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# Effects of Insulation on Fire Safety

## Please note



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This Digest discusses various effects of insulation on fire safety, a subject of current interest because of the greatly increased use of insulation to conserve energy in buildings. It is a summary of Chapter 5 of the National Fire Protection Association Fire Protection Handbook.[1]

**Influence on Ignition of Materials**

If thermal insulation is applied around heat producing objects, such as light fixtures, the heat produced by the electrical current will not dissipate easily and the objects may become sufficiently hot to ignite materials in contact with them. Some of the new insulating materials can increase the potential for overheating because they release heat during their curing period. Improper installation of insulation by inexperienced contractors or homeowners is another factor that increases the chances of fire by overheating of electrical fixtures.

Insulation applied to the back of a thin lining such as a plywood finish can accelerate ignition when exposed to an ignition source. The insulation reduces the rate of heat loss resulting in more rapid rise in the temperature of the surface facing the ignition source. Insulation has much less effect on surface temperatures for linings thicker than 6 mm.

Besides the cases in which insulation can indirectly contribute to the ignition of materials, the insulation itself may be a potential hazard if it ignites relatively easily.

**Influence on Growth of Fire**

Adding insulation to the walls and ceiling of a room may increase the rate at which a fire will grow. The insulation will retain heat from the fire in the room in the same way as heat from heating systems is conserved. This accumulation of heat may result in the flashover* stage being reached much earlier than in a room with less insulation.

Once a material, such as the lining in a room, is ignited, the temperature of the surface of the material will largely determine the speed of flame propagation. An increase in the rate at which surface temperature rises will result in more rapid flame propagation and production of flammable gases. For example, foam plastics in a fire will attain a surface temperature of 200°C in a few seconds whereas wood, under the same circumstances, requires 10 minutes to reach that temperature. The very rapid surface temperature rise of foam plastics is probably why some of them propagate flames so quickly -- particularly thermosetting foam plastics. Thermoplastic foam may melt before its temperature reaches a critical value. If that occurs, extremely fast propagation of fire is unlikely.

### Protected Foam Plastic

At present, plastic foams for some applications, are required to be protected by a cover that will prevent excessive temperature rise. The flame propagation properties of the cover are determined by its surface characteristics and are essentially independent of the foam plastic underneath it.

A test method for measuring the performance of a protective cover has recently been developed.[2] test gives a measure of the time during which the material will protect against a post-flashover* fire. This time is given in Table 1 for various materials. The test ensures that foam plastic will not contribute to the growth of a fire for at least the time indicated by the test results.

**Table 1. Time of protection against post-flashover fire.**
(Thickness of protection 12.5mm)

| *Material of protection* | *Protection time, min.* |
|---|---|
| Gypsum wallboard | 15 |
| Magnesium oxychloride | 20 |
| Plywood | 11 |
| Hardboard | 11 |
| Particleboard | 8 |

The Division of Building Research has carried out tests on the behaviour of foam plastic material in cavity walls. The results indicate that if foam plastic insulation is sandwiched between two layers of non-combustible materials without an air space, upward propagation of fire is slow, even for plastics with a high flame-spread rating. A typical speed of propagation is a few centimetres per hour. However, if there is an air space between the wall and the foam plastic, the fire may spread upward rapidly but will be prevented from spreading to the room side of the cavity by the non-combustible material forming the wall.

Spread of fire from storey to storey in a cavity wall filled with insulation can be prevented by well designed fire stops. The installation of these stops, prescribed in many building codes, is important if combustible insulation is used in cavity walls.

### Insulation in Attics

Fires in concealed spaces can be especially hazardous if the space is wide and enclosed by combustible materials as in some attics. In row houses, for example, fire, smoke and toxic gases may spread quickly through such spaces from one house to another.

The use of loose fill insulation can increase fire potential if the material is combustible. If however, the materials are properly treated with flame retardants and fire stops are correctly installed, loose fill insulation can be used without excessive risk. Proper installation will ensure that electrical devices will not overheat and ignite material surrounding such devices.

### Smoke and Toxic Gases

Fire statistics reveal that the products of thermal decomposition (smoke and toxic gases) are responsible for the majority of fire deaths. Many new insulation materials release harmful decomposition products very rapidly, some more rapidly than traditional building materials. Their increased use presents a smoke and toxicity problem which is of great concern.

*Smoke*. -- The main danger from smoke is the reduction of visibility. It will often impede the escape of occupants from a burning building and prolong the exposure to heat and toxic products produced by the fire.

Table 2 gives the smoke production of various unprotected materials under similar test conditions and the time to obscuration under these conditions. The figures are approximate and are only intended to show the order of magnitude of the smoke production of various materials as observed by one specific fire test.

**Table 2. Smoke production of various unprotected materials.**

| *Material* | *Time to obscuration, min.* |
|---|---|
| Phenolformaldehyde foam | 100 |
| Wood | 10 |
| Cork | 3.3 |
| Polystyrene foam | 2 |
| Cellular PVC | 1 |
| Polyurethane foam | 0.7 |

Some materials used as insulation produce smoke much more rapidly than wood does. If the surface area of the insulation is large and unprotected, most of the smoke produced by a fire in a room may be caused by the insulation. If the surface area is small compared to that of all combustible materials in the room, (not more than 10 per cent), the smoke will not be excessive compared to the smoke produced by all burning materials.

If the insulation is protected, smoke production may drop to very low values. Table 3 shows how a protective cover of 12.5 mm type-X gypsum wallboard influences the smoke production of a number of materials.

*Toxic Gases*. -- Various methods for evaluating the toxic hazard of fires are discussed in Canadian Building Digest 197.[3]

Compounds such as carbon monoxide, hydrogen chloride, hydrogen cyanide, sulphur dioxide and oxides of nitrogen are recognized as harmful products; others such as water vapour and the hydrocarbons contribute little or no toxic hazard. Burning test samples under specified test conditions and determining the resulting concentrations of a few of the most important toxicants usually will give a reasonable indication of the toxicity of insulation materials.

A protective cover over the insulation may substantially delay the development of toxic products. According to measurements made in a room with walls insulated with foam plastic and protected with plywood approximately 6 mm thick, it took more than 20 min. after the ignition of the fire before the insulation generated toxic products.

Under these conditions the materials in the room will play a far greater role than the insulation in the walls in determining whether toxic combustion products will hamper safe evacuation of people during a fire.

**Failure of Structural Elements during Fire**

Because thermal insulation added to the walls and roofs increases the temperature of a fire in a room, it may add to the risk of failure of structural elements during the fully developed stage of a fire. Besides causing higher fire temperatures, insulation may also increase the rate of temperature rise in roof or wall assemblies; e.g., in the plenum between ceiling and roof if insulation is placed on top of the roof. These temperature changes may affect the fire performance of structural elements and fire separations in various ways.

*Roofs*. -- Roofs whose fire performance may be affected by the addition of insulation are those supported by steel members, e.g., joists and beams, and those using steel reinforcing (reinforcing and prestressing steel). Steel loses strength when it is heated to high temperatures -- the higher the temperature the lower its strength. There is a critical temperature at which the steel has lost so much strength that it can no longer support the load.

Typical roofs that are supported by steel members are assemblies consisting of a steel deck supported by steel beams or joists and covered with concrete topping. Installing insulation on top of the concrete increases the temperature of the supporting steel during a fire. If the concrete is sufficiently thick, however. this increase will be small. Adding insulation has no significant effect on the fire resistance of a roof assembly if the thickness of the concrete is 5 cm or greater.[4] If there is no concrete cover and the insulation is placed directly on the steel deck the fire resistance of the roof assembly may be reduced substantially.

*Walls*. -- Walls lined on the room side with an insulating material will increase fire temperatures. There is also risk of flame spread across the insulation if it is combustible and not covered by a protective lining. The temperatures in the wall will be lower and its fire resistance will improve. The over-all effect of a cover on a wall's structural fire performance will be favourable, particularly if the lining is a good insulator.

If the insulation is installed in a cavity, the effect on the structural fire resistance of the wall may be unfavourable. This is particularly trite of thin walls, where large deflections may be produced and cause the wall to buckle due to unequal expansion of the wall material on opposite sides of the cavity.

Although adding insulation may reduce the structural fire performance of fire barriers, such as roofs, floors and walls, it increases their thermal fire resistance, i.e., their ability to prevent excessive heat penetration through the fire barrier.

**Table 3. Influence of protection on smoke production.**
(Protection of 12.5 mm Type-X Gypsum Wallboard)

| *Material* | *Time to Obscuration, min.* | |
|---|---|---|
| | *Unprotected* | *Protected* |
| Cork | 3.3 | 180 |
| Polystyrene foam | 2 | 13 |
| Polyurethane foam | 0.7 | 2.5 |

**Summary**

The effect of thermal insulation on fire safety in buildings and the resulting potential hazards may be summarized as follows:

1. Insulation can affect the ignition of materials.
    - it can increase temperature around heat producing objects such as light fixtures.
    - applied to the back of thin linings it increases the potential for more rapid ignition.
    - it may be a potential hazard if it ignites easily. particularly in confined spaces such as attics.
2. Insulation can influence the rate at which a fire will grow.
    - a well insulated room will retain heat with resulting potential for faster fire growth.
3. Some insulations are potential hazards as they ignite relatively easily and propagate flame.
    - this can increase the rate at which fire propagates as high surface temperatures are attained more quickly.
    - foam plastic in cavity walls with air space has the potential for rapid flame spread.
4. Some insulation products release harmful decomposition products that result in greater production of smoke and toxic gas.
    - smoke and toxic products reduce visibility impeding evacuation during a fire.
5. Higher temperatures during fires in insulated structures may affect structural strength.
    - structural steel members can lose strength when heated to high temperatures.
    - higher temperatures can cause deflection and buckling of thin walls.

Most of these potential hazards from insulation can be reduced or eliminated by the use of suitable protective covers and by proper installation and construction practice.

**References**


1. Fire Protection Handbook, National Fire Protection Association, Boston, 15th ed., Section 5, Chap. 5. (In process.)
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4. Stanzak, W. W., and L. Konicek, Effect of Thermal Insulation and Heat Sink on the Structural Fire Endurance of Steel Roof Assemblies, Can. J. Civ. Eng., 6, 1979, pp. 32-35.


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* Flashover is characterized by an almost instantaneous ignition of materials in all parts of the room.