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The Use of Candles is Associated with the Black Soot Deposition Phenomenon (BSD)

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Over the past five years, the deposition of a gray to black colored substance on surfaces of residential dwellings has been reported. Recent research conducted in Florida¹ has shown that the deposited material is carbon for the main constituent of the deposit. The size of the deposit's particles has been found to be in the range of sub to few microns. The combination of the deposit's particle size range, the deposit patterns and the nature of the deposited material supports the physical characteristics of a "soot." The dark gray to black colored deposition on surfaces was named the "Black Soot Deposition (BSD) Phenomenon."

The occurrence of the BSD problem has been primarily reported in relatively newly constructed dwellings or in older dwellings that have newly installed HVAC/duct systems. Further, moderate to extensive use of candles has been reported in the majority of dwellings that have exhibited BSD.

Where does the soot come from?

Soot is a product of incomplete combustion of carbon – containing fuels, usually petroleum based. Complete combustion would produce practically no soot or carbon monoxide, and is recognized by a blue flame. This applies to all types of combustion processes, including natural gas flames, wood fires and candle flames. While it is understood that soot can be generated by any combustion process, most flames that are used in homes are either vented or carefully controlled, such as gas stoves, with a notable blue flame. A recent Florida research project involving interviews with more than 50 homeowners who have experienced BSD, revealed that the common source of soot is candles. The Florida research project found that certain candles can produce up to 100 times more soot than low soot producing candles. In effect, burning one candle can be equivalent to burning 100 candles at once! The research project also demonstrated that a candle placed in an air draft could increase its soot production by a factor of 50. Soot production from certain candles can be significant and may cause indoor levels of airborne soot to exceed concentrations allowed in outside air by the U.S. EPA.

¹ Krause, David. "Black Soot and Candles: New Research and Case Studies." In: Indoor Environment '99 Proceedings.

Why does soot deposit?

Soot particles that build up in the air of a house eventually deposits onto surfaces due to random collisions with surfaces. When particles in the air collide with each other, they grow in size until they gain enough mass to deposit due to gravity. Soot particles created by candles are 0.06-0.1 microns in diameter. Particles of this size can penetrate almost all home air conditioning filters and can severely reduce an electronic air cleaner's ability to remove them from the air. Soot particles are also attracted to cooler surfaces by thermophoresis. Temperature gradients contribute to soiling of wall surfaces over studs, and air conditioner supply vents. These particles are also attracted to electrically charged surfaces such as injection molded plastic items including medicine cabinets, internal surfaces of freezers, plastic vertical blinds and computers.

What are the possible health concerns?

While the soot is suspended in the air, occupants are at risk of inhalation exposure. Since the particles are less than 1 micron in diameter, they can penetrate the deepest areas of the lung. Studies involving health risks associated with microscopic soot generated from diesel exhaust and factory emissions has shown that when similar size soot particles, as from burning candles, enters the lower respiratory tract including the alveoli, it is not readily discharged, if at all. In addition to soot or carbon particles being produced by burning candles, considerable volatile organic compounds are emitted, including carbon monoxide as well as one or more known carcinogens including vaporized lead when the candle wick contains a wire support. This raises serious health questions about inhalation of candle soot particles, voc's and vaporized lead.

What should be done to remedy the soot deposition?

Cease candle burning and periodically ventilate the home by opening windows. Soot removal from surfaces is difficult, but can be aided by the use of polar solvents. For hard plastic surfaces, rubbing alcohol (isopropyl) is helpful in removing deposits although "ghosting" may result. Ghosting refers to the smallest particles which may not be removed. Consult a cleaning service experienced in fire restoration for cleaning other surfaces.

Candles with the following characteristics have the potential to produce excessive soot:

- Candle with long, untrimmed wicks exceeding 1/8 inch
- Candles poured into glass jars or ceramic containers
- Candles with soft wax
- Aromatic (scented) wax
- Thick wick, or one with a wire core that keeps the wick upright
- Soot deposits on the mouth of the jar
- High, erratic flame when burned
- Visible soot emitted from an erratic flame
- Located in an air draft created by a fan or air conditioner duct
- Pillar candle with signs of uneven burning or thick, erect wick
- Multiple wick candles with thick, erect wicks

Candles with the following characteristics produce minimal soot and no vaporized lead:

- Hard wax
- Thin, braided wick that curls over when burned
- Low aromatic properties
- Tapered and votive candles with thin wicks
- Low, even flame when burned