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EVALUATION OF CORROSION –INHIBITING CONCRETE ADMIXTURES

RESEARCH PROJECT 92-072

FINAL REPORT
NOVEMBER 1998

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AND
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CONDUCTED

BY

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF CONSTRUCTION AND MATERIALS
ENGINEERING TECHNOLOGY AND INFORMATION DIVISION

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This report evaluates the use of corrosion–inhibiting admixtures for constructability, and workability when used along with epoxy coated rebar. Deicing agents contain chloride ions that corrode the steel reinforcement. An epoxy-coated rebar has been used since the 1970's however the epoxy coating controls the problem only to an extent. Corrosion of the steel reinforcements still occurs. As a result, the Department is interested in the performance of corrosion–inhibiting concrete admixtures.
Two manufactures, Sika Corporation and W. R. Grace Concrete Products, supplied corrosion – inhibiting concrete admixtures to be tested for their workability, constructability, placement, and performance. According to the contractor's personnel, and the Departments inspectors, there were no workability, constructability or placement problems with the corrosion –inhibiting admixtures. Periodic checks have been made since construction, and the two test bridges appear to be performing well.

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EXECUTIVE SUMMARY

The deterioration of steel reinforced concrete bridges has become a problem on the forefront across the nation. A major contributor to the deterioration is the corrosion of the steel reinforcements. The corrosion is a product of chloride ions chemically reacting with the steel. This creates greater stresses in the concrete, which results in cracks in concrete. The corrosion of the steel and the concrete breakdown lowers the ultimate strength of the bridge.

Pennsylvania's problem with bridge deterioration stems from deicing agents used, during the winter months, to clear roadways for the passage of commuters. These deicing agents contain chloride ions that corrode the steel reinforcements. Therefore in the 1970's, the Pennsylvania Department of Transportation initiated the use of epoxy coatings on the reinforcement steel to control this problem. However, epoxy coatings 's control the problem only to an extent, but bridge deterioration still occurs.

As a result, the Department is interested in the performance of corrosion inhibiting concrete admixtures. These admixtures are added to the concrete at the site or at the batch plant. The admixtures help retard corrosion rate by promoting the formation of ferric oxides. Ferric oxides do not react with chloride ions, thus protecting the protective oxide layer around the steel.

Two manufactures, Sika Corporation and W. R. Grace Concrete Products supplied corrosion – inhibiting admixtures to be tested for their workability, constructability, placement, and performance. Three bridge decks along Interstate 81 (I-81) were selected to be used as test subjects. These bridges were chosen because to represent similar salting applications and traffic characteristics. Two of the decks received class AAA concrete with one of the corrosion-admixtures. The third l deck received the standard class AAA Concrete without a corrosion inhibitor as a control. All decks used epoxy-coated reinforcement. Testing for corrosion-inhibiting ability had been performed by Materials Testing Laboratory prior to field evaluation.

Three test bridge decks were placed on July 15th, 21st, and 28th, 1995. No Major problems were encountered during the placement of the concrete or afterward. According to the Contractor's and the Department's personnel, there were no workability, constructability, or placement problems with the concrete with the corrosion inhibiting admixtures. Periodic inspections have been made since construction, and the two experimental bridges seem to be performing well. The Sika product is no longer produced because it has been-replaced by another improved product that was not available as this testing began.

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Metric Conversion Factors*

To Convert From:	To:	Multiply By:
Length		
foot (ft)	meter (m)	0.3048
inch (in)	millimeter (mm)	25.4
yard (yd)	meter (m)	0.9144
mile (statute)	kilometer (km)	1.609
Area		
square foot (ft^2)	square meter (m^2)	0.0929
square inch (in^2)	square centimeter (cm^2)	6.451
square yard (yd^2)	square meter (m^2)	0.8361
Volume		
cubic foot (ft^3)	cubic meter (m^3)	0.02832
cubic yard (yd^3)	cubic meter (m^3)	0.00315
gallon (U.S. liquid)	cubic meter (m^3)	0.004546
ounce (U.S. liquid)	cubic centimeter (cm^3)	29.57
Mass		
ounce-mass (avdp)	gram (g)	28.35
pound-mass (avdp)	kilogram (kg)	0.4536
ton (metric)	kilogram (kg)	1000
ton (short, 2000 lbm)	kilogram (kg)	907.2
Density		
pound-mass/cubic foot	kilogram/cubic meter (kg/m^3)	16.02
mass/cubic yard	kilogram/cubic meter (kg/m^3)	0.5933
pound-mass/gallon(U.S.)**	kilogram/cubic meter (kg/m^3)	119.8
pound-mass/gallon(Can.)*	kilogram/cubic meter (kg/m^3)	99.78
Temperature		
deg Celsius (°C)	kelvin (°K)	$t^{\circ K} = (t^{\circ C} + 273.15)$
deg Fahrenheit (°F)	kelvin (°K)	$t^{\circ K} = (t^{\circ F} + 459.67) / 1.8$
deg Fahrenheit (°F)	deg Celsius (°C)	$t^{\circ C} = (t^{\circ F} - 32) / 1.8$

* The reference source for information on SI units and more exact conversion factors is "Metric Practice Guide" ASTM E380.

** One U.S. gallon equals 0.8327 Canadian gallon.

INTRODUCTION

The deterioration of reinforced highway structures is a nation wide problem. The problem stems from corrosion of the steel reinforcement in concrete. The steel is normally located in an alkaline environment, concrete, which will allow a protective oxide film to form at the steel /concrete interface. The oxide layer consists of two (2) types of oxides: (1) ferrous oxide and (2) FERRIC OXIDE. The ferrous oxide is stable in an alkaline environment, but when chloride ions are present, iron chloride complexes form. These complexes will carry away from the steel into the concrete to be oxidized and will form rust. He chord ions will then be released and will attack the oxide layer again until the entire passivating oxide layer is undermined.

Once this film is deteriorated electrical cell forms along the steel or between the steel rebars. Portions of the steel will become either anodic or cathodic which will progress the corrosion process. When the steel rusts, it will expand by as much as four (4) times its original volume. This creates larger tensile stresses in the concrete that will eventually be relieved by cracking or spalling. Thus, the corrosion process will lower the overall ultimate strength of the bridge.

In Pennsylvania, the corrosion of steel reinforcements is a product of deicing agents used, during the winter month, to clear roadways for traffic flow. The soluble chlorides in the deicing agents permeate through the concrete to the reinforcement and corrosion will follow. In the 1970's, Pennsylvania recognized the problem and started using electrostatically applied thermo epoxy coatings on reinforcing steel. However, if the epoxy coating is chipped or scratched, then it will not fully protect the steel reinforcement from the corrosion. When chloride ions are present, they will attack the steel reinforcement and begin to corrode the steel. The epoxy coating may become de-bonded from the steel reinforcement and the corrosion will progress along the steel shaft.

Because of this problem, the Departments interested in the performance of corrosion–inhibiting concrete admixture. These corrosion inhibitors help protect ferrous material embedded in the concrete by reducing the corrosion rate in the presence of the ions, thus inhibiting the corrosion.

OBJECTIVE

The objective of this experimental research project is to evaluate the constructability, workability, placement, and performance of class AAA concrete that will receive one of the two (2) types of corrosion-inhibiting admixtures, either W. R. Grace's DCI and Sika's Armatec 2000. The ability of the products to inhibit corrosion was determined by the Department through laboratory analysis and is not an objective of this project. All bridges used epoxy coated rebar and determination of corrosion –inhibiting admixture performance was limited because of the dual corrosion protection, in this researcher's opinion.

LOCATION

Three Bridges were selected along Interstate 81 (I-81) Southbound in Dauphin County between exits 28 and 26. A project map is located on the following page with a summary of the location conditions. Bridge #2, S-20383, located on southbound I-81 crossing over SR2015, was the control bridge deck using the standard class AAA pump mix design. Bridge # 4, S-20384, located on southbound 81, crossing over Manada Gap Road, was an experimental bridge deck using Armatec 2000, with AAA mix design. Bridge #6, S-20386, located on I-81 southbound, crossing on over Shells Church Road, was the experimental bridge deck using DCI, with an AAA mix design.

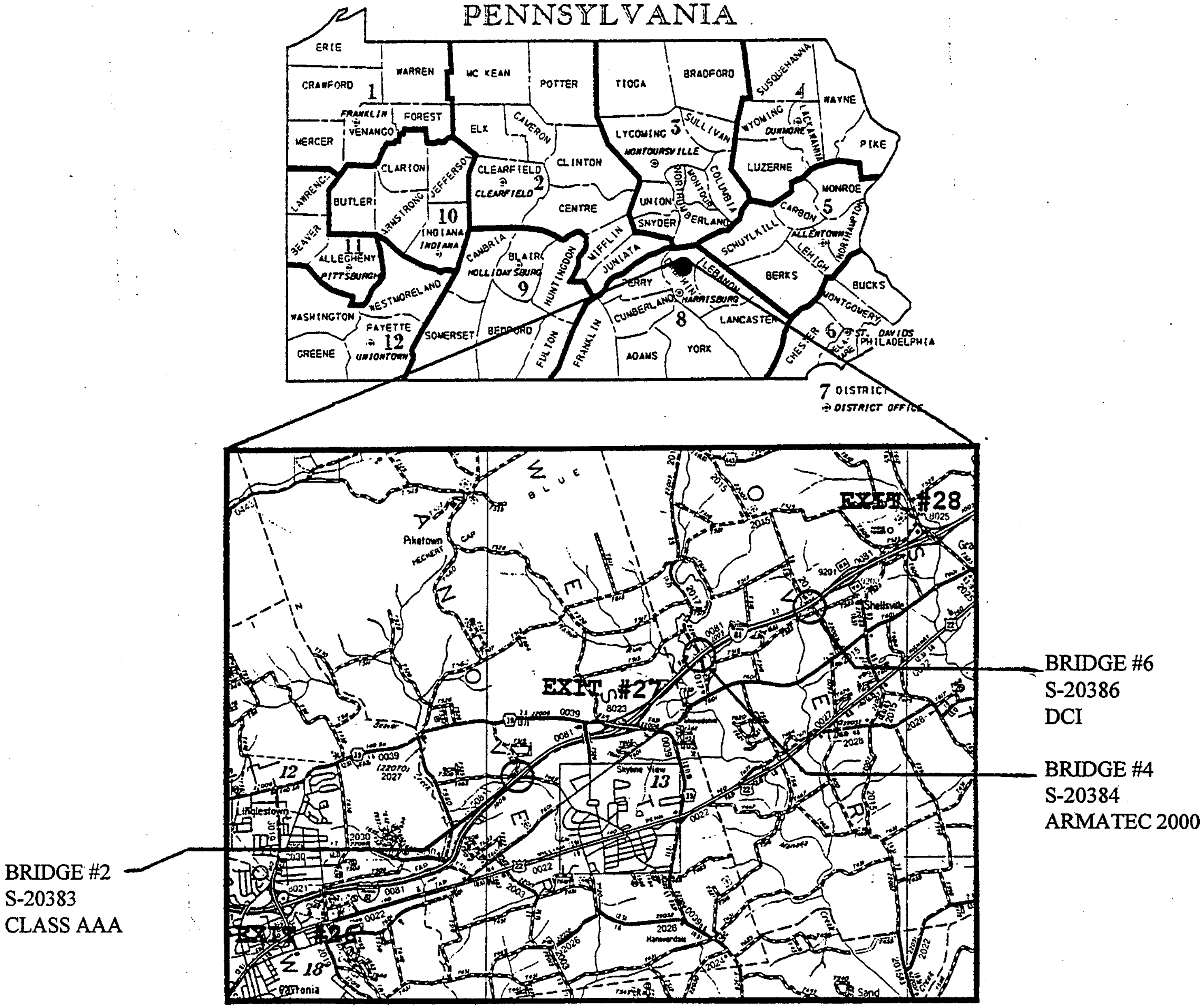

FIGURE 1

PROJECT LOCATION MAP

TABLE 1 - SUMMARY OF PROJECT SITE CONDITIONS

PROJECT SITE NUMBER	BRIDGE STRUCTURE NUMBER	EXPERIMENTAL OR CONTROL SECTION/MATERIAL	SEGMENT AND OFFSET	NUMBER OF SPANS	BRIDGE LENGTH (FEET)	BRIDGE WIDTH (FEET)	NUMBER OF LANES/WIDTH (FEET)	SHOULDER WIDTH (FEET)
4	S-20384	EXPERI./ARMATEC 2000	0774/0819	3	114.75	55.50	3/12.0	10.5 & 9.0
6	S-20386	EXPERI./ DCI	0794/2028	3	98.00	55.50	3/12.0	10.5 & 9.0
2	S-20383	CONTROL/ CLASS AAA	0750/2735	3	135.00	55.50	3/12.0	10.5 & 9.0

MATERIAL DESCRIPTIONS

For this project, an organic and an inorganic corrosion –inhibiting concrete admixture was evaluated. Three different corrosion –inhibiting admixtures, Armatec 2000, Rheocrete 222 and DCI, were tested in the laboratory to determine the ability of each inhibitor. Current reduction tests revealed both DCI and Armatec 2000 seemed to inhibit corrosion, whereas Rheocrete 222 fell short of the proposed goal because a workable mix design could not be obtained. In each case, the tests ran for approximately 20 hours. Further field tests for Armatec 2000 and DCI were needed for correct assessment of their intended task. Armatec 2000 Corrosion Inhibiting Admixture, Is manufactured by the Sika Corporation, 201 Polito Avenue , Lyndhurst, New Jersey 07071, and DCI Corrosion –Inhibiting , is manufactured by W.R. Grace Concrete Products, Amherst, New York 14266.

ARMATEC 2000 CORROSION –INHIBITING ADMIXTURE

Armatec 2000 is an organic admixture composed of amines and esters. It provides corrosion protection by providing a protective layer around the embedded steel wh8ivh inhibits the corrosion caused by moisture, oxygen, and deicing salts. It can be added to the concrete as mix water at the job site or at the batch plant.

In this, projects seen in the mix design in appendix "E" the Armatec 2000 was added to the concrete mix at the rate of 64 ounces per cubic yard (as required).

Armatec 2000 is no longer produced by SIKA. FerroGard 901 and 902 that is a next generation corrosion-inhibitor but was not available at the time of this study. Current reduction tests on Ferroguard 901 have since been completed and its use is available on Bulletin 15 along with three others.

DCI CORROSON IHIBITIOR

DCI Corrosion-Inhibitor, an inorganic admixture, is designed to chemically inhibit the corrosive action of the chlorides on reinforcement steel ands prestressed strand s in concrete. DCI contains calcium nitrate, which interacts with embedded steel in the concrete to form a barrier, which prevents chloride penetration. When added sufficient quantity, DCI maintains an active corrosion controlling systems within the concrete matrix. If corrosion is inhibited, physical disruption of the concrete due to rust formation will not occur. In addition, DCI claims to increase the early strength development of the concrete. Some recent research suggests that anodic inhibitors such as DCI are effective at low chloride concentrations, but when chloride concentrations reach a critical level, they may accelerate the corrosion process. They suggest a maximum design criteria for DCI is 7.8 Kg/M^3 (13 lbs/Yd^3). This design criteria correlates with DCI technical literature for a dosage rate of 4 gallons per cubic yard and a dosage rate of 3gallons per cubic yard was used for this research project see Appendix D. Mix Designs.

CONSTRUCTION SUMMARY

The construction of the three test bridges started on July 15th, 21st, and 28th, 1995 consecutively with no major problems. Test bridge #4, approximately 192 cubic yards was placed on July 15 with Class AAA cement concrete and 64 ounces per cubic yard of Armatec 2000 Corrosion –Inhibiting Admixture. Placement started around 2:20 AM with temperatures near 80 F and continued through the night until 6:30 AM. The characteristics of the concrete with Armatec 2000 are located in TABLE 2.

On July 21,1995, approximately 218 cubic yards of Class AAA cement concrete with no corrosion inhibitors was placed between 1:00 AM and 9:00AM. Concrete placement was halted twice because of rain. The concrete was covered both times with plastic until the rain event ended. The characteristics of the concrete used on Test Bridge # 2 are located on TABLE 3, Appendix 'C' Mix Design, and Maturity Data.

Test bridge # 6, approximately 168 cubic yards with class AAA concrete and 3 gallons per cubic yard of, DCI corrosion inhibitor admixtures, was placed on July 28,1995. Placement occurred between 1:15 AM and 5:30 AM. The Ambient air temperature was between 78 F and 85 F. The characteristics of the concrete used on Test Bridge # 6 are located on TABLE 4. (SEE Mix Design & Maturity DATA Appendix "D".)

All three bridges used epoxy coated rebars for reinforcement, were sprayed with Confilm, an intermediate curing membrane, and were covered with wet burlap and plastic sheeting for curing. The District decided, for all three bridge decks to mechanically groove the wearing surface after construction rather than apply a tine finish during concrete placement.

TABLE 2 - ARMATEC 2000 CEMENT CONDITIONS							
Truck No.	Test Results						
	Slump (in)		% Air		Temp (°F)		W/C Ratio
	At Truck	At Bridge	At Truck	At Bridge	At Truck	At Bridge	
1	4.00	4.00	6.50	7.60	80.00	80.00	0.38
2	4.00		7.00	6.60	80.00		0.36
3	3.00	3.00	7.20	8.00	80.00		0.36
4							
5	4.00	4.00	7.00	7.20	80.00	80.00	0.37
6							
7							
8							
9	4.00	4.00	7.80	6.80	79.00	79.00	0.37
10							
11					77.00		
12	4.00		8.00		77.00		0.37
13							
14	4.00	4.00	7.10	5.60	77.00	77.00	0.37
15							
16							
17	4.00		7.40		78.00		0.37
18							
19							
20	3.50		6.00		78.00		0.37
21							
22	4.00	4.00	7.20	7.00	78.00	78.00	0.37
23							
24							
25							
AVERAGE	3.85	3.83	7.12	6.97	78.55	78.80	0.37

TABLE 3 - STANDARD CLASS AAA CEMENT CONDITIONS					
Truck No.	Test Results				
	Slump (in.)	% Air		Temp. (°F)	W/C Ratio
		At Truck	At Bridge		
1	4.00	7.00	7.80	72.00	0.37
2	3.25	7.80	7.60	74.00	0.37
3	3.00	6.50	7.20	74.00	0.37
4	3.50	7.50	7.90	74.00	0.37
5			7.50		0.37
6	3.50	6.60		74.00	0.37
7		6.40		74.00	0.37
8					0.37
9	3.50	6.90	7.60	77.00	0.37
10					0.37
11					0.37
12	3.25	6.20	6.20	75.00	0.37
13			6.50		0.37
14					0.37
15	3.50	6.00		74.00	0.37
16			6.80		0.37
17	3.25	7.00	6.80	74.00	0.37
18					0.37
19					0.37
20	2.75	5.80	7.20	74.00	0.38
21					0.38
22		8.00			0.37
23	3.25	6.00	6.80	74.00	0.37
24					0.37
25					0.37
26	3.75	5.40	6.40	74.00	0.37
27					0.38
28					0.38
29	3.50	5.60		74.00	0.38
30					0.38
AVERAGE	3.38	6.58	7.10	74.14	0.37

TABLE 4 - DCI CEMENT CONDITIONS					
Truck No.	Test Results				
	Slump (in.)	% Air		Temp. (°F)	W/C Ratio
		At Truck	At Bridge		
1	3.25	7.60	6.60	78.00	0.37
2	4.25	6.80	6.80	74.00	0.37
3	3.75	7.00		76.00	0.37
4					0.37
5					
6	3.75	6.60	7.00	78.00	0.37
7					
8					
9	3.50	7.00		78.00	
10					
11	4.00	7.00		80.00	0.37
12					
13					
14	3.75	6.00	6.50	74.00	0.37
15	3.50	5.40	6.50	76.00	0.37
16		6.20	7.30		
17		7.00		76.00	0.37
18		6.40	7.40	76.00	
19	2.75	6.00	6.50	76.00	0.37
20	2.75	6.40	7.80	76.00	
21					0.37
AVERAGE	3.53	6.57	6.93	76.5	0.36

Maturity equipment was set up during pouring to take measurements of the temperature, heat loss, adiabatic temperature rise, heat development, and the voltage across each bridge for four days after the pouring. Plus, periodic spot inspections have been made since the placement of the bridges to analyze and compare the performance of the two test bridges.

Photographs of the placement of all three bridges and the maturity equipment used are located on the following pages.

PHOTO 1 Placement of Bridge Deck #6

PHOTO 2 Placement of Bridge Deck #2

PHOTO 3 Bridge Deck #4 After Concrete Placement

PHOTO 4 Bridge Deck #4 Covered with Wet Burlap

PHOTO 5 Finished Bridge Deck #2

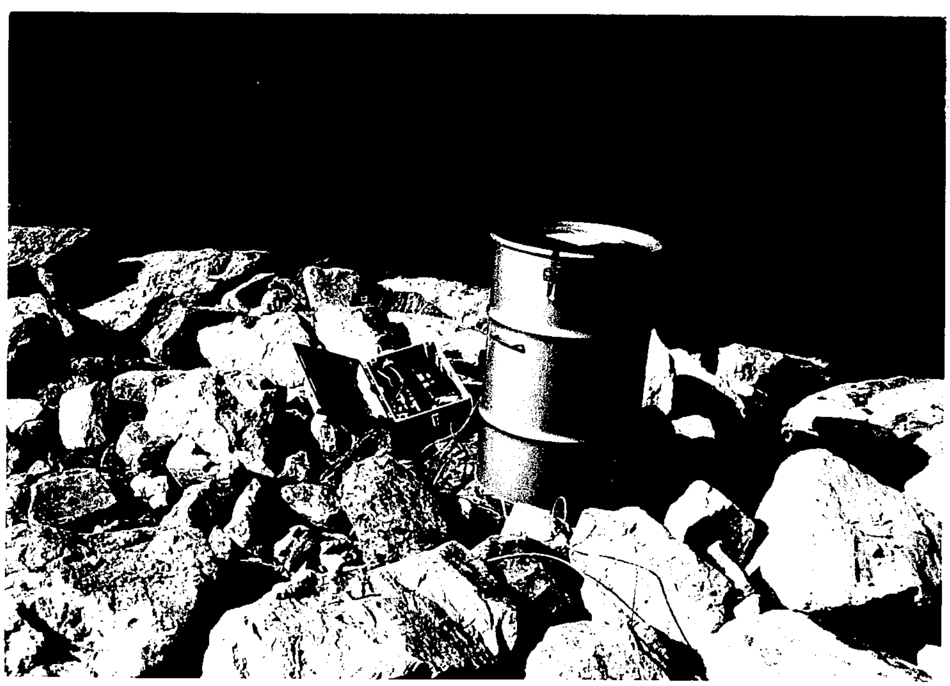

PHOTO 6 Maturity Equipment and Setup

CONCLUSIONS AND RECOMMENDATIONS

During this research project, the workability, constructability, placement, and performance of Class AAA cement concrete with corrosion –inhibitor admixture was to be evaluated. After placement of the concrete, the construction companies personnel and the Department inspectors were questioned about working with the three different bridge placements. The consensus was that workability constructability and concrete placements were the same.

The periodic checks have revealed that the bridges with corrosion –inhibiting admixtures are performing just as well as the Control Class AAA concrete bridges. During the inspection, it was recorded that the bridges with the corrosion –inhibiting admixtures had fewer cracks than the Control Class AAA. However, instrumentation was not setup during construction to allow for corrosion assessment along the steel reinforcements. Therefore, it is impossible to accurately determine which type of concrete admixture is superior in retarding the corrosion at this time.

The maturity testing revealed that the concrete with corrosion –inhibiting admixtures, illustrated in Appendices C, D, and E, had the same trends as the Control standard AAA concrete. This shows admixtures did not affect setting of the concrete. The laboratory data evaluation of corrosion –inhibiting compared well with the on-site data. The laboratory evaluation of corrosion-inhibitors confirmed that both DCI and Armatec 2000 exhibit potential for inhibiting corrosion and have no real negative effect on concrete mixes. The laboratory tests the effects of corrosion inhibitors on the setting of the concrete is valid procedure. The graphs of all three types of concrete are located in Appendices C, D, and E.

Currently the corrosion –inhibiting admixtures do not appear to have any detrimental effects on concrete. A standard special provision is in the process of being developed for the use of these types of corrosion inhibiting products. The special provision consist of a product that would pass ASTM G109-91,"Standard Method of Test for Determining the Effects of Chemical Admixtures on the Corrosion of Embedded Steel Reinforcing in Concrete Exposed to Chloride Environments," and show good workability in a mix design and good constructability in a field application. Pennsylvania Department of Transportation currently will use these products in combination with epoxy coated rebars as an additional measure to counteract corrosion of reinforcement steel. Since the Armatec 2000 has been replaced with the Ferraguard 901 , at this time, only DCI has been documented by the ETI Division and the special provision for its use is attached in appendix F. Three other corrosion–inhibitors are available for use in Bulletin 15. They are Catexol 1000CI, DCI and DCIS, Rheocrete CNI and 222+(Provisional Approval) and Ferroguard 901.

REFERENCES

1. "Corrosion Protection Tests on 3M Scotch Kote 911 Concrete Corrosion Inhibitor for 3M Company", WJE No.840058, March 1986

2. "Condition Evaluation of Concrete Bridges Relative to Reinforcement Corrosion", Volume 8: Procedure manual, Cady , Phillip D. and Gannon, Edward J., Pennsylvania Transportation Institute and Strategic Highway Research Program

APPENDIX A

TECHNICAL DATA for ARMATEC 2000 CORROSION - INHIBITING ADMIXTURE

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Armatec® 2000

Corrosion-Inhibiting Admixture

Sika

Quiet Competence

TECHNICAL DATA

Description: Armatec® 2000 Corrosion-Inhibiting Admixture is a liquid added to concrete either at the batch plant or at the job site. Armatec® 2000 provides corrosion protection for embedded steel and is a cost-effective solution for extending the service life of structures subjected to corrosion caused by exposure to oxygen and water and also chloride ion attack from either deicing salts or marine exposure.

Where to Use: Armatec® 2000 Corrosion-Inhibiting Admixture is recommended for all steel-reinforced, pre-stressed, precast, post tensioned or marine concrete.

- Steel-reinforced concrete streets and highways exposed to corrosive environment (deicing salts), cracking, etc.
- Steel-reinforced concrete in or near a marine environment
- Parking garage decks
- Bridge decks

Advantages: Armatec® 2000 Corrosion-Inhibiting Admixture offers architects, engineers, and owners a reliable corrosion inhibitor that can be specified with confidence.

- No harmful effects to plastic or hardened concrete.
- Organic in nature and environmentally sound.
- Protects against the harmful effects of corrosion such as expansive forces within the concrete, concrete spalling, staining, and ultimate loss of structural integrity.
- Does not contain calcium nitrite.
- Inhibits corrosion even in the presence of salts.
- Has no harmful effect on the durability of concrete.
- Requires lower dosage than traditional corrosion inhibitors.
- Requires no adjustment for water content or set time.
- Compatible with all other admixtures.

Shelf Life: 2 years in original, unopened container.

Storage Conditions: Store above 35 F. Protect from freezing. If frozen, thaw and agitate before using. Do not use pressurized air.

Packaging: 5 gal. drums, 55 gal. drums, and bulk.

How to Use

Dosage: ½ gallon per cubic yard.

Mixing: Add correct amount of Armatec® 2000 at the concrete plant. For best plasticizing results, add directly to the freshly mixed concrete. Minor adjustments in air entrainment may be needed. Field adjust.

Limitations:

- Do not mix with dry cement.
- Do no pre-mix with air-entraining agents.
- Protect from freezing. If frozen, thaw and agitate before using.

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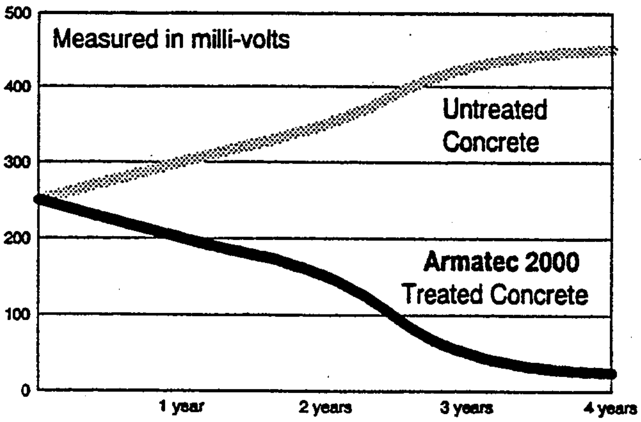
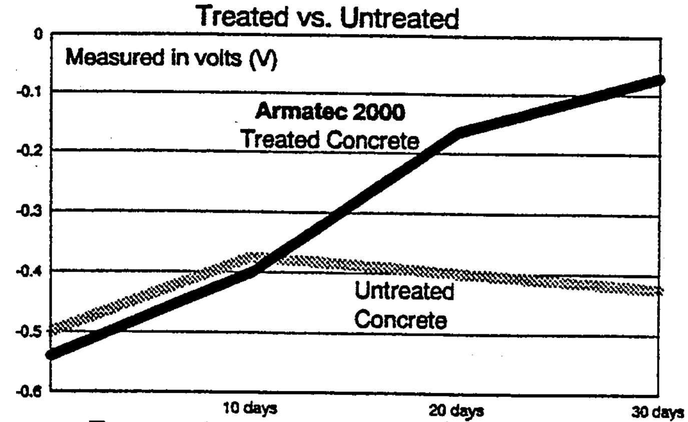
Armatec® 2000
Half-Cell Potential (ASTM-C876)



The lower the half-cell potential, the lower the corrosion

Armatec® 2000
Corrosion Resistance of Concrete Treated vs. Untreated



The greater the value, the greater the resistance to corrosion
Time-to-corrosion testing (ASTM-G5) conducted by Wiss, Janey, Elstner Assoc.

Caution: **Irritant** - Skin and eye irritant. Vapors may cause respiratory tract irritation. Use only with adequate ventilation. Use of safety goggles and chemical resistant gloves is recommended. Remove contaminated clothing.

First Aid: In case of skin contact, wash thoroughly with soap and water. For eye contact, flush immediately with plenty of water for at least 15 minutes; contact physician immediately. For respiratory problems, remove person to fresh air. Wash clothing before re-use.

Clean Up: Dispose of in accordance with current, applicable local, state, and federal regulations.

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APPENDIX B

TECHNICAL DATA for DCI CORROSION - INHIBITING ADMIXTURE

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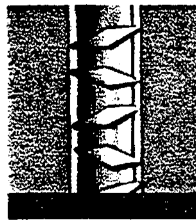
GRACE · concrete admixtures



DCI®
CORROSION INHIBITOR
ASTM C-494 TYPE C

DESCRIPTION:
DCI® corrosion inhibitor is a liquid added to concrete during the batching process. It chemically inhibits the corrosive action of chlorides on reinforcing steel and prestressed strands in concrete. It also promotes strength development of the concrete while meeting ASTM C-494 requirements as a Type C admixture. One gallon of DCI weighs 10.7±0.1 pounds. DCI contains a minimum of 30% calcium nitrite.

USES:
DCI is recommended for all steel-reinforced, post tensioned and prestressed concrete that will come in contact with chlorides from deicing salts or a marine environment. Examples are parking garage decks and support structures, bridge decks and prestressed members, and structures in marine environments. It may also be used in concrete where chlorides are added during manufacture.

FACTS ABOUT STEEL CORROSION:
Corrosion occurs in the presence of oxygen, moisture, and an electrolyte. As chlorides attack the reinforcing steel, the salt intensifies the electrolyte properties of concrete, thereby creating a corrosion cell. As the corrosion reaction occurs, rust is formed. It migrates away from the reinforcing bar, leaving more iron to be corroded. This process continues and two situations develop:

1. The reinforcing bars disintegrate, which reduces the flexural strength of the concrete structure; and,
2. Iron, as it oxidizes, expands to four times its original volume. This expansion results in physical disruption of the concrete. Typical results are cracks, stains, crazing, spalling and potholes; all of which are safety hazards.

CHEMICAL INHIBITION OF CORROSION:
DCI corrosion inhibitor is a patented system containing calcium nitrite which interacts with the embedded steel in concrete to prevent salt attack. By chemically reacting with the reinforcing, a barrier is formed which prevents chloride penetration. Corrosion initiation is delayed and corrosion rates are kept under control. Once corrosion has been inhibited, physical disruption of the concrete due to rust formation will not occur.

When added to concrete in sufficient quantity as determined by the anticipated chloride ion content of the concrete over the design life of the structure, DCI maintains an active corrosion-controlling system within the concrete matrix.

ADDITION RATES:
Recommended addition rates range from 2.0 to 6.0 gallons per cubic yard. The level of corrosion protection increases in proportion to the dosage. The project specification will indicate the addition rate. In the absence of a specified dosage, or where needed to offset premixed chlorides, call your Grace admixture technical representative.

DCI also increases the early strength of a concrete mixture and may have an accelerating action on setting time. These effects become more pronounced as the addition rate rises. Control of setting time can be achieved with retarding admixtures (see set acceleration).

CEMENT COMPATIBILITY:
DCI corrosion inhibitor is fully compatible with all types of portland cements, and concretes containing pozzolans.

MIX WATER REDUCTION:
Mix water adjustment is essential to account for the water in DCI and thus maintain the desired water/cement ratio. The mix water added at the batch plant must therefore be reduced to compensate for the addition of the corrosion inhibitor. The adjustment factor is 7.0 lbs. of water per gallon of DCI.

A high-range water reducer such as Daracem™ 100 or WRDA® 19 may be used to maintain workability in low water/cement ratio concrete.

COMPATIBILITY WITH OTHER ADMIXTURES:
DCI corrosion inhibitor can be used in concrete with other admixtures — including air entraining admixtures, water reducers, superplasticizers, set-retarders and microsilica — without impeding their performance.

Each admixture must be added separately. Individually added, each will deliver exactly the results desired.

SET ACCELERATION:
At all recommended addition rates, DCI corrosion inhibitor may accelerate concrete setting times. To extend the set time to a more normal duration, separately add a retarder such as Daratard® -17 or Daratard HC.

A retarder may not be necessary in cold weather. The full accelerating action of DCI may actually be desirable during the cool months of the year.

AIR ENTRAINMENT:
DCI corrosion inhibitor at the normal addition rates may moderately reduce the entrained air content. It may be necessary to increase the dosage of the air entraining admixture to compensate. Project specifications for DCI generally will show requirements of 7½±1½% air in the plastic or fresh concrete.

PRECONSTRUCTION TRIAL MIX:
It is strongly recommended that trial mixes be made several weeks before construction start up. This will allow the concrete producer an opportunity to determine the proper batching sequence and amounts of other admixtures needed in order to deliver the required concrete mix to the jobsite. Grace's broad experience with this product can help the concrete producer deliver satisfactory product regardless of the mixture proportions. Contact your Grace admixture salesman for help with trial mixes.

FINISHING AND CURING:
Concrete containing DCI corrosion inhibitor finishes with standard tools and techniques. It is no different from any other air entrained, low water/cement ratio mix in terms of finishability. Curing procedures must follow ACI 302 and ACI 308.

DCI corrosion inhibitor is available in bulk quantities by W.R. Grace & Co. metered systems, or, in 55-gallon drums.

DISPENSING EQUIPMENT:
A complete line of accurate dispensers is available. DCI may be introduced on the sand, in the water, at the beginning or the end of the batch cycle. Similar to all concrete admixtures, DCI should not come into contact with other admixtures prior to entering the concrete.

FREEZING POINT:
DCI freezes at approximately 5° F, but its corrosion inhibition and strength gain properties are completely restored by thawing and thorough agitation.

GRACE
Concrete Products

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APPENDIX 'C' MIX DESIGN AND MATURITY DATA FOR CONTROL CLASS AAA CEMENT CONCRETE

TR-4221A (10-94)

CONCRETE MIX DESIGN FORM

JMF No. 95 341

MAT'L CLASS: AAA-Pump
DATE: 12/05/94
DISTRICT: 8-0
CMS NO.: 085172

S.R.: 0081 Section/Segment 004/007 FA No.

Concrete Producer/Code The Lane Construction Corp. Plant #20 Lane

MATERIAL	TYPE	PRODUCER-LOCATION	SUPPLIER CODE	S.G.	ABS.	LAB. #
Cement	I	Allentown-Blandon, PA	ALLN1-15			
Pozzolan	F	National Minerals-Manson,PA	NATMC-15	2.49		94-042850
Fine Aggregate	A	York Building Supply-Belv,MD	YOP-MDC	2.63	.39	93-036073
Coarse Aggregate	#57-A	Pennsy Supply-Hummelstown,PA	PES-22B	2.81	.41	94-030032
Water		On Site Well				
Admixture-AEA	MBAE-90	Master Builders	MASTO-15	6.5	oz./c.y. (as required)	
Admixture	WR MBL-82	Master Builders	MASTO-15	30	oz./c.y. (as required)	
Admixture	RET 100 XR	Master Builders	MASTO-15	15	oz./c.y. (as required)	
					oz./c.y. (as required)	

Strength Data Based On: .38 W/C Ratio Taken From Worksheet Dated: 12/05/94

Compr. Str.: 7 days 5403 avg. psi 28 days 6800 avg. psi %Solids Used N/A F.M. 2.80

Concrete Mix Summary *(One Cubic Yard)* by ACI Method

Mix No.	Trial	#1	#2	#3
W/C Ratio, by Wt.	.38	.37	.36	.35
Cement, lbs.	658	658	658	658
Pozzolan, lbs.	117	117	117	117
Water, lbs.	295	287	279	271
Coarse Agg. (S.S.D), lbs.	1770	1770	1770	1770
______, lbs.				
Fine Agg. (S.S.D.), lbs.	1039	1059	1080	1101
Total, lbs.	3879	3891	3904	3917
Unit Weight, lbs./C.F.	143.7	144.1	144.6	145.1
Water, gals.	35	34.6	33.6	32.7
Mortar Content, C.F.	16.91	16.91	16.91	16.91
At Pt. of Placement: Slump (in.)	4"	4"	4"	4"
Air (%)	6.5	6.5	6.5	6.5

Designed by Harry M Hensch Date 1-26-95

Approved & Submitted by W.E. [signature] Date 1-27-95

Reviewed by Mat'ls Engineer W. E. Brookhart Date

RECEIVED JAN 29 1995 MATERIALS UNIT 8-0

TR-4221A

MIX DESIGN WORKSHEET

Class AAA-Pump Co[illegible]

District 8-0

Date 12/05/94

Concrete Producer The Lane Construction Corp. Project or Plant #20 Plant - Grantvill[illegible]

Mix Design by ACI Method

Square Screen Analysis % Passing

Screen Sizes	1½	1	1/2	3/8	#4	#8	#16	#30	#50	#100
F.A.				100	98	85	67	47	19	4
C.A. #57 Stone	100	98	36		4	1				

Maximum Density ______ P.C.F., S.S.D. F.M. 2.80

S.G. Factor of Slag ______ % Solids (PDT only) ______

Volume of C.A. 10.09

TRIAL MIX

Wt./Volume Calculations:

W C RATIO .38 by

Cement	7.0 Bags x 0.478	=	3.35 C.F. x	(3.15 x 62.4)	=	658
Pozzolan	F	=	.75 C.F. x	(2.49 x 62.4)	=	117
C.A.	#57	=	10.09 C.F. x	(2.81 x 62.4)	=	1770
Water	35.5 Gals. x 0.133	=	4.72 C.F. x	62.4	=	295
6.5 % Air =	27.0 x .065	=	1.76 C.F.			
		Sub-total	20.67 C.F.			
F.A. =	27.00 – 20.67	=	6.33 C.F.			
Weight of F.A.	6.33 x 2.63 x 62.4				=	1039
Totals/C.Y. =	35.5 Gals.		27.00 C.F.			3879

Temperature: Concrete 61° F Air 53° F 145.2 #/C.F. Actual

Initial: Slump 4½ in. Air Content 7.2 % Unit Wt. 143.7 #/C.F. Calculat[illegible]

At Point of Placement: Slump 4 in. Air Content 6.5 % Mortar Content 16.91 [illegible]

Strength	Days	1	2	Avg.	Days	1	2	Avg.
Compressive	4	4952	4899	4926	28	6791	6808	6800
Compressive	7	5411	5394	5403				

MIX NO. 1 (ADJUSTED)

Wt./Volume Calculations:

W C RATIO .37 by

Cement	7.0 Bags x 0.478	=	3.35 C.F. x	(3.15 x 62.4)	=	658 lb
Pozzolan	F	=	.75 C.F. x	2.49 x 62.4)	=	117 lb
C.A.	#57	=	10.09 C.F. x	2.81 x 62.4)	=	1770 lb
Water	34.6 Gals. x 0.133	=	4.60 C.F. x	62.4	=	287 lb
6.5 % Air =	27.0 x .065	=	1.76 C.F.			
		Sub-total	20.55 C.F.			
F.A. =	27.00 – 20.55	=	6.45 C.F.			
Weight of F.A.	6.45 x 2.63 x 62.4				=	1059 lb
Totals/C.Y. =	34.6 Gals		27.00 C.F.			3891 lb

At Point of Placement:

Slump 4 In. Air Content 6.5 % Calc. Unit Weight 144.1 #/C.F. Mortar Content 16.91

TR-42218 (12-77)

MIX DESIGN WORKSHEET

Class AAA-Pump Concrete

District 8-0

Date 12/05/94

Concrete Producer The Lane Construction Corp. Project or Plant #20 Plant - Grantville

Mix Design by ACI Method

MIX NO. 2 (ADJUSTED)

Wt./Volume Calculations: W/C RATIO .36 by Wt.

Cement	7.0	Bags x 0.478	=	3.35 C.F. x	(3.15 x 62.4)	=	658 lbs.
Pozzolan	F		=	.75 C.F. x	(2.49x 62.4)	=	117 lbs.
C.A.	#57		=	10.09 C.F. x	(2.81x 62.4)	=	1770 lbs.
Water	33.6	Gals. x 0.133	=	4.47 C.F. x	62.4	=	279 lbs.
6.5 % Air =	27.0	x .065	=	1.76 C.F.			
		Sub-total		20.42 C.F.			
F.A. =	27.00	− 20.42	=	6.58 C.F.			
Weight of F.A.	6.58	x 2.63 x 62.4				=	1080 lbs.
Totals/C.Y. =	33.6	Gals.		27.00 C.F.			3904 lbs.

Calc. Unit Weight 144.6 #/C.F. Mortar Content 16.91 C.F.

MIX NO. 3 (ADJUSTED)

Wt./Volume Calculations: W/C RATIO .35 by Wt.

Cement	7.0	Bags x 0.478	=	3.35 C.F. x	(3.15 x 62.4)	=	658 lbs.
Pozzolan	F		=	.75 C.F. x	(2.49x 62.4)	=	117 lbs.
C.A.	#57		=	10.09 C.F. x	(2.81x 62.4)	=	1770 lbs.
Water	32.7	Gals. x 0.133	=	4.34 C.F. x	62.4	=	271 lbs.
6.5 % Air =	27.0	x .065	=	1.76 C.F.			
		Sub-total		20.29 C.F.			
F.A. =	27.00	− 20.29	=	6.71 C.F.			
Weight of F.A.	6.71	x 2.63 x 62.4				=	1101 lbs.
Totals/C.Y. =	33.6	Gals.		27.00 C.F.			3917 lbs.

Calc. Unit Weight 145.1 #/C.F. Mortar Content 16.91 C.F.

MIX NO. ______ (ADJUSTED)

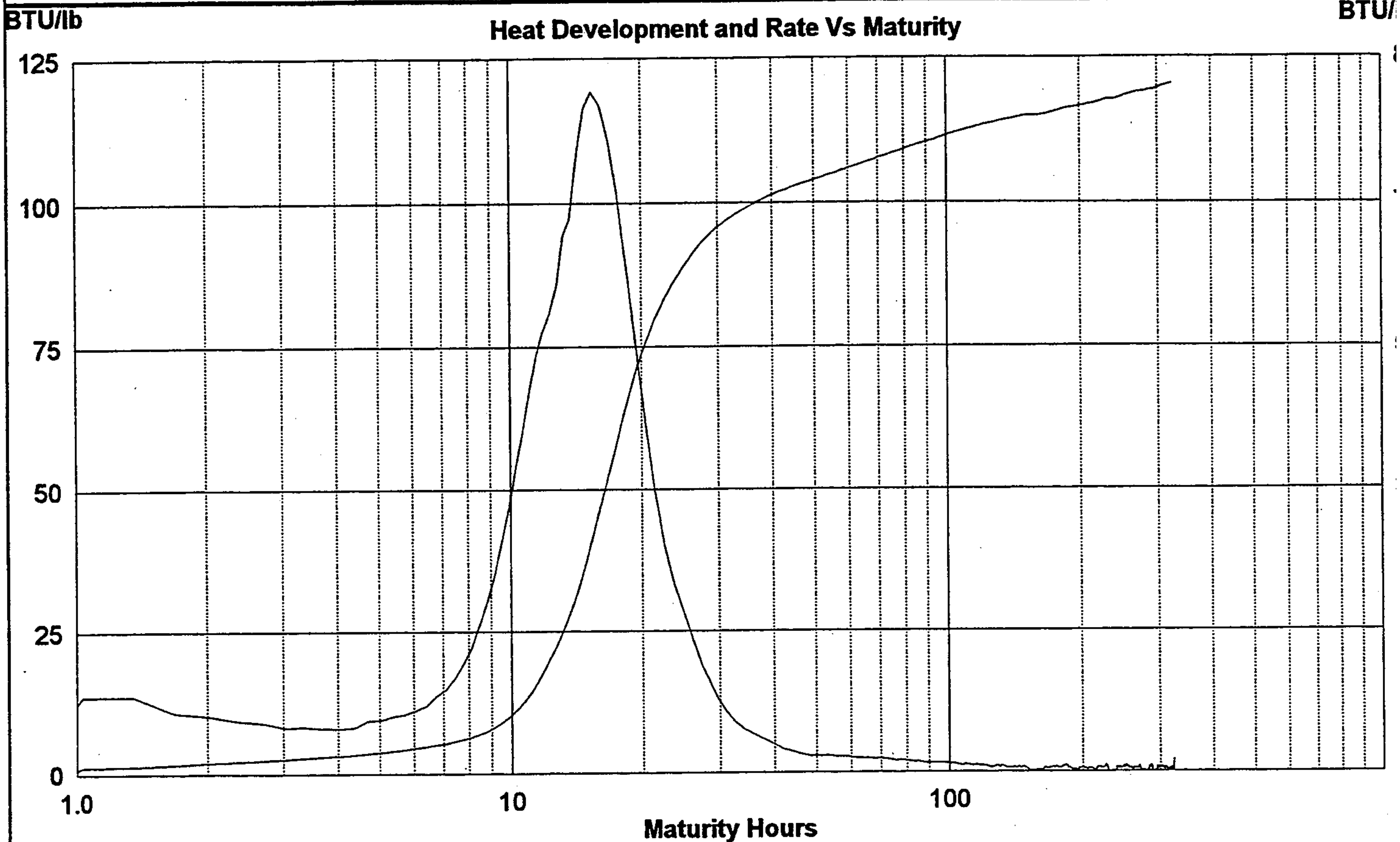
Wt./Volume Calculations: W/C RATIO ______ by Wt.

Cement		Bags x 0.478	=	C.F. x	(3.15 x 62.4)	=	lbs.
Pozzolan			=	C.F. x	(x 62.4)	=	lbs.
C.A.			=	C.F. x	(x 62.4)	=	lbs.
Water		Gals. x 0.133	=	C.F. x	62.4	=	lbs.
___% Air =	27.0	x	=	C.F.			
		Sub-total		C.F.			
F.A. =	27.00	−	=	C.F.			
Weight of F.A.		x x 62.4				=	lbs.
Totals/C.Y. =		Gals		27.00 C.F.			lbs

Calc. Unit Weight ______ #/C.F. Mortar Content ______ C.F.

PenDOT Harrisburg	QUADREL 1.5 Graphing

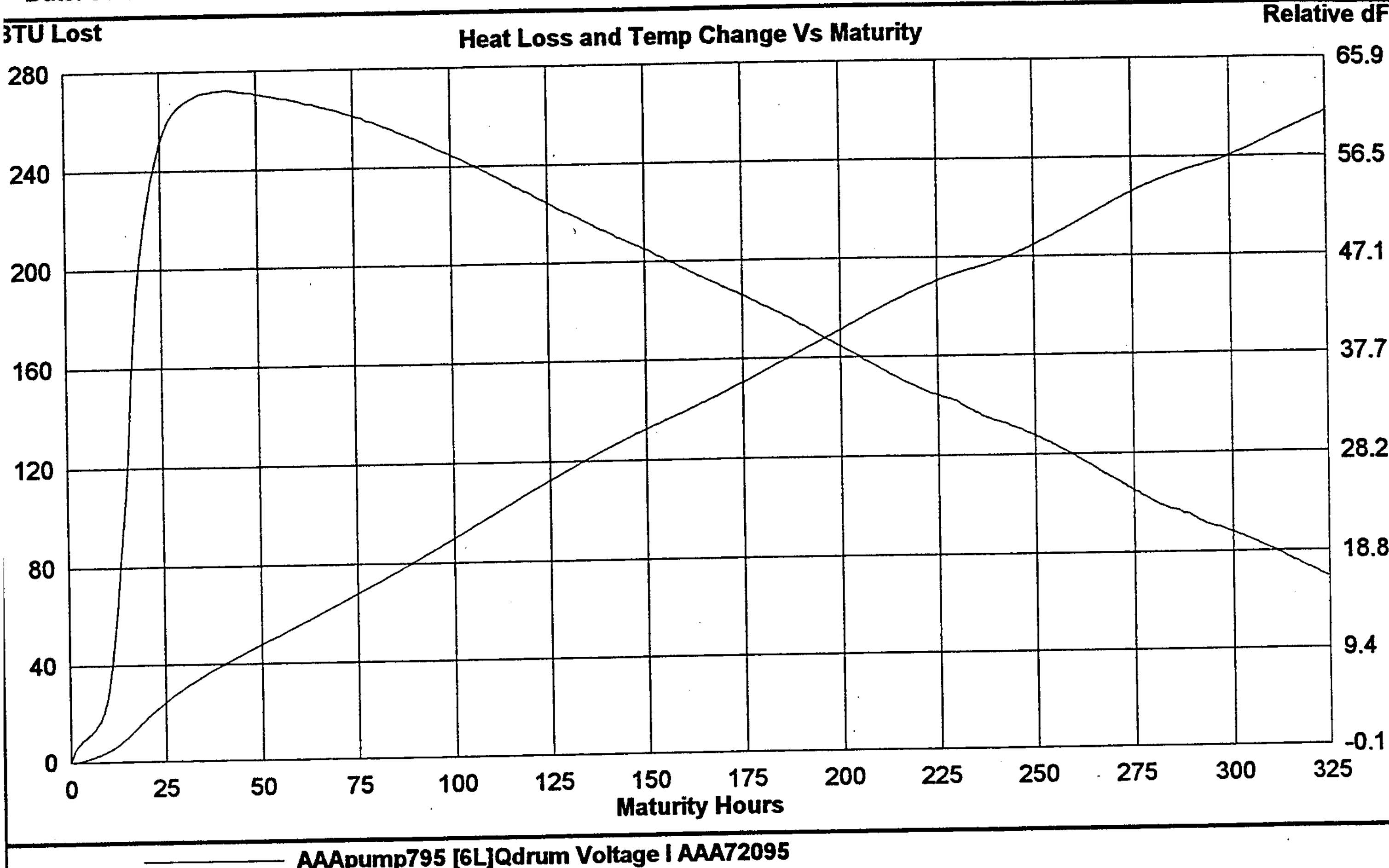
Date: 06-17-1996



AAApump795 [6L]Qdrum Voltage I AAA72095

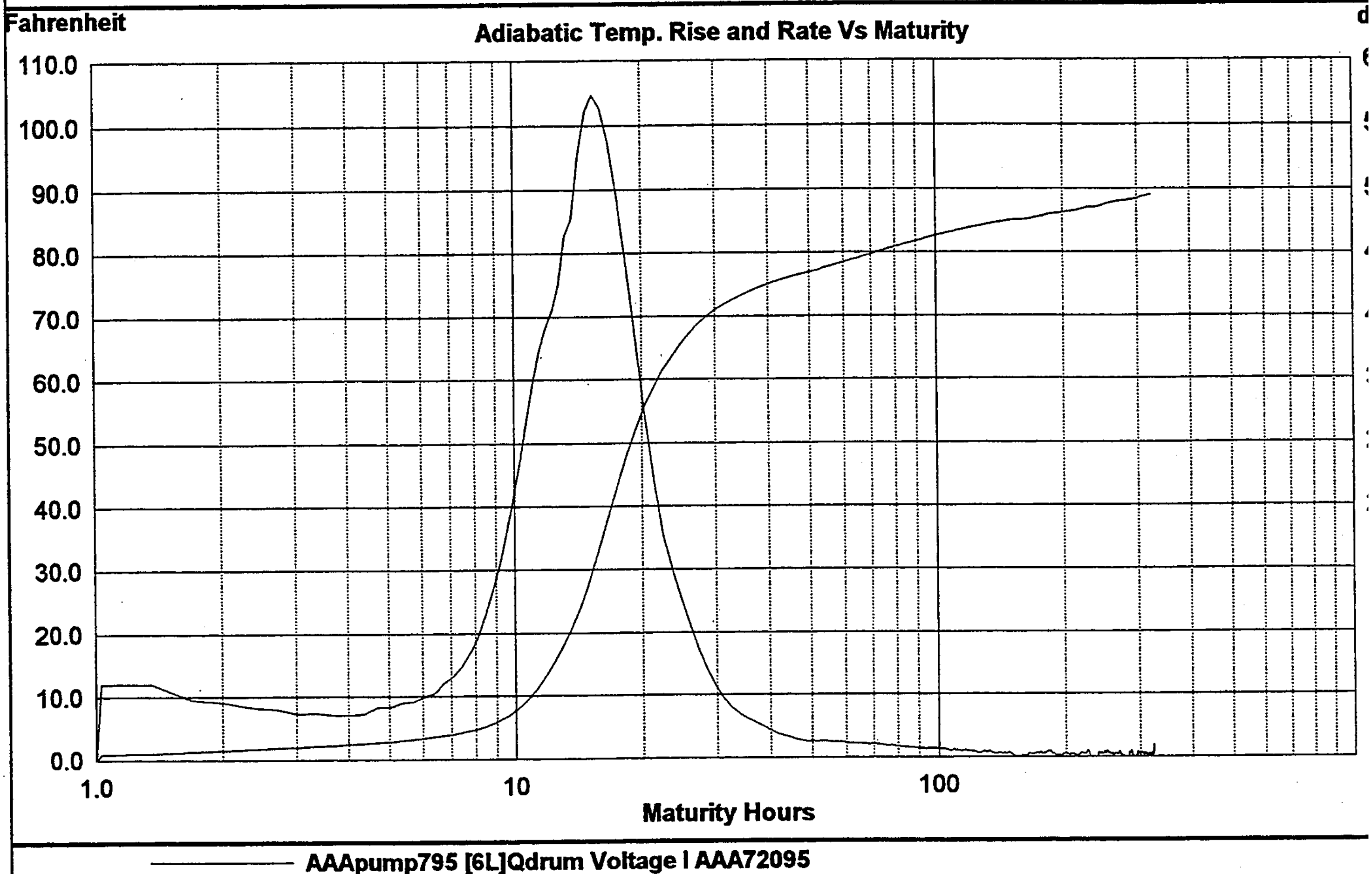
PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



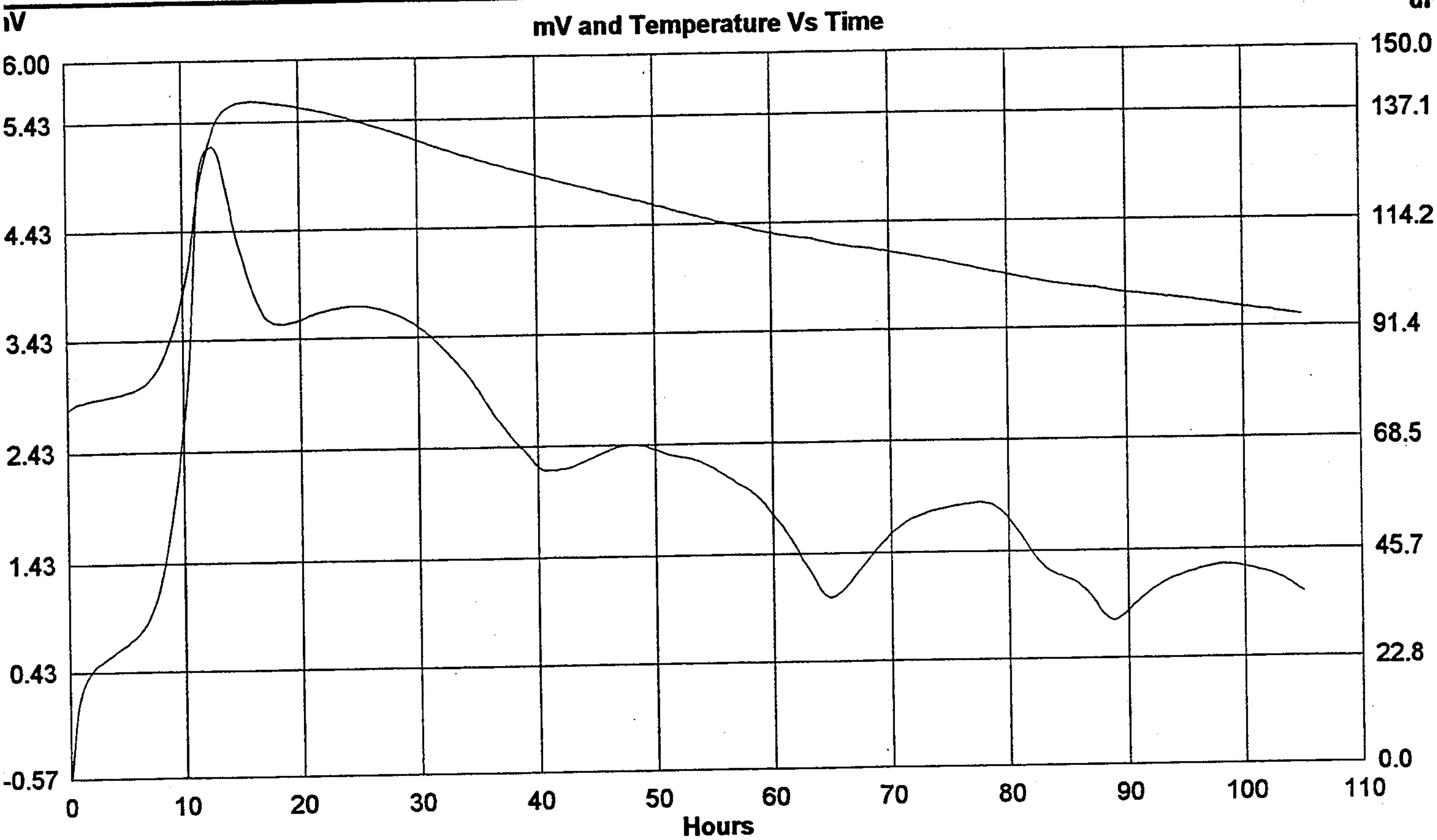
PenDOT

Harrisburg

QUADREL 1.5

Graphing

Date: 06-17-1996



AAApump795 [6L]Qdrum Voltage I AAA72095

APPENDIX 'D' MIX DESIGN AND MATURITY DATA FOR EXPERIMENTAL CLASS AAA CEMENT CONCRETE WITH DCI CORROSION-INHIBITOR

TR-4221A (10-94)

CONCRETE MIX DESIGN FORM

JMF No. 95 345

MAT'L CLASS AAA-Flyash
DATE: 12/05/94
DISTRICT: 8-0
CMS NO.: 085172

S.R.: 0081 Section/Segment 004/007 FA No.

Concrete Producer/Code The Lane Construction Corp. Plant #20 Lane

MATERIAL	TYPE	PRODUCER-LOCATION	SUPPLIER CODE	S.G.	ABS.	LAB. #
Cement	I	Allentown-Blandon, PA	ALLN1-15			
Pozzolan	F	National Minerals-Manson, PA	NATMC-15	2.49		94-042850
Fine Aggregate	A	York Building Supply-Belv, MD	YOP-MDC	2.63	.39	93-036073
Coarse Aggregate	#57-A	Pennsy Supply-Hummelstown, PA	PES-22B	2.81	.41	94-030032
Water		On Site Well				
Admixture-AEA	MBAE-90	Master Builders	MATSO-15	8.0	oz./c.y. (as required)	
Admixture	RET 100 XR	Master Builders	MATSO-15	22.5	oz./c.y. (as required)	
Admixture	WR MBL-82	Master Builders	MATSO-15	30	oz./c.y. (as required)	
Admixture	Corrosive	Inhibitor DCI Grace	GRACO-15	3	gal/c.y. (as required)	

Strength Data Based On: .38 W/C Ratio Taken From Worksheet Dated: 12/05/94

Compr. Str.: 7 days 5245 avg. psi 28 days 6189 avg. psi %Solids Used N/A F.M. 2.80

CONCRETE MIX SUMMARY (One Cubic Yard) by ACI Method

Mix No.	Trial	#1	#2	#3
W/C Ratio, by Wt.	.38	.37	.36	.35
Cement, lbs.	636	636	636	636
Pozzolan, lbs.	114	114	114	114
Water, lbs.	286	278	270	263
Coarse Agg. (S.S.D), lbs.	1855	1855	1855	1855
____, lbs.				
Fine Agg. (S.S.D.), lbs.	1003	1024	1045	1065
Total, lbs.	3894	3907	3920	3933
Unit Weight, lbs./C.F.	144.2	144.7	145.2	145.7
Water, gals.	34.5	33.5	32.5	31.7
Mortar Content, C.F.	16.42	16.42	16.42	16.42
At Pt. of Placement: Slump	4 in.			
Air	6.5 %			

Designed by Harry McHenrich Date 1-26-95

Approved & Submitted by [signature] Date 1-27-95

Reviewed by Mat'ls Engineer [signature] Date

RECEIVED JAN 2 9 1995 MATERIALS UNIT 8-0

TR-4221A

MIX DESIGN WORKSHEET

Class AAA-Flyash Co

District 8-0

Date 12/05/94

Concrete Producer The Lane Construction Corp. Project or Plant #20 Plant - Grantvil

Mix Design by ACI Method

Square Screen Analysis % Passing

Screen Sizes	1½	1	1/2	3/8	#4	#8	#16	#30	#50	#100
F.A.				100	98	85	67	47	19	4
C.A. #57 Stone	100	98	36		4	1				

Maximum Density ______ P.C.F., S.S.D. F.M. 2.80

S.G. Factor of Slag ______ % Solids (PDT only) ______

Volume of C.A. 10.58

TRIAL MIX

Wt./Volume Calculations: W C RATIO .38 b

Cement	6.77 Bags x 0.478	=	3.23 C.F. x	(3.15 x 62.4)	=	636
Pozzolan	F	=	.73 C.F. x	(2.49 x 62.4)	=	114
C.A.	#57	=	10.58 C.F. x	(2.81 x 62.4)	=	1855
Water	34.5 Gals. x 0.133	=	4.59 C.F. x	62.4	=	286
6.5 % Air	= 27.0 x .065	=	1.76 C.F.			
		Sub-total	20.89 C.F.			
F.A.	= 27.00 − 20.89	=	6.11 C.F.			
Weight of F.A.	6.11 x 2.63 x 62.4				=	1003
Totals/C.Y. =	34.5 Gals.		27.00 C.F.			3894

Temperature: Concrete 58 F Air 54 F 142.8 #/C.F. Actual

Initial: Slump 5 in. Air Content 7.4 % Unit Wt. 144.2 #/C.F. Calcula

At Point of Placement: Slump 4 in. Air Content 6.5 % Mortar Content 16.42

Strength	Days	1	2	Avg.	Days	1	2	Avg.
Compressive	4	4562	4474	4518	28	6189	6189	6189
Compressive	7	5218	5271	5245				

MIX NO. 1 (ADJUSTED)

Wt./Volume Calculations: W C RATIO .37 by

Cement	6.77 Bags x 0.478	=	3.23 C.F. x	(3.15 x 62.4)	=	636
Pozzolan	F	=	.73 C.F. x	(2.49 x 62.4)	=	114
C.A.	#57	=	10.58 C.F. x	(2.81 x 62.4)	=	1855
Water	33.5 Gals. x 0.133	=	4.46 C.F. x	62.4	=	278
6.5 % Air	= 27.0 x .065	=	1.76 C.F.			
		Sub-total	20.76 C.F.			
F.A.	= 27.00 − 20.76	=	6.24 C.F.			
Weight of F.A.	6.24 x 2.63 x 62.4				=	1024
Totals/C.Y. =	33.5 Gals.		27.00 C.F.			3907

At Point of Placement:

Slump 4 In. Air Content 6.5 % Calc. Unit Weight 144.7 #/C.F. Mortar Content 16.42

TR-4221B (12-77)

MIX DESIGN WORKSHEET

Class AAA-Flyash Concrete

District 8-0

Date 12/05/94

Concrete Producer The Lane Construction Corp. Project or Plant #20 Plant - Grantville

Mix Design by ACI Method

MIX NO. 2 (ADJUSTED)

Wt./Volume Calculations: W/C RATIO .36 by Wt.

Cement	6.77	Bags x 0.478	=	3.23 C.F. x	(3.15 x 62.4)	=	636 lbs.
Pozzolan	F		=	.73 C.F. x	(2.49 x 62.4)	=	114 lbs.
C.A.	#57		=	10.58 C.F. x	(2.81 x 62.4)	=	1855 lbs.
Water	32.5	Gals. x 0.133	=	4.33 C.F. x	62.4	=	270 lbs.
6.5 % Air =	27.0	x .065	=	1.76 C.F.			
		Sub-total		20.63 C.F.			
F.A. =	27.00	— 20.63	=	6.37 C.F.			
Weight of F.A.	6.37	x 2.63 x 62.4				=	1045 lbs.
Totals/C.Y. =	32.5	Gals.		27.00 C.F.			3920 lbs.
Calc. Unit Weight	145.2	#/C.F.			Mortar Content		16.42 C.F.

MIX NO. 3 (ADJUSTED)

Wt./Volume Calculations: W/C RATIO .35 by Wt.

Cement	6.77	Bags x 0.478	=	3.23 C.F. x	(3.15 x 62.4)	=	636 lbs.
Pozzolan	F		=	.73 C.F. x	(2.49 x 62.4)	=	114 lbs.
C.A.	#57		=	10.58 C.F. x	(2.81 x 62.4)	=	1855 lbs.
Water	31.7	Gals. x 0.133	=	4.21 C.F. x	62.4	=	263 lbs.
6.5 % Air =	27.0	x .065	=	1.76 C.F.			
		Sub-total		20.51 C.F.			
F.A. =	27.00	— 20.51	=	6.49 C.F.			
Weight of F.A.	6.49	x 2.63 x 62.4				=	1065 lbs.
Totals/C.Y. =	31.7	Gals.		27.00 C.F.			3933 lbs.
Calc. Unit Weight	145.7	#/C.F.			Mortar Content		16.42 C.F.

MIX NO. (ADJUSTED)

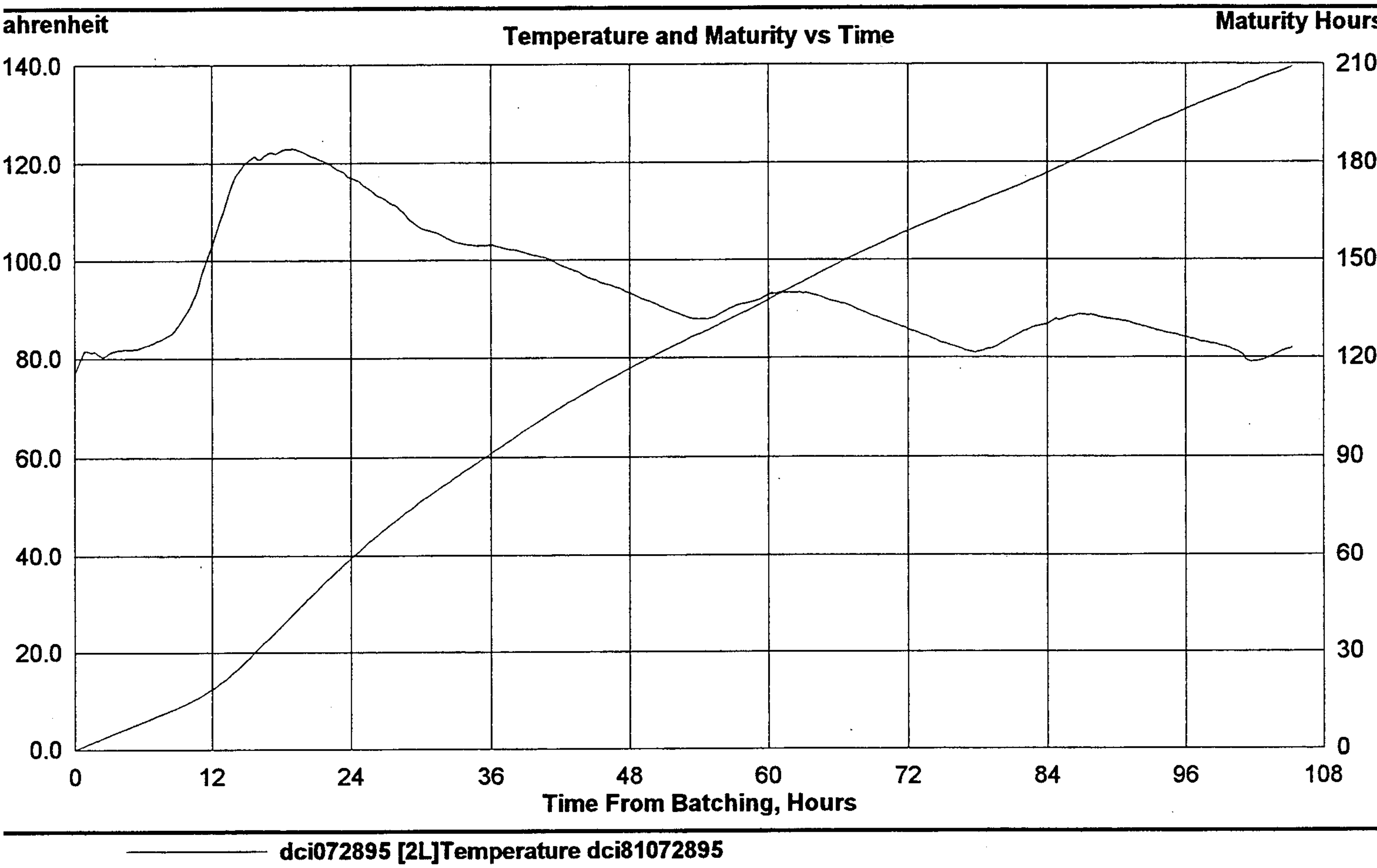
Wt./Volume Calculations: W/C RATIO ___ by Wt.

Cement		Bags x 0.478	=	C.F. x	(3.15 x 62.4)	=	lbs.
Pozzolan			=	C.F. x	(x 62.4)	=	lbs.
C.A.			=	C.F. x	(x 62.4)	=	lbs.
Water		Gals. x 0.133	=	C.F. x	62.4	=	lbs.
% Air =	27.0	x	=	C.F.			
		Sub-total		C.F.			
F.A. =	27.00	—	=	C.F.			
Weight of F.A.		x x 62.4				=	lbs.
Totals/C.Y. =		Gals		27.00 C.F.			lbs.
Calc. Unit Weight		#/C.F.			Mortar Content		C.F.

FIELD MATURITY TEST DATA FOR JULY 28,1995

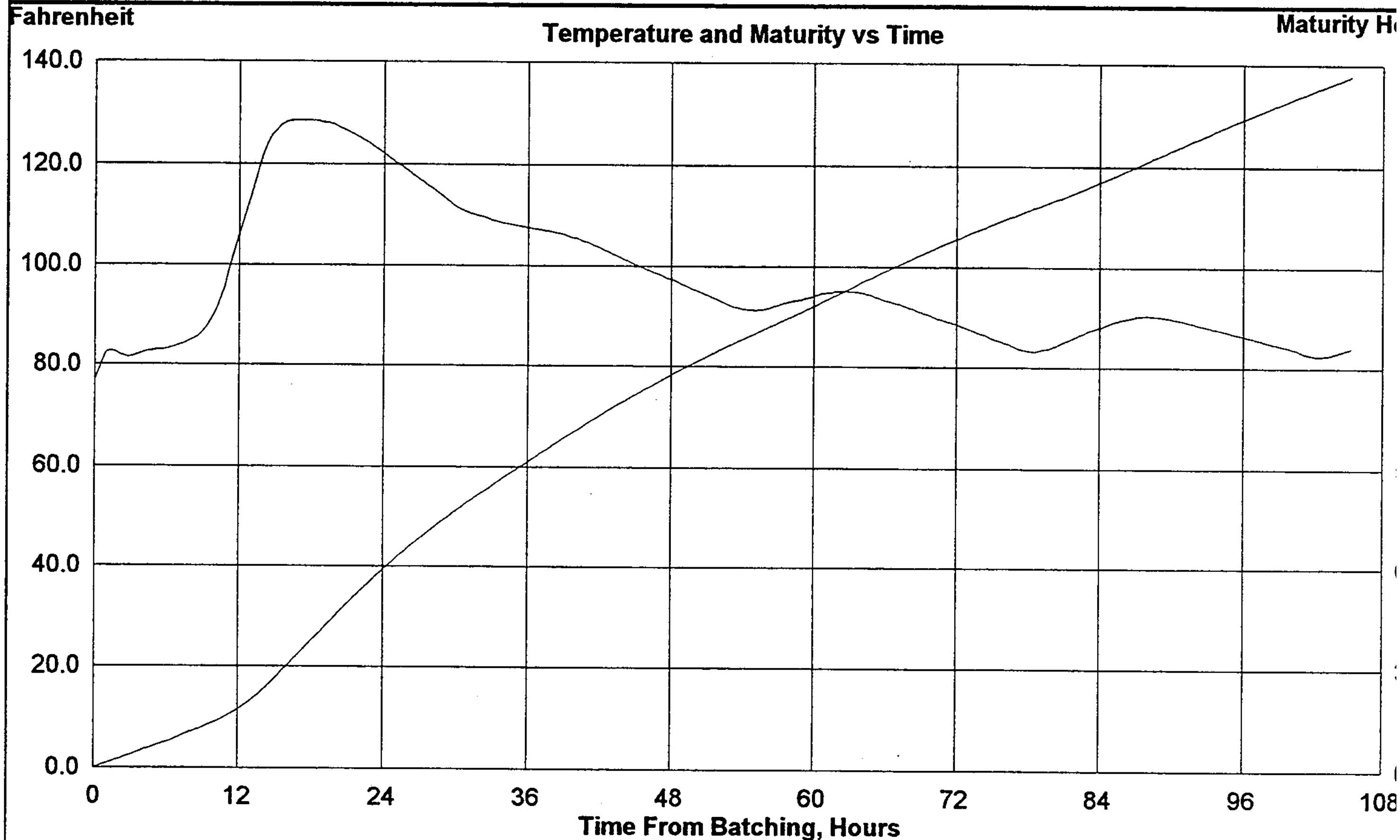
PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



PenDOT Harrisburg	QUADREL 1.5 Graphing

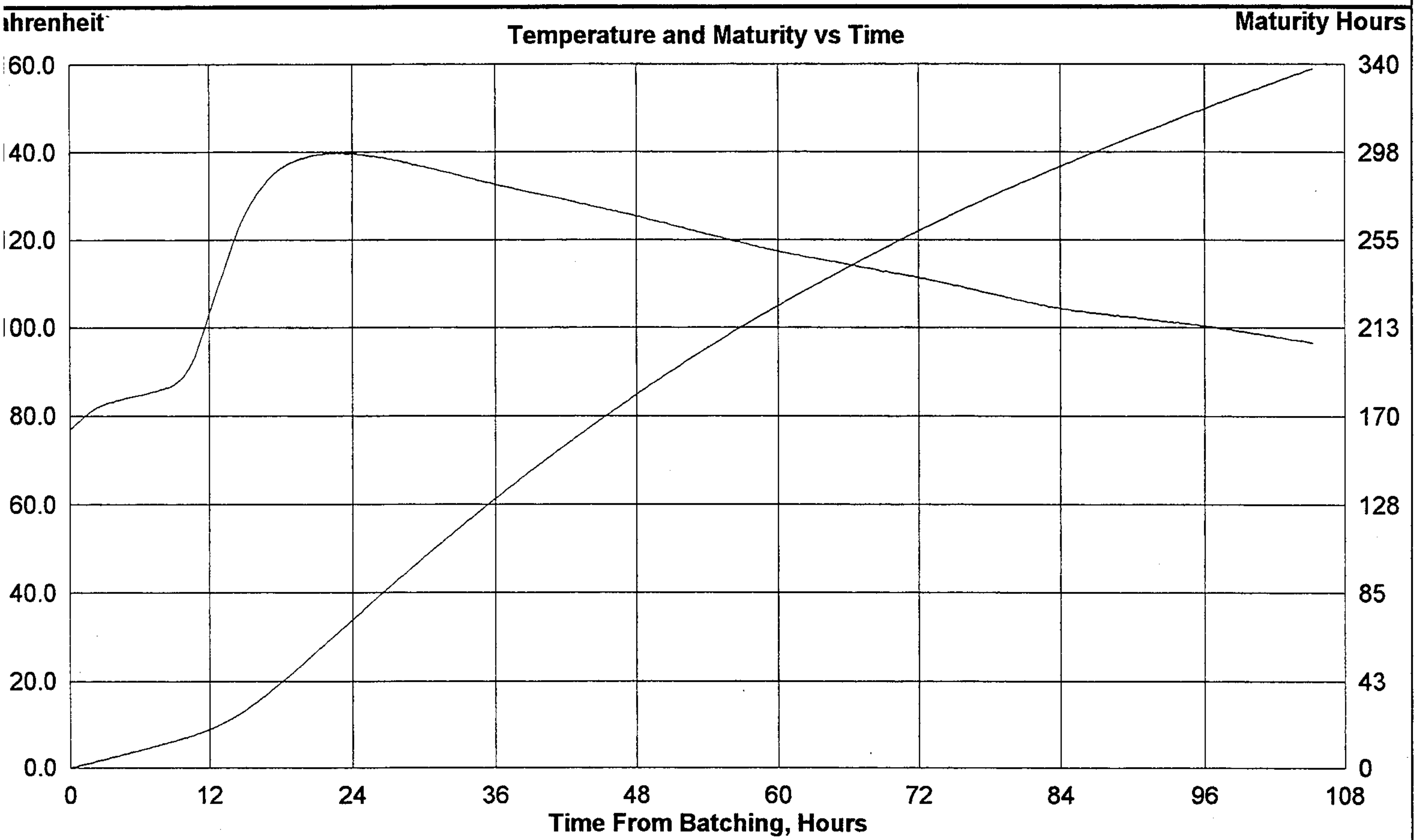
Date: 06-17-1996



dci072895 [4L]Temperature dci81072895

PenDOT	QUADREL 1.5
Harrisburg	Graphing

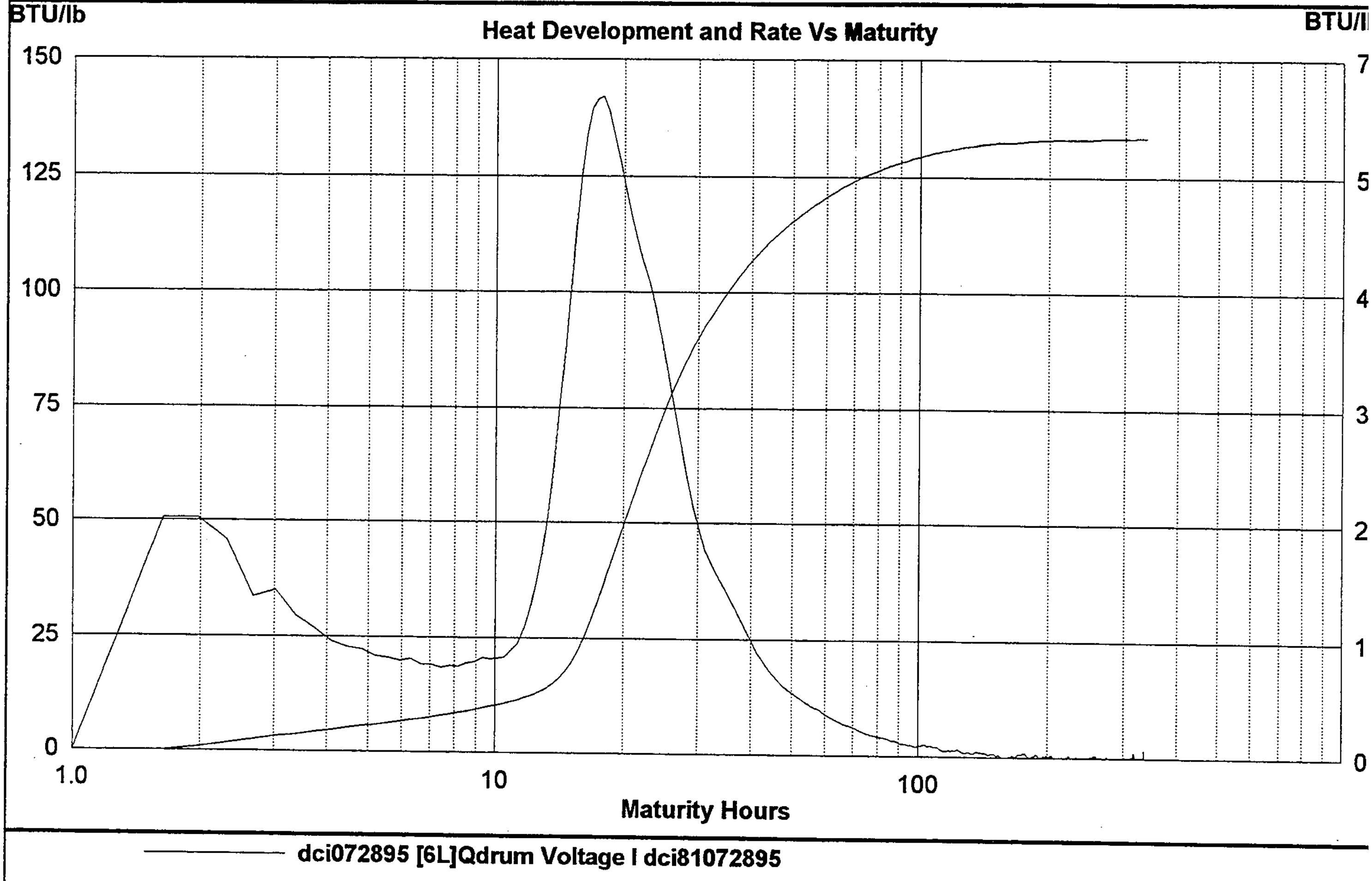
Date: 06-17-1996



dci072895 [6L]Qdrum Voltage I dci81072895

PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



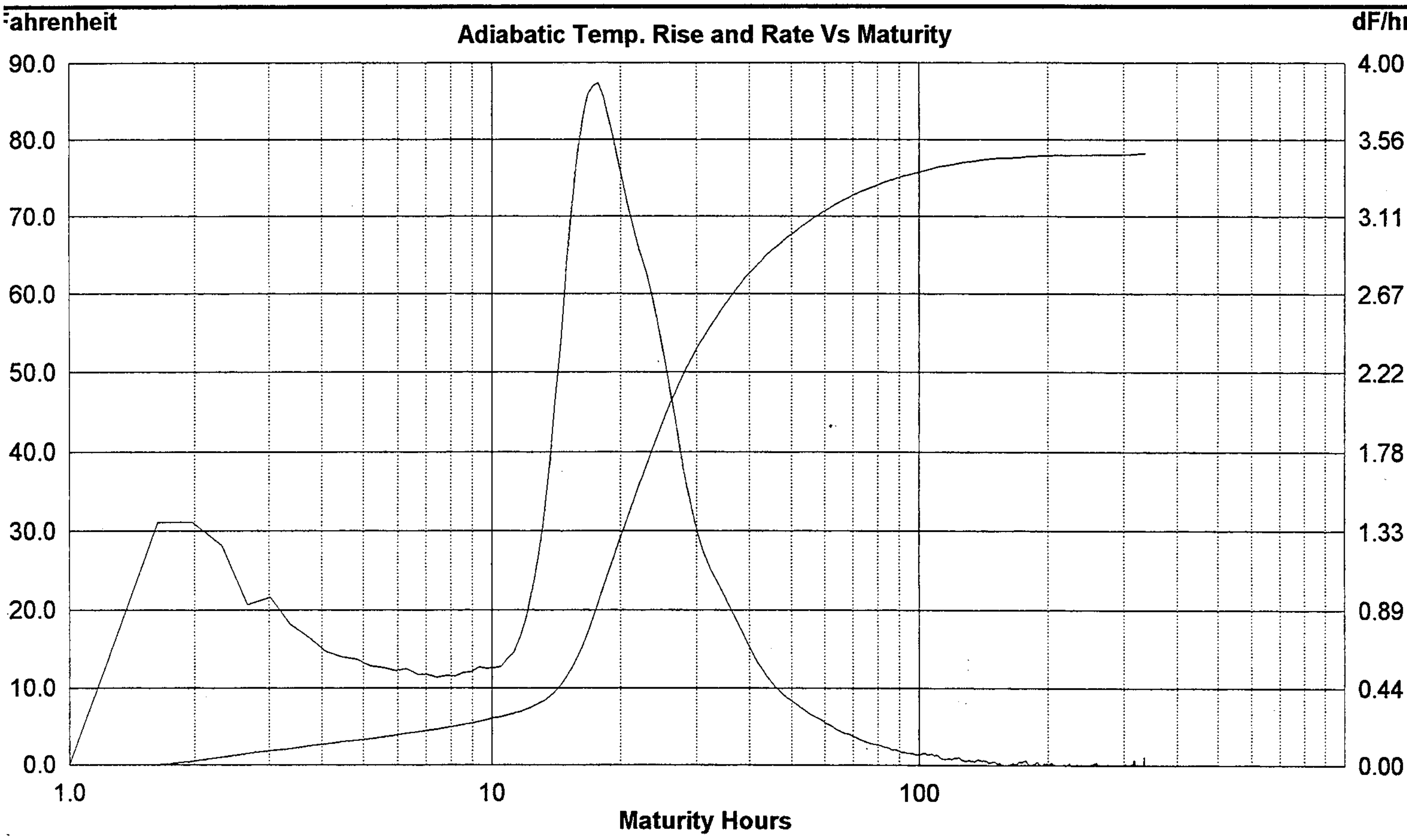
PenDOT

Harrisburg

QUADREL 1.5

Graphing

Date: 06-17-1996



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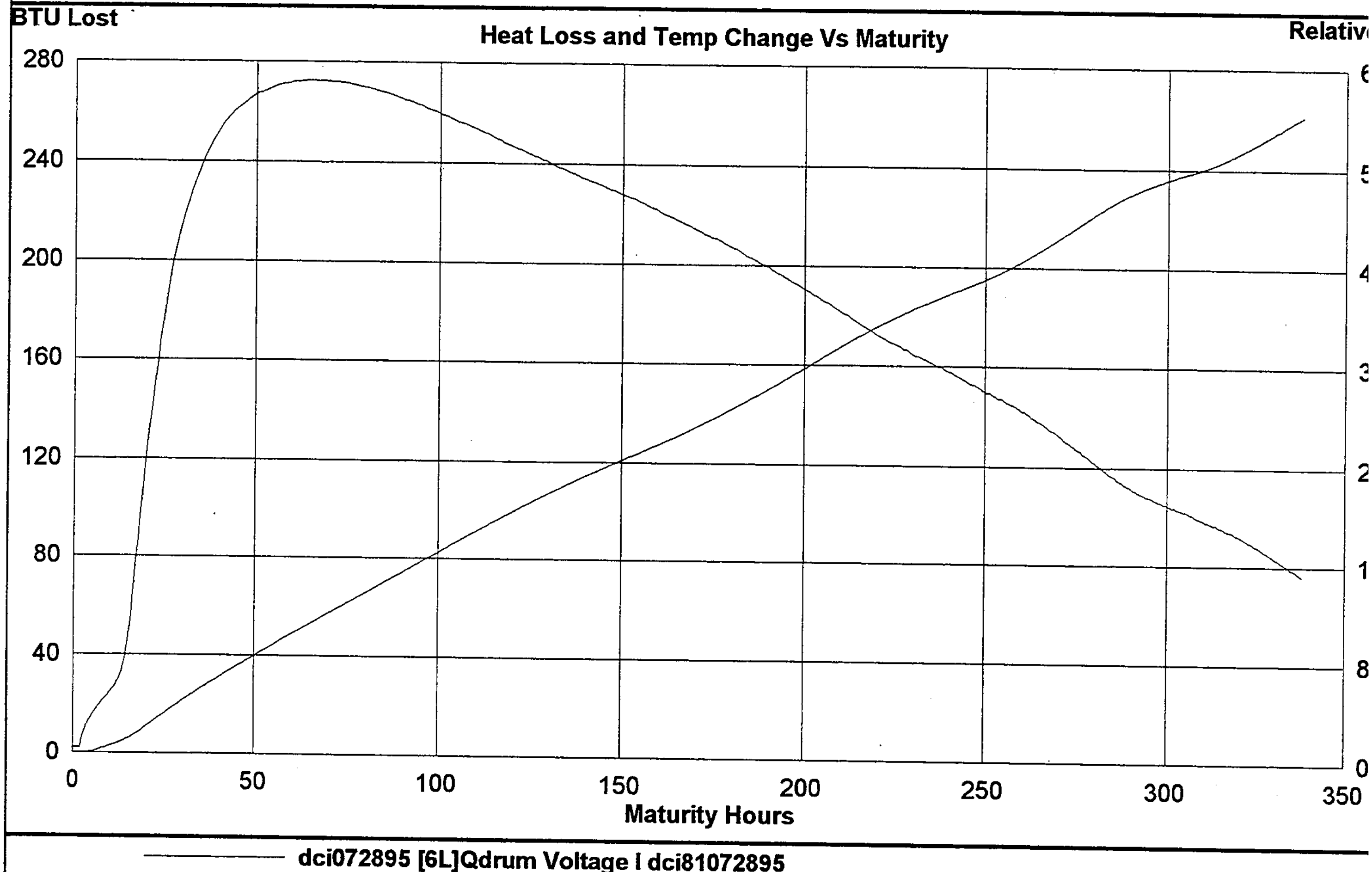
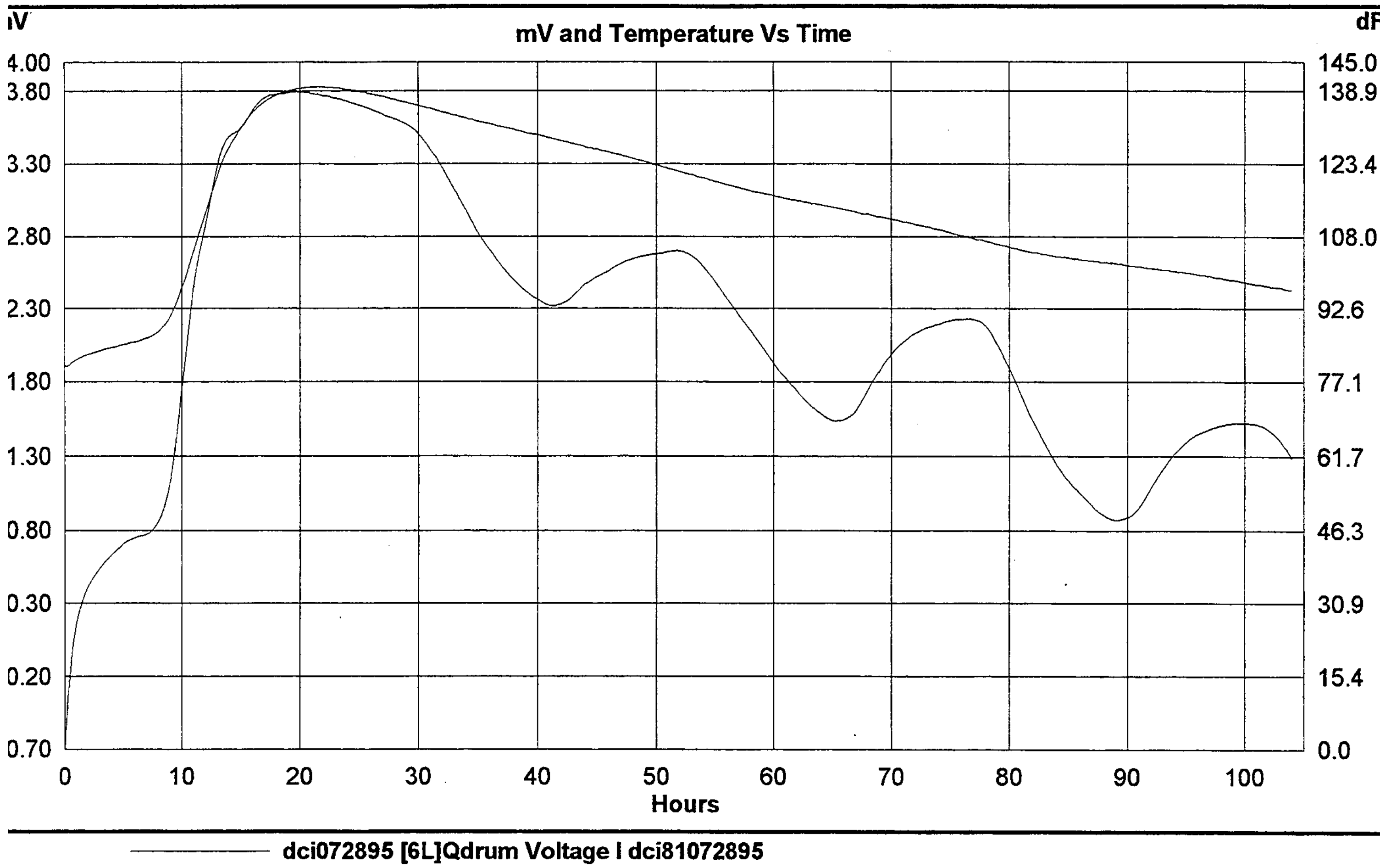
PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



PenDOT	QUADREL 1.5
Harrisburg	Graphing

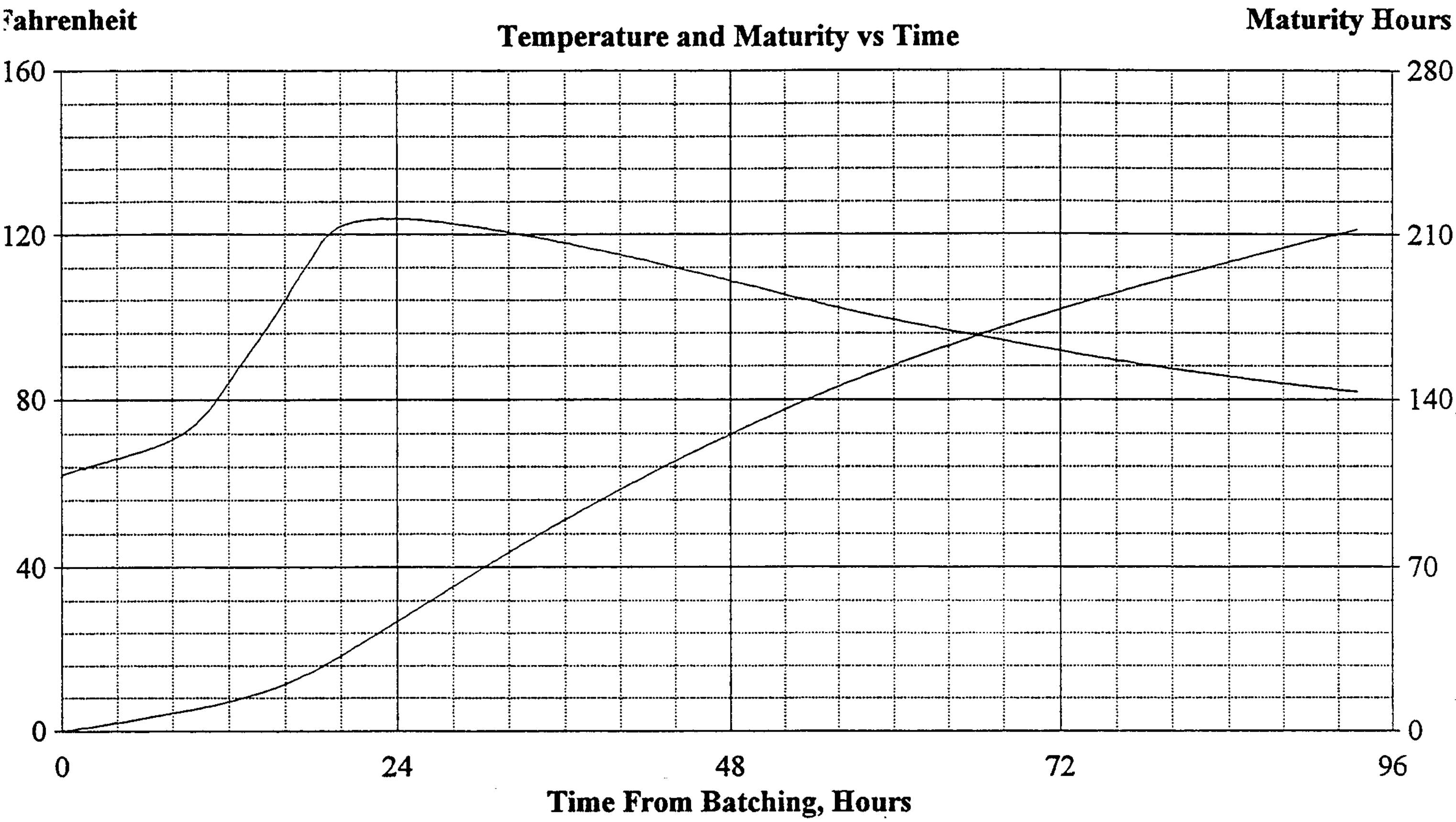
Date: 06-17-1996



PLANT MATURITY TEST DATA FOR NOVEMBER 9,1994

PennDOT

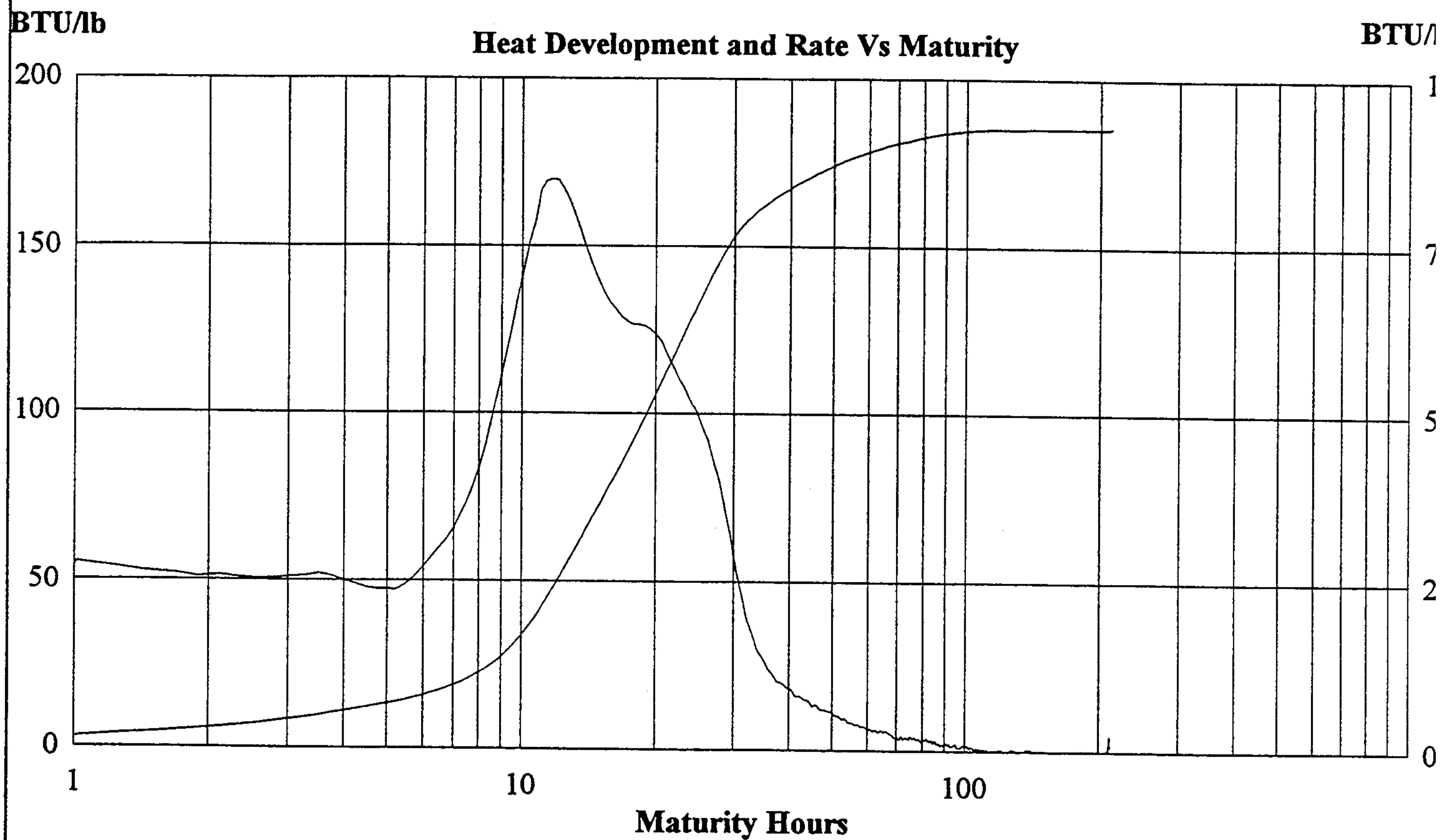
2/3/95



dci110994 [6L] dci111494

PennDOT

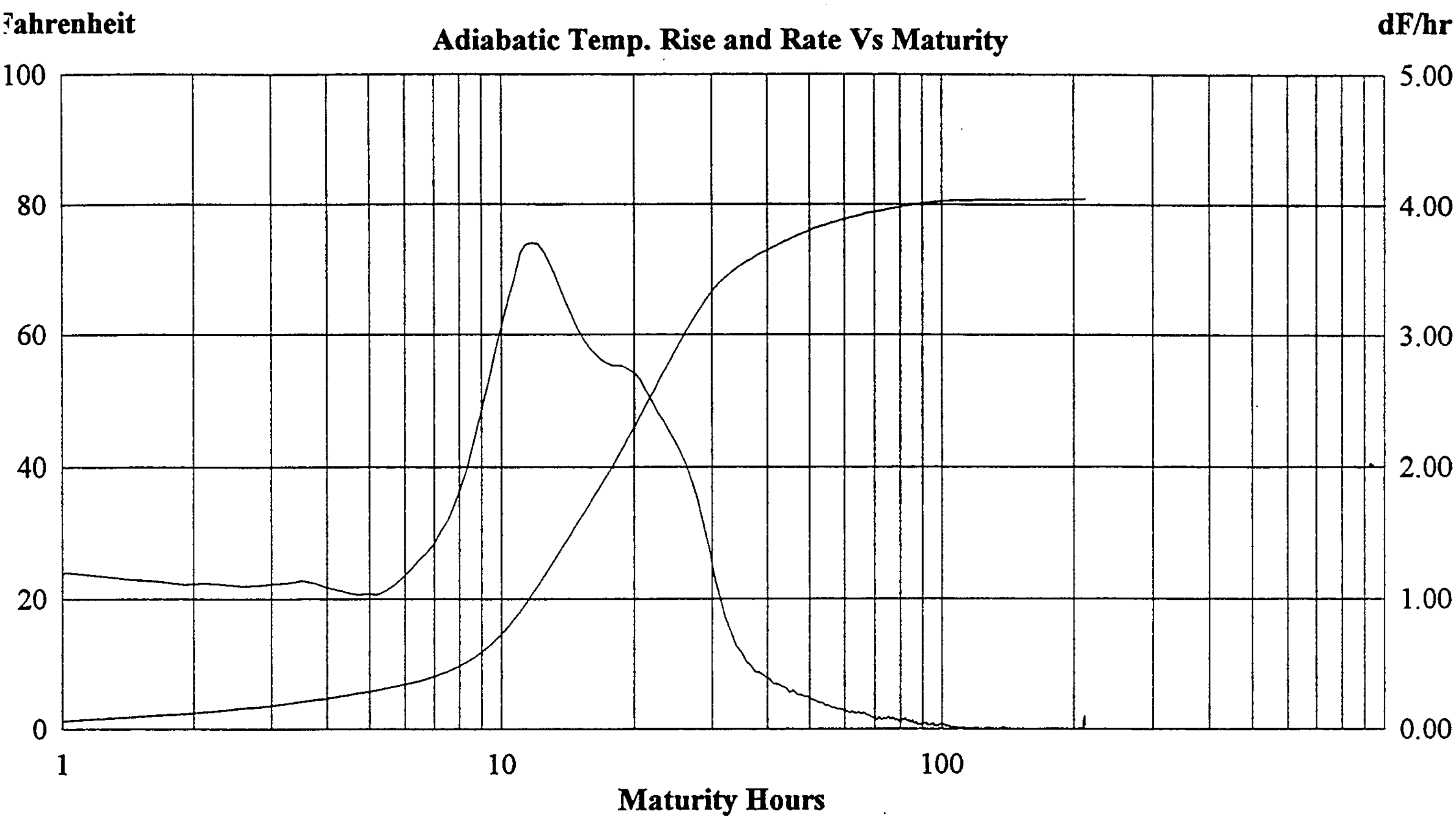
2/3/95



dci110994 [6L] dci111494

PennDOT

2/3/95



dci110994 [6L] dci111494

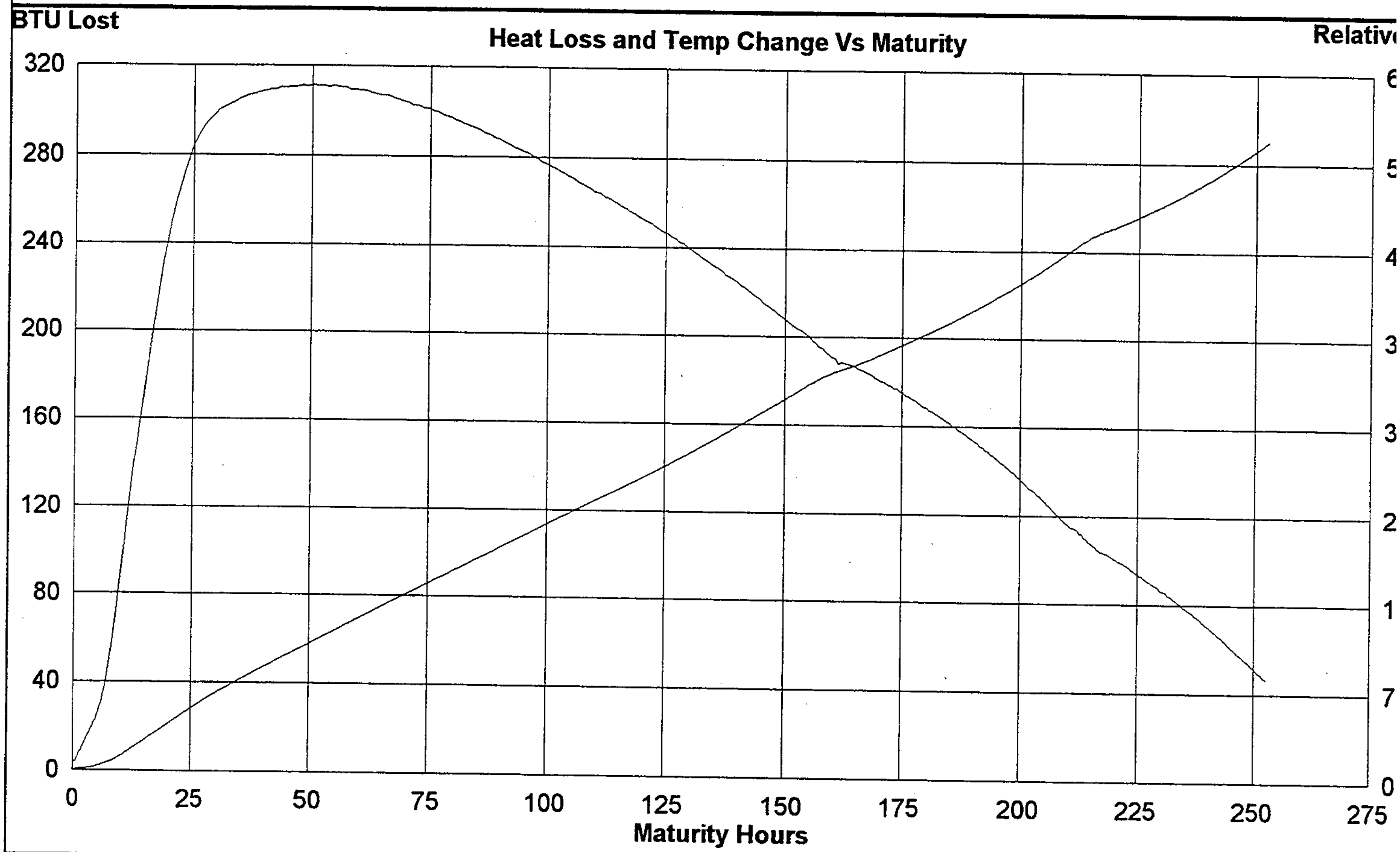
PenDOT

Harrisburg

QUADREL 1.5

Graphing

Date: 06-17-1996



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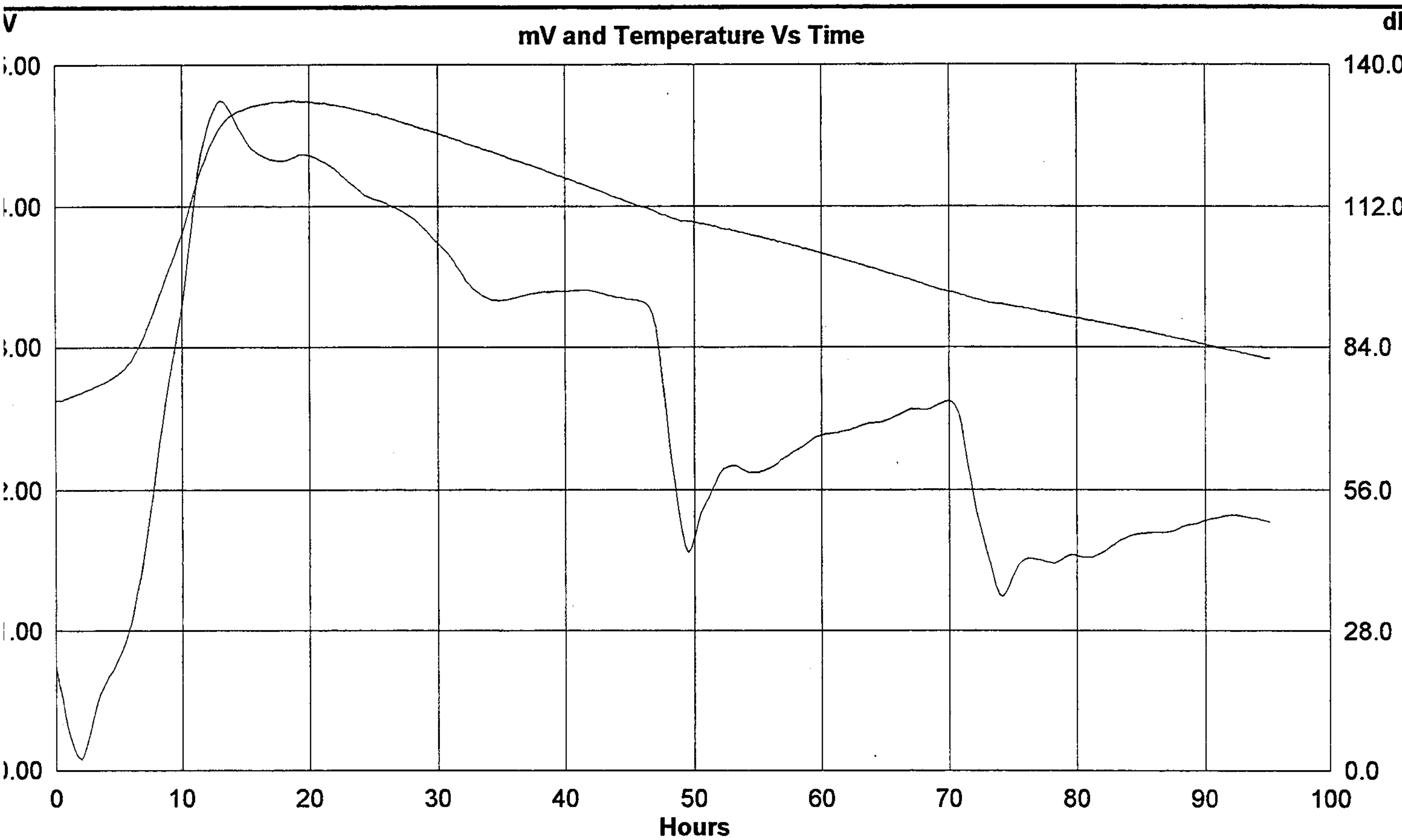
PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



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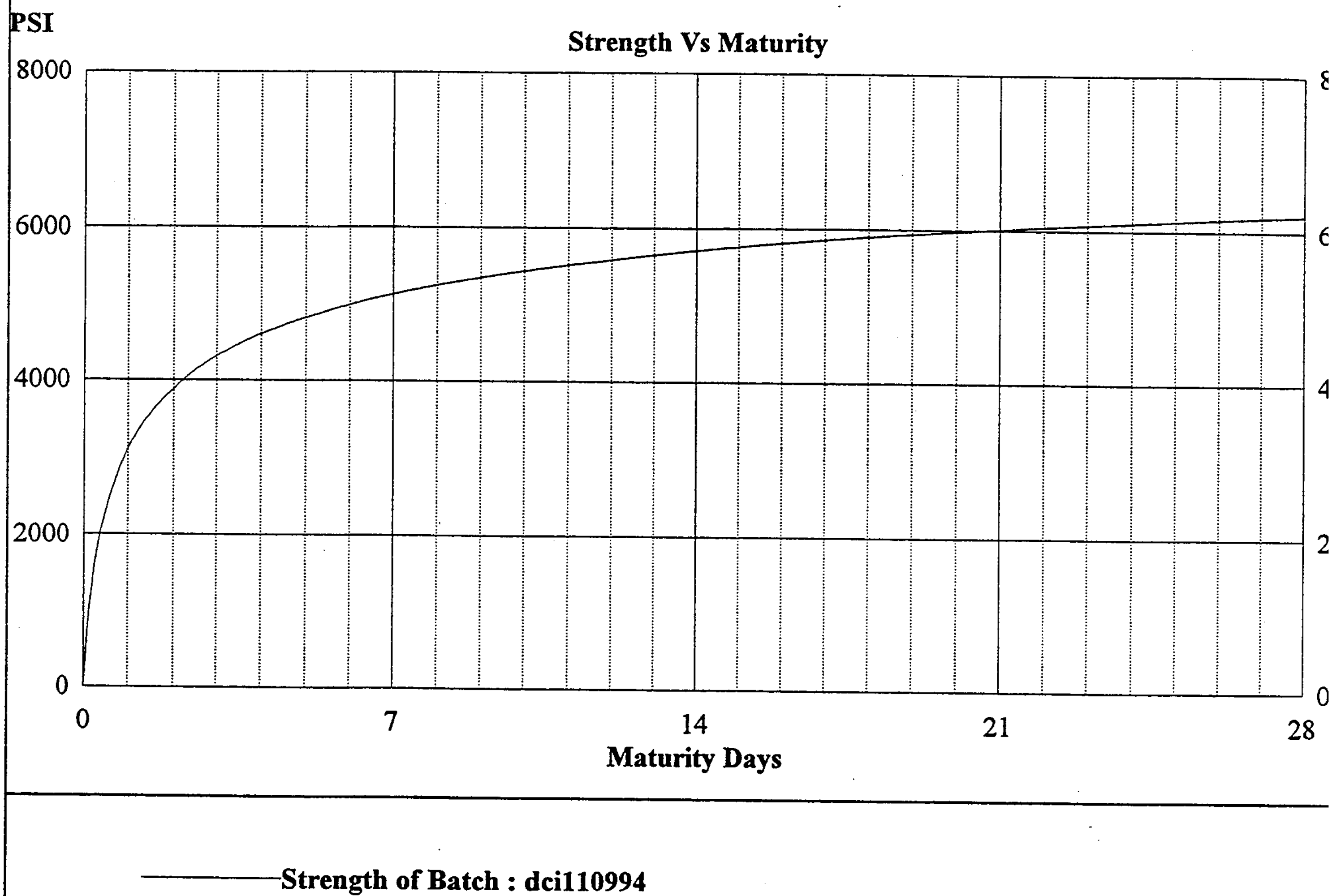
PennDOT

2/3/95



APPENDIX 'E' MIX DESIGN AND MATURITY DATA FOR EXPERIMENTAL CLASS AAA CEMENT CONCRETE WITH ARMATEC 2000 CORROSION-INHIBITOR

TR-4221A (10-94)

CONCRETE MIX DESIGN FORM

JMF No. 95 342

MAT'L CLASS AAA-Flyash

DATE: 12/05/94

DISTRICT: 8-0

CMS NO.: 085172

S.R.: 0081 Section/Segment 004/007 FA No.

Concrete Producer/Code The Lane Construction Corp. Plant #20 Lane

MATERIAL	TYPE	PRODUCER-LOCATION	SUPPLIER CODE	S.G.	ABS.	LAB. #
Cement	I	Allentown-BLandon,PA	ALLN1-15			
Pozzolan	F	National Minerals-Manson,PA	NATMC-15	2.49		94-042
Fine Aggregate	A	York Building Supply-Belv,MD	YOP-MDC	2.63	.39	93-036
Coarse Aggregate	#57-A	Pennsy Supply-Hummelstown,PA	PES-22B	2.81	.41	94-030
Water		On Site Well				
Admixture-AEA	MBAE-90	Master Builders	MASTO-15	4.5	oz./c.y. (as required)	
Admixture WR	MBL-82	Master Builders	MASTO-15	30	oz./c.y. (as required)	
Admixture	RET 100 XR	Master Builders	MASTO-15	15	oz./c.y. (as required)	
Admixture	Corrosive	Inhibitor Armatec 2000 Seka	SEKA-15	64	oz./c.y. (as required)	

Strength Data Based On: .38 W/C Ratio Taken From Worksheet Dated: 12/05/94

Compr. Str.: 7 days 5137 avg. psi 28 days 6269 avg. psi

CONCRETE MIX SUMMARY (One Cubic Yard) by ACI Method

%Solids Used: N/A F.M.: 2.80

Mix No.	Trial	#1	#2	#3
W/C Ratio, by Wt.	.38	.37	.36	.35
Cement, lbs.	636	636	636	636
Pozzolan, lbs.	114	114	114	114
Water, lbs.	286	278	270	263
Coarse Agg. (S.S.D), lbs.	1855	1855	1855	1855
______, lbs.				
Fine Agg. (S.S.D.), lbs.	1003	1024	1045	1065
Total, lbs.	3894	3907	3920	3933
Unit Weight, lbs./C.F.	144.2	144.7	145.2	145.7
Water, gals.	34.5	33.5	32.5	31.7
Mortar Content, C.F.	16.42	16.42	16.42	16.42
At Pt. of Placement:				
Slump	4 in.			
Air	6.5 %			

Designed by Harry M. Henrich Date 1-26-95

Approved & Submitted by [signature] Date 1-29-95

Reviewed by Mat'ls Engineer [signature] Date

RECEIVED JAN 29 1995 MATERIALS UNIT 8-0

TR-4221A

MIX DESIGN WORKSHEET

Class AAA-Flyash Concret
District 8-0
Date 12/05/94

Concrete Producer The Lane Construction Corp. Project or Plant #20 Plant - Grantville
Mix Design by ACI Method

Square Screen Analysis % Passing

Screen Sizes	1½	1	1/2	3/8	#4	#8	#16	#30	#50	#100
F.A.				100	98	85	67	47	19	4
C.A. #57 Stone	100	98	36		4	1				

Maximum Density ______ P.C.F., S.S.D. F.M. 2.80
S.G. Factor of Slag ______ % Solids (PDT only) ______
Volume of C.A. 10.58

TRIAL MIX

Wt./Volume Calculations:

					W/C RATIO .38 by Wt		
Cement	6.77 Bags x 0.478	=	3.23	C.F. x	(3.15 x 62.4)	=	636 lbs.
Pozzolan	F	=	.73	C.F. x	(2.49 x 62.4)	=	114 lbs.
C.A.	#57	=	10.58	C.F. x	(2.81 x 62.4)	=	1855 lbs.
Water	34.5 Gals. x 0.133	=	4.59	C.F. x	62.4	=	286 lbs.
6.5% Air =	27.0 x .065	=	1.76	C.F.			
		Sub-total	20.89	C.F.			
F.A. =	27.00 − 20.89	=	6.11	C.F.			
Weight of F.A.	6.11 x 2.63 x 62.4					=	1003 lbs.
Totals/C.Y. =	34.5 Gals.		27.00	C.F.			3894 lbs.

Temperature: Concrete 59° F Air 53° F 145.4 #/C.F. Actual
Initial: Slump 5" in. Air Content 6.5 % Unit Wt. 144.2 #/C.F. Calculated
At Point of Placement: Slump 4 in. Air Content 6.5 % Mortar Content 16.42 C.F.

Strength	Days	1	2	Avg.	Days	1	2	Avg.
Compressive	7	5075	5199	5137	28	6172	6366	6269
Compressive								

MIX NO. 1 (ADJUSTED)

Wt./Volume Calculations:

					W/C RATIO .37 by Wt.		
Cement	6.77 Bags x 0.478	=	3.23	C.F. x	(3.15 x 62.4)	=	636 lbs.
Pozzolan	F	=	.73	C.F. x	(2.49 x 62.4)	=	114 lbs.
C.A.	#57	=	10.58	C.F. x	(2.81 x 62.4)	=	1855 lbs.
Water	33.5 Gals. x 0.133	=	4.46	C.F. x	62.4	=	278 lbs.
6.5 % Air =	27.0 x .065	=	1.76	C.F.			
		Sub-total	20.76	C.F.			
F.A. =	27.00 − 20.76	=	6.24	C.F.			
Weight of F.A.	6.24 x 2.63 x 62.4					=	1024 lbs.
Totals/C.Y. =	34.5 Gals		27.00	C.F.			3907 lbs.

At Point of Placement:
Slump 4 In. Air Content 6.5 % Calc. Unit Weight 144.7 #/C.F. Mortar Content 16.42

TR-42218 (12-77)

MIX DESIGN WORKSHEET

Class AAA-Flyash Conc

District 8-0

Date 12/05/94

Concrete Producer The Lane Construction Corp. Project or Plant #20 Plant - Grantville

Mix Design by ACI Method

MIX NO. 2 (ADJUSTED)

Wt./Volume Calculations: W/C RATIO .36 by

Cement	6.77	Bags x 0.478	=	3.23	C.F. x	(3.15 x 62.4)	=	636
Pozzolan	F		=	.73	C.F. x	(2.49x 62.4)	=	114
C.A.	#57		=	10.58	C.F. x	(2.81x 62.4)	=	1855
Water	32.5	Gals. x 0.133	=	4.33	C.F. x	62.4	=	270
6.5 % Air =	27.0	x .065	=	1.76	C.F.			
		Sub-total		20.63	C.F.			
F.A. =	27.00	— 20.63	=	6.37	C.F.			
Weight of F.A.	6.37	x 2.63 x 62.4					=	1045
Totals/C.Y. =	32.5	Gals.		27.00	C.F.			3920

Calc. Unit Weight 145.2 #/C.F. Mortar Content 16.42 C

MIX NO. 3 (ADJUSTED)

Wt./Volume Calculations: W/C RATIO .35 by

Cement	6.77	Bags x 0.478	=	3.23	C.F. x	(3.15 x 62.4)	=	636
Pozz olan	F		=	.73	C.F. x	(2.49x 62.4)	=	114
C.A.	#57		=	10.58	C.F. x	(2.81x 62.4)	=	1855
Water	31.7	Gals. x 0.133	=	4.21	C.F. x	62.4	=	263
6.5 % Air =	27.0	x .065	=	1.76	C.F.			
		Sub-total		20.51	C.F.			
F.A. =	27.00	— 20.51	=	6.49	C.F.			
Weight of F.A.	6.49	x 2.63 x 62.4					=	1065
Totals/C.Y. =	31.7	Gals.		27.00	C.F.			3933

Calc. Unit Weight 145.7 #/C.F. Mortar Content 16.42 C.F.

MIX NO. (ADJUSTED)

Wt./Volume Calculations: W/C RATIO by

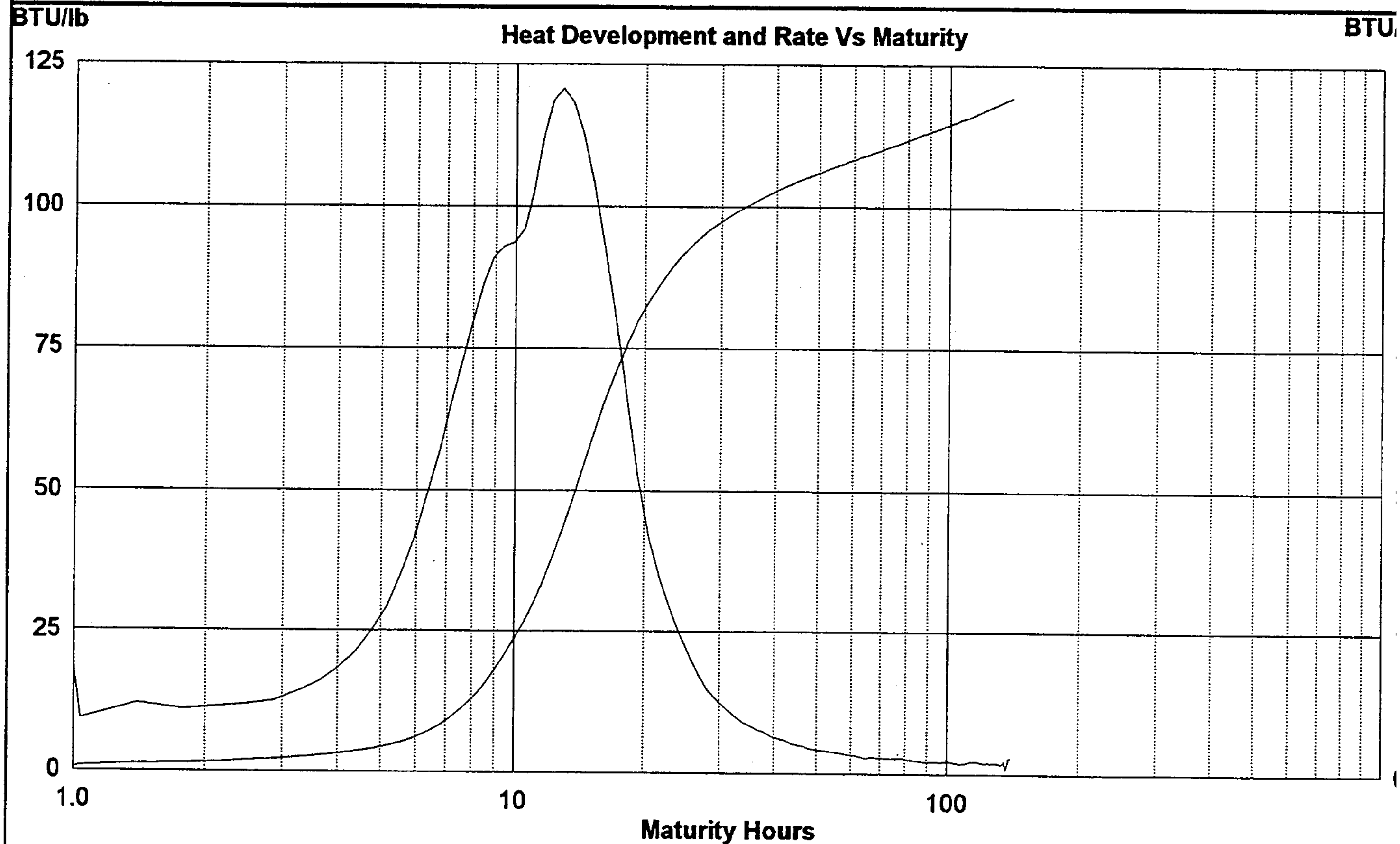
Cement		Bags x 0.478	=		C.F. x	(3.15 x 62.4)	=	lb
Pozzolan			=		C.F. x	(x 62.4)	=	lb
C.A.			=		C.F. x	(x 62.4)	=	lb
Water		Gals. x 0.133	=		C.F. x	62.4	=	lb
% Air =	27.0	x	=		C.F.			
		Sub-total			C.F.			
F.A. =	27.00	—	=		C.F.			
Weight of F.A.		x x 62.4					=	lb
Totals/C.Y. =		Gals		27.00	C.F.			lb

Calc. Unit Weight #/C.F. Mortar Content C.F

FIELD MATURITY TEST DATA FOR JULY 15,1995

PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



armatec71595 [6L]Qdrum Voltage I armatec200071595

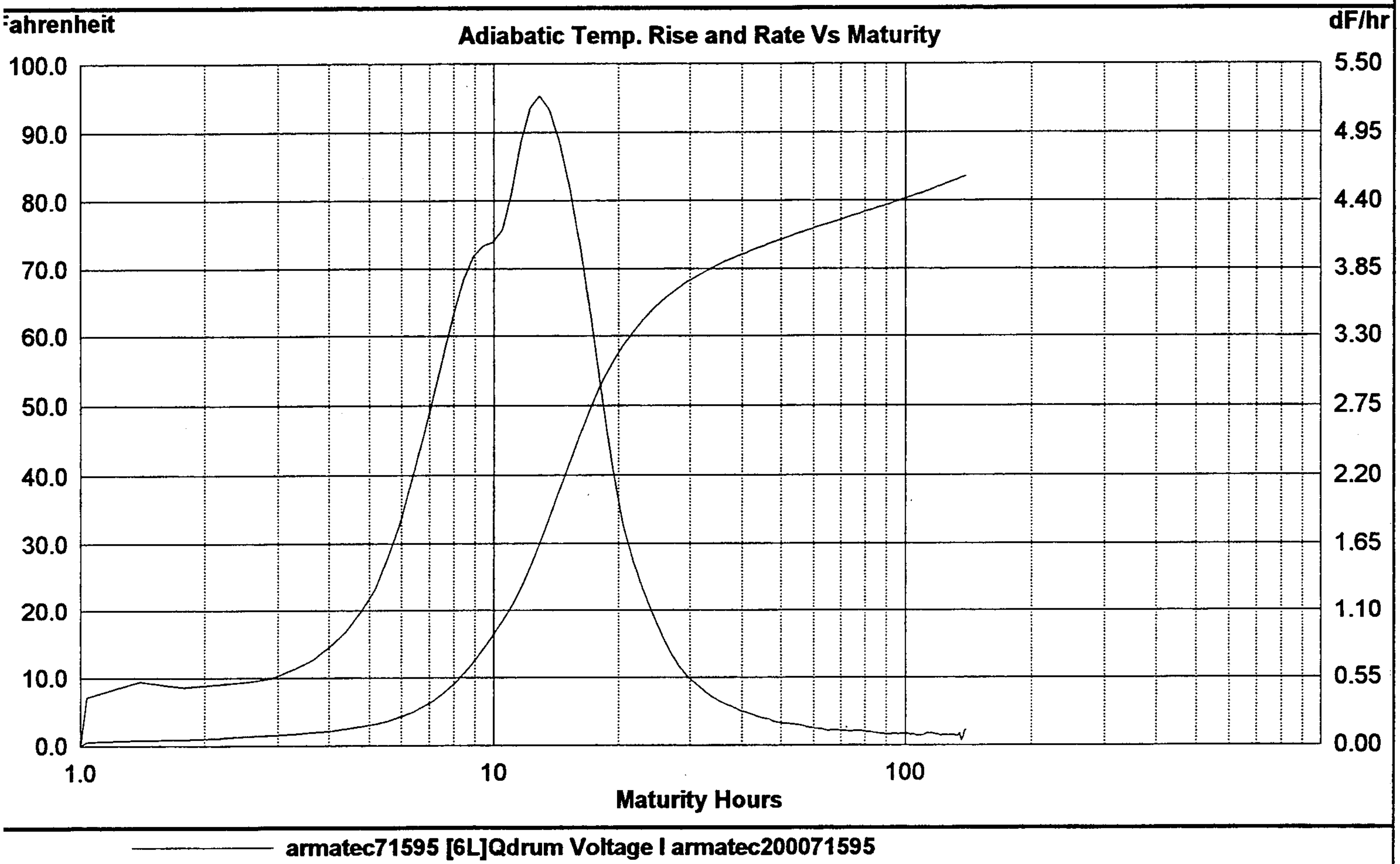
PenDOT

Harrisburg

QUADREL 1.5

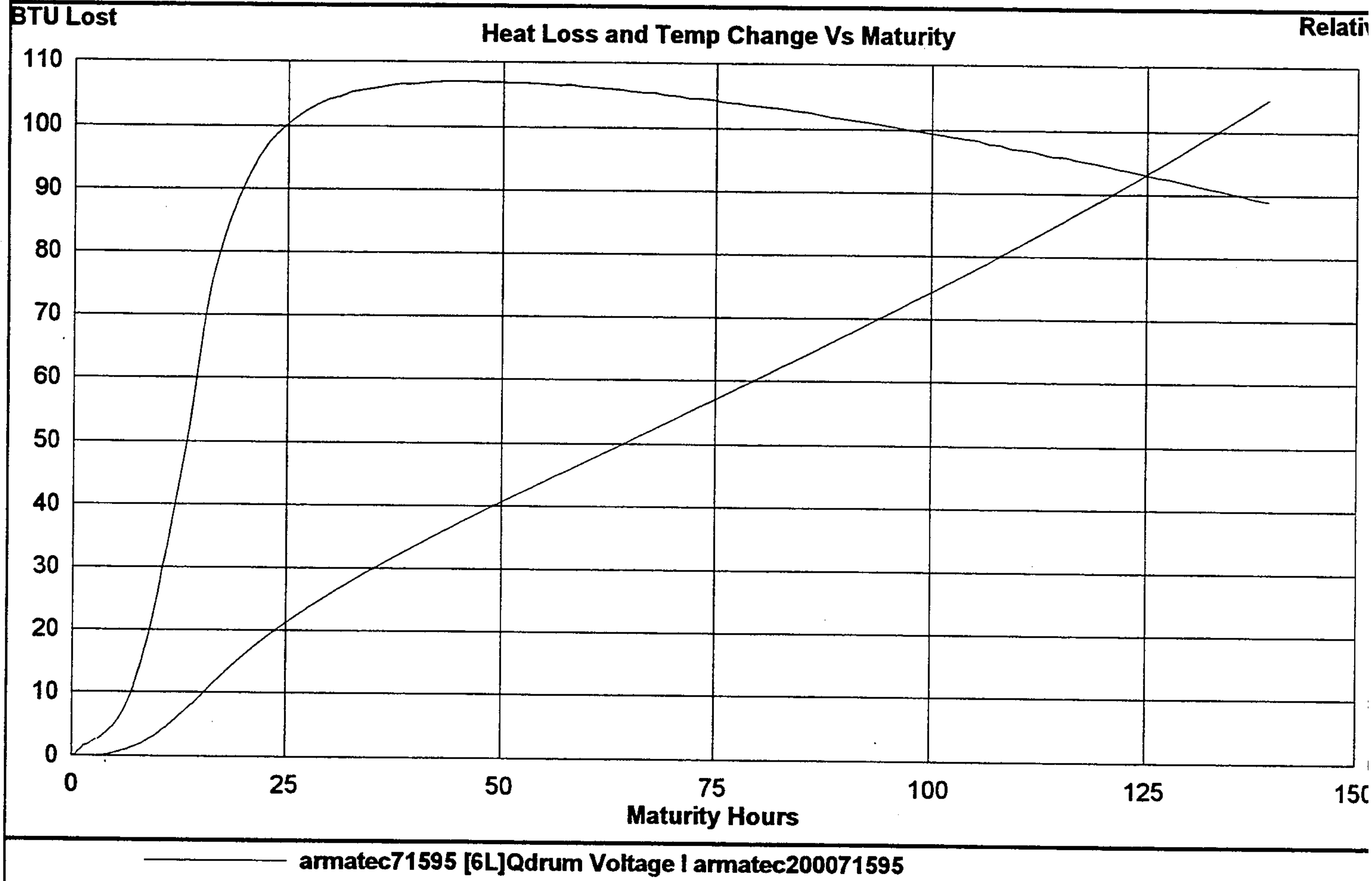
Graphing

Date: 06-17-1996



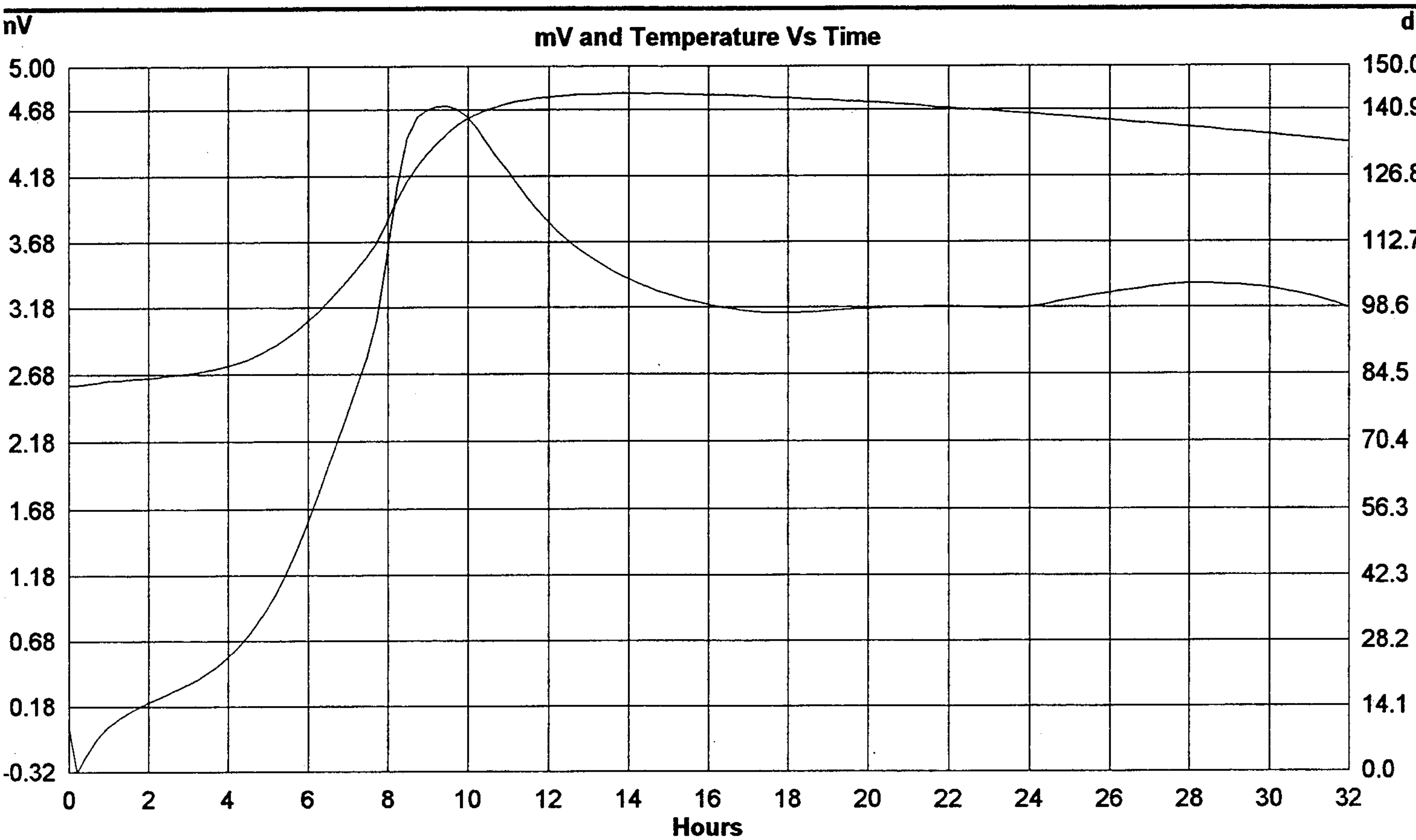
PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996

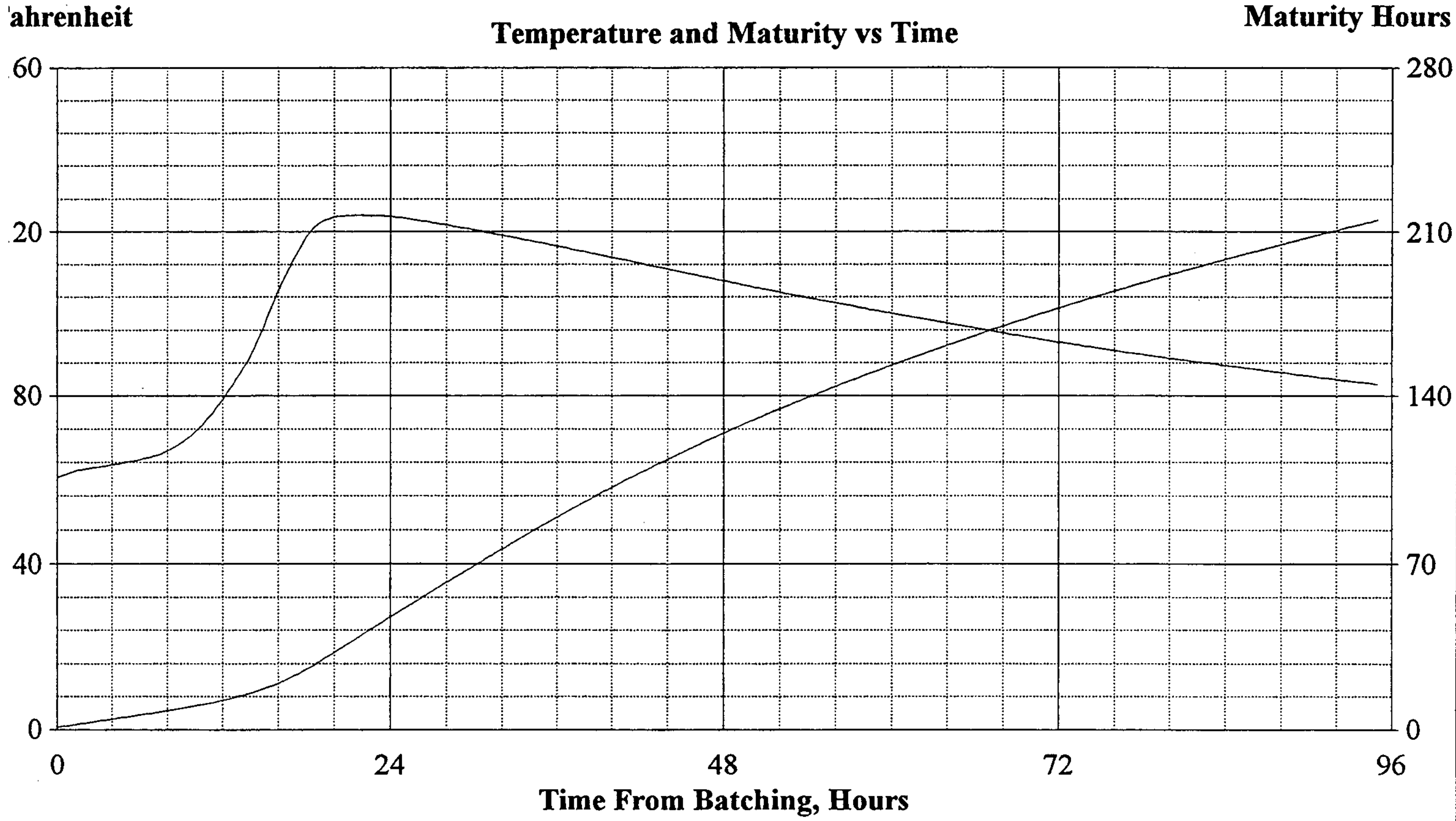


armatec71595 [6L]Qdrum Voltage I armatec200071595

PLANT MATURITY TEST DATA FOR NOVEMBER 8,1994

PennDOT

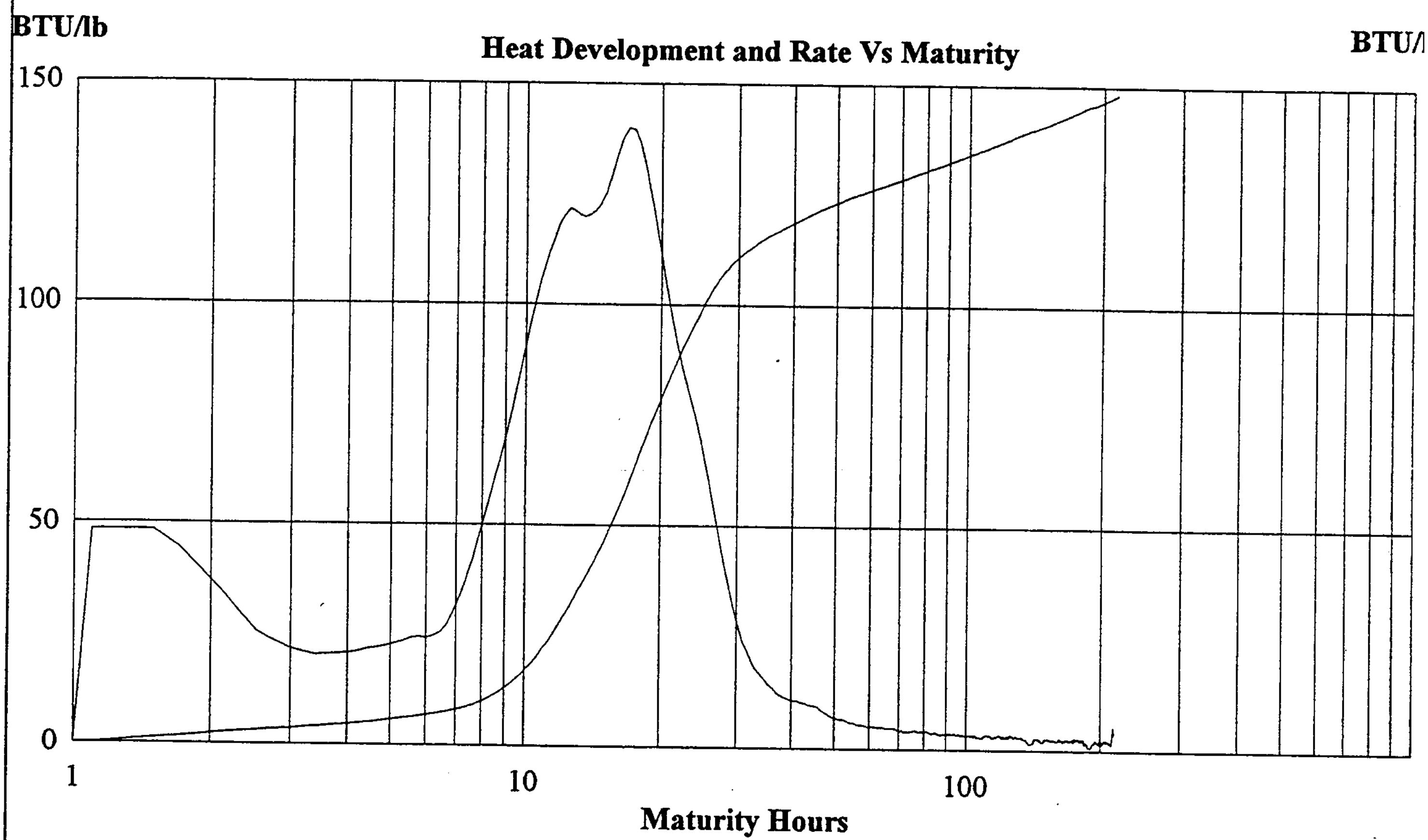
2/3/95



ARMATEC2000 [6L] sika110894

PennDOT

2/3/95



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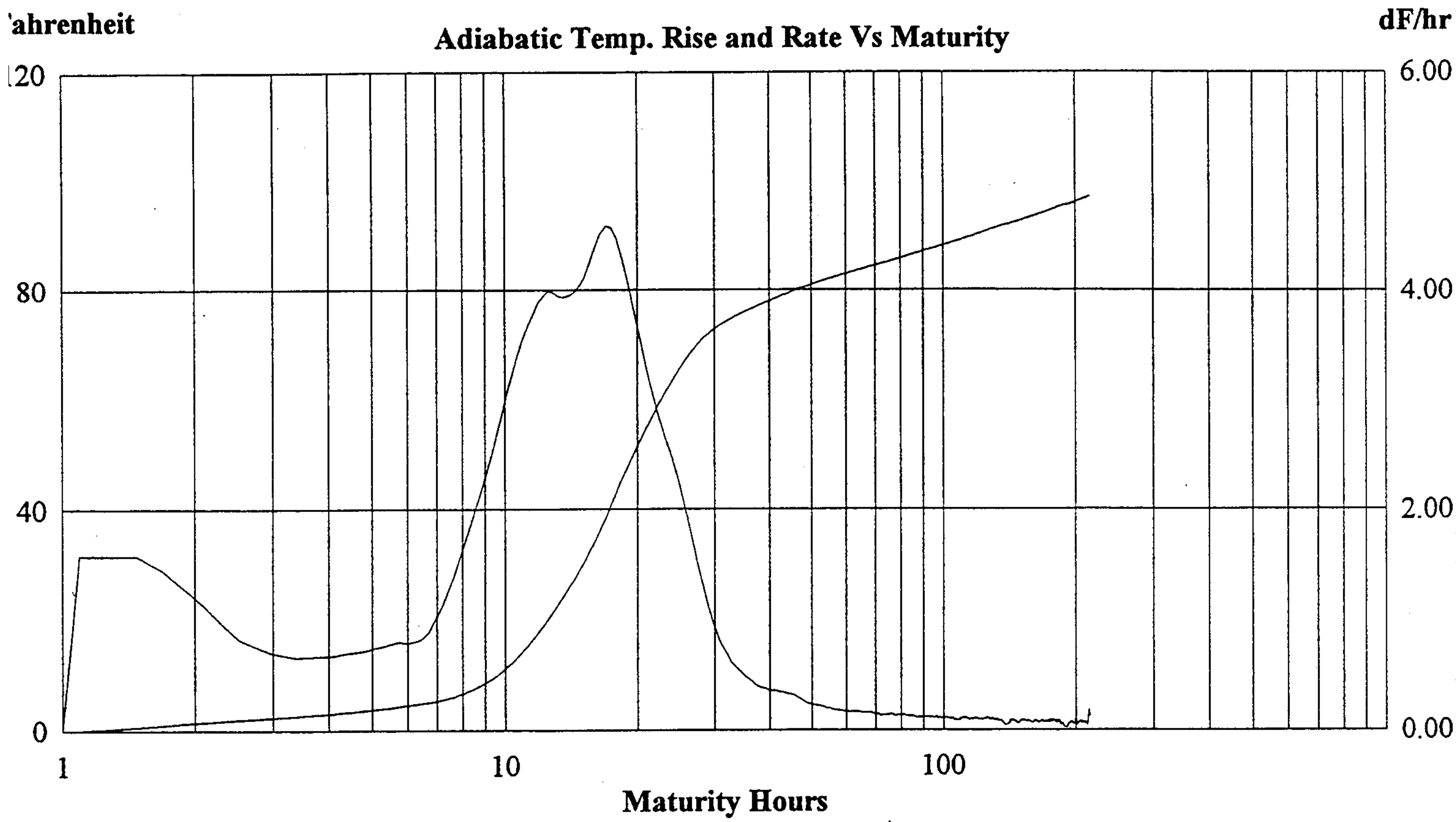
PennDOT

2/3/95



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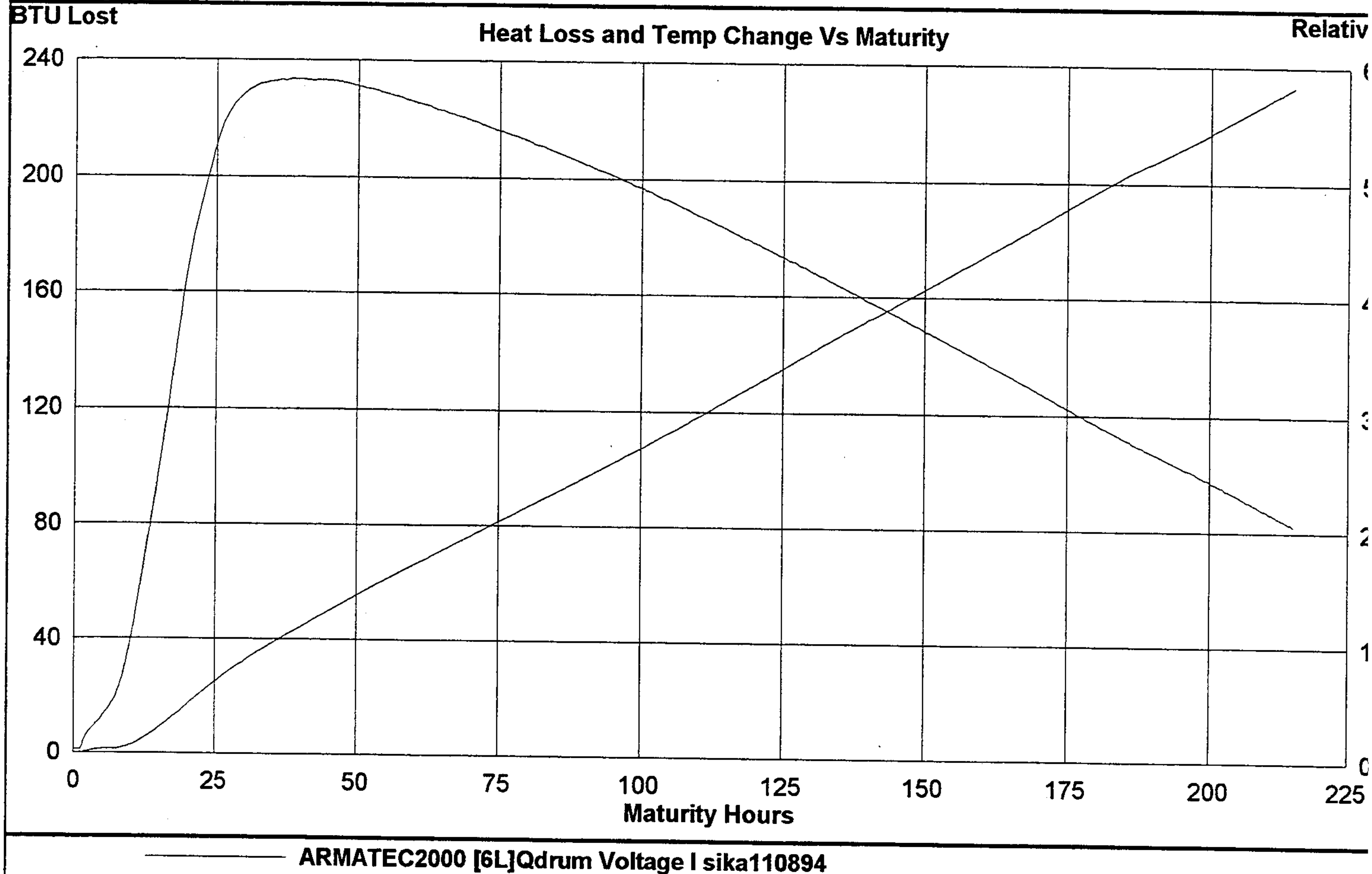
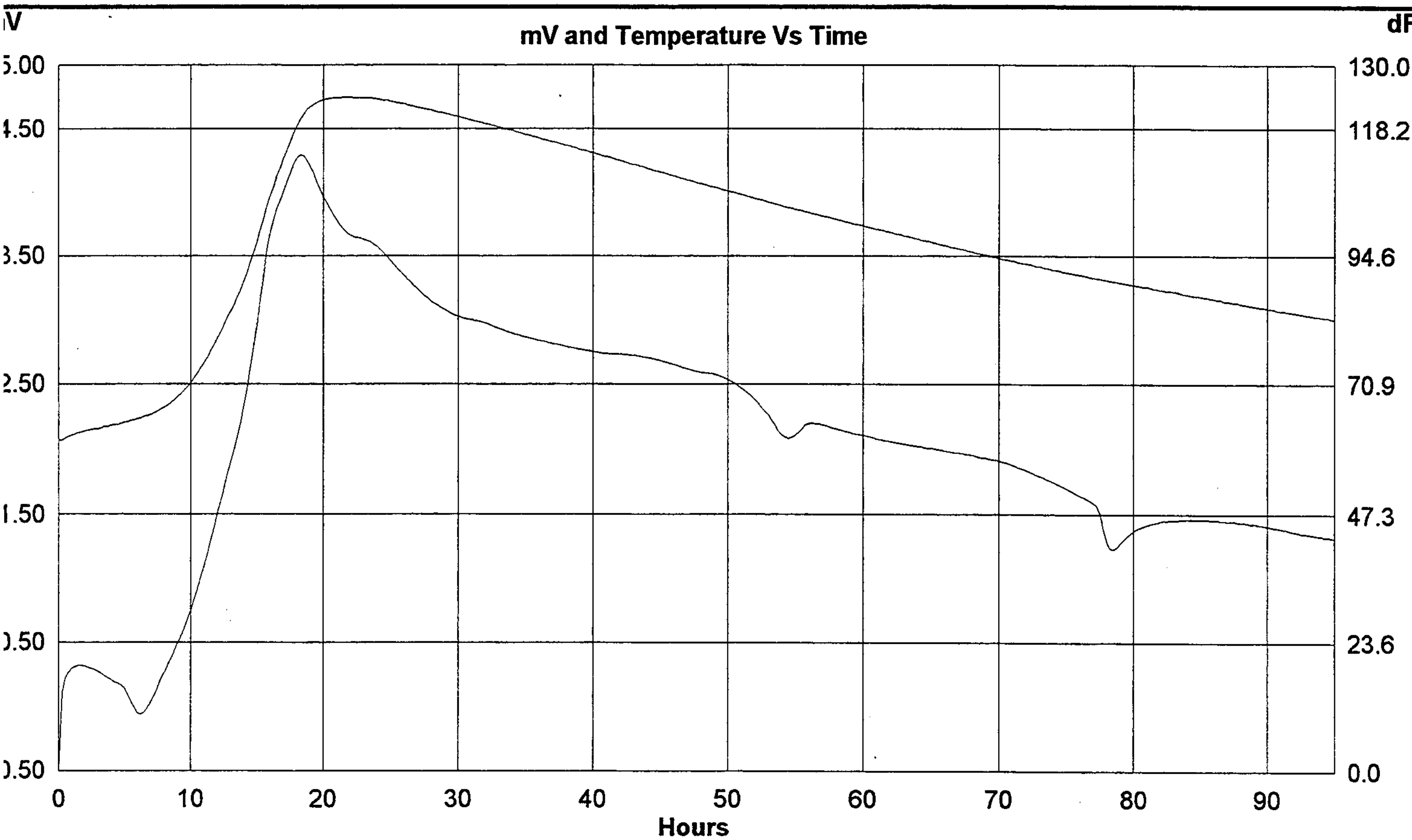
PenDOT Harrisburg	QUADREL 1.5 Graphing

Date: 06-17-1996



PenDOT	QUADREL 1.5
Harrisburg	Graphing

Date: 06-17-1996



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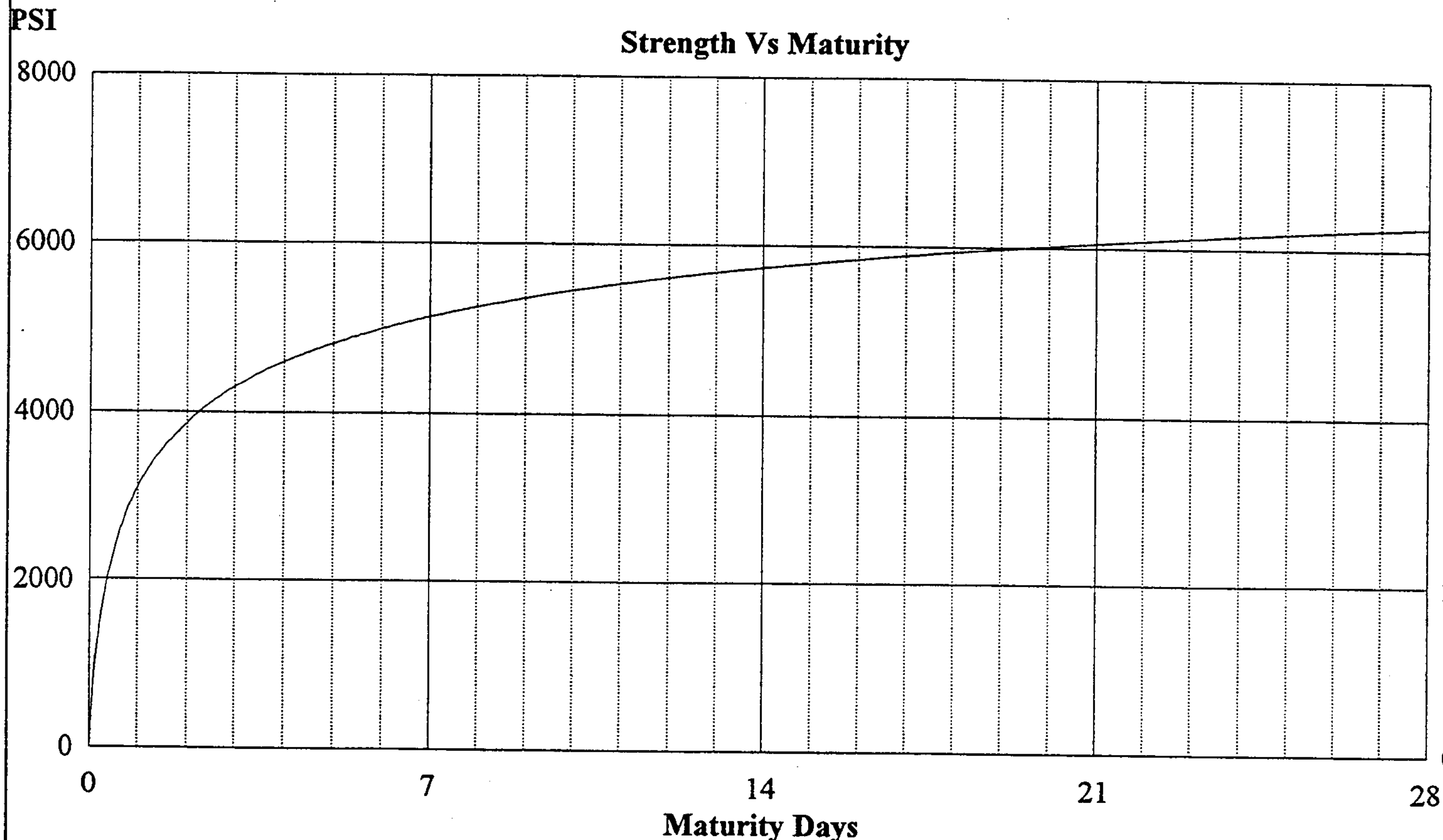
PennDOT

2/3/95



Strength of Batch : ARMATEC2000

APPENDIX 'F' SPECIAL PROVISION FOR THE USE OF DCI CORROSION-INHIBITOR

SPECIAL PROVISION FOR CORROSION INHIBITING CONCRETE

Provide Class AAA Cement Concrete as specified in Section 704 modified as follows:
Section 704.1(b) Material. Revise as follows:

Revise fifth bullet to read:

- Admixtures - Section 711.3 and as follows:
  Use a calcium nitrate corrosion-inhibiting admixture in the concrete.

  Add corrosion inhibiting admixture to the concrete at the rate of 3 gallons per cubic yard of concrete.
  Add the calcium nitrate as an aqueous solution containing 30+/- 3% calcium nitrate by weight. Count water in such solution as mixing water fir the purpose of determining the water to cement ratio of the concrete.

Section 704.1(b) Table A - Cement Concrete Criteria. Add a Note (9) to read:

9. For corrosion inhibiting cement concrete, design Class AAA Cement Concrete to have water to cement ratio of 0.40

Section 704.1© Design Basis. Revise the third paragraph to read:

Submit each design for review at least 21 calendar days prior to its use in the work. The mix design process must include a sample placement to check that no adverse placing or finishing problems occur. Do not change an accepted design unless reviewed by the District Engineer.

Section 704.1. GENERAL - add the following new subsection:

(h) Technical Representation arrange for a technical representative from the manufacturer of the corrosion-inhibiting admixture to be present at the Preconstruction Conference and at the initial placement.