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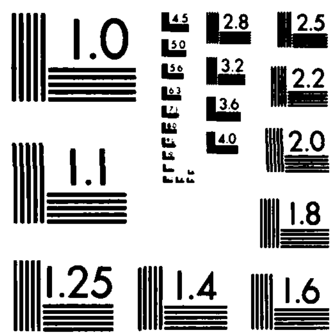

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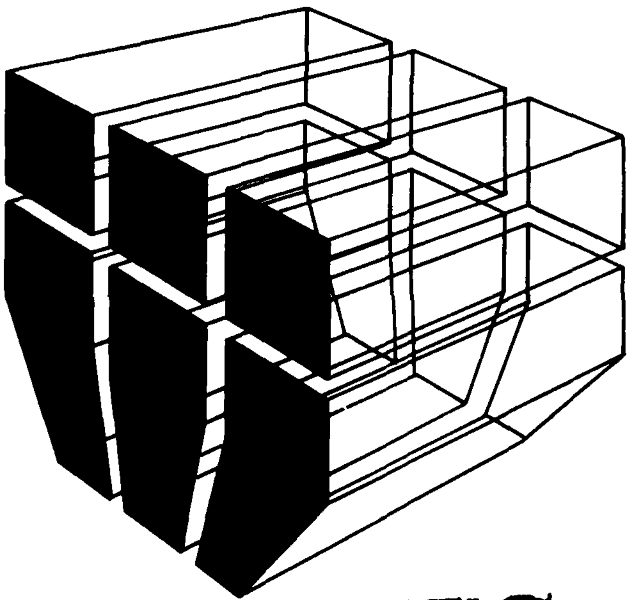
TECHNICAL REPORT M-85/09
March 1985

AD-A154 207

COMPARISON OF TT-F-1098 SOLVENT-THINNED BLOCK FILLERS WITH WATER-THINNABLE BLOCK FILLERS

by
Susan Johnston



Failures of paint systems using solvent-based block fillers to smooth concrete surfaces prior to painting have been reported in two Corps of Engineers Districts. This study has evaluated water-thinnable block fillers as a possible alternative to solvent-based block fillers. The evaluation was based on tests of compatibility between the block fillers and various types of topcoats and on accelerated weathering tests. Solvent-based block fillers are adequate for use with some restrictions; however, latex block fillers are equal to solvent-based fillers in their compatibility with most topcoats and are superior for use when the topcoats contain strong organic solvents. They are also more resistant to deterioration caused by ultraviolet light and condensation, are easier to work with, provide fewer vapor problems, and are easier to procure. Latex block fillers are therefore considered a good alternative to solvent-based block fillers.

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FOREWORD

This study was conducted for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Funding Authorization Document 2-24-71, dated 25 March 1983. The work was performed by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (USA-CERL). The OCE Technical Monitor was John Ichter, DAEN-ECE-S.

Dr. Robert Quattrone is Chief of EM. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

COMPARISON OF TT-F-1098 SOLVENT-THINNED BLOCK FILLERS WITH WATER-THINNABLE BLOCK FILLERS

1 INTRODUCTION

Background

Before painting porous surfaces such as rough concrete, concrete block, stucco, and other masonry, Army installation maintenance personnel use masonry fillers to fill open pores and voids to produce a fairly smooth surface. Corps of Engineers Guide Specification (CEGS) 09910[1] specifies TT-F-1098 block filler as a first coat on exterior-surface concrete masonry units and on interior surfaces where there will be frequent cleaning or where the surfaces will often be wet or damp. TT-F-1098 is a solvent-thinned material based on vinyl toluene butadiene copolymer resin. This coating has been implicated in coating failures in field use, and private industry, which uses mostly latex block fillers, considers the coating to be very inadequate.

In September 1982, the Corps of Engineers' Fort Worth District suggested replacing the TT-F-1098 paint systems with systems based on a water-thinnable block filler. Advantages cited were: greater compatibility with topcoats containing strong solvents, easier to work with and clean up, less sensitivity to damp substrates, fewer problems with vapors in enclosed areas, and greater availability from manufacturers.

Although a Commercial Item Description (CID)[2] for a water-thinnable block filler (A-A-1500A) was published in 1981, its use is not widespread because it is not mentioned in the guide specification.

Objectives

The objectives of this study were to (1) investigate the use and failures of TT-F-1098 block fillers and (2) compare TT-F-1098 to water-thinnable (latex) products formulated for the same purpose. Results would determine if the TT-F-1098 specification (1) is adequate, (2) can be used with some restrictions, or (3) should be removed from the guide specification in favor of CID A-A-1500A or some other type of material.

Approach

Problems with TT-F-1098 reported at two Army installations were investigated and categorized.

Two samples of TT-F-1098 block filler and six samples of water-thinnable block fillers were selected from various manufacturers. The samples were tested for conformance to Federal Specification TT-F-1098 or CID A-A-1500A, as appropriate. The samples were applied to rough concrete block surfaces and topcoated as specified in CEGS 09910 to test compatibility. The block fillers were also tested by accelerated weathering techniques to evaluate their resistance to the effects of sunlight and condensation.

Mode of Technology Transfer

It is anticipated that the information in this report will impact on CEGS 09910.

2 REPORTED FIELD PROBLEMS

Indiana Army Ammunition Plant

The 155-mm Center Core Building at Indiana Army Ammunition Plant, Charlestown, IN, was built in 1982 using concrete block construction. Some of the building's rooms required a water-resistant coating system that would be able to withstand hosing down with water. The system specified for these interior walls was of TT-F-1098 block filler, topcoated with TT-C-535 epoxy. This system is recommended in CEGS 09910 for use on concrete masonry units located in heavy traffic areas and in areas requiring a high degree of sanitation. The coatings had been applied in the fall of 1982.

The contractor had been instructed to apply the block filler with a long-nap paint roller, wait about 5 minutes, and then remove the excess block filler from the surface of the concrete block with a squeegee. The epoxy topcoat was to be applied no sooner than 24 hours after application of the block filler. Within 4 months after application of the coatings, the paint began to peel and crack. In May 1983, Louisville District asked the U.S. Army Construction Engineering Research Laboratory (USA-CERL) to inspect the site to help determine the cause of the failure and recommend corrective measures.

[1] Corps of Engineers Guide Specification (CEGS) 09910, *General Painting*, (Office of the Chief of Engineers, January 1978).

[2] Commercial Item Description A-A-1500A, *Sealer, Surface (Latex Block Filler)* (General Services Administration, July 29, 1981).

When USA-CERL personnel visited the facility, the epoxy paint system was peeling and cracking on wall surfaces in several rooms within the building; large chips of paint up to 8 in. (203.2 mm) or more across had come loose from the concrete block wall. The paint had disbonded within the layer of block filler. The paint chips had a total thickness of 15 to 25 mils (.38 to 64 mm), and several mils of block filler remained on the wall. In many areas, the pattern of the nap of the paint roller was visible on the surface of the block filler. Thus, it was apparent that the contractor had not followed instructions to remove excess block filler from the wall surface.

Block filler had also been applied as a first coat on structural support members with a smooth concrete surface, which was unnecessary, since TT-C-535 epoxy will adhere to smooth concrete surface without a prime coat. The coating had failed on these areas as well. A latex paint had been used over the block filler on interior areas of the building that are not required to be water-resistant. No failure of the latex system was observed.

In at least one room in the building, the epoxy block filler system did not fail. Because the adhesion was good, it was difficult to judge the thickness of the filler. However, no marks from the nap of the paint roller were visible. The appearance of the surface indicated that the underlying block filler was not as thick as on the failed areas. USA-CERL thus concluded that the failure was due to excessive thickness of the block filler and recommended that the peeling areas be scraped thoroughly, and that the excess block filler be removed by hand or power tools down to the surface of the concrete block. The affected areas could then be recoated with the original epoxy topcoat. Adhesion would be expected to improve because the epoxy would be in contact with the surface of the concrete block to some extent; the block filler would only be in the pores, not on the entire surface of the block.

In April 1984, Louisville District contacted USA-CERL once again because the peeling problem had worsened, expanding into areas that had not been affected previously. Two manufacturers of TT-F-1098 block filler had submitted letters to Louisville District stating that the resin in the block filler was incompatible with strong solvents such as those found in TT-C-535 epoxy. Further investigations at USA-CERL showed that the strong organic solvents in the TT-C-535 topcoat readily dissolve the vinyl toluene butadiene copolymer resin in TT-F-1098. Thus, the topcoat could soften the film and keep it soft until the solvents evaporated. This means that the filler would be soft while the epoxy was curing, a time when stresses are built up in the epoxy film as it hardens. This could result in the type of failure noted.

White Sands Missle Range

In 1978 and again in 1982, the White Sands Missile Range in the Fort Worth District experienced failures of the TT-F-1098/TT-C-535 system. In a Design or Project Deficiency Report dated 8 September 1982, poor bonding was reported between the block filler and the epoxy topcoat. Paint spalls had been coming off the concrete masonry unit (CMU) walls all the way down to the CMU substrate. The strong solvents in the two-component epoxy topcoats were thought to be affecting the resin of the TT-F-1098 block filler and "lifting" it off the wall.

The problem was avoided by placing a barrier coat of TT-P-29 interior latex paint between the two materials. The latex was not visibly affected by the strong solvents in the epoxy. The system originally specified called for two coats of the epoxy to be applied over the block filler. However, White Sands personnel found that they could get a good system by replacing one coat of the TT-C-535 with the TT-P-29. This also saved money, because the latex is less expensive than the epoxy it replaced. In both cases, the masonry walls were dampened before the filler was applied, in accordance with Guide Specification CE-250, now superseded by CEGS 09910. However, CE-250 recommended dampening the surface of the masonry walls before application of cement-emulsion filler. This recommendation does not apply to solvent-thinned materials such as TT-F-1098, which must be applied to thoroughly dry substrates (see para. 12.5 of CEGS 09910).

3 SPECIFICATION COMPLIANCE TESTING

Block fillers were selected from various manufacturers and tested for compliance with CEGS 09910 according to test methods outlined in Fed. Spec. TT-F-1098 and CID A-A-1500A. Tables 1 and 2 summarize the test results.

Two of the water-thinnable block fillers (Chemrex Vinyl and Sandstrom) had a viscosity reading of more than 141 Krebs Units (KU), which was the maximum

Table 1
Results of TT-F-1098 Tests for Block Fillers

	Requirements Min.	Requirements Max.	Chemrex TT-F-1098	PPG TT-F-1098
Condition in Container			OK	OK
Viscosity, Krebs Units	120		118	104
Appearance			OK	OK
Total Solids, %			71.6	70.7
Nonvolatile Vehicle Content, %	22		27.6	35.2
Vehicle % of Filler	40	43	38.9	40.9
Pigment Content, %	57	60	61.1	59.1
Weight per Gallon, lb	11		11.9	11.8
Dry Set-to-Touch, hr	1/4	3/4	OK	OK
Dry Hard, hr		2	OK	OK
Brushing Properties			OK	OK
Dilution Stability			OK	OK
Lifting			OK	OK
Storage Stability, 6 mos.			OK	OK
Skinning			OK	OK
Adhesion			OK	OK
Color (near white)			OK	OK
Vinyl Copolymer % NVV	58		66.5	65.9
Freeze-thaw			OK	OK

Table 2
Results of CID A-A-1500A Tests for Block Fillers

	Requirements Min.	Requirements Max.	Chemrex NV	Moor-craft	Bloc-Fil	Sand-strom	Chemrex Vinyl	Vista
Condition in Container			OK*	OK	OK	OK	OK	OK
Viscosity, Krebs Units	110	125	110	107	123	141+	141+	100
Appearance			OK	OK	OK	OK	OK	OK
Total Solids, %			55.8	59.4	63.4	61.8	62.0	58.8
Nonvolatile Vehicle Content, %			24.6	18.1	20.3	10.1	20.0	24.8
Vehicle % of Filler			58.6	49.6	45.9	42.5	30.4	54.8
Pigment Content, %			41.4	50.4	54.1	57.5	69.6	45.2
Weight per Gallon, lb			11.5	12.4	12.8	12.7	13.7	11.2
Dry Set-to-Touch, hr	1/4	3/4	OK	OK	OK	OK	OK	OK
Dry Hard, hr		2	OK	OK	OK	OK	OK	OK
Brushing Properties			OK	OK	OK	OK	OK	OK
Lifting			OK	OK	OK	OK	OK	OK
Storage Stability			OK	OK	OK	OK	OK	OK
Skinning			OK	OK	OK	OK	OK	OK
Adhesion			OK	OK	OK	OK	OK	OK
Color (near white)			OK	OK	OK	OK	OK	OK
Freeze-thaw			OK	FAIL	OK	OK	OK	OK

*Chemrex Nonvibrated Block Filler has an unusual, almost "curdled" consistency, but this is normal for this product.

viscosity measurable by the Krebs-Stormer viscometer. They were still brushable, but were more difficult to work with than the less viscous block fillers.

Moorcraft water-thinnable block filler failed the freeze-thaw test. The filler formed a gummy solid which could not be broken up. The other products passed the freeze-thaw test, with viscosity increases never exceeding 8 KU after three cycles of 16 hours at 9 ± 1°C followed by one cycle of 8 hours at 25 ± 1°C. These fillers showed no significant changes in either brushing properties or appearance of the dried film.

One conclusion was also made regarding the testing methods based on the test results. CID A-A-1500A should be updated to include two changes. First, the flexibility test should be eliminated, because concrete masonry units do not expand or contract significantly, so flexibility is not a necessary requirement. Second, the method for testing adhesion with an Elcometer adhesion tester should be updated. Currently, the filler is applied with a drawdown blade to electrolitic tin panels of unspecified thickness at a wet film thickness of 10 mils (.25 mm). The same method is used to prepare test specimens for the flexibility test, which generally uses tin panels only 1/32 in. (.8 mm) thick. Elcometer tests should be performed on substrates at least 1/4 in. (6.4 mm) thick to avoid errors caused by deformation of the substrate during the test.

4 DESCRIPTION OF COMPATIBILITY AND ACCELERATED WEATHERING TESTS

The most critical factor in evaluating the latex block fillers is their compatibility with various types of topcoats. Therefore, a series of compatibility tests was devised to compare the latex and the solvent-based block fillers. Additional tests were developed in response to the field complaint that TT-F-1098 block fillers yellowed and chalked severely if left exposed without a topcoat to sunlight for more than a few days. The guide specification does not warn against leaving the block fillers uncoated for a period of time. The accelerated weathering tests are significant, but not as critical as the compatibility tests because the block fillers are not recommended for use without a topcoat.

Compatibility Tests

CEGS 09910 specifies several systems for interior and exterior concrete masonry units. TT-F-1098 or cement-emulsion filler is specified as the first coat for exterior systems to increase water resistance, and TT-F-1098 is specified for filling concrete block surfaces in interior laundry or latrine areas which will be wet frequently, are in heavy traffic areas, and require a high degree of sanitation. Many types of topcoats are specified for use over TT-F-1098, including latex, epoxy, polyurethane, chlorinated rubber, and oil-based paints. Seven of these were selected to test their compatibility with block fillers:

1. TT-S-179, Sealer, Surface: Pigmented Oil, for Plaster and Wallboard.

2. TT-E-545, Enamel, Odorless, Alkyd, Interior Undercoat, Flat, Tints, and White.

3. TT-P-19, Paint, Acrylic Emulsion, Exterior.

4. TT-P-95, Paint, Rubber, for Swimming Pools and Other Concrete and Masonry Surfaces.

5. TT-C-535, Coating, Epoxy, Two-Component, for Interior Use on Metal, Wood, Wallboard, Painted Surfaces, Concrete, and Masonry.

6. TT-C-542, Coating, Polyurethane, Oil-Free, Moisture Curing.

The paints were purchased from the General Services Administration.

Concrete patio block 8 X 16 X 2 in. (203.2 X 406.4 X 50.8 mm) were used as test specimens. Each system tested was applied to one half of one face of nine patio blocks an 8- X 8-in. (203.2- X 203.2-mm) area. The block fillers, both TT-F-1098 and water-thinnable, were applied at a spreading rate of 50 sq ft/gal (4.5 m^2/3.8 L). The fillers were allowed to dry 3 to 5 minutes, and then the excess material was removed with a squeegee. The block fillers were dried for 24 hours before topcoats were applied. The topcoats were brushed on at the spreading rates recommended for each paint. The test specimens were dried for 14 days before testing.

The adhesion of each specimen was tested according to ASTM D 3359, Method B, "Measuring Adhesion by Tape Test," in which a number of parallel cuts are made through the film to the substrate. Identical cuts are then made perpendicular to the first ones to make a cross-hatch pattern. Adhesive tape is pressed over the area and removed by pulling back at an angle of 180 degrees. The area is inspected with an illuminated magnifier for removal of the coating from the substrate or from a previous coating. A kit manufactured by Paul N. Gardner Company, Inc., Lauderdale By-The-Sea, FL, provided the cutting tools, tape, and magnifier. The cutting tool has teeth to make eight cuts at a time, 2.0 mm apart.

Accelerated Weathering Tests

The latex and the TT-F-1098 block fillers were tested in accelerated exposure to compare the resistance of each to degradation by a combination of sunlight and condensation. The ASTM Test Method G 53, "Operating Light- and Water-Exposure Apparatus for Exposure of Nonmetallic Materials," was used, in which specimens are alternately exposed to ultraviolet (UV) light alone and then condensation alone in a repetitive cycle. The UV source is an array of fluorescent lamps, whose emissions are concentrated in the UV range. Condensation is produced by exposing the test surface to a heated, saturated mixture of air and water vapor, while exposing the reverse side of the specimen to the cooling influence of ambient room air. The apparatus used was the UVCON model UC-1 manufactured by Atlas Electrical Devices Company, Chicago, IL.

The test panels were pieces of cement asbestos siding material of 3 × 9 × 1/8 in. (76.2 × 228.6 × 3.2 mm). Block fillers were applied to the panels and allowed to dry for 3 days before testing. The panels were then exposed in the UVCON for 16 days. Tristimulus color values were determined every 48 hours, according to ASTM D 2244 "Standard Method for Instrumental Evaluation of Color Differences of Opaque Materials." The yellowness index, N, was calculated from the following formula published in Fed. Test Method Std. No. 141B (February 1, 1979), Method 6131:

$$N = \frac{(1.250X - 1.038Z)}{Y} \qquad \text{[Eq 1]}$$

where X, Y, and Z are the International Commission on Illumination tristimulus values. Reported N values are the average of five readings on each panel at each 48-hour interval.

Compatibility Test Results

Table 3 summarizes the compatibility test results. Columns 3 and 4 of the table list the values of the cross-hatch adhesion test before and after 7 days at elevated temperature and humidity. Columns 5 and 6 are the sum of the "before" and "after" values for each system, and the average of the sums for each block filler, respectively.

The appearance of all the fillers was satisfactory. Voids were filled so that a smooth, continuous coat of paint could be applied. Chemrex Nonvibrated Block Filler gave a somewhat rougher surface than the others because of its "curdled" consistency; however, this roughness appeared to affect only the appearance, not the performance.

It should be noted that the TT-F-1098 from Chemrex had a much lower average adhesion value than any of the others. The TT-F-1098 manufactured by PPG had an average well within the range of the water-thinnable block fillers.

One system (TT-E-545 alkyd enamel applied over Chemrex TT-F-1098) began to peel severely after only 3 days of curing at room temperature (see Figure 1). When the test was repeated, similar results were obtained. However, none of the other systems showed visible failure during the testing.

Accelerated Weathering Test Results

The binders in the latex block fillers were much more resistant to the effects of ultraviolet light and condensation than was the the vinyl toluene butadiene copolymer resin in the TT-F-1098 block fillers. The latex block fillers showed much less yellowing and chalking.

Figure 2 plots the yellowness index (N) vs. time for each of the block fillers. The latex block fillers yellowed very little during the test. The solvent-thinned block fillers yellowed very rapidly at first, then leveled off as chalk residues covered the surface. The Chemrex Nonvibrated Block Filler had an initial yellowing index much higher than any of the others, but it did not increase significantly during the test.

The latex block fillers had only traces of chalk on the surface after 16 days of exposure in the UVCON. The TT-F-1098 block fillers began to chalk heavily very early in the test.

5 CONCLUSIONS AND RECOMMENDATIONS

The TT-F-1098 block filler specification is adequate under most conditions encountered at Army installations. However, it should not be used under topcoats with strong organic solvents such as TT-C-535 epoxy. The most often reported field problems center around

Table 3

Compatibility Test Results*

Block Filler**	Adhesion Topcoat	Adhesion Before	Adhesion After	Total	Average
Chemrex TT-F-1098	TT-C-535	5	4	9	3.5
	TT-C-542	1	0	1	
	TT-E-545	0	0	0	
	TT-P-19	2	1	3	
	TT-P-95	3	0	3	
	TT-S-179	3	2	5	
PPG TT-F-1098	TT-C-535	4	4	8	7.2
	TT-C-542	4	2	6	
	TT-E-545	4	3	7	
	TT-P-19	4	4	8	
	TT-P-95	5	3	8	
	TT-S-179	4	2	6	
Bloc-Fil	TT-C-535	5	4	9	7.3
	TT-C-542	4	3	7	
	TT-E-545	4	3	7	
	TT-P-19	4	3	7	
	TT-P-95	4	3	7	
	TT-S-179	4	3	7	
Chemrex Nonvibrated	TT-C-535	5	4	9	7.8
	TT-C-542	5	4	9	
	TT-E-545	3	4	7	
	TT-P-19	4	2	6	
	TT-P-95	4	5	9	
	TT-S-179	5	2	7	
Chemrex Vinyl	TT-C-535	5	2	7	7.2
	TT-C-542	5	4	9	
	TT-E-545	4	2	6	
	TT-P-19	4	4	8	
	TT-P-95	5	2	7	
	TT-S-179	4	2	6	
Moorcraft	TT-C-535	5	4	9	7.0
	TT-C-542	5	3	8	
	TT-E-545	3	2	5	
	TT-P-19	4	2	6	
	TT-P-95	4	3	7	
	TT-S-179	5	2	7	
Sandst[illegible]	TT-C-535	5	5	10	6.8
	TT-C-542	4	2	6	
	TT-E-545	4	2	6	
	TT-P-19	4	2	6	
	TT-P-95	4	3	7	
	TT-S-179	4	2	6	
	TT-C-535	5	4	9	7.8
	TT-C-542	4	3	7	
	TT-E-545	4	2	6	
	TT-P-19	4	4	8	
	TT-P-95	5	4	9	
	TT-S-179	4	4	8	

* [illegible] in ASTM Method D3359.

** [illegible] solvent-based; the remainder are water-based.

Figure 1. Example of severe peeling of filler.

failings of the TT-C-535 epoxy topcoat when applied over TT-F-1098 solvent-thinned block filler. These problems occur when the vinyl toluene butadiene copolymer resin in TT-F-1098 is softened by the strong organic solvents in the epoxy topcoat. This system, in particular, would be improved by replacing the TT-F-1098 block filler with a latex block filler that would be more resistant to attack from the strong solvents in the epoxy topcoat.

Latex block fillers are as compatible as or more compatible than TT-F-1098 block fillers with the topcoats selected from CEGS 09910. They perform better than the TT-F-1098 block fillers when topcoated with paints containing strong solvents and do not yellow and chalk excessively if left exposed to sunlight. They also have several other advantages over TT-F-1098:

1. They are easier to work with and clean up.

2. They can be applied over damp substrates.

3. They pose fewer problems with vapors in enclosed areas.

4. They are more widely manufactured and therefore easier to procure.

Concrete masonry units do not expand or contract significantly, so block fillers do not need testing for flexibility. Substrates used for testing adhesion should be at least 1/4 in. (6.4 mm) thick to avoid errors caused by deformation.

Since water-thinnable block fillers have now been shown to be compatible with the topcoats specified in CEGS 09910, and have many other advantages, they should be included in CEGS 09910 as a contractor's option. TT-F-1098 can be used, but not under epoxy topcoat TT-C-535. It should remain in the guide specification because it alone should be used on surfaces which have been painted previously. The guide specification should state specifically that to prevent yellowing or chalking, TT-F-1098 block filler should not be left without a topcoat for more than a few days on exterior *surfaces*. Commercial *Item Description* A-A-1500A should be updated to eliminate the flexibility test and to specify a substrate panel thickness of at least 1/4 in. (6.4 mm) for the Elcometer adhesion test.

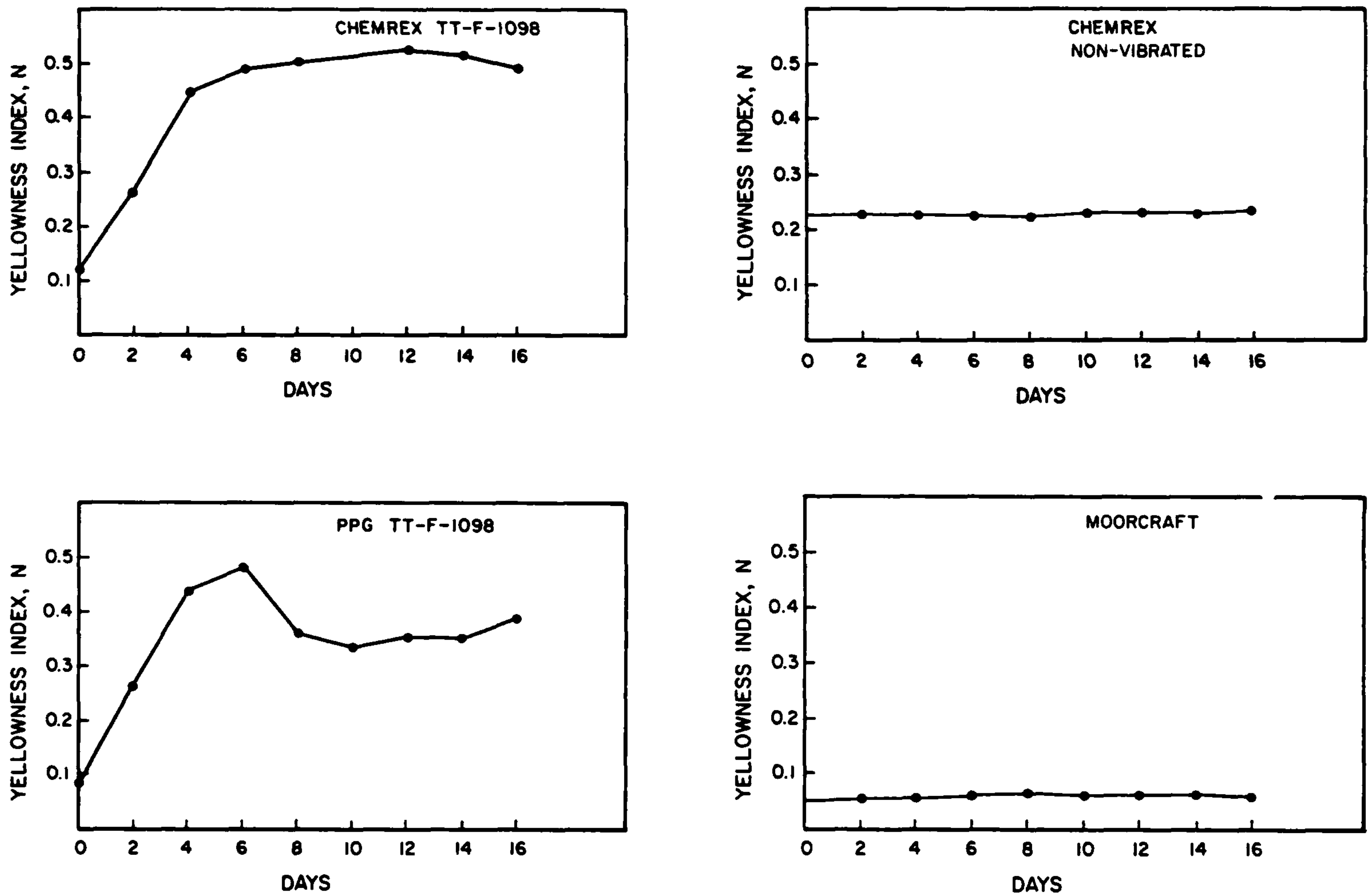
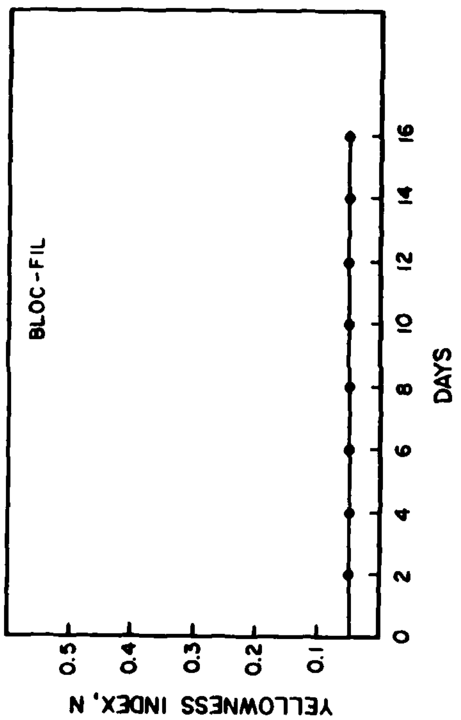


Figure 2. Yellowing vs. time for block fillers.


BLOC-FIL
YELLOWNESS INDEX, N
0.5
0.4
0.3
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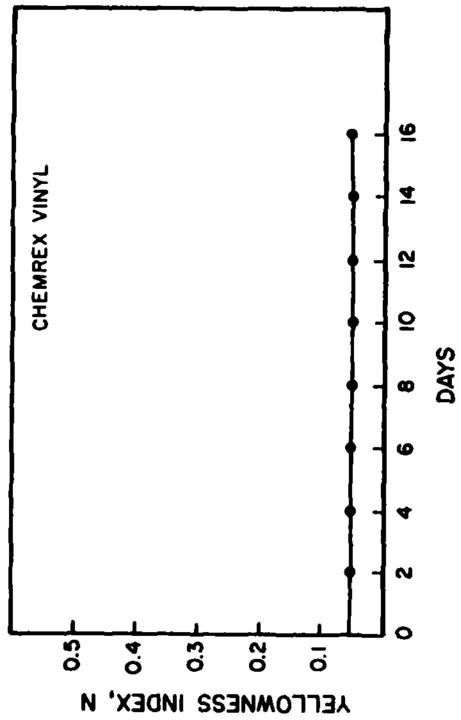
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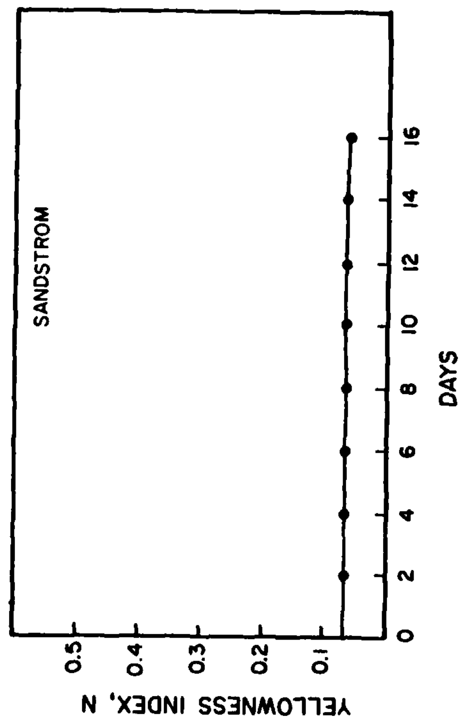
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