7836 U-005-307.28

HERRICK ENGINEERING, INC., TRANSITE FIBER STABILIZATION STUDY, FEMP, WESTINGHOUSE ENVIRONMENTAL MANAGEMENT COMPANY (WEMCO) - (USED AS A REFERENCE IN OU3 RI/FS/PP - APPENDIX B)

09/07/92

HERRICK ENG WEMCO
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REPORT

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TRANSITE FIBER STABILIZATION STUDY

Final Report

September 7, 1992

to

Westinghouse Environmental Management Company of Ohio

by

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1. Abstract

The Fernald facility uses corrugated asbestos-cement sheets (Transite) for the walls and roofs of many buildings. The condition of the surface of these materials ranges from nearly perfect to badly deteriorated. There is a concern over the possible loss of asbestos fibers from the surface of the Transite. Such loss is more likely when the cement component of the Transite has been chemically attacked or physically damaged.

Surface treatment of Transite has been proposed as a way to stabilize its surface, thus arresting the loss of fibers to the environment. The thousands of possible products which could be considered include many which would not perform adequately. There is a need for an orderly, scientific evaluation of the two aspects of the situation.

The first of these aspects is an understanding of the aging and/or deterioration process of Transite's cement surface. The methodology of the study is to evaluate cement industry experience and technology in the context of the unique characteristics of the Transite product. There is no clear, single answer to the question of why Transite deteriorates. Chemical attack from atmospheric acid gases and the physical erosion of rain, ice, wind and temperature cycling are the most influential factors.

The second part of the study is the determination of those pertinent characteristics of treatments which might stabilize the surface of Transite as well as arrest (or at least delay) further deterioration. This defines the types of candidate surface treatments which have high success probability.

The family of products known as penetrating encapsulants are identified as having a high probability of success in this application. Special formulations may be required for these coatings to keep them stable during long term ultraviolet light exposure.

The actual evaluation of candidate treatment products will require an orderly test methodology. A method is described which can be used to evaluate the fiber release potential from untreated or treated Transite.

2. Objectives

a. Statement of the problem

Most of the manufacturing buildings at the Fernald site are of structural steel construction with corrugated Transite walls

and roofs. These buildings were erected in the 1940's and 1950's. The durability of this construction is confirmed by the generally good condition of these structures.

It was determined in 1991 that debris in the gutters of buildings with Transite roofs contained asbestos fibers. WEMCO commissioned a Pilot Study for Transite Fiber Migration, which was completed in February, 1992. This Study confirmed above-background levels of asbestos fibers in the ground and on the concrete near Transite-clad buildings.

It is desired to stabilize the asbestos fibers on the surface of the Transite so as to minimize the migration of asbestos fibers to the air, water and soil. There are many approaches to surface stabilization, each represented by dozens of commercial products. It is essential to understand the mechanism of surface deterioration before considering the different types of treatment.

b. Purpose of the study

The purpose of the Transite Fiber Stabilization Study is to define the characteristics of surface treatments which will have a reasonable probability of success, both short term and long term.

To achieve this understanding a stepwise process of information gathering and interpretation was undertaken. A thorough understanding of the Transite product is one of the foundation elements. Another foundation is an understanding of Portland cement and the materials produced with it. Cement industry literature reports of repair and restoration establish the technical mechanisms of the aging and deterioration of cement surfaces.

Once the mechanisms of surface deterioration were understood the various alternatives to arresting these mechanisms were evaluated. Understanding these mechanisms leads to the recommendation of a method for evaluating the condition of surfaces to be treated as well as the testing of candidate products or materials in service.

3. Transite

a. Product history

The first asbestos-cement products were developed in Italy in the 1920's. The utility of these products was noted in the United States and they were made here within only a few years after their invention. Large diameter pipe for water mains was a high volume product for many years. Flat sheet and corrugated sheet are different shapes of the same basic material.

Transite was the Johns-Manville Company's trade name for their brand of such asbestos-cement products. While there were other manufacturers and product names, the term Transite has become a generic name for all such materials.

b. Manufacturing techniques

Transite is a mixture of Portland cement, fine silica sand, asbestos fibers and water. Production specifications for each component had rigid control limits so as to maintain product quality. The length of the asbestos fibers was a factor. Longer fibers contribute more reinforcement to the product than shorter fibers. The weight percent of asbestos in the mix was adjusted for the fiber length. The mix contained an average of 50% asbestos on a dry weight basis. The balance of the dry mix was an approximately equal blend of silica sand and cement.

Water was added to the dry mix and the resulting slurry pressed into sheets under hydraulic pressure. The mold was covered with a fabric, through which the excess water was pressed out. At this point in the process the material was called "green" Transite. Looking at both sides of a sheet of Transite will reveal which side is which because of the presence or absence of the fabric weave pattern. The "green" material was cured in autoclaves at 100 psi steam pressure for about eight hours. This provided a thorough initial cure of the Portland cement.

Personal correspondence with scientists involved in Transite product development at the prior Johns-Manville Company revealed that there were evaluations of surface treatments of Transite products. There was a particular interest in making asbestos-cement shingles in colors for the consumer market. Some colored shingles were made by a process of incorporating colored pigment in the dry product mix. The colored mix was autoclaved, making the color a part of the base material as opposed to a coating. Painting was tried but rejected because the painted surface had less long-term durability than the parent material; i.e. painted material would have to be re-painted at regular intervals, but the parent material needed no such maintenance.

Transite product literature from the 1940's and 1950's states that there is no advantage to painting Transite. If a user wanted to do so, for example to match an existing building color, the preferred coating would be a chlorinated rubber enamel. The second preference would be a heavy prime coat of boiled linseed oil followed by two coats of "a good exterior paint" with an oloeresinous vehicle.

c. Physical properties

A width of 42 inches was standard, with lengths varying to eleven feet. The corrugations have a pitch of 4.2 inches. The vertical

thickness of the sheets is 7/16 inch. The peaks and valleys are a full 7/16 inch thick. The webs are somewhat thinner.

Dry Transite has a density of 110 pounds per cubic foot. The in-place weight of dry corrugated Transite is 4.1 pounds per square foot of gross area. The product, as manufactured, had a transverse strength of 3,000 psi. The Brinell Hardness (500 kg load, 10 mm ball, 10 sec) was 25 at the crown and 30 at the flanks.

d. Aging experience

The inspection of multiple installations of Transite roofs and siding is not difficult because of the large amount of Transite used for these purposes. Much of this material appears to be in excellent condition even after 50 or more years in service. Where there are known conditions that could be expected to aggressively attack the cement, such as in Fernald's nitric acid processing buildings, the predictable deterioration is apparent.

Some generalizations can be drawn. One, as noted above, is that acids attack cement. Another is that vertical panels (walls) appear to have less deterioration than roofs. On balance, there are enough Transite installations in very good condition that it can be stated that there is nothing inherent in Transite that will cause it to "wear out of its own accord" after some number of years. There are causes for degradation. The purpose of this study is to identify them so they can be arrested.

4. Cement technology

a. Mechanisms of curing and aging

Portland cement is a dry material that, when mixed with the proper amount of water, undergoes a chemical reaction to form a hard and durable building material. Cured cement is very much like native stone. It has high compressive strength but is much weaker in tension.

The proper "setting" of portland cement is a chemical reaction that should produce an excess of calcium hydroxide in the cured material. The initial setting of the cement is essentially complete in a few days. The excess alkali forms a durable gel with the water in the mix. Very slowly, this gel reacts with carbon dioxide in the air to form calcium carbonate. This conversion to calcium carbonate is the reason for the increase of the strength of cement with age. While the gel contributes no strength to the matrix, calcium carbonate can be as weak as chalk or as strong as granite. The best cement is the result of favorable calcium carbonate formation. The "carbonate front"

progresses from the surface to the interior of the matrix at a more or less predictable rate. The rate at which the carbonation front penetrates into the cement is a function of the square root of time, measured in years.

b. The difference between cement and concrete

When cement is mixed with aggregate materials like sand and stone the material is known as concrete. The aggregate does not contribute strength, but at one-eighth the cost of cement it makes a composite of more modest cost. The addition of reinforcing bars, typically made of steel, provides the tensile strength that masonry materials lack. Reinforced concrete is a wonderfully versatile building material and the literature provides considerable information about its design and maintenance.

c. Mechanisms of deterioration

The durability of reinforced concrete is controlled by factors related to the cement, the aggregate, and the reinforcing steel. Steel is the particularly vulnerable component. Iron oxide, iron chloride and iron sulfate have volumes many times that of steel. The expansion forces that develop as these compounds are formed causes internal stress so that the surface of the concrete "pops off." This exposes more reinforcing steel and the problem gets progressively worse.

A substantial body of literature is available to show that the existence of calcium hydroxide gel in the cement is a protection for reinforcing steel. Almost all of the reactions that attack steel are acidic in nature, so the strong alkali is a protection because it is preferentially consumed. Once the gel is gone (when the carbonation front reaches the steel) this protection is gone and the steel corrodes. Corrosion of reinforcing steel, particularly from the calcium chloride used as a de-icing salt on roads and bridges, is the primary cause of failure of reinforced concrete structures.

A factor which is important in the deterioration of masonry structures is the effect of atmospheric acidic gases. The action of "acid rain" on the historic granite and limestone structures in places like the Acropolis in Athens are ample evidence of the rapid deterioration that is possible. Calcium carbonate is nearly insoluble in water. Calcium sulfate, calcium chloride and calcium nitrate, formed by reaction with acid gases, are water soluble. Rain will dissolve them and a fresh layer of calcium carbonate is exposed to further chemical attack.

Some installations like bridge piers and ocean shoreline pilings are known to have been eroded by the action of waves and sand. These are unusual circumstances. Physical erosion from such intense scouring is not a common damage factor.

The physical action of thermal expansion and freeze-thaw cycles is another consideration. Thermal expansion is significant when the coefficients of expansion of the cement and the aggregate are different. The larger the aggregate, the more potential for this to happen. The interface between the cement and the aggregate particles is critical in that this bond must be maintained if the matrix is to hold its properties. Differential thermal expansion can break the bond.

The freeze-thaw cycling which is the normal circumstance in many locales must be considered. As water freezes the volume of the resulting ice increases. Just as described above in relation to the volume of oxidized steel, the increase in volume of the ice can cause surface materials to "pop off" when a critical moisture content is exceeded. Conventional wisdom advises that the prevention of "puddling" is the best protection against freeze-thaw damage of concrete structures. To meet the needs of persons who would like to "waterproof" cement or masonry surfaces there are several commercial products available. Appropriately drained cement surfaces, like natural rock formations, are well suited to handling the normal seasonal cycling of the elements.

d. Implications for Transite

Transite is a unique material in that its "aggregate" component is fine sand. Asbestos fibers provide the same tensile strength reinforcement <u>function</u> as steel, but are chemically non-reactive. The degradation mechanisms against which asbestos-reinforced cement does <u>not</u> provide protection are acid attack, abrasion and freeze-thaw cycling.

The net of these observations is that hypotheses regarding the stabilization of the surface of Transite are not the same as those regarding the protection and maintenance of concrete. The absence of steel reinforcing in Transite means the conversion of calcium hydroxide gel to calcium carbonate is favorable in Transite, not a negative aspect as is the case for reinforced concrete.

An essential element in consideration of the current issue is that asbestos fibers are chemically non-reactive. They will not dissolve, but the cement that binds them is vulnerable to attack. As long as the asbestos fibers are imbedded in cement they are immobilized. Should there be a loss of the surface cement the fibers will be exposed and may then become mobile. The first issue, then, is to arrest the loss of cement at the surface of the Transite. The second issue is to immobilize the fibers and partially deteriorated cement which are already partially exposed. If these can be accomplished the asbestos fibers will not be released to the water, air or soil environment.

e. Testing procedures

No testing procedures that can be simply "picked up and applied" were found that would be totally appropriate for the current study. Testing procedures must be adapted from those available and then tailored for this specific purpose.

5. Cement repair and restoration

a. Industry research

The repair of concrete has been studied from many different aspects. The literature abounds with testimonials, case studies and theories regarding the protection of reinforced concrete. There is much information regarding the chemical reaction of cement components with ill-chosen aggregates and other aspects of poor mixing or curing. Most of this literature is of only marginal value in the consideration of stabilization of the asbestos fibers on the surface of Transite.

b. Industry experience

The American Concrete Institute's "Guide to Durable Concrete" includes a chapter entitled "Use of Coatings to Enhance Concrete Durability." Their classification of coatings according to thickness is useful. Surface water repellents (Class I) have a thickness under 5 mils (0.13 mm). Class II plastic and elastomeric coatings have a thickness from 5 to 50 mils (0.13 to 1.3 mm). Class III plastic and elastomeric coatings have a thickness from 50 to 250 mils (1.3 to 6.4 mm).

Classes II and III coatings are impermeable protective barriers. Coatings which allow the transmission of water vapor (breathable coatings) are found only in Class I, but not all Class I coatings are breathable. For Transite treatment it is considered important to have a breathable coating. The ACI document addresses the subject:

> 7.2.3. *Precautions when using coatings to minimize freeze-thaw damage*: The intent of coatings here is to keep the moisture content of the concrete below the critical saturation point so that it will not sustain damage during freezing. Such coatings should be used with extreme caution, particularly on slabs or walls which are exposed continuously to moisture on the back side. The indiscriminate use of impervious coatings under these conditions may actually trap water in the concrete and adversely affect durability. . . . Breathable coatings, which are claimed to keep additional water from penetrating a concrete section, while allowing vapor to escape, are available and show some promise.

Observations at installations where impervious coatings have been applied to Transite show a consistent pattern of dismal performance. The bond between the Transite and the coating is the weak link, presumably because moisture in the Transite cannot escape.

The concrete maintenance and repair business has wide experience in overcoating existing structures. Rendering is the application of a new masonry surface layer by troweling or casting. Gunniting is the spray application of fresh cement or mortar to the surface. In these applications a new layer of material, up to several inches in thickness, is applied on top of the old material. The critical element is the bond between the new material and the old. ACI's statement clearly presents conventional coating technology wisdom:

> 7.2.2.1. Most coating materials specifically formulated for use over concrete develop and maintain an adhesive bond strength greater than the tensile strength of the concrete. For this reason, adhesion is not a major problem affecting the performance of a coating provided it is applied to a clean, dry surface. The surface must be free of (1) loose particles of dirt and dust, (2) oil or other chemicals that prevent adhesion, and (3) water. If the surface is not clean, alkaline washing, acid etching, or sandblasting may be employed. If these methods prove unsuccessful, all of the contaminated material at or near the surface should be removed by a scarifier or jackhammer. . .

The Transite surfaces at Fernald cannot be aggressively scoured because the result would be to create a contamination problem where one may not currently exist. A successful Transite surface stabilization treatment will anchor the exposed fibers to the sheets, not tear them away. This is yet another aspect where conventional wisdom does not apply to the current situation.

c. Types of commercial products

Rendering, gunniting, Class II and Class III coatings will not be addressed because they are unsuitable to the present need, as described above. Certain Class I compounds may be applicable.

<u>Cement slurry</u> products lightly re-surface cement for decorative purposes. On the positive side, the alkali in the formula provides some fresh protection against acid attack. Negatively, the new cement may not bond well to the present surfaces and they would add weight to the Transite. On balance, cement slurry treatment is not recommended.

<u>Paints</u>, whether oil or water based, are totally dependent on their bond to the substrate. Potential bubbling and peeling from the retention of liquid water in the Transite limit the consideration of those paints which produce a breathable coating. Since the

Transite situation does not allow for abrasive surface preparation, paints can only be considered if the surface is or has been made compatible with the paint such that a secure bond will develop. This limits the consideration of paints to relatively few situations.

Waterproofing products may have applicability. A major application of these products is in situations such as parking lots, where the water contains dissolved road salt. While waterproofing is not a major factor for Transite surface stabilization, this class of products may have other favorable characteristics. Hydrocarbon based waterproofing products, sometimes supplied in a base of organic solvent, are preferred. Silicone or silane based products are not recommended for Transite because the vapor pressure of these compounds, though low, results in the sublimation of the material with time.

6. Asbestos abatement products

a. Mechanisms of fixation

The immobilization of asbestos fibers can be accomplished by enclosure or encapsulation. Enclosure is the construction of an air-tight box around the asbestos containing material such that fibers will not be dispersed even if they are released from the material. The jacketing on insulated pipe is a form of an enclosure.

Encapsulation is by one of two types of products. With *penetrating encapsulants* a low viscosity liquid penetrates the asbestos containing material and adhesive binds the fibers to each other and the substrate. With *bridging encapsulants* a high viscosity liquid or paste is applied to "bridge over" the surface of the asbestos containing material so as to retain the fibers within. Bridging encapsulants perform much the same function as enclosures.

b. Types of commercial products

Enclosure will not be a normal consideration for Transite. One commercial product system, called encasement by its manufacturer (Barrier Systems, Inc.) combines bridging encapsulation and enclosure. This two-step system is based on an initial surface application of urethane foam. This adheres strongly to most surfaces. The foam is covered by a rigid layer of the same material used to make boat hulls. The resulting matrix is durable, strong, and effective in preventing asbestos fiber release. These advantages must be balanced against the added weight and volume of the material and the fact that the encasement would make a monolith out of what had been a series of individual

panels. In cases where physical contact with Transite is unavoidable and removal is impractical the encasement approach may be applicable.

Bridging encapsulants will, in general, be unacceptable for the reasons detailed for Class II and Class III coatings. Those which are breathable might be considered in situations where neither added weight nor surface bonding are concerns.

Penetrating encapsulants offer significant promise for Transite surface stabilization. There are two chemical families of such materials; crystalline silicates and elastomers. The silicate materials are soluble in water and thus unsuitable for outdoor use.

Encapsulant products based on organic chemistry, with water-based latex formulations being most common, exhibit useful properties. These products are formulated to soak through up to several centimeters of depth of spray fireproofing or acoustical plaster. The success of the products depends on the liquid material penetrating to the substrate. With an adhesive bond to the substrate and a cohesive bond for the bulk material, the asbestos fibers are immobilized. Such asbestos-related products are marketed under the names of penetrating encapsulant, lockdown, post-removal encapsulant, and soil encapsulant.

7. Application of knowledge to the Transite at Fernald

a. Evaluation of the current condition of Transite

All Transite at Fernald is not equal. Most interior building side walls that have not been subjected to physical abuse are in excellent condition. Many exterior side walls are in similar good condition. Roof surfaces show some damage, and the interior of the nitric acid processing building shows severe surface cement attack.

It is important to note that the Transite surface condition concern has not progressed to the point of impending structural failure. While it is always unwise to walk on Transite roofs because of the inherent brittleness of the material, normal roof loading from wind, rain and snow has not caused structural failures. It would be prudent to develop an evaluation criterion for Transite to judge when it is so weak that it should be replaced for safety reasons, but that is beyond the scope of this study.

b. Causes of surface deterioration

The exposure of the Transite to the elements is considered to be

the primary mechanism of surface degradation. Ambient levels of acid gases, particularly sulfur oxides and nitrogen oxides, cause rain water to be somewhat acidic at times. When this water is in contact with Transite the acids will react with the alkali gel (if present) or the calcium carbonate component of the Transite. The calcium sulfate or calcium nitrate formed is water soluble and will ultimately be dissolved and washed away.

Since wetting will be more intense on roofs than on side walls, greater attack from water-borne acids is predictable. There will be more abrasion from wind, ice, snow and rain on the roofs than on the side walls. For these reasons the roof Transite is considered to be the primary source of possible asbestos fiber migration from the Transite at Fernald.

Reducing the likelihood of asbestos fiber loss from the surface of Transite requires two distinct actions. First, the cement component of the Transite should be protected from further deterioration. Secondly, the asbestos fibers and partially deteriorated cement must be anchored to the lower layer of remaining sound Transite.

c. Characteristics of protective materials

Neither concrete structure restoration procedures nor conventional protective coating technology fully satisfy these objectives because they demand surface cleaning so as to expose a sound surface layer for bonding. In the case of Transite such aggressive surface preparation would release asbestos fibers to the environment, creating a problem where one may not now exist.

The application of coatings of epoxy, bitumen or bridging encapsulants requires, according to the manufacturers, similar aggressive surface preparation. In the absence of such preparation the coating system will fail at the surface bond. The polymerized coating has a relatively high tensile strength, so it will peel off when it delaminates. This will expose a fresh layer of unprotected asbestos fibers, which is undesirable.

Any coating material that contains a suspension of inert particles in a liquid would form a surface layer and is undesirable for that reason. This would be the case for pigmented paint or similar products. Normal application instructions for such materials call for surface preparation (sanding, brushing, etc.) and then the application of a primer. The primer is usually a low viscosity liquid which will penetrate the substrate to provide an improved bonding surface.

Preferred coating materials would be applied by low pressure spraying, without air atomization. Brushing or high pressure spraying would disturb the surface and produce an unnecessary release of asbestos fibers.

A material which is completely soluble in a water based formulation would be ideal. A latex emulsion without inert fillers may provide an acceptable uniformity of penetration. Latex polymer particles are typically 0.2 micrometers in diameter, which may provide adequate mobility of the liquid treatment down to the solid part of the Transite. Latex solids concentrations in the range of 10% to 20% by weight are typical for penetrating encapsulants. One manufacturer suggested that a lower percentage of solids might give more uniform penetration of the latex. Another manufacturer suggested using the higher solids percentage for the same reason. There is no single, clear answer because there are very few situations where Transite has been treated for the reasons being considered here.

An ideal coating would cure (polymerize) to a flexible film, attaching itself equally firmly to the sound Transite, the asbestos fibers and the dust or other forms of partially deteriorated surface cement and sand. This coating would provide some liquid water protection but be permeable to water vapor (breathable) so the Transite could dry out after a rain. A useful service life, i.e. longer than ten years, would require that the coating be durable under the influence of sunlight (especially ultraviolet light exposure), ice, rain, wind and freeze/thaw cycles.

An ideal coating should add minimally to the weight and volume of the Transite so that final disposal cost is not increased. There should be no adverse effect on the fire rating of the Transite as a result of the treatment. During application and through its service life the material should not cause undue concerns over worker health (inhalation, dermatitis), air pollution (solvent evaporation), or soil contamination (overspray). The ideal material would be able to be applied to Transite that was damp so that the application would not be overly subject to weather conditions, and it would cure in a relatively short time.

d. A strategy for evaluation of candidate materials

Commercial products can be screened for consideration on the basis of these criteria. An article in a British Journal had an appropriate warning:

> "There is a maxim in the coatings field that if someone has put a product in a can then somebody else has not only painted an inappropriate surface with it but also at least some percentage of the time views the result as a success."

Once a list of candidate products is developed it may be appropriate to make site visits to locations where successful treatment is claimed. The longer the in-service life of these installations, the more valuable will be the observations.

Just as not all treatment products are not the same, the existing Transite is in various stages of condition. Some Transite, especially wall materials in protected locations, may be in such excellent condition that no treatment is needed. It would be desirable to have some quantitative methodology to rate the condition of Transite building sides and roofs so that a Fernald-specific priority schedule for treatment could be developed. Such a method or methods would also be the basis for the evaluation of candidate treatments.

Among the more useful references is the work of S. K. Brown in Australia. He has published information about the degrees of deterioration of "asbestos-cement cladding" and fiber losses during demolition and renovation. He further reports on several surface coating systems, and has developed methods for measuring the fiber loss from surfaces by the "brush erosion method". This is a miniature "broom and vacuum cleaner" adapted to the type of small filter used to determine ambient airborne asbestos fiber concentration. This method shows promise because it quantifies the amount of material dislodged from the surface of the Transite by a given amount of physical disturbance.

Brown's technique evaluates an area of about one square inch, and it measures only asbestos fibers. It is proposed that Brown's surface brushing technique be used in principle, but in a Fernald/Herrick improved manner. The test device would use a High Volume air sampler, similar to the unit used for air pollution particulate monitoring. The sampler would be outfitted with a four inch diameter glass fiber filter rather than the 8x10 inch glass fiber filter used for ambient air pollution tests. "Test Device" Figures 1 and 2 show two different filter aggangements for a High Volume air sampler.

The test would measure the particulate dislodged from a four square foot area of Transite surface while brushing that surface with a stiff-bristled nylon brush for a period of two minutes. The test area would be defined by a disposable cardboard shield, like an open 2x2x2 foot box without a top or bottom. The High Volume sampler's filter would be positioned at the center of this opening, two feet above the surface of the Transite. The individual performing the test would don a respirator and put on a single glove bag-type sleeve. As the surface is being brushed any particulate, including asbestos as well as other materials, will become airborne and be swept to the filter by the air sampler. The Figure "Test Arrangement" shows this process. At the conclusion of the test the glove bag sleeve and the cardboard would be disposed of as asbestos waste. The glass fiber filter from the high volume air sampler would be weighed. This release would be reported as milligrams per square meter of Transite surface.

This method for evaluating the soundness of Transite surfaces is equally applicable to untreated and treated surfaces. This is a proposal for a new testing technique. There are no existing

TEST DEVICE
FILTER ARRANGEMENT 1

TEST DEVICE
FILTER ARRANGEMENT 2

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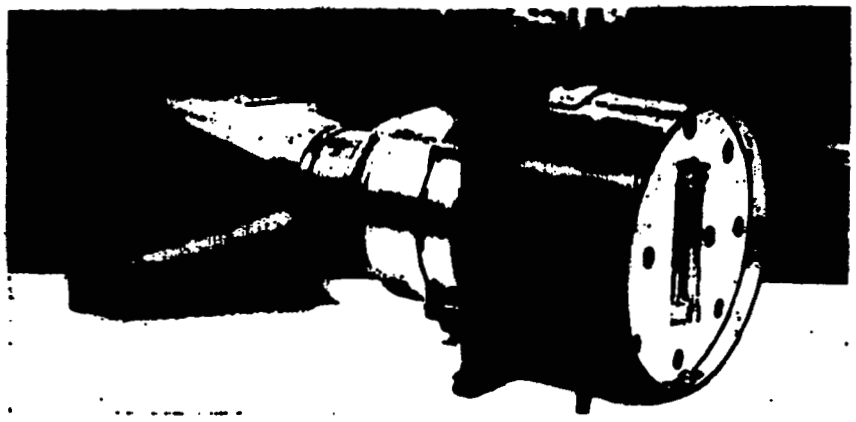

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TEST ARRANGEMENT

numbers against which to compare the test results. The measurements obtained will be correlated with each other, as testing is done. It is foreseeable that there will be a range of test results that can be used to make judgments. Transite in excellent current condition and Transite which has been treated with an effective coating will produce "low" numbers. Moderately deteriorated Transite and marginally effective surface treatments will produce "mid range" measurement numbers. Surfaces in poor condition will, when tested by the proposed method, produce test date that will be numerically higher.

The actual number ranges will be determined once testing is under way. The results will be valuable for comparison with other test results obtained by the method. Once the data bank is established, the trend of measurement numbers over several years will be the quantitative indicator of the performance of various treatment techniques.

The next step will be the testing of individual products. the need for such testing is well stated by ACI:

> 7.2.1. "There is no guarantee that coatings made by different manufacturers will perform the same, even when classified as the same generic type."

Candidate surface treatments should be evaluated under both long term and accelerated aging conditions. The paint industry has somewhat standardized tests for these purposes. While these tests are useful, the only real proof will be in actual service life. Actual experience cannot be accelerated, but coating systems that do not successfully complete the artificially accelerated aging tests can be considered less likely to show satisfactory in-service performance.

As part of the product evaluation program it would be appropriate to demonstrate several commercial products at a specific location on the Fernald site. A building with an east-west orientation would have its south half of the roof designated for this purpose. Vertical rows of Transite panels would have different products applied, leaving untreated strips between them. This could be done before the results of the accelerated aging tests were available, and would provide valuable experience in the specifics of application of the products.

8. Summary and Recommendation

Protecting the Transite surface from the slow dissolving effects of acidic precipitation and the erosion associated with weather cycles will extend the useful service life of the Transite. Such protection of the surface will deter the loss of cement at the surface as well as immobilize the asbestos fibers.

This can be accomplished by treating the Transite with a compound which will coat the surface, including dust and partially exposed asbestos fibers, with a material that cures to a flexible polymer. The treatment compound must penetrate through the surface to sound Transite beneath, bonding the entire surface mass to this underlying sound material.

a. Candidate products

Commercial products have been surveyed according to these criteria. Some concrete treatment products and a family of asbestos encapsulation products are identified as likely to meet the criteria. Representative products are:

Product(s)	Manufacturer
Certane 2050 - Undercoat Certane 909 - Lockcoat	Certified Technologies Eden Prairie, MN
Penetrating Encapsulant #1 Fiber-Seal	Eppert Co. Detroit, MI
Serpilock Serpiflex Shield (clear)	International Protective Coatings Ocean, NJ
Surtreat	Surtreat Corp. Pittsburgh, PA
Thompson's Water Seal	Thompson-Formby Co. Memphis, TN

These are representative products, not intended to be an exhaustive listing. In discussion with the manufacturers, a willingness to provide modified formulation for the treatment of Transite was the rule, not the exception. The single most common observation by the these technical representatives was that ultraviolet protection may be required for durability in an outdoor environment. The two ways to approach this protection are to add UV inhibitors to the material or to apply a separate surface layer.

Even though there is very little actual experience with the use of any of these treatments on Transite, there is a basis for an initial ranking of the products. The Surtreat material is designed as a treatment for concrete, which may be more toward the needs of a Transite treatment. Surtreat is recommended as a product which definitely should be evaluated.

Of the asbestos encapsulant products, solid technical understanding was demonstrated by the Eppert Company's product expert. The other named asbestos encapsulant products are listed because of their positive response to an inquiry specific to this

study. Other products in this general category could also be considered.

Thompson's Water Seal is the only solvent-based formulation as well as the only retail product in the recommended list.

b. Short vs. long term considerations

Any of the above products should be applicable to a building demolition project. Applying such a coating would reduce the probability of asbestos fiber release during demolition. On this basis it is recommended that such treatment be incorporated in the project specifications for building demolition. In this situation, and for buildings where the projected life is only five or so years, ultraviolet light deterioration of the coating is not an issue so any of the above products could be used "off the shelf" as asbestos fiber control agents.

For long term protection (more than ten years) the possible deterioration of the polymer must be considered. Ultraviolet protection is accomplished either by blocking the light with inert fillers or by formulating ultraviolet blockers into the coating material. On a personal level, this is like the prevention of sunburn by using zinc oxide paste or a liquid sun-block lotion.

A sun block would be accomplished on Transite by applying a separate surface film which contains inert fillers. Such a surface film should be breathable (not a vapor barrier), and should adhere strongly to the initial encapsulant. In this situation the encapsulant would only be a primer for the surface coating. While this would provide additional protection against weathering, the disadvantage is the formation of a bond which might ultimately fail. Treatment with a single component penetrating treatment, if one can be found that meets the criteria, is preferred.

Formulation of a coating product with ultraviolet inhibitors would require special arrangements. In asbestos product applications there is no need for such materials since they are used inside buildings. The inhibitors add cost to the product. In at least one instance an asbestos encapsulant product was formulated with an ultraviolet inhibitor, with successful application in an outdoor installation. The added cost of a special formulation should be evaluated in the context of the expected coating life with and without the inhibitor.

c. Cost

Cost will be an appropriate consideration at every stage of the program. Some of the building Transite at Fernald may be in such good condition that the marginal added protection against asbestos fiber release from a surface coating may not be appropriate. Short and long term projected building life will be a factor.

The cost of the material in dollars per gallon is not a sufficient criterion. The appropriate measure is the total applied cost of the treatments. This will be the sum of the labor cost and the material cost required to accomplish the desired treatment. Some products may lend themselves to a single coating, while others may perform optimally with two or more applications. If re-treatment is anticipated in a defined number of years, this cost can be included in a calculation of life cycle costing.

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