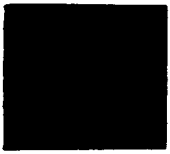
EPRI
Electric Power
Research Institute

Topics:
PCB
Waste management
Hazardous materials
Porous materials
Cleaning
Solvents

EPRI CS-4925
Project 1263-25
Final Report
November 1986



Development and Testing of Equipment for Removal of PCBs From Porous Surfaces

Prepared by
Quadrex HPS, Inc.
Richland, Washington

MONS 018335

REPORT SUMMARY

SUBJECT: Hazardous/toxic substances

TOPICS:
- PCB
- Waste management
- Hazardous materials
- Porous materials
- Cleaning
- Solvents

AUDIENCE: Environmental and R&D engineers and scientists

Development and Testing of Equipment for Removal of PCBs From Porous Surfaces

Cleanup of PCBs from materials such as concrete, brick, or asphalt typically involves removal of the contaminated area or manual scrubbing and mopping. This study shows that PCB removal by mechanical equipment can be as effective as manual cleaning, depending on the age and condition of the surface.

BACKGROUND Removal of polychlorinated biphenyls (PCBs) from porous materials is a costly and often labor-intensive process—with the contaminated surface often requiring repeated manual scrubbing and mopping. Typically, contaminated wood and asphalt are replaced instead of cleaned; brick and concrete surfaces are often replaced as well. A mechanical system that cleaned adequately could lower labor costs and make replacement of the contaminated surface unnecessary.

OBJECTIVE To evaluate equipment for fast and effective removal of PCB contamination from porous materials such as concrete.

APPROACH The researchers first searched the open literature for information on removal of PCBs from porous surfaces. They then contacted approximately 70 vendors of spray vacuum-cleaning equipment, evaluated available products, and selected two cleaning devices for testing. One device was a combination spray and vacuum unit modified for concrete cleaning and the other was a commercial rug cleaner. One series of tests involved removing uncontaminated transformer oil from aged (30-to-40-year-old) concrete. A second set of tests compared the effectiveness of both devices in removing Askarel (a mixture of PCB and tri- and tetrachlorobenzenes) from newly placed (three-week-old) concrete with the results achieved by vigorous scrubbing using a wire brush.

RESULTS Very little published information is available on cleanup of PCBs on asphalt, brick, or wood. The survey showed, however, that PCB penetration of porous materials depends on the type of PCB contamination, the elapsed time since the PCB was deposited, and the porosity of the material.

Both mechanical devices were more effective in removing PCBs from aged concrete than new concrete—probably because of the high moisture

MONS 018336

content (up to 90% of saturation) of the new concrete. Of the two mechanical devices, the commercial rug cleaner was the more effective. This unit was as effective at removing PCBs as vigorous hand brushing. A surface-sampling technique indicated that the cleaning procedures were probably confined to the first 0.0004 in. from the surface but also showed that a large fraction of the PCB contamination was at or very near the surface. This combination of characteristics maximizes the effect of cleaning.

EPRI PERSPECTIVE

This report offers new techniques for removing PCB contamination of porous concrete surfaces, but it also highlights the problems involved. If the moisture content of the concrete is too high, the effectiveness of both manual and mechanical cleaning is reduced. If the concrete is fractured, penetration of PCBs may be so deep that replacement of contaminated sections is necessary. These tests show that under some conditions mechanical cleanup of PCB contamination can be as effective as manual cleaning, but cleaning effectiveness depends on the equipment used, on the condition of the concrete, and on the elapsed time since the contamination. These variables all need to be considered by a utility planning a cleanup operation.

PROJECT

RP1263-25
EPRI Project Managers: R. Y. Komai; M. E. McLearn
Coal Combustion Systems Division
Contractor: Quadrex HPS, Inc.

For further information on EPRI research programs, call EPRI Technical Information Specialists (415) 855-2411.

MONS 018337

Development and Testing of Equipment for Removal of PCBs From Porous Surfaces

CS-4925
Research Project 1263-25

Final Report, November 1986

Prepared by

QUADREX HPS, INC.
451 Hills Street
Richland, Washington 99352

Principal Investigators
H. R. Gardner
D. B. Bateman

Prepared for

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
R. Y. Komai

Heat, Waste, and Water Management Program
Coal Combustion Systems Division

MONS 018338

ORDERING INFORMATION

Requests for copies of this report should be directed to Research Reports Center (RRC), Box 50490, Palo Alto, CA 94303, (415) 965-4081. There is no charge for reports requested by EPRI member utilities and affiliates, U.S. utility associations, U.S. government agencies (federal, state, and local), media, and foreign organizations with which EPRI has an information exchange agreement. On request, RRC will send a catalog of EPRI reports.

Electric Power Research Institute and EPRI are registered service marks of Electric Power Research Institute, Inc.

Copyright © 1988 Electric Power Research Institute, Inc. All rights reserved.

NOTICE

This report was prepared by the organization(s) named below as an account of work sponsored by the Electric Power Research Institute, Inc. (EPRI). Neither EPRI, members of EPRI, the organization(s) named below, nor any person acting on behalf of any of them: (a) makes any warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report or that such use may not infringe privately owned rights; or (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Prepared by
Quadrex HPS, Inc.
Richland, Washington

MONS 018339

ABSTRACT

The objective of this project was to identify or develop equipment that could be used with existing cleaning solutions to decreese the cost and labor intensive nature of PCB spill cleanup from a variety of porous surfaces. The approach included a sequence of: acquisition of background and existing PCB spill cleanup information, preliminary testing on concrete surfaces using transformer oil as a surrogate for Askarel, and finally proof-of-principle testing on Askarel (60% Aroclor 1260, 40% trichlorobenzene) coated concrete surfaces. A three-jet vacuum head and a commercial rug cleaning system were satisfactorily tested for use in PCB spill cleanup. Using a nonsolvent cleaning material and machine and hand cleaning, the surface PCB concentration was reduced by factors of 53 to 170 for an Askarel application of 480 ml/m^2. When the Askarel application was 160 ml/m^2, the PCB concentration was only reduced by factors of 1.1 to 1.8.

The near saturation moisture content of the three-week old concrete used for the PCB removal testing was believed to have severely limited the ability of solvent type cleaning materials to remove PCBs from the concrete surface. The NIOSH wipe technique and a specially developed technique for incremental concrete surface removal both produced samples that resulted in meaningful PCB concentration data.

MONS 018340

EPRI FOREWORD

Cleanup of porous surfaces exposed to polychlorinated biphenyls (PCBs) has generally been approached in two ways: (1) repeated manual scrubbing and mopping with a detergent or a solvent or (2) complete removal and disposal of the contaminated material. Both approaches are costly and labor-intensive. The need exists for a rapid, cost-effective cleanup method using readily available equipment such as the spray cleaner-vacuum used in commercial carpet-cleaning processes.

Because sufficient funds were not available to address this problem exhaustively, EPRI initiated a scoping study to examine this identified need. The initial results indicate that mechanical removal of PCBs from porous surfaces by using commercial cleaning equipment is approximately as effective as manual cleaning and probably requires substantially less operator time. However, neither quantification of percent removal of PCBs nor reclamation of cleaning solvents containing PCBs was performed. Both of these issues must be resolved before commercialization of this technique can be accomplished.

Although this R&D project was limited in scope, the information contained in this report is being made available for consideration and judicious use by utilities in PCB cleanups. It may also serve as a seed for other investigations into methods for the cleanup of PCBs from porous surfaces.

MONS 018341

Page 4 is blank

ACKNOWLEDGMENTS

The authors extend their appreciation to H. L. Butts for his highly valued conceptual designs, assistance in equipment fabrication and assembly, and consultation on the establishment of cleaning system operating parameters all of which contributed greatly to progress on this project. In addition, the purchasing, organizational, editorial, and typing skills of V. A. Scorup contributed to a high rate of progress on the project and expedited the completion of this report.

MONS 018342

page 6 is blank

CONTENTS

Section		Page
1	INTRODUCTION	1-1
2	BACKGROUND DEVELOPMENT	2-1
	PCB Cleanup from Concrete Surfaces	2-1
	Penetration of PCBs into Concrete	2-2
	Results of Equipment Survey	2-2
	PCB Cleanup of Other Materials	2-3
	References	2-3
3	PRELIMINARY TESTING AND DEVELOPMENT	3-1
	Approach	3-1
	Application of Transformer Oil (Texaco CT-JT)	3-1
	Equipment Development and Selection	3-2
	Three-Jet Vacuum System	3-2
	Commercial Rug Cleaning System	3-5
	Evaluation of Cleaning Solutions	3-7
	Classification	3-7
	Effectiveness	3-10
	Concentration Gradient Sampling	3-13
	References	3-15
4	PREPARATION FOR TESTING ON ASKAREL COATED CONCRETE SURFACES	4-1
	Approach	4-1
	Procedure	4-1
	Pouring of Concrete Sections	4-1
	Coating with Askarel	4-1
	PCB Sampling	4-3
	Extraction and Analysis	4-6
5	TESTING OF CLEANING METHODS ON ASKAREL COATED CONCRETE SURFACES	5-1
	Approach	5-1
	Three-Jet Vacuum Head	5-1

page 8 is blank

MONS 018343

Section		Page
	Commercial Rug Cleaning Equipment	5-4
	Wipe Test Results	5-4
	Concrete Sampling Results	5-6
	Hand Brushing	5-6
	Visual Effects of Cleaning	5-11
	General Effect	5-11
	Concrete Comparison	5-11
	Effect of Power Cleaner 155 Soak Time	5-11
	Effect of Power Cleaner 155 Concentration	5-14
	Surface Replenishment	5-14
	Time Interval Before Cleaning	5-14
	Wipe Test Replication	5-14
	Air Sample Results	5-15
6	CONCLUSIONS	6-1
APPENDIX A	Concrete Mix Design and Property Data	A-1
APPENDIX B	Procedure for Wipe Sampling	B-1

MONS 018344

ILLUSTRATIONS

Figure		Page
3-1	Three-jet vacuum head with exhaust and handling wand attached	3-3
3-2	Three-jet vacuum head with integral vacuum and pressurized fluid couplings	3-3
3-3	Underside of three-jet vacuum head with fan jet nozzles and interior peripheral gap to confine vacuum. 0.75X	3-3
3-4	Components of commercial rug cleaning system	3-6
3-5	Portion (lower right) of transformer oil coated concrete surface cleaned in 45 sec by one treatment with Freon-113 using three-jet vacuum head. 0.1X	3-10
3-6	Visual effect of indicated cleaning approach. 0.1X	3-12
3-7	Diamond impregnated bottoming tool. 1.3X	3-13
3-8	Fixture and drill used to abrade concrete surface in an ~90° arc to obtain concrete particles for PCB analysis. 0.1X	3-14
3-9	Area abraded with bottoming tool to remove particulate sample for PCB analysis. Note spots of higher PCB concentration present at 0.055 in. depth of sampling. Concrete section no. 9. 0.5X	3-14
4-1	Surface roughness of concrete used for PCB removal testing (top) compared to normally brushed and worn concrete bottom. Direction of broomed finish is vertical. 1.3X	4-2
4-2	Lower row, 480 ml/in.^{2} Askarel application on left and 160 ml/m^2 application on right. Note appearance of uncoated concrete in upper row	4-4
4-3	480 ml/in.^{2} Askarel application on left, 160 ml/in.^{2} Askarel application on right. 0.125X	4-4
4-4	Askarel around pieces of aggregate (arrow) at depth of 0.055 in. from concrete surface coated with 160 ml/m^2 Askarel. Concrete section no. 11 before cleaning. 1.3X	4-5
4-5	Wipe sampling using mask to define area. Note gauze fibers retained on rough concrete surface that had to be picked up with a tweezer. 0.15X	4-5
5-1	Dark appearance of new concrete fracture surface (right) indicating high moisture content. Old concrete on left. 0.5X	5-3

MONS 018345

Figure		Page
5-2	Macrostructure of old concrete (left) compared to new concrete (right). 1.4X	5-4
5-3	Steel wire brush used for HAND BRUSH approach. 0.3X	5-8
5-4	Steel wire brushing Power Cleaner 155 on concrete surface	5-8
5-5	Head attachment for vacuuming Power Cleaner 155 from concrete surface. 0.5X	5-9
5-6	Appearance of Power Cleaner 155 after brushing for three minutes. Note that foam on left edge of section has been vacuumed up	5-9
5-7	Cleaning results with Power Cleaner 155	5-12
5-8	Presence of higher PCB concentration spots to depth of 0.047-0.050 in. on concrete section number 7 after third MACHINE BRUSH cleaning. 0.3X	5-13
5-9	Network of cracking delineated by a higher concentration of transformer oil after cleaning attempt. 0.3X	5-13

MONS 018346

SUMMARY

The cleanup of polychlorinated biphenyls (PCBs) in spill or other contamination situations is costly and labor intensive. Particularly difficult is the removal of PCBs from porous surfaces such as concrete, asphalt, brick, and wood. In the interest of reducing labor and other costs associated with spill cleanup, a project was initiated with the objective of developing equipment that could be used with existing cleaning solutions to reduce PCB concentrations on porous surfaces to acceptable levels.

The approach involved the following sequence: acquisition of background information on PCB spill cleanup practices and results, preliminary evaluation of equipment and cleaning solutions using uncontaminated transformer oil applied to concrete surfaces, and finally proof-of-principle testing on Askarel coated concrete surfaces.

Two types of cleaning equipment were evaluated for removal of uncontaminated transformer oil from concrete surfaces. One used a vacuum head that contained three spray jets. With the spray and vacuum activated, and the head positioned in contact with the surface, the head could be moved in a systematic pattern to obtain complete coverage at a rate of 14 in./min. Confining the vacuum to a rectangular annulus around the interior of the head was essential for control and pick up of the volume of fluid sprayed from the jets. Based on test results, it appeared that this head would be most effective on concrete when used with solvent type cleaning solutions where the agitation provided by the jets was adequate for cleaning purposes. In the preliminary testing of the three-jet vacuum head with Freon-113 to remove transformer oil from concrete surfaces, the removal effectiveness was very good based on visual comparison of the cleaned surface to an uncoated surface. The testing also indicated that the head could be used with equally good results on floors and walls. Although not demonstrated, it is believed that this head could be used to clean nonporous surfaces with solvent or nonsolvent cleaning solutions.

MONS 018347

The second type of equipment evaluated was a commercial rug cleaner (1) that had spray (five jets), vacuum, and rotating brush capability in the cleaning head. Cleaning fluid for the head was pumped from a portable module containing a supply, and a used solution recovery tank each with 14 gal capacity. In use, the cleaning head is pulled along the surface to be cleaned at a rate of 8 in./min. The cleaning solution sprayed from the jets is agitated against the contaminated surface with the rotating brush. The used cleaning solution is picked up by the vacuum slit on the trailing edge of the cleaning head. In preliminary testing on transformer oil coated surfaces it was found that of the nonsolvent cleaning solutions tested, Power Cleaner 155 (2) appeared to perform the best on a visual comparison basis.

Proof-of-principle testing was conducted with Askarel (60% Aroclor 1260, 40% trichlorobenzene) coated concrete surfaces. The concrete used for testing, however, was poured three weeks prior to testing and as a result was within 90% of saturation with moisture. This high moisture content; 6.1% compared to 2.4% for completely cured concrete 30 years old, was believed to have caused a decrease in the effectiveness of the cleaning methods tested. In the extreme case it was found that the presence of moisture at, or near saturation (4-7%) in concrete (new or old) severely limited the ability of Freon-113, Freon-113 plus 35% ethanol, or perchloroethylene used in the three-jet vacuum head to remove PCBs from concrete surfaces.

While using Power Cleaner 155 in the commercial rug cleaning system and hand brushing tests, it was determined for Askarel applications of 480 ml/m^2 that factors of reduction in PCB concentration of 53 to 170 could be obtained. The two modes of machine cleaning tested appeared to be as effective as the hand brushing approach. However, when the Askarel application was reduced to 160 ml/m^2, a reduction in PCB concentration of only 1.1 to 1.8 could be obtained. The data appear to indicate that there is a limit to the degree of PCB removal that can be achieved. Other than implicating the high moisture content of the new concrete that was used for testing, no reason can be given for this greatly diminished effectiveness at reduced initial concentrations of PCB.

The effectiveness of the Power Cleaner 155 for removing PCBs appeared to decrease when the Power Cleaner concentration was increased from 1:32 to 1:1.

The PCB concentration results obtained from use of the wipe technique were in general very reproducible and permitted the compilation of an acceptable body of

data. Considering the roughness of the concrete surface being sampled by wiping this was a surprising result.

A surface sampling technique that permits the removal of incremental layers of concrete was successfully demonstrated. The results obtained indicate that the action of a cleaning method is probably confined to the first 0.004 in. of the surface. The results also indicate that before cleaning a large fraction of the PCB concentration is at or near the surface. Thus, a large proportion of the PCB contamination is accessible to the action of a cleaning method.

Airborne PCBs were detected during the concrete surface sampling activity (a fine powder was generated), and also in the exhaust hose during vacuuming operations involving the removal of Power Cleaner 155, and Freon-113 from concrete surfaces. The presence of airborne PCB requires that appropriate masks be worn by exposed cleaning personnel, and that vacuum exhaust hose be vented through an activated charcoal drum or other means to remove the PCB before release to the atmosphere.

For the purposes of the initial development of equipment and preliminary selection of cleaning approach and materials, transformer oil was considered to be an acceptable surrogate for Askarel. Rate of progress on these activities was accelerated by using visual appearance to evaluate the relative effectiveness of cleaning techniques and materials for oil removal. It is important to recognize, however, that based on the results of the testing on Askarel coated concrete surfaces, although substantial reductions in PCB concentration were associated with the visual indication of the removal of Askarel, the remaining measured PCB concentration was considerably higher than expected.

REFERENCES

1. Power Stractor 16 and Extrator (14 gal), National Super Service, Maumee, OH.

2. Power Cleaner 155, a product of Penetone Corporation, 74 Hudson Avenue, Tenafly, NJ.

MONS 018349

Section 1

INTRODUCTION

Because of the labor intensive nature and high cost of polychlorinated biphenyl (PCB) spill cleanup in electrical utilities, there is a need for equipment that can be used to decrease the cost and time for a cleanup operation. Particularly difficult is the removal of PCBs from such porous surfaces as concrete, asphalt, brick, and wood. In many cases, removal of PCBs from these materials is not even attempted, rather the contaminated material itself is either completely removed or removed to a depth where the PCB content is not considered hazardous. Thus, there is a need for techniques or methods that result in cleanup to levels that will not require physical removal of the surface in question. This report describes the results of preliminary work directed toward the development of equipment and support systems for use in PCB spill cleanup from porous surfaces. Since concrete is the surface commonly contaminated with PCBs, it was selected for use in the testing program.

The general approach for the project was to review the nature of PCB spills and existing spill cleanup practices, and then identify or develop equipment for testing and evaluation with existing cleaning solutions using first transformer oil and then in a proof-of-principle demonstration, Askarel coated concrete surfaces.

MONS 018350

Section 2

BACKGROUND DEVELOPMENT

The objective of the work reported in this section was to obtain background information that would both focus and expedite the development of equipment for removal of PCBs from porous surfaces. Information was sought from a variety of sources including the United States Environmental Protection Agency (USEPA) and its regional offices, National Institute for Occupational Safety and Health (NIOSH), independent consultants, electrical utilities, publications, and vendors. Although the search for information was not considered exhaustive, the compilation of observations and data provided a good starting point for the work. Despite the fact that information was sought on porous surfaces in general (concrete, asphalt, brick, and wood), it was found that a preponderance of work had been done on the cleaning of concrete. Accordingly, most of the following discussion concerns the cleaning of concrete.

PCB CLEANUP FROM CONCRETE SURFACES

A major consideration when developing an approach to PCB removal from porous surfaces concerns the depth of penetration of PCBs. If the depth is such that surface cleaning is not expected to reduce the PCB level to a releasable or acceptable value, the contaminated surface material has to either be completely removed, or the PCB removed sufficiently from the surface that it is not available to human contact. This can be achieved because of little or no leach back after cleaning or through the use of a sealant coated on the surface. Removal of the surface material was not part of this project. Only general cleaning approaches will be discussed that represent a consensus of the information reviewed.

The cleaning method generally used consist of: 1) pouring a cleaning solution on the contaminated area; 2) soaking for approximately 10 min followed by scrubbing with a brush; 3) adding an absorbent to the PCB-solution mixture; 4) shoveling/sweeping the mixture into a drum for disposal; and 5) mopping the floor with a general detergent, e.g., trisodium phosphate. If necessary, the cleaning method is repeated three times or more depending on whether the cleaning is successful or the decrease in PCB level per cleaning is rapidly approaching an acceptable value. Cleaning solutions that have been used for PCB cleanups include: kerosene,

MONS 018351

diesel fuel, Triton X-100, Triton X-114, Power Cleaner 155, hexane, petroleum ether, toluene, isooctane, perchloroethylene, and trichloroethylene. Use of many of these solutions causes concern over fire and health hazards. Some sources also point out that the use of solvents tends to drive the PCBs further into the concrete. In addition to the above procedure, the use of hot water or steam has been suggested as a potential cleaning method.

In a separate project from the work being performed on this project, Quadrex HPS, Inc. has tested the use of Quadcote-100, a paint-on, self-peeling material for cleanup of PCB. Quadcote-100 is applied with a brush or roller to a surface requiring decontamination. A film is formed which during drying spontaneously flakes or spalls from the surface. The debris can be vacuumed or swept up for disposal. Although the spontaneous spalling action is exhibited from metallic and other smooth surfaces, its performance on concrete surfaces is variable. After application to a concrete surface, some of the Quadcote-100 flakes off and the rest forms a hard surfaced material that had to be scraped or abraded off. It has not been determined what causes this behavior. At the present time the use of Quadcote-100 is not recommended for use in decontamination of concrete surfaces.

With respect to the influence of time between a spill and a cleanup attempt, one source stated that cleanup should only be attempted if the time between spill and cleanup is less than 24-48 hours. Beyond this time the concrete should be removed. Other sources identified possible alternatives to surface material removal such as use of sealants or epoxy coatings, and re-covering the contaminated surface with fresh concrete or asphalt.

PENETRATION OF PCBS INTO CONCRETE

The degree of PCB penetration into concrete is a function of amount and type of PCB supply, duration of leak, and physical characteristics of the concrete, i.e., porosity. In cases where the supply of PCB has been more or less continuous such as under a leaky transformer, as much as 50 ppm PCB has been found at depths up to 6 in. In another instance 200-300 ppm PCB was found at a depth of 4 in. These determinations were made through the use of core samples and/or chipping with a jack hammer.

RESULTS OF EQUIPMENT SURVEY

Contact with approximately 70 vendors resulted in information on a number of types of spray-vacuum equipment:

MONS 018352

- Integral spray and vacuum
  - With rotating brush
  - Without rotating brush
- Separate spray and vacuum
- Complete spray and vacuum supply systems
  - With mobile head
  - Complete mobile system

Based upon the previously discussed general approach to cleaning it was apparent that a mechanical device for cleaning should have spray and brush capability, particularly with nonsolvent cleaning materials. It was believed that vacuum capability was also essential to remove cleaners. Several systems having these capabilities were identified. One was found that could be used at no cost to the project (1). For application of solvent type cleaning materials and hot water, a three-jet vacuum head developed by Quadrex HPS, Inc. was fabricated for testing.

Information was also obtained on commercial wallpaper steamers for use in PCB removal from porous surfaces. Evaluation of the information indicated that although the steam application approach could be useful, the device would require incorporation of vacuum capability to contain the removed contaminants. Depending on the success of removing PCBs from concrete floors with hot water or steam, adding vacuum capability to a wall steamer for testing may be worth consideration.

PCB CLEANUP OF OTHER MATERIALS

Little information could be obtained on PCB removal from materials such as asphalt, brick and wood. Independent sources stated that PCB contaminated asphalt and wood should be removed. This approach for wood, however, may be tempered depending on whether the wood was painted and the type of paint, e.g., epoxy, water base, etc. Another source pointed out that asphalt may have residual PCB from its initial manufacture. This could mask the magnitude of a spill and complicate evaluation of the progress of a cleanup.

REFERENCES

1. Power Stractor 16 and Extractor (14 gal), National Super Service, Maumee, OH.

MONS 018353

Section 3

PRELIMINARY TESTING AND DEVELOPMENT

APPROACH

The general approach for preliminary testing and development of PCB cleanup equipment was to perform the work on evaluation and selection of cleaning materials in parallel with the work on development and/or selection of equipment for cleaning material application and removal.

To reduce costs in this phase of the project, the following measures were taken:

- Texaco CT-JT uninhibited transformer oil (uncontaminated with PCB) was substituted for Askarel. This was based on the following considerations: a) PCB contaminated transformer oil is involved in some spills; b) visual estimation of oil removal from a concrete surface could be used for preliminary evaluation rather than expensive and time consuming chemical analysis of wipes or core sample debris; and c) the viscosity of transformer oil is nominally comparable to the more common Askarels. The visual estimation of oil removal as the result of a cleaning treatment was based upon comparison of the appearance of the cleaned surface (after evaporation of surface moisture, generally about 2 hours) to the appearance of oiled and unoiled surfaces.

- Emphasis was placed on the use of concrete for preliminary evaluation of cleaning solutions and equipment. This was done because it is probably the most common material contaminated with Askarel. A local source of concrete test sections approximately 4 ft x 5 ft x 5 in. thick and having a broomed surface finish was found. Ten to twelve sections were obtained for test purposes. These sections were estimated to be 30-40 years old.

APPLICATION OF TRANSFORMER OIL (Texaco CT-JT)

In preliminary work it was found that the surface of the 4 ft x 5 ft concrete sections could be completely and uniformly covered with transformer oil by application at an areal density of 160 ml/m^2. After 12-18 hours, however, enough of the oil had soaked in that its appearance was the same as the uncontaminated sections. To provide a concrete surface that would stay uniform in appearance (in the uncleaned condition) for a one to two week period it was necessary to apply oil three times, each at an areal density of 160 ml/m^2 for a total of 480 ml/m^2. After this level of oiling the concrete surface was a dark brown color. The

MONS 018354

effect of a cleaning attempt (if oil removal took place) was to restore the surface appearance to the light sandy color of dry concrete. The degree of approach to the dry concrete color was used to estimate the effectiveness of a cleaning attempt.

The rate of oil penetration along a crack and through the thickness of a concrete section was very high. For a 4 in. thick concrete section, oil was observed to travel along a crack completely through the section in 5 min. This indicates that it is probably not possible to clean badly cracked or damaged concrete.

EQUIPMENT DEVELOPMENT AND SELECTION

As discussed in Section 2, two types of equipment were selected for testing and evaluation. One was a combination spray and vacuum head that contained three 80° fan jets and had static vacuum capability to 100 in. water provided by a standard shop vacuum. It was patterned after a previous Quadrex HPS Inc. design. The other type was a commercial rug cleaning system that contained five 110° fan jets, a nylon bristle rotating brush, and a vacuum slit. Information on the development, application, and testing of both systems is provided below.

Three-Jet Vacuum System

The three-jet vacuum system is composed of a spray-vacuum head and exhaust and handling wand, Figure 3-1, with connections to a standard shop vacuum and a pump and reservoir for supply of the cleaning fluid. The configuration of the vacuum head is illustrated in Figures 3-2 and 3-3. Note the approximately 1/4 in. wide slit or gap adjacent to and around the interior of the head, Figure 3-3. This confines the vacuum exhaust to this annulus region and was found to be essential to keeping the flow of cleaning fluid within the boundary of the head during cleaning. An earlier version without the gap did not effectively vacuum the cleaning fluid from the concrete surface. The three nozzles used in the head are identical and have an 80° spray pattern. Depending on flow requirements or restrictions, nozzles with different size orifices can be used.

The head with jets and vacuum activated is moved on a contaminated area at a traverse rate of about 14 in./min. This traverse rate was established by evaluation of visual cleaning results during stationary testing for 5, 10, 15, and 30 sec dwell times; and also by testing at traverse rates from 10 to 150 in./min. In tests with Freon-113 (referred to as Freon in the remainder of the report) it was determined that the head performed equally well on floor and wall areas.

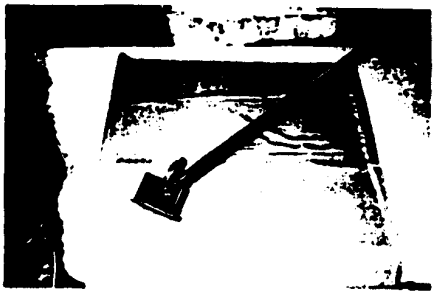


Figure 3-1. Three-jet vacuum head with exhaust and handling wand attached.

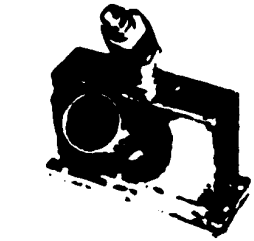


Figure 3-2. Three-jet vacuum head with integral vacuum and pressurized fluid couplings.

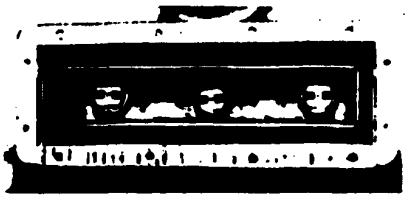


Figure 3-3. Underside of three-jet vacuum head with fan jet nozzles and interior peripheral gap to confine vacuum. 0.75X*.

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018356

In initial tests with this system, the Freon was pressurized to 700-1000 psi with a flow of 0.5 gpm. It was found that the impact of the Freon on the oil coated concrete surface drove the oil into the surface and as the head was moved the oil came up to the surface again (leach back). Lowering the pressure to 20-30 psi with a flow of 0.3-0.4 gpm resulted in very effective visual cleaning with little or no leach back. For pressures in this range it was found that an inexpensive pump (1) mounted on a standard 1/4 in. drill would provide the desired pressure and flow.

A comparison of the effect of flow rate in the three-jet head was made for a pressure of 16 psi. For a traverse rate of 11-14 in./min it was determined that for the combined three-jets, a flow rate of 0.36 gpm (0.036 in. orifice) produced 50% better cleaning than a flow rate of 0.18 gpm (0.026 in. orifice).

Using the three-jet head, tests were then made to compare two methods of application of fresh Freon at 30 psi and a traverse rate of 12 in./min. One method consisted of spraying the Freon on an oil coated concrete surface at a distance of 4 in. for 10 sec followed by vacuuming up the Freon and oil mixture. The other method was the one in common use which maintains contact of the three-jet head with the concrete surface during the spraying and vacuuming operation. After a total of 10 tests of each method on adjacent sections of concrete surface, it was concluded that the contact method in common use was 50% more effective in the removal of oil as indicated by appearance.

Vacuum to the three-jet head is provided by a standard wet or dry shop vacuum with 100 in. water static vacuum pressure (2). Because of concern over Freon leakage from this unit during use, a halide leak detector kit using a standard propane fuel bottle was used to detect any Freon leakage. Through the use of this detector it was possible to seal up the leaks in the shop vacuum thus confining Freon discharge to the exhaust hose whose effluent can be vented in a controlled manner, e.g., through an activated charcoal drum.

During use of the three-jet head with Freon, some operational problems were noted that may influence the development of a commercial system. Any moisture vacuumed into the head freezes on its interior surfaces and on the interior of the metal handling wand. Under prolonged use there is a possibility of sufficient ice build up to block the exhaust passage, at least in the head. This cooling of the wand requires the use of gloves during use. Another problem involves the build up of ice and water in the cannister containing the used Freon. Provision for accom-

MONS 018357

modation of these problems should be included in the design and/or operating procedure of a commercial system based on this technology.

At this point it was decided that the state of development of the three-jet head had progressed far enough that proof-of-principle tests could be conducted on Askarel coated surfaces.

Commercial Rug Cleaning System

The components of this system are illustrated in Figure 3-4. The cleaning head contains five 110° fan jets each with a 0.026 in. orifice that together spray cleaning solution at 16-195 psi and 0.3-1.1 gpm. It also contains a rotating brush with nylon bristles and a vacuum slit. The portable supply-recovery tank system contains a 14 gal cleaning solution supply tank, a 14 gal solution recovery tank and associated pump and instrumentation.

While cleaning a surface the head is pulled along at a rate of 8 in./min. The jets spray cleaning solution from the supply tank. The solution is agitated against the surface by the rotating brush. The used cleaning solution is picked up by the vacuum slit on the trailing edge of the cleaning head and vacuumed into the recovery tank. With a flow rate of 0.8 gpm and 14 gal supply tank capacity the system can be operated for approximately 18 min. The value for traverse rate was determined by testing at rates ranging from 8 to 24 in./min and visual evaluation of cleaned surfaces. Tests of the effect of traverse rates on Askarel coated surfaces should be conducted to determine if a faster traverse rate can be used.

Preliminary tests indicated that cleaning by moving the cleaning head parallel to the direction of the broomed finish on the concrete surface may be more effective than cleaning perpendicular to the direction of brooming.

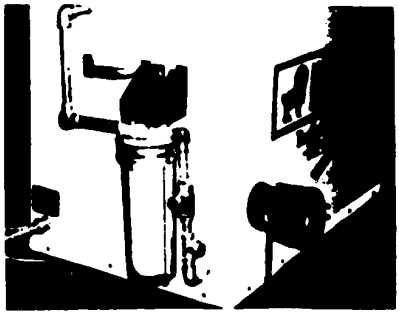
Tests were run on oiled concrete surfaces with and without the rotating brush using Freon to determine if the rotating brush would improve oil removal. The traverse rate was 20-24 in./min with a spray pressure of 16 psi. It was found that 50% better oil removal could be obtained without the use of the rotating brush. It is believed that use of the brush decreases the surface contact time of the Freon which reduces the degree of oil removal.

To improve cleaning fluid management of the supply-recovery tank system, two modifications were made. A 2000 watt heater was installed through the wall of the

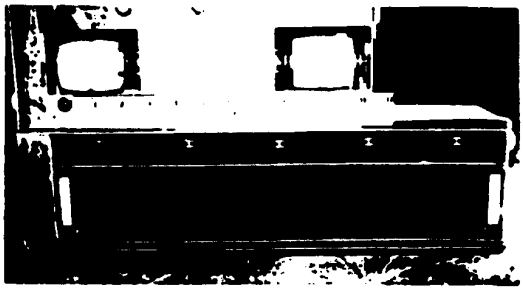
MONS 018358



Extraction head and control handle. 0.03X*



Supply recovery tank with added heater (arrow) and recirculation piping with filter. 0.1X*



Underside of extractor head with nozzles (5), rotatable brush and vacuum slit (bottom of assembly). 0.25X*

Figure 3-4. Components of commercial rug cleaning system

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018359

supply tank to permit heating of the cleaning solution to 50-60°C prior to use. The second modification included a pump and piping to permit recirculation of the cleaning solution from the recovery tank to the supply tank in the event this mode of operation was determined to be feasible.

The proof-of-principle testing on Askarel coated surfaces (Section 5) was conducted with the system modified as described above.

EVALUATION OF CLEANING SOLUTIONS

Classification

Two general types of cleaning solutions were selected for testing: solvents and nonsolvents. To classify the cleaning material as to type, one ml of transformer oil was mixed with four ml of cleaning solution in a 10 ml graduate and the mixture vigorously agitated by shaking. Based on this test the cleaning solutions selected for testing were classified as follows:

Solvent Behavior (oil and cleaning solution completely miscible)

- Freon-113 (3)
- Kerosene
- Triton X-114 (4)
- Slix (5)

Nonsolvent Behavior (oil segregated from cleaning solution)

- Power Cleaner 155 (6)
- Citrikleen (7)
- Eco-Clean (8)
- Ezz Clean (9)
- Nokomis-3 (10)
- Magnusol 728 (11)
- Blazer (12)
- Hot Water (90°C)

A summary of the properties of these solutions is presented in Tables 3-1 and 3-2. The nonsolvent solutions all foamed to various degrees when agitated with the transformer oil and then segregated from the transformer oil as the foam collapsed. Unlike the other nonsolvents, Citrikleen partially dissolved in the transformer oil. The time for collapse of the foam varied from 2-3 hours for the Power Cleaner 155 to several days for some of the other solutions.

As discussed in the following paragraph the degree of foaming and time for foam collapse are of concern from several aspects. During use in the commercial rug cleaning machine the combination of spraying and brush agitation promote foaming.

MONS 018360

Table 3-1

CHARACTERISTICS OF SOLVENT[a] TYPE CLEANING SOLUTIONS

Property	Freon-113	Kerosene	Triton X-114	Slix
Type Degreaser	Solvent	Solvent	Solvent	Detergent emulsifier
Solubility in Water	Insoluble	Insoluble	Excellent	Complete
Specified pH	c	c	6.0-8.0	11.5
Measured pH[b]	6.0	6.0	6.0	12.0
Specific Gravity	1.565	0.81	1.05-1.06 (75°C)	1.048
Flash Point (°C)	None	46	>150	None
Boiling Point (°C)	47.6	c	c	100
Foaming Tendency[b]	Low	Low	Low to moderate	Moderate
Rinsability (with water)	Leaves no residue	Leaves residue	c	Leaves no residue
Threshold Limit Value (ppm)	1000	Not established	Not established	None
Hazards:				
Eyes	Yes	Yes	Yes	Yes
Inhalation	Yes	Yes	Yes	No
Skin	Mild effect	Yes	Yes	No
Volatile Volume (%)	99.5	99.9	0	62.0
Biodegradability	Evaporates	Incinerate	90%	Complete
Ionic Nature	c	c	Nonionic	c
Recommended Concentration	Full strength	Full strength	5-10% in water	1:20-1:100 in water

[a]Based on behavior with uncontaminated transformer oil

[b]As supplied concentrate

[c]Not available

MONS 018361

Table 3-2

CHARACTERISTICS OF NONSOLVENT[a] TYPE CLEANING SOLUTIONS

Property	Power Cleaner 155	Citrikleen	Eco-Clean	Ezz Clean	Nokomis-3	Magnusol 728	Blazer
Type Degreaser	Alkaline	Solvent emulsifier	Alkaline	Alkaline	Colloid dispersant	Blend: Solvent penetrant, emulsifier	Alkaline solvent
Solubility in Water	Complete	Complete	Complete	Complete	Complete	Moderate	Complete
Specified pH	12.0	10.4	c	9.5-10.0	c	11.5	13.1
Measured pH[b]	12.5	11.0	13.0	13.0	11.0	12.0	c
Specific Gravity	1.170 (20°C)	0.955	1.02	>1.0	c	0.965-0.985	1.056
Flash Point (°C)	None	74	None	340	None	57	>93
Boiling Point (°C)	100	100	99	104	100	100	100
Foaming Tendency[b]	Moderate	High	Moderate	Moderate	High	Very high	Very high
Rinsability (with water)	Leaves no residue	Leaves no residue	Leaves no residue	Leaves no residue	c	c	Leaves no residue
Threshold Limit Value (ppm)	None	Not established	None	None	None	Not established	50
Hazards:							
Eyes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inhalation	No	Mild effect	No	No	No	No	Yes
Skin	Mild effect	Yes	Yes	Mild effect	No	Yes	Yes
Volatile Volume (%)	0	0	c	0	80	60	85
Biodegradability	Complete	Complete	Complete	Complete	99%	c	Complete
Ionic Nature	c	c	Nonionic	c	Nonionic, anionic	c	c
Recommended Amount in Water	1:6	Concentrated or 1:3	1:1-1:4	1:5-1:64	1:1-1:5	1:4	1:15

[a]Based on behavior with uncontaminated transformer oil

[b]As supplied concentrate

[c]Not available

MDNS 018362

A cleaning solution with a high foaming tendency would be more difficult to work with because the volume of foam formed could exceed the volume in the solution recovery tank before the volume of solution in the supply tank could be used. In addition, the formation of large amounts of foam could cause problems for reuse of the solution. Foam formation and the time for foam collapse are important from a waste management standpoint. Solutions with shorter foam collapse times may be more amenable to recovery, waste reduction, and reuse. If the time for foam collapse and segregation of the oil is a matter of days rather than hours, volume reduction of the used solution by natural oil segregation may not be practical.

Effectiveness

Solvent Type Cleaning Solutions. The three-jet vacuum head was used to test kerosene and Freon for removal of transformer oil from concrete surfaces. Only a single test was made with kerosene because it left a coating similar in appearance to transformer oil on the concrete surface. The presence of this coating made it impossible to estimate the degree of transformer oil removal. Use of Freon resulted in an estimated 90% removal of the transformer oil, Figure 3-5. Since the relative solvent power of Freon and kerosene are essentially identical (Kauri Butanol Nos. for Freon and kerosene are 31 and 29, respectively), Freon was selected for future testing on Askarel coated surfaces because of its capability to effect a high degree of removal of transformer oil from concrete surfaces as indicated by visual appearance.

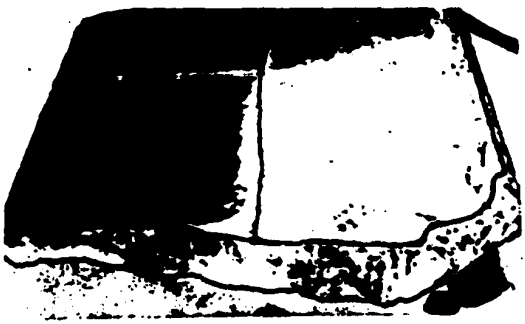


Figure 3-5. Portion (lower right) of transformer oil coated concrete surface cleaned in 45 sec by one treatment with Freon-113 using three-jet vacuum head. 0.1X.*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018363

Small pieces of asphalt were immersed in Freon, kerosene, and concentrated Power Cleaner 155 to determine the limits of application of these solutions as cleaning materials for asphalt. Dissolution of the asphalt started upon immersion in kerosene and continued extensively with time. The dissolution in Freon and Power Cleaner 155 was considerably less with Power Cleaner 155 being the least active. For cleaning tests it is believed that either Freon or Power Cleaner 155 could be used on asphalt.

A test was made with the three-jet head on asphalt using 30 psi Freon and a traverse rate of 8 in./min. Although the effect of the cleaning could not be visually estimated, the Freon did not appear to damage the surface of the asphalt. In another test, 0.4 ml of Freon was poured on a 1 in. diameter area on the asphalt and allowed to soak in and/or evaporate. In this case, there may have been some softening of the surface of the asphalt which could result in permanent damage.

Freon that had been used to remove transformer oil from concrete surfaces was tested to determine its potential for reuse. Within the limits of visual evaluation, the used Freon appeared to clean as well as new Freon. The capability for reuse before purification should be determined with PCB contaminated surfaces.

Nonsolvent Type Cleaning Solutions. All of the nonsolvent type cleaning solutions were tested using the commercial rug cleaning system described earlier. Although other dilution ratios were evaluated, most of the comparative testing was done with a dilution ratio of one part cleaning solution to 32 parts water (1:32). Comparative tests were conducted with many of the solutions at both ambient temperatures and 50-60°C. In all tests the Power Cleaner 155 produced visibly better cleaning results than the other solutions with an estimated oil removal of 95-98%, Figure 3-6. In early testing the Citrikleen was a close second. However, since it partially dissolved in the transformer oil, its amenability to waste reduction techniques was not considered to be as good as the Power Cleaner 155 and it was dropped from the test program.

Based on the results with the Power Cleaner 155 it was decided to use this solution in subsequent development work. A more intensive examination of the effect of dilution ratio was conducted. Power Cleaner 155 solutions ranging from concentrated to 1:1, 1:5, 1:10, 1:20, and 1:32 were tested with the commercial rug cleaning system. Since no visual benefit could be observed from any of the more concentrated solutions, the 1:32 solution was selected for use in PCB removal studies. A comparison was also made of the effect of application at a temperature

MONS 018364



Concrete surface after transformer oil application and before cleaning.

Concrete surface after four cleanings with commercial rug cleaning system and Power Cleaner 155 (1:32) at ~55°C.

Figure 3-6. Visual effect of indicated cleaning approach. 0.1X*

of 55°C in contrast to room temperature. Although no visual improvement in effectiveness could be observed as the result of cleaning with the 55°C solution, this application temperature was selected for use in PCB removal studies because of a belief that higher temperature application should be better.

The Power Cleaner 155 solution was reused approximately 10 times on transformer oil coated surfaces with no apparent decrease in effectiveness. Reuse on Askarel contaminated surfaces may be possible until recontamination associated with the reuse becomes a problem. At this point a switch to fresh solution should be made.

The three-jet vacuum head was used to test Power Cleaner 155, Citrikleen, Nokomis-3, Triton X-114, and hot water (90°C) for removal of transformer oil from concrete surfaces. Estimated oil removal was 95, 85, 85, 89, and 93% for Power Cleaner 155, Citrikleen, Nokomis-3, Triton X-114, and hot water, respectively. Since these were all somewhat lower than what was obtained with the commercial rug cleaning system, it was believed that the action of the rotating brush contributed to the capability for oil removal.

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018365

Based upon the preceding results, the commercial rug cleaning system with Power Cleaner 155 at 50-60°C was selected for testing on Askarel coated concrete surfaces.

CONCENTRATION GRADIENT SAMPLING

A diamond impregnated bottoming tool, Figure 3-7, was specially fabricated for removing layers of concrete for analysis to determine PCB concentration gradients in concrete slabs. The fixturing for abrading the concrete surface in a 90° arc is illustrated in Figure 3-8. Moving the rotating tool across the surface of a concrete section will abrade a 1-1/2 in. wide area, Figure 3-9, to produce concrete debris in the form of small particles that can be analyzed for PCB content. By relating the PCB content to the depth of material removed for a series of samples taken at successive depths, a concentration gradient can be established.

During the establishment of operating parameters for this sampling method, it was determined that approximately seven grams of concrete powder was obtained for a 0.050 in. depth of removal over an area of 15 $in.^2$.



Figure 3-7. Diamond impregnated bottoming tool. 1.3X*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018366

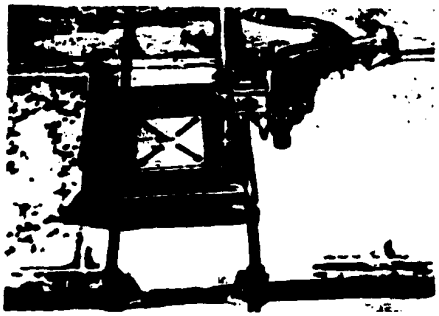


Figure 3-8. Fixture and drill used to abrade concrete surface in an ~90° arc to obtain concrete particles for PCB analysis. 0.1X*



Figure 3-9. Area abraded with bottoming tool to remove particulate sample for PCB analysis. Note spots of higher PCB concentration present at 0.055 in. depth of sampling. Concrete section no. 9. 0.5X*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018367

REFERENCES

1. Teel Drill Driven Pump, Model IP866, Dayton Electric Mfg. Co., Chicago, IL.

2. Wet/Dry Pickup Vacuum, Model 4Z227, Dayton Electric Mfg. Co., Chicago, IL.

3. Trademark. E.I. DuPont de Nemours & Co., Inc., Wilmington, DE.

4. Triton X-114, a product of Rohm and Haas Company, Independence Mall West, Philadelphia, PA.

5. Slix, a product of Penetone Corporation, 74 Hudson Avenue, Tenafly, NJ.

6. Power Cleaner 155, a product of Penetone Corporation, 74 Hudson Avenue, Tenafly, NJ.

7. Citrikleen, a product of Penetone Corporation, 74 Hudson Avenue, Tenafly, NJ.

8. Eco-Clean, a product of Uniflo Resources, Inc., 9 Dunbar Road, Springfield, NJ.

9. Ezz Clean, a product of M&J Marketing, Inc., 1228 S. 5th, Pasco, WA.

10. Nokomis-3, a product of Nokomis International, Inc., P.O. Box 4815, Hayward, CA.

11. Magnusol 728, a product of Magnus Sales Center, Osborn Building, St. Paul, MN.

12. Blazer, a product of Associated Chemists, Inc., 4401 S.E. Johnson Creek Blvd., Portland, OR.

MONS 018368

Section 4

PREPARATION FOR TESTING ON ASKAREL COATED CONCRETE SURFACES

APPROACH

The approach used to determine the capability of cleaning methods and solutions for removal of PCBs was to perform tests on Askarel coated concrete surfaces at the Quadrex HPS, Inc. Gainesville, FL facility. In preparation for the testing, concrete sections were poured and final surface finished by brooming. PCB removal effectiveness was evaluated by surface wipes and concrete surface sampling. Analysis of solvent extracted solutions from the wipe and concrete samples was performed by gas chromatography in the Quadrex HPS, Inc. laboratory.

PROCEDURE

Pouring of Concrete Sections

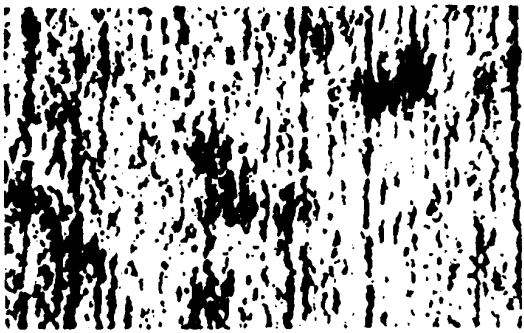
Selection of the concrete mix design (proportions of cement, sand, aggregate, water, and additives) and broomed surface finish was based on the properties of sidewalk type concrete which was believed to be comparable to that found in transformer vaults and other likely spill locations. The concrete mix design and resultant property and test data are provided in Appendix A.

For the anticipated test program, a total of 36 concrete sections were poured on January 9, 1986. Twenty-four of the sections were 22-1/2 x 24 x 3-3/4 in. and twelve were 22-1/2 x 48 x 3-3/4 in. Other than the broomed surface being considerably rougher than expected compared to the old concrete used in preliminary testing, Figure 4-1, the sections appeared to be suitable for test purposes.

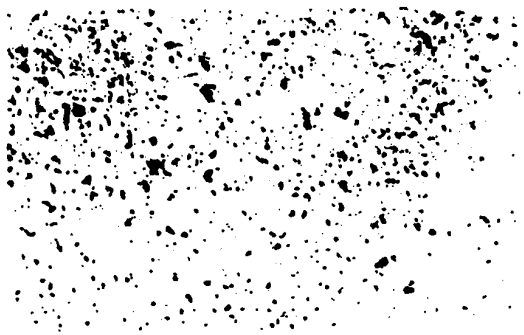
Coating with Askarel

Prior to coating with Askarel, a silicone rubber bead was placed around a concrete surface near its edge to act as a containment for the cleaning solution when required. This prevented Askarel contaminated cleaning solution from leaking down the interface between the concrete and its form. The Askarel used was a mixture of Aroclor 1260 and trichlorobenzene in a 60:40 ratio. Two Askarel concentrations were used on the concrete: 160 ml/m^2 and 480 ml/m^2. The lower concentration was

MONS 018369



New concrete with 160 ml/in.^{2} Askarel application. Note dark spots that are higher in Askarel concentration than surrounding area.



Old uncoated concrete used in preliminary testing.

Figure 4-1. Surface roughness of concrete used for PCB removal testing (top) compared to normally brushed and worn concrete bottom. Direction of broomed finish is vertical. 1.3X*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018370

obtained in one application by pouring on a measured amount and spreading it around the concrete surface with a previously Askarel conditioned paint brush. The higher concentration was obtained by three applications of the lower concentration with a few hours of soak time between each application. The lower application was made on six 22-1/2 x 24 in. concrete sections on January 23, 1986. The higher application was started on January 23, 1986 and finished on January 25, 1986. The difference in appearance between the two levels of Askarel application and uncoated concrete is illustrated in Figures 4-2 and 4-3. Note the dark spots on the surface with the lower level of Askarel application, Figures 4-1 and 4-3. The spots are small areas of higher PCB concentration than the surrounding area. These spots are believed to be cracks or areas of higher porosity that allow the Askarel to readily concentrate and channel below the concrete surface. An example is illustrated in Figure 4-4 where Askarel was observed to be associated with and around pieces of aggregate at a depth of 0.055 in. from the surface. The aggregate pieces were apparently at, or close enough to the surface to allow contact by the Askarel. It is important to note that microcracks are commonly present at the interface between the cement and aggregate particles in concrete.

PCB Sampling

Two sampling methods were used to evaluate the effect of cleaning attempts on the Askarel contaminated surfaces. One method is a surface wipe procedure recommended by the National Institute of Occupational Safety and Health (NIOSH), Appendix B. The procedure used is not exactly that defined by NIOSH. A mixture of 1:1 hexane: acetone was used as the solvent on the wipe rather than hexane alone. For the wipe sampling, a mask was used, Figure 4-5, to restrict the sample to the area desired and provide the area reference for reporting of analyses. After the wipe sampling, it was found that the rough concrete surface tore gauze fibers from the pad and retained them on the concrete surface, Figure 4-5. From a sampling standpoint, and to avoid interference of these fibers with subsequent cleaning and sampling attempts, they were picked up with a stainless steel tweezer and put in the bottle containing the wipe sample.

The second sampling method used the diamond impregnated, rotating bottoming tool, Figure 3-7, to remove in powder form, an arc of concrete surface approximately 10 in. long, 1-1/2" wide and 0.043-0.044 in. deep. The test arrangement is illustrated in Figure 3-8. The area of concrete removed is illustrated in Figure 3-9. The concrete powder generated was swept up on smooth textured weighing paper using disposable brushes and transferred to a glass sample bottle for soxhlet extraction. The reason for using this sampling technique was to obtain data on the depth of

MONS 018371

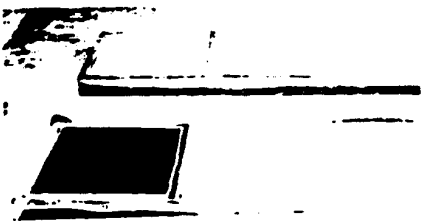


Figure 4-2. Lower row, 480 ml/in.^{2} Askarel application on left and 160 ml/m^2 application on right. Note appearance of uncoated concrete in upper row.



Figure 4-3. 480 ml/in.^{2} Askarel application on left, 160 ml/in.^{2} Askarel application on right. 0.125X*

MONS 018372

* Please note that the illustration(s) on this page has been reduced 10% in printing.

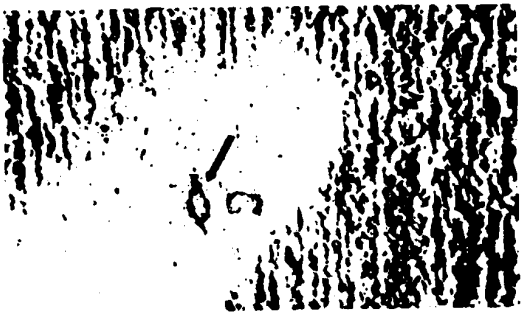


Figure 4-4. Askarel around pieces of aggregate (arrow) at depth of 0.055 in. from concrete surface coated with 160 ml/m² Askarel. Concrete section no. 11 before cleaning. 1.3X*



Figure 4-5. Wipe sampling using mask to define area. Note gauze fibers retained on rough concrete surface that had to be picked up with a tweezer. 0.15X*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018373

penetration of PCBs. Note in Figure 3-9 that the Askarel has penetrated in localized areas (dark spots) to a depth of 0.055 in.

Extraction and Analysis

For extraction of PCB from the wipe samples, each was placed in a soxhlet extraction tube and extracted for 5 hours with 1:1 hexane:acetone. The concrete powder was placed in a pure cellulose extraction thimble (25 x 80 mm) which in turn was placed in a soxhlet extraction tube and extracted as above. Except for the extraction time, the procedure for sample preparation prior to introduction to the gas chromatograph was taken from EPA Procedure 3540.

Section 5

TESTING OF CLEANING METHODS ON ASKAREL COATED CONCRETE SURFACES

APPROACH

The testing of cleaning methods was done on Askarel coated concrete surfaces during the period January 27 through February 7, 1986 at the Quadrex HPS, Inc., Gainesville, FL facility. Methods evaluated included: 1) the three-jet vacuum system with Freon, Freon plus 35% ethanol, and perchloroethylene; 2) the commercial rug cleaning system in two modes of operation using Power Cleaner 155; and 3) hand scrubbing with a wire brush also with Power Cleaner 155. Cleaning was done in a direction parallel to the surface grooves produced by the broom finishing operation. Details on the tests are provided below.

THREE-JET VACUUM HEAD

Freon, Freon plus 35% ethanol, and perchloroethylene were applied to both Askarel and mineral oil contaminated concrete surfaces in a stationary mode and a slow traverse rate both with the head in contact with the concrete, and by spraying the fluids from 6 in. followed by vacuuming up. It was found that none of the tests resulted in the type of strikingly visual cleaning that had been observed for mineral oil on the old concrete at the Richland Engineering Office (REO). The cleaning attempts were so poor that no wipes or concrete samples were taken.

Upon speculation as to the reason(s) for the difference in behavior, the differences that became suspect included: 1) possible differences in response to cleaning between Askarel and mineral oil; 2) differences between the type of mineral oil used at Gainesville and that used at the REO; and 3) the age of the concrete and consequently the moisture content. In an attempt to establish the reason(s) for the difference in behavior, some of the uncontaminated mineral oil used at Gainesville was tested with Freon on the old concrete at the REO. The same degree of visual oil removal that had been observed earlier for the Texaco mineral oil was observed for the Gainesville mineral oil. Since Freon was not effective on either Askarel or the Gainesville mineral oil on the new concrete, and was effective for both types of mineral oil on the old concrete, the moisture content of the concrete appeared to be the major difference. To test this consi-

MONS 018375

deration, a section of the old concrete was immersed in water for three days. After removal, it exhibited a uniformly dark brown appearance. Texaco mineral oil was applied to this concrete section and allowed to soak for one hour. At this point Freon was poured on the oil soaked concrete and vacuumed up within a few seconds. This is a treatment that normally provides striking visual evidence of cleaning. Little or no cleaning was observed indicating that the moisture was somehow tying up the oil so that it could not be extracted. This phenomenom then is believed to be the cause of the poor cleaning results obtained with the solvent type cleaning materials on the new concrete.

To obtain additional information on the differences between the new concrete and the old concrete, 2 in. core samples were taken from each type and subjected to moisture, absorption, porosity and density determinations according to ASTM Test C127 for specific gravity and absorption of coarse aggregate. The results are presented in Table 5-1. The new concrete contained 90% of the total moisture that could be absorbed in a 24 hour period compared to 53% for the old concrete. This

Table 5-1

SELECTED PROPERTIES OF CONCRETE USED FOR SURFACE CLEANING TESTS
(Determined on 1.7 in. Diameter x 4 in. Long Core Samples)

Specimen Source	Density (lb/ft^3)	Initial Moisture (%)	Absorption (%)	Porosity (%)
New concrete	136.3	5.8	6.3	13.8
New concrete	131.7	6.4	7.2	15.2
Old concrete 1-1	140.4	2.2	4.6	10.4
Old concrete 1-2	141.3	2.6	4.6	10.5
Old concrete 2-1	138.2	3.1	5.0	11.1
Old concrete 2-2	143.0	2.7	4.2	9.7
Old concrete 3	140.6	2.9	5.4	12.2
Old concrete 4-1	140.8	1.4	4.1	9.2
Old concrete 4-2	138.6	2.2	5.4	12.0
Old concrete 5	140.5	2.3	4.7	10.6
Old concrete 6	142.2	1.9	4.4	10.0
Old concrete 7	140.8	2.5	5.3	11.9
Old concrete 8-1	139.2	3.0	5.1	11.4
Old concrete SH	145.5	1.7	4.2	9.9

MONS 018376

corresponded to 154% more moisture in the new concrete than in the old concrete during the testing of cleaning techniques. Based on the high moisture content of the new concrete and the behavior of the old concrete when soaked with water, it is believed that the presence of moisture, either at or close to saturation, inhibits the action of solvents for transformer oil or PCB removal on concrete surfaces.

As an additional point of interest a section of the new concrete was fractured and compared with a similar fractured section of the old concrete. The new concrete fracture was very dark indicating a higher moisture content, Figure 5-1. After a few days of exposure to air the fracture surface lightened in appearance indicating a loss of moisture and became comparable in appearance to the old concrete. Although of unknown significance, the differences in the macro structure between the old and new concrete are illustrated in Figure 5-2.



Figure 5-1. Dark appearance of new concrete fracture surface (right) indicating high moisture content. Old concrete on left. 0.5X*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018377



Figure 5-2. Macrostructure of old concrete (left) compared to new concrete (right). 1.4X.*

COMMERCIAL RUG CLEANING EQUIPMENT

Two approaches were tested with the commercial equipment using Power Cleaner 155 at 55°C. In one, the extraction head was moved across the contaminated concrete section at a traverse rate of 8 in./min using the complete spraying and brushing capability of the machine (MACHINE APPLY AND BRUSH approach with no solution soak time). In the other, 22 oz of Power Cleaner 155 was manually applied and the following operations performed (MACHINE BRUSH approach):

- The Power Stractor was used to brush the surface at a traverse rate of 8 in./min;
- The Power Cleaner was allowed to soak on the concrete surface for 10 min;
- Another brushing operation was performed;
- The Power Cleaner was vacuumed up with the Power Stractor as its brush was rotating.

Wipe Test Results

Based on the wipe results presented in Table 5-2, both machine approaches produced significant reductions in the PCB concentration of the sections treated with 480 ml/m^2 of Askarel. (No reason can be given for the approximate factor of three variation in starting PCB concentration at this level.) After the third cleaning attempt the MACHINE BRUSH approach had reduced the PCB concentration from

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018378

Table 5-2

EFFECT OF CLEANING APPROACH ON CONCRETE DECONTAMINATION WITH POWER CLEANER 155
(Wipe Test Results, 10^6 $\mu g/m^2$)

Concrete Section	Cleaning Approach	Soak Time min	Askarel Amount ml/m^2	As-Oiled	Cleaning Attempts						
					First	Second	Third	Fourth	Fifth	Sixth	Seventh
8	Hand brush[a]	10	480	6.8	0.20	0.11	0.084	0.044	0.044	0.037	0.039(0.040)[b]
10	Hand brush[a]	10	160	0.057	-	0.052	0.056	0.042	0.037	0.031	0.031(0.028)[b]
7	Machine brush[a]	10	480	8.6	0.39	0.068	0.11	-	-	-	-
11	Machine brush[a]	10	160	0.050	-	0.045	0.056	-	-	-	-
3	Machine apply and brush[a]	None	480	2.9	0.24	0.055	0.064	-	-	-	-
4	Machine apply and brush[a]	None	160	0.054	-	0.047	-	-	-	-	-
9	Hand brush[a]	20	480	2.4	0.089	0.070	0.047	0.047(0.052)[b]	-	-	-
2	Hand brush[c]	10	480	2.9	-	0.12(0.08)[b]	0.088	0.097	0.088	-	-
12	Hand brush[c]	10	160	0.048	0.068	0.059(0.057)[b]	0.041	0.048	0.035	-	-

[a] 1:32, Water:Power Cleaner 155 solution

[b] Second wipe taken 63 hours after wipe from indicated cleaning

[c] 1:1, Water:Power Cleaner 155 solution

MONS 018379

8.6 to 0.11 x 10^4 $\mu g/m^2$ while the MACHINE APPLY AND BRUSH approach had reduced the concentration from 2.9 to 0.064 x 10^4 $\mu g/m^2$. The 10 min soak time in the MACHINE BRUSH approach may be the reason why this approach produced a greater reduction in PCB concentration after each cleaning attempt. From another perspective, the greater reduction with the MACHINE BRUSH approach may simply be the result of a higher starting PCB concentration on the surface used to test this approach.

Within the variability of the test results for both machine cleaning approaches, the first three cleanings of the sections treated with 160 ml/m^2 of Askarel did not measurably decrease the PCB concentration on the surface. There was however, a visual effect indicating that some cleaning had taken place.

Concrete Sampling Results

Comparing the results from the concrete powder samples, Table 5-3, the factors of reduction in PCB concentration on the sections treated with 480 ml/m^2 were only 1.5 (0.43 ÷ 0.28) for the MACHINE BRUSH approach and 5.2 (1.4 ÷ 0.27) for the MACHINE APPLY AND BRUSH approach. Comparison of these factors to the much larger factors for the wipe tests indicates that the depth affected by cleaning is very small, certainly less than the 0.045 - 0.050 in. deep sampling increment taken after the third cleaning attempt. The data also indicate that the depth of penetration of PCBs into the concrete exceeds the 0.045 - 0.050 in. sampling depth.

For the concrete sections treated with 160 ml/m^2 of Askarel, three cleanings using the MACHINE BRUSH approach did not produce a significant reduction in PCB. Although a factor of 2.8 reduction was achieved with the MACHINE APPLY AND BRUSH approach, the PCB concentration after the third cleaning was essentially equal to that for the MACHINE BRUSH approach.

HAND BRUSHING

To determine the effect of a more vigorous brushing approach, a steel wire hand brush, Figure 5-3, was used in the following sequence of operations (HAND BRUSH approach):

- Apply 22 oz of Power Cleaner 155 at 55°C;
- Hand brush for 3 min, Figure 5-4;
- Allow Power Cleaner 155 to soak for 10 min;
- Hand brush for 3 min;
- Vacuum up Power Cleaner 155, Figure 5-5.

MONS 018380

Table 5-3

EFFECT OF CLEANING APPROACH ON CONCRETE DECONTAMINATION WITH POWER CLEANER 155
(Concrete Removal with Diamond Bottoming Tool, 10^5 ppm)

Concrete Section	Cleaning Approach	Soak Time min	Askarel Amount ml/m²	As-Oiled	Cleaning Attempts							
					Third	Fourth		Fifth		Seventh		
						1[c]	2[d]	1[c]	2[d]	1[c]	2[d]
8	Hand brush[a]	10	480	0.67 (0.043)	0.27 (0.047)	-	-	-	-	0.27 (0.038)	0.28 (0.044)
10	Hand brush[a]	10	160	0.28 (0.046)	0.21 (0.057)	-	-	-	-	0.22 (0.042)	0.21 (0.056)
7	Machine brush[a]	10	480	0.43 (0.047)	0.28 (0.050)	-	-	-	-	-	-
11	Machine brush[a]	10	160	0.23 (0.055)	0.22 (0.058)	-	-	-	-	-	-
3	Machine apply and brush[a]	None	480	1.4 (0.035)	0.27 (0.045)	-	-	-	-	-	-
4	Machine apply and brush[a]	None	160	0.70 (0.051)	0.25 (0.056)	-	-	-	-	-	-
9	Hand brush[a]	20	480	0.45 (0.055)	-	0.28 (0.062)	0.29 (0.067)	-	-	-	-
2	Hand brush[b]	10	480	1.3 (0.041)	-	-	-	0.30 (0.056)	0.32 (0.063)	-	-
12	Hand brush[b]	10	160	0.30 (0.050)	-	-	-	0.23 (0.055)	0.27 (0.065)	-	-

() Data in parenthesis is maximum depth of sampling (in.)

[a] 1:32, Water: Power Cleaner 155 solution

[b] 1:1, Water: Power Cleaner 155 solution

[c] Concrete removed from first grinding

[d] Concrete removed from second grinding in same area as first

MONS 010381



Figure 5-3. Steel wire brush used for HAND BRUSH approach. 0.3X*



Figure 5-4. Steel wire brushing Power Cleaner 155 on concrete surface.

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018382



Figure 5-5. Head attachment for vacuuming Power Cleaner 155 from concrete surface. 0.5X*

During agitation with the brush on the concrete surface the Power Cleaner 155 foams to a moderate degree. The appearance of the foam is illustrated in Figure 5-6.



Figure 5-6. Appearance of Power Cleaner 155 after brushing for three minutes. Note that foam on left edge of section has been vacuumed up.

As illustrated in Table 5-2, the HAND BRUSH approach did not appear to produce any significantly greater reduction in PCB concentration than the machine approaches discussed above. A total of seven HAND BRUSH operations were performed on concrete sections 8 and 10 to determine the extent of PCB reduction achievable. Wipe tests for the 480 ml/m^2 Askarel application indicate that the PCB concentration was reduced from 6.8 x 10^6 to 40,000 µg/m^2. For the lower Askarel applications, 160 ml/m^2, the PCB concentration was reduced from 57,000 to 31,000 µg/m^2. For

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018383

both the 480 and 160 ml/m² Askarel applications, no reduction in PCB concentration occurred after the sixth cleaning. In fact, for all practical purposes the reduction in PCB concentration after the fourth cleaning was inconsequential. This result, the inability to clean below a certain concentration, indicates that for concrete surfaces either the Power Cleaner 155 solution is unable to remove PCBs below a particular concentration or there is some inhibiting factor present that affects the ability to clean. As was noted in the work on cleaning attempts with solvents the high moisture content of the new concrete may also be a factor influencing the cleaning effectiveness of nonsolvent type solutions, in this case Power Cleaner 155.

After all cleaning attempts the concentration of PCB was lower for the 160 ml/m² Askarel application than for the 480 ml/m² application. This suggests that in addition to only being able to clean to a minimum concentration, the minimum concentration itself may be dependent on starting PCB concentration, i.e., the higher the starting concentration the higher the minimum concentration that can be achieved.

The results from the concrete powder samples, Table 5-3, support the above observations. In addition, as illustrated by the results after the seventh cleaning, the PCB concentration is essentially constant over the depth sampled. In the case of concrete section 8 one sample was taken to a depth of 0.038 in. Immediately afterward a second sample in the same area was taken which extended the depth of the sample area from 0.038 to 0.044 in. Because of the small difference in PCB concentration between the two samples, it is reasonable to suggest that the increment of depth affected by the cleaning operation is quite small. Comparison of the results from samples taken in the same area in succeeding increments at nearly the same point in time, i.e., from concrete sections 8, 10, 9, 2, and 12, reveals that in four of the five cases the sample taken at the deeper increment has more PCB. Assuming that the smaller amount of PCB in the upper increment is the result of cleaning and that the difference in PCB concentration between increments indicates the fractional thickness affected by cleaning, it is possible to calculate the concrete surface thickness affected by the cleaning. For example, taking concrete section 8:

Second sample increment: 28,000 ppm PCB

First sample increment: 27,000 ppm PCB

1,000 ppm PCB reduction because of cleaning

$\frac{1,000}{28,000}$ x 0.038 in. thickness of first increment = 0.0014 in.

MONS 018384

Correspondingly, the estimated depth affected by the cleaning on concrete sections 9, 2, and 12 is 0.0021, 0.0035 and 0.0096 in., respectively. Thus, it is reasonable to conclude that in general the depth affected by the performed cleaning operations is certainly less than 0.010 in. with a probable depth of less than 0.004 in.

VISUAL EFFECTS OF CLEANING

General Effect

The effect of a single HAND BRUSH cleaning on a surface initially coated with 480 ml/m^2 Askarel is illustrated in Figure 5-7. The surface appearance is transformed from a general dark appearance to a spotted appearance. The corresponding reduction in PCB level was from 2.4 to 0.089 x 10^6 $\mu g/m^2$.

Also illustrated is the appearance of the same sample after the third and fourth HAND BRUSH cleanings of a section initially coated with 160 ml/m^2 Askarel. The spots are fading out and the general surface looks clean despite still having a PCB level of 42,000 $\mu g/m^2$.

Concerning the spotted appearance of the cleaned areas, it was determined that the spots extend at least to a depth of 0.047-0.050 in., the depth of the concrete samples on concrete section no. 7, Figure 5-8. As discussed previously these spots are areas of higher PCB concentration.

Concrete Comparison

The general spotted appearance of the new concrete treated with 480 ml/m^2 Askarel after at least one cleaning was different than for similar treatment of the old concrete. The old concrete was probably 30 years old and reasonably stabilized with respect to drying shrinkage and associated cracking. The manifestation of this cracking can be observed in Figure 5-9, where after a cleaning attempt, a higher concentration of Texaco transformer oil remains in, and delineates, a network of cracks on the surface. Since the new concrete was still essentially wet, comparable cracking apparently had not yet occurred. The spots on the new concrete are believed to be the result of a concentration of PCB at aggregate pieces at or near the surface, Figure 4-4.

EFFECT OF POWER CLEANER 155 SOAK TIME

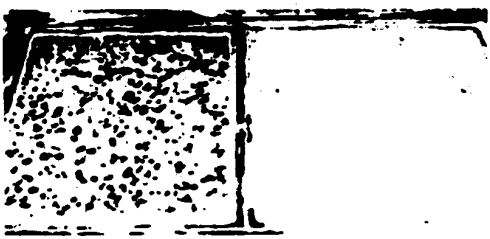
For the HAND BRUSH approach, although increasing the soak time from 10 to 20 min on concrete section 9 appeared to result in a greater reduction in PCB concen-

MONS 018385



Section no. 9, 480 ml/m² as-coated

Section no. 10, 160 ml/m² HAND BRUSH, third cleaning



Section no. 9, 480 ml/m² HAND BRUSH, first cleaning

Section no. 10, 160 ml/m² HAND BRUSH, fourth cleaning

Figure 5-7. Cleaning results with Power Cleaner 155.

MONS 018386



Figure 5-8. Presence of higher PCB concentration spots to depth of 0.047-0.050 in. on concrete section number 7 after third MACHINE BRUSH cleaning. 0.3X*



Figure 5-9. Network of cracking delineated by a higher concentration of transformer oil after cleaning attempt. 0.3X*

* Please note that the illustration(s) on this page has been reduced 10% in printing.

MONS 018387

tration after the first cleaning the effect on subsequent cleanings was inconsequential, Table 5-2.

EFFECT OF POWER CLEANER 155 CONCENTRATION

Increasing the Power Cleaner 155 concentration from 1:32 (32 water) to 1:1 appeared to reduce the effectiveness of the HAND BRUSH approach for the 480 ml/m² Askarel application, Table 5-2. The effect on the 160 ml/m² application was inconsistent.

Surface Replenishment

Long term data on the replenishment of PCBs on the concrete surface through migration from the interior (leach back) was not obtained because of funding restraints. On a short term basis, the 2 to 15 hour time interval between cleaning and the taking of wipe samples did not, within the reproducibility of sampling and analysis, indicate that measurable leach back was occurring in these short time periods. It was observed, however, that the higher PCB concentration spots, Figure 5-8, did diminish in sharpness and become more diffuse between cleanings indicating that lateral PCB migration was occurring.

Time Interval Before Cleaning

To provide a frame of reference for other PCB removal work, the time interval between Askarel application and cleaning attempt is provided in Table 5-4. These data can be used with the data of Tables 5-2 and 5-3 to compare PCB removal effectiveness for similar initial (precleaning) Askarel applications.

WIPE TEST REPLICATION

To obtain information on the reproducibility of wipe testing, the following comperative tests were made:

- Tests on Adjacent Areas. One concrete section was divided into three areas and wipe tests were taken on each area at two different points in time. The as-oiled (160 ml/m²) PCB concentration taken one day after oiling was 62,000 µg/m². The wipe tests on the three areas were taken seven days after oiling and were identical at 120,000 µg/m². In a retest, the wipes on the three areas were taken three days after the first set of three. The results were 44,000, 46,000, and 48,000 µg/m². Since these latter results were much closer to the as-oiled contamination level it is believed that the 120,000 µg/m² results were in error. Nevertheless, the reproducibility within each wipe test series was very good.

- Tests on Same Area. The wipe tests were repeated three times in the same area at essentially the same point in time on two concrete sections. On one section with an initial Askarel concentration of 480 ml/m² the wipe test result after the third cleaning was

MONS 018388

110,000 ug/m². The three replications approximately 12 hours later gave results of 100,000, 90,000, and 64,000 ug/m² in order of testing. On the other section with an Askarel concentration of 160 ml/m², the wipe test result after the third cleaning was 56,000 ug/m². The three replications approximately 12 hours later gave results of 72,000, 58,000, and 8,600 ug/m². It is apparent for each section that the point-in-time replications on the same surface did not serve to demonstrate the reproducibility of the technique but instead demonstrated the cleaning ability of the hexane:acetone solvent on the wipe.

Table 5-4

TIME INTERVAL BETWEEN ASKAREL APPLICATION AND CLEANING ATTEMPT (DAYS)

Concrete Section	Cleaning Approach	Askarel Amount ml/m²	Cleaning Attempts						
			First	Second	Third	Fourth	Fifth	Sixth	Seventh
8	Hand brush[a]	480	3.0	3.5	4.0	5.0	5.5	6.0	6.5
10	Hand brush[a]	160	5.0	5.5	6.0	7.0	7.5	8.0	8.5
7	Machine brush[a]	480	3.0	3.5	4.0	-	-	-	-
11	Machine brush[a]	160	5.0	5.5	6.0	-	-	-	-
3	Machine apply and brush[a]	480	3.0	3.5	4.0	-	-	-	-
4	Machine apply and brush[a]	160	5.0	5.5	6.0	-	-	-	-
9	Hand brush[a]	480	5.0	5.5	6.0	6.5	-	-	-
2	Hand brush[b]	480	6.0	6.5	9.0	10.0	10.5	-	-
12	Hand brush[b]	160	8.0	8.5	11.0	12.0	12.5	-	-

[a] 1:32, Water:Power Cleaner 155 solution
[b] 1:1, Water:Power Cleaner 155 solution

AIR SAMPLE RESULTS

To obtain information on the potential for airborne PCBs, air samples were taken using glass tubes containing Florisil. Analysis was by gas chromatography after desorption by 1:1 acetone:hexane. The results are presented in Table 5-5. Concerning the air in the work area, the activity of concrete sampling appeared to generate airborne PCBs above the background levels indicated by the overnight/weekend sampling. During cleaning attempts, the exhaust systems used to vacuum up the Power Cleaner 155 and the Freon were sampled before discharging into an acti-

MONS 018389

vated charcoal drum. The exhaust during application of either cleaning approach contained PCB levels considerably above background, particularly for one cleaning sequence involving Freon. It is apparent that for a cleaning operation involving an exhaust system, the exhaust system should be sealed to prevent PCB escape to the atmosphere, and should be vented through a carbon drum.

Table 5-5

ROOM AIR/EXHAUST SYSTEM RESULTS

Activity	PCB Concentration ($\mu g/m^3$) Room Air	Exhaust	Sampling Time (hrs)
Power Cleaner 155 Cleaning	-	28.0	2.2
Power Cleaner 155 Cleaning	-	39.0	2.0
Power Cleaner 155 Cleaning	-	77.0	1.3
Power Cleaner 155 Cleaning	-	87.5	0.4
Freon Cleaning	-	283.0	2.2
Freon Cleaning	-	58.0	0.8
Concrete Sampling	19.0	-	8.0
Concrete Sampling	3.0	-	3.9
Over Night	2.3	-	12.8
Over Night	1.2	-	14.7
Over Night	3.4	-	14.8
Over Weekend	1.3	-	63.0

Section 6

CONCLUSIONS

Because of the limited nature of this project the results obtained should be regarded as a starting point for a more comprehensive and definitive project that could establish boundary conditions or limits for the effectiveness of cleaning methods to be used for PCB removal from a variety of porous surfaces.

Based on the results obtained the following conclusions/observations are made:

- The concrete used in the PCB removal work was only three weeks old and had a moisture content that was 90% of saturation. This high moisture content was suspected as being a factor in reducing the effectiveness of the cleaning methods applied.
- For Askarel applications of 480 ml/m^2, factors of reduction in PCB concentration from 53 to 170 were obtained for machine and hand cleaning with Power Cleaner 155. When the Askarel application was 160 ml/m^2 the reduction in PCB concentration ranged from 1.1 to 1.8. Other than implicating the high moisture content of the concrete tested, no reason can be given for this greatly diminished effectiveness.
- Use of the commercial rug cleaning system appeared to be as effective in reducing PCB concentration as a vigorous hand brushing approach.
- The effectiveness of the Power Cleaner 155 for removing PCBs appeared to decrease when the Power Cleaner 155 concentration was increased from 1:3 to 1:1.
- After incorporation of the vacuum confining rectangular annulus, the three-jet vacuum head performed very well for the spraying and vacuuming of Freon and other fluids from floor and wall areas. Although not demonstrated, it is believed that this head could be used to clean nonporous surfaces with solvent or nonsolvent cleaning solutions.
- The expected high removal effectiveness of such solvents as Freon, Freon plus 35% ethanol, and perchloroethylene was not achieved. Testing indicated that the high moisture content of the concrete used severely inhibited the action of the solvents.
- Although substantial reductions in PCB concentration were associated with the removal of Askarel from concrete surfaces as indicated by visual appearance, the remaining PCB concentration was considerably higher than expected.
- A surface sampling technique that permits the removal of incremental layers of concrete was successfully demonstrated. The results

MONS 018391

obtained indicate that the action of a cleaning method is probably confined to the first 0.004 in. from the surface. The results also indicate that before cleaning a large fraction of the PCB concentration is at or near the surface. This combination of characteristics tends to maximize the effect of a cleaning attempt.

- The PCB concentration results obtained from use of the wipe technique were in general very reproducible and permitted the compilation of an acceptable body of data. Considering the roughness of the concrete surface being sampled by wiping this was a surprising result.

- Airborne PCBs were detected during the concrete surface sampling activity (a fine powder was generated), and also in the exhaust hose during vacuuming operations involving the removal of Power Cleaner 155, and Freon from concrete surfaces.

- For the purposes of the initial development of equipment and preliminary selection of cleaning approach and materials, transformer oil was considered to be an acceptable surrogate for Askarel. Rate of progress on these activities was accelerated by using visual appearance to evaluate the relative effectiveness of cleaning techniques and materials for oil removal.

Appendix A

CONCRETE MIX DESIGN AND PROPERTY DATA

MONS 018393

FLORIDA ROCK INDUSTRIES, INC.
MATERIALS TESTING LABORATORY
700 Palmetto Street / P. O. Box 2319
Jacksonville, Florida 32203
(904) 354-8266

Denny Division - Gainesville
(DIVISION)

CONCRETE MIX DESIGN

CLASS OF CONCRETE: 4000 PSI MIX NO 7-4117

PROJECT: Floor Test Panels

ARCHITECT/ENGINEER:
CONTRACTOR: Quadrex

DATE: 1/7/86
REPORT NO 1

MATERIALS

1.	CEMENT:	Type I	Florida Mining & Materials
2.	POZZOLAN:		
3.	FINE AGGREGATE:	Keuka Sand	Florida Rock Industries, Inc.
4.	COARSE AGGREGATE I:	#57 Crushed Limestone	Florida Rock Industries, Inc.
5.	COARSE AGGREGATE II:		
6.	AIR-ENTRAINING AGENT:	Darex AEA	W. R. Grace & Company
7.	CHEMICAL ADMIXTURE:	WRDA - 79	W. R. Grace & Company
8.			

TESTS ON AGGREGATES

FINE AGGREGATE	Specific Gravity	Unit Weight	Colorimetric Test	GRADATION (% PASSING U.S. SIEVE) 3/8"	#4	#8	#16	#30	#50	#100	#200	F.M.
	2.63	105.0	lighter than standard	100	100	97	83	54	22	3	-	2.41

COARSE AGGREGATE	Specific Gravity	Unit Weight	L.A. Abrasion	GRADATION (% PASSING U.S. SIEVE) 2"	1½"	1"	3/4"	1/2"	3/8"	#4	#8	#16	F.M.
I	2.43	90.0	35%		100	97	75	39	16	3	-	-	7.04
II													

MIX DESIGN FOR 4000 PSI CONCRETE AT 28 DAYS

Cement Content*:	5.6 cwt/cu. yd.	Slump:	4.0 in.	P. A. Volume:	41.4 %
Water-Cement Ratio*:	0.47 by wt.	Air:	5.0 %	Unit Weight:	141.6 Pcf

*) Based on total cementitious material, if pozzolan is used.

MATERIALS	QUANTITIES (SSD BASIS)	VOLUME (CU. FT.)
Cement	560	2.85
Sand	1300	7.92
#57 Stone	1701	11.22
Water	262	4.20
Darex AEA, oz.	1.2	0.81
WRDA - 79, oz.	28.0	----
		27.00

AVERAGE COMPRESSIVE STRENGTH, PSI, AT 3 DAYS --- ; 7 DAYS 3900 ; 28 DAYS 5280

REMARKS:

Robert A. Hays - Technical Services

MONS 018394

UNIVERSAL
ENGINEERING TESTING COMPANY
4679 S.W. 35th Terrace • Gainesville, Florida 32608 • (904) 372-3381

Order No: 86-3034
Report No: 0098
Date 1st Issue: 1-17-86
2nd Issue: 2-7-86
3rd Issue:
Final Issue:

COMPRESSIVE STRENGTH OF 6 x 12 CONCRETE TEST SPECIMENS

Client: Quadrex HPS, Inc.
1940 NW 67th Place
Gainesville, Florida 32606
Attn: G. McIlvaine

Project: Quadrex HPS
1940 NW 67th Place, Gainesville, Florida P.O. # 11 22YR

DESIGN DATA
Specified Strength: 4000 psi at 28 days

FIELD & LAB DATA

Date Sampled:	1-9-86		Time Sampled	10:45 a.m.	
Sampled By:	UETC (D.Y.)		Slump:	3	in.
Truck Number:	1366		Air Content (by volume):	3½	%
Ticket Number:	440075		Concrete Temperature:	61°	F
Time Batched:	N/S		No. of Cylinders Cast:	3	
Quantity of Load:	2.75	cu. yds.	Ambient Temperature:	N/S	F
Water Added at Site:	N/S	gallons	Weather Conditions:	N/S	
Contractor:	Sanford & Son Concrete		Admixture:	Daren	
Supplier:	Florida Rock		Unit wt.:	135.2	
Location of Placement:	Test pads				

RESULTS OF TESTING

Date Tested	Age (days)	Type of Fracture	Test Specimen Diameter (in.)	Area (sq. in.)	Max. Compressive Load (lbs.)	Test Compressive Strength (psi)	Average (psi)
1-16-86	7	5	6	28.27	147,[illegible]	5200	
2-6-86	28	4	6	28.27	161,[illegible]	5700	
2-6-86	Hold		6	28.27	[illegible] to laboratory		

REMARKS: THIS FORM CONFORMS WITH ASTM C-39

Kenneth Luther, P.E.

Jack Ray
Regional Manager, UETC

UNIVERSAL ENGINEERING TESTING COMPANY

[illegible]

MQNS 018395

Appendix B

PROCEDURE FOR WIPE SAMPLING[a]

1. Use 3" x 3" Johnson and Johnson Steri Pads.
2. Roll up pad and insert in wide mouth glass bottle with screw cap. Inside of cap should be lined with teflon or aluminum foil.
3. Apply 8 ml of hexane to pad and cap bottle.
4. Before taking a wipe sample, cover hands with nonlinear polyethylene gloves.
5. Open bottle and empty rolled up gauze pad into gloved hand. Any excess hexane in bottle should be poured on pad.
6. Hold one side of pad (opposite folded edge) and using a series of adjacent left to right traverses completely wipe 0.25 m^2 (50 cm x 50 cm) area. Then turn pad over, still holding side opposite folded edge, and completely wipe same area in a series of adjacent top to bottom traverses.
7. Open pad and fold over so the two contaminated sides are inside, and roll up.
8. Insert rolled pad into bottle and cover.
9. Pad is now ready for analysis.
10. Use new set of gloves for each sample.

[a]To reduce effects of operator differences, all wipe sampling on a given project should be performed by the same operator.

MONS 018396

MONS 018397