FLUOR DANIEL FERNALD

INTEROFFICE MEMORANDUM

To:	Don Paine, MS52-4	Date:	January 9, 1998
Location:	Fernald	Reference:	C:WMTSP(SP):97-0083
From:	John Smets, MS52-4	FD Fernald #:	M:SP:98-0030
Location:	Fernald	Client:	DOE DE-AC24-92OR21972
Extension:	648-4845	Subject:	SILO INTEGRITY

c: Doug Daniels, FDF, MS52-4
Richard L. Maurer, FDF, MS52-4
Dennis Nixon, FDF, MS52-4
Sue Peterman, FDF, MS52-4
Tom Shiner, FDF, MS19
Kareld Solomon, FDF, MS19
Karen Wintz, FDF, MS20
File Record Copy 106.4.35.9
Project File #40010

As a result of concern regarding the physical condition of the K-65 Silos (Silo 1 and 2) and the Cold Metal Oxide Silo (Silo 3), it was proposed that additional testing be performed to ascertain the current condition. A field inspection and literature review of past destructive and non-destructive test results was performed by a structural engineer from Fluor Daniel Inc, Irvine, California (FDI), and raised concerns regarding some apparent inconsistencies in the data. FDF proposed that additional physical testing be performed to establish the current condition of the concrete and rebar (steel reinforcement). In order to expedite the process and provide a general understanding of the areas of concern, it was decided that the testing would be performed on Silo 4 because it is easily accessible and did not present any radiological hazard.

There were concerns with regard to the condition of the silos as documented in the Memo from FDI. Some of the concerns related to the concrete and aggregate that was used in the original construction. It appears that the silo contents are not a factor in establishing the condition of the concrete since there was no obvious chemical attack, however, there are two specific failure modes that are of interest. The first is the alkali-silica reaction and the impact that it may have on the corrosion of the rebar and the post tensioning wires. The second issue, also related to the rebar and wire corrosion, results from the freeze-thaw cycles of the concrete. This process would gradually introduce cracks and weaken the concrete itself. This freeze-thaw reaction, if left unmitigated, would widen the cracks and allow more water to migrate into the pores and then as the cycle continues there is a potential to expose the rebar and wires to corrosive water and air.

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Several factors indicate that although Silo 4 offers no risk to the public, it may have seen the most severe service. This assumption is based on the following considerations. The Silos were constructed in the same relative time frame with similar materials and from the same basic design drawings and specifications. It is anticipated that Silo 4 may have seen the worst of the freeze-thaw condition since it was unused and therefore there were no contents or mass that may have mitigated this thermal action. The three silos that were full of material could have seen some protection internally since the dynamics of the freeze-thaw may have been reduced significantly due to the mass inside and the energy required to cool this mass to below freezing. Although the silos surface may have cooled rapidly, migration through the walls would have been significantly slower and the most dramatic impact would have been on the extreme external surface. Silo 1 and 2 have an earthen berm that would have provided additional protection since there is significant mass on both sides of the walls and the domes are protected with a layer of foam.. In contrast, Silo 4 had no mass inside, no foam on the dome, and therefore the freeze-thaw would have worked from both sides toward the middle.

The results of the tests (FDF letter #M:SP:97-0143) were consistent with the concerns indicated in the initial review by Fluor Daniel, Irvine. Mr. Tan, indicated in his response (CCMail attached), that after reviewing the results of the testing, he was surprised that the rebar was found to be in excellent condition and that although the predicted alkali-silica reaction was identified, the freeze-thaw process had not been as detrimental as predicted. It appears that the concrete has maintained its strength very well and the testing for compressive strength has validated this. As a result of difficulties in retrieving samples from the dome area, it was requested that compressive strength be developed from the petrographic analysis. The prediction of the actual compressive strength from the petrographic analysis was difficult since this process is not normally utilized for compressive strength testing. The petrographic analysis is a visual evaluation and the only method was comparison to previous materials testing, it has been found that in order to polish samples, the concrete must have a compressive strength greater than 3000 psi. Since samples were successfully prepared and polished, it appears that the samples were at least 3000 psi. Side wall samples were also prepared and the petrographic analysis predictions appear to confirm the actual compressive strength testing. This resulted in the conclusion that as long as the rebar and wires remain in good condition, the silo walls will remain sound.

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INTEROFFICE MEMORANDUM

The dome area of the silos remains a concern, and as indicated in the Fluor Daniel, Irvine response, failure of the dome is difficult to predict. It appears that under its own load the dome will remain stable but external loads, especially in combination of vertical and horizontal, could result in failure. The current limitation for loads on the dome were determined based on the potential for significant weakening of the concrete. Testing has not provided any conclusive basis for modification of the existing load limitations, as indicated in the Operational Safety Requirement (OSR) and the appropriate cautions should continue to be utilized when operating in proximity of or on top of the domes until additional evaluations can be performed.

The conclusion as a result of the testing on Silo 4 indicate that the deterioration of the silos has been less severe than anticipated. With the above thermal considerations, it also appears that the condition of Silos 1, 2 and 3 are significantly better than forecast with data from the previous testing. Although there remains a concern with loading on the dome, the sidewalls are most likely stable and as a result of the protection offered by the berm and the material inside, the freeze-thaw damage concern is also limited. As a result of these findings and the current path forward with regard to accelerated retrieval, it is recommended that further testing on the other silos be deferred. The results of this testing would have little influence on additional acceleration of the retrieval process. If the proposed retrieval method requires additional information with regard to silo integrity, the testing can be performed at that time.

JLS:cml
Attachment

Author: Mehmet Tan at FDIV-06
Date: 11/4/97 12:09 PM
Priority: Normal
TO: John Smets at FNST-03
Subject: Silo 4 Concrete Testing
---------- Message Contents ----------

John,

I Reviewed the core testing and the field observation results. It was to my surprize to find out that in spite of the cracks in the core speciments wire and the re-bars were not corroded.It was not suprize to me that past NDT findings differ so much from (except concrete thickness) what is determined from this distructive testing. If the field observations are correct and wires and the re-bars are not corroded only problem silos will have alkali-silica reaction crackes and the cracking due to cyclic freezing and thawing of the concrete. Freezing and thawing cracks develop paralell to the surface of the concrete.
In the wall because of post tensioning wires concrete and the crackes are confined and some degree concrete will keeps its structural integrity. Since the concrete does not containe air entrainment, without a surface protection damage will continue to happen. On the other hand cracks in the dome concrete creates another problem. Because of weakening of the concrete and direction of the stresses can cause a Shear-Flexure failure. Under what load this failure would take place will be difficult to determine. The reason is that damage to the concrete is random and the test spaciments show different degrees of cracking. Under its own load, most likely dome would be stabile. But under any additional loading espacialy under an uneven loading (combination of vertical and horizantal) failure of the dome might take place.

If you need more assistance in this matter please let me know.

Regards, Mehmet

ATC ASSOCIATES INC.

ENVIRONMENTAL, GEOTECHNICAL AND MATERIALS PROFESSIONALS

SILO 4 CONCRETE EVALUATION
FERNALD, OHIO
ATC FILE NUMBER 58679.0003

SILO 4 CONCRETE EVALUATION
FERNALD, OHIO
ATC FILE NUMBER 58679.0003

Prepared for: Attn: Mr. Tom Shiner
Flour Daniel Fernald
7400 Wiley Road
Fernald, Ohio 45030

Prepared By: ATC Associates, Inc.
11121 Canal Road
Cincinnati, Ohio 45241

October 22, 1997

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ATC ASSOCIATES INC.
ENVIRONMENTAL, GEOTECHNICAL AND MATERIALS PROFESSIONALS

October 22, 1997

Mr. Tom Shiner
Fluor Daniel Fernald
7400 Wiley Road
Fernald, Ohio 45030

RE: Silo 4 Concrete Evaluation
Fernald, Ohio
ATC File Number 58679.0003

Dear Mr. Shiner:

ATC Associates Inc. has completed analysis of the concrete cores, obtained from the above referenced project. These cores were submitted to our Testing Lab for Compressive Strength and full Petrographic Analysis. We performed Compressive Strength testing here in our Cincinnati Testing Laboratory. The Petrographic Analyses was performed at two separate labs, as per your request. These labs are American Petrographic Services, Inc. and CMI Labs. Each of these reports are enclosed. You also requested that we have the concrete reinforcing analyzed for Tensile Strength and Micrometer Measurements, this was done by Sherry Labs located in Muncie, Indiana. This report is also enclosed.

The concrete cores that were tested for Compressive Strength were 97W203, 97W102, and 97W303. One of these cores, 97W203, was not able to be tested for Compressive Strength due to excessive cracking through the core, running horizontally. This particular core broke up several times during the preparation process. The other two cores were tested and the results are as follows:

CORE I.D.	COMPRESSIVE STRENGTH (PSI)
97W102	6710
97W303	3510

11121 Canal Rd. • Cincinnati, OH 45241-1861 • (513) 771-2112 • FAX (513) 782-6908

You also asked for approximate Compressive Strength from the Petrographic Analysis. Unfortunately, it is not possible to do this, however, according to a phone conversation I had with Mr. Scott Wolters of American Petrographic Services, Inc. on October 22, 1997, in order to polish a concrete sample it would have to have a minimum of 3000 psi. These cores were polished, so this concrete appears to have a Compressive Strength of 3000 psi or better.

In summary, according to the Petrographic Analyses, this concrete has had severe subhorizontal freeze-thaw microcracking. In areas where the freeze-thaw is most severe, the compressive strength would be greatly compromised. This concrete also contains several reactive chert, quartize and silicified limestone particles. Some of the cores exhibited minor to moderate alkali-silica reactivity. We would expect the deterioration to continue to occur when the concrete becomes frozen.

Thank you for allowing ATC Associates Inc. to be of service to you and your company. Please feel free to call us with any further needs you may have on this or other projects that we may assist you with. Also, feel free to contact our office with any questions you may have concerning this report.

Respectfully Submitted:
ATC Associates Inc.
d.b.a. ATEC Associates Inc.

Gene McVey
Soils Laboratory Manager

1278

OCT 23 1997

2203 S. Madison St.
Muncie, IN 47302-4156
Telephone 765-747-9000

SHERRY LABORATORIES
INDIANA LOUISIANA OKLAHOMA

LABORATORY REPORT

P.O. Box 2847
Muncie, IN 47307-0847
Fax 765-747-0228
800-874-3563

Reported To:	GENE MCVEY	Sherry Labs No.:	1997100792
Customer:	ATC ASSOCIATES INCORPORATED 1121 CANAL ROAD CINCINNATI OH 45241-1861	Customer P.O.:	CN54000138
		Date Received:	10-21-97

Material: Steel
Size: .141/.231 diameter
Description: 2 - Concrete reinforcing wires

Dimensional Test

		Approximate Diameter
Sample No. 1	Wire	.142 inch
Sample No. 2	Bar	.231 inch

Tensile, RT/As Rec'd - ASTM E 8-96/MTP 2004

	Sample No. 1 (wire)	Sample No. 2 (bar)
Diameter, in.	.1415	.126
Tensile, psi	242,000	101,000
Yield (0.2% offset), psi	--	93,000
Elongation (4 X D), %	--	14
Reduction, %	--	57

Return samples via common carrier.

A2LA Certification #0174-01 & #0174-02.

NADCAP Certification #0009.

The recording of false, fictitious, or fraudulent statements or entries on this document may be punished as a felony under federal law.

This document shall not be reproduced, except in full, without the written approval of Sherry Laboratories, Inc.

Jennifer Marek
Materials Engineer
10-22-97

sg/1

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CONCRETE MICROSCOPY INC.

90 S. 9th Street
Suite 409
Minneapolis, MN 55402
(612) 338-3109
Fax (612) 338-4309

1278

TO: ATC Associates, Inc.
Attn: Mr. Gene McVey
11121 Canal Road
Cincinnati, Ohio 45241

DATE: October 22, 1997

PROJECT NO: 1097-975

PROJECT: FERNALD SILO 4
ATC FILE NO. 58679.0003

PETROGRAPHIC ANALYSIS

INTRODUCTION:

Four concrete cores, labeled 97W3-02, 97D2-04, 97D1-04 and 97W2-02, were received October 6, 1997, from Mr. Gene McVey of ATC Associates, Inc., located in Cincinnati, Ohio. Mr. McVey reported that the samples were removed from the referenced project and requested petrographic (microscopical) examination in accordance with American Society for Testing and Materials (ASTM) Designation ASTM C 856-95, "Standard Practice for Petrographic Examination of Hardened Concrete," to review concrete properties.

SUMMARY AND CONCLUSIONS:

Numerous cracks oriented nearly parallel to exterior surfaces are present in the cores. Cracking is attributed to a combination of cyclic freezing and thawing and expansive alkali-silica reactions (ASR), a chemical reaction between certain minerals (chalcedonic cherts and carbonates in this concrete) and alkalies, including alkalies released from hydrating portland cement and external sources of alkalies.

Based on the location of cracks, reaction rims and aggregate particles that have experienced expansive reaction, cracks originating from freeze/thaw exposure are considered to have provided avenues for the penetration of moisture (which is necessary for the ASR reaction to proceed), causing the development of ASR and additional cracking. In combination these may produce cracking that would not arise from a single cause alone.

It has been reported that no structure or part of a structure is known to have collapsed due to ASR alone. Corollary moisture-dependent processes such as freeze-thaw distress or steel corrosion often are the main causes of distress. In reinforced concrete, the reinforcement contributes considerable resilience against decline of the structural safety. Studies of dams affected by ASR conclude that in 20 to 30 years, the reactive elements were consumed and expansion ceased.

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PETROGRAPHIC ANALYSIS

ADDITIONAL TEST RESULTS:

1. The concrete is not air entrained (the incorporation of air in the form of minute bubbles), based on the virtual lack of spherical voids having diameters less than 1 millimeter (the dimension of entrained air voids, by definition). An appropriate volume, size and distribution of microscopic air bubbles intentionally incorporated in concrete (entrained air voids) help protect concrete from freezing damage by providing areas for freezing and migrating water and relieving the resultant development of disruptive hydraulic and osmotic pressures. In addition, a sufficient quantity of minute air bubbles is somewhat effective in reducing ASR expansion, a result of air bubbles in contact with reactive aggregate partially isolating the aggregate from chemical reactions. Also, air voids provide spaces for the accumulation of the expansive alkali-silica gel.

   American Concrete Institute [ACI] Committee Report ACI 313, "Standard Practice for Design and Construction of Concrete Silos and Stacking Tubes for Storing Granular Materials," states that exterior concrete in silo walls which will be exposed to cycles of freezing and thawing shall be air entrained.

   An air content of 6±1½ percent is recommended for concrete having a ¾ in. maximum size aggregate and subjected to severe exposure (ACI 201.2R, "Guide to Durable Concrete," and ACI 212.3R, "Chemical Admixtures for Concrete"). Severe exposure is defined as outdoor exposure in a cold climate where the concrete may be in contact with moisture prior to freezing, or where deicing salts are used.

2. Water-cement ratio is interpreted at 0.40 to 0.45 in all four cores, based on physical and mineralogical properties of the cement pastes. Concrete in cast-in-place concrete silos is required to have a compressive strength of not less than 3000 psi at 28 days, or 4000 psi for precast units (ACI 313, "Standard Practice for Design and Construction of Concrete Silos and Stacking Tubes for Storing Granular Materials"). Note that typical 3500 psi air-entrained concrete can be made with a water-cement ratio of approximately 0.53.

3. Crystallization of ettringite (high-sulfate calcium sulfoaluminate hydrate, ($3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$) has occurred in cracks and entrapped air voids throughout the cores. However, the concrete does not contain any evidence of detrimental cracking or expansion associated with secondary ettringite formation. The occurrence of ettringite in itself is not indicative of sulfate attack, for ettringite is found as a secondary reaction product of a variety of mechanisms of deterioration (including ASR and freeze/thaw) due to changes of the equilibria conditions of the pore liquid in the cement paste. Furthermore, the crystallization of ettringite is commonplace in matured concrete exposed to a variety of climatic conditions and is often simply a common effect of concrete permeability and ageing.

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PETROGRAPHIC ANALYSIS

ADDITIONAL TEST RESULTS:(continued)

4. Secondary deposits of calcite ($CaCO_3$) have crystallized in cracks in cracks throughout the cores. The occurrence of secondary calcite is indicative of the penetration of moisture and/or aggressive solutions, resulting in the chemical removal of portland cement hydration products and their redeposition as calcite.

5. Cracks have maximum widths of 0.05 in. Regarding the potential for steel corrosion, the maximum tolerable crack width for reinforced concrete exposed to humidity or moist air is 0.012 in., or 0.007 in. for concrete exposed to deicing chemicals. However, in some cases, in concrete having crack widths up to 0.02 inch, and with cover over the reinforcement of at least 1 inch, a high alkaline environment is maintained and the steel protected from corrosion, provided the movement of water through the cracks does not cause destruction of the alkaline environment. In addition, cracks may heal (autogenous healing) in a moist environment.

6. Cement paste is carbonated to maximum depths of 0.08 in. The depth of carbonated cement paste, an indication of relatively permeability, results from the penetration of environmental carbon dioxide which converts calcium-containing hydration products to carbonate compounds.

   Well consolidated and cured concrete of relatively low water-cement ratio will carbonate to a depth of approximately 1/4 in. after 10 years of exposure, and the depth of carbonation will increase to approximately 1/2 in. after 50 years. The rate of carbonation is a function of time, mix composition and proportions, curing regime and environmental conditions. The cause of high carbonation rates is generally attributed to high permeability. The greatest factor influencing permeability is water-cement ratio. Increase in water-cement ratio causes a greater network of capillary pores and voids. Concrete permeability is mainly a function of the volume, size, distribution and continuity of the capillary pores or voids.

   If surface carbonation is deep enough to reach the level of steel reinforcement it may cause steel corrosion due to a lowering of the alkalinity of the protective, high pH oxide film normally provided by portland cement paste in contact with embedded steel reinforcement.

   It should be noted that pH indicator solutions, as well as thin-section microscopy, often fail to recognize partial, submicroscopic carbonation and slight changes in alkalinity. Most of these methods only identify the depth of carbonated paste, that is, they identify regions in which the pH is less than 9, and fail to differentiate localized difference in alkalinity. It has been shown that steel corrosion can initiate at a pH of about 11.4, although corrosion intensities are likely to be weak. Thermogravimetric analysis studies have shown that the carbonation front (partially carbonated concrete) extends an average additional 1/2 in. beyond the level where complete carbonation has been identified.

PETROGRAPHIC ANALYSIS

ADDITIONAL TEST RESULTS:(continued)

7. Paste-aggregate bond is judged as tight. The mechanical (strength) and physical (such as porosity, permeability, and absorption) and chemical resistance properties of concrete are to a significant degree affected by the nature of the adhesive bond between aggregate particles and the hardened cement paste. A tight adhesive bond between cement paste and aggregates increases abrasion resistance and resistance to moisture penetration, and results in enhanced shrinkage restraint by the aggregate particles.

8. Additional details of petrographic observations are presented in the attached data sheets.

DISCUSSION:

For ASR expansion to occur, a simultaneous presence of reactive aggregate, high concentrations of alkalis, calcium hydroxide (a normal hydration product), and water is necessary. A shortage of any one of these will mitigate or eliminate expansion. Expansion may naturally decelerate, even cease, with time as the original alkali is consumed, provided none is added or regenerated. The following equation is simplified and idealized and the inclusion of other cations (such as potassium) which may be involved in similar reactions are omitted:

$$\underset{\text{Reactive Silica}}{SiO_2} + \underset{\text{Alkali Hydroxide}}{2NaOH} + \underset{\text{Water}}{H_2O} \rightarrow \underset{\text{Alkali-Silica Gel}}{Na_2SiO_3 \cdot 2H_2O}$$

The reaction proceeds in stages as follows:

(1) Hydrolysis of the reactive silica by OH^- to form alkali-silica gel.

(2) Absorption of water by the gel accompanied by an increase in volume.

(3) Swelling of the gel causes the formation of microcracks which propagate and coalesce to produce cracking and expansion of the concrete.

(4) Cracks provide access of external solutions to interior regions of the concrete and allow other deleterious or innocuous mechanisms to operate. Secondary deposits associated with these mechanisms may include ettringite and calcium hydroxide and calcium carbonate.

PETROGRAPHIC ANALYSIS

TEST PROCEDURES:

Petrographic examinations of Cores 97W3-02, 97D2-04, 97D1-04 and 97W2-02 were performed in accordance with ASTM C 856-95, "Standard Practice for Petrographic Examination of Hardened Concrete." A slice was sawcut from the exterior to the interior surface of each core, polished, and examined utilizing a stereomicroscope at magnifications up to 250X, as were freshly fractured surfaces. A thin section (a flat slice of concrete mechanically reduced until translucent and mounted between glasses as a microscope slide) was prepared from each core in the following manner: An approximately 2-in. by 3-in. rectangular block was cut from the exterior surface to a depth of approximately 2 in., polished, affixed to a large format (2-in. by 3-in.) microscope slide, reduced to thicknesses of approximately 25 micrometers, and examined utilizing a polarized-light microscope at magnifications up to 1000X to review cement paste mineralogy and micromorphology.

REMARKS:

The samples will be retained for a period of ninety days from the date of this report. Unless other disposition is requested by that time, the samples will be discarded.

Should you have any questions concerning this report, or if we may be of further assistance, please feel free to contact us at (612) 338-3109.

Dean E. Kofoed
President/Principal Petrographer
Concrete Microscopy, Inc.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM: C 856-95

CLIENT:	ATC Associates, Inc. Cincinnati, Ohio	**DATE:**	October 22, 1997
		CMI PROJECT NO:	1097-975
PROJECT:	FERNALD SILO 4 ATC FILE NO. 58679.0003	**PERFORMED BY:**	Dean E. Kofoed
		DATA SHEET:	1 of 4

SAMPLE IDENTIFICATION: Core 97W3-02.

GENERAL SAMPLE OBSERVATIONS:

Sample Dimensions: 3.7 in. diameter, 5.5 to 5.8 in. long.

Surface Condition:

Exterior - Fractured surface at level of wire reinforcement.

Interior - Fractured surface passes through a large majority of aggregate particles.

Reinforcement: The exterior surface contains the impression of parallel 0.135-in.-diameter wires which contain traces of corrosion products.

Cracks and Distinctive Features: Numerous cracks oriented nearly parallel to the ends of the core are present throughout the core, the cracks having maximum widths of 0.02 in. and passing through many aggregate particles.

AIR CONTENT & DISTRIBUTION: Estimated at less than 2%; not air entrained, based on the virtual lack of spherical voids having diameters less than 1 millimeter.

INTERPRETED WATER-CEMENT RATIO: 0.40 to 0.45

MICROCRACKING: Numerous throughout the sample.

PASTE-AGGREGATE BOND: Tight; fractured induced utilizing a small hammer pass through a large majority of aggregate particles.

PASTE MATRIX:

Color: Medium gray.

Hardness: Hard.

Luster: Vitreous to dull.

Depth of Carbonation: 0.01 to 0.03 in. from core ends.

Residual Portland Cement Particles, %, By Volume of Paste: 5 to 7%.

Calcium Hydroxide, %, By Volume of Paste: 13 to 15%.

Residual Fly Ash, %, By Volume of Paste: None observed.

AGGREGATE:

Coarse: Natural gravel mainly comprised of dolomite, dolomitic limestone and limestone includes a relatively small quantity of siliceous rock types.

Fine: Natural sand mainly comprised of quartz, feldspar, chert and carbonates includes the variety of rock types represented in the coarse aggregate fraction and their associated minerals.

Gradation and Size: Well graded to a nominal maximum size of 3/4 in.

Shape and Distribution: Rounded to angular, subspherical to tabular. Uniform aggregate distribution.

SECONDARY DEPOSITS: Cracks contains calcite, ettringite and alkali-silica gel.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM: C 856-95

CLIENT:	ATC Associates, Inc. Cincinnati, Ohio	**DATE:**	October 22, 1997
		CMI PROJECT NO:	1097-975
PROJECT:	FERNALD SILO 4 ATC FILE NO. 58679.0003	**PERFORMED BY:**	Dean E. Kofoed
		DATA SHEET:	2 of 4

SAMPLE IDENTIFICATION: Core 97D2-04.

GENERAL SAMPLE OBSERVATIONS:

Sample Dimensions: 3.7 in. diameter, 6.0 to 6.9 in. long.

Surface Condition:

Exterior - Abraded surface containing exposed fine aggregate particles contains remnants of an elastomeric coating. Several cracks are present from which calcite has exuded.

Interior - Fractured surface passes through a large majority of aggregate particles.

Reinforcement: None observed.

Cracks and Distinctive Features: Numerous cracks oriented nearly parallel to the exterior surface are present throughout the core, the cracks having maximum widths of 0.04 in. and passing through many aggregate particles.

AIR CONTENT & DISTRIBUTION: Estimated at less than 2%: not air entrained, based on the virtual lack of spherical voids having diameters less than 1 millimeter.

INTERPRETED WATER-CEMENT RATIO: 0.40 to 0.45

MICROCRACKING: Numerous throughout the sample.

PASTE-AGGREGATE BOND: Tight; fractured induced utilizing a small hammer pass through a large majority of aggregate particles.

PASTE MATRIX:

Color: Medium gray.

Hardness: Hard.

Luster: Vitreous to dull.

Depth of Carbonation: 0.03 to 0.06 in. from the exterior surface.

Residual Portland Cement Particles, %, By Volume of Paste: 5 to 7%.

Calcium Hydroxide, %, By Volume of Paste: 14 to 16%.

Residual Fly Ash, %, By Volume of Paste: None observed.

AGGREGATE:

Coarse: Natural gravel mainly comprised of dolomite, dolomitic limestone and limestone includes a relatively small quantity of siliceous rock types.

Fine: Natural sand mainly comprised of quartz, feldspar, chert and carbonates includes the variety of rock types represented in the coarse aggregate fraction and their associated minerals.

Gradation and Size: Well graded to a nominal maximum size of 3/4 in.

Shape and Distribution: Rounded to angular, subspherical to tabular. Uniform aggregate distribution.

SECONDARY DEPOSITS: Cracks contains calcite, ettringite and alkali-silica gel.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM: C 856-95

CLIENT:	ATC Associates, Inc. Cincinnati, Ohio	**DATE:**	October 22, 1997
		CMI PROJECT NO:	1097-975
PROJECT:	FERNALD SILO 4 ATC FILE NO. 58679.0003	**PERFORMED BY:**	Dean E. Kofoed
		DATA SHEET:	3 of 4

SAMPLE IDENTIFICATION: Core 97D1-04.

GENERAL SAMPLE OBSERVATIONS:

Sample Dimensions: 3.7 in. diameter, 1.8 to 2.2 in. long.

Surface Condition:

Exterior - Fractured surface passes through a large majority of aggregate particles.

Interior - Fractured surface passes through a large majority of aggregate particles.

Reinforcement: None observed.

Cracks and Distinctive Features: Numerous cracks oriented nearly parallel to the exterior surface are present throughout the core, the cracks having maximum widths of 0.04 in. and passing through many aggregate particles.

AIR CONTENT & DISTRIBUTION: Estimated at less than 2%; not air entrained, based on the virtual lack of spherical voids having diameters less than 1 millimeter.

INTERPRETED WATER-CEMENT RATIO: 0.40 to 0.45

MICROCRACKING: Numerous throughout the sample.

PASTE-AGGREGATE BOND: Tight; fractured induced utilizing a small hammer pass through a large majority of aggregate particles.

PASTE MATRIX:

Color: Medium gray.

Hardness: Hard.

Luster: Vitreous to dull.

Depth of Carbonation: 0.05 to 0.08 in. from core ends.

Residual Portland Cement Particles, %, By Volume of Paste: 5 to 7%.

Calcium Hydroxide, %, By Volume of Paste: 10 to 12%.

Residual Fly Ash, %, By Volume of Paste: None observed.

AGGREGATE:

Coarse: Natural gravel mainly comprised of dolomite, dolomitic limestone and limestone includes a relatively small quantity of siliceous rock types.

Fine: Natural sand mainly comprised of quartz, feldspar, chert and carbonates includes the variety of rock types represented in the coarse aggregate fraction and their associated minerals.

Gradation and Size: Well graded to a nominal maximum size of 3/4 in.

Shape and Distribution: Rounded to angular, subspherical to tabular. Uniform aggregate distribution.

SECONDARY DEPOSITS: Cracks contains calcite, ettringite and alkali-silica gel.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM: C 856-95

CLIENT:	ATC Associates, Inc. Cincinnati, Ohio	**DATE:**	October 22, 1997
		CMI PROJECT NO:	1097-975
PROJECT:	FERNALD SILO 4 ATC FILE NO. 58679.0003	**PERFORMED BY:**	Dean E. Kofoed
		DATA SHEET:	4 of 4

SAMPLE IDENTIFICATION: Core 97W2-02.

GENERAL SAMPLE OBSERVATIONS:

Sample Dimensions: 3.7 in. diameter, 6.6 to 7.0 in. long.

Surface Condition:

Exterior - Formed surface.

Interior - Fractured surface passes through a large majority of aggregate particles.

Reinforcement: None observed.

Cracks and Distinctive Features: Numerous cracks oriented nearly parallel to the exterior surface are present throughout the core, the cracks having maximum widths of 0.05 in. and passing through many aggregate particles.

AIR CONTENT & DISTRIBUTION: Estimated at less than 2%; not air entrained, based on the virtual lack of spherical voids having diameters less than 1 millimeter.

INTERPRETED WATER-CEMENT RATIO: 0.40 to 0.45

MICROCRACKING: Numerous throughout the sample.

PASTE-AGGREGATE BOND: Tight; fractured induced utilizing a small hammer pass through a large majority of aggregate particles.

PASTE MATRIX:

Color: Medium gray.

Hardness: Hard.

Luster: Vitreous to dull.

Depth of Carbonation: 0.04 to 0.06 in. from the exterior surface.

Residual Portland Cement Particles, %, By Volume of Paste: 5 to 7%.

Calcium Hydroxide, %, By Volume of Paste: 8 to 10%.

Residual Fly Ash, %, By Volume of Paste: None observed.

AGGREGATE:

Coarse: Natural gravel mainly comprised of dolomite, dolomitic limestone and limestone includes a relatively small quantity of siliceous rock types.

Fine: Natural sand mainly comprised of quartz, feldspar, chert and carbonates includes the variety of rock types represented in the coarse aggregate fraction and their associated minerals.

Gradation and Size: Well graded to a nominal maximum size of 3/4 in.

Shape and Distribution: Rounded to angular, subspherical to tabular. Uniform aggregate distribution.

SECONDARY DEPOSITS: Cracks contains calcite, ettringite and alkali-silica gel.

AMERICAN
PETROGRAPHIC
SERVICES, INC.

REPORT OF CONCRETE TESTING

PROJECT:

ATC #58679-0003
FERNALD SILO
P.R. #CN45000140

REPORTED TO:

ATC ASSOCIATES INC.
11121 CANAL ROAD
CINCINNATI, OH 45241

ATTN: GENE McVEY

APS JOB NO: 97-9359

DATE: OCTOBER 20, 1997

INTRODUCTION

This report presents the results of laboratory work performed by our firm on four concrete cores and one shotcrete sample submitted to us by Mr. Gene McVey of ATC Associates Inc. on October 8, 1997. We understand the concrete cores were obtained from an exterior concrete silo currently under evaluation. The concrete was reportedly placed prior to 1990. The scope of our work was limited to performing petrographic analysis testing to document the overall quality of the concrete.

CONCLUSIONS

Based on our observations, test results, and past experience, our conclusions are as follows:

1. The overall quality of the concrete ranged from fair to good (#1) to poor (cores #2, 3, and 4). The cement paste was relatively dense and hard with carbonation up to 3/16". The carbonate gravel aggregate was hard but reactive. We observed several reactive chert, quartzite and silicified limestone particles. The concrete in cores #2, 3, and 4 exhibited severe subhorizontal freeze-thaw microcracking. The concrete was placed with a moderate to moderately high slump.

2. The concrete in cores #1, 2, 3, and 4 have poor durability. The concrete was not purposefully air entrained. We expect deterioration to continue to occur if the concrete becomes frozen when saturated.

3. Cores #2, 3, and 4 exhibited minor to moderate alkali-silica reactivity. We observed fractured aggregate with secondary silica gel and ettringite deposits within adjacent air voids and fractures. We expect ASR deterioration to continue to occur if the concrete is exposed to moisture.

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4. The overall quality of the shotcrete was fair due to variability in the water cement ratio of the paste. The application lines were roughly horizontal and the material appeared well consolidated. The quartz and lithic sand aggregate was hard, sound, and durable. The cement paste was partially carbonated at the surface up to 3/16".

SAMPLE IDENTIFICATION

Sample Number:	1	2	3	4	5
Sample Location:	97W101-1445	97D203-1300	97W203-1425	97D101-1230	
Sample Type:	Hardened Concrete Core				Hardened Gunnite Core
Original Sample Dimensions, in:	3-11/16" diam by 7-3/4" long	3-11/16" diam by ~7" long	3-11/16" diam by unknown long	3-11/16" diam by ~6" long	3-11/16" diam by 13/16" long

TEST RESULTS

Our complete petrographic analysis test results appear on the attached sheets entitled 00 LAB 001 "Petrographic Examination of Hardened Concrete, ASTM:C856." A brief summary of these results is as follows:

a. The coarse aggregate in the cores was comprised of 3/4" maximum sized carbonate gravel that was fairly well graded with good overall uniform distribution.

b. Fly ash pozzolanic admixture was not observed in any of the concrete samples.

c. The paste color of the cores was mottled light gray with the slump estimated to be medium to high (3" to 6").

d. The paste hardness of the cores was judged to be medium to hard with the paste/aggregate bond considered good.

e. The depth of carbonation ranged from negligible up to 3/16".

f. The water/cement ratio of the concrete cores was estimated at between 0.45 to 0.51 with approximately 8-10% unhydrated cement particles.

Air Content Testing

Sample Identification:	1	2	3	4	5
Total Air Analysis -					
Air Void Content, %	1.0	0.3	0.3	1.0	2.7
Spacing Factor, in	0.045	0.076	0.138	0.034	0.005
Entrapped Air (%)	0.6	0.1	0.2	0.6	0.0
Entrained Air (%)	0.4	0.2	0.1	0.4	2.7

TEST PROCEDURES

Laboratory testing was performed on October 8, 1997 and subsequent dates. Our procedures were as follows:

Petrographic Analysis

A petrographic analysis was performed in accordance with APS Standard Operating Procedure 00 LAB 001, "Petrographic Examination of Hardened Concrete," ASTM:C856-latest revision. The petrographic analysis consisted of reviewing cement paste and aggregate qualities on a whole basis as well as on a cut/polished section. The depth of carbonation was documented using a phenolphthalein indicator solution applied on a freshly cut and polished surface of the concrete samples. Further, our analysis included a review for the presence of deleterious substances. The water/cement ratio of the concrete was estimated by viewing a thin section of the concrete under an Olympus BH-2 polarizing microscope at magnification up to 1000x.

Air Content Testing

Air content testing was performed using APS Standard Operating Procedure 00 LAB 003, "Microscopical Determination of Air Void Content and Parameters of the Air Void System in Hardened Concrete," ASTM:C457-latest revision (linear traverse method). The concrete cores were cut perpendicular with respect to the horizontal plane of the concrete as placed and then polished prior to testing.

REMARKS

The test samples will be retained for a period of thirty days from the date of this report. Unless further instructions are received by that time, the samples will be discarded.

Report Prepared By:

Scott F. Wolter, C.P.G.
Certification No. 8260

Richard D. Stehly, P.E.
MN Reg. No. 12856

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #: 97-9359 Date: 10/16/97
Sample Identification: #1 Performed by: G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on a 7-3/4" x 3-11/16" x 2" thick polished section that was cut from the original 3-11/16" diameter x 7-3/4" long core.

2. Surface Conditions:

Outer: Smooth, formed surface
Inner: Rough, formed surface placed on form

3. Reinforcement: None observed.

4. General Physical Conditions: Overall, the concrete was characterized by a moderately dense paste with a good paste-aggregate bond. Few, sinuous, bleedwater void spaces and areas of soft porous paste, along with a mottled paste color was observed. Good overall condition.

II. Aggregate

1. Coarse: 3/4" maximum sized carbonate gravel. Rock types include mostly carbonate and granite, with some chert. Fairly well graded with good overall uniform distribution.

2. Fine: Natural lithic sand with some quartz that was fairly well graded. The grains were mostly rounded with some sub-angular particles. Fair overall distribution.

III. Cementitious Properties

1.	Air Content:	1.0% total, 0.6% entrapped, 0.4% entrained
2.	Depth of carbonation:	Negligible, up to 3/16"
3.	Pozzolan presence:	None observed
4.	Paste/aggregate bond:	Good
5.	Paste color:	Mottled light gray to gray
6.	Paste hardness:	Medium to hard
7.	Paste proportions:	28% to 30%
8.	Microcracking:	Several fine microcracks were observed scattered throughout the sample at various depths and orientations.
9.	Secondary deposits:	None observed
10.	Slump:	Estimated, medium (3" to 5")
11.	Water/cement ratio:	Estimated at between 0.45 to 0.50 with approximately 9-10% unhydrated portland cement clinker particles.
12.	Degree of hydration:	Well to fully hydrated

IV. Conclusions

The general overall quality of the concrete was fair to good.

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #: 97-9359 Date: 10/16/97
Sample Identification: #2 Performed by: G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on the polished sections taken from the original 3-11/16" diameter x approximately 7" long core.

2. Surface Conditions:

Outer: Fairly rough, mortar eroded surface
Inner: Rough, irregular, fractured surface

3. Reinforcement: A 1/4" diameter steelmesh member was included with the sample. No corrosion observed.

4. General Physical Conditions: The outer surface has undergone moderate mortar erosion exposing many fine aggregates and some coarse aggregate surfaces. The sample is severely fractured, macro cracked and micro cracked throughout, in orientations subparallel to the outer surface. The cracking passes through most of the carbonate gravel-coarse aggregate. Some ASR gel was observed within cracks through a few chert and silicified carbonate particles. Ettringite or calcite, with small amounts of CaOH (secondary deposits) was observed lining or filling macro and micro cracks throughout the sample. The concrete does not appear to contain any purposeful air entrainment. Very poor overall condition.

II. Aggregate

1. Coarse: 3/4" maximum sized carbonate gravel. Rock types include mostly carbonate with some quartzite. Fairly well graded with good overall uniform distribution.

2. Fine: Natural lithic sand with some quartz that was fairly well graded. The grains were mostly rounded with some sub-angular particles. Fair to poor overall distribution.

III. Cementitious Properties

1. Air Content:	0.4% total, 0.2% entrapped, 0.2% entrained. Surface area size does not meet the ASTM:C457 minimum requirement.
2. Depth of carbonation:	Negligible
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Good
5. Paste color:	Light gray
6. Paste hardness:	Medium to hard
7. Paste proportions:	25% to 27%
8. Microcracking:	Several observed throughout the sample at various depths and in a subparallel orientation to the outer surface, proceeding through many coarse aggregates including reactive cherts and silicified carbonates.
9. Secondary deposits:	Ettringite was observed partially filling void spaces in the sample. Ettringite or calcite, with some CaOH was observed lining or filling most micro and macro cracks throughout the sample.
10. Slump:	Estimated, medium (3" to 5")
11. Water/cement ratio:	Estimated at between 0.45 to 0.50 with approximately 9-10% unhydrated portland cement clinker particles.
12. Degree of hydration:	Fully hydrated

IV. Conclusions

The general overall quality of the concrete was poor.

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #: 97-9359 Date: 10/16/97
Sample Identification: #3 Performed by: G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on a 3-11/16" x 2" x 1-11/16" thick and 3-11/16" x 2-5/8" x 1-5/8" thick polished section that was cut from the original 3-11/16" diameter x unknown length core.

2. Surface Conditions:

Outer: Rough, formed surface with some spalling
Inner: Rough, irregular, fractured surface

3. Reinforcement: None observed.

4. General Physical Conditions: The sample is severely fractured, macro cracked, and micro cracked throughout, in orientations subparallel to the outer surface. The cracking passes through nearly all coarse aggregate particles. ASR gel was observed filling micro cracks in a few silicified carbonate particles, secondary ettringite and calcite were observed lining many of the cracks and fracture planes. The concrete does not appear to contain any purposeful air entrainment. Very poor overall condition.

II. Aggregate

1. Coarse: 3/4" maximum sized carbonate gravel. Rock types include mostly carbonate with some quartzite. Fairly well graded with good overall uniform distribution.

2. Fine: Natural lithic sand with some quartz that was fairly well graded. The grains were mostly rounded with some sub-angular particles. Fair overall distribution.

III. Cementitious Properties

1. Air Content:	0.3% total, 0.2% entrapped, 0.1% entrained. Surface area size does not meet the ASTM:C457 minimum requirement.
2. Depth of carbonation:	Negligible
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Good
5. Paste color:	Light gray
6. Paste hardness:	Medium
7. Paste proportions:	23% to 25%
8. Microcracking:	Severe microcracking observed throughout the sample at various depths and in subparallel orientations to the outer surface, proceeding through most coarse aggregates.
9. Secondary deposits:	Ettringite was observed partially filling most void spaces in the sample, clumps/mats of ettringite were observed on fracture planes. Calcite was observed lining numerous micro cracks. ASR gel was observed partially filling some microcracking in a few reactive coarse aggregates.
10. Slump:	Estimated, medium to high (4" to 6")
11. Water/cement ratio:	Estimated at between 0.46 to 0.51 with approximately 8-10% unhydrated portland cement clinker particles.
12. Degree of hydration:	Fully hydrated

IV. Conclusions

The general overall quality of the concrete was poor.

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #: 97-9359 Date: 10/16/97
Sample Identification: #4 Performed by: G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on a 5" x 3-11/16" x 1-7/8" thick and a 3-11/16" x 1-5/8" x 1" thick polished section that was cut from the original 3-11/16" diameter x at least 6" length core.

2. Surface Conditions:

Outer: Fairly rough, mortar eroded surface
Inner: Smooth, formed surface placed on form

3. Reinforcement: A 1/4" diameter steelmesh member was observed approximately 7/8" depth from the inner surface. No corrosion observed.

4. General Physical Conditions: The outer surface has undergone moderate mortar erosion exposing many fine aggregate. The outer up to 1" of the sample consists of a dark gray colored repair concrete placed upon the irregular fractured surface of the base concrete. The base concrete is severely fractured, macro cracked, and micro cracked throughout, in orientations subparallel to the outer surface. The cracking passes through nearly all coarse aggregate particles. ASR gel was observed within the micro cracking in a few reactive coarse aggregates, quartzite, silicified carbonate, and chert. Secondary ettringite was observed lining or filling most void spaces and many crack planes. Very poor overall condition.

II. Aggregate

1. Coarse: 3/4" maximum sized carbonate gravel. Rock types include mostly carbonate with some quartzite. Fairly well graded with good overall uniform distribution.

2. Fine: Natural lithic sand with some quartz that was fairly well graded. The grains were mostly rounded with some sub-angular particles. Fair overall distribution.

III. Cementitious Properties

1. Air Content:	0.9% total, 0.5% entrapped, 0.4% entrained.
2. Depth of carbonation:	Negligible from both surfaces
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Good
5. Paste color:	Light gray
6. Paste hardness:	Medium
7. Paste proportions:	23% to 25%
8. Microcracking:	Severe microcracking observed throughout the sample at various depths and in subparallel to the outer surface, proceeding through most coarse aggregates.
9. Secondary deposits:	Ettringite was observed lining or filling most void spaces and cracks. ASR gel was observed within microcracking in a few reactive aggregate particles.
10. Slump:	Estimated, medium to high (4" to 6")
11. Water/cement ratio:	Estimated at between 0.46 to 0.51 with approximately 8-10% unhydrated portland cement clinker particles.
12. Degree of hydration:	Fully hydrated

IV. Conclusions

The general overall quality of the concrete was poor.

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #: 97-9359 Date: 10/16/97
Sample Identification: #5 Performed by: G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on a 3-11/16" x 1-3/4" x 13/16" thick polished section that was cut from the original 3-11/16" diameter x 13/16" length core.

2. Surface Conditions:

Outer: Fairly rough, mortar eroded surface
Inner: Rough, irregular, fractured surface

3. Reinforcement: None observed.

4. General Physical Conditions: The inner surface of the sample is characterized by a fractured plane across a series of closely spaced, parallel, 1/8" diameter impressions; much like steelmesh without cross members present. Visible application lines are characterized by different paste color, void space volume (differential consolidation), and at least two cold joints. Fair overall condition.

II. Aggregate

1. Fine: Natural lithic sand with some quartz that was fairly well graded. The grains were mostly rounded with some sub-angular particles. Fair overall distribution.

III. Cementitious Properties

1. Air Content:	2.7% total, 0.0% entrapped, 2.7% entrained. Surface area size does not meet the ASTM:C457 minimum requirement.
2. Depth of carbonation:	Partial up to 3/16"
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Good
5. Paste color:	Layered gray to light tannish gray
6. Paste hardness:	Medium to soft
7. Paste proportions:	26% to 28%
8. Microcracking:	Two microcracks, subparallel to the outer surface were observed proceeding to 5/16" and through the sample, respectively.
9. Secondary deposits:	None observed
10. Slump:	Estimated, low (1" to 3")
11. Water/cement ratio:	Estimated at between 0.35 to 0.55 with approximately 8-16% unhydrated portland cement clinker particles.
12. Degree of hydration:	Moderately hydrated

IV. Conclusions

The general overall quality of the concrete was fair.

REPORT OF AIR VOID ANALYSIS

PROJECT:

ATC #58679-0003
FERNALD SILO
P.R. #CN45000140

REPORTED TO:

ATC ASSOCIATES INC.
11121 CANAL ROAD
CINCINNATI, OH 45241

ATTN: GENE McVEY

APS JOB NO: 97-9359

DATE: OCTOBER 20, 1997

Sample No:	#1	#2	#3	#4	#5
Conformance:	The samples contain an air void system which is not consistent with current technology for freeze-thaw resistance.				
Sample Data:					
Description:	Hardened Concrete Core				Hardened Shotcrete Core
Dimensions:	3-11/16" diam by 7-3/4" long	3-11/16" diam by ~7" long	3-11/16" diam by unknown length	3-11/16" diam by ~6" long	3-11/16" diam by 13/16" long

Test Data ASTM:C457 Linear Traverse Method, APS Standard Operating Procedure 00 LAB 003

Air Void Content, %	1.0	0.3	0.3	1.0	2.7
Entrained, % $\leq$ 0.040"	0.4	0.2	0.1	0.4	2.7
Entrapped, % > 0.040"	0.6	0.1	0.2	0.6	0.0
Air Voids/inch	0.56	0.17	0.08	0.34	8.48
Specific Surface, in^2/in^3	220	200	120	150	1240
Spacing Factor, inches	0.045	0.076	0.138	0.067	0.005
Paste Content, %	28	26	25	25	26
Magnification	50x	50x	50x	50x	50x
Traverse Length, inches	90	95	90	90	56
Test Date	10/10/97	10/10/97	10/13/97	10/13/97	10/10/97

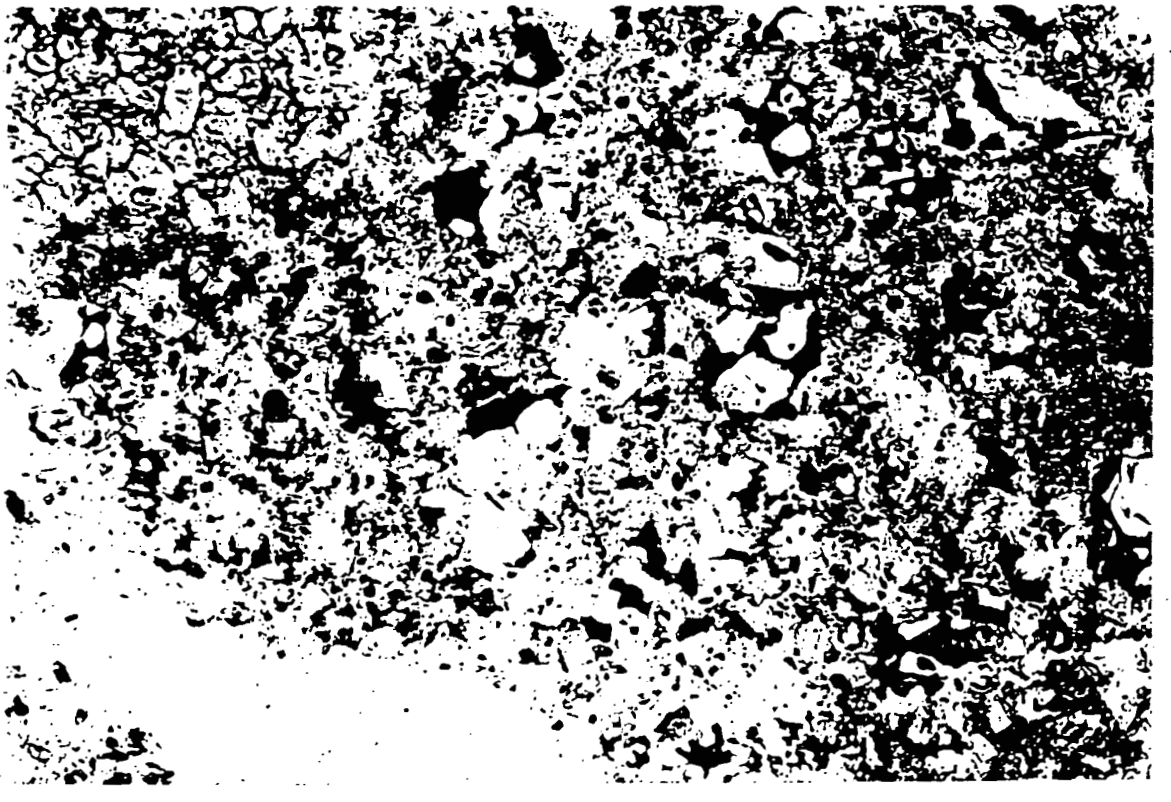
Remarks: The test samples will be retained for 30 days. We will discard the samples unless we receive other instructions.

APS# 97-9359 DATE: 10-21-97

PROJECT: ATC #58679-0003, FERNALD SILO. P.R. #CN45000140

SAMPLE IDENTIFICATION: 1
MAGNIFICATION: 100x

SAMPLE DESCRIPTION: Dark, amber colored unhydrated cement (9-10%)under plane polarized light.



SAMPLE IDENTIFICATION: 1
MAGNIFICATION: 200x

SAMPLE DESCRIPTION: Fully hydrated silicates under plane polarized light.

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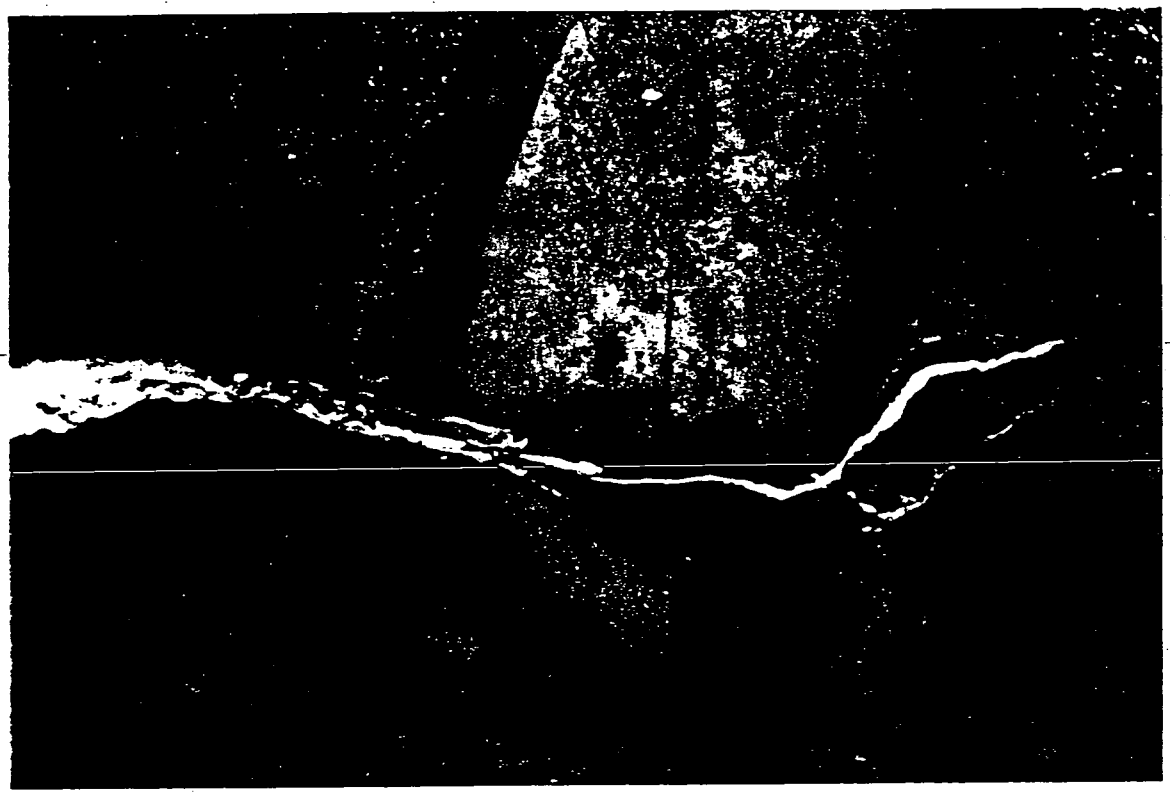
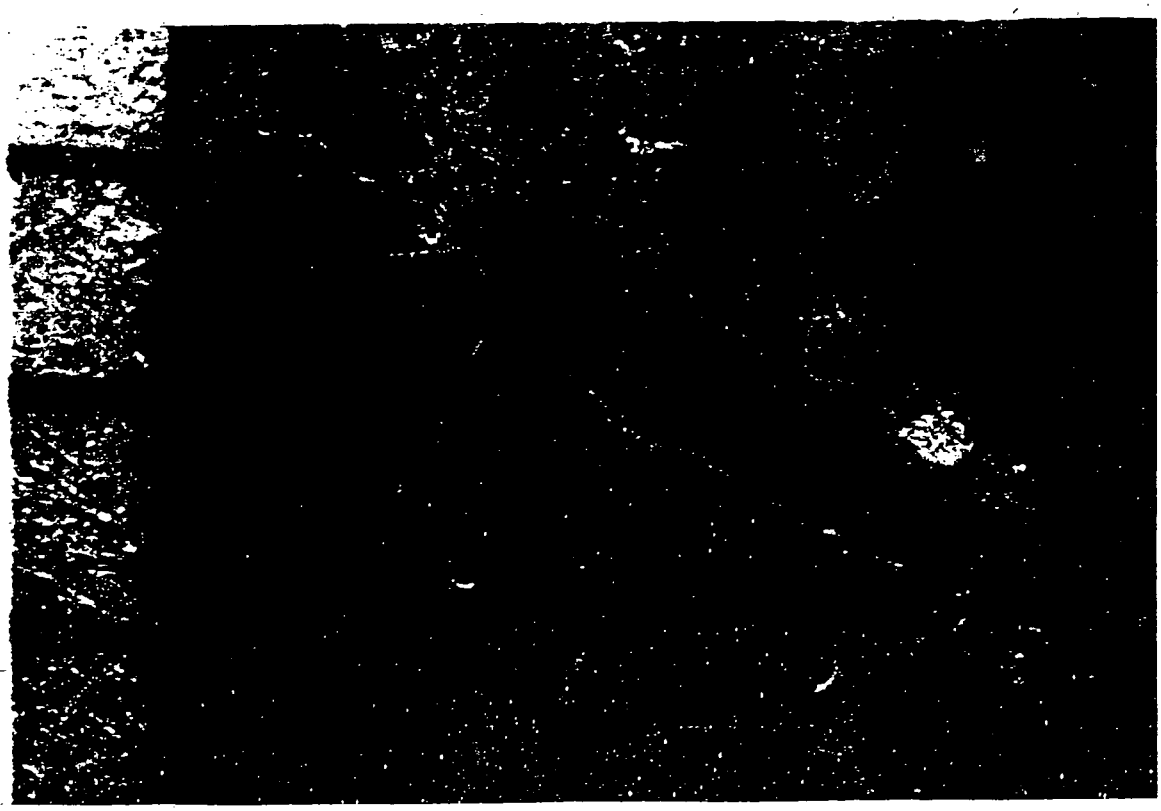
PROJECT: ATC #58679-0003, FERNALD SILO, P.R. #CN45000140



SAMPLE IDENTIFICATION: 2
MAGNIFICATION: 20x

SAMPLE DESCRIPTION: Silica gel filled crack through reactive chert particle.



SAMPLE IDENTIFICATION: 2
MAGNIFICATION: 20x

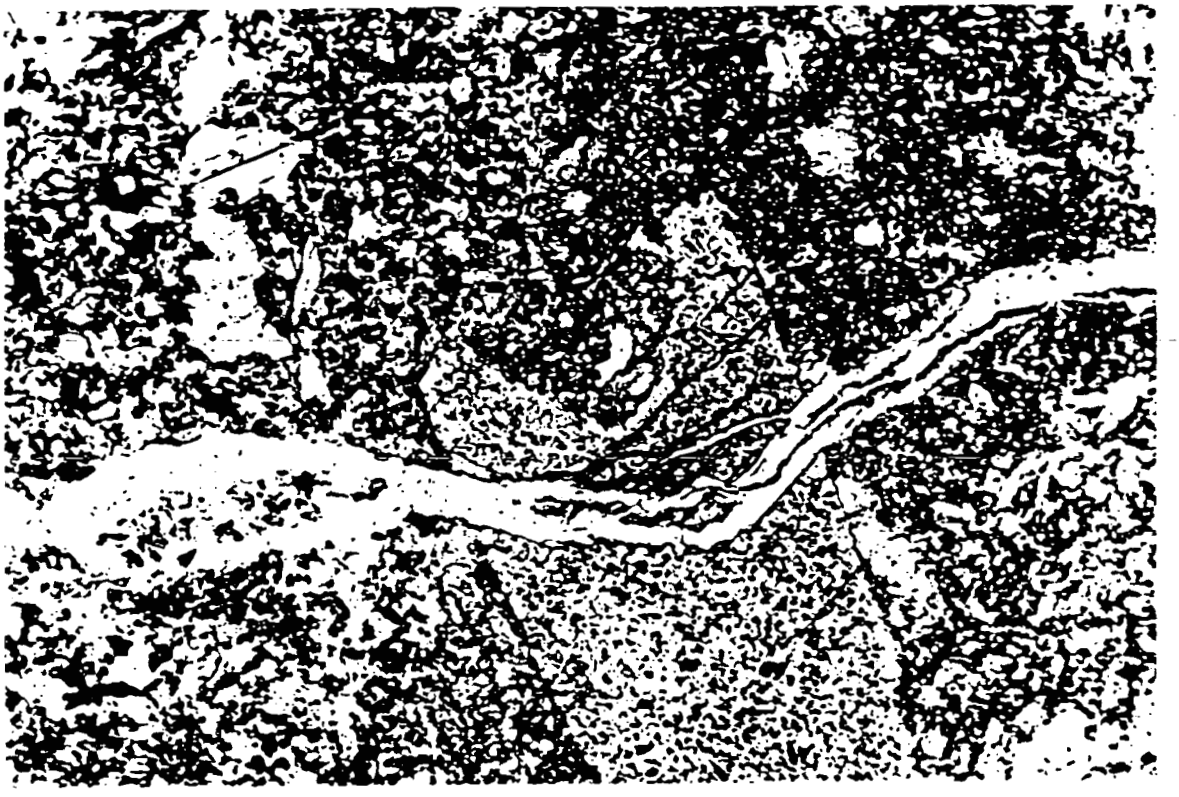
SAMPLE DESCRIPTION: Silica gel filled crack through reactive chert particle.

30

APS# 97-9359 DATE: 10-21-97

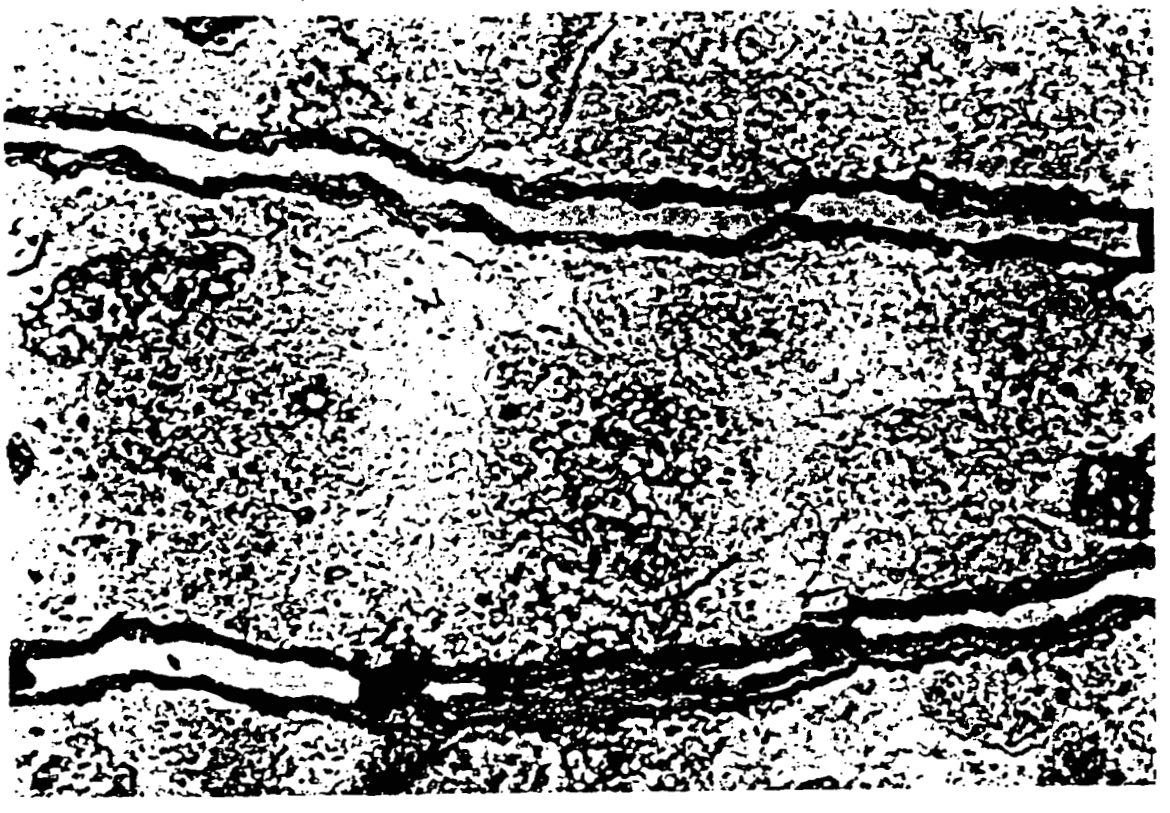
1278

PROJECT: ATC #58679-0003, FERNALD SILO, P.R. #CN45000140



SAMPLE IDENTIFICATION: 2
MAGNIFICATION: 100x

SAMPLE DESCRIPTION: ASR lined carbonate particles under plane polarized light.

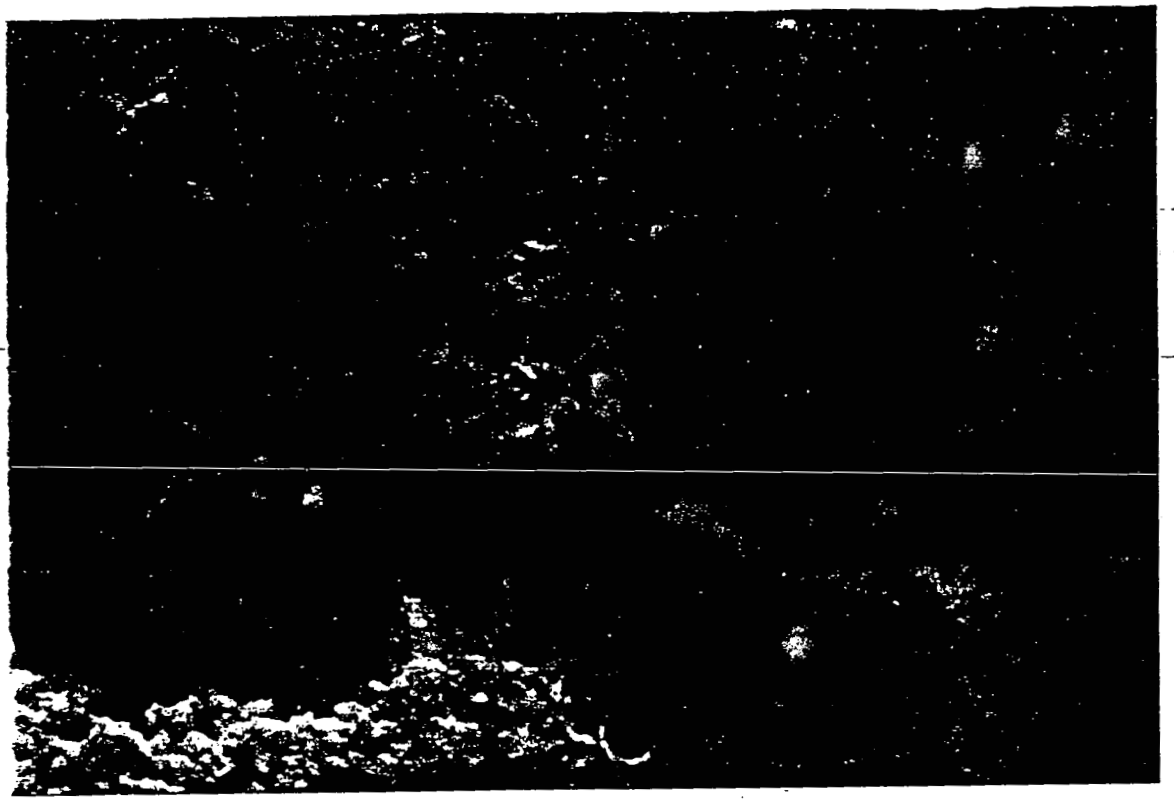


SAMPLE IDENTIFICATION: 3
MAGNIFICATION: 200x

SAMPLE DESCRIPTION: ASR lined carbonate particles under plane polarized light.

APS# 97-9359 DATE. 10-21-97

PROJECT: ATC #58679-0003. FERNALD SILO. P.R. #CN45000140



SAMPLE IDENTIFICATION: 3
MAGNIFICATION: 20x

SAMPLE DESCRIPTION: Silica gel lined air void adjacent to reactive coarse aggregate particle.

SAMPLE IDENTIFICATION: 3
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: Extensively fractured aggregate particle.

APS# 97-9359 DATE: 10-21-97

PROJECT: ATC #58679-0003, FERNALD SILO, P.R. #CN45000140

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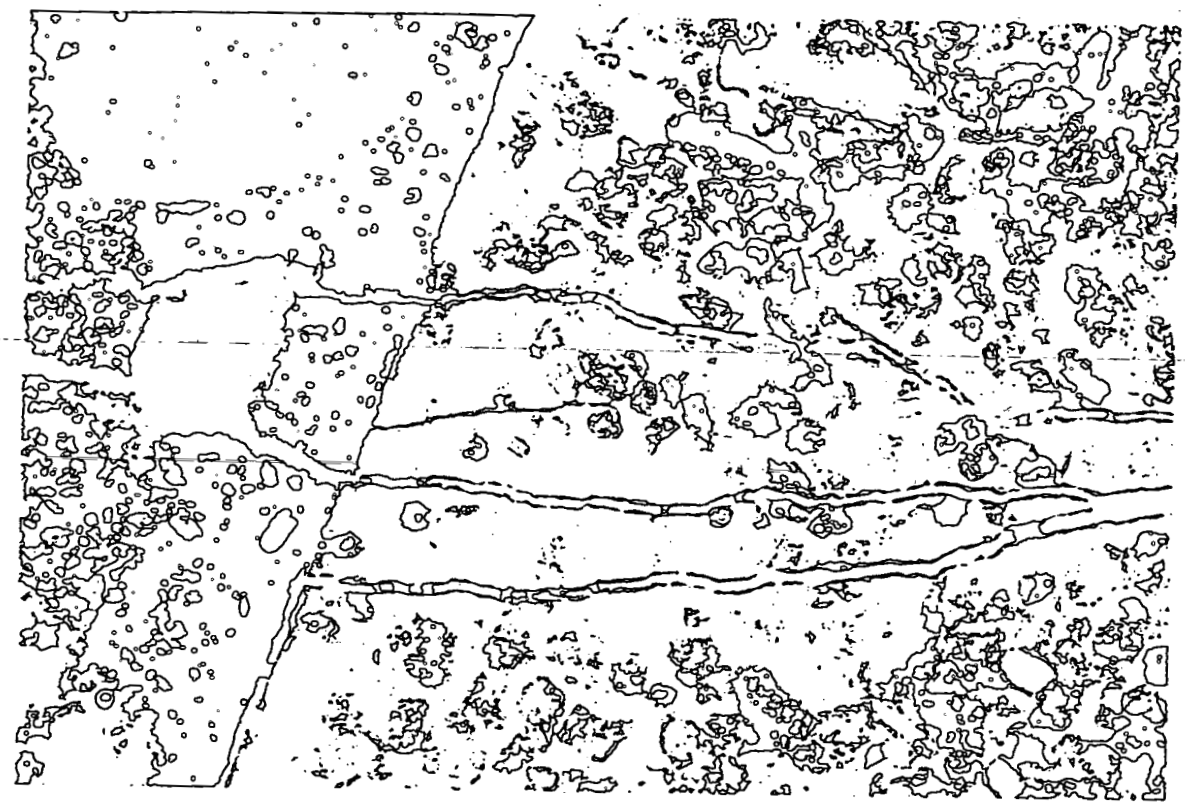
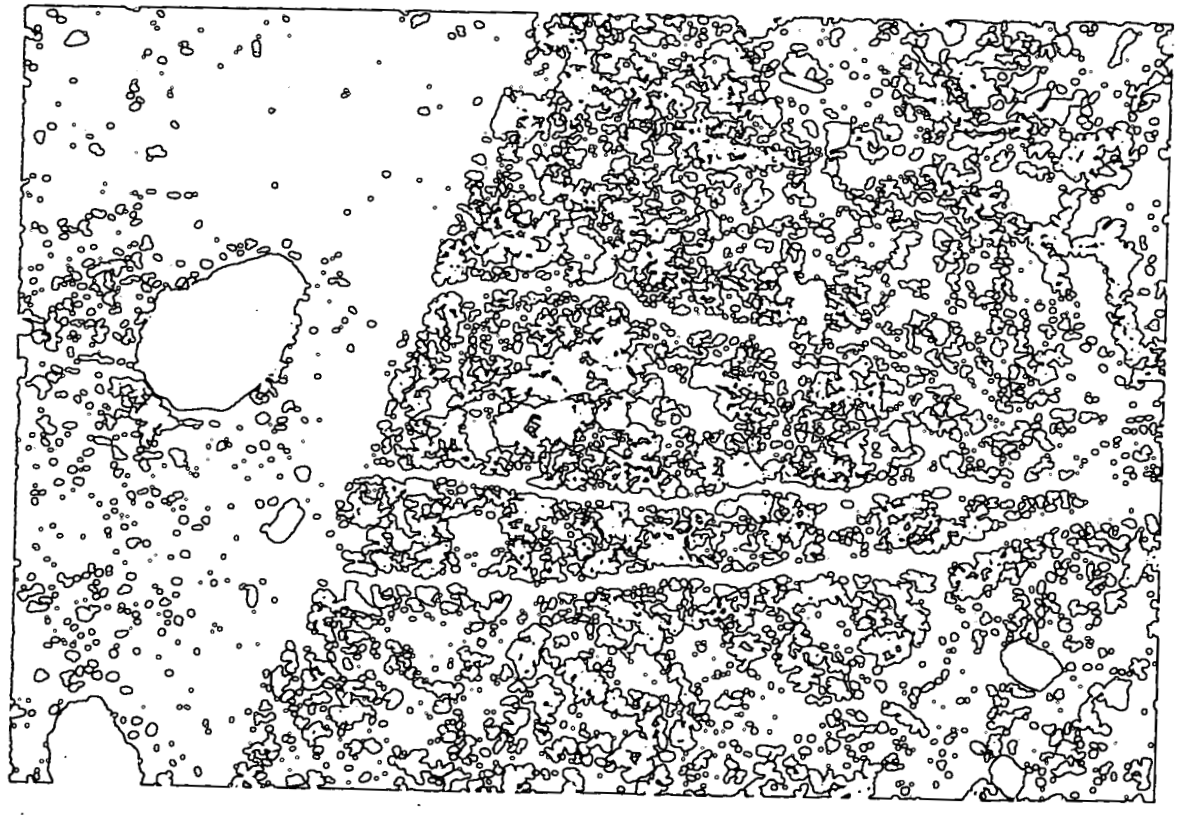


SAMPLE IDENTIFICATION: 3
MAGNIFICATION: 40x

SAMPLE DESCRIPTION: Silica gel lined cracks propagating from silicified carbonate particle under plane polarized light.



SAMPLE IDENTIFICATION: 3
MAGNIFICATION: 40x

SAMPLE DESCRIPTION: Silica gel lined cracks propagating from silicified carbonate particle under cross polarized light.

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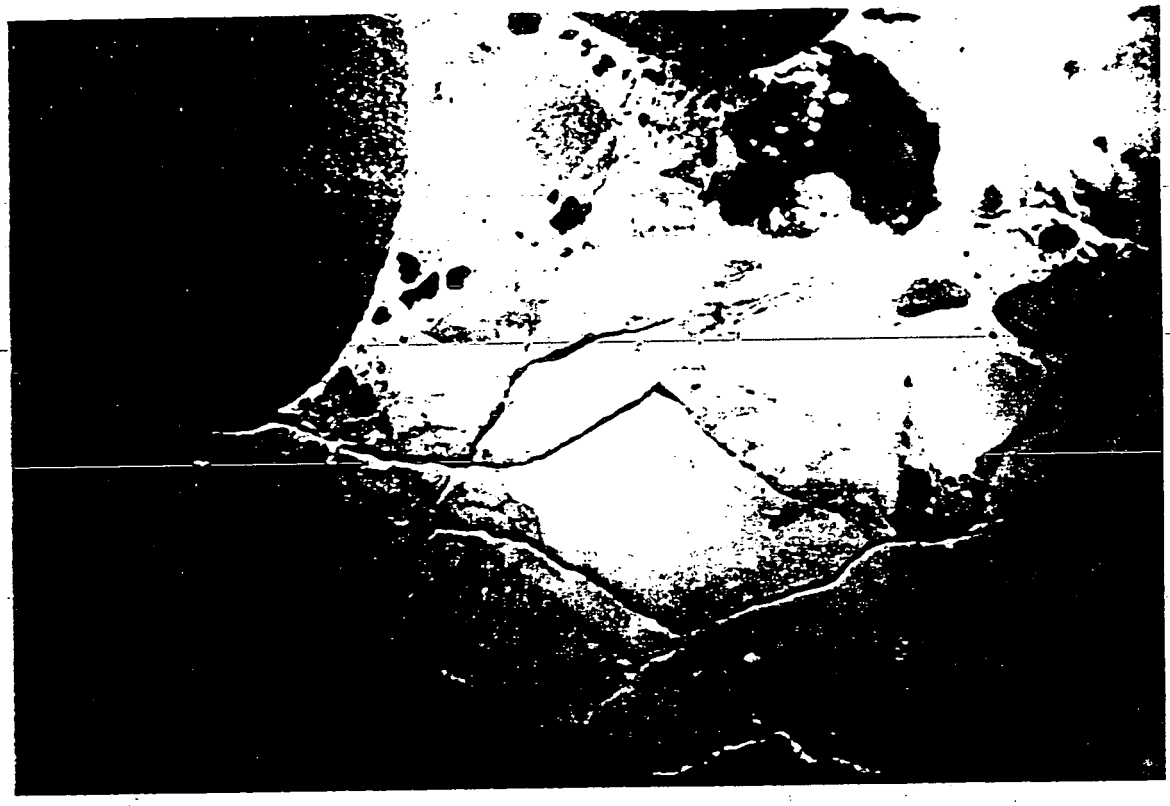
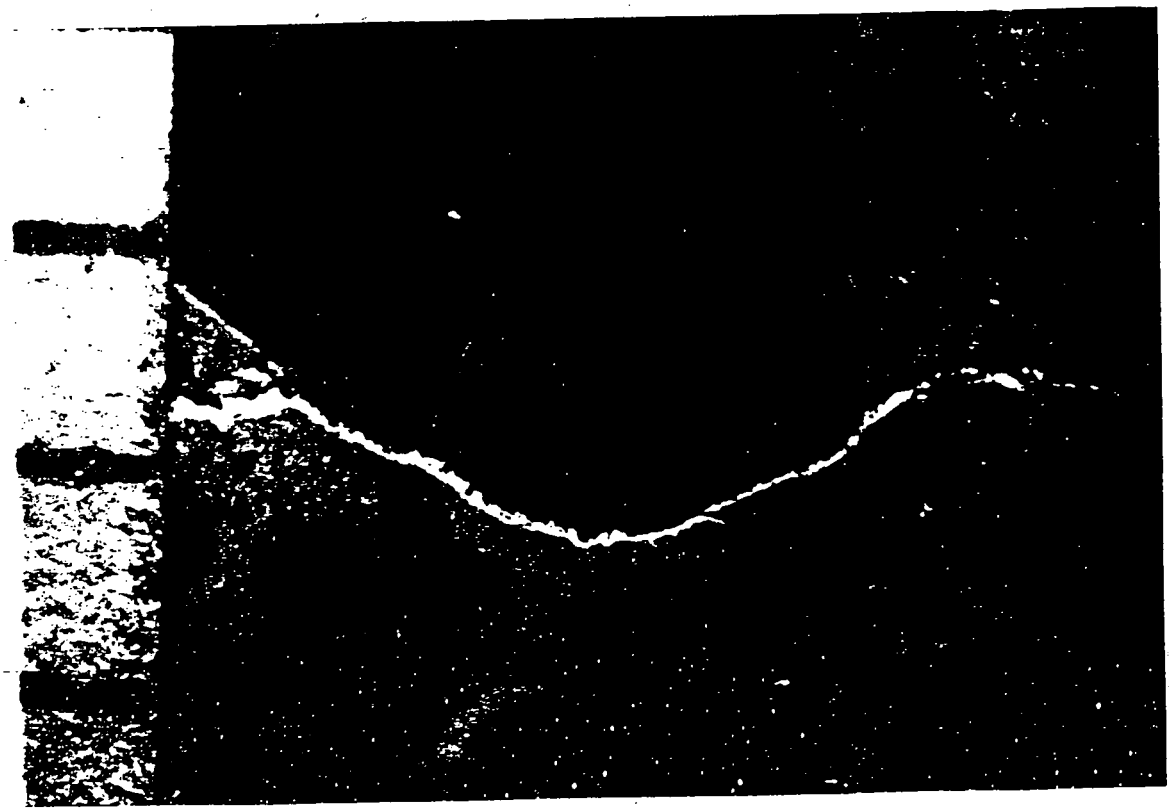


SAMPLE IDENTIFICATION: 4
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: Microcracked carbonate particle in distressed area of core.

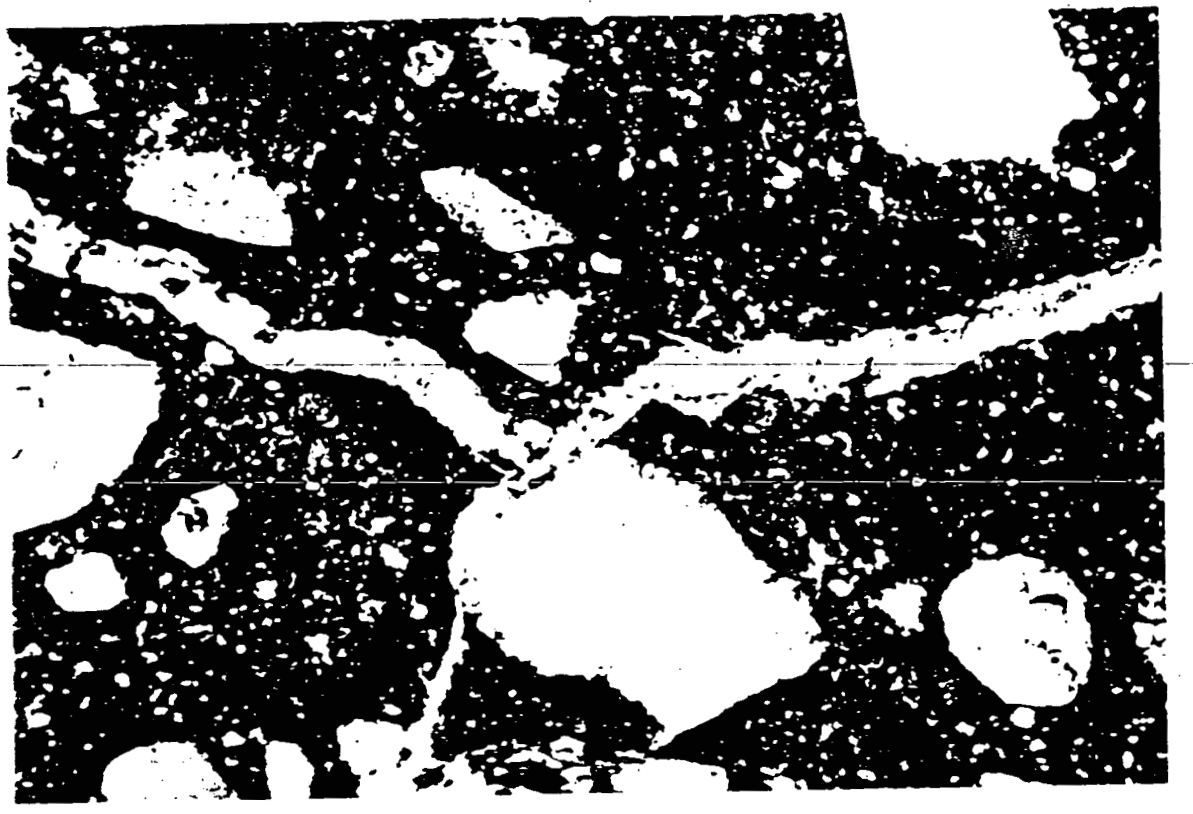


SAMPLE IDENTIFICATION: 4
MAGNIFICATION: 20x

SAMPLE DESCRIPTION: Ettringite filled crack around perimeter of aggregate.

APS# 97-9359 DATE: 10-21-97

PROJECT: ATC #58679-0003, FERNALD SILO, P.R. #CN45000140



SAMPLE IDENTIFICATION: 4
MAGNIFICATION: 40x

SAMPLE DESCRIPTION: Ettringite filled crack under plane polarized light.

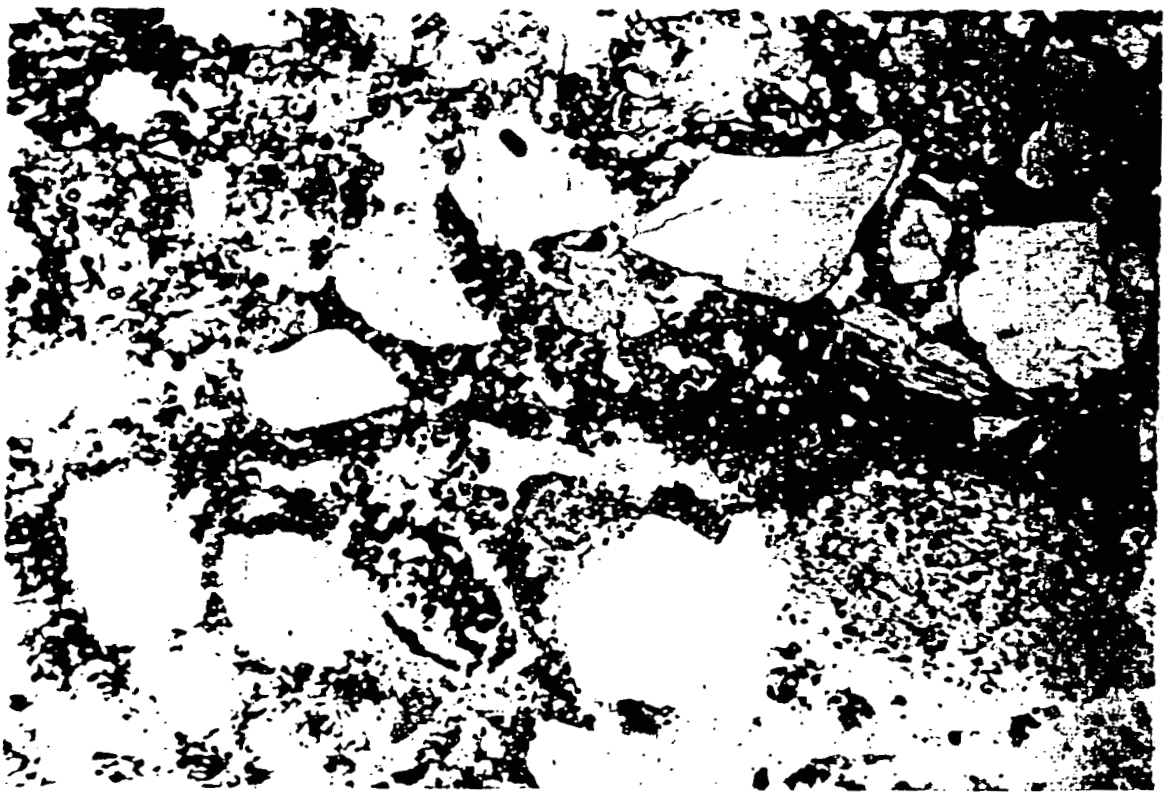
SAMPLE IDENTIFICATION: 4
MAGNIFICATION: 40x

SAMPLE DESCRIPTION: Ettringite filled crack under cross polarized light.

PROJECT: ATC #58679-0003, FERNALD SILO, P.R. #CN45000140

SAMPLE IDENTIFICATION: 4
MAGNIFICATION: 100x

SAMPLE DESCRIPTION: Banded ASR gel within cracked quartzite particle under plane polarized light.

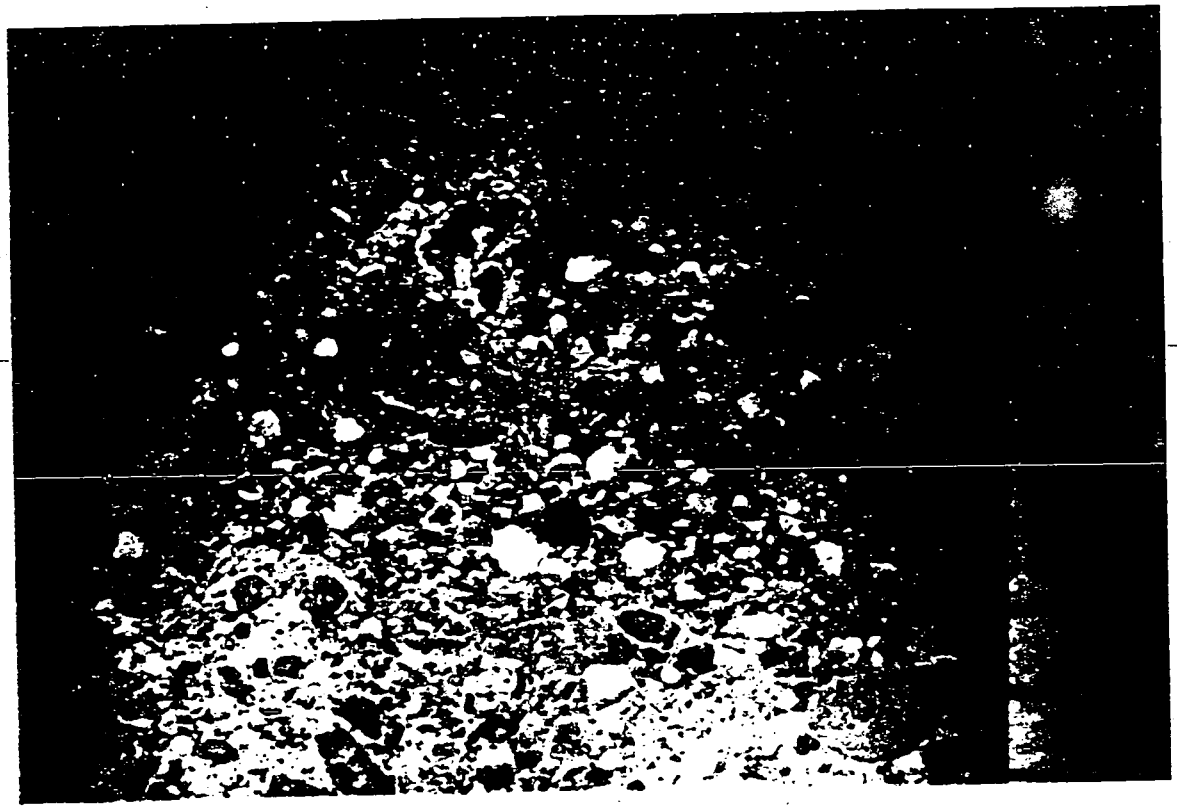


SAMPLE IDENTIFICATION: 5
MAGNIFICATION: 40x

SAMPLE DESCRIPTION: Unhydrated portland cement concentration along application line under plane polarized light.

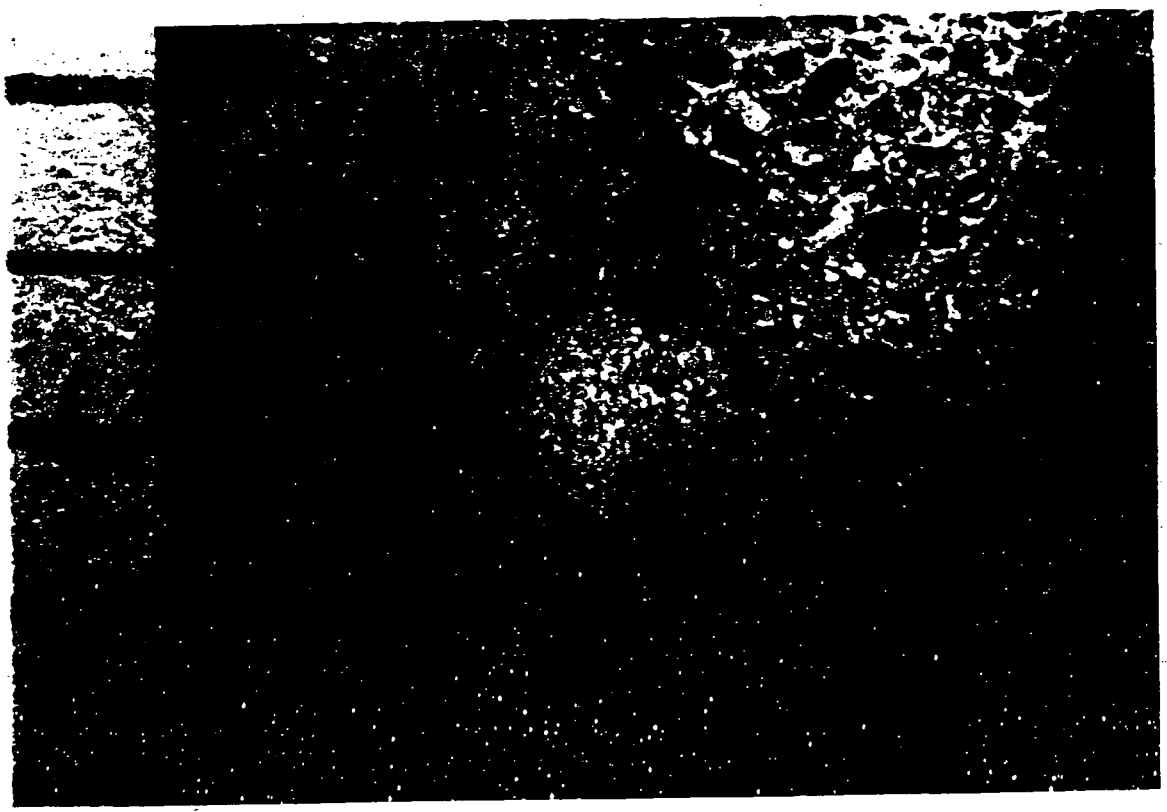
APS# 97-9359 DATE: 10-21-97 1278

PROJECT: ATC #58679-0003, FERNALD SILO. P.R. #CN45000140



SAMPLE IDENTIFICATION: 5
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: White, up to 3/16" deep carbonation at the surface.



SAMPLE IDENTIFICATION: 5
MAGNIFICATION: 15x

SAMPLE DESCRIPTION: Cold joint between low and high w/c application layers.

October 26, 1997

Mehmet

The final test report for silo 3 concrete has been received and is attached. Please review the report and provide comments. I reviewed the report but since my background is very limited in this field, I could not get a definitive position. I am looking at the results in plain English. Could you summarize the report and provide your comments.

Since the beginning of the Fiscal year the charge number has changed and you should use the following:

Contract:	04424331
Area/Unit/CO	4FN1B

Everyone is anxious to find the results so your attention to this matter at your earliest convenience would be appreciated. Should you have any question or comments please feel free to call me at 513 648-4845.

John

ATEC Associates, Inc.
11121 Canal Road
Cincinnati, Ohio 45241
Office (513) 771-2112
Fax (513) 782-6908

DAILY FIELD REPORT

TESTED FOR:	Mr. Jim Reuter 45 Doe c/o Fluor Daniel Fernald 7400 Willey Road Fernald, OH 45030	PROJECT: ATC/ATEC FILE NO.: REPORT NO.: DATE:	Silo #4 Fernald, Ohio 58679.0003 1 (Revised) September 15, 1997

WEATHER: Clear and Warm

TYPE OF INSPECTION BEING PERFORMED: Core Drilling

TECHNICIAN GIVEN INSTRUCTIONS BY: Tom Shiner

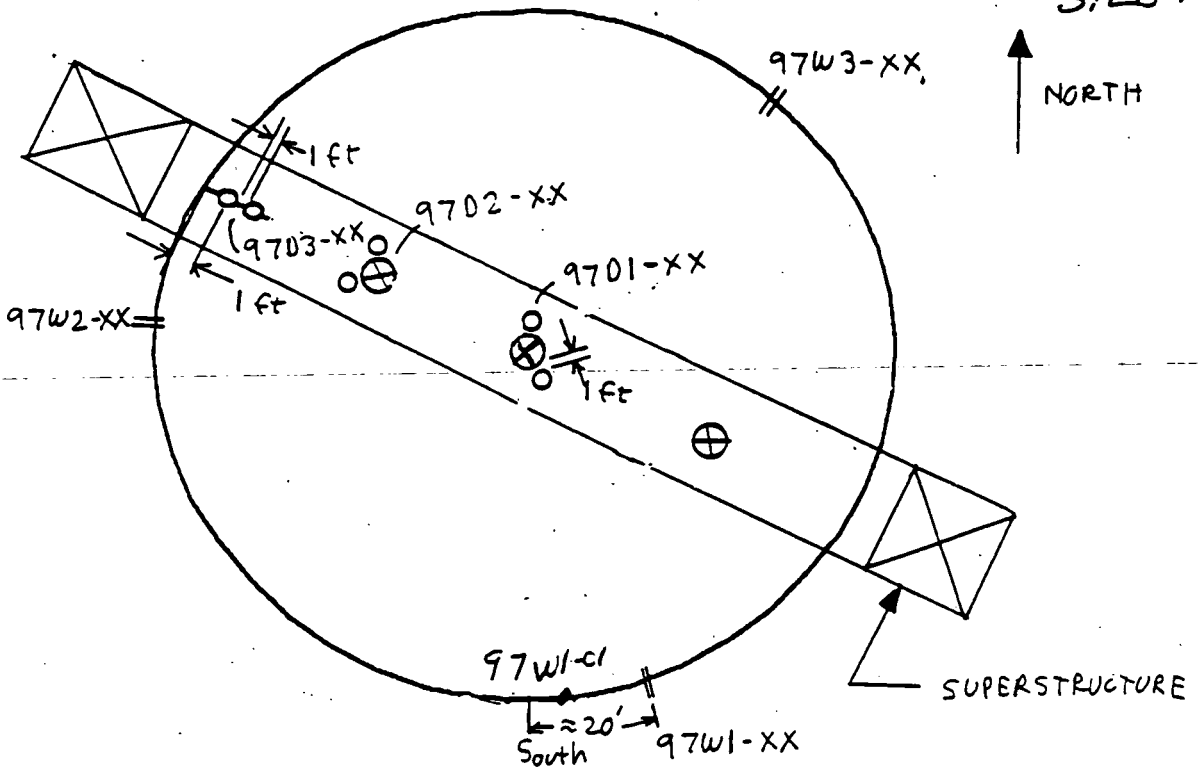
WORK ACTIVITIES FOR THE DAY:

The ATC/ATEC representative arrived on the above referenced site as requested by the client's representative. Upon arrival, the technician was advised on the set up of Milwaukee Core Drilling for Silo #4 drilling the South wall (97W1-01 see drawing) about 68 inches up from the silo floor. Using a new four inch core bit #4539 taking core sample 97W1-01. The technician observed this to be a good sample core and filled out change of custody and returned to the ATC office.

FIELD TECHNICIAN: John Gilkison/mac

REVIEWED BY: Thomas R. Baker

9-15-971278
03776.0009-1
Silo #4



Note: All dimensions typ.
All cores 4" diameter (O indicates cores)
⊗ - Indicates 20" diameter manway
Total 12 cores (2 each at 6 locations)
Location of cores at manways may be adjusted to avoid cover plates and repair.
Identify cores from each of 6 locations with sequential numbers (ie -01, -02, etc)

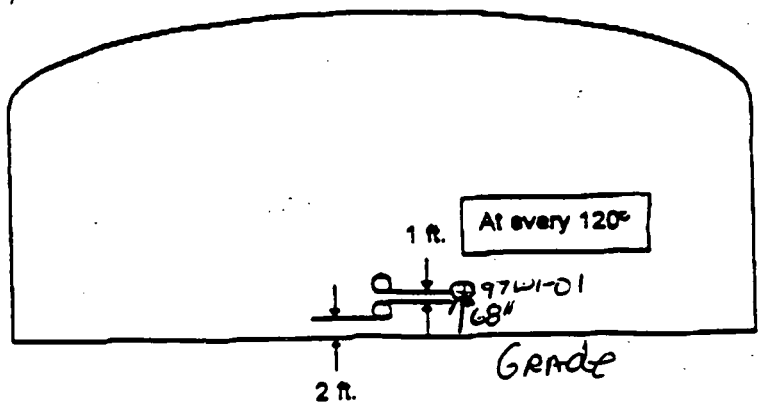


FIGURE 1

T Ramp Shaw
7/2/97

ATEC Associates, Inc.
11121 Canal Road
Cincinnati, Ohio 45241
Office (513) 771-2112
Fax (513) 782-6908

DAILY FIELD REPORT

TESTED FOR:	Mr. Jim Reuter 45 Doe c/o Fluor Daniel Fernald 7400 Willey Road Fernald, OH 45030	PROJECT: ATC/ATEC FILE NO.: REPORT NO.: DATE:	Silo #4 Fernald, Ohio 58679.0003 2 (Revised) September 16, 1997

WEATHER: Clear and Warm

TYPE OF INSPECTION BEING PERFORMED: Core Drilling

TECHNICIAN GIVEN INSTRUCTIONS BY: Tom Shiner

WORK ACTIVITIES FOR THE DAY:

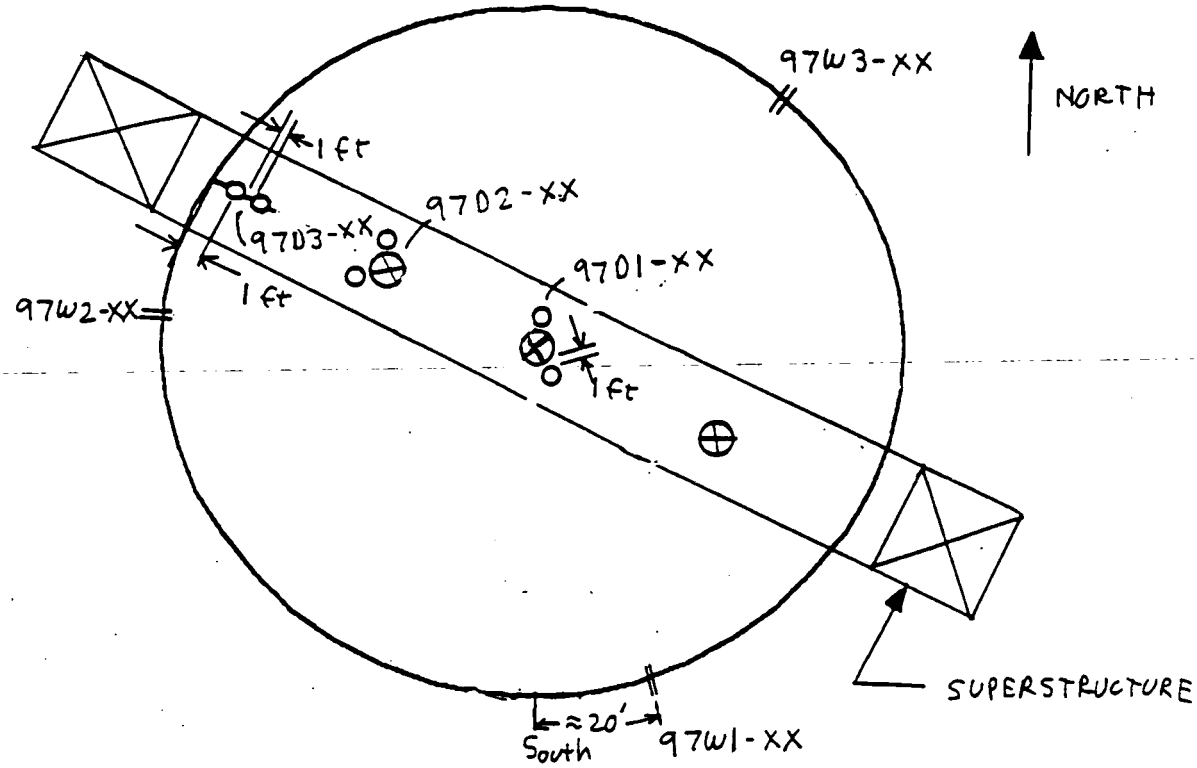
The ATC/ATEC representative arrived on the above referenced site as requested by the client's representative. Upon arrival, the technician obtained a second sample from the South side 97W1-02 drilled 14 inches East and 11 inches up from core sample #97W-01 using a 4 inch core bit # 4539.

The FEMCO milwrights moving the core drill to the second location 97W3 (64" above floor; see drawing). The first sample cracked because of tensioning wires. On the second sample 97W 3-02 10 inches up and 13 inches West of 97W3-01, we removed the gunite and wire from the first 1 1/2 inch of the core and proceeded with a new 4 inch bit #4541. On the third sample 12 inches up and 13 inches East of 97W 3-01 using the same procedure, a good second sample (97W3-03) was obtained

The FEMCO milwrights moved the core drill to the third location 97W 2. The first sample cracked because of the drill hitting a vertical tensioning cable bundle and wasn't usable. The second sample 97W2-02 56 inches up from grade. The sample broke into two pieces but seems to be usable. The third sample (97W2-03) 18 inches up from 97W2-02 broke into three pieces but is usable for petrographic. The technician obtained a change of custody and returned the samples to the ATC office.

FIELD TECHNICIAN: John Gilkison/mac

REVIEWED BY: Thomas R. Baker



Note: All dimensions typ.
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Total 12 cores (2 each at 6 locations)

Location of cores at manways may be adjusted to avoid cover plates and rebar.

Identify cores from each of 6 locations with sequential numbers (ie -01, -02, etc)

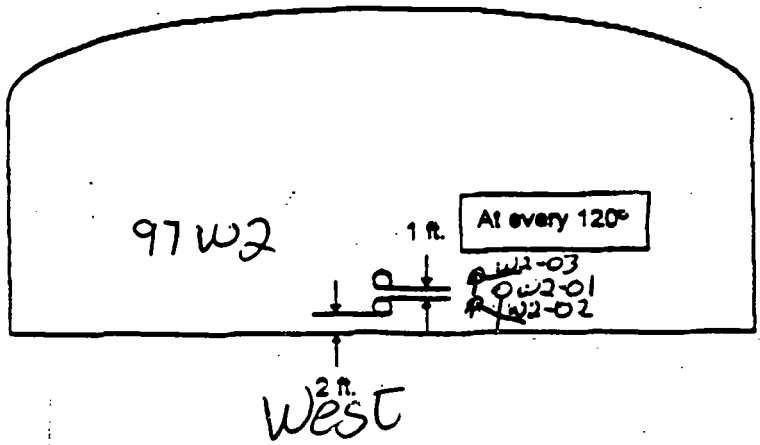
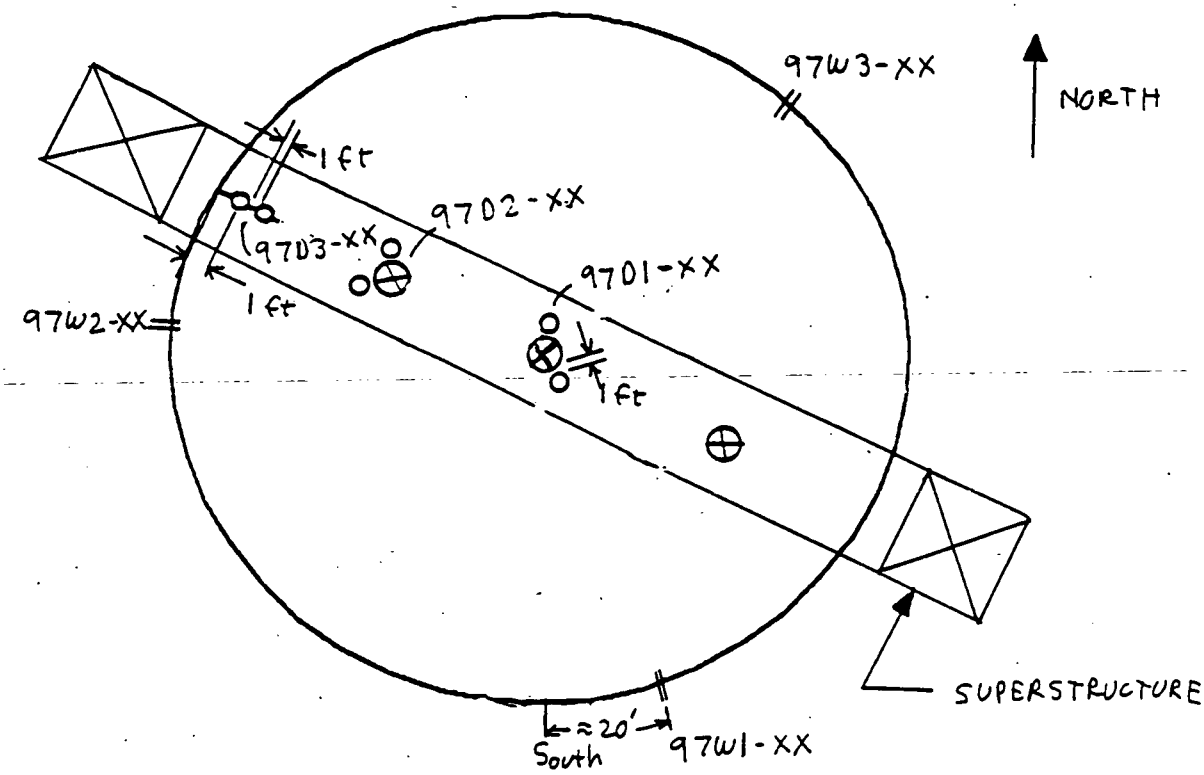


FIGURE 1

T Ramp Shinn
7/2/97



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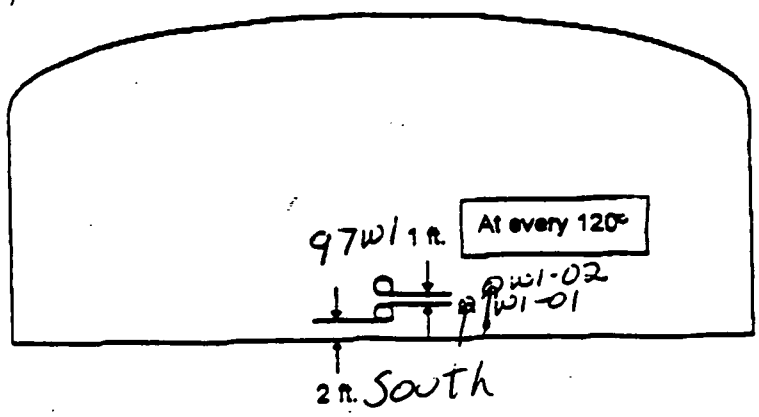
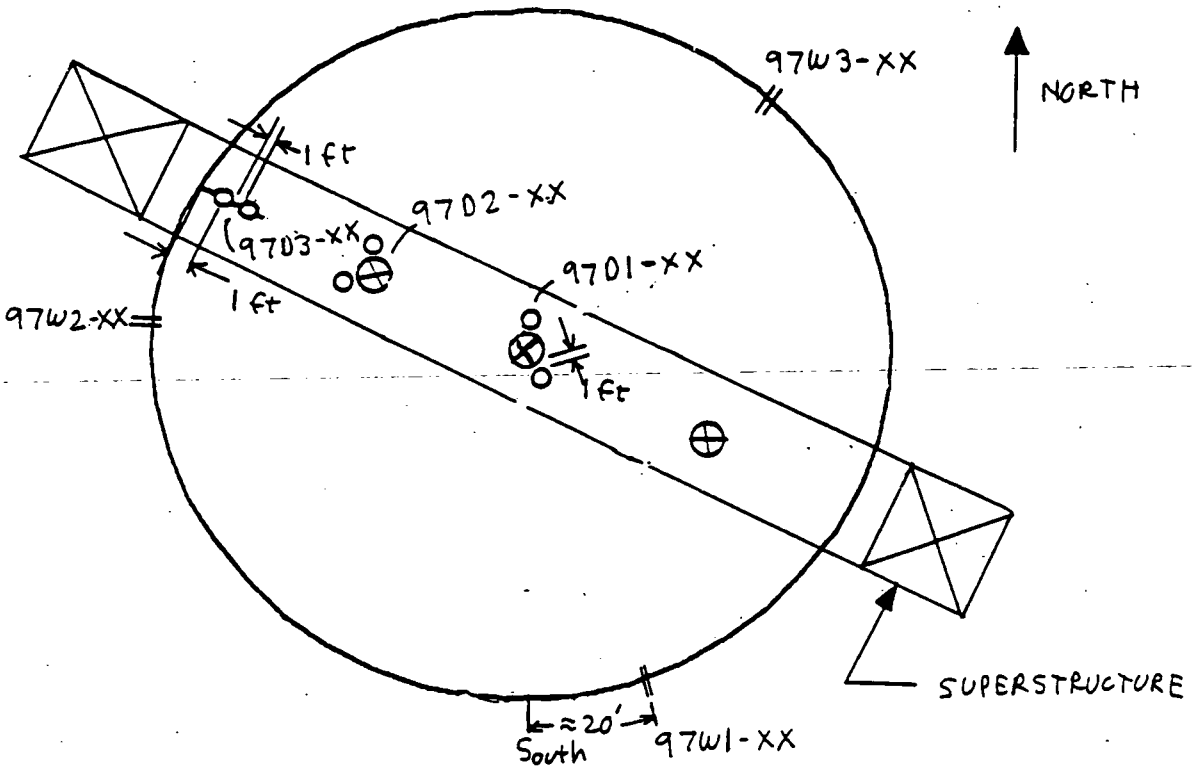


FIGURE 1

T Ramp Shaw
7/2/97



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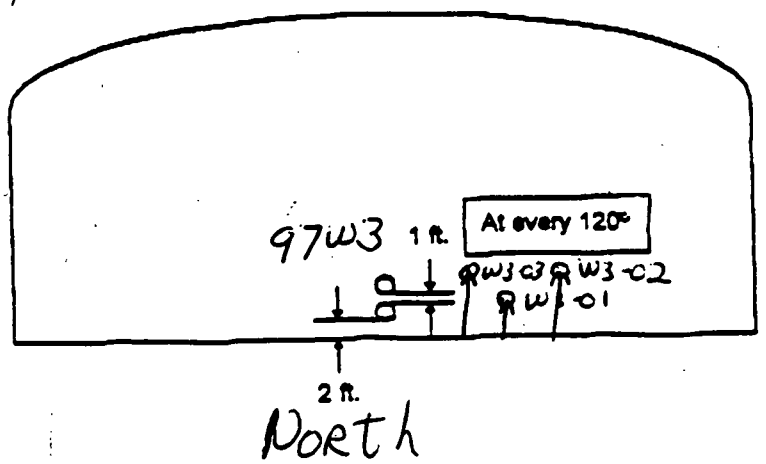


FIGURE 1

T Ramp Shinn
7/2/97

ATEC Associates, Inc.
11121 Canal Road
Cincinnati, Ohio 45241
Office (513) 771-2112
Fax (513) 782-6908

DAILY FIELD REPORT

TESTED FOR:	Mr. Jim Reuter 45 Doe c/o Fluor Daniel Fernald 7400 Willey Road Fernald, OH 45030	PROJECT:	Silo #4 Fernald, Ohio
		ATC/ATEC FILE NO.:	58679.0003
		REPORT NO.:	3 (Revised)
		DATE:	September 18, 1997

WEATHER: Clear

TYPE OF INSPECTION BEING PERFORMED: Core Drilling

TECHNICIAN GIVEN INSTRUCTIONS BY: Client

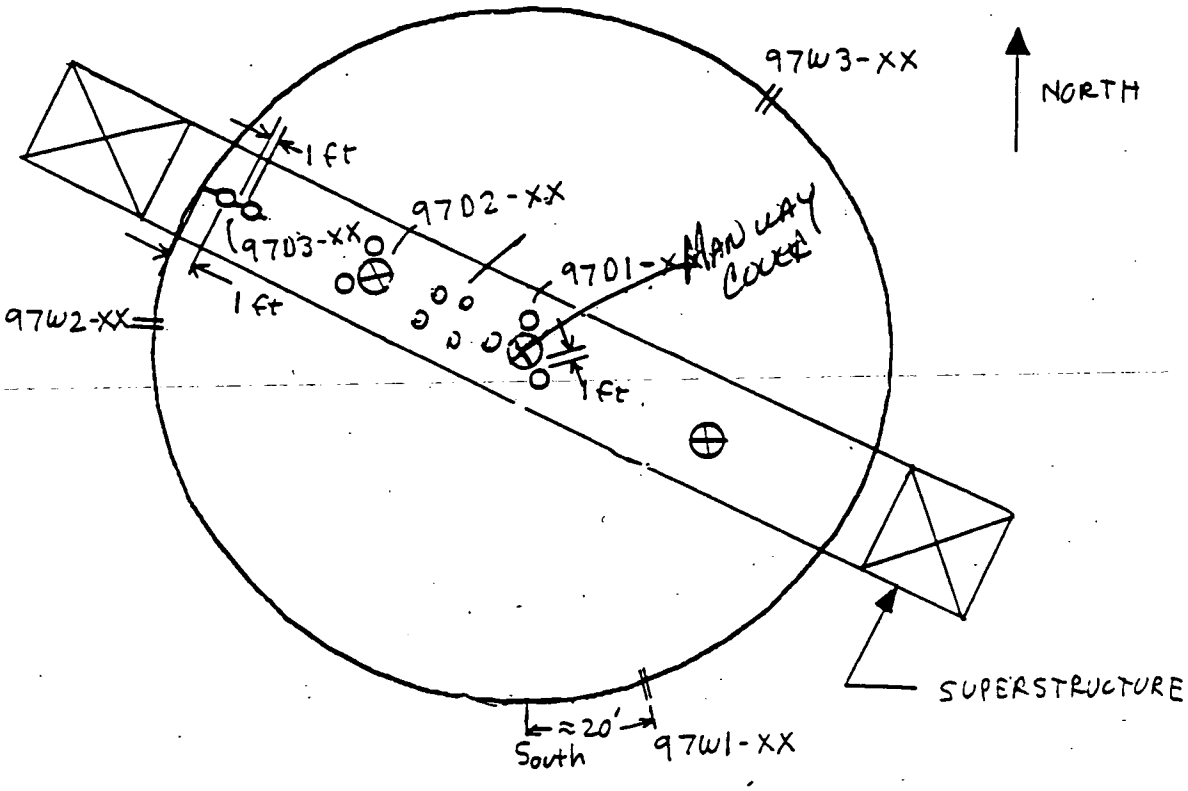
WORK ACTIVITIES FOR THE DAY:

The ATC/ATEC representative arrived on the above referenced site as requested by the client's representative. Upon arrival, the technician climbed to the top of the cat walk for Silo #4. the milwrights were coring the top by the center man way cover. No usable samples were obtained today. Drilling is to proceed on Monday. A detailed review will follow on these top drillings. The technician suggested cutting a sample out with a concrete saw because of a 1/4 inch wire mesh and rebar which seems to be breaking sample cores.

The technician then returned to the ATC office.

FIELD TECHNICIAN: John Gilkison/mac

REVIEWED BY: Thomas R. Baker



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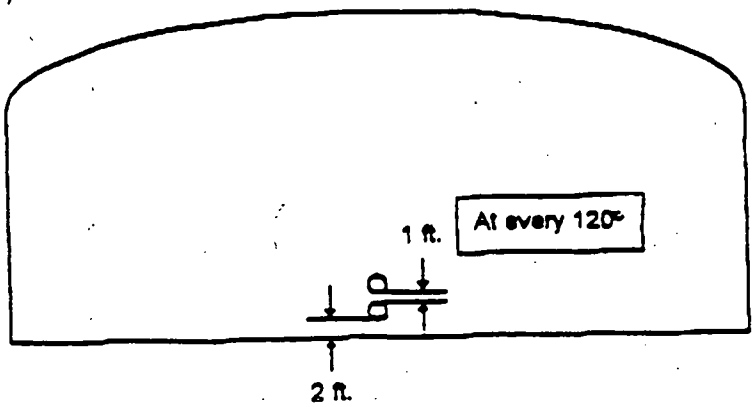

FIGURE 1

T Ramp Shaw
7/2/97

ATEC Associates, Inc.
11121 Canal Road
Cincinnati, Ohio 45241
Office (513) 771-2112
Fax (513) 782-6908

DAILY FIELD REPORT

TESTED FOR:	Mr. Jim Reuter 45 Doe c/o Fluor Daniel Fernald 7400 Willey Road Fernald, OH 45030	PROJECT:	Silo #4 Fernald, Ohio
		ATC/ATEC FILE NO.:	58679.0003
		REPORT NO.:	4
		DATE:	September 22, 1997

WEATHER: Clear and Mild

TYPE OF INSPECTION BEING PERFORMED: Core Drilling

TECHNICIAN GIVEN INSTRUCTIONS BY: Client

WORK ACTIVITIES FOR THE DAY:

The ATC/ATEC representative arrived on the above referenced site as requested by the client's representative. Upon arrival, the technician met with FEMP's, Mr. Tom Shinner and observed the core drilling of Silo #4 on the top of the dome on the North side. The reason for these cores is Distructive testing. Mr. Shinner informed the technician that this should be all the drilling to be done on Silo #4. The technician then returned to the ATC office.

FIELD TECHNICIAN: John Gilkison/mac

REVIEWED BY: Thomas R. Baker

ATEC Associates, Inc.
11121 Canal Road
Cincinnati, Ohio 45241
Office (513) 771-2112
Fax (513) 782-6908

DAILY FIELD REPORT

TESTED FOR:	Mr. Jim Reuter 45 Doe c/o Fluor Daniel Fernald 7400 Willey Road Fernald, OH 45030	PROJECT: ATC/ATEC FILE NO.: REPORT NO.: DATE:	Silo #4 Fernald, Ohio 58679.0003 5 September 25, 1997

WEATHER: Clear and Mild

TYPE OF INSPECTION BEING PERFORMED: Sample Pick-Up

TECHNICIAN GIVEN INSTRUCTIONS BY: --

WORK ACTIVITIES FOR THE DAY:

The ATC/ATEC representative arrived on the above referenced site as requested by the client's representative. Upon arrival, the technician went to Rad Control to obtain core samples held and tested for radiation containment by FEMCO. Change of custody forms were filled out and the samples were transported by the technician to the ATC office and given to ATC's, Mr. Gene McVey.

FIELD TECHNICIAN: John Gilkison/mac

REVIEWED BY: Thomas R. Baker