Fly Ash Affect on Alkali-Aggregate Reactivity

Final Report for MLR-88-7

June 1989

Highway Division

Iowa Department of Transportation

FLY ASH AFFECT ON ALKALI-AGGREGATE REACTIVITY

Final Report
MLR-88-7

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Highway Division
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June 1989

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DISCLAIMER

ABSTRACT

Cement-aggregate reactions were first reported in the 1940's. Depletion of quality aggregate, changes in cement and the use of fly ash make cement-aggregate reactions a problem still today. This latest research into alkali-aggregate reactivity was initiated to evaluate the new ASTM style test containers and evaluate the effect of Class C fly ash on the expansive reaction.

Three aggregates were tested in combination with three cements and three fly ashes available in Iowa. Thirty-six combinations were made and tested over a six-month period. The conclusions were:

1. The new style ASTM containers were much more effective than the containers used by the Iowa DOT in the past.

2. Some mixes with 15 percent Class C fly ash had increased expansion over comparative mixes without fly ash.

3. The Oreapolis #8 pit did not appear to have an alkali-silica reaction problem based on this testing and earlier reported testing.

INTRODUCTION

In the early 1940's, cement-aggregate reactions in concrete were first reported. The portland cement can react chemically with certain minerals present in the coarse or fine aggregate to produce expansion and cracking in the concrete. The most notable cement-aggregate reaction in Iowa is that experienced with Platte River aggregate. Research indicated that the addition of limestone to the concrete mixture would eliminate the harmful reaction.

The other type of reaction of concern to Iowa is an alkali-silica reaction. Expansion and cracking of the concrete are produced when the sodium and potassium oxide of the cement react with certain silica minerals. The solution to preventing the reaction has been to limit the amount of alkalies in the cement when used with suspect aggregates. The present limit on alkalies in Iowa is 0.90 percent which was established in 1979. Prior to that, the limit was 0.75 percent. ASTM and AASHTO suggest a limit of 0.60 percent alkalies when the cement is to be used in concrete with aggregates that may be deleteriously reactive.

Alkalies are generally present in the finer fraction of the cement. Before air quality was an issue, kiln dust was released with the exhaust gases into the air. Now filtering equipment is used to collect the dust and return it to the cement. For some plants the kiln dust returned to the cement

increases the alkalies above current limits. In those plants the kiln dust is collected separately and is disposed of. Disposal can be an expensive alternative.

The Iowa DOT has performed alkali-silica testing twice since 1978. In both instances, the test failed to work as intended. ASTM recently changed the alkali-silica test procedures (C227 and C441) because of testing difficulties.

OBJECTIVES

The objectives of the study were:

1. To test the effectiveness of the new ASTM type mortar boxes.

2. To test the effect of 3 commonly used Iowa fly ashes on the alkali-silica reaction.

MATERIALS

The following materials were used in the study:

Cements:	Northwestern States	(Na20+0.658K20=0.21)	(AC7-826)
	Dixon Marquetta	(Na20+0.658K20=0.90)	(AC8-156)
	Davenport	(Na20+0.658K20=0.48)	(AC8-633)

Fly Ashes:	Ottumwa	Class C	(ACF8-22)
	Louisa	Class C	(ACF8-23)
	Council Bluffs	Class C	(ACF8-21)

Fine Aggregate:	Oreapolis #8	(ANE514)
	Cordova	(AIL502)
	Pyrex Glass (No. 7740)	

Test results for the materials are in Appendix A. X-ray diffraction testing was performed on the two sands to document their composition.

TESTING

All preparation and testing was done in accordance with ASTM C227-87 with the following exceptions:

1. One batch per cement-fly ash-aggregate combination was made instead of two.

2. Measurements were made to the nearest 0.001 inch instead of 0.0001 inch.

The materials were chosen to represent the range of materials used in Iowa. Cordova aggregate from the Mississippi River was considered to be of low probability for reactive material. The Oreapolis aggregate is from the Platte River basin in Nebraska. The probability of reactive material was considered higher for this material than for the Cordova sand. Pyrex glass is very reactive in the presence of alkalies. It is used as the standard aggregate in ASTM C441, "Effectiveness of

Mineral Admixtures in Preventing Excessive Expansion of Concrete Due to Alkali Aggregate Reaction". The cements were chosen to represent the low, medium and high alkali cements that are currently available in Iowa. The fly ashes were three commonly used sources for concrete in Iowa.

Preparation and Storage

Two, 1-inch x 1-inch x 10-inch mortar bars were made for each combination of cement, fly ash and aggregate. Seventy-two bars were made on three separate days. The mix proportions were as follows:

Cement	300 g	255 g
Fly Ash	--	45 g
Aggregate	675 g	675 g

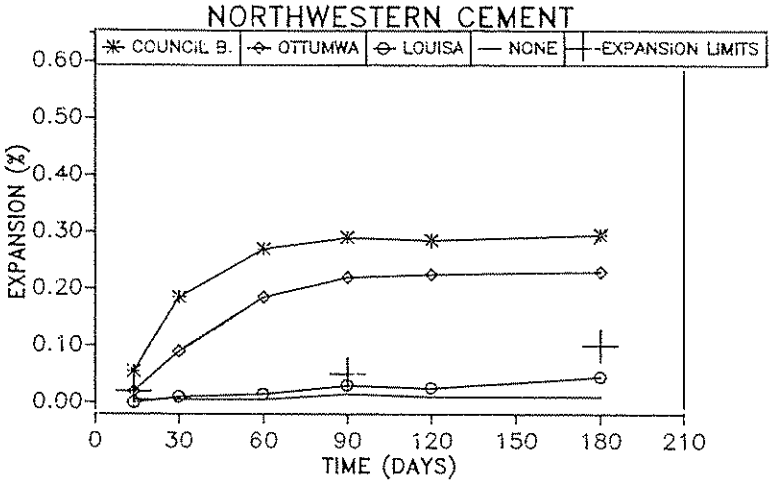
The specimens were stored in containers of the type noted in the ASTM procedure. Each container holds 6 bars placed on end. Water was poured in the bottom of the container and each container was sealed with vinyl tape as noted in the procedure. The containers were stored at 100°F ± 3°F.

Test Results

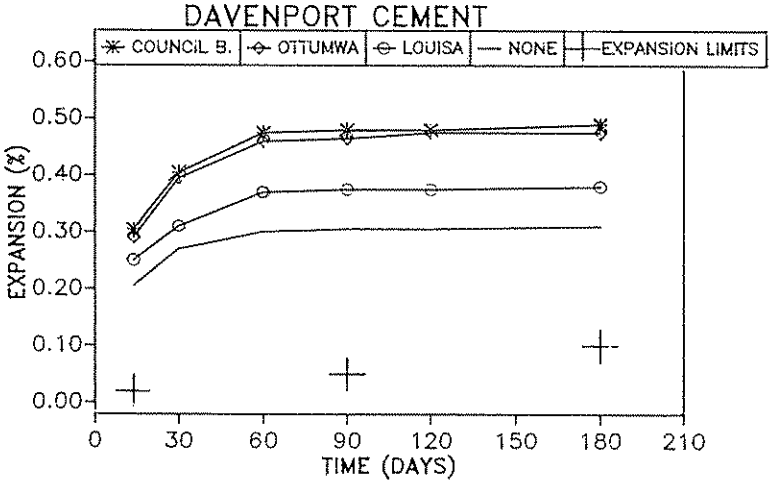
Each specimen was examined at 14 days and 1, 2, 3, 4 and 6 months after molding. The results are in Appendix B and shown graphically in Figures 1 through 3.

FIGURE 1. EFFECT OF FLY ASH ON EXPANSION WITH PYREX AGGREGATE

NORTHWESTERN CEMENT



DAVENPORT CEMENT



DIXON–MARQUETTA CEMENT

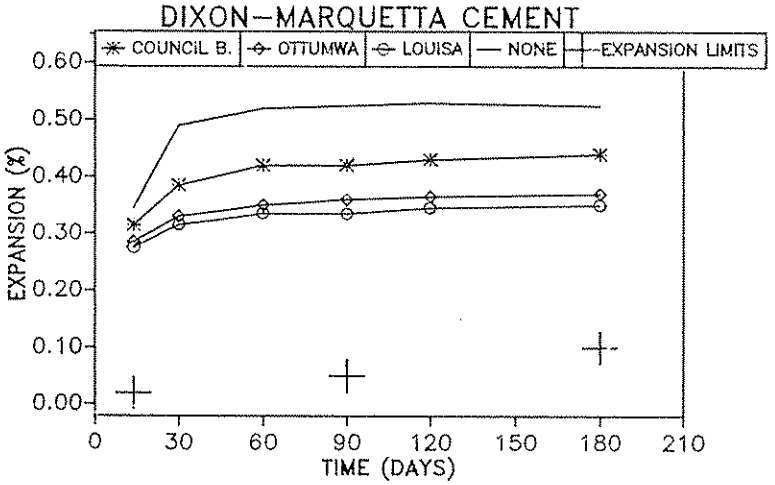
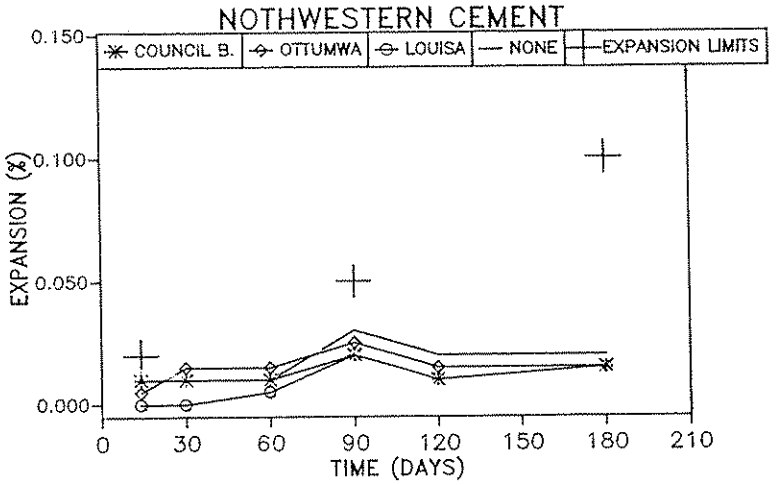
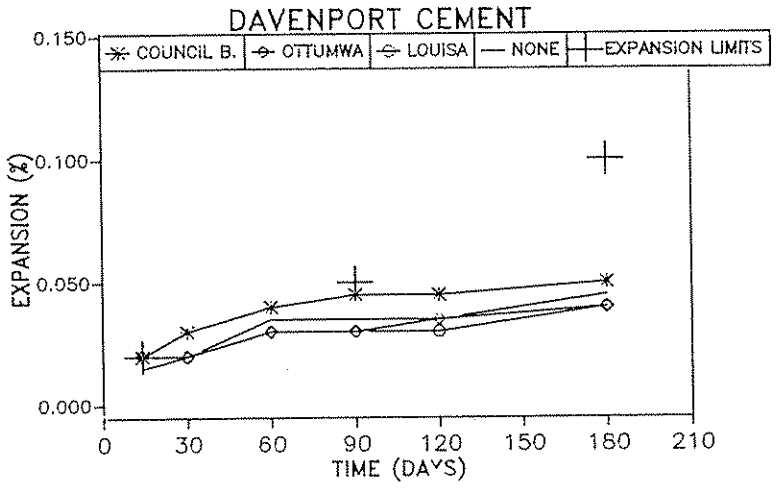


FIGURE 2. EFFECT OF FLY ASH ON EXPANSION WITH OREAPOLIS AGGREGATE





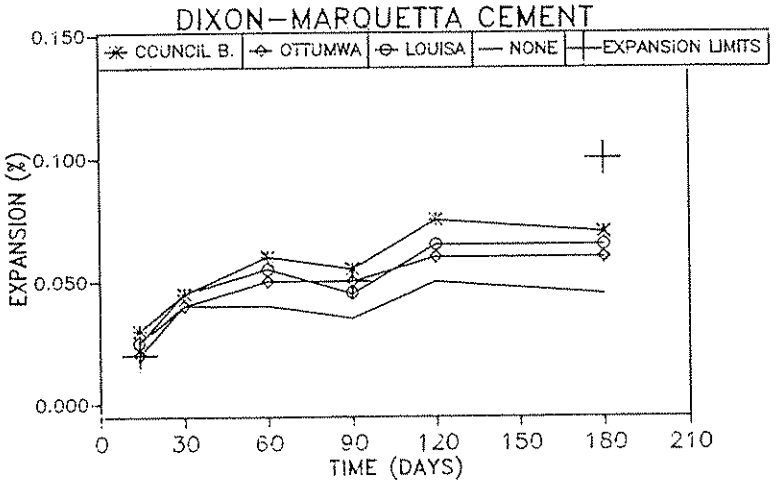
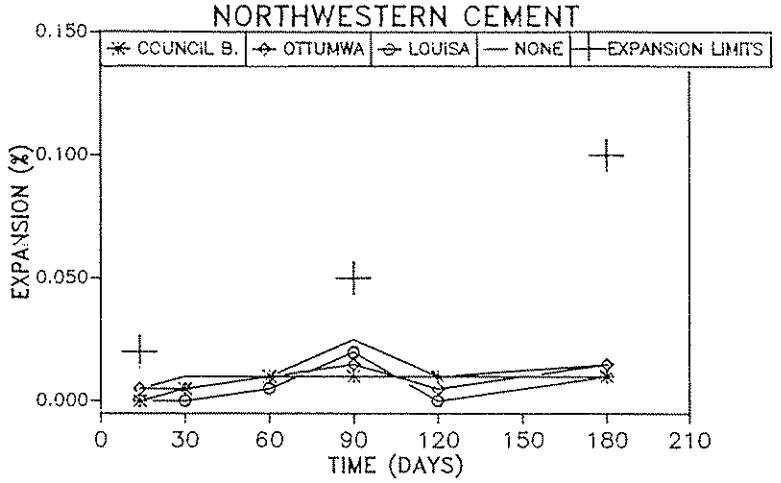
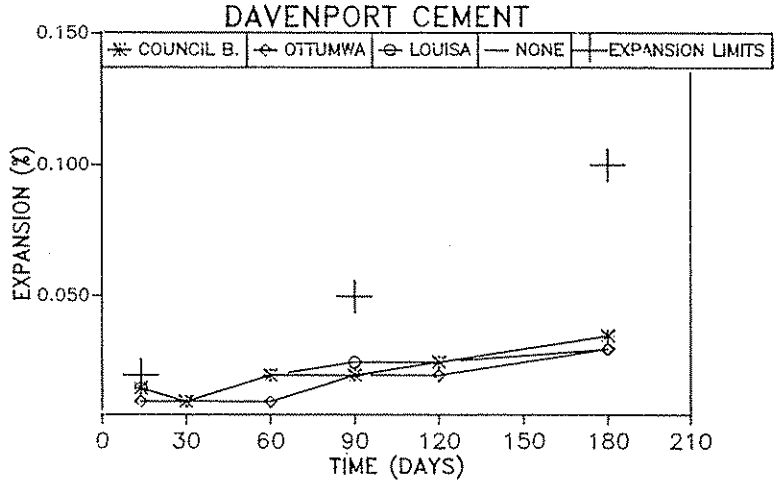


FIGURE 3. EFFECT OF FLY ASH ON EXPANSION WITH CORDOVA AGGREGATE

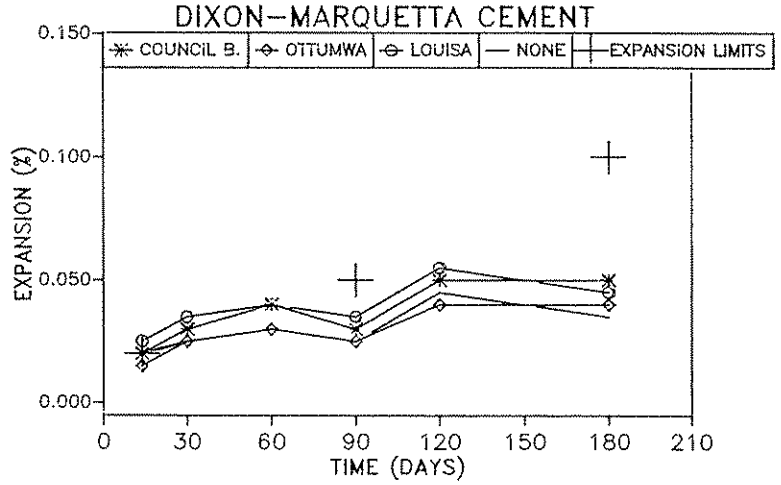
NORTHWESTERN CEMENT



DAVENPORT CEMENT



DIXON–MARQUETTA CEMENT



DISCUSSION OF RESULTS

The new containers functioned properly for the tests. The criteria for the testing with pyrex glass is that cement containing more than 0.60 percent alkalies is expected to expand more than 0.020 percent at 14 days. Nine of the 12 pyrex combinations exceeded that limit. Eight of the 9 combinations were above 0.200 percent at 14 days. The three combinations at 0.020 percent or less were with the low alkali Northwestern Cement.

Expansion of 0.05 percent at 3 months or 0.10 percent at 6 months are considered the limits of acceptability for a cement-aggregate combination. When 6-month data is available, the 6-month result governs. None of the Oreapolis or Cordova combinations exceeded 0.10 percent.

The most interesting part of the study was the expansions that occurred with a 15 percent replacement of cement with fly ash. With the lower alkali cements and pyrex, Class C fly ash increased the amount of expansion over comparative mixes with no fly ash. Similar results were reported by Iowa State University, the Nebraska Department of Roads, and the Kansas Department of Transportation. The reason for the increase does not appear to be related to the total or available alkali content of the fly ash. Council Bluffs fly ash had lower alkalies but produced larger expansions.

CONCLUSIONS

The following conclusions can be drawn from the study:

1. The new style ASTM containers are much more effective than the containers used by the Iowa DOT in the past.

2. Some mixes with 15 percent Class C fly ash had increased expansion over comparative mixes without fly ash.

3. The Oreapolis #8 pit does not appear to have an alkali-silica reaction problem based on this testing and earlier reported testing.

RECOMMENDATIONS

The following recommendations are suggested:

1. Testing done and reported in 1980 as MLR-80-3, "Special Report on Alkali-Aggregate Reactivity" should be verified using the new ASTM style containers. Thirty-one sands were tested with 3 cements. Only 1 of the 93 combinations showed any expansion at either 3 months or 6 months. The majority of bars showed shrinkage.

2. Class C fly ashes in Iowa appear to, in some cases, increase the expansion when used at 15% in the mortar bars. Class C fly ashes should be included in future testing.

Appendix A

Form 292
7-72

IC DEPARTMENT OF TRANSPORTATION

REPORT OF CEMENT TESTS

MATERIALS DEPARTMENT

CEMENT TESTS

PROJECT Dept. Info.

COUNTY

LABORATORY AC8-156

DATE 4-25 19 88

PRODUCER Dixon Marquette Cement Co.

PLANT Dixon, IL

COPIES TO K. Jones

CONTRACTOR

DESTINATION

SAMPLED BY Producer AT

DATE SAMPLED 19

Intended use: Fly Ash effects on Alkali-Agg Reactivity

Laboratory Number	Identification of Samples		Number of Barrels	Type	N. C.	Time of Set	Blaine Specific Surface	Per Cent of Air C-185	Auto-Clave Expansion Per Cent	Strength		Disposition
	Senders Number	Bin, Car or Invoice Number								3 Day Average	7 Day Average	
AC8-156				I	25.6	ok	369	10.6	.41	3110	4350	Complies
		Chemical Analysis %										
		MgO	3.82									
		SO3	2.85									
		Ign. Loss Insol Res.	0.49 0.12									
		Fe2O3	3.03									
		AT2O3	5.30									
		CaO	60.83									
		C3A	8.92									
		Na2O K2O	0.07 1.26									
		Na2O Equiv.	0.90									

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SIGNED Orrin J. Lane Jr.

Form 292
7-72

IOWA DEPARTMENT OF TRANSPORTATION

REPORT OF CEMENT TESTS

MATERIALS DEPARTMENT

CEMENT TESTS

PROJECT Dept. Info.

COUNTY

LABORATORY Ames

DATE February 19 19 88

PRODUCER Northwestern States Cemet Co. PLANT Mason City, IA COPIES TO Cement

CONTRACTOR DESTINATION K. Jones

SAMPLED BY R. Kalsem AT DATE SAMPLED 12/16/87 19

Laboratory Number	Identification of Samples		Number of Barrels	Type	N. C.	Time of Set	Blaine Specific Surface	Per Cent of Air C-185	Auto-Clave Expansion Per Cent	Strength		Disposition
	Senders Number	Bin, Car or Invoice Number								3 Day Average	7 Day Average	
AC7-826		14 Bags		I	25.4	OK	381	9.1	.02	4830	5280	Comply
	Chemical Analysis %											
MgO		1.15										
SO_3		3.39										
Ign. Loss		0.97										
Insol Res.		0.27										
Fe_2O_3		1.66										
Al_2O_3		5.14										
CaO		63.65										
C_3A		10.81										
Na_2O		0.03										
K_2O		0.27										
Na_2O Equiv.		0.21										

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SIGNED Ernie J. Lane

Form 292
7-72

IOWA DEPARTMENT OF TRANSPORTATION

REPORT OF CEMENT TESTS

MATERIALS DEPARTMENT

CEMENT TESTS

PROJECT Dept. Info.

COUNTY

LABORATORY AC8-633

DATE 11-15 19 88

PRODUCER Davenport Cement Co.

PLANT Buffalo, Iowa

COPIES TO K. Jones

CONTRACTOR

DESTINATION

SAMPLED BY R.Kalsem AT

DATE SAMPLED 19

Rec'd. 10-19-88

Laboratory Number	Identification of Samples		Number of Barrels	Type	N. C.	Time of Set	Blaine Specific Surface	Per Cent of Air C-185	Auto-Clave Expansion Per Cent	Strength		Disposition
	Senders Number	Bin, Car or Invoice Number								Day Average	Day Average	
AC8-633				I	24.4	OK	398	10.1	.05			

Intended Use: MLR-88-7. Fly ASh effects on alkali-aggregate reactivity & composite of sample sent to lab for monitor testing.

Chemical Analysis %

MgO	SO_3	Ing. Res.	Insol Res.	Fe_2O_3	Al_2O_3		CaO	C_3A	Na_2O	K_2O	Na_2O Equiv.
3.28	2.43	1.23	0.05	2.34	4.33		63.46	7.51	0.18	0.45	0.48

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SIGNED

Fly Ash
K. Jones
Cement

Form 820259
6-83

Iowa Department of Transportation

MATERIALS DEPARTMENT

TEST REPORT - MISCELLANEOUS MATERIALS

AMES LABORATORY

Material Fly Ash Class C Laboratory No. ACF8-23

Intended Use Fly Ash effects on Alkali - Agg. Reactivity

County _____ Proj. No. Dept. Info.

Producer Louisa Generating Station Marketer ~~Contractor~~ Davenport Cement Co.

Source Muscatine, IA

Unit of Material _____

Sampled by Producer Sender's No. _____

Date Sampled _____ Date Rec'd 6-17-88 Date Reported 6-17-88

Chemical Analysis %

SiO_2	35.61
Al_2O_3	23.09
Fe_2O_3	5.45
Subtotal	64.15
Na_2O	1.65
K_2O	0.39
Alkali Equivalent	1.91
Available Alkali	1.33
SO_3	1.83
Moisture	0.00
Loss on 800 C Ignition	0.17
MgO	4.74
CaO	26.65

Physical test ASTM C-311-87	
Specific Gravity	2.69
Pozz. Activity:	
7 Day	113.8 %
28 Day	106.0 %
Water Requirement	90.5 %
Autoclave:	.03 %
325 Mesh:	89.6 %
Spec. Surf:	11871 cm^2/cm^3
Compressive Strenth	
Fly Ash & Sand:	7
1 Day	207 PSI
7 Day	243 PSI

Complies

DISPOSITION:

Signed _____ Testing Engineer

Fly Ash
K. Jones
Cement

Form 820259
6-83

Iowa Department of Transportation

MATERIALS DEPARTMENT

TEST REPORT - MISCELLANEOUS MATERIALS

AMES LABORATORY

Material Fly Ash Class C Laboratory No. ACF8-21

Intended Use Fly Ash effects on Alkali-AGG Reactivity

County _____ Proj. No. Dept. Info.

Producer Council Bluffs Unit #3 Marketer ~~Contractor~~ Mid West Fly Ash

Source Council Bluffs, IA

Unit of Material _____

Sampled by Producer Sender's No. _____

Date Sampled _____ Date Rec'd 6-17-88 Date Reported 6-17-88

Chemical Analysis %

SiO_2	31.34
Al_2O_3	18.98
Fe_2O_3	6.60
Subtotal	56.92
Na_2O	2.32
K_2O	0.30
Alkali Equivalent	2.52
Available Alkali	1.52
SO_3	3.55
Moisture	0.00
Loss on 800 C Ignition	0.35
MgO	6.28
Cao	29.26

Complies

Physical test ASTM C-311-87	
Specific Gravity	2.70
Pozz. Activity:	
7 Day	104.6%
28 Day	98.8%
Water Requirement	90.5%
Autoclave:	.06%
325 Mesh:	82.6%
Spec. Surf.:	11827 cm^2/cm^3
Ccompressive Strength	
Fly Ash & Sand:	
1 Day	213 PSI
7 Day	542 PSI

DISPOSITION:

Signed Orrin J. Lane Jr.
Testing Engineer

Fly Ash
K. Jones
Cement

Form 820259
6-83

Iowa Department of Transportation

MATERIALS DEPARTMENT

TEST REPORT - MISCELLANEOUS MATERIALS

AMES LABORATORY

Material: Fly Ash Class C — Laboratory No.: ACF8-22

Intended Use: Fly Ash Effects on Alkali AGG Reactivity

County: _____ — Proj. No.: Dept Info.

Producer: Ottumwa Generating Station — Marketer ~~Contractor~~: Mid West Fly Ash

Source: Chillicothe, IA

Unit of Material: _____

Sampled by: Producer — Sender's No.: _____

Date Sampled: _____ — Date Rec'd: 6-17-88 — Date Reported: 6-17-88

Chemical Analysis %	
SiO_2	31.65
Al_2O_3	22.53
Fe_2O_3	5.37
Subtotal	59.55
Na_2O	3.47
K_2O	0.36
Alkali Equivalent	3.71
Available Alkali	2.52
SO_3	2.78
Moisture	0.00
Loss on 800 C Ignition	0.14
MgO	4.72
CaO	26.85

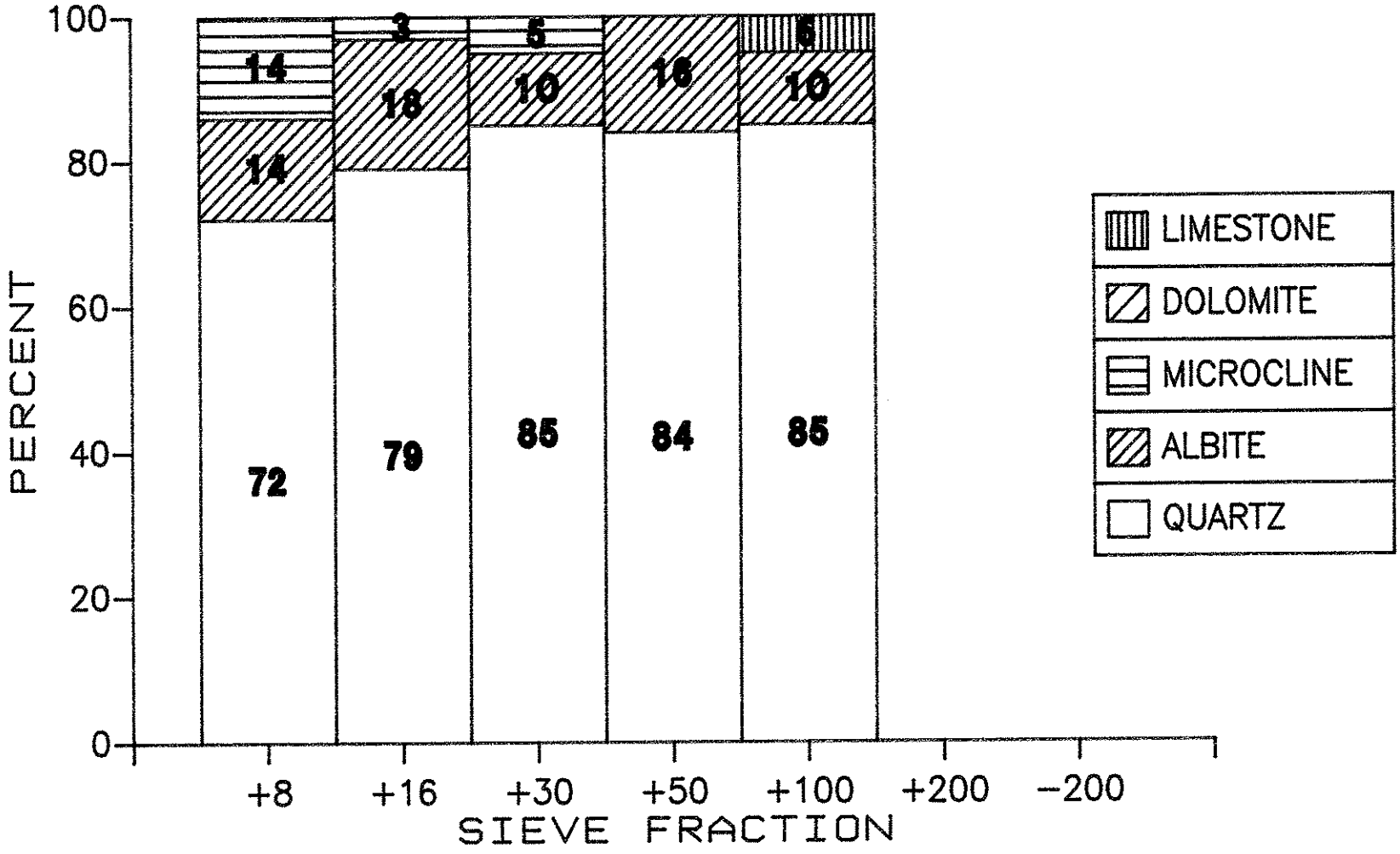
Complies

Physical tests ASTM C-311 87	
Specific Gravity	2.72
Pozz. Activity:	
7 Day	91.1%
28 Day	96.2%
Water Requirement	90.5%
Autoclave:	.06%
325 Mesh:	84.4%PSG
Spec. Surf:	11988 cm^2/cm^3
Compressive Strength	
Fly Ash & Sand:	
1 Day	198 PSI
7 Day	302 PSI

DISPOSITION:

Signed: _____ Testing Engineer

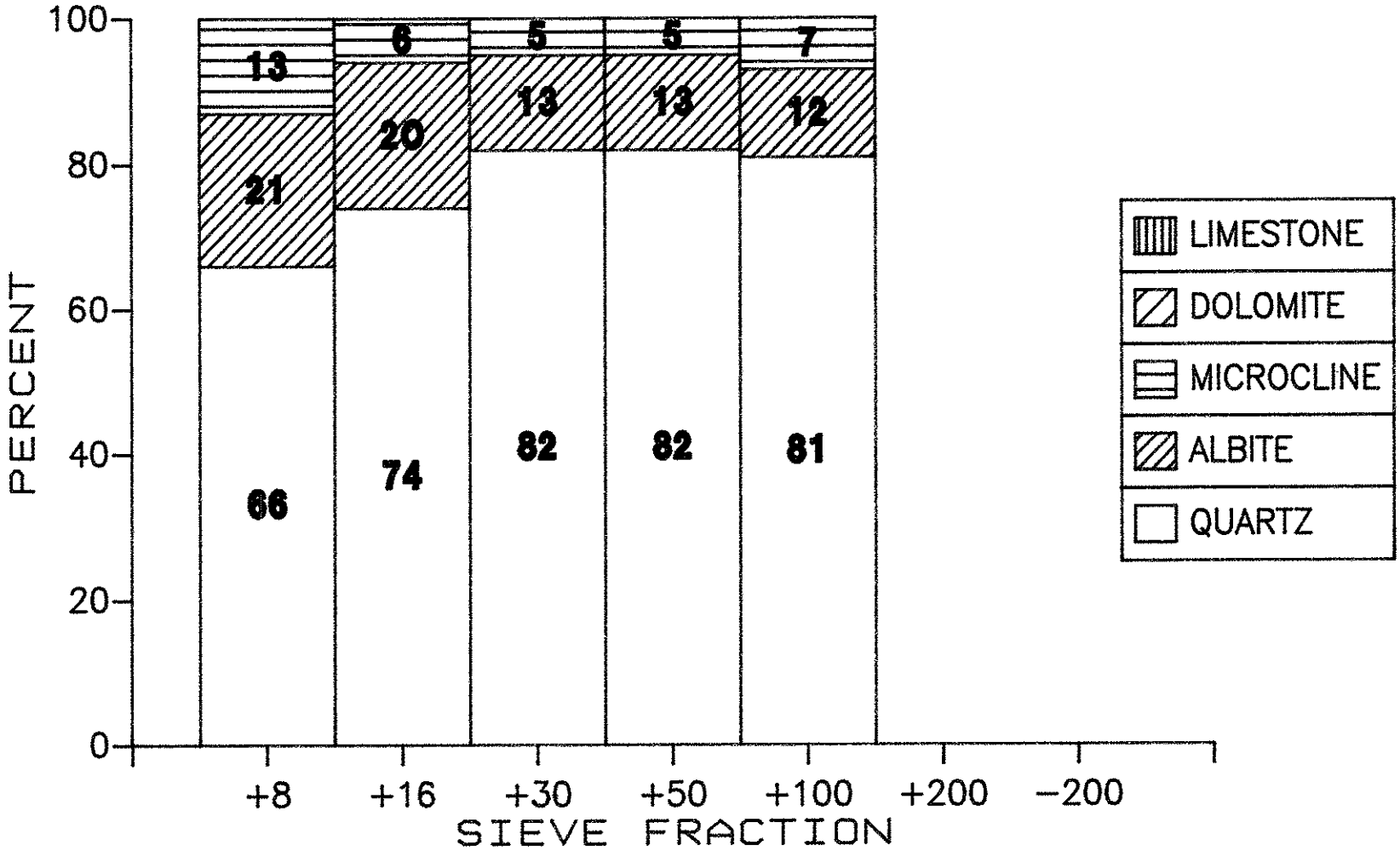
CORDOVA PIT
XRD FINE AGGREGATE ANALYSES



NOTE: ALBITE IS A SODIUM FELDSPAR AND MICROCLINE IS A POTASSIUM FELDSPAR

SAVECODE FAXRD004

LYMAN RICHEY PIT
XRD FINE AGGREGATE ANALYSES



NOTE: ALBITE IS A SODIUM FELDSPAR AND MICROCLINE IS A POTASSIUM FELDSPAR

SAVECODE FAXRD003

Appendix B

LENGTH COMPARISON MEASUREMENTS (INCHES X 0.001)

						INITIAL	14-DAY	1-MO.	2-MO.	3-MO.	4-MO.	6-MO.
1 A	NORTHWESTERN	NONE	PYREX	1 A		502	502	503	503	504	503	503
B	NORTHWESTERN	NONE	PYREX	B		519	520	519	519	520	520	520
2 A	NORTHWESTERN	NONE	CORDOVA	2 A		547	548	548	548	550	548	549
B	NORTHWESTERN	NONE	CORDOVA	B		546	546	547	547	548	547	547
3 A	NORTHWESTERN	NONE	OREAPOLIS #8	3 A		543	544	544	544	546	545	545
B	NORTHWESTERN	NONE	OREAPOLIS #8	B		540	541	541	541	543	542	542
4 A	NORTHWESTERN	LOUISA	PYREX	4 A		544	544	545	545	546	545	547
B	NORTHWESTERN	LOUISA	PYREX	B		542	542	543	544	546	546	548
5 A	NORTHWESTERN	LOUISA	CORDOVA	5 A		498	498	498	498	500	498	499
B	NORTHWESTERN	LOUISA	CORDOVA	B		524	524	524	525	526	524	525
6 A	NORTHWESTERN	LOUISA	OREAPOLIS #8	6 A		531	531	531	532	533	532	533
B	NORTHWESTERN	LOUISA	OREAPOLIS #8	B		528	528	528	528	530	529	529
7 A	NORTHWESTERN	COUNCIL BLUFFS	PYREX	7 A		530	535	548	557	559	558	559
B	NORTHWESTERN	COUNCIL BLUFFS	PYREX	B		538	544	557	565	567	567	568
8 A	NORTHWESTERN	COUNCIL BLUFFS	CORDOVA	8 A		533	533	533	534	534	534	534
B	NORTHWESTERN	COUNCIL BLUFFS	CORDOVA	B		515	515	516	516	516	516	516
9 A	NORTHWESTERN	COUNCIL BLUFFS	OREAPOLIS #8	9 A		546	547	547	547	548	547	547
B	NORTHWESTERN	COUNCIL BLUFFS	OREAPOLIS #8	B		538	539	539	539	540	539	540
10A	NORTHWESTERN	OTTUMWA	PYREX	10A		524	526	533	543	546	547	547
B	NORTHWESTERN	OTTUMWA	PYREX	B		536	538	545	554	558	558	559
11A	NORTHWESTERN	OTTUMWA	CORDOVA	11A		527	527	527	528	528	527	528
B	NORTHWESTERN	OTTUMWA	CORDOVA	B		510	511	511	511	512	511	512
12A	NORTHWESTERN	OTTUMWA	OREAPOLIS #8	12A		534	534	535	535	536	535	535
B	NORTHWESTERN	OTTUMWA	OREAPOLIS #8	B		513	514	515	515	516	515	515
13A	DAVENPORT	NONE	PYREX	13A		537	558	565	568	569	569	569
B	DAVENPORT	NONE	PYREX	B		539	559	565	568	568	568	569
14A	DAVENPORT	NONE	CORDOVA	14A		546	547	547	548	549	549	549
B	DAVENPORT	NONE	CORDOVA	B		547	548	548	549	549	549	550
15A	DAVENPORT	NONE	OREAPOLIS #8	15A		522	523	524	525	525	525	526
B	DAVENPORT	NONE	OREAPOLIS #8	B		521	523	523	525	525	525	526
16A	DAVENPORT	LOUISA	PYREX	16A		520	545	552	559	559	559	560
B	DAVENPORT	LOUISA	PYREX	B		496	521	526	531	532	532	532
17A	DAVENPORT	LOUISA	CORDOVA	17A		528	530	529	530	531	531	531
B	DAVENPORT	LOUISA	CORDOVA	B		531	532	532	533	533	533	534
18A	DAVENPORT	LOUISA	OREAPOLIS #8	18A		505	507	507	508	508	508	509
B	DAVENPORT	LOUISA	OREAPOLIS #8	B		529	531	531	532	532	532	533

LENGTH COMPARISON MEASUREMENTS (INCHES X 0.001)

					INITIAL	14-DAY	1-MO.	2-MO.	3-MO.	4-MO.	6-MO.
19A	DAVENPORT	COUNCIL BLUFFS	PYREX	19A	511	541	550	557	557	557	558
B	DAVENPORT	COUNCIL BLUFFS	PYREX	B	537	568	579	586	587	587	588
20A	DAVENPORT	COUNCIL BLUFFS	CORDOVA	20A	529	530	530	531	531	531	532
B	DAVENPORT	COUNCIL BLUFFS	CORDOVA	B	500	502	501	502	502	503	504
21A	DAVENPORT	COUNCIL BLUFFS	OREAPOLIS #8	21A	534	536	537	539	539	539	539
B	DAVENPORT	COUNCIL BLUFFS	OREAPOLIS #8	B	535	537	538	538	539	539	540
22A	DAVENPORT	OTTUMWA	PYREX	22A	535	563	573	580	581	582	582
B	DAVENPORT	OTTUMWA	PYREX	B	557	587	598	604	604	605	605
23A	DAVENPORT	OTTUMWA	CORDOVA	23A	541	542	542	542	543	543	544
B	DAVENPORT	OTTUMWA	CORDOVA	B	542	543	543	543	544	544	545
24A	DAVENPORT	OTTUMWA	OREAPOLIS #8	24A	527	529	529	530	530	531	531
B	DAVENPORT	OTTUMWA	OREAPOLIS #8	B	503	505	505	506	506	506	507
25A	DIXON-MARQUETTA	NONE	PYREX	25A	501	536	550	553	552	554	553
B	DIXON-MARQUETTA	NONE	PYREX	B	492	526	541	544	546	545	545
26A	DIXON-MARQUETTA	NONE	CORDOVA	26A	524	526	526	527	526	528	527
B	DIXON-MARQUETTA	NONE	CORDOVA	B	510	512	513	513	513	515	514
27A	DIXON-MARQUETTA	NONE	OREAPOLIS #8	27A	499	502	503	503	503	504	504
B	DIXON-MARQUETTA	NONE	OREAPOLIS #8	B	493	495	497	497	496	498	497
28A	DIXON-MARQUETTA	LOUISA	PYREX	28A	520	547	551	553	553	554	554
B	DIXON-MARQUETTA	LOUISA	PYREX	B	520	548	552	554	554	555	556
29A	DIXON-MARQUETTA	LOUISA	CORDOVA	29A	534	537	538	538	538	540	539
B	DIXON-MARQUETTA	LOUISA	CORDOVA	B	530	532	533	534	533	535	534
30A	DIXON-MARQUETTA	LOUISA	OREAPOLIS #8	30A	521	524	526	527	526	528	528
B	DIXON-MARQUETTA	LOUISA	OREAPOLIS #8	B	535	537	539	540	539	541	541
31A	DIXON-MARQUETTA	COUNCIL BLUFFS	PYREX	31A	547	578	584	587	587	588	589
B	DIXON-MARQUETTA	COUNCIL BLUFFS	PYREX	B	548	580	588	592	592	593	594
32A	DIXON-MARQUETTA	COUNCIL BLUFFS	CORDOVA	32A	535	537	538	539	538	540	538
B	DIXON-MARQUETTA	COUNCIL BLUFFS	CORDOVA	B	533	535	536	537	536	538	540
33A	DIXON-MARQUETTA	COUNCIL BLUFFS	OREAPOLIS #8	33A	550	553	555	556	556	558	557
B	DIXON-MARQUETTA	COUNCIL BLUFFS	OREAPOLIS #8	B	548	551	552	554	553	555	555
34A	DIXON-MARQUETTA	OTTUMWA	PYREX	34A	484	512	516	518	519	519	520
B	DIXON-MARQUETTA	OTTUMWA	PYREX	B	519	548	553	555	556	557	557
35A	DIXON-MARQUETTA	OTTUMWA	CORDOVA	35A	519	521	522	522	522	523	523
B	DIXON-MARQUETTA	OTTUMWA	CORDOVA	B	505	506	507	508	507	509	509
36A	DIXON-MARQUETTA	OTTUMWA	OREAPOLIS #8	36A	511	513	515	516	516	517	517
B	DIXON-MARQUETTA	OTTUMWA	OREAPOLIS #8	B	549	551	553	554	554	555	555

PERCENT EXPANSION

					14-DAY	1-MO.	2-MO.	3-MO.	4-MO.	6-MO.
1	NORTHWESTERN	NONE	PYREX	1	0.005	0.005	0.005	0.015	0.010	0.010
2	NORTHWESTERN	NONE	CORDOVA	2	0.005	0.010	0.010	0.025	0.010	0.015
3	NORTHWESTERN	NONE	OREAPOLIS #8	3	0.010	0.010	0.010	0.030	0.020	0.020
4	NORTHWESTERN	LOUISA	PYREX	4	0.000	0.010	0.015	0.030	0.025	0.045
5	NORTHWESTERN	LOUISA	CORDOVA	5	0.000	0.000	0.005	0.020	0.000	0.010
6	NORTHWESTERN	LOUISA	OREAPOLIS #8	6	0.000	0.000	0.005	0.020	0.010	0.015
7	NORTHWESTERN	COUNCIL BLUFFS	PYREX	7	0.055	0.185	0.270	0.290	0.285	0.295
8	NORTHWESTERN	COUNCIL BLUFFS	CORDOVA	8	0.000	0.005	0.010	0.010	0.010	0.010
9	NORTHWESTERN	COUNCIL BLUFFS	OREAPOLIS #8	9	0.010	0.010	0.010	0.020	0.010	0.015
10	NORTHWESTERN	OTTUMWA	PYREX	10	0.020	0.090	0.185	0.220	0.225	0.230
11	NORTHWESTERN	OTTUMWA	CORDOVA	11	0.005	0.005	0.010	0.015	0.005	0.015
12	NORTHWESTERN	OTTUMWA	OREAPOLIS #8	12	0.005	0.015	0.015	0.025	0.015	0.015
13	DAVENPORT	NONE	PYREX	13	0.205	0.270	0.300	0.305	0.305	0.310
14	DAVENPORT	NONE	CORDOVA	14	0.010	0.010	0.020	0.025	0.025	0.030
15	DAVENPORT	NONE	OREAPOLIS #8	15	0.015	0.020	0.035	0.035	0.035	0.045
16	DAVENPORT	LOUISA	PYREX	16	0.250	0.310	0.370	0.375	0.375	0.380
17	DAVENPORT	LOUISA	CORDOVA	17	0.015	0.010	0.020	0.025	0.025	0.030
18	DAVENPORT	LOUISA	OREAPOLIS #8	18	0.020	0.020	0.030	0.030	0.030	0.040
19	DAVENPORT	COUNCIL BLUFFS	PYREX	19	0.305	0.405	0.475	0.480	0.480	0.490
20	DAVENPORT	COUNCIL BLUFFS	CORDOVA	20	0.015	0.010	0.020	0.020	0.025	0.035
21	DAVENPORT	COUNCIL BLUFFS	OREAPOLIS #8	21	0.020	0.030	0.040	0.045	0.045	0.050
22	DAVENPORT	OTTUMWA	PYREX	22	0.290	0.395	0.460	0.465	0.475	0.475
23	DAVENPORT	OTTUMWA	CORDOVA	23	0.010	0.010	0.010	0.020	0.020	0.030
24	DAVENPORT	OTTUMWA	OREAPOLIS #8	24	0.020	0.020	0.030	0.030	0.035	0.040
25	DIXON-MARQUETTA	NONE	PYREX	25	0.345	0.490	0.520	0.525	0.530	0.525
26	DIXON-MARQUETTA	NONE	CORDOVA	26	0.020	0.025	0.030	0.025	0.045	0.035
27	DIXON-MARQUETTA	NONE	OREAPOLIS #8	27	0.025	0.040	0.040	0.035	0.050	0.045
28	DIXON-MARQUETTA	LOUISA	PYREX	28	0.275	0.315	0.335	0.335	0.345	0.350
29	DIXON-MARQUETTA	LOUISA	CORDOVA	29	0.025	0.035	0.040	0.035	0.055	0.045
30	DIXON-MARQUETTA	LOUISA	OREAPOLIS #8	30	0.025	0.045	0.055	0.045	0.065	0.065
31	DIXON-MARQUETTA	COUNCIL BLUFFS	PYREX	31	0.315	0.385	0.420	0.420	0.430	0.440
32	DIXON-MARQUETTA	COUNCIL BLUFFS	CORDOVA	32	0.020	0.030	0.040	0.030	0.050	0.050
33	DIXON-MARQUETTA	COUNCIL BLUFFS	OREAPOLIS #8	33	0.030	0.045	0.060	0.055	0.075	0.070
34	DIXON-MARQUETTA	OTTUMWA	PYREX	34	0.285	0.330	0.350	0.360	0.365	0.370
35	DIXON-MARQUETTA	OTTUMWA	CORDOVA	35	0.015	0.025	0.030	0.025	0.040	0.040
36	DIXON-MARQUETTA	OTTUMWA	OREAPOLIS #8	36	0.020	0.040	0.050	0.050	0.060	0.060