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Paper Title: Removal of PCBs From Concrete

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I. Removal of PCBs From Concrete

Decontamination of concrete containing polychlorinated biphenyls (PCBs) has become a major concern to government and industry. Particularly related to heightened activity in replacement of PCB containing electrical transformers, discovery of contaminated concrete has prompted the need to know available solutions and their costs.

Methods available for solving concrete/PCB problems include solvent washing, encapsulation and removal. The method selection is determined by level and depth of contamination, and must be executed in an environmentally-safe manner to prevent spreading the contamination over a wider area.

Several techniques are commercially available. As demonstrated in a case history example, these techniques have been proven effective and accepted by the EPA.

Equipment/methods reviewed include modified scabbling and shot-blasting systems which operate in conjunction with multi-stage vacuum system that deposits removed concrete directly into disposal drums. The vacuum system's final stage filter removes 99.97% of all particles greater than 0.3 microns in size. Air monitoring data collection during operation verifies that no dust escapes to the surrounding environment.

Concrete problems can be solved economically, yet in an environmentally-safe manner.

II. Introduction

Government and industrial awareness of the problems associated with PCB-contaminated concrete is becoming a major concern. Leaks and spills from transformers containing PCBs have contaminated the surfaces on which they stand which--in the majority of cases--is concrete.

As government and industrial managers address the PCB transformer problems with turnkey replacement or reclassification, many are also responding to the PCB contamination in the concrete. Due to the porous nature of concrete, testing methods are fairly complex, decontamination methods are many and varied, regulatory instructions are still at the policy (guideline) stage--and yet--decontamination is being driven by concern for human health.

Three methods of handling PCB contamination in concrete are currently being used. These are: Chemical Cleaning, Concrete Encapsulation, and PCB-Contaminated Concrete Removal. Each of these methods has merit in certain applications.

This paper covers the equipment and methods which have been used to perform PCB concrete sampling, cleaning, encapsulation and removal in an environmentally-safe fashion. A case study is reviewed starting with the planning stages through completion of the job. The particular job covers all three of the decontamination techniques which were completed as part of a PCB removal project involving turnkey transformer replacement.

III. Determination of Extent of Concrete PCB Contamination

The sampling plan used to determine the extent of PCB concrete contamination is the most important step in a PCB-contaminated concrete decontamination project. The sampling must be extensive enough to accurately define the problem while still minimizing the number of samples to minimize cost.

The extent and depth of PCB contamination in concrete will be a function of the PCB concentration of the spilled material, the porosity of the concrete and the length of time the contaminant remained on the surface. Wipe sampling will indicate the surface contamination level while core sampling is used to determine the depth of PCB contamination. Core sampling is performed to an estimated depth of contamination. The sample is then cut into incremental sections and each is analyzed. In this way the depth of PCB contamination can be determined.

The EPA has published EPA-560/5-86-017 **Field Manual for Grid Sampling of PCB Spill Sites to Verify Clean Up** to assist industry and government with PCB spill clean up. This article recommends that spill sites be sampled in a hexagonal grid with 7, 19, or 37 samples depending on the size of the spill site. If surface and subsurface sampling is performed in accordance with the hexagonal grid sampling method, a high a degree of confidence will be obtained that all PCB contamination has been located. The cost of performing both wipe sampling and core sampling in a hexagonal grid pattern on large concrete slabs can become prohibitive.

Government and industry has, in many cases, elected to perform sampling with alternate schemes in order to reduce costs. Wipe samples are much cheaper to obtain and analyze than core tests, therefore industry has tended to rely heavily on them. Wipe sampling on porous surfaces however, tells little about what lies below the surface. Repainted surfaces further complicate matters by hiding contamination below the surface. The importance of subsurface testing cannot be over-emphasized in the case of PCB contamination of porous materials such as concrete.

One common sampling scheme is to perform wipe sampling in areas with a high probability of PCB contamination such as under transformer drain valves. Additional wipe sampling is then performed in the transformer area on a random basis. Core samples are then only taken in areas where wipe samples have shown high levels of contamination. All of the data is then analyzed to determine the action that must be taken in the contaminated area. The EPA has approved plans of this nature for historic spill clean up.

When designing a sampling scheme for PCB contamination in concrete, many factors must be considered. The critical issue is that the information obtained from the data must be sufficient to meet the objectives of the PCB project.

IV. Concrete Decontamination Techniques

The following procedures for concrete surface cleaning, concrete encapsulation, and concrete removal have been used to perform decontamination at PCB-contaminated sites. All three procedures can be performed in an environmentally-safe fashion with no chance of cross-contamination to uncontaminated areas.

Each one of the three methods has applications where it is more suitable than the other two. However, the three methods combined can handle nearly all PCB-contaminated concrete problems.

Each of the procedures and the limits of its application are described below.

Concrete Surface Cleaning

Concrete surface cleaning is the most common method applied to PCB contamination. Unfortunately, due to the porous nature of concrete, it is usually not the correct technique. Chemical cleaning has been demonstrated to only be effective if the depth of contamination is no greater than .004 inches[1]. If chemical cleaning is attempted on concrete which is contaminated below the surface, there is a high probability that surface contamination will return through leachback after chemical cleaning. This has been documented in the literature. Due to the porous nature of concrete, if a spill is not cleaned almost immediately, it will penetrate the surface and make chemical cleaning an inappropriate solution.

Chemical cleaning is applicable on vertical porous surfaces (concrete) and impervious materials. In the case of vertical porous surfaces, the penetration will not be as great due to absence of time to allow the PCBs to soak in.

On any porous surface where chemical cleaning is attempted, an additional measure of protection (encapsulation) should be completed.

The effectiveness of chemical cleaners for PCB cleaning has been investigated.[2] When comparing non-solvent to solvent-type cleaners, the net cleaning effect of the two types is equivalent. Some solvent-type cleaners pose a fire hazard, therefore the non-solvent types are preferred. Of the non-solvent type cleaners, Penetone Power Cleaner 155 appears to perform the best.

To perform the cleaning, the detergent cleaner is sprayed onto the surface and mechanically agitated. The liquid is then vacuumed up with a vacuum system equipped with both a HEPA filter and a charcoal filter. In this way PCBs removed during the cleaning process will not escape into the environment.

When using the detergent/vacuum method for cleaning porous surfaces, the time the detergent is allowed to remain on the surface must be limited. If the detergent is allowed to remain on the surface for extended periods, it may carry the PCB further into the concrete.

PCB-Contaminated Concrete Encapsulation

PCB-contaminated concrete encapsulation is, at first glance, a viable solution to the problem. In reality, however, it presents several problems which must be considered.

Existing concrete is in very few cases without imperfections. Cracks and expansion joints among many other things make encapsulation a more complicated process than would first appear.

The choice of encapsulating material is a difficult one. There are several products on the market, however, they do not offer warranty when it comes to PCBs. **40 CFR 761** **Polychlorinated Biphenyls Spill Clean Up Policy; Final Rule** Preface points out that the "Agency is aware of no empirical data which verify the effectiveness of encapsulants in reducing exposure" although they do believe encapsulation to be beneficial. In this light, encapsulation of PCBs in concrete does not appear to be an option for the prudent manager, if other options are available. The encapsulated area must continually be monitored to ensure that personnel are not being exposed to PCBs.

Encapsulation is an option when concrete removal is not possible or when a surface has been detergent washed and an extra measure of protection is desired. The following encapsulation procedure has been used in industry with some success. Prior to the application of the encapsulating material, the surface must be prepared. This involves either shot blasting or scabbling of horizontal surfaces. Needle scaling or hand scabbling can be used on walls. In either of the cases, the tools must work in conjunction with a vacuum system which collects all of the removed material and uses a HEPA filter as the final filter media. In this way, cross-contamination to uncontaminated areas is prevented.

A two-color system of epoxy paint is then installed. When the lower color begins to show through, it is time to re-apply the top coat. In this way, the integrity of the barrier can be visually inspected.

Cracks and joints must be filled with an appropriate material prior to applying the two-color system of epoxy paint.

The surface of the floor must be monitored for new cracks and failures so the epoxy barrier between the contaminated concrete and personnel foot traffic can be maintained.

PCB-Contaminated Concrete Removal

PCB-contaminated concrete removal is the only permanent solution to the problem. As part of either turnkey replacement or reclassification of PCB transformers, PCB-contaminated concrete removal provides complete removal of PCBs from a site.

The EPA Polychlorinated Biphenyls Spill Clean Up Policy requires that soils be cleaned to either 25 ppm or 10 ppm depending on whether the location is in a restricted or non-restricted area. These levels are easily and economically attainable for concrete. Based on the human health risk, the 10 and 25 ppm levels should be the targets for PCB-contaminated concrete removal projects.

Several commercial methods are available to remove concrete. They are: sandblasting, scarifying, high-pressure water cutting, scabbling and shot blasting.

The method used to remove PCB-contaminated concrete must perform the work effectively while preventing cross-contamination to uncontaminated areas of the facility. The method must also minimize the amount of waste that is generated.

The sandblasting method is effective; but it generates large quantities of additional waste and control of dust to prevent cross-contamination is extremely difficult. Scarifying is also effective; however--again--dust control to prevent cross-contamination is difficult. High-pressure water cutting is also an effective method of removing concrete; but the process generates large volumes of water which must be handled and disposed of. This leaves scabbling and shot blasting. Both techniques generate large quantities of dust, however, high-volume vacuum systems with HEPA filtration can be adapted to the units to allow them to operate virtually dust free. The shot-blasting technique is generally used for shallow removal of less than 1/2 inch. The scabbling technique can be used to the level of any reinforcement and beyond. High-volume scabbling machines with up to twelve tungsten carbide tipped pistons are available which quickly remove the concrete to the level of the rebar. Below the rebar, triple and single-head scabbling machines can be used. All of these machines can be adapted to a high-volume vacuum system equipped with a HEPA filter. The properly designed vacuum system must deposit the waste into a disposal container to minimize the amount of handling required.

A system of this design has been used to eradicate PCBs from government and industrial sites. Air-monitoring equipment has verified that the system operates without the escape of PCB-laden dust.

V. Case Study

This particular project was completed for the General Services Administration Washington, DC site. This plant supplies steam for heating and cooling purposes in government buildings. Hill International acted as Project Consultant and Field Inspector for the GSA. Sun Environmental, Inc. was contracted to perform the PCB-removal project which involved turnkey replacement of three 1500 kVA askarel-filled transformers in one vault, turnkey replacement of three 750 kVA askarel-filled transformers in another vault, and replacement of one 500 kVA askarel-filled transformer at an outdoor pad.

Prior to the time of the contract award, limited wipe samples and core samples had been obtained in the vaults, but the scope of PCB-contaminated concrete removal had not been defined.

The preliminary data indicated PCB contamination was present up to one inch in depth on the concrete floors of the indoor vaults. No data was obtained at the outdoor pad location.

Sun Environmental, Inc. was asked to recommend a sampling plan to fully define the problem. Sun Environmental, Inc. recommended grid sampling of both wipe and core testing after stripping the paint from the vault floors. This plan was deemed too costly--therefore the following guidelines were used.

At transformer vault or pad locations containing three or less transformers, wipe tests were to be obtained at the following locations:

1. One wipe test at each entrance.
2. One under each transformer drain valve.
3. Four random locations in the vault.

At transformer locations vault or pad locations containing four or more transformers, wipe tests were to be obtained at the following locations:

1. One wipe test at each entrance.
2. One under each transformer drain valve.
3. Six random locations in the vault.

The wipe test data was used to draw a contour of the area that had contamination greater than 10 micrograms per 100 cm^2.

Two core samples were performed for each 100 square feet of floor space contaminated to greater than 10 micrograms per 100 cm^2.

The data obtained from the two vaults and the one outdoor pad is shown on Tables 1, 2, and 3; and in Figures 1, 2, and 3.

Once the data was obtained, the following guidelines were used to determine what actions were required in each area:

1. In areas contaminated to less than 10 micrograms per 100 cm^2 the surfaces had to be cleaned and one coat of epoxy paint applied.
2. In areas contaminated in the range of 10 micrograms per 100 cm^2 to 100 micrograms per 100 cm^2 and core tests showing less than 25 ppm, the surfaces had to be cleaned down to 10 micrograms per 100 cm^2 using the solvent vacuum method and one coat of epoxy paint applied.
3. In areas contaminated to greater than 100 micrograms per 100 cm^2 and core tests showing less than 25 ppm, one inch of concrete removal was required. The area was to be patched with polymer concrete and one coat of epoxy paint was to be applied.
4. In areas contaminated to greater than 10 micrograms per 100 cm^2 and core tests showing greater than 25 ppm contamination, all concrete with

contamination greater than 25 ppm had to be removed. The area was to be patched with polymer concrete and one coat of epoxy paint applied.

These guidelines were general in nature and each site was handled on a case-by-case bases taking into consideration factors such as whether the slab was above grade or whether the slab was under hydrostatic pressure.

The three boxed/shaded areas in Figure 1 show where PCB-contaminated concrete removal was performed in Vault A. One inch of concrete was removed in all three areas. The work was performed with a modified FB5 scabbler used in conjunction with a three-stage vacuum system. The final stage of the vacuum system was a HEPA filter. The heavy surface contamination found near the the drain valves of Transformers T4 and T6 prompted the removal in the two smaller areas. The core sample taken near the entrance to vault showed significant contamination, to a depth of two inches. Since the floor in question was located on the fifth floor of the power plant, it was decided to limit the concrete removal to one inch and to encapsulate with polymer concrete. The modified FB5 scabbler was used to strip 1/8" of concrete from the entire vault floor to ensure that all surface contamination had been removed. A 1/8" overlay of polymer concrete was installed to encapsulate any remaining PCBs.

Only one area required significant concrete removal in Vault B shown on Figure 2. This area is designated by boxed/shaded area. In this case, heavy surface contamination was found near the drain valve of Transformer T1 and the core sample taken near the drain valve showed 110 ppm/PCB in the top inch. One inch of concrete removal was performed in this area. The removed concrete was replaced replaced with polymer concrete. A 1/8" layer of concrete was also stripped from the entire vault floor to ensure that all surface PCB contamination was eliminated. A 1/8" overlay of polymer concrete was installed to encapsulate any remaining PCBs.

In both vaults, only one transformer could be out of service at a time. For this reason, Methyl Methacrylate (MMA) Polymer Concrete was chosen as the replacement concrete. The MMA polymer concrete sets to a usable strength in less than two hours. By utilizing the modified scabbler and Methly Methacrylate Polymer Concrete, only one shift was required to perform the PCB-contaminated concrete removal, polymer concrete installation, and cure time for the polymer concrete for each transformer changeout.

A seamless industrial top coat was applied to both vaults as a final coating upon completion of all electrical work.

At the outdoor pad location shown on Figure 3, wipe and core tests showed some surface contamination with no subsurface contamination. At this location three detergent/ vacuum washes were performed on the surface. Thereafter a topcoat of epoxy paint was applied.

The vacuum system used was equipped with both a HEPA filter and a charcoal filter.

Discussion

The wipe sampling scheme used to locate surface contamination of PCBs at the power plant appeared to be adequate. The number of core samples, however, was insufficient. Additional sampling in Vault A (Figure 1), around T4 and T6 may have uncovered addtional contamination. Another approach would have been to remove all concrete to a one-inch depth around T4, T5, and T6. The additional cost of performing this work would have given the insurance that the majority of contamination had been removed and the remaining well encapsulated under an inch of polymer concrete overlay.

A high level of PCB contamination was found in Vault A (Wipe Sample 6 and Core Sample 2) in a location far from the transformer drain valves. This again demonstrates the need for sufficient subsurface sampling. The relatively haphazard handling of transformer fluids prior to the knowledge of the dangers of PCBs, make most areas around PCB transformers highly suspect.

For the GSA project, the wipe tests were performed on the existing paint. The paint in these vaults was very old and probably did not effect the data.

It is still the writer's contention that consideration should be given to performing wipe tests after the paint has been removed--especially if the paint has been applied recently. By performing wipe tests on a newly painted surface, a concrete floor could be assumed to be clean when in actuality it is not.

Wipe tests and/or chip tests were performed on all surfaces prior to applying the new polymer concrete. The data was not available at this writing.

Air sampling was performed with both real time dust monitors and personal air samplers. At no time were dust levels detected above the normal back ground level as measured with real time dust monitor or were any PCBs detected on the filter cassettes from the personal air samplers.

Conclusions

1. PCB-contaminated concrete problems can addressed efficiently, economically and above all--safely.
2. By taking an environmental engineering approach on PCB-contaminated concrete, the work can be performed without the fear of cross-contamination to uncontaminated areas.

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APPENDIX

TABLE 1

Wipe and Core Test Samples from Transformer Vault A

Wipe Tests	Micrograms/100 CM²
1	10
2	22
3	11
4	5
5	12
6	5,800
7	11
8	300
9	11
10	10,000
11	15
12	16,000

Core Tests		PPM/PCB
1 (Three-Inch Core)	Top 1"	7.4
	Middle 1"	3.8
	Lower 1"	2.3
2 (Three-Inch Core)	Top 1"	5,300
	Middle 1"	520
	Lower 1"	5.8
3 (Three-Inch Core)	Top 1"	1.1
	Middle 1"	<0.1
	Lower 1"	<0.1
4 (Three-Inch Core)	Top 1"	2.6
	Middle 1"	<0.1
	Middle 1"	<0.1

TABLE 2

Wipe and Core Test Samples from Transformer Vault B

Wipe Tests	Micrograms/100 CM^2
1	14,000
2	6
3	25
4	18
5	23
6	21
7	29
8	6

Core Tests	PPM/PCB	
1 (Three-Inch Core)	Top 1"	110
	Middle 1"	0.7
	Lower 1"	0.5
2 (Three-Inch Core)	Top 1"	4.0
	Middle 1"	0.3
	Lower 1"	<0.1
3 (Three-Inch Core)	Top 1"	2.8
	Middle 1"	0.1
	Lower 1"	<0.1

TABLE 3

Wipe and Core Test Samples from Outdoor Transformer Pad

Wipe Tests		Micrograms/100 CM^2
1		<0.1
2		<0.1
3		11
4		28
Core Tests	**PPM/PCB**	
1 (Three-Inch Core)	Top 1"	0.1
	Middle 1"	<0.1
	Lower 1"	<0.1

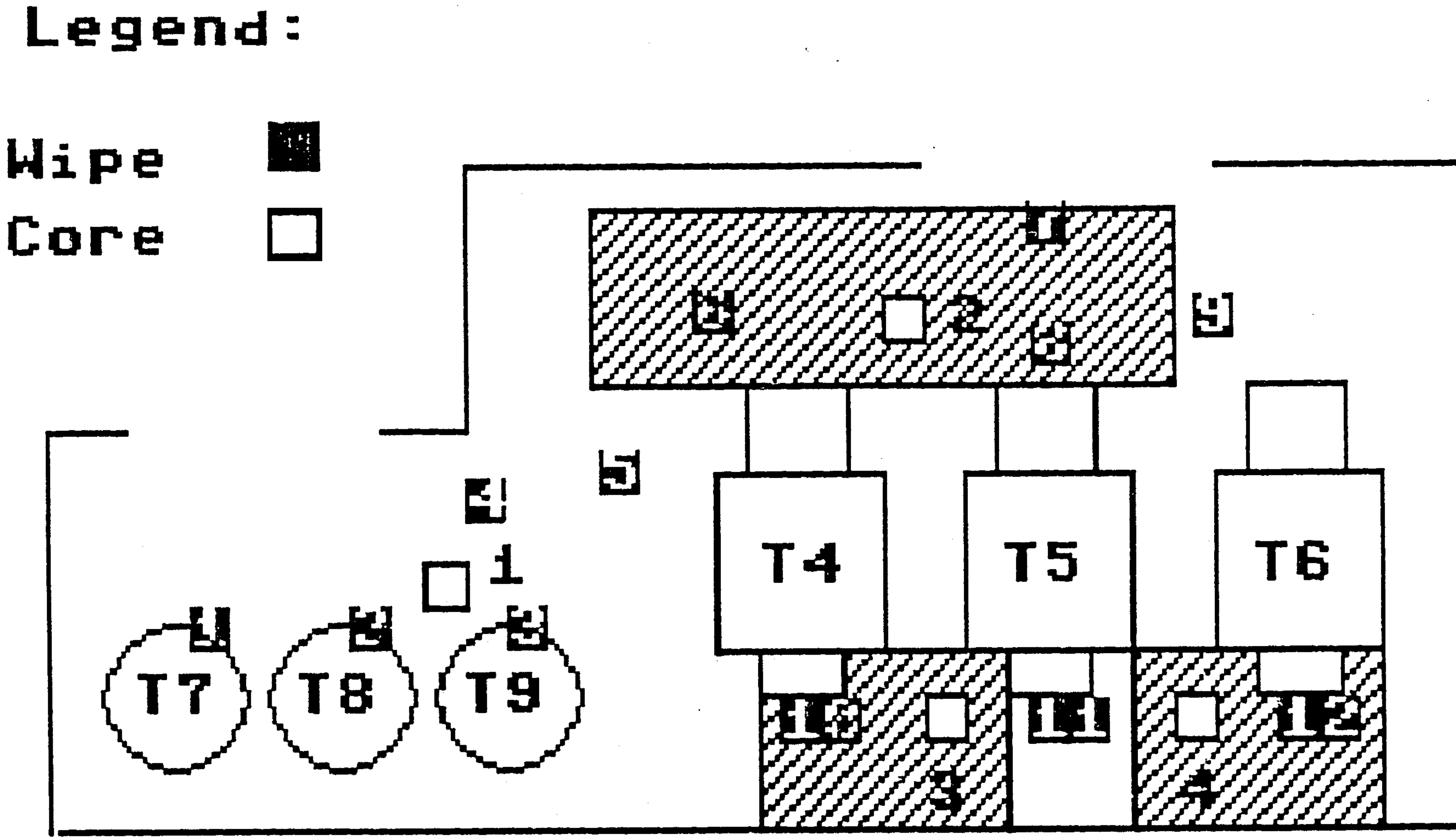

Figure 1, Transformer Vault A

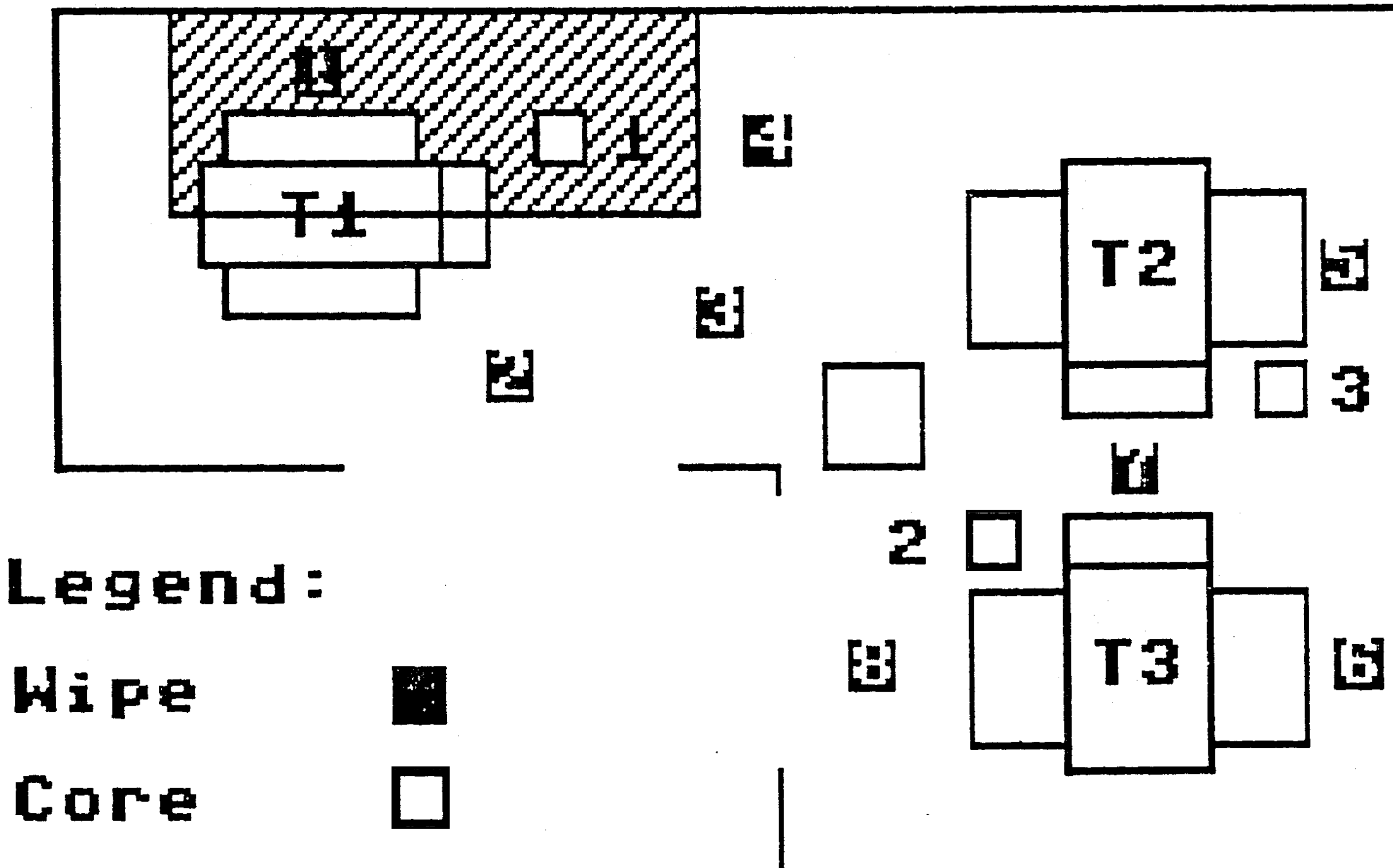

Figure 2, Transformer Vault B

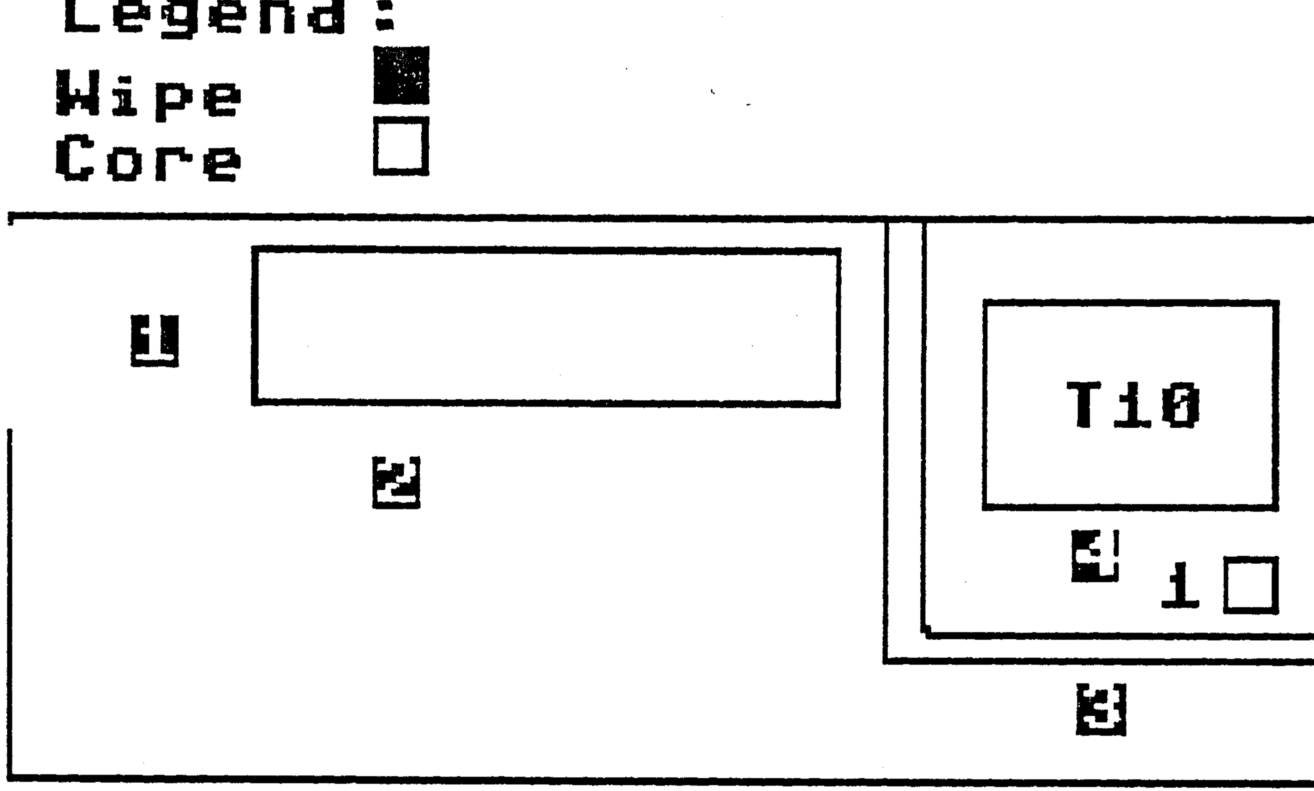

Figure 3, Out Door Transformer Pad