Portland Cement Concrete Curing Compound Performance Phase I and Phase II

Final Report
for
MLR-02-03

April 2003

Highway Division

Iowa Department
Of Transportation

Portland Cement Concrete
Curing Compound Performance
Phase I and Phase II

Final Report
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8. ABSTRACT

Testing the efficiency of PCC curing compounds is currently done following Test Method Iowa 901-D, May 2002. Concrete test specimens are prepared from mortar materials and are wet cured 5 hours before the curing compound is applied. All brands of curing compound submitted to the Iowa Department of Transportation, are laboratory tested for comparative performance under the same test conditions. These conditions are different than field Portland Cement Concrete (PCC) paving conditions. Phase I tests followed Test Method Iowa 901-D, but modified the application amounts of the curing compound. Test results showed that the application of two coats of one-half thickness each increased efficiency compared to one full thickness coat. Phase II tests also used the modified application amounts, used a concrete mix (instead of a mortar mix) and applied curing compound a few minutes after molding. Measurements of losses, during spraying of the curing compound, were noted and were found to be significant. Test results showed that application amounts, testing techniques, concrete specimen mix design and spray losses do influence the curing compound efficiency. The significance of the spray losses indicates that the conventional test method being used (Iowa 901 D) should be revised.

9. KEY WORDS	10. NO. OF PAGES
Portland Cement Concrete Curing Compound Test Method	37

TABLE OF CONTENTS

DISCLAIMER

INTRODUCTION

Curing compounds are used to prevent moisture loss from a Portland Cement Concrete (PCC) surface during the early concrete curing stage. The performance of a curing compound is stated in terms of efficiency. The efficiency rating indicates what percent, by weight, of the original moisture the curing compound is capable of containing within the test specimen over the test period.

Curing compounds are tested for efficiency in the Iowa DOT laboratory, following Test Method Iowa 901-D (see Appendix B). This method uses a concrete mortar specimen. The curing compound is applied to the specimen five hours after molding. When various curing compounds are tested, each under the same conditions, the comparison of their performance indicates which product offers the highest efficiency. However, in field PCC paving operations the curing compound is applied to a PCC mix, not a mortar, and it is applied at about 15 minutes after (molding) paving, not five hours. Since the laboratory test does not simulate actual field conditions, a modified test should be used that does.

PROBLEM STATEMENT

Variations between curing compound brands, coating thickness, application methods, number of coats and concrete mix design will have an impact on curing efficiency. The significance of some of these variations or combinations of them is not fully known.

Current laboratory methods use a mortar mix design and five hours of moist curing time before a curing compound is applied to the specimen. A laboratory test should be done, simulating field conditions to determine more accurately the curing compound performance. A (PCC) field mix design should be used and the curing compound should be applied about 15 minutes after molding time to best simulate actual field conditions.

In addition, no account for curing compound spray loss is currently considered in calculating the efficiency of the curing compound product. Observations should be made to determine the portion of the curing compound which is lost while being sprayed to the concrete surface.

Recent laboratory research (TR-451) done in Iowa on pavement curing materials did tests on pastes and mortars but did not test performance using a field concrete mix design or consider spraying losses, as proposed in this research.

OBJECTIVE

- A comparison of curing compound performance will be made from the test results following the standard laboratory test method Iowa 901-D, called Phase I, and a modified test procedure simulating field conditions (15 minute time after molding to curing, calculating losses of curing compound to the environment during spraying and using a field concrete mix), called phase II (see Proposals in Appendix A). A new efficiency standard could be set based on this data.

- Determine the best rates and methods to apply a curing compound to concrete for both, Phase I and Phase II of the project.

TESTING PROCEDURE

Phase 1

Phase 1 tests were conducted using Test Method Iowa 901-D (see Appendix B). The spraying equipment is shown in Figure 1. Curing compound was applied at a rate of one gallon per 15 square yards. This amount is considered to be 100% when comparing with other rates. The curing compound used in phases 1 and 2 was a product commonly used in Iowa. It was W. R. Meadows, Inc. Sealtight 1645-White (see Curing Compound Data in Appendix F).

Phase 2

Phase 2 tests were conducted simulating more field conditions. The concrete was a standard field mix (C-3WR-C15) (see Mix Design in Appendix C). Curing compound was applied approximately 15 minutes after the concrete was molded. The 24 hour drying time began immediately after the curing compound was applied. Temperature and humidity were controlled during the test, the same as in phase I.

The test specimens were identified as No.s 1 thru 6 and Foil. No.1, was the control which had no curing compound. Foil was a flat sheet of aluminum foil representing the top surface area of a concrete specimen. The foil test was to determine the weight loss attributed to volatiles within the liquid curing compound. Curing compound amounts sprayed on the test specimens were as follows:

No. 1,	0.0%
No. 2,	100%
No. 3,	75%
No. 4,	150%
No. 5,	2 X 50%
No. 6,	2 X 75%
Foil,	100%

In both phases, two efficiency indexes were calculated; one in which the amount of curing compound lost in the spraying process was <u>not</u> taken into account (theoretical), and one in which the amount of curing compound lost in spraying <u>was</u> taken into account (applied). Calculations in both phases made use of a control test conducted using an aluminum foil (see Figure 3) cover over the concrete top surface and a rim cover for over the exposed wall of the specimen pan.

The theoretical amount (weight) of the curing compound was sprayed onto the concrete surface. Immediately after spraying, weights were taken to determine the weight gain on the surface. The weight measurements showed that two significant losses occurred. One was to the rim and exposed wall of the sample pan and the other was spray vapor lost to the atmosphere or ventilation system as spraying is done under a ventilation hood (see Figure 2). This loss is important because in the conventional test method, the amount of curing compound is measured from the change in weight of the spray bottle. Losses on the sample or to the air will distort the measure of compound used.

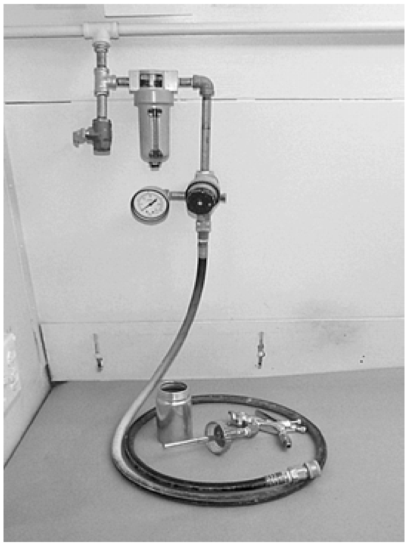


Figure 1
Curing Spray Apparatus

RESULTS

A significant difference was seen in the amount of curing compound that left the sprayer and the amount that actually made it to the surface of the concrete. Weights were taken immediately at the completion of spraying. In addition, a lower efficiency was seen in the phase II curing compound test that used a concrete mix and eliminated the five hour wet cure period.

A "tack-test" was done on the curing compound surface several times during the 24-hour test period to determine dryness. For test specimens having more than 100% of cure applied there was concern that the thicker amount of cure may remain wet or tacky (see Appendix D). In actual field operations a wet or tacky surface may cause a problem with the early entry sawing equipment wheels and their traction.

Figure 2
Rim, Foil, and Concrete in Mold

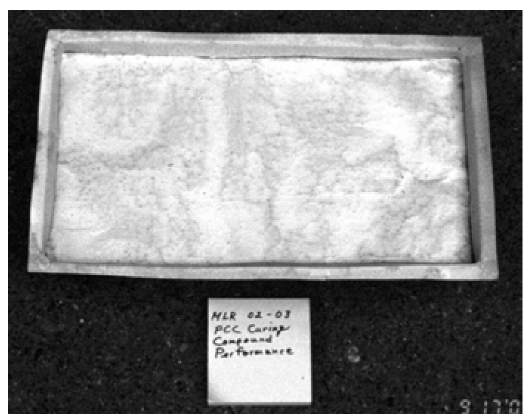


Figure 3
Rim, Foil, and Concrete in Mold
Assembled for Testing

Curing Compound Losses

When normal curing compound tests are conducted, calculations are made assuming all curing compound that leaves the sprayer will be applied to the concrete surface. In reality, this is not the case. When using test method Iowa 901-D, through weight measurements, it was determined that an average of approximately 12.1% of the curing compound sprayed out of the sprayer was not applied to the test surface of the concrete specimens in Phases I and II. This loss went to several places. First, some curing compound attaches itself to the exposed rim and wall of the pan and a very small amount of it goes outside the pan. Second, some of the curing compound is lost to the laboratory ventilation system or the atmosphere, as the spraying is done under a ventilation hood. From test results, it was determined that the amount of curing compound actually applied to the concrete surface was, on average, 12.7% less than the weight that was sprayed out of the sprayer in phase I, and an average of 10.5% less in phase II (see Chart 1).

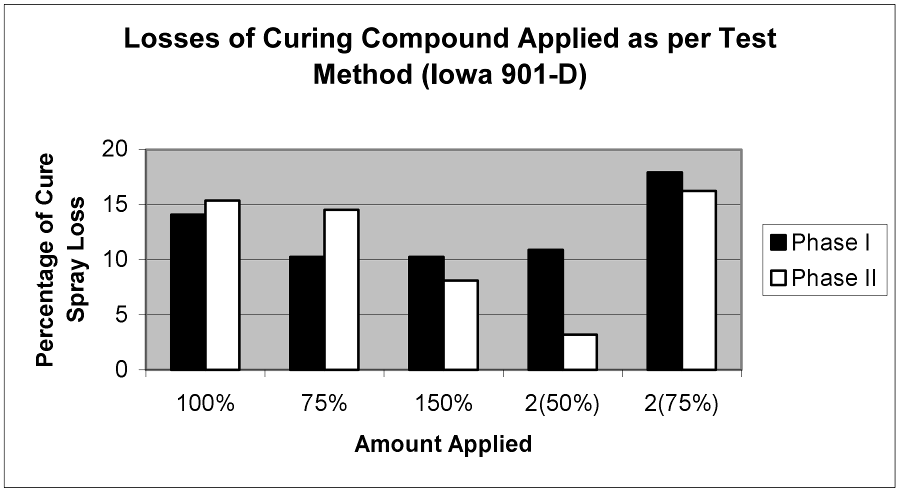


Chart 1
Percentage Losses of Curing Compound

Because of this difference, two separate efficiency indexes were found; the theoretical calculation using the curing material weight that left the sprayer, and the applied calculation using the weight actually measured on the concrete specimen surface. While the two values for efficiency indexes were different, they did coincide in a uniform pattern, as seen in Charts 2 and 3.

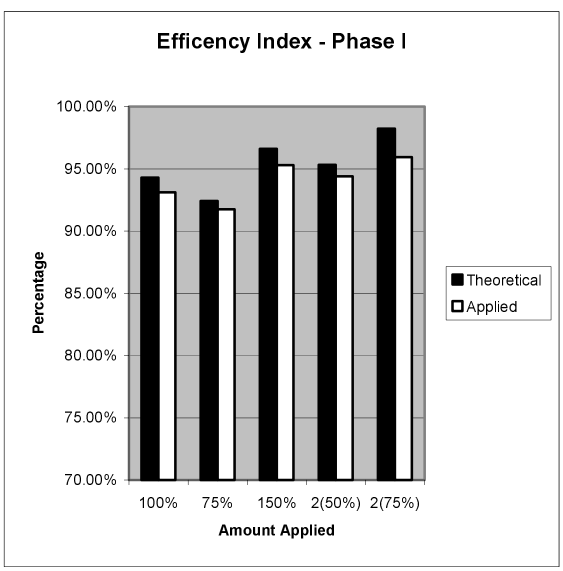


Chart 2
Phase I

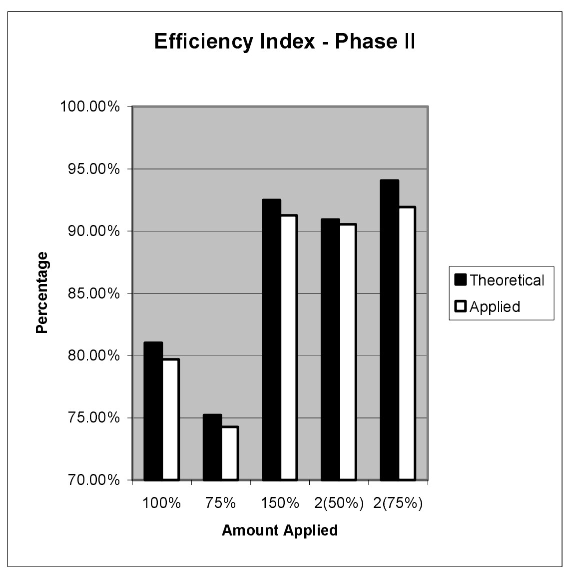


Chart 3
Phase II

Phase I

The results from Phase I, using a "theoretical" curing weight value, show that the curing compound used, met or exceeded the minimum efficiency value of 95% in three cases. However, looking at the efficiency indexes for the "applied" values, only two specimens passed, both having 150% spray coverage (see Chart 2).

Phase II

The results from Phase II show that the curing compound (the same brand and amount as in Phase I) failed to meet the minimum efficiency value of 95% in all cases when using Test Method Iowa 901-D modified with a concrete mix and curing times simulating those used in the field.

CONCLUSION

Concrete curing compound efficiency tests done in the laboratory should take into account material spraying losses, which occur when using the current laboratory procedure (Iowa 901-D). Results should be based on the weight of curing compound actually applied to the surface of the test specimen after losses are deducted to gain a more representative value for the efficiency index. In Phase II test results, simulating more field conditions and spray losses (applied data) compared to the spray losses (theoretical data) of phase I, an approximate average drop of 9.9% was observed in the efficiency index.

Any use of curing compound efficiencies determined by Test Method Iowa 901-D in relationship to other research, such as concrete curing or strength developments, needs to take into account whether the curing compound amount applied to the test specimen was theoretical or the actual. This research showed that the weight of the curing compound applied to the specimen surface was significantly less than the weight sprayed out of the sprayer. The difference, as found from all specimens in this research, averaged 11.6% less than anticipated (see Chart 3).

When specifically comparing the competitive performance of various brands of curing compounds, test method Iowa 901 D should be modified to try to make spraying losses equal for each specimen. However, this will not guarantee adequate performance in the field.

It was seen that applying two coats of $^1/_2$ thickness of curing compound with an eight-minute time gap yielded a higher efficiency than applying one full thickness coat of curing compound. Two applications of the curing compound on a concrete surface would be preferable to obtain optimum efficiency. However, the double spraying operations and costs must also be considered.

IMPLEMENTATION

This research will point out the difference in results from curing compound efficiency tests when more actual field conditions are applied in comparison to laboratory conditions. The research will also point out the differences between theoretical application rates and actual rates, which take into account losses of curing material during the spraying process. The results of this research can provide additional information to be considered when reviewing research done in project TR-451, or TR-479. These results should lead to a review and modification of Iowa Test Method 901-D and the associated specifications.

REFERENCES

TR-451 "Investigations into Improved Pavement Curing Materials and Techniques: Part I, Phases I and II" Wang, K., J.K. Cable, G. Zhi

TR-479 "Investigations into Improved Pavement Curing Materials and Techniques: Part II, Phase III" Cable, J. K., K. Wang, G. Zhi

APPENDIX A

RESEARCH PROPOSALS - PHASES I AND II

DATE: May 2002

PROJECT: MLR-02-03

PROJECT TITLE: PCC Curing Compound Performance - Phase I

PRINCIPAL INVESTIGATOR: Bob Steffes

INTRODUCTION: Curing compounds are used to prevent moisture loss from a PCC surface during the concrete curing stage. The performance of a curing compound is given in terms of efficiency. The efficiency rating (percent) indicates what percent (by weight) of the original moisture, the curing compound is capable of containing within the test specimen over the test period.

PROBLEM STATEMENT: Variations in curing compound brands, coating thickness, application methods and number of coats will have an impact on efficiency. The significance of those variations is not fully known.

OBJECTIVES: The objective of this research is to determine the efficiencies of one brand of curing compound for various rates and methods of coating application.

PROPOSED RESEARCH: The proposed research will consist of using one brand of curing compound, the brand most commonly used in the Iowa DOT, and apply it to 6 slabs of concrete prepared and cured as per Test Method number Iowa 901-D.

Slabs will be identified as numbers 1 through 6. Each slab will be cured as follows:

1 - Control (ie, no curing compound)

2 - Iowa standard

3 - 75% of Iowa standard (one coat)

4 - 150% of Iowa standard (one coat)

5 - 50% of Iowa standard
wait 8 minutes
50% of Iowa standard

6 - 75%of Iowa standard
wait 8 minutes
75% of Iowa standard

EVALUATION: Efficiency ratings will be obtained as per testing procedures from Iowa 901-D.

Two times during the test period plus at the end of the test, the coatings will be checked to determine a degree of tackiness or dryness.

IMPLEMENTATION: The results of this study will be compared with the results from the research project TR-451, Part I and II.

RESPONSIBILITIES: The General Test laboratory will perform the test.

REPORTING: The Principal Investigator from the Materials Research Office will write a final report.

DATE: May 2002

PROJECT: MLR-02-03

PROJECT TITLE: PCC Curing Compound Performance, Phase II

PRINCIPAL INVESTIGATOR: Bob Steffes

INTRODUCTION: Curing compounds are used to prevent moisture loss from a PCC surface during the concrete curing stage. The performance of a curing compound is given in terms of efficiency. The efficiency rating (percent) indicates what percent (by weight) of the original moisture, the curing compound is capable of containing within the test specimen over the test period.

PROBLEM STATEMENT: Variations in curing compound brands, coating thickness, application methods and number of coats will have an impact on efficiency. The significance of those variations is not fully known.

OBJECTIVES: The objective of this research is to determine the efficiencies of one brand of curing compound for various rates and methods of coating application, while simulating actual field conditions for materials and timing of construction operations.

PROPOSED RESEARCH: The proposed research will consist of using one brand of curing compound, the brand most commonly used in the Iowa DOT, and the same brand as used in Phase I. It will be applied to 6 slabs of concrete, the size of those used in Test Method number Iowa 901-D but prepared and cured to simulate actual field conditions.

The concrete mix will be a C mix with top size aggregate of ½".

After the slabs have been prepared, they will be left to air dry in the laboratory 15 minutes. <u>NOTE: throughout this research, the slabs of plastic concrete must be kept level and handled such that the concrete does not shift.</u> After the 15 minute period, the slabs will each be tined then caulk sealed and cured in the same manner as done in Phase I.

Slabs will be identified as numbers 1A through 6A.

Each slab will be cured as follows:

1 - Control (ie, no curing compound)

2 - Iowa standard (ie, 100%)

3 - 75% of Iowa standard (one coat)

4 - 150% of Iowa standard (one coat)

5 - 50% of Iowa standard
wait 8 minutes
50% of Iowa standard

6 - 75%of Iowa standard
wait 8 minutes
75% of Iowa standard

EVALUATION: Efficiency ratings will be obtained as per testing procedures from Iowa 901-D.

Two times during the test period plus at the end of the test, the coatings will be checked to determine a degree of tackiness or dryness.

IMPLEMENTATION: The results of this study will be compared with the results from the research project TR-451, Part I and II.

RESPONSIBILITIES: The General Test laboratory will perform the test.

REPORTING: The Principal Investigator from the Materials Research Office will write a final report.

APPENDIX B

LABORATORY TEST METHOD IOWA 901-D

METHOD OF DETERMINING THE EFFICIENCY INDEX OF LIQUID MEMBRANE CURING COMPOUNDS

SCOPE

This method of test covers the procedure for determining the moisture retaining efficiency of liquid membrane forming curing compounds when applied to concrete mortar specimens.

PROCEDURE

A. Apparatus

1. Mortar molds. Molds that are made of metal, are watertight, and have approximately 6-3/8 inches by 12-1/4 inches inside dimensions at the top; 6 by 12 inches at the bottom and are 2-1/2 inches in depth.

2. Curing Cabinet. A closed cabinet for curing specimens at a temperature of 100 ± 3° F. and at a relative humidity of 35 to 50 percent. Means are provided to circulate the air inside the cabinet, and vent holes are provided to permit the volatile material to escape.

3. Balances

   a. A balance having a capacity of at least 7000 grams and accurate to 0.1 gram.

   b. A balance having a capacity of at least 1000 grams and accurate to 0.1 gram.

   c. A balance having a capacity of at least 100 pounds and accurate to 0.1 pound.

4. Compressed air supply with regulator to control pressure.

5. Paint sprayer.

6. Wood float.

7. Moist closet at 73.4° ± 3° F. with a relative humidity of not less than 98 percent.

8. Moisture proof covers.

9. Large mixing spoons.

10. Three 12-quart pails.

11. One 1-gallon pail.

12. A 3 x 4 foot sheet of plastic film.

13. Mechanical mixer.

14. Flow table.

15. Electric hot plate.

16. Fiber brush.

17. Sealing wax.

B. Specimens

1. All test and control specimens are approximately 12-1/4 x 6-3/8 x 2 inches in size.

2. Proportioning

   a. Mortar for the specimens shall be of plastic consistency. Combine cement and water to produce a cement paste having a water-cement ratio of 0.40 by weight. Add dry sand complying with Iowa DOT Standard Specifications, Section 4110, to produce a mortar flow of 60 $\pm$ 5 percent.

   b. Perform the flow test on a 10-inch flow table using ten 1/2 inch drops in six seconds. By using sand from one source, only occasional checking of the flow is required.

C. Mixing

1. Mix the mortar by mechanical means.

2. Wash the mixer bowl and paddle with clean water.

3. Pour a predetermined amount of water and cement into the mixing bowl to produce the number of specimens needed, plus one or more control specimens. (Each specimen will weigh approximately 12 pounds.) Mix the cement paste to a uniform consistency, making sure that none is sticking unmixed to the bowl. Placing a small amount of sand in the bottom of the bowl before mixing the cement paste helps to keep it from sticking to the bowl.

4. Add the required amount of dry sand, and mix for 2 minutes.

D. Molding

1. Mold the specimens in previously oiled and weighed pans. Wipe all oil from the top 1/2 inch of the pan. Weigh to the nearest tenth of a gram. Record weight as N.

2. Immediately after mixing, spoon the mortar into the molds. Press it down firmly with the spoon until it is within ½ inch of the top of the mold. Weigh the mold with the mortar and adjust the amount if necessary so that the net weight of the mortar is a little over 12 pounds.

3. Smooth the surface with a wooden float. Bump the mold firmly on a solid surface to help consolidate the mortar, being careful not to over vibrate it. Wipe the top 1/2 inch of the mold free of any mortar.

4. Determine and record the weights of the specimens to the nearest gram. Record as J.

E. Storage of Specimens

1. Immediately after molding, cover the molds with a moisture proof cover.

2. Place specimens in the moist closet making sure they are level. Remove all surface air bubbles.

3. Replace moisture proof covers, cover with a sheet of plastic film and cure for 5 hours.

F. Treatment of Specimens

1. After the initial cure, remove plastic film, remove moisture beads from under the moisture proof covers, replace covers and remove specimens from the moist closet.

2. Remove any surface water by placing specimens in front of a fan. Weigh to the nearest gram and record as K.

3. Brush the surface of the specimen lightly with a fiber brush to remove the surface laitance. Use an air hose to remove all loosened material.

4. Remove any material on the upper inside edge of the pan, but do not break the seal between the pan and the mortar.

5. Weigh to the nearest gram. Record as L.

6. Seal the edges of mortar and mold with (Paraseal) wax.

7. Weigh to the nearest tenth of gram. Record as P.

8. Replace the moisture proof cover on the specimen and make application of the curing compound within several minutes.

G. Application of Curing Compound

1. Mix the curing material by shaking and check for thorough mixing with a spatula.
2. Fill the sprayer with curing compound. Attach spraying head, and record the weight to the nearest 0.1 gram. Record as A.
3. Attach the sprayer to the compressed air. Adjust pressure as necessary to get a uniform spray. Spray curing material uniformly on the surface of the specimen until the prescribed rate has been applied. Record as B the calculated weight (to the nearest 0.1 gram) the amount of curing material to be applied.
4. Spray curing from sprayer until the remaining curing and sprayer weigh the same as the calculated weight (C).
5. Weigh the specimen to the nearest 0.1 gram and record as R.

H. Control Specimens

1. For each series of test runs, a control specimen or specimens, made and tested in accordance with this method, shall be run concurrently with the regular test specimens except that no curing agent shall be applied to the exposed surface.

I. Final Curing

1. Place specimens in the curing cabinet.
2. Arrange the spacing of the individual specimens so as to provide a clear space on all sides.
3. Use dummy specimens to fill the shelf of the cabinet when it is not filled with test specimens.
4. Cure the specimens in the cabinet for 24 hours.
5. Remove the specimens, weigh to the nearest 0.1 gram and record as S.

J. Correction for Loss in Weight Due to Volatile Materials

1. Determine the loss in weight of volatile material from the liquid curing compound by coating the bottom of a clean, previously weighed, empty, foil lined mold at the prescribed rate of application. (See Section G.)

2. Weigh and record weight of sprayed mold (to the nearest 0.1 gram). Record as D.

3. Place the coated pan in the curing cabinet and subject to the same treatment as the coated specimen.

4. Remove volatile loss specimen and weigh (to the nearest 0.1 gram) of the curing material before calculating the moisture loss. Record as E.

5. Apply as a correction the loss in weight (to the nearest 0.1 gram) of the curing material before calculating the moisture loss. Record as F.

K. Definition of Terms

A = Weight (to the nearest 0.1 gram) of sprayer full of curing compound.

B = Calculated weight (to the nearest 0.1 gram) of curing material to be applied at the prescribed rate.

C = Weight (to the nearest 0.1 gram) of sprayer with remaining curing material after spraying.

D = Weight (to the nearest 0.1 gram) of a mold plus weight of curing material applied.

E = Weight (to the nearest 0.1 gram) of mold plus weight of curing material applied after 24 hours in curing cabinet.

F = Weight (to the nearest 0.1 gram) of volatile material lost.

G = Weight of mixing water per batch of mortar.

H = Total weight of mixing water, sand and cement per batch.

I = Percent of mixing water in batch of mortar.

J = Weight (to the nearest 0.1 gram) of mold plus weight of mortar after molding.

K = Weight (to the nearest 0.1 gram) of mold plus weight of mortar after initial moist closet curing and surface water blotted.

L = Weight (to the nearest 0.1 gram) of mold plus weight of mortar after brushing surface.

M = Original weight of mold and mortar minus the weight of the loss from brushing the surface.

N = Weight of empty mold (to the nearest 0.1 gram).

O = Weight of water in mortar specimen slab (to the nearest 0.1 gram).

P = Weight of blotted, brushed and sealed slab.

Q = Corrected weight of water in the slab immediately prior to application of curing material (to the nearest 0.1 gram).

R = Weight (to the nearest 0.1 gram) of slab coated with curing material.

S = Weight (to the nearest 0.1 gram) of slab coated with curing material after 24 hours in curing cabinet (S_1 is without curing material).

T= Total loss of weight (to the nearest 0.1 gram) in coated slab after 24 hours in curing cabinet.

T_1= Total loss of weight (to the nearest 0.1 gram) in control slab after 24 hours in curing cabinet.

U = Corrected loss of water from the coated slab after final cure (to the nearest 0.1 gram).

V = Percent of water loss in test specimen after final cure.

W = Percent of water loss in control specimen after final cure.

X = Efficiency Index.

L. Calculations

1. Calculations of weight of curing material to be applied at the prescribed rate.

$$B = \frac{(\text{Density of curing compound in lbs/gal})(453.6\ \text{g/lb})}{(1296\ \text{in}^2/\text{yd}^2)\ (15\ \text{yd}^2/\text{gal})}$$

2. Final weight of sprayer and remaining contents.

C = A - B

3. Calculation of volatile loss.

F = D – E

4. Percentage of mixing water.

$$I = \frac{G}{H} \times 100$$

5. Correction for brushed loss.

$$M = J - (K - L)$$

6. Determination of water content in slabs after molding.

$$O = (M - N) \frac{I}{100}$$

7. Correction for moisture loss.

$$Q = O - (J - K)$$

8. Determination of total weight loss after final cure

$$T = R - S \qquad T_1 = P - S_1$$

9. Correction for volatile loss.

$$U = T - F$$

10. Percent of water loss in coated slab after final cure.

$$V = \frac{U}{Q} \times 100$$

11. Percent of water loss in control specimen after final cure.

$$W = \frac{T_1}{Q} \times 100$$

12. Efficiency Index

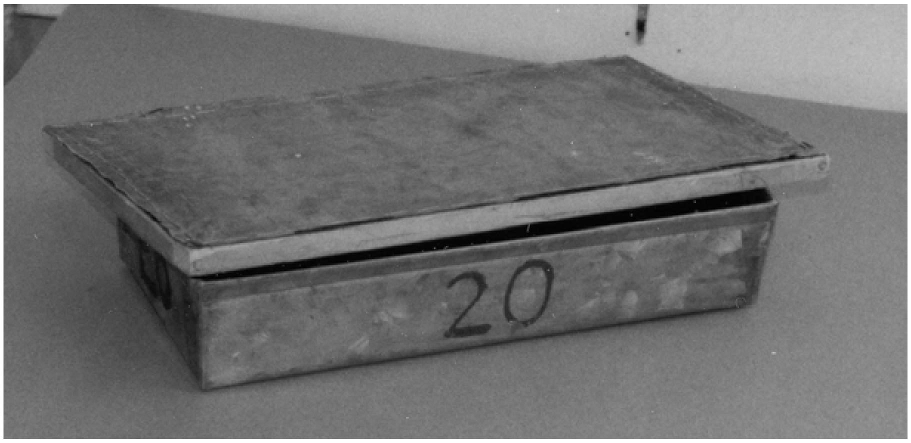
$$X = \frac{W - V}{W} \times 100$$

IOWA DEPARTMENT OF TRANSPORTATION
Materials Laboratory

Efficiency Index of Liquid Membrane Curing Compounds

Description	Sprayed Specimen	Control Specimen
Ames Laboratory Number	ADE0-000	
Pan Number	1	2
Method of Application	Spray	-
Rate, Sq. Yd./Gallon	15	None
Number of Applications	1	-
Weight Cement, Lbs.	14.0	14.0
Weight Sand, Lbs.	36.0	36.0
(G) Wt. Water, Lbs.	5.6	5.6
(H) Total Wt. Materials, Lbs.	55.6	55.6
(N) Weight Pan Empty, g	790.0	837.0
(J) Wt. Pan Plus Mortar, g	6246.0	6291.0
(K) Wt. Slab After Moist Curing, g	6242.0	6287.0
(L) Wt. Surface Brushed, g	6233.0	6277.0
(M) Original Wt. minus Brushed Loss, g	6237.0	6281.0
(0) Water in Brushed Slab, g	549.0	548.0
(P) Wt. Slab Blotted, Brushed & Sealed, g	6236.0	6280.0
(Q) Corrected Water, g	545.0	544.0
(B) Wt. Curing Compound Applied, g	15.8	-
(R) Weight Coated Slab, g	6247.2	-
(S) Weight after 24 hours Curing, g	6239.7	6150.0(S_1)
	R-S	P-S_1
(T) Total Loss after 24 hours, g	7.5(T)	130.0(T_1)
(F) Volatile Loss after 24 hours, g	5.5	-
(U) Corrected Loss after 24 hours, g	2.0	-
(V) Percent Loss after 24 hours	0.37 (V)	23.90 (W)
(X) Efficiency Index	98.45	

Volatile Loss Determination		
(D) Weight Pan plus Curing, g	795.9	-
(E) Weight After 24 hours, g	790.4	-
(F) Weight Loss 24 hours, g	5.5	-



Mortar Mold with Cover

Paint Sprayer with Compressed Air Supply

APPENDIX C

PHASE I MORTAR AND PHASE II FIELD CONCRETE MIX DESIGN

Mortar Mix Proportion: Phase I

MATERIALS	Source	Type/Class	SPG	Percent
CEMENT:	HOLNAM	I/II	3.14	26
SAND:	CORDOVA		2.67	63
WATER:	AIL520			11

Concrete Mix Proportion: Phase II (C-3WR-C15)

MATERIALS	Source	Type/Class	SPG	Percent
CEMENT:	HOLNAM	I/II	3.14	
FLY ASH:	OTTUMWA	C	2.61	15
FINE AGGREGATE:	AIL520		2.65	45
COARSE AGGREGATE:	A94002		2.66	55
AIR ENTRAINING AGENT:	DARAVAIR 1400			
WATER REDUCER:	WRDA-82			
DESIGN W/C(+FLY ASH):	0.4			
DESIGN SLUMP:	1			
DESIGN AIR CONTENT:	6			

APPENDIX D

DATA / EFFICIENCIES

PCC Curing Coumpound Performance - Phase I (Theoretical)
MLR-02-03
Date: 5/20/01

		1 Control	2 100%	3 75%	4 150%	5 2(50%)	6 2(75%)	Foil
N	Weight Empty Pan	824	824	755	822	822	822	822.2
G	Weight of Mixing Water	3810.24						
	Weight of Mixing Sand	3855.6	3855.6	3855.6	3855.6	3855.6	3855.6	
	Weight of Mixing Cement	1587.6	1587.6	1587.6	1587.6	1587.6	1587.6	
H	Total weight of Sand Mixing per Batch	36469.44						
B	Weight of Curing Theoretically		15.6	11.7	23.4	15.6	23.4	15.6
D	Mold+Foil+Curing Comp							837.2
E	Mold+Foil+Curing Comp after Oven							826.6
F	Calculation of Volatile Loss							10.6
I	% of Mixing Water in Batch of Concrete (by weight)	10.45%						
M	Weight of Mortar+Mold	6273.5	6263	6212.5	6272.5	6265.5	6272	
O	Determintaion of Water Content in each slab after Molding	635.40	635.40	635.40	635.40	635.40	635.40	
Q	Correction of Loss Moisture	565.50	566.00	565.50	563.50	563.50	566.00	
	Weight of Concrete + Mold + Wax	6259.90	6253.10	6200.00	6258.00	6252.50	6263.00	
R	Weight of Concrete + Mold + Wax + Curing Mat'l		6266.50	6210.50	6279.00	6266.40	6282.20	
S	Weight after 24 hrs	6135.30	6248.80	6193.10	6258.90	6250.00	6264.10	
T	Total Loss after Final Cure (24 hours), in **Coated** Slab		17.70	17.40	20.10	16.40	18.10	
T1	Total Loss after Final Cure (24 hours), in **Control** Slab	124.60						
U	Correction for Volatile Loss		7.10	9.45	4.20	5.80	2.20	
V	% Water Loss in Coated Slab after Final Cure		1.25%	1.67%	0.75%	1.03%	0.39%	
W	% H_2O Loss in Control Speciment after Final Cure	22.03%						
X	Efficiency Index		94.31%	92.41%	96.62%	95.33%	98.24%	

PCC Curing Coumpound Performance - Phase I (Applied)

MLR-02-03

Date: 5/20/02

		1 Control	2 100%	3 75%	4 150%	5 2(50%)	6 2(75%)	Foil
N	Weight Empty Pan	824	824	755	822	822	822	822.2
G	Weight of Mixing Water	3810.24						
	Weight of Mixing Sand	3855.6	3855.6	3855.6	3855.6	3855.6	3855.6	
	Weight of Mixing Cement	1587.6	1587.6	1587.6	1587.6	1587.6	1587.6	
H	Total weight of Sand Mixing per Batch	36469.44						
B	Weight of Curing Applied		13.4	10.5	21	13.9	19.2	15
D	Mold+Foil+Curing Comp							837.2
E	Mold+Foil+Curing Comp after Oven							826.6
F	Calculation of Volatile Loss							10.6
I	% of Mixing Water in Batch of Concrete (by weight)	10.45%						
M	Weight of Mortar+Mold	6273.5	6263	6212.5	6272.5	6265.5	6272	
O	Determintaion of Water Content in each slab after Molding	635.40	635.40	635.40	635.40	635.40	635.40	
Q	Correction of Loss Moisture	565.50	566.00	565.50	563.50	563.50	566.00	
	Weight of Concrete + Mold + Wax	6259.90	6253.10	6200.00	6258.00	6252.50	6263.00	
R	Weight of Concrete + Mold + Wax + Curing Mat'l		6266.50	6210.50	6279.00	6266.40	6282.20	
S	Weight after 24 hrs	6135.30	6248.80	6193.10	6258.90	6250.00	6264.10	
T	Total Loss after Final Cure (24 hours), in **Coated** Slab		17.70	17.40	20.10	16.40	18.10	
T1	Total Loss after Final Cure (24 hours), in **Control** Slab	124.60						
U	Correction for Volatile Loss		8.59	10.27	5.83	6.96	5.05	
V	% Water Loss in Coated Slab after Final Cure		1.52%	1.82%	1.03%	1.23%	0.89%	
W	% H_2O Loss in Control Speciment after Final Cure	22.03%						
X	Efficiency Index		93.11%	91.76%	95.30%	94.40%	95.95%	

PCC Curing Coumpound Performance - Phase II (Theoretical)
MLR-02-03
Date: 8/21/02

		1	2	3	4	5	6	Foil
		Control	100%	75%	150%	2(50%)	2(75%)	
N	Weight Empty Pan	824	824	755	811	822	822	825.1
G	Weight of Mixing Water per Batch of Mortar.	4626.64						
H	Total weight; Mixing Water+Aggregate+Cement+ etc	78652.92						
B	Weight of Curing at Prescribe Rate		15.6	11.7	23.4	15.6	23.4	15.6
D	Mold+Foil+Curing Comp							841
E	Mold+Foil+Curing Comp after Curing							829.8
F	Calculation of Volatile Loss							11.2
I	% of Mixing Water in Batch of Concrete (by weight)	5.882%						
M	Weight of Concrete + Mold	6443	6612.3	6377.2	6218.2	6631.5	6506.6	
O	Determintaion of Water Content in each slab after Molding	330.53	340.49	330.72	318.07	341.74	334.39	
Q=O	Correction of Loss Moisture	330.53	340.49	330.72	318.07	341.74	334.39	
	Weight of Concrete + Mold + Wax	6447.80	6615.80	6380.20	6221.10	6634.10	6510.30	
R	Weight of Concrete + Mold + Wax + Curing Mat'l		6629.00	6390.20	6242.60	6649.20	6529.90	
S	Weight after 24 hrs	6308.20	6590.50	6347.20	6215.70	6624.90	6504.70	
T	Total Loss after Final Cure (24 hours), in **Coated** Slab		38.50	43.00	26.90	24.30	25.20	
T1	Total Loss after Final Cure (24 hours), in **Control** Slab	139.60						
U	Correction for Volatile Loss		27.30	34.6	10.1	13.1	8.4	
V	% Water Loss in Coated Slab after Final Cure		8.02%	10.46%	3.18%	3.83%	2.51%	
W	% H_2O Loss in Control Speciment after Final Cure	42.24%						
X	Efficiency Index		81.02%	75.23%	92.48%	90.92%	94.05%	

PCC Curing Coumpound Performance-Phase II (Applied)
MLR-02-03
Date: 8/21/02

		1 Control	2 100%	3 75%	4 150%	5 2(50%)	6 2(75%)	Foil
N	Weight Empty Pan	824	824	755	811	822	822	825.1
G	Weight of Mixing Water per Batch of Mortar.	4626.64						
H	Total weight; Mixing Water+Aggregate+Cement+ etc	78652.92						
B	Weight of Curing Applied		13.20	10.00	21.50	15.10	19.60	15.9
D	Mold+Foil+Curing Comp							841
E	Mold+Foil+Curing Comp after Curing							829.8
F	Calculation of Volatile Loss							11.2
I	% of Mixing Water in Batch of Concrete (by weight)	5.882%						
M	Weight of Concrete + Mold	6443	6612.3	6377.2	6218.2	6631.5	6506.6	
O	Determintaion of Water Content in each slab after Molding	330.53	340.49	330.72	318.07	341.74	334.39	
Q=O	Correction of Loss Moisture	330.53	340.49	330.72	318.07	341.74	334.39	
	Weight of Concrete + Mold + Wax	6447.80	6615.80	6380.20	6221.10	6634.10	6510.30	
R	Weight of Concrete + Mold + Wax + Curing Mat'l		6629.00	6390.20	6242.60	6649.20	6529.90	
S	Weight after 24 hrs	6308.20	6590.50	6347.20	6215.70	6624.90	6504.70	
T	Total Loss after Final Cure (24 hours), in **Coated** Slab		38.50	43.00	26.90	24.30	25.20	
T1	Total Loss after Final Cure (24 hours), in **Control** Slab	139.60						
U	Correction for Volatile Loss		29.20	35.96	11.76	13.66	11.39	
V	% Water Loss in Coated Slab after Final Cure		8.58%	10.87%	3.70%	4.00%	3.41%	
W	% H_2O Loss in Control Speciment after Final Cure	42.24%						
X	Efficiency Index		79.69%	74.26%	91.25%	90.53%	91.93%	

Tack Test

	5/20/2002, 4:00pm	5/21/2002, 7:30am	5/21/2002, 2:30pm
Temp (^{0}F)	100.0	100.0	100.0
Humidity (%)	45.0	45.0	45.0
1	C o n t r o l		
2	tender/firm/soft	Dry, minor rub off	Dry
3	tender/firm	Dry, no rub off	Dry
4	tender/puddle	Dry, minor rub off	Dry
5	tender/firm/soft	Dry, minor rub off	Dry
6	tender/firm/puddle	Dry, minor rub off	Dry
Alum	wet/puddle	Dry, tacky puddle	Dry

PCC Curing Compound Performance, Phase II
MLR-02-03
Tack Test

	8/20/2002, 3:30pm	8/21/2002, 7:55am	8/21/2002, 10:00am
Temp (^{0}F)	100.0	100.0	100.0
Humidity (%)	46.5	47.0	45.0
1	Control		
2	tender/soft	Dry, minor rub off	Dry
3	tender/soft$^-$	Dry, minor rub off	Dry
4	tender/soft$^-$	Tender, minor rub off	Tender
5	tender/soft	Dry$^+$, minor rub off	Dry
6	tender/soft$^-$	Tender, minor rub off	Tender
7	Control		

APPENDIX E

RESULTS SUMMARY

Efficiency Index of Phases I and II

	Phase I		Phase II	
	Theoretical	Applied	Theoretical	Applied
2. 100%, Iowa standard	94.31%	93.11%	81.02%	79.69%
3. 75 % of IA std (one coat)	92.41%	91.76%	75.23%	74.26%
4. 150% of IA std (one coat)	96.62%	95.30%	92.48%	91.25%
5. 50% - 8 minutes - 50% of IA std	95.33%	94.40%	90.92%	90.53%
6. 75% - 8 minutes - 75% of IA std	98.24%	95.95%	94.05%	91.93%

Loss of water at 24 hrs

	Phase I	Phase II
1. Control	22.03%	42.24%

APPENDIX F

PRODUCT DATA SHEET

NO. 1645 MAY 2003

SEALTIGHT® 1645-WHITE

Water-Base, Wax Base Concrete Curing Compound

DESCRIPTION

SEALTIGHT 1645-WHITE Water-Based, Wax-Based Concrete Curing Compound, when properly applied, provides an impermeable film which optimizes water retention. The white pigment reflects the sun's rays to help keep the concrete surface cooler and prevent excessive heat buildup. **1645-WHITE** is a true, water-based product which meets maximum VOC content of 350 g/L for Concrete Curing Compounds as required by U.S. EPA Architectural Coatings Rule.

SEALTIGHT 1645-WHITE has a substantially lower Volatile Organic Compound content (VOC) than the 350 g/L allowed by the above noted rule.

USES

SEALTIGHT 1645-WHITE is ideal for application on exterior horizontal surfaces such as highways, airports, street and curb paving--for excellent curing when protection from the sun's heat is desired.

SPECIFICATIONS

- ASTM C 309, Type 2, Class A
- AASHTO M 148, Type 2, Class A
- Specifically formulated to meet specifications for various Federal, State, County and City requirements

FEATURES AND BENEFITS

- When properly applied, it provides an impermeable film which optimizes water retention
- Protects by reflecting the sun's rays to keep the concrete surface cooler and prevent excessive heat buildup, which can cause thermal cracking
- Furnished as a ready-to-use, true water-based compound
- Produces hard, dense concrete…minimizes hair-checking, thermal cracking, dusting and other defects
- Enhances the functional capabilities of concrete by "sealing-in" the performance assets of strength and long-life
- Offers a compressive strength significantly greater than improperly cured concrete
- Increases tensile strength for greater resistance to cracking and surface crazing
- Improves resistance to abrasion and corrosive action of salts and chemicals…minimizes shrinkage
- Applies quickly and easily with conventional, commercial spray equipment
- VOC compliant

PACKAGING

5 Gallon (18.93 Liter) Pails
55 Gallon (208.20 Liter) Drums

CONTINUED ON REVERSE SIDE…

APPLICATION

PREPARATION…Application equipment must be clean and free of any previously-used materials.

MIXING… Any settling or separation in the container must be re-dispersed with gentle agitation prior to use. CAUTION: DO NOT MIX EXCESSIVELY.

APPLICATION METHOD…Spray on in one even coat with a hand or power sprayer as soon as the surface water disappears from horizontal concrete surfaces. Use a Chapin 8005 spray tip, or equivalent, that produces a flow of ½ gallon (1.89 liters) per minute under 40 psi (.276 MPa) of pressure.

COVERAGE…Approximately 200 sq. ft. /gal. (4.9 sq. m/L).

DRYING TIME…Approximately one (1) hour. Restrict foot traffic for at least four (4) hours.

CLEAN-UP…Prior to drying, equipment may be easily cleaned with soap and water. Once dried, use Mineral Spirits or other suitable petroleum distillate.

PRECAUTIONS

KEEP FROM FREEZING. Do not apply when the temperature of the concrete is less than 40°F (4°C). DO NOT MIX WITH COMPOUNDS CONTAINING SOLVENT. DO NOT ADD OR DILUTE WITH ANY OTHER COMPOUND. Do not use on surfaces that are later to be painted, tiled, hardened, sealed or treated in any manner. Do not use on patios, sidewalks or other areas where there is typically no wheel traffic to abrade the white film surface. Not recommended for use on residential driveways.

HEALTH HAZARDS
Direct contact may result in mild irritation. Refer to product Material Safety Data Sheet for complete health and safety information.

For MSDS or further assistance, please call: 1-800-342-5976

LIMITED WARRANTY

"W.R. MEADOWS, INC. warrants at the time and place we make shipment, our material will be of good quality and will conform with our published specifications in force on the date of acceptance of the order." Read complete warranty. Copy furnished upon request.

Disclaimer

The information contained herein is included for illustrative purposes only, and to the best of our knowledge, is accurate and reliable. W.R. MEADOWS, INC. cannot however under any circumstances make any guarantee of results or assume any obligation or liability in connection with the use of this information. As W.R. MEADOWS, INC. has no control over the use to which others may put its product, it is recommended that the products be tested to determine if suitable for specific application and/or our information is valid in a particular circumstance. Responsibility remains with the architect or engineer, contractor and owner for the design, application and proper installation of each product. Specifier and user shall determine the suitability of products for specific application and assume all responsibilities in connection therewith.

*** MATERIAL SAFETY DATA SHEET ***

Date of preparation: 05/01/03 3016450 (Page 1)

SECTION I

Manufacturer : W. R. MEADOWS, INC.
Address : 300 Industrial Drive
: Hampshire, Illinois 60140

Telephone # : (847) 683-4500
Emergency # : 1-800-424-9300 Chemtrec

- H M I S -	
Health	1
Flammability	1
Reactivity	0
Personal Protection	

(Hazard Rating: 0=Least,1=Slight,2=Moderate,3=High,4=Extreme,*=Chronic)

Product Class : DIVISION 3
Mfg. code I.D. : 3016450
Trade Name : SEALTIGHT 1645 WHITE, WAX, WATER-BASE CONCRETE CURING COMPOUND

SECTION II-A HAZARDOUS COMPONENTS

No.	Component	CAS#	% by Weight	SARA 313	VAPOR PRESSURE (mm Hg @ 20 C)	LEL (@ 25 C)
1.	Titanium Dioxide	13463-67-7	1 - 5	NO	N/A	N/A

None of the components of this product are recognized as carcinogenic. N/A: Not Applicable
Under the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA)and 40 CFR Part 372, chemicals listed on the 313 List (40 CFR Part 373.65) are identified under the heading "SARA 313".

SECTION II-B OCCUPATIONAL EXPOSURE LIMITS

	OSHA				ACGIH			
No.	PEL/TWA	PEL/CEILING	PEL/STEL	SKIN	TLV/TWA	TLV/CEILING	TLV/STEL	SKIN
1.	15 mg/m3*+	N/E	N/E	N/E	10 mg/m3*	N/E	N/E	NO

* = Total Dust + = 5 mg/m3: Respirable fraction N/E: Not established

SECTION III PHYSICAL DATA

Boiling Point : 212 degrees F
Evaporation Rate : < 1 (ether = 1)
Vapor Density : > 1 (air = 1)
pH Level : 8.67

% Volatile by volume : 75.79 (Theoretical)
% Volatile by weight : 76.37 (Theoretical)
Weight per gallon : 8.36 (Theoretical)

SECTION IV HEALTH INFORMATION

EYE CONTACT: Direct contact may cause mild irritation of the eyes.
SKIN CONTACT: Direct contact may cause mild irritation of the skin.
INHALATION: Exposure may produce irritation to the nose, throat, respiratory tract, and other mucous membranes.
INGESTION: May cause irritation of the gastrointestinal tract.
SIGNS AND SYMPTOMS: Symptoms of eye irritation include pain, tearing, reddening, and swelling. Symptoms of skin irritation include reddening, swelling, rash, and redness. Symptoms of respiratory irritation include runny nose, sore throat, coughing, chest discomfort, shortness of breath, and reduced lung function. Symptoms of gastrointestinal irritation include sore throat, abdominal pain, nausea, vomiting, and diarrhea.
AGGRAVATED MEDICAL CONDITIONS: Pre-existing skin, eye, and respiratory disorders may be aggravated by exposure to this product. OTHER HEALTH EFFECTS: Chronic overexposure to Titanium Dioxide dust may cause slight lung fibrosis.

SECTION V EMERGENCY AND FIRST AID PROCEDURES

EYE CONTACT: Immediately flush eyes with copious amounts of water for at least fifteen (15) minutes while holding eyelids open. Seek prompt medical attention.
SKIN CONTACT: Remove contaminated shoes and clothing. Cleanse affected area(s) thoroughly by washing with mild soap and water. If irritation or redness develops and persists seek medical attention.
INHALATION: If respiratory symptoms develop, move victim away from exposure source and into fresh air. If symptoms persist, seek medical attention. If victim is not breathing, immediately begin artificial respiration. If breathing difficulties develop, oxygen should be administered by qualified personnel. Seek immediate medical attention.
INGESTION: Dilute with liquid unless the victim is unconscious or very drowsy. If vomiting spontaneously occurs, keep the victim's head below the hips to prevent aspiration into the lungs. Consult a physician, hospital or poison control center and/or transport to an emergency facility immediately.

SECTION VI FIRE AND EXPLOSION HAZARDS

FLAMMABILITY CLASSIFICATION - NFPA : Combustible Liquid - Class IIIB
- DOT : Not regulated
FLASH POINT: Greater than 210 degrees F.
EXTINGUISHING MEDIA: Use water fog, foam, dry chemical or Carbon Dioxide.
SPECIAL FIRE FIGHTING PROCEDURES AND PRECAUTIONS: None recognized.
UNUSUAL FIRE AND EXPLOSION HAZARDS: None recognized.

SECTION VII REACTIVITY

STABILITY: Stable **HAZARDOUS POLYMERIZATION :** Will not occur
CONDITIONS AND MATERIALS TO AVOID: No recognized.
HAZARDOUS DECOMPOSITION PRODUCTS: Combustion may yield Carbon Dioxide, Carbon Monoxide, and/or incomplete combustion products. Do not breathe smoke or fumes. Wear appropriate protective equipment.

SECTION VIII EMPLOYEE PROTECTION

RESPIRATORY PROTECTION: None recognized with normal product use.
PROTECTIVE CLOTHING: Wear safety glasses, goggles, or a splash shield to prevent eye contact. Contact lenses should not be worn. Wear appropriate gloves and protective clothing to prevent contact with skin and clothing.
ADDITIONAL PROTECTIVE MEASURES: Eye wash fountains and safety showers should be available for use in an emergency.

SECTION IX ENVIRONMENTAL PROTECTION

SPILL OR LEAK PROCEDURES: LARGE SPILLS>> Evacuate the hazard area of unprotected personnel. Wear appropriate respirator and protective clothing. Shut off source of leak only if safe to do so. Dike and contain. If vapor cloud forms, water fog may be used to suppress; contain run-off. Remove with vacuum trucks or pump to storage/salvage vessels. Soak up residue with an absorbent such as clay, sand or other suitable material; place in non-leaking containers for proper disposal. Flush area with water to remove trace residue; dispose of flush solutions as above. SMALL SPILLS>> Take up with an absorbent material and place in non-leaking containers; seal tightly for proper disposal.
WASTE DISPOSAL: Observe all Federal, State and local regulations regarding proper disposal.

SECTION X ADDITIONAL PRECAUTIONS

Containers may hold product residues even when empty. Wash with soap and water before eating, drinking, smoking or using toilet facilities.