Coatings form effective barriers in PCB-contaminated silos

L. B. WILLETT

The polychlorinated biphenyls (PCB's) have been valuable industrial chemicals which have been used extensively in many products since about 1930. However, in 1966, PCB's were identified as environmental contaminants which are persistent and tend to accumulate up the food chain. The production and industrial use of PCB's have been curtailed in recent years; however, PCB's can still enter the environment from materials containing biphenyls.

One source of PCB's entering the human food chain is a coating material called Cumar for concrete silos. More precisely, the coating contained the PCB's called Aroclor 1254 (Monsanto). It was used between 1941 and 1970 by several silo companies in Ohio and neighboring states. The PCB's from the Cumar silo coating are dissolved by the silage juices and PCB residues migrate into the silage. When the contaminated silage is fed to cows, the PCB residues accumulate in the body fat and are excreted in the milk. The Food and Drug Administration (FDA) has established a "temporary tolerance" for PCB's of 2.5 parts per million (ppm) for milk on a fat basis. If this tolerance is exceeded, the milk can no longer be marketed.

In 1971, after the silo coating was identified as the source of PCB-contamination, a research program was initiated to develop methods of decontaminating silos previously coated with Cumar. Preliminary laboratory studies determined that various coating materials would form barriers to PCB residues. The coatings which provided the most effective barriers to the residues in laboratory tests were then applied to dairy farm silos known to be contaminated.

Preliminary results of these trials were very encouraging. The barrier coatings effectively reduced the residues appearing in the silage. However, these results did not indicate whether the barrier coatings would be effective when the silo was used continually.

Study of the effectiveness of the barrier coatings on the early-treated silos has continued. Additional silos have also been coated. Table 1 summarizes the average concentrations of PCB's in silo wall scrapings and silages collected before and after treatment with a barrier coating. All of the silage samples were collected adjacent to the silo walls at approximately 2-week intervals.

Silos 1 and 4 were both cleaned by wire brushing the wall surfaces and recoating with hydraulic cement containing an acrylic bonder (Thoroseal and Acryl 60—Standard Dry Wall, Inc., Miami, Fla.). Silo 1 has been filled alternately with grass and corn silages a total of five times. Silo 4 has been filled twice, once with grass and once with corn silage since recoating.

Silo 2 was cleaned with high pressure water (500 psi), then recoated with water-carried epoxy (009 Epoxy—Action! Plastic, Inc., Charlotte, Mich.). The top 13 feet of this silo remained uncoated. The silo was filled four times with corn silage.

Silo 3 was also cleaned with high pressure water and then recoated with furfuryl resin coating (Silenzcrete—Universal Cooperatives, Alliance, Ohio). This silo was half filled with grass silage. When the grass silage was emptied, the silo was filled with corn silage, then refilled with grass silage.

Silo 5 was cleaned by wire brushing the wall surfaces then recoating with a water-carried epoxy designed to give a "high build" or thick coating (009-900 HB epoxy—Action! Plastic, Inc., Charlotte, Mich.). This silo has been filled twice with corn silage.

Silo 6 was constructed of waxed staves, therefore, sandblasting was required as a cleaning method. This silo was coated with a polyester coating (KanGlas—Feller Enterprises, Inc., Waukon, Iowa). This silo was filled with grass silage, partially emptied, and then refilled.

All of the barrier coatings used on these silos have provided an effective reduction in the concentration of PCB's in the silages and have maintained their effectiveness with continued use. The use of trade names is to identify the prod-

TABLE 1—Effectiveness of Barrier Coatings.

	Scrapings before recoating	Silages before recoating	Silages after recoating
	Parts per million (ppm) of PCB's		
Silo 1	20,155	7,132	0.19
Silo 2	398	32	1.02
Silo 3	366	182	1.23
Silo 4	>10,000	60	0.19
Silo 5	32,503	126	0.75
Silo 6	298	36	0.14

L. B. Willett is an assistant professor, Department of Dairy Science, Ohio Agricultural Research and Development Center.

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ucts used in this research report is not an endorsement of these products nor meant to discriminate against similar products not tested.

The hydraulic cement coating was the most effective material. The average concentrations of PCB residues in silages from the hydraulic cement-coated silos were about five to six times lower than from the silos protected with epoxy or furfuryl coatings. However, all coatings reduced the PCB's in silage sufficiently to keep contamination below the actionable level.

The "high-build" epoxy and polyester coatings have not been evaluated for as many seasons as the other materials. Both appear to be promising materials. The "high-build" epoxy shows a marked improvement in effectiveness over the other water-carried epoxy. The polyester appears to be as effective as the hydraulic cement and will continue to be studied.

The coatings have remained well-bonded to the silo walls. Bonding has failed in only two instances. A small area (approximately 3 feet by 3 feet) of the coating in Silo 1 came loose after four fillings. A similar area of the coating came loose in Silo 3 after the second filling. These failures probably resulted from insufficient cleaning of the silo wall in those areas before the coating was applied. In each case the area was easily repaired by the dairyman.

It has been determined that dairy cows deposit between 11 and 22 percent of the PCB's they consume into the milk. Therefore, under most dairy feeding systems, the concentration in silage adjacent to the silo walls would need to exceed 5 ppm (dry matter basis) before the "temporary tolerance" would be approached. The effectiveness of the barrier coatings has been further verified as the PCB concentrations in milk produced on the farms with these silos have all declined below the "tolerance level.

A dairyman who owns a silo which was once coated with Cumar and is PCB-contaminated may wish to use the barrier coating approach to eliminate the residue. In many instances, barrier coatings are more practical than removal of the silo considering time, expense, and convenience. However, if various barrier coatings are to be effective the following considerations and precautions should be observed.

If a silo is to be decontaminated by recoating, dirt and loose particles of old coatings and/or deteriorating wall surfaces must be removed. The barrier coating will be no better than the surface upon which it is applied. If the silo is in very poor repair it probably will be best to replace it.

Sandblasting is an excellent method of cleaning a silo wall surface upon which a new coating is to be applied. When this method is used, care should be taken to control the dust, debris, and sand which can spread PCB contamination to other areas of the farm. The expense of sandblasting makes this approach impractical under some circumstances.

Washing the surface with high-pressure water (500 psi) has been shown to be an effective means of cleaning silo walls. When this method is used, the runoff must be controlled to prevent PCB contamination of waterways. Time must be allowed for the silo walls to dry prior to application of the coating. Therefore, some delay must be expected when water is used. This is particularly important in the winter when frost may build in the silo walls, preventing good bonding of the coating.

Wire brushing of the silo surface is also effective, but requires a great deal of time and labor.

A special problem is presented in preparing to recoat a silo which still has a previous coating intact or was constructed of wax-treated blocks. Unless the old surface is removed or a firm rough surface prepared, the chances of good bonding of the new coating are greatly reduced. A coating should never be removed with an organic solvent because it will spread the PCB contamination and may leave the surface unfit for recoating. With solvents, there is also the danger of fire and/or toxic vapors. Sandblasting may be the best way to remove an intact coating.

The coating used as a barrier to PCB's must withstand the harsh environment inside a silo, plus prevent the acids in silage juices from reaching the silo wall. Some of the desirable coating properties are listed below.

(1) The coating must bond well to concrete.

(2) The coating must be waterproof, non-porous, and cover completely.

(3) The coating must be acid-resistant because pH values as low as 3.5 are encountered.

(4) The coating must withstand temperature ranges from below freezing to 160° F without failure.

(5) The coating should be tough as that machines, such as unloaders don't cause it to flake off.

(6) The coating should not contain chlorinated hydrocarbons or toxic chemicals which will contaminate the silage. FDA approval of the product for feed containers is recommended.

(7) The coating should meet Occupational Safety and Health Act (OSHA) standards to protect the workers applying the material from toxic or flammable vapors. The product must also meet local air pollution control regulations.

(8) The coating should not contain a solvent in which PCB's are readily soluble because PCB's from the silo wall may migrate into the new coating as it is applied.

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