FIRE PERFORMANCE
Differences Between Elastomeric and Polyethylene/Polyolefin Insulations

Why a 25/50 rating alone does not assure fire safety
1. The Meaning of a 25/50 Rating for Pipe Insulation.
For mechanical insulation, a common fire performance specification is 25/50. This reflects a flame spread rating of 25 or less and a smoke developed rating of 50 or less, according to the ASTM E 84 test which is specified by all building codes for the testing of materials to be used in building construction.

The numbers are indexes, established to allow the comparison of one material to another. However, the numbers alone may not tell the whole story.

In the case of polyethylene/polyolefin insulations, the flame-spread index gives no indication of the effects of melting and dripping of the material during the combustion process. Because they change form, polyethylene/polyolefin materials may burn quite differently from other flexible insulations in their end-use applications.

Long an accepted test method for pipe insulation fire performance, ASTM E 84 and the resulting indexes alone may not assure fire safety in some applications.

2. What Is Polyethylene/Polyolefin Insulation?
Polyolefin materials are polymers that are similar in character to high molecular weight wax. Polyethylenes are a type of polyolefin, comprising a specific chain of carbon-based monomers. As closed-cell materials, polyethylene/polyolefins are used as insulation because of their low water vapor transmission characteristic.

3. Aren’t All Flexible Insulations the Same?
Two distinct types of flexible insulation are available in the market today. These are:
   a) Elastomeric – rubber-based, closed-cell products such as AP Armaflex
   b) Polyethylene/Polyolefin – thermoplastic closed-cell products such as Tubolit

Contrasting the two types of flexible insulations are significant differences in fire performance. These differences are not reflected in the 25/50 rating commonly required for mechanical system insulation, but they can be readily identified through simulated end-use testing.

4. Where Is Fire Performance a Concern?
In commercial construction, insulation fire performance is of concern to code officials and others in areas where the insulation may contribute to a fire and may pose potential danger to life and property. Examples of these areas include long vertical runs or chases and plenum areas. Because of their fire performance characteristics, polyolefin insulations often are not an appropriate choice.

5. ASTM E 84 Tunnel Test – Strengths and Weaknesses in Testing Polyethylene/Polyolefin Pipe Insulation.
The ASTM E 84 Tunnel Test is specified by all US building codes to determine the surface burning characteristics of building materials. In the test, the material to be tested is applied to the ceiling of the apparatus. Intense flame is applied to one end of the specimen and the effects are measured for a period of ten minutes (Figure 1).

Invented in the 1920s, the ASTM E 84 test is not always a reliable predictor of end-use performance. Fire testing professionals caution that the test can yield flame-spread indexes of 25 or less for materials that may perform poorly in simulated-use fire tests. They point out that the ASTM E 84 test makes no allowance for materials that melt and drip when exposed to heat or flame. However, melting and dripping may directly influence the performance of a material.

In fact, when polyethylene/polyolefin insulations are tested, they may literally fall from the ceiling of the E 84 test in a matter of seconds – long before they can be assigned a flame-spread index. Polyethylene/polyolefin materials that have fallen to the floor of the test apparatus burn in molten pools until extinguished.

Because it tests all materials in a horizontal orientation, ASTM E 84 does not always yield results that reflect material performance in a vertical orientation.

6. ASTM Warnings Concerning Polyethylene/Polyolefin Insulation Test Results.
"This test method may not be appropriate for obtaining comparative surface burning behavior of some cellular plastic materials."

Source: ASTM E 84-00, Section 1.4

"Testing of materials that melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed results in low flame spread indices that do not relate directly to indices obtained by testing materials that remain in place."

Source: ASTM E 84-00, Section 1.5
7. **Vertical Pipe Chase Test (TM 232).** The Vertical Pipe Chase Test is a simulated-use fire test that employs a vertical chase 18' x 24' x 8' high. Developed by Armstrong World Industries, the test simulates one of the most severe conditions that could be found in a building: a fire involving multiple insulated pipes in a confined vertical configuration (Figure 3).

The test utilizes a metal enclosure, protected internally with millboard and connected to a horizontal chase. Three 2" iron pipes covered with test insulation are positioned within the vertical chase for testing.

A four-pound wood crib acts as a flame source and is positioned two inches beneath the short horizontal run of the pipe assembly to engulf the elbows in flames. The flame source is directed to attack the pipe elbows, and the flame is transmitted vertically.

The Vertical Pipe Chase Test demonstrates that the fire performance of pipe insulations with the same flame-spread index of 25 or less can differ in a simulated-use test. These differences in performance are not predicted by an ASTM E 84 Tunnel Test.

The Vertical Pipe Chase Test is not intended to suggest the elimination of recognized fire-protection features normally found in vertical pipe chases and required by building codes. As with any fire test, the results may differ if the wall thickness and specific formulation of the materials selected are varied.

8. **Failure Criteria for Vertical Pipe Chase Test.**

Pipe insulations that permit flame spread to the top of the chase are considered to have failed the test. The criteria used are:

a) full involvement of the material

b) transmission of flame over a distance equivalent to a commercial building story

9. **Recognized Simulated End-Use Tests for Fire Performance.**

The Factory Mutual Research Corporation (FMRC) Full-Scale Horizontal Simulated Pipe Chase is a full-scale fire test conducted as a mock-up of a pipe chase containing three 2" NPS pipes covered with a one inch thickness of insulation. If fire does not spread 24 feet in ten minutes, the insulation is considered acceptable (Figure 3).

The FMRC Flammability Test is a piloted ignition test conducted in normal air flow conditions. A 4" x 4" x 3/4" sample of insulation is blackened with wood charcoal and then subjected to a radiant heat source. Fire properties such as chemical heat release rate, mass loss rate and optical density of smoke are then measured as a function of time.

The UBC (Uniform Building Code) 26-3 Room Fire Test is a test method consisting of an 8' x 12' room with an eight-foot ceiling. Test samples consist of two 8' x 8' sections of insulation material forming a corner in which a wood crib ignition source is located. If char does not extend to the outer extremities of the sample within a fifteen-minute period, and smoke levels are not considered excessive, the insulation is considered acceptable (Figure 4).

10. **FMRC Continuing Supervision of Armaflex Insulations.**

Each of the FMRC test methods mentioned in item 9. above are used in the continuing supervision of AP Armaflex. FMRC is the testing arm of Factory Mutual, the largest industrial insurance company in the United States. FMRC evaluates products by examinations and inspections to determine if they satisfy the criteria for approval by FMRC. The examinations and inspections are performed by FMRC engineers and technicians according to FMRC requirements or recognized national or international requirements.

AP Armaflex is the first elastomeric insulation to be approved through continuing supervision by FMRC. The approval covers key insulation performance properties that AP Armaflex must meet or exceed:

- Thermal conductivity: 0.27
- Water vapor permeability: 0.08
- Fire performance: Will not contribute significantly to fire

AP Armaflex insulation carries the Factory Mutual seal of approval.

11. **Long-Term Polyethylene/Polyolefin Performance in Critical Applications.**

Beyond fire performance, there are other concerns when using polyethylene/polyolefin materials. For example, in refrigeration applications, they can melt or deform from heat generated during the defrost cycle. In chilled water and dual temperature systems, they may pull apart because of thermal expansion and contraction. Polyethylene/polyolefin insulations do not have the elastic properties required for these critical applications.

12. **Appropriate Uses for Polyethylene/Polyolefin Insulation.**

Polyethylenes/polyolefins are an appropriate choice for some domestic plumbing applications. In such construction, it is assumed that the building materials surrounding the insulation will be a greater contributor to fire and smoke in total than the insulation.

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**Figure 3. FMRC Full-Scale Horizontal Simulated Pipe Chase Test.**

This horizontal test subjects a specimen to an intense flame twice the size of the ASTM E 84 tunnel test. If the fire does not spread the full distance of 24 feet in a ten-minute period, the insulation is accepted.

**Figure 4. UBC 26-3 Room Fire Test used by FMRC.**

Two adjacent walls are covered with insulation material; a fire is set in a 30-lb. wood crib where the walls join. If char does not extend to the extremities of the sample within a fifteen-minute period, the insulation is accepted.
CONCLUSIONS

1. The Vertical Pipe Chase Test demonstrates that pipe insulations with the same 25/50 rating can differ in simulated end-use performance.

2. The test further illustrates the anticipated fire performance characteristics of elastomeric and polyethylene/polyolefin insulations in a real fire situation.

3. Finally, the test shows that polyethylene/polyolefin insulations may not be appropriate in commercial construction areas where fire performance is a concern, including vertical chases and plenums.
OBSERVATIONS ON FIRE TESTING OF POLYETHYLENE/POLYOLEFIN INSULATIONS

“Polyethylenes and Polyolefins Tend to ‘fool’ the ASTM E 84 Tunnel Test”

“There are two things to keep in mind relative to building codes. First, all building codes are minimum standards—a base level of performance for building materials. Second, they are primarily concerned with providing an index or value for building code officials to follow.

“Not all cellular materials perform in the same way in all situations. Specifically, not all pipe insulation, although it may be the same color and have a 25/50 rating, may perform in the same way under similar circumstances.

“Some materials, such as AP Armaflex insulation, develop a char layer that provides an insulating surface to reduce the contribution to fire. Other materials, such as polyethylene, are thermoplastics that tend to melt and drip and particularly to change form quickly, from a solid when it begins to undergo fire exposure to a combustible pool fire—much like a flammable liquid. As such, the material will burn very differently from what it would have if it had retained its original form.

“Because they melt and drip, polyethylenes and polyolefins tend to “fool” the ASTM E 84 test and can provide misleading results.

“Armstrong World Industries developed the Vertical Pipe Chase Test after it appeared that, within the cellular plastics industry, some inappropriate tests were specified that gave misleading results. One of these tests was the ASTM E 84 Tunnel Test. When exposed to real fires, these thermal plastic materials were shown to behave much differently from what one would have expected based on fire test results. As a result, the Federal Trade Commission took action to develop realistic end-use tests where cellular materials were concerned, and the Vertical Pipe Chase was our answer to addressing this need.

“We have tested a number of polyethylene and polyolefin formulations, including Tubolit, and have not found any great difference between the performance of one polyethylene versus another.”

Jesse J. Beitel
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Fire Science and Engineering
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“ASTM E 84 Is an Accepted Test, But May Not Reflect Performance in Real Fire Conditions”

“For many years, the ASTM E 84 test has been our primary tool for evaluating the flammability of materials and products used inside commercial buildings. As such, the test has performed very well. However, for some types of materials, the values and performance we see in the ASTM E 84 test may not reflect their performance in certain real fire conditions. In real fires, orientation, ignition source and other factors can influence the flammability performance of the materials.

“The 25/50 rating that polyolefin and polyethylene insulation may attain may not tell the whole story in terms of actual performance. These materials are what we call thermoplastic, which means that when they come in contact with heat, they can potentially melt and drip. In the ASTM E 84 test, if a material melts and drips, it falls out of the exposing flame zone and may not give appropriate results.

“The ASTM test standard has several caveats to try to provide guidance to people in the application of the test and the interpretation of the results. One caveat states that if the materials do melt and drip or delaminate during the test, then the results may not accurately reflect the material’s flammability properties.

“Specifiers and owners need to be aware of the potential limitations that exist with the ASTM E 84 test, because it is still the primary test used for construction materials, whether the materials are typically used in horizontal or vertical orientations.

“There are several large scale tests that are used to evaluate the performance of pipe insulations especially in their end-use configurations and with more realistic ignition scenarios. One of these is Armstrong’s Vertical Pipe Chase Test, and another is the Factory Mutual Large Scale Horizontal Pipe Chase Test.

“If specifiers or owners feel the material or its orientation may not be appropriately tested under ASTM E 84, they should ask for additional information from the manufacturer in terms of other types of tests that have been performed to provide a more real life configuration and a more real life evaluation of that product or material.”

Thomas W. Fritz
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These and other materials on mechanical system insulation are available from the Armacell Technical Library. For more information, call 1 800 866-5638. Or visit our website, at http://www.armacell.com.

TECHNICAL INFO-SERVICE - concise technical bulletins on insulation system performance.

No. 005  "Thermal Conductivity of Polyethylene/Polyolefin Pipe Insulation."

No. 006  "Water Vapor Permeability and Polyethylene/Polyolefin Pipe Insulation."

No. 007  "Direct Burial of Polyethylene/Polyolefin Pipe Insulation."

No. 008  "Fire and Smoke Properties of Polyethylene/Polyolefin Foams."

No. 009  "What Is the Mil Spec - MIL-P-15280J?"

No. 010  "Temperature Limits of Polyethylene/Polyolefin Foams."

No. 011  "Weathering of Polyethylene/Polyolefin Foam Insulation."

No. 022  "Know the Facts About Polyethylene/Polyolefin Insulations."

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