NATIONAL
ROOFING
CONTRACTORS
ASSOCIATION

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Dear NRCA Member:

Enclosed is a report prepared by NRCA that discusses considerations pertaining to the use of polyisocyanurate insulation in low-slope membrane roof assemblies.

During the past several years, NRCA has received a significant number of reports about problems relating to the use of polyisocyanurate insulation in low-slope membrane roof assemblies. NRCA's Low-Slope Roofing Committee and Technical Operations Committee developed this report to notify the roofing industry of the reported problems and disseminate information NRCA has received from roofing contractors and product manufacturers.

By issuing this report, NRCA does not mean to imply that polyisocyanurate insulation is problematic or the reported problems are widespread in the industry. However, the information contained in this report may be beneficial to roofing-industry professionals who encounter similar problems.

If you have any questions regarding this report or if NRCA may be of assistance in other matters, please do not hesitate to contact NRCA's Technical Services Section at (800) 323-9545 or (847) 299-9070.

Very truly yours,

Dane Bradford
Chairman, NRCA Technical Operations Committee

Enclosure

Considerations Pertaining to Polyisocyanurate Insulation

May 1999

Since the current generation of blowing agents for manufacturing polyisocyanurate insulation was introduced into the U.S. roofing industry, the National Roofing Contractors Association (NRCA) has received a significant number of reports about problems associated with polyisocyanurate insulation used in low-slope roof assemblies. A majority of these problems involve polyisocyanurate insulation used as a component of single-ply membrane roof systems. However, NRCA does not believe the problems reported are limited solely to single-ply membrane roof systems. Cover-board insulation, which frequently is used over polyisocyanurate insulation in bituminous membrane roof systems, may mask some polyisocyanurate insulation problems in built-up and polymer modified bitumen sheet membrane roof systems.

By issuing this report, NRCA does not mean to imply that polyisocyanurate insulation is problematic or the reported problems are widespread in the industry. However, when these problems do occur, they typically are noticed some time after the roof membrane is installed. As a result, correcting these problems can be difficult and costly, often resulting in roof membrane removal and replacement. NRCA's intention with this report is to notify the roofing industry of the reported problems with polyisocyanurate insulation and disseminate information NRCA has received from roofing contractors and product manufacturers. This information may be beneficial to roofing-industry professionals who encounter similar problems.

NRCA recognizes there are considerable shortcomings in the U.S. material standard for polyisocyanurate insulation, American Society for Testing and Materials (ASTM) Standard C1289-95 titled "Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation." This standard does not address the need for manufacturers to adequately cure products prior to shipment and, in NRCA's opinion, the standard's values for compression strength, dimensional stability and facer-sheet adhesion of finished products are not adequate to assure roof system performance.

Until this standard is appropriately revised, NRCA recommends that polyisocyanurate insulation manufacturers and designers who specify polyisocyanurate insulation implement the interim recommendations in this report. These recommendations are intended to minimize problems that may occur on future low-slope roofing projects.

Types of Problems

Some problems with polyisocyanurate insulation initially occurred in late 1993 and early 1994 when manufacturers were required to change their products' blowing agent component. Prior to January 1994, almost all polyisocyanurate insulation manufacturers used a blowing agent (CFC-11) that contained chlorofluorocarbons. CFC-11 was determined to be harmful to the earth's ozone layer, and government regulations were implemented that required manufacturers to change the blowing agent. This change introduced new variables into the product's manufacturing and took some time to perfect; however, it is doubtful that any of the current reported problems with polyisocyanurate insulation are from this transition in blowing agents.

Many problems currently observed in the field are related to an improper mix ratio of the foam's components, which is a manufacturing defect. Polyisocyanurate insulation is manufactured from two primary components, referred to as A and B components. The A component is isocyanate; the B component consists of polyol, catalysts, additives and the blowing agent(s). In the manufacturing process, A and B components must be combined in precise quantities to achieve the desired chemical reaction that creates proper foam cell structure. Off-ratio component mixing can result in foam cells that are elongated rather than properly spherical or foam that is too soft or brittle.

The following is a discussion of some of the reported problems experienced with polyisocyanurate insulation.

Facer-Sheet Delamination: Facer-sheet delamination is the separation of the facer sheet, which is typically a glass fiber or asphalt felt, from the polyisocyanurate foam core. This can be the result of the manufacturing process where the foam is off proper ratio, resulting in foam that is too soft or elongated foam cells that are directly adjacent to the facer sheet. Elongated cells are not as strong as spherical cells and can cause crushed or powdered foam when subjected to minor surface loads (e.g., normal installation traffic). Off-ratio foam and elongated foam cell structure are manufacturing defects.

Facer-sheet delamination sometimes is found when there is excessive traffic (e.g., heavy equipment traffic) over the insulation's surface. Facer delamination caused by excessive traffic typically will exhibit crushed cells immediately below the interface between the foam and facer sheet. When facer-sheet delamination is caused by excessive traffic, the affected area generally will be limited to the traffic areas only, rather than other large portions of the roof.

Edge Cavitation: Board-edge cavitation is a condition in which the exterior edges of individual boards exhibit concave depressions. Edge cavitation is a manufacturing defect that once was associated most frequently with the change in blowing agent; however, it still is reported occasionally.

Currently, edge cavitation is caused most often when a minor amount of water is used as an ingredient in the manufacturing process. Small amounts of water sometimes are added during the product's manufacturing to generate carbon dioxide as a co-blowing agent. The carbon dioxide can be useful in improving some of the foam's physical properties. When changes first were made in the blowing agent, it was not known that the new blowing agent (HCFC 141b) had a greater tendency to dissolve in the foam's polymer matrix than the older blowing agent (CFC-11). If a significant amount of the blowing agent dissolves into the cell walls, the walls are weakened.

Also, the chemical reaction between the A and B components produces heat, with the temperature within the foam reaching as high as 300 F (149 C) during manufacturing and curing. The high reaction temperatures cause the gas pressure within the cells to be less than the ambient atmospheric pressure when the product cools. If carbon dioxide is present (e.g., the result of using a small amount of water in the process), the carbon dioxide will diffuse out of the cells faster than the air components diffuse into the cells, magnifying the pressure differential between the foam cells and environment.

The combination of weakened cell walls and great pressure differential creates elongated cells too weak for the board's thickness. This occurs most rapidly at the board's edges, resulting in poor foam structure and board-edge cavitation.

Cupping or Bowing: Board cupping or bowing can be caused by an off-ratio mix, a manufacturing defect, that creates distorted cell structures to be distributed unevenly within the foam's thickness. The uneven distribution of the cells creates inherent dimensional instability and will exhibit substantially different compressive strength values in the board's length, width and thickness directions. When placed under load, the board will resist the load differently, resulting in cupping or bowing.

Cupping or bowing also can occur when one of the board's sides gets wet. As it dries, the board's side shrinks, which exerts unbalanced forces within of the board. This causes the board to become concave.

Condensation can occur within the insulation's packaging, which allows the top board in a bundle to become wet on its top surface. The top surface of the top board in a bundle also can become wet if the insulation is not properly protected from precipitation (e.g., rain). When this happens, the boards may become cupped.

Cupping of boards as a result of them becoming wet typically is the result of inadequate packaging of the insulation bundles, which can be considered a manufacturing defect, or inadequate material handling, storage or application, which may be application problems. The cupped boards as a result of wetness generally will appear in random locations throughout the roof. It would be rare for all the boards in any bundle of insulation to have only their top surfaces wet.

Shrinkage: Board shrinkage generally is associated with an off-ratio foam mix, which is a manufacturing defect. However, ASTM C1289 allows up to a 4 percent linear change. This linear change value represents the product's dimensional stability when conditioned at 158 F (70 C) and 97 percent relative humidity for seven days.

When applying this 4 percent value to a 4-foot by 8-foot (1.2-m by 2.4-m) polyisocyanurate insulation board, it can be interpreted that the long dimension is allowed to shrink or expand up to 3.8 inches (98 mm) and still be in compliance with the ASTM standard. As a result of this high allowable dimensional stability value, board joints installed tightly butted can be found with wide gaps, which can impact roof system performance.

Crushing or Powdering: Board crushing or powdering sometimes is attributable to foam crushing or powdering from an off-ratio mix that is too rich in isocyanate, resulting in foam that is too brittle. Even minor loads (e.g., normal installation traffic) on the insulation's surface can crush the foam and turn it to powder. This also can cause the facer sheet to delaminate from the foam core. This is a manufacturing defect.

Crushing or powdering also can be caused by excessive traffic (e.g., heavy equipment) over the insulation's or membrane's surface. This condition generally is not a manufacturing defect and usually will be confined only to high traffic areas, rather than other large portions of the roof.

Interim Recommendations

Until ASTM C1289-95 is revised to address the manufacturing problems reported or some other appropriate material standard is developed for use in the United States, NRCA recommends that polyisocyanurate insulation used in low-slope roof assemblies be manufactured to the following criteria.

Compressive strength: 23 pounds per square inch (158 kPa) minimum.
Dimensional stability: 2 percent maximum linear change when conditioned at 158 F (70 C) and 97 percent relative humidity for seven days.
Curing time: 24 hours minimum, plus an additional 24 hours minimum per inch (25 mm) of thickness, at a minimum of 60 F (16 C) before shipment from the manufacturer.
Board thickness: 2 inches (51 mm) maximum.

Also, as indicated in *The NRCA Roofing and Waterproofing Manual, Fourth Edition*, roof system manufacturers and designers who specify polyisocyanurate insulation in their designs are urged to incorporate the following criteria.

Board size: 4-foot by 8-foot (1.2-m by 2.4-m) maximum board size for loose-laid and mechanically attached insulation boards, 4-foot by 4-foot (1.2-m by 1.2-m) maximum board size for insulation boards adhered to a substrate.
Board thickness: 2 inches (51 mm) maximum; when thicker total thicknesses are necessary, specify insulation boards in multiple layers to achieve the desired total thickness. When multiple insulation layers are used, the insulation board's joints in the top layer should be staggered vertically and offset from the joints in the underlaying layer(s).