Cellulose Insulation Manufacturers Association

TECHNICAL BULLETIN

CELLULOSIC INSULATION PRODUCT INFORMATION AS IT RELATES TO FIREFIGHTING TECHNIQUES

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Introduction

Cellulose insulation is a commonly used component in residential building construction. While it is primarily installed for its thermal and acoustic properties, cellulose insulation is a well-engineered, safe product designed to provide excellent fire performance.

Most structures will never experience a fire. However, history has provided valuable lessons regarding how fires start and spread throughout residential structures and the effect of fire and smoke on occupants and structures. Despite the rarity of a fire, its destructive potential must be appreciated. Organizations such as the American Society for Testing and Materials (ASTM) have provided valuable testing documentation regarding how fire acts on a variety of residential construction materials, including cellulose insulation. Governing bodies such as the International Code Council (ICC) have taken this information and developed safety standards for construction materials. All insulation materials, including cellulose, must comply with rigid standards for residential construction. It is important to note that only materials manufactured to industry standards exhibit the characteristics described in this paper. Unfortunately, DIY and untested materials are sometimes found in residential structures. These materials can create dangerous fire hazard conditions.

Members of the Cellulose Insulation Manufacturers Association (CIMA) have written this document to serve as a tool for the fire service industry to better understand the benefits and overall characteristics of cellulose insulation. Specifically, our hope is that the firefighting community will appreciate the steps taken to ensure that cellulose insulation aids firefighters in minimizing fire spread, occupant risk, and property loss. Furthermore, it is our desire that the firefighting community is provided the information it needs to determine how best to extinguish and overhaul areas that contain cellulose insulation.

Insulation Material Choices

Building insulation is typically chosen based on cost, R-value, safety, and ease of application. Building contractors have three primary choices when choosing insulation: foam plastic, mineral fiber, and cellulose. All three are effective thermal insulators with a Class 1 fire rating. All have been tested and possess unique performance characteristics as defined by ASTM material standards, the I-Codes, and other testing agencies.

Foam Plastic Insulation

Foam plastic insulation, commonly called spray foam, is installed by mixing two separate components using a machine known as a reactor before pumping it through a spray nozzle onto walls, ceilings, and roof decks. The foam adheres to the surface where it is applied, expands, and hardens to form insulation. Foam plastic insulation ignites at approximately 700°F. It is noteworthy that foam plastic insulation has a unique code section in both the international codes (ICC) and Residential and Building Codes. I-Codes require that spray foam insulation be separated from living spaces by thermal barriers, indicating that there is a recognized fire threat. Spray foam is often chosen for applications where a typical attic space is limited (e.g., cathedral ceiling). This type of application poses unique challenges for firefighters. Spray foam enhances the structural integrity of walls, ceilings, and roof decks making it more difficult for firefighters to remove structure to cool a space or provide ventilation. Finally, burning foam creates dense, toxic smoke that can be a danger to occupants and firefighters.

Mineral Fiber Insulation

Mineral fiber insulation is made from glass or rock fibers. Fiberglass is the most common insulation in the mineral fiber family and is made from components found in glass. Neither glass nor rock are combustible, but because mineral fiber insulation products are made from fibers and lack density (which is what makes it an effective insulator), it is relatively ineffective at resisting fire. Steel wool serves as an illustration: steel is effective at resisting fire, but steel wool's lack of density makes it ineffective in comparison. Mineral fiber insulation is commonly produced in batts that are placed between framing members. Small spaces and odd shaped spaces may prohibit the use of batts. Mineral fiber batts sometimes include a vapor barrier (kraft paper or foil) that is combustible. Kraft faced batts must also be protected from fire and the paper facing cannot be left exposed. Fiberglass will melt at temperatures above 1000°F, which can cause heat to be transferred to more flammable framing members. In the event of a fire, fiberglass insulation batts should be removed during overhaul to ensure that all hot spots are exposed and detected.

Cellulose Insulation

Cellulose insulation dates back centuries, however the modern cellulose insulation we are familiar with today was developed during the 1970s during a time when fuel costs were rising dramatically in the United States, leading to sharp increases in home heating costs. As a result, consumers began placing greater emphasis on heating efficiency. Many homeowners retroactively insulated their attics to make their homes more energy efficient and reduce heating costs. Consumers and contractors quickly acknowledged cellulose insulation as an effective solution to a new and growing demand. Cellulose insulation was appealing for several reasons. Most importantly, it was – and is – a highly effective insulator. Cellulose insulation provided a tangible return on investment by allowing homeowners to quickly decrease their home heating costs. Cellulose insulation was also affordable, readily available, and could be installed by an industrious homeowner or capable contractor.

Recently, as homeowners have become more environmentally conscious, the fact that cellulose insulation is composed of the highest percentage of recycled materials has added to its appeal. Cellulose insulation is made from up to 85% recycled newsprint and other cellulose-based materials (recycled paper products) that are converted into insulation via a process called fiberization. Treating the fibers to make them resistant to fire and fungal growth takes place during this process. Improvements in how recycled materials are made into fibers and treated is the key to why cellulose is a safe, effective, and economical insulation choice.

As cellulose insulation has become more prevalent in construction, greater attention has been focused on its safety. Initially it appeared risky to fill void spaces with a known combustible paper product, but a study performed by the State of California dispelled that myth. An 11-year study from 1974 through 1984 showed that .009% of residential fires started in attic insulation. As the use of cellulose insulation became widespread, the federal government, based on perceptions, sought to regulate the industry via the Consumer Product Safety Commission (CPSC). An interim order was put in place and remains to this day. This order places significant emphasis on the performance of cellulose insulation in fire conditions. Few other building materials are federally regulated. This scrutiny has resulted in cellulose insulation being one of the safest and most reliable building materials in use today.

Fire retardants are added during the manufacturing process to make the recycled material fire resistant. Cellulose insulation has been tested more than any other insulation product and has been found to effectively extend the duration of a structure during a fire, allowing occupants more time to escape and firefighters more time to preserve the structure. Rigorous testing has demonstrated that cellulose insulation does a good job resisting combustion and slowing the spread of fire. Cellulose insulation is so effective at absorbing thermal energy that is often settles into a slow smoldering state that can be difficult to detect even with the use of thermal imaging cameras. In the event of a fire, the cellulose insulation in the proximity (or suspected proximity) of the fire should be removed. Often, such as in an attic, all the cellulose insulation should be removed to stop any potential spread due to smoldering and allow a complete inspection of the framing materials. Extra overhaul is a reasonable trade-off for reducing the ability of the fire to spread. Due to its insulative nature, smoldering can spread along the combustible surface of gypsum wall board. There is also potential for melt or burn along electrical or communication wires as well as their plastic coating.

Fire Retardants

Since the 1920s, various chemicals have been used to treat cellulose insulation and provide it with fire retardant qualities. Fire retardants have dramatically reduced the flammability of cellulose insulation, reduced the ability of fire to spread in concealed spaces, and ultimately reduced the risk of injury and property loss.

Cellulose insulation, treated or not, does not pose a risk during normal use. In other words, cellulose insulation will not spontaneously combust.

Developing an effective fire retardant requires a thorough understanding of fire itself. For fire to get started, gain momentum, and sustain itself, several conditions must exist. First, in the case of cellulose insulation, the material must get hot. As heating occurs, the chemical bonds of carbon, oxygen, and hydrogen deteriorate. Generally, this deterioration is complete once the material reaches 480°F (250°C). In the absence of oxygen this is called pyrolysis. However, if the biproducts of the heating and subsequent deterioration process mix with air, vapor combustion occurs. At this point flaming combustion becomes self-propagating and the fire begins to grow. Growth will continue if there is an ample supply of oxygen. However, if there is a lack of oxygen the fire will become ventilation-limited and begin to decay, at which time smoldering may occur.

Burning of cellulose materials occurs by two mechanisms. High temperatures (above 300°F) create flammable gasses that can ignite and cause even more heat which accelerates the combustion process. Lower temperature (under 300°F) can result in charring from pyrolysis. Oxidation of the char is a slow and localized process sometimes referred to as smoldering combustion. Smoldering combustion generally proceeds as a front in the solid state rather than as a flame in the gaseous state. Smoldering combustion is the primary cellulose insulation concern due to its potential to transition to flaming combustion (usually when a flammable construction material such as wood is ignited by the smoldering insulation front).

The most common chemical fire retardants used to treat cellulose insulation – borates and ammonium sulfates – include both flame retardants and smoldering retardants. Other chemicals are sometimes added to enhance overall fire resistance. The treatment process thoroughly integrates the fire retardant into the cellulose material to ensure complete and uniform treatment and optimum fire protection.

Current cellulose insulation manufacturing processes can produce products with high fire safety ratings. Cellulose insulation treated with fire retardants generally meet a class 1 fire rating. Some cellulose products have been independently laboratory tested in two- and three-hour load bearing firewall designs. The use of the cellulose insulation is integral in the firewall designs.

Treated cellulose insulation retains its fire-retardant performance capabilities over long periods of time. While research in this area is limited, there is evidence to suggest it could take over 300 years of extreme conditions to reduce the fire retardant efficacy; the fact that over a long period of time structures insulated with treated cellulose have been no more likely to burn than structures treated with other types of insulation indicates that treated cellulose can be expected to retain its fire resistance properties for the life of the structures in which it is installed.

Testing

ASTM is a recognized source of testing data for a wide variety of materials including construction materials. ASTM develops and maintains standards used by industries worldwide including the building construction industry.

ASTM C739 is the Standard Specification for Cellulosic Fiber Loose-Fill Thermal Insulation. Other tests are also used to provide more comprehensive testing. ASTM C739 provides tests for R-value, odor, moisture vapor absorption, and fungi resistance, as well as critical radiant flux (minimum radiant energy a fire needs to sustain flame propagation on a material), smoldering combustion (the slow, flameless form of combustion sustained by the heat evolved when oxygen directly attacks the surface of a condensed-phase fuel such as insulation), corrosiveness, and settled density.

The critical radiant flux test included in ASTM C739 is mandated by the Consumer CPSC to give an indication of the effectiveness of the fire retardant. ASTM E970 analyzes the critical radiant flux of exposed attic floor insulation using a radiant heat source. For this test, a tray with dimensions one meter long and one-quarter meter wide is filled with cellulose insulation. The tray enters a cabinet that houses a gas-fed burner. The rectangular burner is heated to 840° F (425° C). The burner is directed at the tray at a 30-degree angle. By angling the burner, the tray is heated unevenly, thus creating a heat flux profile throughout the insulation. Simply put, some cellulose insulation (closest to the burner) is experiencing a lot of heat energy while the other end (further from the burner) receives less heat energy. This energy is measured in watts per square centimeter. The sample is heated for two minutes, after which an open flame is introduced to the material that endured the highest heat load.

It is worth noting that even after exposure to significant heat energy (840°F for two minutes), the cellulose insulation sample does not spontaneously combust. An external flame is required to initiate combustion. Cellulose insulation does not contain enough energy in the material to sustain combustion. This is evidence of the fire retardants at work. Without the retardants, paper would easily ignite and sustain combustion. With fire retardants, the product self-extinguishes. This point of self-extinguishment is the Critical Radiant Flux (CRF). The CPSC set this value at 0.08 watts per square centimeter and then added 50% to that amount. The intention was to allow for potential loss of effectiveness over time. This has not been shown to occur, yet the CRF is fixed at 0.12 W/cm2. Cellulose insulation used in building construction must pass this test.

In addition to open combustion, cellulose insulation is also tested for smoldering combustion. The smoldering combustion test is simple but effective as it employs the use of a lit cigarette. The bedding industry uses the same method for testing its products. Cigarettes are remarkably consistent in their behavior, proving to be the best surrogate for smolder testing. The test begins when a lit cigarette is inserted into a box of cellulose insulation. The cigarette is then allowed to burn to completion. The insulation is weighed before and after the test with lost weight being attributed to pyrolysis. Too much total weight loss (15% or greater) results in failure. Cellulose insulation typically loses 1-2% of its weight. This test is required by the CPSC and is also in the C739 material specification.

ASTM E84 analyzes the projected flame spread and smoke production of cellulose insulation. For the E84 test (open flaming/combustion), cellulose insulation material is fixed to the ceiling of a tunnel that is 25 feet long and two feet wide. A draft is developed through this tunnel. At the head end (origin of the draft), two ¾-inch pipes feed methane gas which is ignited and allowed to burn directly in contact with the material. A trained test operator observes the flame front through windows in the sidewall of the tunnel. The length of fire travel is recorded as well as the time it takes to achieve maximum distance. After 10 minutes the test concludes. This is known as the flame spread index (FSI). Cellulose insulation typically has a FSI of 15 or less, with some applications netting a zero FSI. As a means of comparison, red oak has a flame spread index of 100. This test is required for many building materials with an emphasis on those materials being used as a finish in a building. Despite the severity of this test, cellulose insulation performs well and contributes little to flame spread.

ASTM E119 is commonly known as the "fire wall test." In this test, cellulose insulation undergoes additional testing to evaluate how it responds when used in fire walls as a protective layer for metal building components, foams, and plastics. Remarkably, this test indicates that cellulose insulation can be used as an effective component of a fire wall, helping to deter and delay the spread of fire.

Firefighting Considerations Where Cellulose Insulation is Present

When a fire company arrives at the scene and finds extensive involvement, including the roof structure, the obvious priority is to quickly extinguish the fire. After initial knockdown, personnel should evaluate the attic area and other void spaces and formulate a plan for salvage and overhaul. Thorough overhaul should be performed to ensure there is no smoldering insulation. Thanks to the fire-retardant characteristics of cellulose insulation, personnel usually have ample time to place salvage covers before removing smoldering insulation.

In some cases, a fire event may be less straightforward. For example, an occupant may smell smoke, notice discoloration of a ceiling or wall around a fixture or appliance, or may simply report an electrical problem. Fire personnel will likely use thermal imaging devices to identify an area of concern. Once the problem is located, fire personnel should mitigate property loss by placing salvage covers. An extinguishment method should be chosen and staged near the area of concern. Personnel can anticipate the source and location of the problem by identifying the locations of light fixtures, bathroom fans, chimneys, etc.

Once a hot spot is identified, spread fireproof tarpaulins on the area below the attic space or adjacent to the wall. Remove wall or ceiling covering to access the fire. Once initial extinguishment is achieved, the charred and smoldering insulation should be removed. The capacity of cellulose insulation to keep fires small and contained and to suppress flaming combustion also means that cellulose is very good at concealing smoldering within and under the insulation deck. Even insulation not directly involved in the fire should be scrutinized for hot spots. Any insulated walls or attic areas that could have been affected by the fire should be thoroughly investigated. This is achieved by performing thorough overhaul of the fire-affected area. Thermal imaging equipment is helpful in locating smoldering materials but requires a careful and thorough scanning technique. Scan from every angle as you would while performing a search. As you identify hot spots, remove insulation until you reach the material that is smoldering. As with any scene do not rely solely on your TIC. Cellulose is a very effective insulator, which means it may insulate the heat signature from your TIC. Physical inspection and overhaul of any suspicious areas should be used to confirm the thermal image you see.

Removing insulation material from suspect areas is essential. At a minimum, remove insulation from the fire-affected area and at least three feet around that area. If you locate smoldering, increase your overhaul area until you find “clean” materials. It is worth noting that cellulose insulation comes in many colors. Black or darkened insulation does not necessarily indicate charring or smoldering. However, if in doubt, remove it. When considering how much to overhaul, consider that a rekindle will likely result in far more property loss than the cost of the overhaul effort and the insulation material that is removed.

The easiest, fastest, and best way to remove insulation is with an insulation vacuum but most departments do not have this equipment in their fleet. Vacuums reduce property loss (as ceiling and wall covering can be left in place), require less manpower, and promote generous insulation removal. Traditional overhaul equipment such as hooks, shovels, pails, debris bags, tarps and trash cans are also effective. Whatever method is chosen, work systematically focusing on one area at a time until thorough overhaul is complete.

Writing in the June 2008 issue of Firehouse magazine, Deputy Chief Mark McLees (Syracuse, NY) offered some very practical tips for dealing with fire in a cellulose-insulated building: “My advice is simple. If you find yourself facing a smoldering fire involving blown-in cellulose insulation, slow down. It will be a long, drawn-out ordeal as you systematically remove sheetrock ceilings, smoldering insulation, and charred structural members. Remove insulation at least four feet on either side of the charred joists.”

Conclusion

Cellulose insulation is a proven product that has stood the test of time. Cellulose is an effective thermal insulator that uses recycled materials and is easy to install, long-lasting, cost effective, and safe. Cellulose insulation has a Class 1 fire rating. In the event of a fire, it resists combustion and slows the spread of fire providing valuable time for occupants to seek safety and property damage to be minimized. A basic understanding of how cellulose insulation reacts to fire conditions allows firefighters to effectively extinguish and overhaul fire affected areas containing cellulose insulation.

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