities in walls in a fire test would be subject to elevated temperatures. At elevated temperatures, prior to ignition, polymer pipe would soften, resulting in the pipe sagging. Polymer pipe that may sag to the point where they come in contact with the ceiling or wall sheathing would impose a weight on the sheathing; this would lead to premature failure of the sheathing. Installation practise which specifically support spacing may affect sag.

In addition to the above polymer pipe characteristics, the layout and the quantity of polymer pipes in an assembly will also have an effect on the fire rating of the assembly.

In concrete floor systems, ignition temperature, heat release rate and sag properties of polymer pipes would not significantly impact the fire resistance properties of concrete floor systems. The number, size and layout of polymer pipes is important as these pipes would form cavities in concrete and would affect heat transmission.
4. BACKGROUND INFORMATION ABOUT EVALUATION OF FIRE RESISTANCE AND GENERAL DETAILS OF FIRE RATED ASSEMBLIES

Fire resistance of floor, floor/ceiling and wall assemblies are evaluated in accordance with CAN/ULC-S101, Standard Methods of Fire Endurance Tests of Building Construction and Materials. In this Standard, test specimens of sizes specified in the Standard are placed in a furnace and exposed to a standard fire that is defined by the time-temperature curve as illustrated below.

During the fire test, assemblies that are intended to be load bearing are tested under load. After the fire test, wall assemblies are exposed to impact and cooling effect of water discharged through a fireman's hose at a specific pressure for a specified duration depending on the duration of the fire test.

Assemblies are considered to acquire a specific fire rating provided they meet all of the following criteria:

A. The assembly withstands the fire endurance test without passage of flame and/or hot gasses;
B. The temperature of the assembly away from the fire (unexposed side) shall not have exceeded a temperature of 180°C for any individual thermocouple (TC) or 140°C for the average temperature measured by the thermocouple specified in the Standard; and.

C. The wall assembly withstood the hose stream test without passage of hose stream.

It is important to note that the fire rating registers the performance during the period of exposure and should not be construed as having determined suitability for use after fire exposure.

Typical non-combustible floor/ceiling assembly listed with ULC in which polymer pipe would be installed in the ceiling plenum is illustrated below:
Typical combustible floor/ceiling assembly listed with ULC in which polymer pipe would be installed in the ceiling plenum is illustrated below:

![Diagram of a combustible floor/ceiling assembly with wood subfloor, wood joist, and gypsum wallboard ceiling.]

Typical ULC listed wall assembly in which polymer pipe would be installed in the wall cavity is illustrated below:

![Diagram of a ULC listed wall assembly with gypsum wallboard and wall studs.]
Fire resistance of structural concrete floor assemblies are normally established based on specifications stated in Building Codes. The governing criteria for concrete floor systems are the thickness of concrete and the amount of concrete cover to the reinforcing steel.

Typical concrete floor assembly in which polymer pipe would be installed is illustrated below:

![Concrete Slab and Reinforcing Steel Diagram]

5. **EVALUATION OF POLYMER PIPE PROPERTIES**

5.1 **IGNITION TEMPERATURE**

Ignition temperature of polymer pipe is determined in accordance with ASTM D1929- Standard Method for Determining Ignition Temperature of Plastics. All polymer pipe material shall be tested to obtain ignition temperature.

5.2 **EVALUATION OF HEAT RELEASE RATE**

All polymer pipe material shall be tested in accordance with CAN/ULC-S135, Standard Method of Test for Determination of Degrees of Combustibility of Building Material Using an Oxygen Consumption Calorimeter (Cone Calorimeter). Results from the cone calorimeter test shall determine an upper bound limit placed on the polymer pipe for the fire resistance test.

5.3 **SAG PROPERTIES**

Polymer pipe softens with rise in temperature. For a given type of polymer pipe, the amount of sag depends on the diameter of pipe, spacing of supports and temperature. The specific temperature for evaluating sag properties shall be the temperature prior to fall-off of the membrane protection in a floor/ceiling assembly. Sag properties are not considered to be significant in cases where the pipe is installed within concrete.

Sag properties shall be determined by measuring deflection of the polymer pipe at temperatures that are measured in the cavities of floor/ceiling and walls during a fire test. Sag properties shall be evaluated for the full range of diameter for different support spacing that is typical for field installation.
The test shall be conducted in the small-scale floor furnace. The small-scale furnace is capable of testing a 4 ft by 9 ft specimen. The temperature of the furnace shall simulate the time temperature of the temperature in the plenum of a floor/ceiling system prior to the fall-off of the ceiling membrane. Monitoring the deflection of the pipe during the fire test is critical and shall be measured during the test.

SECTION – B. PEX (CROSS-LINKED POLYETHYLENE) PIPES

1. GENERAL

This section states requirements specific to PEX pipes used for radiant floor heating, hydronic heating distribution systems, and for conveying potable water, as part of fire-rated assemblies.

2. SELECTION OF PEX PIPE FOR FIRE TEST

PEX pipe selected for the test program shall be based on the result of the ignition temperature, heat release rate and sag properties as stated in Section A — General. If the most adverse property is not exhibited by one type and size of PEX pipe, tests shall be conducted on all PEX pipes that exhibit the worst property in any one of the above categories.

3. REPRESENTATIVE FIRE RESISTANT ASSEMBLIES

Representative assemblies are determined based on floor, floor/ceiling assemblies and wall systems that PEX pipe is normally installed in for the purpose of floor heating, hydronic heating distribution and for conveying of potable water.

The representative assemblies shall be as follows:

A. Concrete floor assembly with a 2-h fire rating;
B. Combustible and non-combustible floor/ceiling assemblies with a 1-h and 2-h fire rating;
C. Combustible and non-combustible load bearing and non-load-bearing 1-h fire rated stud wall assemblies protected with gypsum wallboard.

4. REPRESENTATIVE LOADING OF PEX PIPE

The loading (number, size and distribution of PEX pipe) is determined based on requirements to provide the intended service.

For the purpose of this test protocol, the cross sectional area and amount of plastic material in the PEX pipe are important because these two properties represent the amount of voids that the pipe would create in a concrete floor and the amount of combustible materials that the PEX pipe would provide.

See Table 1 below for PEX pipe diameter, wall thickness, volume and weight per foot. Pipe properties are based on ASTM F876, Standard Specification for Crosslinked Polyethylene Tubing)
### Table 1.

<table>
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<tr>
<th>Nominal Tubing Size (in.)</th>
<th>Avg Outside Diameter (in.)</th>
<th>Average Wall thickness (in.)</th>
<th>Volume of material (cubic inch per ft)</th>
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5. **REPRESENTATIVE LOADING OF POTABLE WATER AND HYDRONIC HEATING DISTRIBUTION PEX PIPE IN FLOOR AND FLOOR/CEILING ASSEMBLIES**

For potable water distribution, 1/2 inch OD to 2-1/8 inches OD are used for horizontal runs. At manifold locations, the PEX pipe spacing is as close as 1-1/2 inches. Maximum numbers of pipes at the manifold are twenty four. PEX pipes for potable water distribution are located over the bottom layer of reinforcing steel. All PEX pipe installed in concrete are sleeved with utility grade polyethylene sleeves. In floor/ceiling assemblies, PEX pipe placed parallel to floor joists are attached to the floor joists with steel staples. The minimum distance from the top of the protection membrane to the PEX pipe shall be established based on tests that determine sag characteristics.

6. **RADIANT HEAT PEX PIPES IN FLOOR ASSEMBLIES**

PEX pipe with utility grade polyethylene sleeves for radiant heating are installed in representative reinforced concrete floor systems. The pipes are sleeved only at entry and exit points of the slab. Normal pipe sizes vary between 1/2 inch OD to 2-1/8 inches OD at spacings varying from 3 inch to 12 inches apart. At the manifold, a maximum of twenty four pipes converge together. The main concern of PEX pipes installed within a concrete slab is dependent on the amount of pipe since the amount of pipe relates directly with the maximum voids introduced in the concrete. Voids in concrete shall have a direct bearing on the fire resistance performance of the concrete floor system.

7. **POTABLE WATER, HYDRONIC HEATING DISTRIBUTION AND RADIANT FLOOR HEATING PEX PIPE IN WALL ASSEMBLIES**

The maximum loading of pipes in a wall assembly are pipes for the manifold. The largest diameter of pipes spaced adjacent to each other constitute the worse case pipe loading. The pipes are located close to the gypsum wallboard that is exposed to the fire.
Both load-bearing and non-load-bearing wall assemblies framed with wood studs shall be evaluated. Test data derived from the fire test shall be extended to wall systems with steel stud framing.

8. TESTING FOR CORRELATION

Results of ignition temperature, cone calorimeter and sag evaluation tests shall be analysed to arrive at a relationship that shall identify the critical combination fire characteristics (CCFC) of PEX pipe. CCFC shall then be evaluated in combination with different amounts of PEX pipes in small-scale and full-scale fire tests to determine if a relationship can be established between the full-scale and small-scale fire tests.

A small-scale test shall also be conducted with the PEX pipe filled with water to ascertain the worse case test requirements.

A small-scale test shall be conducted on a floor/ceiling assembly without any pipe to determine the control criteria. Subsequent tests shall be conducted on floor/ceiling assemblies at various pipe loadings to ascertain the reduction in fire endurance. Tests shall be conducted at maximum pipe loading as determined by field application requirements. If the results at full pipe loading detract significantly from the fire endurance period, additional testing shall be conducted at other pipe loadings to determine the decrease in fire endurance.

Similarly, small-scale tests shall be conducted on concrete assemblies with PEX pipe at the maximum loading as determined by field application requirements to determine the loss of fire endurance. If the results at full pipe loading detract significantly from the fire endurance period, additional testing shall be conducted at other pipe loadings to determine the decrease in fire endurance.

The pipe in the small-scale fire test shall be distributed uniformly to resemble as close as possible the distribution in the field. In the middle of the assembly, PEX pipes representing the manifold shall be constructed to simulate the effect of the manifold.

9. FULL SCALE TESTING

To validate the small-scale test results, full-scale fire tests in accordance with CAN/ULC-S101, Standard Method of Fire Endurance Tests of Building Construction and Materials, shall be conducted on:

A. 1-h and 2 h wood framed floor/ceiling assembly;
B. 2-h concrete floor assembly;
C. 1-h wood frame load-bearing wall assembly.

The pipe in the full-scale tests shall be distributed uniformly to resemble as close as possible the distribution in the field. In the middle of the floor assembly, PEX pipes representing the manifold configuration shall be constructed to simulate the effect of the manifold.

10. EVALUATION OF SMALL-SCALE AND FULL-SCALE TEST DATA

The fire resistance assigned to assemblies listed in ULC Directories are based on full-scale fire tests in accordance with CAN/ULC-S101. The fire resistance of the test specimen in a fire test
is listed in increments of 30 minutes, therefore, an assembly that has a fire endurance of 70 minutes is listed by ULC as an assembly with a fire resistance of 1-hour. The difference in the fire endurance and the listed fire resistance of assemblies shall be reviewed to ascertain if a factor of safety exists in the listed assemblies that could accommodate the reduction in fire endurance due to the presence of PEX pipes.

SECTION – C. PEX-AL-PEX (CROSS-LINKED POLYETHYLENE/ALUMINUM/CROSS-LINKED POLYETHYLENE) PIPES

1. GENERAL

This section states requirements specific to PEX-AL-PEX pipes used for radiant floor heating, hydronic heating distribution systems, and for conveying potable water, as part of fire-rated assemblies.

2. SELECTION OF PEX-AL-PEX PIPE FOR FIRE TEST

PEX-AL-PEX pipe selected for the test program shall be based on the result of the ignition temperature, heat release rate and sag properties as stated in Section A, General. If the most adverse property is not exhibited by one type and size of PEX-AL-PEX pipe then tests shall have to be conducted on all PEX-AL-PEX pipes that exhibit the worst property in any one of the above categories.

3. REPRESENTATIVE FIRE RESISTANT ASSEMBLIES

Representative assemblies are determined based on floor, floor/ceiling assemblies and wall systems that the PEX-AL-PEX pipes are normally installed for the purpose of floor heating, hydronic and for conveying of potable water.

The representative assemblies selected be as follows:

A. Concrete floor assembly with a 2-h fire rating;

B. Combustible and non-combustible floor/ceiling assemblies with a 1-h and 2-h fire rating;

C. Combustible and non-combustible load bearing and non-load-bearing 1-h fire rated stud wall assemblies protected with gypsum wallboard.

4. REPRESENTATIVE LOADING OF PEX-AL-PEX PIPE

The loading (number, size and distribution of PEX-AL-PEX pipe) is determined based on requirements to provide the intended service.

For the purpose of this test protocol, the cross sectional area and amount of plastic material in the PEX-AL-PEX pipe are important because these two properties represent the amount of voids that the pipes would create in a concrete floor and the amount of combustible materials that the PEX-AL-PEX pipes would provide.

PEX-AL-PEX pipe properties are stated in ASTM F1281-02 (Standard Specification for Crosslinked Polyethylene/Aluminum/ Crosslinked Polyethylene) Pressure Pipe.
5. **REPRESENTATIVE LOADING OF POTABLE WATER, HYDRONIC HEATING DISTRIBUTION AND PEX-AL-PEX PIPE IN FLOOR AND FLOOR/CEILING ASSEMBLIES**

For potable water distribution, 1/2 inch OD to 2-1/8 inches OD are used for horizontal runs. At manifold locations, the PEX-AL-PEX pipe spacing is as close as 1-1/2 inches. Maximum numbers of pipes at the manifold are twenty four. PEX-AL-PEX pipes for potable water distribution are located over the bottom layer of reinforcing steel. All PEX-AL-PEX pipes installed in concrete are sleeved with utility grade polyethylene sleeves. In floor/ceiling assemblies, PEX-AL-PEX pipe placed parallel to floor joists are attached to the floor joists with steel staples. The minimum distance from the top of the protection membrane to the PEX-AL-PEX pipe shall be established based on tests that determine sag characteristics.

6. **RADIANT HEAT PEX-AL-PEX PIPES IN FLOOR ASSEMBLIES**

PEX-AL-PEX pipes with utility grade polyethylene sleeves for radiant heating are installed in representative reinforced concrete floor system. Normal pipes sizes vary between 1/2 inch OD to 2-1/8 inches OD at spacing varying from 3 inches to 12 inches apart. At the manifold, a maximum of twenty four pipes come together. The main concern of PEX-AL-PEX pipes installed within concrete is dependent on the amount of pipe since the amount of pipe relates directly with the maximum voids introduced in the concrete. Voids in concrete shall have a direct bearing on the fire resistance performance of the concrete floor system.

7. **POTABLE WATER & RADIANT FLOOR HEATING PEX-AL-PEX PIPES IN WALL ASSEMBLIES**

The maximum loading of pipes in a wall assembly are pipes for the manifold. The largest diameter of pipes spaced adjacent to each other constitute the worse case pipe loading. The pipes are located close to the gypsum wallboard that is exposed to the fire.

Both load-bearing and non-load-bearing wall assemblies framed with wood studs shall be evaluated. Test data derived from the fire test shall be extended to walls with steel stud framing.

8. **TESTING FOR CORRELATION**

Results of ignition temperature, cone calorimeter and sag evaluation tests shall be analysed to arrive at a relationship that shall identify the critical combination of fire characteristics (CCFC) of PEX-AL-PEX pipe. CCFC shall then be evaluated in combination with different amounts of PEX-AL-PEX pipe in small-scale and full-scale fire tests to determine if a relationship can be established between the full-scale and small-scale fire test.

A small-scale test shall also be conducted with the PEX-AL-PEX pipe filled with water to ascertain the worse case test requirements.

A small-scale test shall be conducted on a floor/ceiling assembly without any pipe to determine the control criteria. Subsequent tests shall be conducted on floor/ceiling assemblies at various pipe loadings to ascertain the reduction in fire endurance. Tests shall be conducted at maximum pipe loading as determined by field application requirements. If the results at full pipe loading detract significantly from the fire endurance period, additional testing shall be conducted at other pipe loadings to determine the decrease in fire endurance.
Similarly, small-scale tests shall be conducted on concrete assemblies with PEX-AL-PEX pipe at the maximum loading as determined by field application requirements to determine the loss of fire endurance. If the results at full pipe loading detract significantly from the fire endurance period, additional testing shall be conducted at other pipe loadings to determine the decrease in fire endurance.

The pipe in the small-scale fire test shall be distributed uniformly to resemble as close as possible the distribution in the field. In the middle of the assembly, PEX-AL-PEX pipes representing the manifold shall be constructed to simulate the effect of the manifold.

9. FULL SCALE TESTING

To validate the small-scale test results, full-scale fire tests in accordance with CAN/ULC-S101, Standard Method of Fire Endurance Tests of Building Construction and Materials, shall be conducted on:

A. 1-h and 2-h wood framed floor/ceiling assembly;
B. 2-h concrete floor assembly;
C. 1-h wood frame load-bearing wall assembly.

The pipe in the full-scale tests shall be distributed uniformly to resemble as close as possible the distribution in the field. In the middle of the floor assembly, PEX-AL-PEX pipe representing the manifold configuration shall be constructed to simulate the effect of the manifold.

10. EVALUATION OF SMALL-SCALE AND FULL-SCALE TEST DATA

The fire resistance assigned to assemblies listed in ULC Directories are based on full-scale fire tests in accordance with CAN/ULC-S101, Standard Method of Fire Endurance Tests of Building Construction and Materials. The fire resistance of the test specimen in a fire test is listed in increments of 30 minutes, therefore, an assembly that has a fire endurance of 70 minutes is listed by ULC as an assembly with a fire resistance of 1-hour. The difference in the fire endurance and the listed fire resistance of assemblies shall be reviewed to ascertain if a factor of safety exists in the listed assemblies that could accommodate the reduction in fire endurance due to the presence of PEX-AL-PEX pipes.

SECTION – D      PE-AL-PE (POLYETHYLENE/ALUMINUM/POLYETHYLENE) PIPE

1. GENERAL

This section states requirements specific to PE-AL-PE pipes used for radiant floor heating, hydronic heating distribution systems, and for conveying potable water, as part of fire-rated assemblies.

2. SELECTION OF PE-AL-PE PIPE FOR FIRE TEST

PE-AL-PE pipe selected for the test program shall be based on the result of the ignition temperature, heat release rate and sag properties as stated in Section A. If the most adverse property is not exhibited by one type and size of PE-AL-PE pipe then tests would have to be
conducted on all PE-AL-PE pipes that exhibit the worst property in any one of the above categories.

3. **REPRESENTATIVE FIRE RESISTANT ASSEMBLIES**

Representative assemblies are determined based on floor, floor/ceiling assemblies and wall systems that the PE-AL-PE pipes are normally installed for the purpose of floor heating, hydronic and for conveying of potable water.

The representative assemblies selected shall be as follows:

   A. Concrete floor assembly with a 2-h fire rating;

   B. Combustible and non-combustible floor/ceiling assemblies with a 1-h and 2-h fire rating;

   C. Combustible and non-combustible load bearing and non-load-bearing 1-h fire rated stud wall assemblies protected with gypsum wallboard.

4. **REPRESENTATIVE LOADING OF PE-AL-PE PIPE**

The loading (number, size and distribution of PE-AL-PE pipe) is determined based on requirements to provide the intended service.

For the purpose of this test protocol, the cross sectional area and amount of plastic material in the PE-AL-PE pipe are important because these two properties represent the amount of voids that the pipes would create in a concrete floor and the amount of combustible materials that the PE-AL-PE pipes would provide.

5. **REPRESENTATIVE LOADING OF POTABLE WATER, HYDRONIC HEATING DISTRIBUTION AND PE-AL-PE PIPE IN FLOOR AND FLOOR/CEILING ASSEMBLIES**

For potable water distribution, 1/2 inch OD to 2-1/8 inches OD are used for horizontal runs. At manifold locations, the PE-AL-PE pipe spacing is as close as 1-1/2 inches. Maximum numbers of pipes at the manifold are twenty four. PE-AL-PE pipes for potable water distribution are located over the bottom layer of reinforcing steel. All PE-AL-PE pipes installed in concrete are sleeved with utility grade polyethylene sleeves. In floor/ceiling assemblies, PE-AL-PE pipe placed parallel to floor joists are attached to the floor joists with steel staples. The minimum distance from the top of the protection membrane to the PE-AL-PE pipe shall be established based on tests that determine sag characteristics.

6. **RADIANT HEAT PE-AL-PE PIPES IN FLOOR ASSEMBLIES**

PE-AL-PE pipes with utility grade polyethylene sleeves for radiant heating are installed in representative reinforced concrete floor system. Normal pipe sizes vary between 1/2 inch OD to 2-1/8 inches OD at spacing varying from 3 inches to 12 inches apart. At the manifold, a maximum of twenty-four pipes come together. The main concern of PE-AL-PE pipes installed within concrete is dependent on the amount of pipe, since the amount of pipe relates directly with the maximum voids introduced in the concrete. Voids in concrete shall have a direct bearing on the fire resistance performance of the concrete floor system.
7. **POTABLE WATER & RADIANT FLOOR HEATING**

**PE-AL-PE PIPES IN WALL ASSEMBLIES**

The maximum loading of pipes in a wall assembly are pipes for the manifold. The largest diameter of pipes spaced adjacent to each other constitute the worse case pipe loading. The pipes are located close to the gypsum wallboard that is exposed to the fire.

Both load-bearing and non-load-bearing wall assemblies framed with wood studs shall be evaluated. Test data derived from the fire test shall be extended to walls with steel stud framing.

8. **TESTING FOR CORRELATION**

Results of ignition temperature, cone calorimeter and sag evaluation tests shall be analysed to arrive at a relationship that shall identify the critical combination of fire characteristics (CCFC) of PE-AL-PE pipe. CCFC shall then be evaluated in combination with different amounts of PE-AL-PE pipe in small-scale and full-scale fire tests to determine if a relationship can be established between the full-scale and small-scale fire test.

A small-scale test shall also be conducted with the PE-AL-PE pipe filled with water to ascertain the worse case test requirements.

A small-scale test shall be conducted on a floor/ceiling assembly without any pipe to determine the control criteria. Subsequent tests shall be conducted on floor/ceiling assemblies at various pipe loadings to ascertain the reduction in fire endurance. Tests shall be conducted at maximum pipe loading as determined by field application requirements. If the results at full pipe loading detract significantly from the fire endurance period, additional testing shall be conducted at other pipe loadings to determine the decrease in fire endurance.

Similarly, small-scale tests shall be conducted on concrete assemblies with PE-AL-PE pipe at the maximum loading as determined by field application requirements to determine the loss of fire endurance. If the results at full pipe loading detract significantly from the fire endurance period additional testing shall be conducted at other pipe loadings to determine the decrease in fire endurance.

The pipe in the small-scale fire test shall be distributed uniformly to resemble as close as possible the distribution in the field. In the middle of the assembly PE-AL-PE pipes representing the manifold shall be constructed to simulate the effect of the manifold.

9. **FULL SCALE TESTING**

To validate the small-scale test results, full-scale fire tests in accordance with CAN/ULC-S101, Standard Method of Fire Endurance Tests of Building Construction and Materials, shall be conducted on:

- **A.** 1-h and 2-h wood framed floor/ceiling assembly;
- **B.** 2-h concrete floor assembly;
- **C.** 1-h wood frame load-bearing wall assembly.
The pipe in the full-scale tests shall be distributed uniformly to resemble as close as possible the distribution in the field. In the middle of the floor assembly, PE-AL-PE pipe representing the manifold configuration shall be constructed to simulate the effect of the manifold.

10. EVALUATION OF SMALL-SCALE AND FULL-SCALE TEST DATA

The fire resistance assigned to assemblies listed in ULC Directories are based on full-scale fire tests in accordance with CAN/ULC-S101, Standard Method of Fire Endurance Tests of Building Construction and Materials. The fire resistance of the test specimen in a fire test is listed in increments of 30 minutes, therefore an assembly that has a fire endurance of 70 minutes is listed by ULC as an assembly with a fire resistance of 1 hour. The difference in the fire endurance and the listed fire resistance of assemblies shall be reviewed to ascertain if a factor of safety exists in the listed assemblies that could accommodate the reduction in fire endurance due to the presence of PE-AL-PE pipes.