Westinghouse
Savannah River Company

P.O. Box 616
Aiken, SC 29802

Keywords: Disposal Vaults, Z-Area, Cracks Vault Caps

October 11, 1990

OPS-DTZ-90-0018

RECORD COPY
SIGNATURE CJB
DATE 10-19-90

Mr. Steven Gebler
Construction Technology Laboratory
5420 Old Orchard Road
Skokie, Ill. 60077-1030

Crack Repair Study and Mix Design for Vault Cap (U)

Based on the phone conversation of 10/9/90 and the meeting that was held several months ago in Chicago, we recommend that you focus on the following items as you come to a close on contract AA01199N.

- **Task 1 - Complete the crack repair study.**

The requested vault core drill samples have been mailed and should be arriving soon. Two of the samples were cored over a crack and then injected with an epoxy resin. The cracks should appear as they did in their original state. The third sample was taken from a section of the wall that did not have a crack. All three of the samples were drilled at the 16 foot level of the vault wall.

Included with this letter are a series of reports that provide information that may be useful to you. Listed below is a summary of what is included:

- Attachment 1 - *Vault Crack Map #1*. The cracks of cell 1, vault 1 were mapped by Ebasco in mid 1988. Although the map for the entire vault is not provided, the cell 1 map is representative of the rest of the vault. This document also provides crack sizes (a crack as large as 0.032 inch was measured).

- Attachment 2 - *Vault Crack Map #2*. This document, also provided by Ebasco, maps a few key cracks throughout the entire vault. It also provides crack sizes.

- Attachment 3 - *Crack movement #1*. This study used strain gages to monitor crack movement.

- Attachment 4 - *Crack movement #2*. An optical comparitor was used to monitor crack movement. Unlike the other studies, this study also monitored the effect of temperature on crack movement.

- **Task 2 - Development of a Mix Design and Emplacement Details for the Vault Cell Caps.**

  The report that was issued on June 15, 1990, which detailed a variety of different vault capping concepts has provided the needed information. Currently we are planning to cap the cells as soon as they are filled with saltstone with a self-leveling type of concrete. Once all six cells are capped (and the rolling roof removed), the final concrete roof will be placed. It is our request that the focus of your effort be in the development of this concrete mix and the details necessary for the placement of the cap. The mix and placement design should be compatible with the concepts presented in the June 15 report. The primary criteria for this cap which was specified in the original contract (Section 6.1.1) has not changed.

  The development of a more detailed design for the final concrete roof is certainly of interest, but should not be pursued under this contract. It is our intention to write a separate contract for this service.

The other items that were requested in the contract have been completed and have met (and often exceeded) our expectations. It has been a pleasure working with you and we look forward to working with you again in the future.

Sincerely,

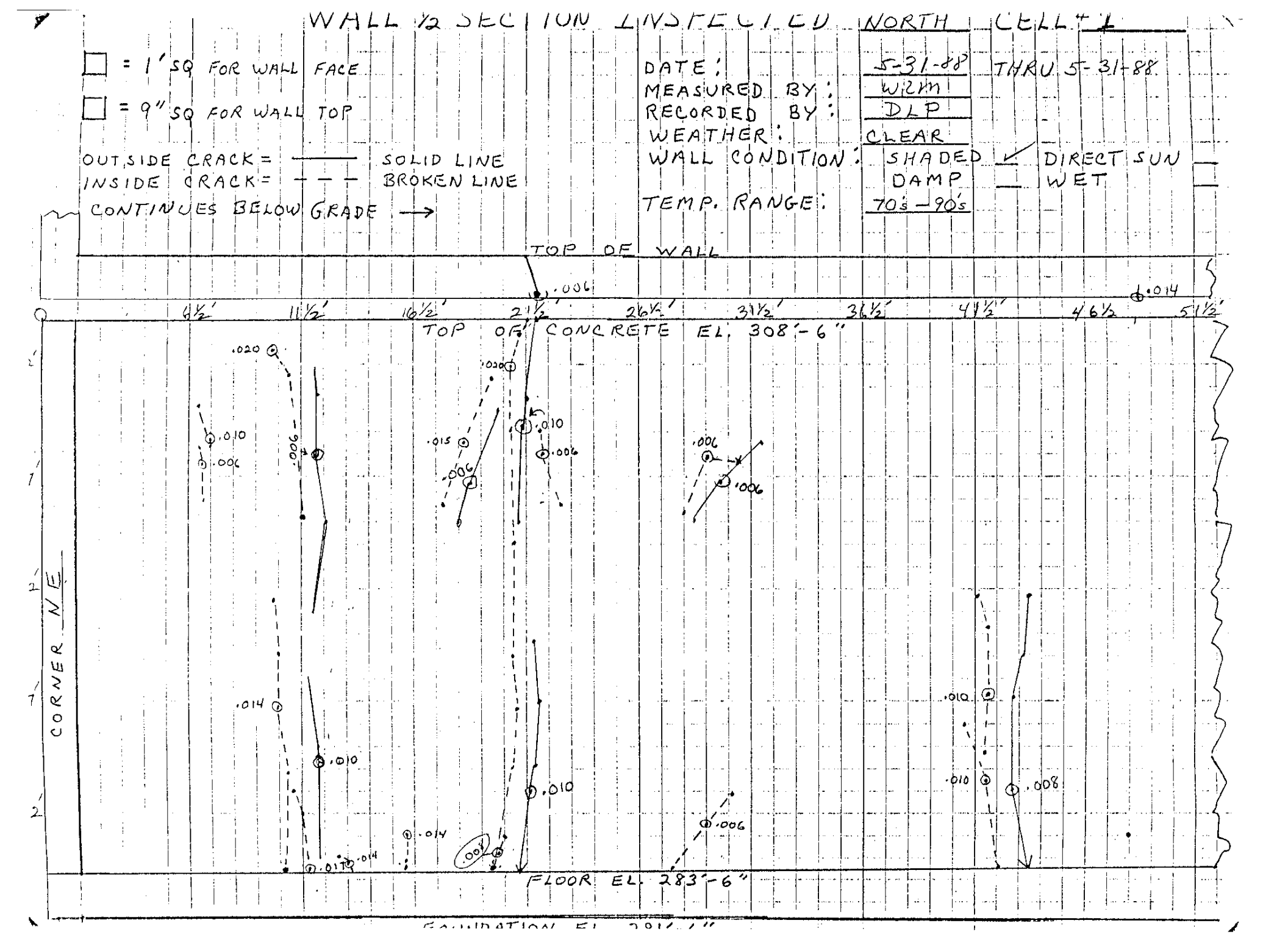
Dennis G. Thompson
Defense Waste Processing Facility
Saltsone - Tecnical

Chris A. Langton
Savannah River Laboratory
Interim Waste Technology

Attachments

ATTACHMENT 1

VAULT CRACK MAP #1

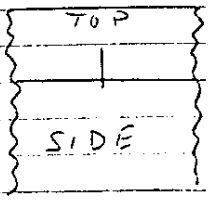

WALL ½ SECTION INSPECTED
NORTH
CELL #1
□ = 1' SQ FOR WALL FACE
□ = 9" SQ FOR WALL TOP
OUTSIDE CRACK = ——— SOLID LINE
INSIDE CRACK = – – – BROKEN LINE
CONTINUES BELOW GRADE →
DATE: 5-31-88 THRU 5-31-88
MEASURED BY: WLM
RECORDED BY: DLP
WEATHER: CLEAR
WALL CONDITION: SHADED ✓ DIRECT SUN
DAMP WET
TEMP. RANGE: 70's – 90's
TOP OF WALL
4½' 11½' 16½' 21½' 26½' 31½' 36½' 41½' 46½' 51½'
TOP OF CONCRETE EL. 308'-6"
FLOOR EL. 283'-6"
CORNER N/E
.020 .010 .006 .006 .020 .015 .006 .010 .006 .006 .006 .014 .010 .010 .014 .010 .006 .010 .010 .008 .014 .014 .006

COORDINATES 5-31-88

NORTH WALL CELL #1 EAST HALF

OUTSIDE

DIRECTION OF MEASUREMENT ↓	DIRECTION OF MEASUREMENT ↔
2'3"	12'3"
3'4"	12'4"
6'	12'3" (.006)
9'	12'2"
13'	12'
16'	11'10"
19'5"	12'4" (.010)
24'	12'4"
3'10"	20'3"
7'3"	19' (.006)
9'	11'
ACROSS TOP	22'½"
3'5"	21½'
4'11"	21'5" (.010)
9'	21'4"
14'4"	21'8"
17'	22'1"
20'	21'9"
21'11"	21'2" (.010)
24'11"	21'2"
5'5"	31'11"
7'2"	30'2" (.006)
9'	28'11"
12'3"	43'5"
14'11"	43'8"
16'11"	43'4"
21'	43'4" (.008)
TOS	43'10"
On Top	48'8"
1"	48'8" (.014) 5" long



TOS = TOP OF SLAB

O = WIDTH OF CRACK

COORDINATES

NORTH WALL CELL #1 EAST HALF 5-31-88

INSIDE

DIRECTION OF MEASUREMENT ↓	↔
3'10"	6'11"
5'4"	7½' (.010)
5'7"	7½'
5'8"	7'
6½'	7'2" (.006)
8'2"	7'3"
1'5"	10'3" (.020)
2½'	11'
8'11"	11'1"
12½'	10'3"
15'	10½'
17'3"	10½' (.014)
20'3"	10'10"
TOS	10'8"
21'	11'2"
22'	11½'
TOS	11'5" (.017)
23'	16'2" (.014)
24'2"	16'1"
TOS	16'
23'11"	13'2"
24'3"	13½' (.014)
TOS	13'5"
2'8"	15'11"
5'5"	18'9" (.015)
8'3"	17'5"

TOS = TOP OF SLAB

(.) = WIDTH OF CRACK

COORDINATES

5-31-88

NORTH WALL CELL #1 EAST HALF

INSIDE

DIRECTION OF MEASUREMENT ↓	DIRECTION OF MEASUREMENT ↔	
ACROSS TOP	22'	
9"	21'3"	
2'	20'8"	.020
5'	20'8"	
10'	20'10"	
15"	20'10"	
17'4"	21'2"	
20'	20'10"	
TOS	20'	
22'	20½'	
23'10"	20'3"	.008
TOS	20'	
5'	22'2"	
6'	22'3"	.006
8'3"	23'1"	
6'1"	29'7"	.006
6'4"	31'	
8'7"	28½"	
21'2"	30'8"	
22½'	29½'	.006
TOS	28'	
12'3"	41'8"	
13'5"	42'2"	
16'5"	42'2"	.010
19'3"	41'11"	
18'	41'	
20½'	42'	.010
TOS	42'7"	

TOS = TOP OF SLAB

(.XXX) = WIDTH OF CRACK

WALL ½ SECTION INSPECTED

NORTH CELL # 1

□ = 1' SQ FOR WALL FACE

□ = 9" SQ FOR WALL TOP

OUTSIDE CRACK = ——— SOLID LINE

INSIDE CRACK = – – – BROKEN LINE

CONTINUES BELOW GRADE →

DATE: 5-31-88

MEASURED BY: WAM

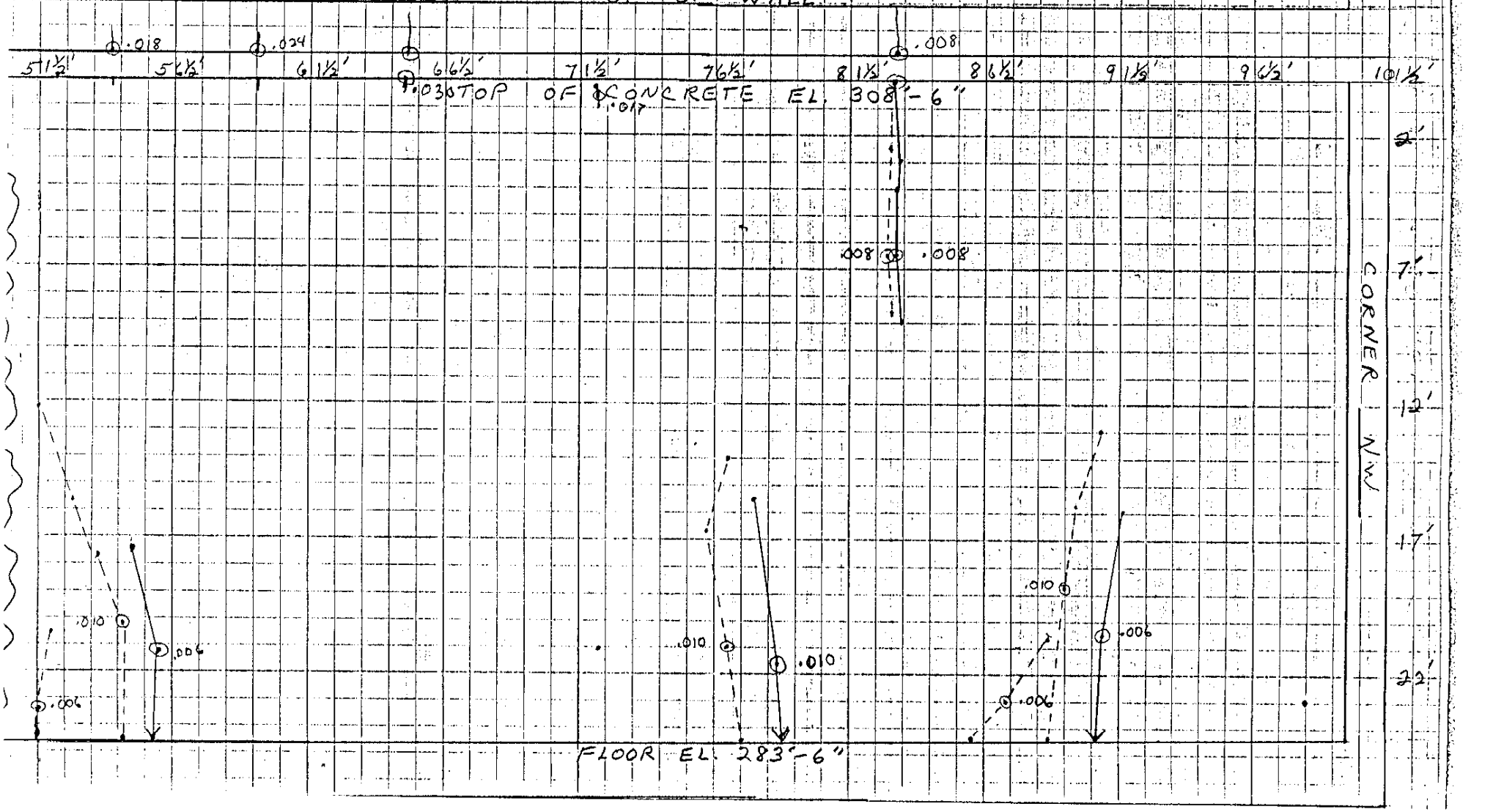
RECORDED BY: DLP

WEATHER: CLEAR

WALL CONDITION: SHADED ✓ DIRECT SUN ___

DAMP ___ WET ___

TEMP. RANGE: 70's - 90's



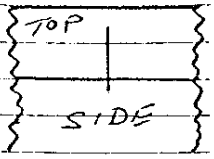
COORDINATES

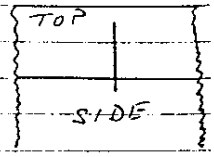
NORTH WALL CELL #1 WEST HALF

OUTSIDE

DIRECTION OF MEASUREMENT ↓ ⟷

ON TOP	54'2"
1"	54'2" (.018) 12" LONG
ON TOP	59½'
1½"	59½' (.024) 10" LONG
17'5"	55'1"
21'4"	55'11" (.006)
TOS	55'9"
ACROSS TOP	65'2"
2"	65'2½" (.031)
4"	72'1"
5"	72'2" (.017)
8"	72'4"
15½'	77'11"
21'7"	79'5" (.010)
TOS	79'11"
ACROSS TOP	83'2"
2'	83'5"
3'11"	83'3"
6½'	83'2" (.008)
9'	83'5"
16'	91'2"
20'8"	90'11" (.006)
TOS	90'2"





TOS = TOP OF SLAB

(.) = WIDTH OF CRACK

COORDINATES

NORTH WALL CELL #1 WEST HALF

INSIDE

DIRECTION OF MEASUREMENT ↓	DIRECTION OF MEASUREMENT ↔	
12'2"	51'6½"	
15'5"	52'5"	
17'5"	53'7"	
20'2"	54'5"	.010
TOS	54'4"	
20'5"	52'	
23'5"	53'7"	.006
TOS	53'5"	
14'	76'11"	
16'5"	76'3"	
21'1"	76'11"	.010
TOS	77'6"	
ACROSS TOP	81'10"	
2'5"	81'5"	
6'5"	81'5"	.008
8'5"	81'10"	
20'10"	88'4"	
23'	87'3"	.006
TOS	86'2"	
12'11"	90'2"	
15'5"	89'10"	
18'5"	89'6"	.010
TOS	88'10"	

TOS = TOP OF SLAB

(.010) = WIDTH OF CRACK

WALL ½ SECTION INSPECTED — WEST — CELL # 1

□ = 1' SQ FOR WALL FACE

□ = 9" SQ FOR WALL TOP

OUTSIDE CRACK = ——— SOLID LINE

INSIDE CRACK = – – – BROKEN LINE

CONTINUES BELOW GRADE →

DATE: 6-2-88

MEASURED BY: WRM

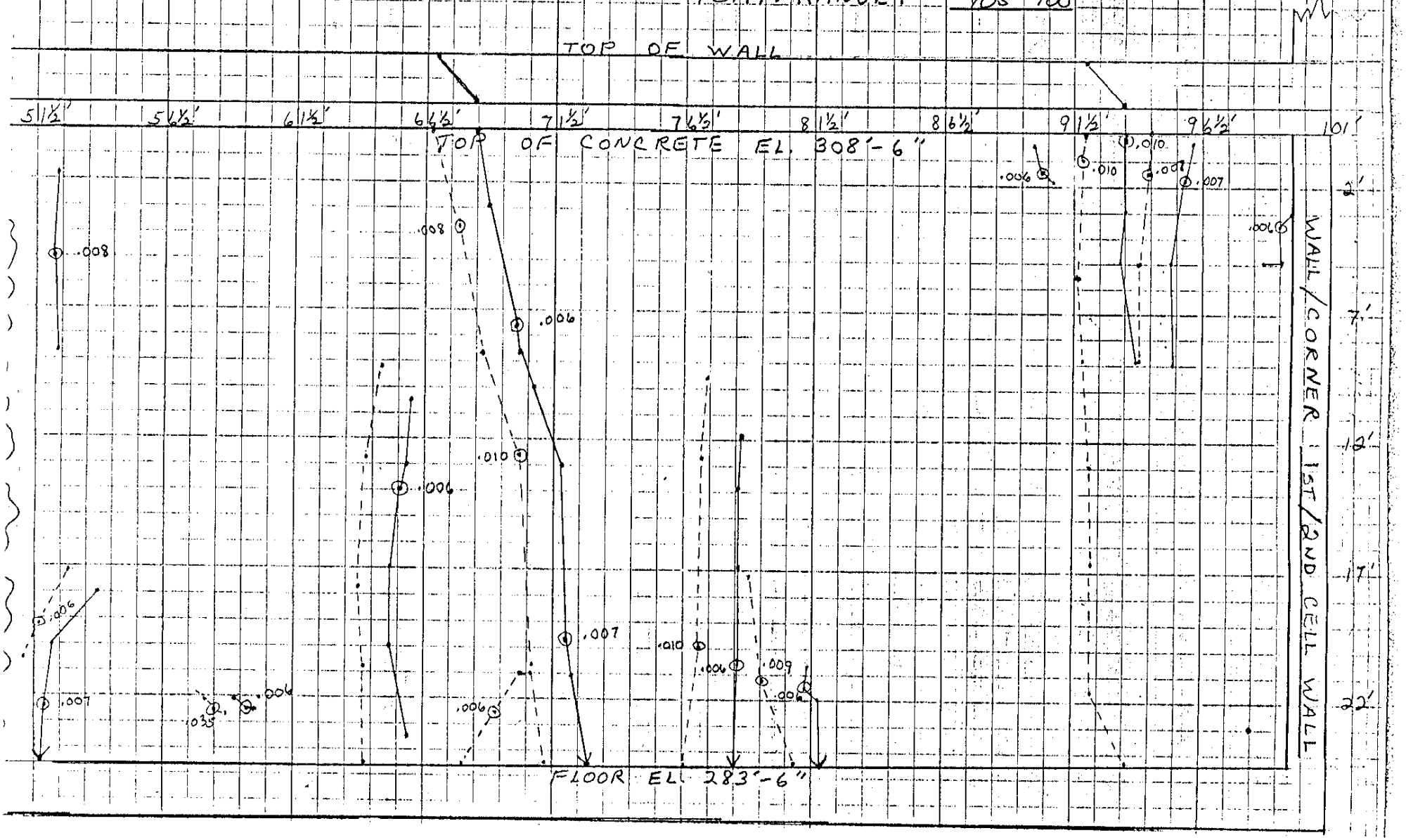
RECORDED BY: DLP

WEATHER: CLEAR

WALL CONDITION: SHADED ✓ AM DIRECT SUN PM

DAMP ___ WET

TEMP. RANGE: 70's - 100



WALL 1/2 SECTION INSTALLED WEST CELL 1

□ = 1' SQ FOR WALL FACE

□ = 9" SQ FOR WALL TOP

OUTSIDE CRACK = ——— SOLID LINE

INSIDE CRACK = — — — BROKEN LINE

CONTINUES BELOW GRADE →

EXTENDS BEHIND WALL --→

DATE: 6-1-88

MEASURED BY: WRM

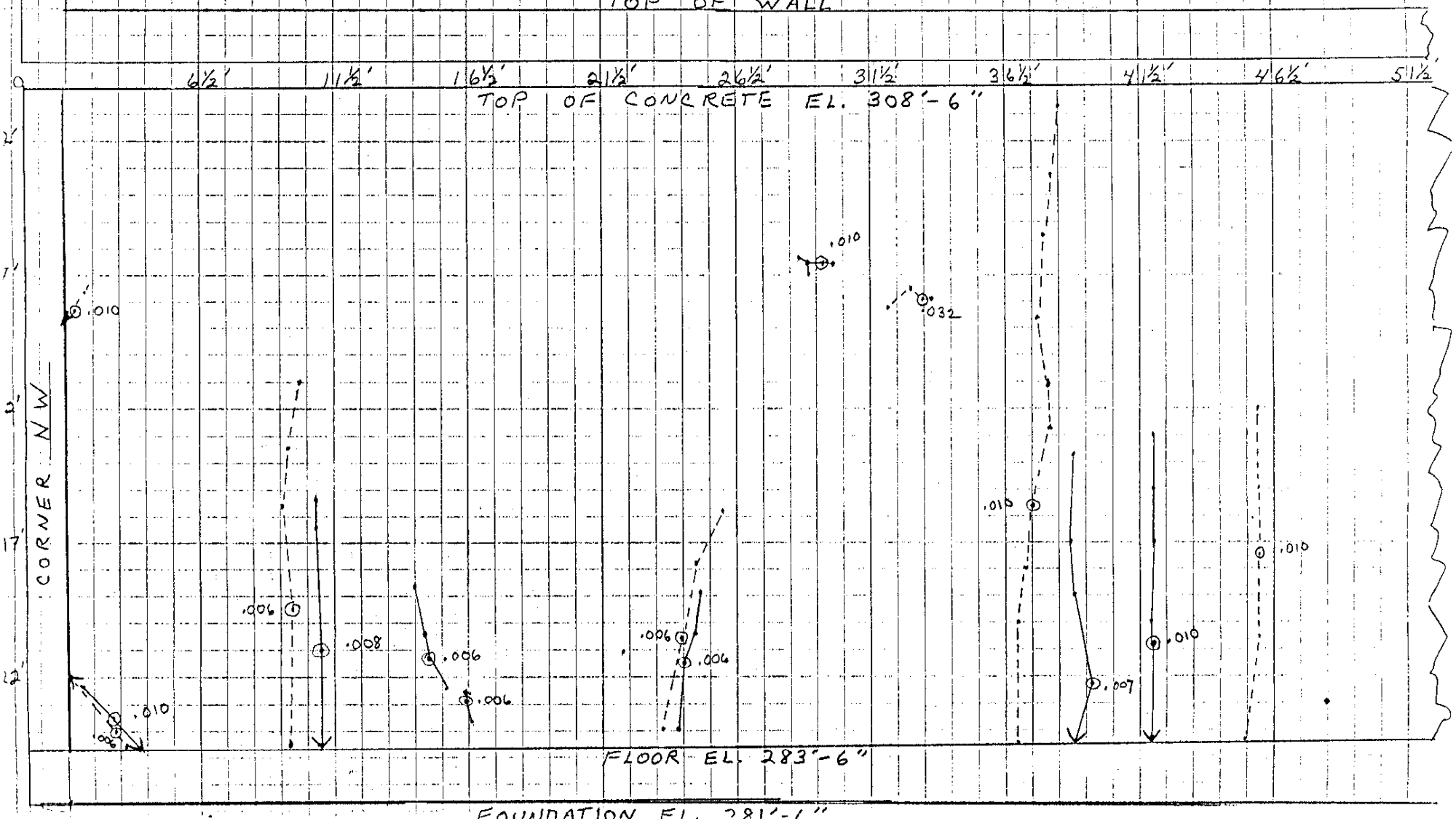
RECORDED BY: DLP

WEATHER: CLEAR

WALL CONDITION: SHADED ✓ DIRECT SUN —

DAMP — WET —

TEMP. RANGE: 70's - 90's



COORDINATES
WEST WALL CELL #1
INSIDE

6-6-88

DIRECTION OF MEASUREMENT ↓	↔
7'9"	9"
8'5"	3" (.010)
8'6"	0'0" Extends behind North Wall
22'	0'0" Extends behind North Wall
24'	1'11" (.006)
TOS	2'11"
11'	10'3"
13'9"	9'9"
15'9"	9'2"
19'9"	9'5" (.006)
TOS	5'5"
15'5"	26'
17'9"	25'
20'7"	23'8" (.006)
24'	23'
8'	33'9"
8'	33'6" (.032)
7'6"	32'11"
8'3"	32'2"
9"	38'7"
3'3"	38'3"
5'6"	38'
8'5"	37'5"
10'11"	38'6"
12'5"	37'9"
15'9"	37'6" (.010)
18'9"	37'3"
20'5"	37'
TOS	37'
12'	45'5"
14'5"	45'5"
17'5"	45'5" (.010)
20'6"	45'5"
TOS	45'5"
17'2"	52'9"
19'2"	51'8" (.006)
20'6"	51'2" Extends behind Plywood Marker

Height Marker covered wall from 51'2" to y

TOS = TOP OF SLAB
(.010) = WIDTH OF CRACK

COORDINATES
WEST WALL CELL #1
INSIDE

6-6-88

DIRECTION OF MEASUREMENT ↓	⟷	
22'3"	58'3"	
22'7"	58'6"	.035
22'9"	58'9"	
9"	67'	
4'5"	67'9"	.008
8'5"	68'8"	
12'6"	70'2"	.010
20'5"	70'8"	
TOS	71'3"	
9'3"	64'9"	
12'5"	64'4"	
17'5"	63'11"	
20'5"	64'4"	.010
TOS	64'4"	
21'	70'8"	
21'	70'4"	
22'6"	69'8"	.006
TOS	68'1"	
5'6"	77'5"	
12'5"	77'2"	
20'	77'3"	.010
TOS	76'7"	
17'3"	78'11"	
21'4"	79'7"	.009
TOS	80'8"	

TOS = TOP OF SLAB
○ = WIDTH OF CRACK

COORDINATES
WEST WALL CELL #1
INSIDE

6-6-88

DIRECTION OF MEASUREMENT ↓	↔	
ACROSS TOP	91'5"	
11"	91'8"	.010
5'5"	91'7"	
8'9"	91'11"	
12'9"	92'3"	
16'9"	92'4"	
21'9"	92'4"	
TOS	93'7"	
ACROSS TOP	94'6"	
1'6"	94'5"	.007
5'	93'10"	
8'11"	93'10"	

TOS = TOP OF SLAB.
○ = WIDTH OF CRACK

COORDINATES
WEST WALL CELL #1
OUTSIDE

6-1-88

DIRECTION OF MEASUREMENT

↓	⟷	
22'3"	1'5"	
23'8"	3'2"	.010
TOS	4'3"	
15'4"	10'10"	
17'7"	10'10"	
21'	11'	.008
TOS	10'11"	
18'	14½'	
19'2"	14'10"	
21'5"	15'4"	.006
22'5"	15'7"	
22'7"	16'5"	
22'11"	16'5"	.006
23'7"	16'7"	
18'11"	25'3"	
20'5"	24'10"	
21'7"	24'7"	.006
24'	23'10"	
6'8"	30'2"	
6'8"	30'	.010
6'8"	29'5"	
6'6"	29'	SPLIT
7'0"	29'5"	SPLIT

TOS = TOP OF SLAB
(.010) = WIDTH OF CRACK

COORDINATES
WEST WALL CELL #1
OUTSIDE

6-2-88

DIRECTION OF MEASUREMENT ↓	↔	
13'8"	39'2"	
17'	39'	
19'	39'1"	
22'3"	39'8"	.007
TOS	39'2"	
13'	43'	
15'	43'	
17'	43'	
20'	41'11"	
20'11"	41'11"	.010
TOS	41'11"	
1'10"	52'4"	
5'	52'3"	.008
8'8"	52'5"	
17'10"	53'10"	
20'	52'3"	
22'4"	51'11"	
TOS	51'10"	
10'6"	67'	
13'	67'4"	
14'1"	67½'	.006
17'	67'5"	
20'	67'8"	
23'6"	67'2"	
22'2"	63½'	
22'5"	62'11"	.006
22'6"	62'10"	

TOS = TOP OF SLAB
( ) = WIDTH OF CRACK

COORDINATES
WEST WALL CELL #1
OUTSIDE

6-2-88

DIRECTION OF MEASUREMENT ↓	DIRECTION OF MEASUREMENT ⟷	
ACROSS TOP	68'5"	
3'	67'11"	
7'8"	70'	.006
8'7"	70'2"	
10'	70'7"	
13'	71'5"	
19'8"	72'	.007
TOS	72'8"	
11'11"	78'8"	
14'	78'7"	
17'	78'8"	
20'8"	78'7"	.006
TOS	78½'	
20'10"	81'4"	
21½'	81'3"	.006
22'	81'8"	
TOS	81'5"	
6"	89'11"	
1'6"	90'3"	
1'11"	90'8"	
ACROSS TOP	93'	
1"	93'	.010
3'	93'	
5'	92'10"	
8'11"	93'4"	
5"	96'2"	
1'10"	95'8"	.007
5'	95'4"	
9'	95'5"	
3'6"	99½'	
3'	99'10"	
3'11"	99'7"	
3'11"	99'2"	

TOS = TOP OF SLAB
( ) = WIDTH OF CRACK

FLOOR 1/2 SECTION INSPECTED _____ CELL 1

□ = 1' SQ

CRACK = ——— SOLID LINE (ALL CRACKS GRAPHED EXCEED 5' IN LENGTH)

⊙ = POINT OF CRACK WIDTH MEASUREMENT

DATE: 6-11-88

MEASURED BY: C Hamm

RECORDED BY: T Palmer

WEATHER: Clear & Cool

FLOOR CONDITION:

STANDING WATER: ___

DAMP: ___

DRY: ✓

OTHER: ___

EAST WALL

NORTH WALL

0

4'3"

14'3"

24'3"

34'3"

44'3"

49'3"

℄

006

4'3" 14'3" 24'3" 34'3" 44'3" 54'3" 64'3" 74'3" 84'3" 94'3" 98'3"

DWG. W 780625

FLOOR ½ SECTION INSPECTED _____ CELL 1

□ = 1' SQ.

CRACK = _____ SOLID LINE (ALL CRACKS GRAPHED EXCEED 5' IN LENGTH)

⊙ = POINT OF CRACK WIDTH MEASUREMENT

DATE: 6-14-88 B.M.+C.H.

MEASURED BY: Coleman

RECORDED BY: T. Fridrich

WEATHER: Rain + Cool

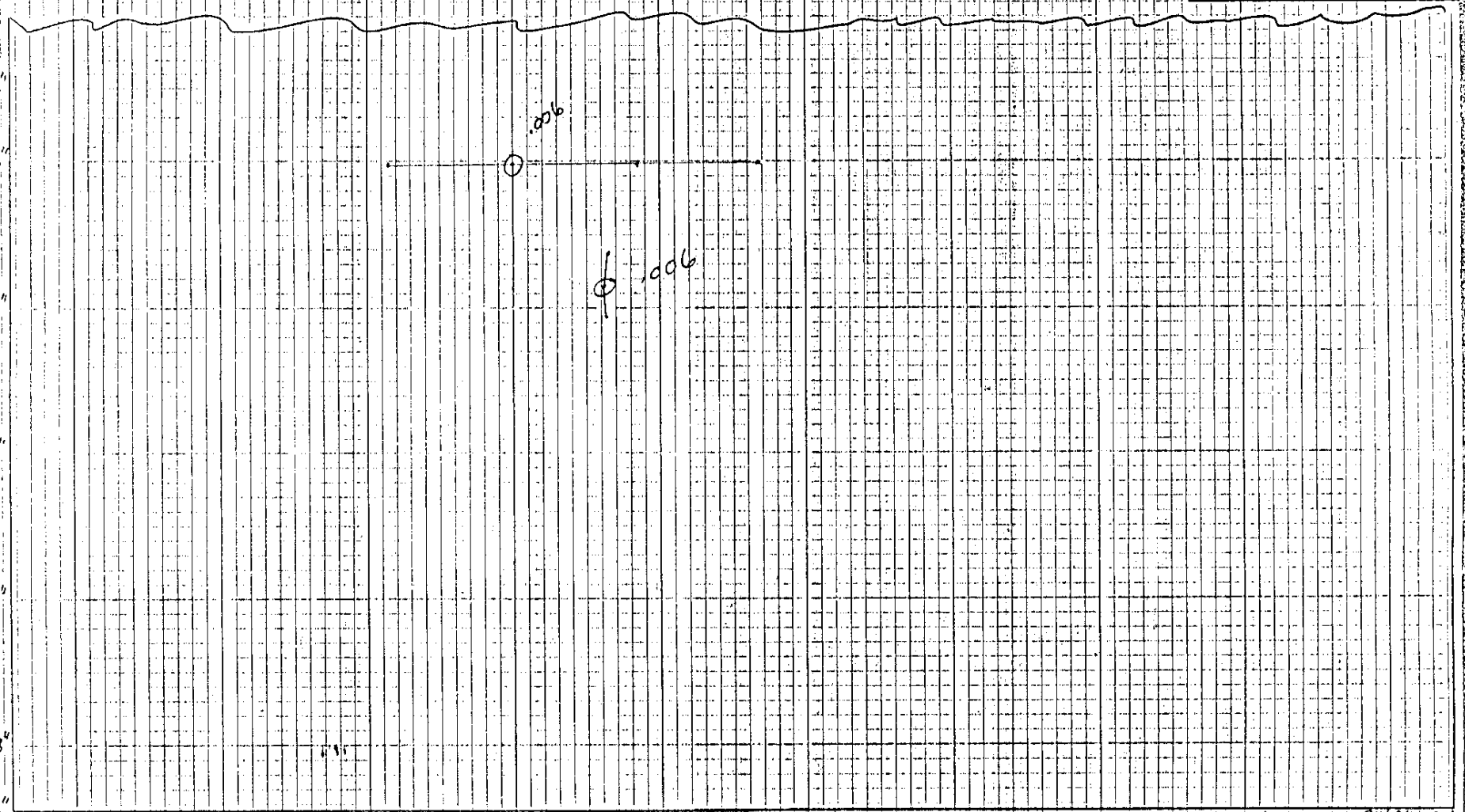
FLOOR CONDITION:

STANDING WATER: ____

DAMP: ____

DRY: ✓

OTHER: ____



COORDINATES
CELL #1 FLOOR

6-11-88

DIRECTION OF MEASUREMENT

N TO S	E TO W	
0"	54'8"	
14'	54½'	(.006)
26'4"	53'5"	
40'8"	64'11"	
40'6"	63'	(.006)
40'8"	60'6"	
25'9"	54½'	
34'3"	54½'	
51'	54'4"	
42'5"	54'5"	

(.006) = WIDTH OF CRACK

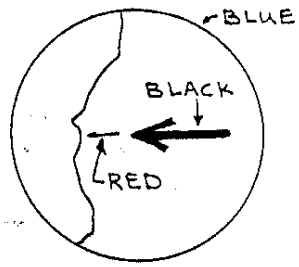
ATTACHMENT 2

VAULT CRACK MAP #2

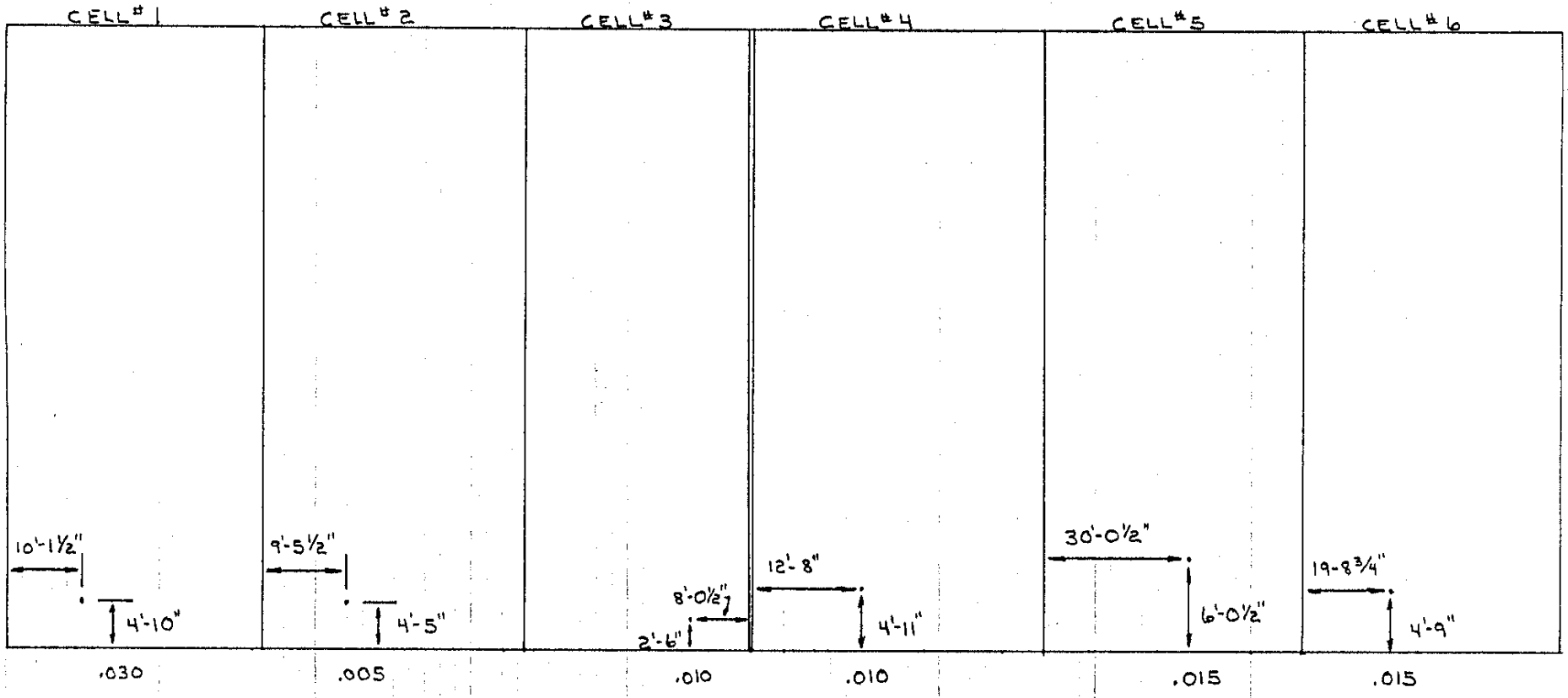
11/10/88

WEST WALL

Note: Measurements taken in cracks that showed a leaching effect.



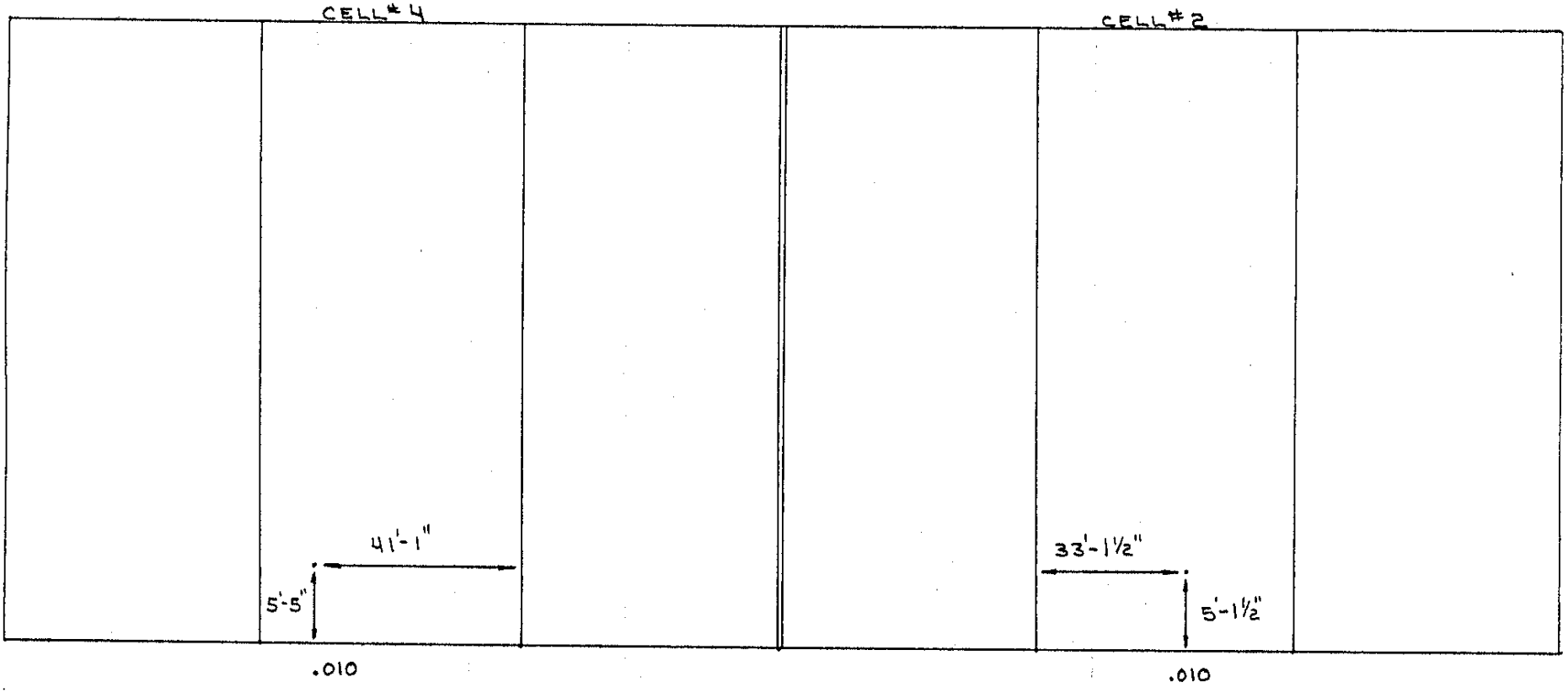
TYP.



FOR INFORMATION ONLY

EAST WALL

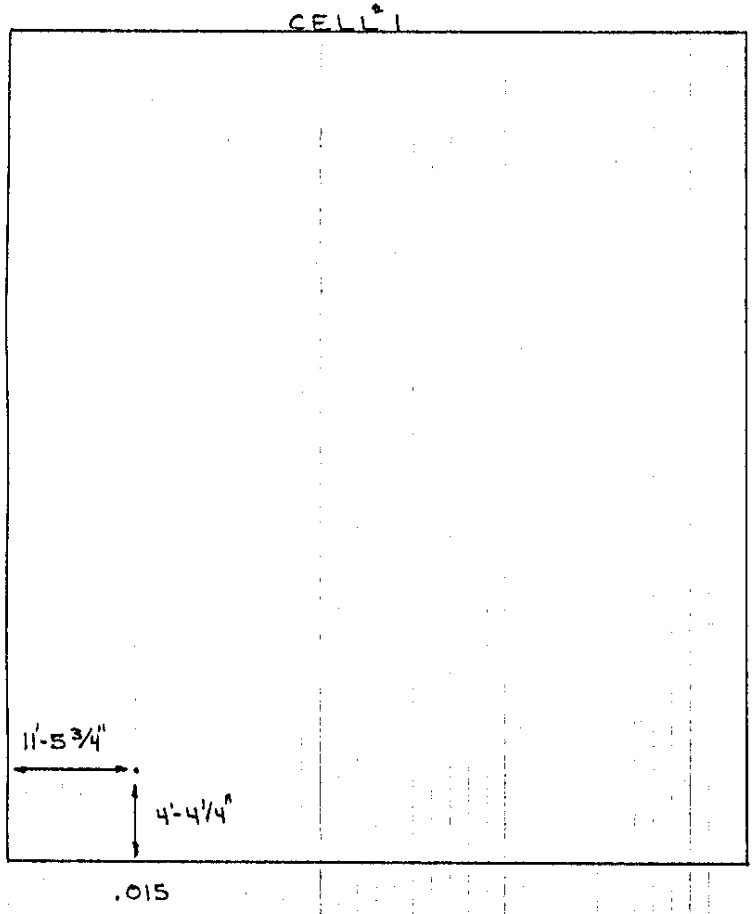
Note: Measurments taken in cracks that showed a leaching effect.



FOR INFORMATION ONLY

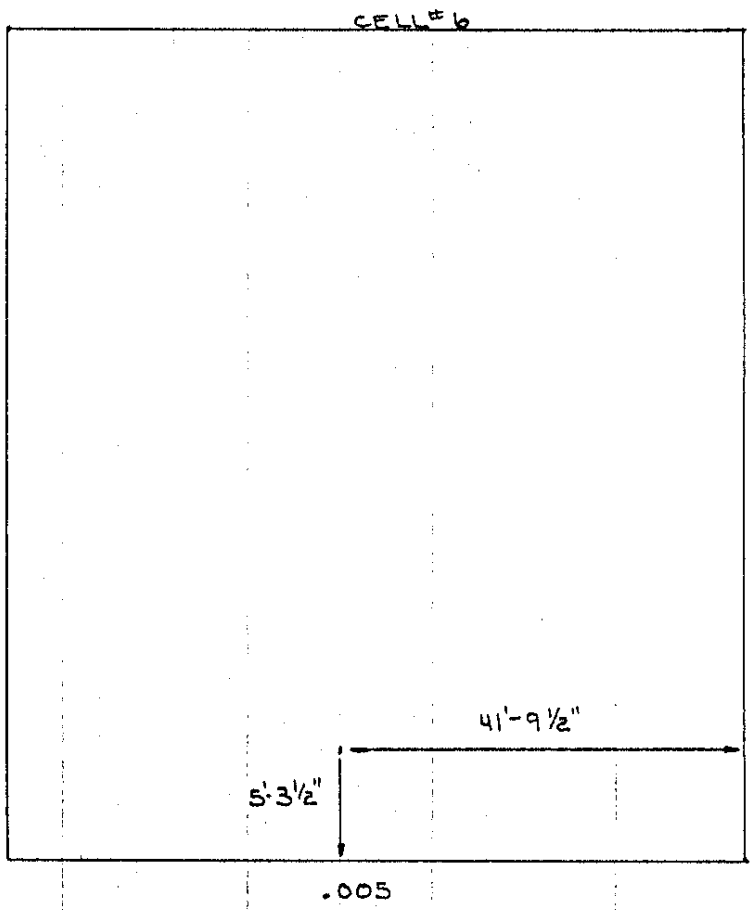
NORTH WALL

Note: Measurment taken in crack that showed a leaching effect.



SOUTH WALL

Note: Measurment taken in a crack that showed a leaching effect.



FOR INFORMATION ONLY

ATTACHMENT 3

CRACK MOVEMENT #1

XC: Thompson
Oakes

MAY

WESTINGHOUSE SAVANNAH RIVER COMPANY

INTER-OFFICE MEMORANDUM

EED890489
"Z"- Area Crack
Strain Gauge Measurements
Retention: 3 Years

April 27, 1989

DAICY

TO: R. SPRAGUE, 704-2Z
DWPFWE

FROM: K. PYTLEWSKI, 730-A KRP
EQUIPMENT ENGINEERING DIVISION
G. CADELLI, 730-A
EQUIPMENT ENGINEERING DIVISION

copy: RJO
HB

"Z-AREA" VAULT WALL CRACK MONITORING

Background

Strain gauges were installed by the Equipment Engineering Division across vertical cracks in the concrete walls of the Z-Area #1 vault. Gauges were placed over cracks on the east, north and west walls. The location of the vault and relative placement of the gauges is depicted in Figure 1.

The purpose of the project was to measure an approximate strain of the cracks in the vault walls induced by daily environmental thermal cycles. This strain information was gathered to assist Z-Area Waste Management in selecting a coating with suitable elastic properties for sealing the existing wall cracks.

Results

Measurements of the expansion of a crack is not a standard strain gauge technique. In these tests, the strain gauge element is not in contact with any material at the crack opening. The total measured strain is the strain in the sensor element bridged across the crack plus
the strain of the element in contact with the concrete. As a result, the calculated strain values are estimates.

An attempt was made to use a larger gauge so that the void space was small in comparison to the sensing area of the gauge. This technique could be further developed to reduce error in the measurements by use of a gauge larger than used in this program.

Measurements of strain were taken for at least 3 daily temperature cycles.

Results show the east wall to have the least temperature range at 6 F. This is probably due to the short exposure time of this wall to the sun. The north wall had a temperature range of 15 F. The west wall had the greatest temperature range at 30 F. All measurements were taken during late November/early December.

The following table gives actual data of temperature range and strain readings.

East Wall		North Wall		West Wall	
Temp Range	Counts	Temp Range	Counts	Temp Range	Counts
6 F	-85	11 F	-239	25 F	-365
1 F	-13	9 F	-210	21 F	-553
6 F	-57	15 F	-1	30 F	-600

Applying the corrections and calibration factor, the final strain readings are:

East Wall	North Wall	West Wall
.0015 in/in	.004 in/in	.008 in/in

Since concrete does not follow Hooke's law, an average modulus of elasticity for concrete would be needed to calculate an approximate stress.

Conclusions & Recommendations

1. The west wall of vault #1 has the highest temperature range.

2. Approximate concrete crack expansion on a winter day with a temperature range of 30 F could be .008 inches. During spring temperature cycles, when the daily temperature differential is the greatest, strains may be much higher.

3. If an extended time period in monitoring crack expansion is foreseen, strain gage techniques should be developed to predict more accurate strain values.

4. For an extended monitoring program, temperature indicators should be cemented to the concrete walls to give accurate wall temperature.

5. Nearly any elastomeric polymer system chosen to coat the vault walls will be capable of withstanding the strains experienced by the concrete.

CC: O. M. Ebra-Lima, 773-A
S. K. Formby, 730-A
E. G. Caveness, 730-A
J. M. Ferrell, 723-A
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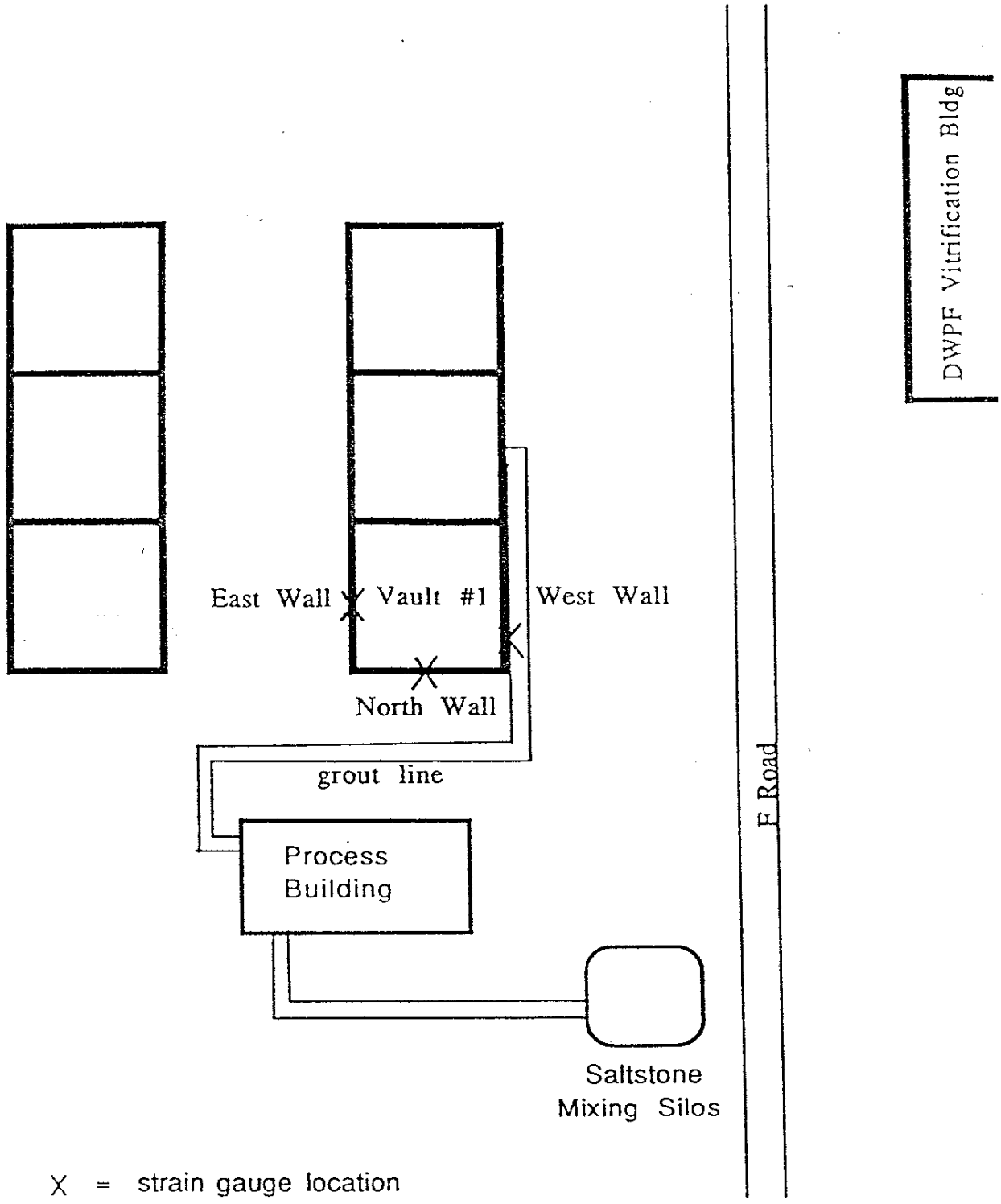


Figure 1: Layout of Z-Area showing strain gauge locations.

ATTACHMENT 4

CRACK MOVEMENT #2

OCTOBER 4, 1990

TO: DENNIS THOMPSON, 704-Z
DWPFT

FROM: PATRICK D. SCHNEIDER, 704-5Z
DWPFT

Z-AREA VAULT CRACK STUDY

I. INTRODUCTION

A study was conducted to trace the movement of selected cracks on the concrete walls of Vault #1, Cell #6 in Z-Area (see attached layout of Z-Area vaults for location). The crack gap distance as well as the ambient air temperature at different times during the day were measured and recorded for several days. It was found that the crack gaps do indeed increase and decrease in accordance to the surrounding temperatures. Movements up to 0.007 of an inch were found to occur.

II. METHODS

A method to measure the crack gaps was needed that was accurate and simple -- meaning a method in which excessive or uncalcuable errors would not be a problem. Thus, direct measurement of the cracks was chosen. A hand-held microscope (see Figure 1), with a magnification power of 50X, was obtained to increase the crack gap

size to a magnitude that was easily measurable. Figure 2 depicts the viewers scale as seen through the microscope.

The microscope was first used to select cracks in the vault's walls which contained gaps that remained easily measurable throughout the crack's movements. Nine cracks in all were traced in which three cracks were located on each of the three outer vault walls. Each crack was marked and numbered for easy and accurate documentation.

Once the cracks were selected, a part of the crack, which had smooth edges to it, was chosen to be the study area. The circumference of the microscope's plastic base was then traced out on the vault wall in order to ensure identical placement of the microscope over the study area each time the crack gap was measured (see Figure 3). Also, marks were set on both the microscope base and the traced circle, which were later used to line up the two. These marks along with the traced out circumference added to the precision of the study by ensuring precise placement of the microscope over the study area each time a measurement was obtained.

The ambient air temperature was recorded for each set of three cracks contained on a vault wall by means of a temperature probe. These temperatures were obtained from the same spot along the vault walls each time. The temperature probe was allowed to rest unmolested for a duration of time long enough for the readout to stabilize.

III. RESULTS

Data on crack movement -- crack gap size and ambient air temperature -- was monitored from September 25, 1990 until October 4, 1990. The data was obtained at 7:30 am, 11:00 am and 3:00 pm on various days during this period and recorded on the attached data sheets.

The recorded data shows as the temperature changed over the course of a day so would the crack gap size. The interesting thing about the crack movement though is it appears that change in the crack gap size is depended on the previous nights low temperature. This is demonstrated by crack #1 in the west wall. On 9/27/90 and then

again on 10/2/90 a daily temperature range of 35.8F was realized. Even though the magnitude of this temperature range for both days was the same, the crack gap movement was different. On 9/27/90 crack #1 of the west wall moved 0.007 inches while on 10/2/90 this same crack had only a 0.004 inch movement. This is a 43% difference in movement over the same magnitude of temperature change but over a different range of temperatures. This seems to show that at a certain high temperature the crack is no longer going to be effected and the same goes for a low temperature but the air temperature never reached the low end of this scale.

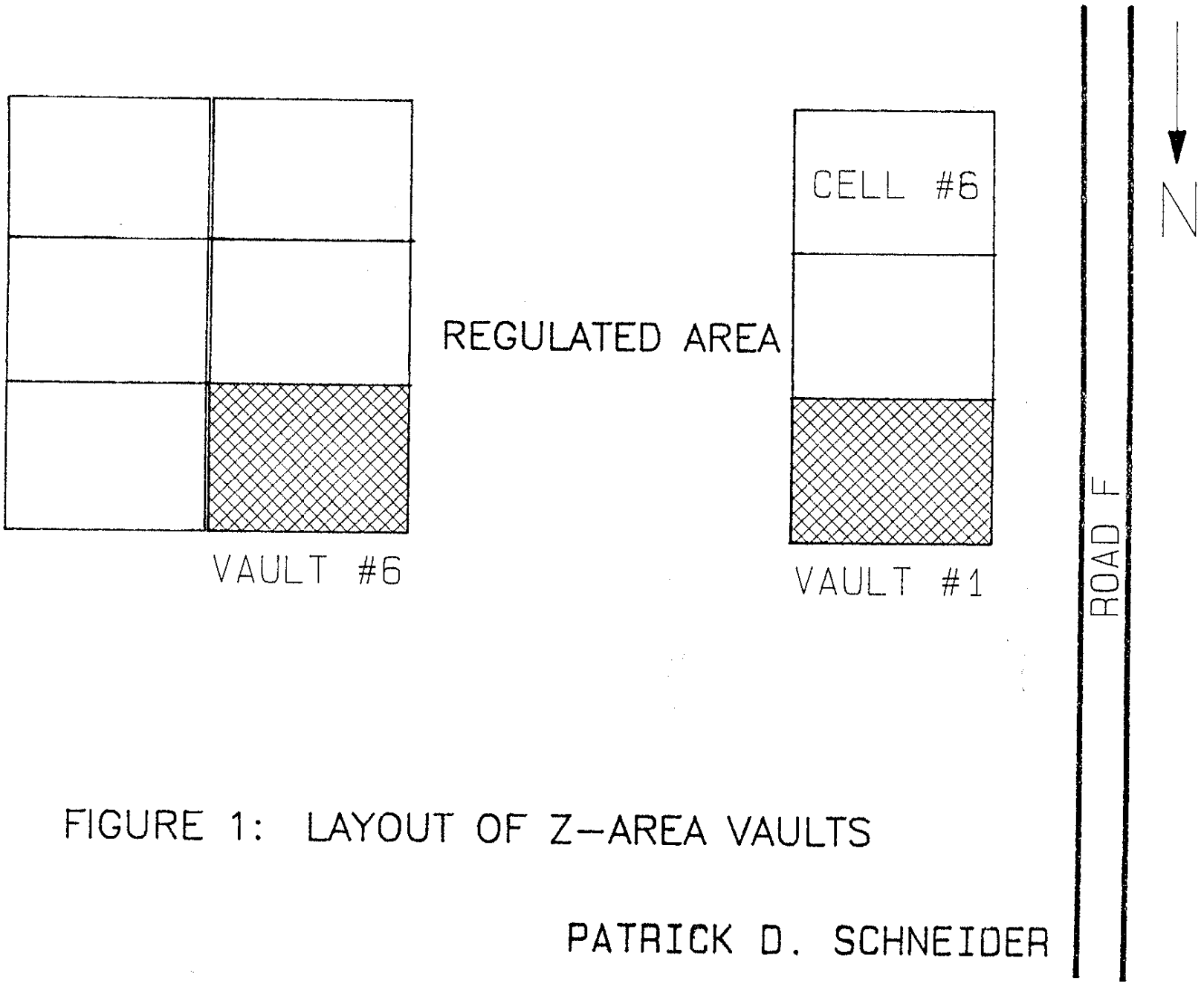


FIGURE 1: LAYOUT OF Z-AREA VAULTS

PATRICK D. SCHNEIDER

which makes it easy to read under magnification.

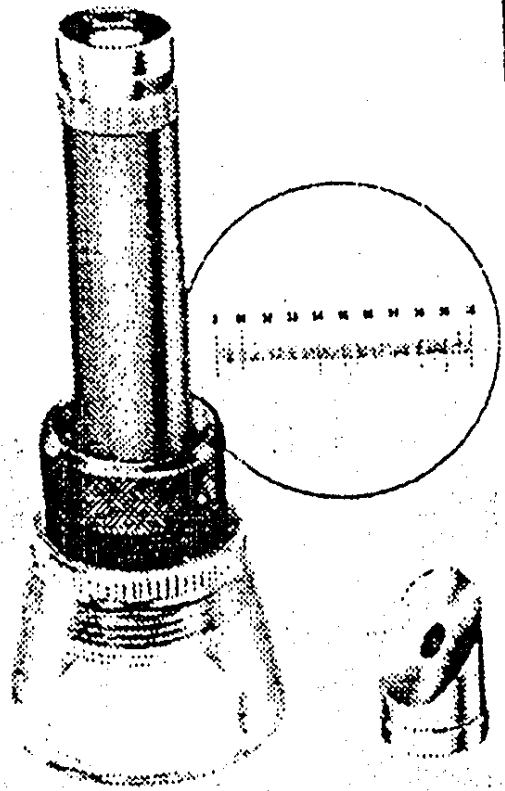
A special feature of the reticle is the thickness comparison scale (E). A series of parallel lines .002" to .007" apart make it possible to measure visually and directly the thickness of materials such as paper, plastic, gaps between mechanical parts, etc. Mechanical measurements of such items are sometimes inaccurate because the materials are apt to compress.

transparent Lucite ad
No. 50,076 can also t
locked to suit individ

Reticle Only. As desc
used in standard micr

FIGURE 1

New Low-Cost 50X Microscope for Direct Measurements to .001"



Powerful, pocket-size scope with measuring reticle is mounted in clear plastic base...excellent for surface measuring metals, fibers, printing, etc. Base admits plenty of light, keeps instrument in sharp focus for measuring 1/10" by .001 divisions...without calculations. Scope can be removed from base and used alone with chrome reflector incl: **No. 60,465**

$54.

MAGNETIC INK COMPARATOR MAGNIFIES 12 TIMES With Revised B2 Reticle

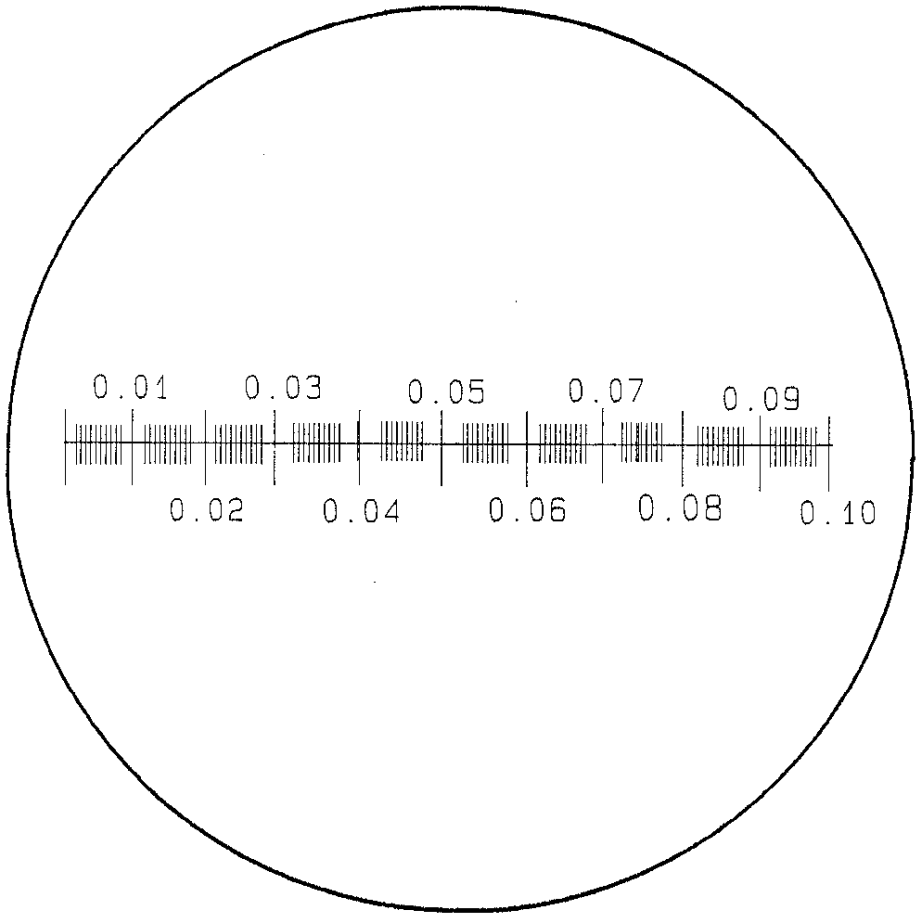
This comparator is an ir
netic ink printing.

Every bank, check p
ment ideal for "go,"
x 1 1/4" diam. makes

Reticle as illustrated
coverage, voids, etc. a

12X Magnifier, as abov

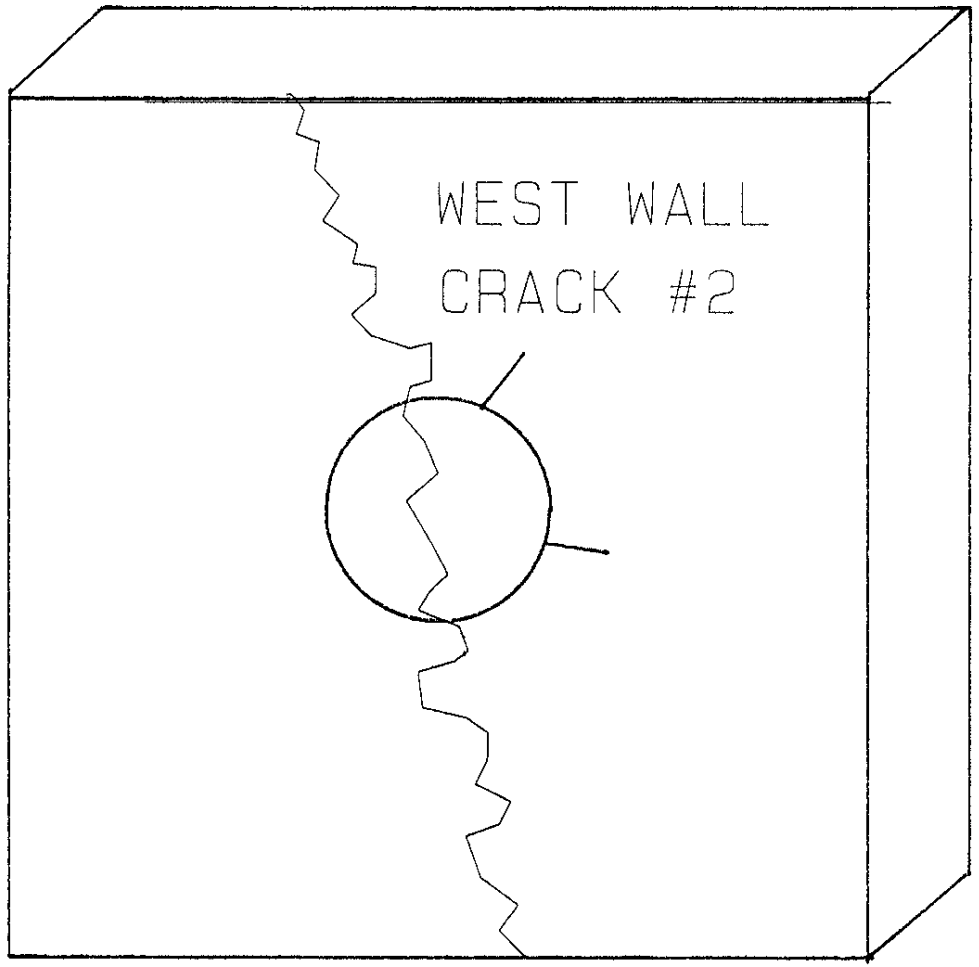
Figure 2



MEASURING RETICLE OF 50X MICROSCOPE
DIRECT MEASUREMENT TO 0.001 INCHES

PATRICK D. SCHNEIDER

BLOWN UP VIEW OF A SELECTED VAULT CRACK



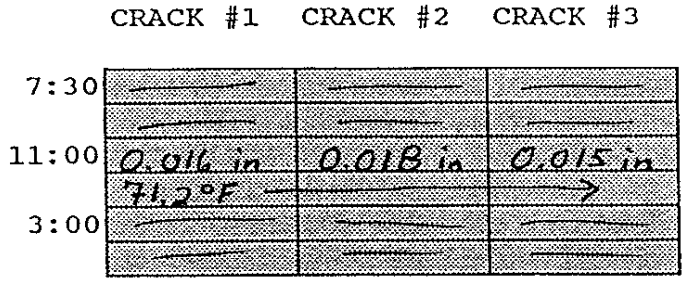
PATRICK D. SCHNEIDER

FIGURE 3

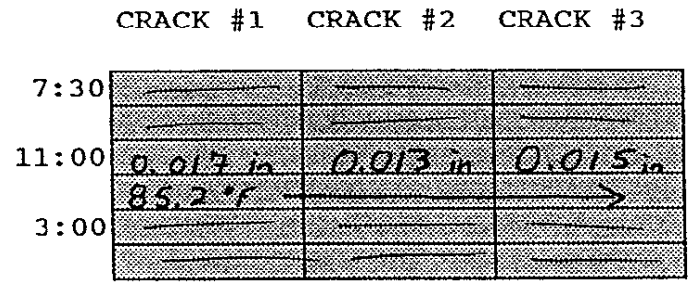
VAULT CRACK STUDY

DATE: 9/25/90

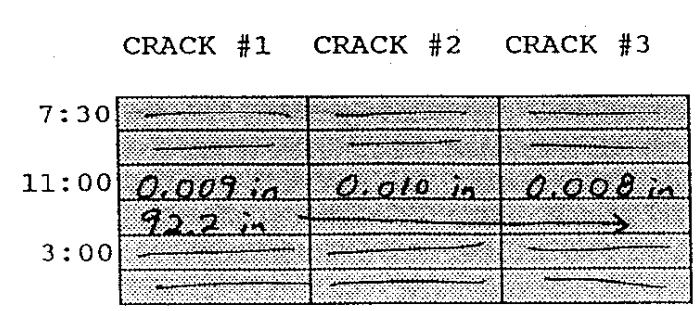
EAST WALL



WEST WALL



SOUTH WALL



VAULT CRACK STUDY

DATE: 9/26/90

EAST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.016 in	0.020 in	0.014 in
	62.4 °F →		→
11:00	0.015 in	0.015 in	0.013 in
	74.4 °F →	→	→
3:00			

WEST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.021 in	0.016 in	0.018 in
	57.2 °F →	→	→
11:00	0.020 in	0.017 in	0.018 in
	74.8 °F →	→	→
3:00			

SOUTH WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.014 in	0.014 in	0.013 in
	64.4 °F →	→	→
11:00	0.011 in	0.011 in	0.008 in
	84.4 °F →	→	→
3:00			

VAULT CRACK STUDY

DATE: 9/27/90

EAST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.015 in	0.015 in	0.014 in
	55.4 °F	→	→
11:00	0.014 in	0.014 in	0.012 in
	76 °F	→	→
3:00	0.016 in	0.018 in	0.018 in
	85.4 °F	→	→

WEST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.020 in	0.015 in	0.017 in
	54.4 °F	→	→
11:00	0.019 in	0.015 in	0.016 in
	84.8 °F	→	→
3:00	0.013 in	0.012 in	0.012 in
	90.2 °F	→	→

SOUTH WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.010 in	0.015 in	0.013 in
	56 °F	→	→
11:00	0.009 in	0.010 in	0.008 in
	90 °F	→	→
3:00	0.007 in	0.009 in	0.007 in
	87.6 °F	→	→

VAULT CRACK STUDY

DATE: 9/28/90

EAST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.014 in 59.6 °F	0.015 in	0.013 in
11:00			
3:00			

WEST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.018 in 60 in	0.015 in	0.015 in
11:00			
3:00			

SOUTH WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.015 in 60.4 °F	0.015 in	0.013 in
11:00			
3:00			

VAULT CRACK STUDY

DATE: 10/1/90

EAST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.014 in	0.015 in	0.013 in
	60.8 °F	→	→
11:00	0.013 in	0.013 in	0.012 in
	77.8 °F	→	→
3:00	0.014 in	0.016 in	0.015 in
	82.4 °F	→	→

WEST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.018 in	0.015 in	0.016 in
	61.2 °F	→	→
11:00	0.020 in	0.015 in	0.015 in
	77.8 °F	→	→
3:00	0.013 in	0.010 in	0.011 in
	89.2 °F	→	→

SOUTH WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.015 in	0.015 in	0.013 in
	61.4 °F	→	→
11:00	0.011 in	0.011 in	0.008 in
	82.0 °F	→	→
3:00	0.010 in	0.010 in	0.007 in
	87.6 °F	→	→

VAULT CRACK STUDY

DATE: 10/2/90

EAST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.013 in	0.013 in	0.011 in
	62.4 °F	→	→
11:00	0.012 in	0.013 in	0.011 in
	75.6 °F	→	→
3:00	0.013 in	0.015 in	0.015 in
	82.2 °F	→	→

WEST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.016 in	0.015 in	0.015 in
	62.8 °F	→	→
11:00	0.016 in	0.015 in	0.015 in
	81.0 °F	→	→
3:00	0.012 in	0.011 in	0.012 in
	98.0 °F	→	→

SOUTH WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	0.014 in	0.014 in	0.011 in
	63.4 °F	→	→
11:00	0.012 in	0.011 in	0.008 in
	83.4 °F	→	→
3:00	0.009 in	0.009 in	0.008 in
	94.0 °F	→	→

VAULT CRACK STUDY

DATE: 10/3/90

EAST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	—	—	—
	—	—	—
11:00	0.012 in	0.013 in	0.011 in
	79.6 °F	→	→
3:00	0.012 in	0.013 in	0.013 in
	84.4 °F	→	→

WEST WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	—	—	—
	—	—	—
11:00	0.017 in	0.015 in	0.014 in
	80.3 °F	→	→
3:00	0.013 in	0.011 in	0.012 in
	91.2 °F	→	→

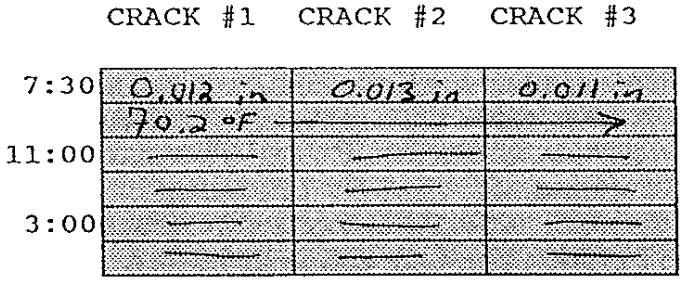
SOUTH WALL

	CRACK #1	CRACK #2	CRACK #3
7:30	—	—	—
	—	—	—
11:00	0.011 in	0.013 in	0.010 in
	81.6 °F	→	→
3:00	0.010 in	0.011 in	0.008 in
	86.8 °F	→	→

VAULT CRACK STUDY

DATE: 10/4/90

EAST WALL



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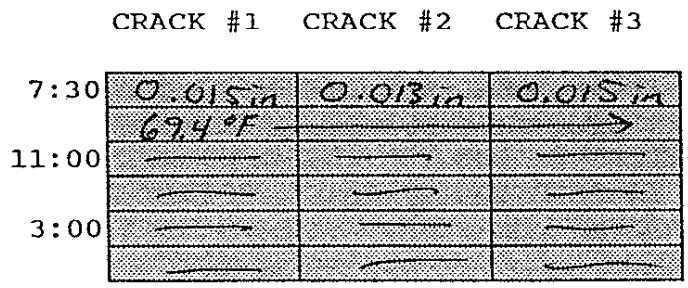
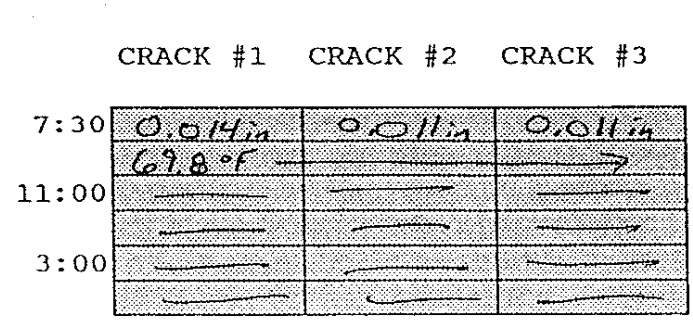
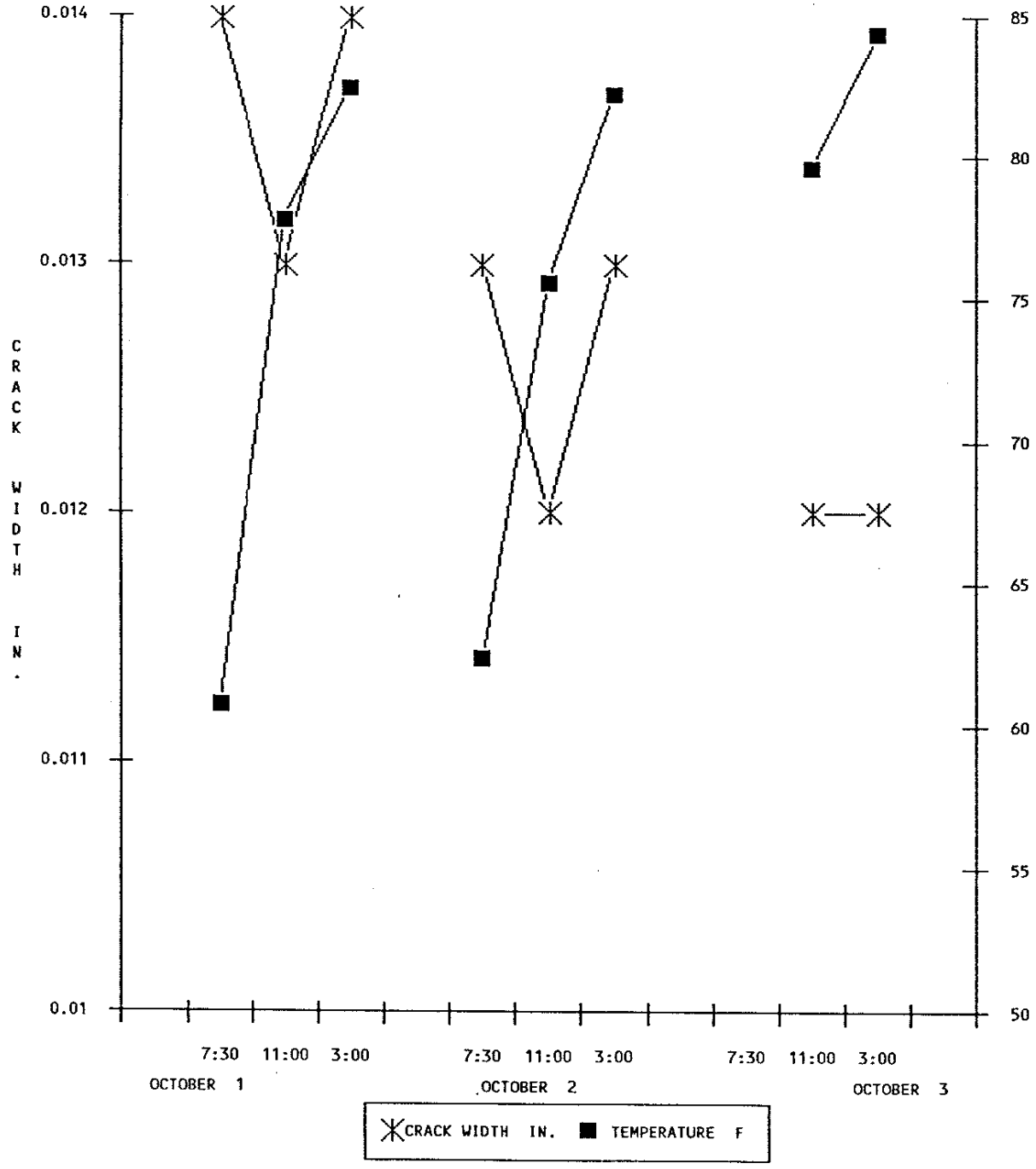


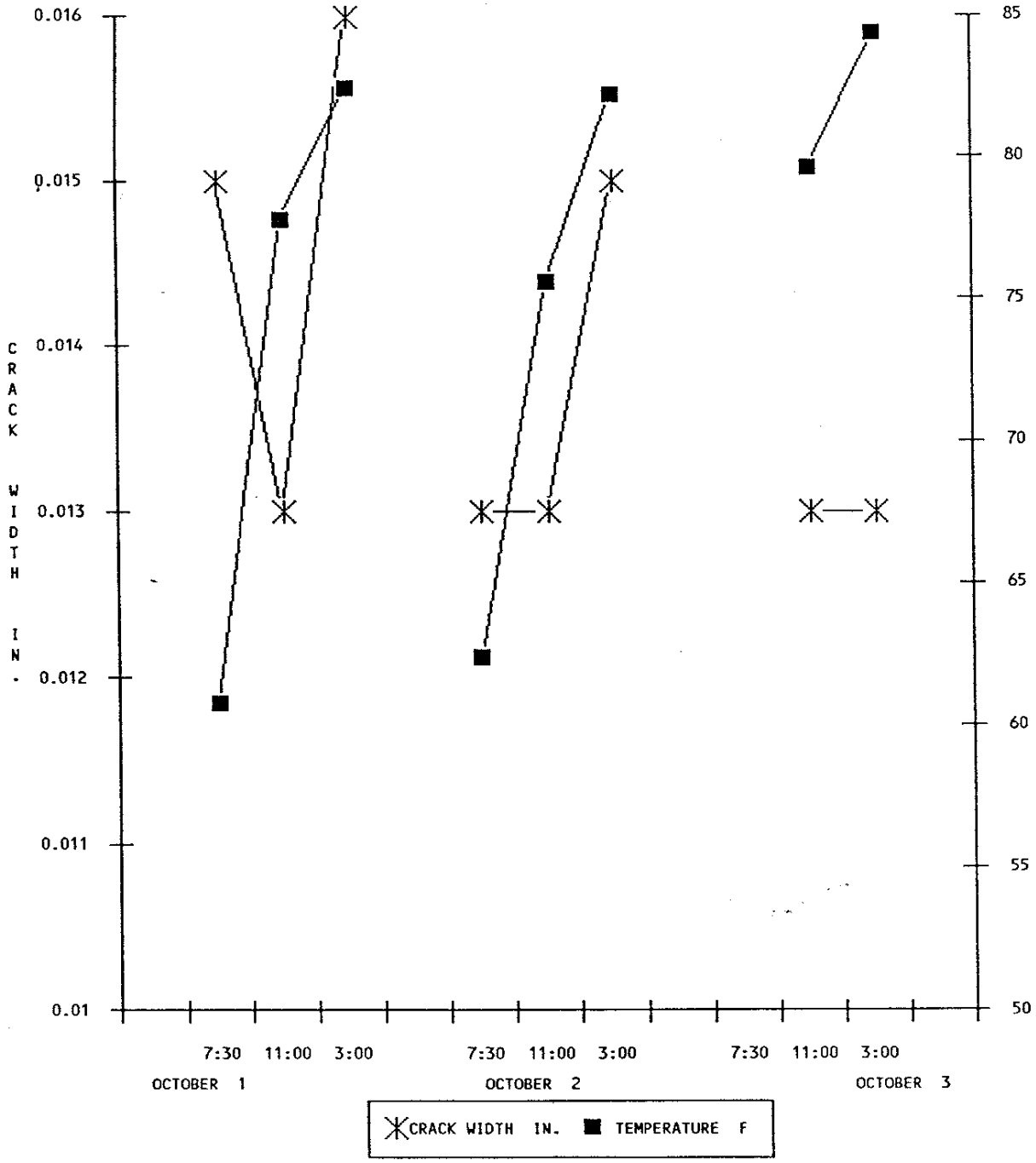
SOUTH WALL



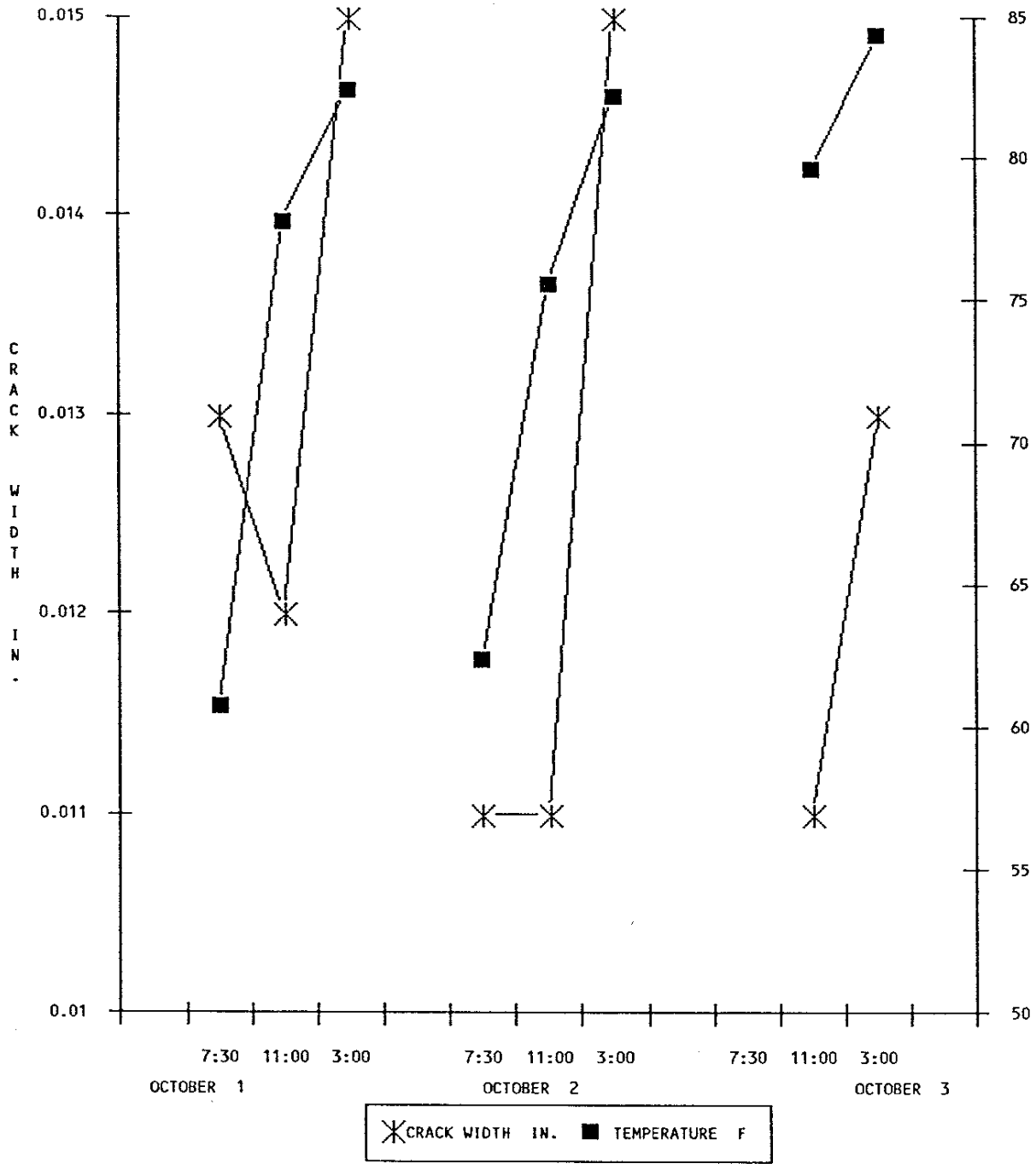
EAST VAULT WALL -- CRACK #1

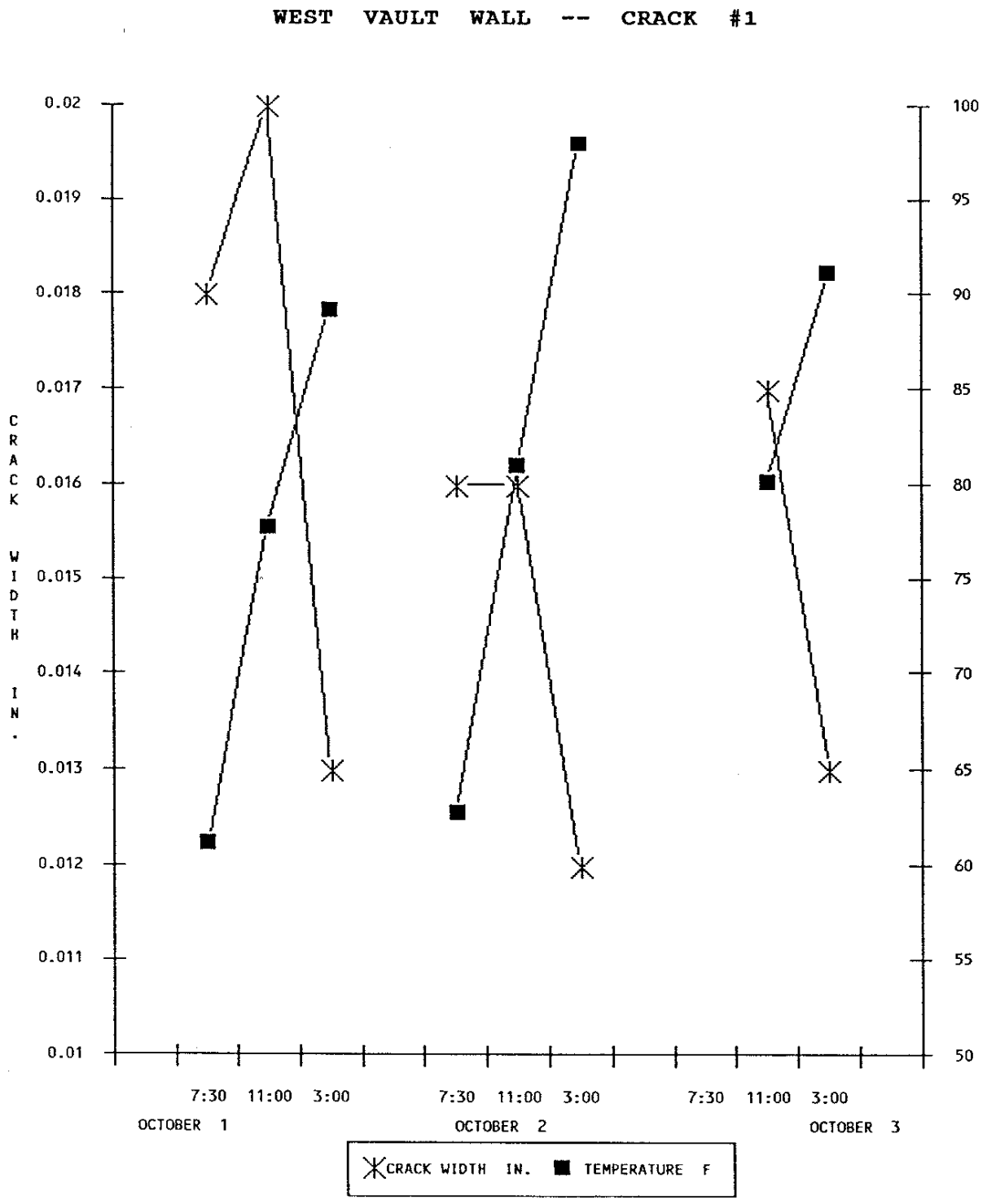


EAST VAULT WALL -- CRACK #2

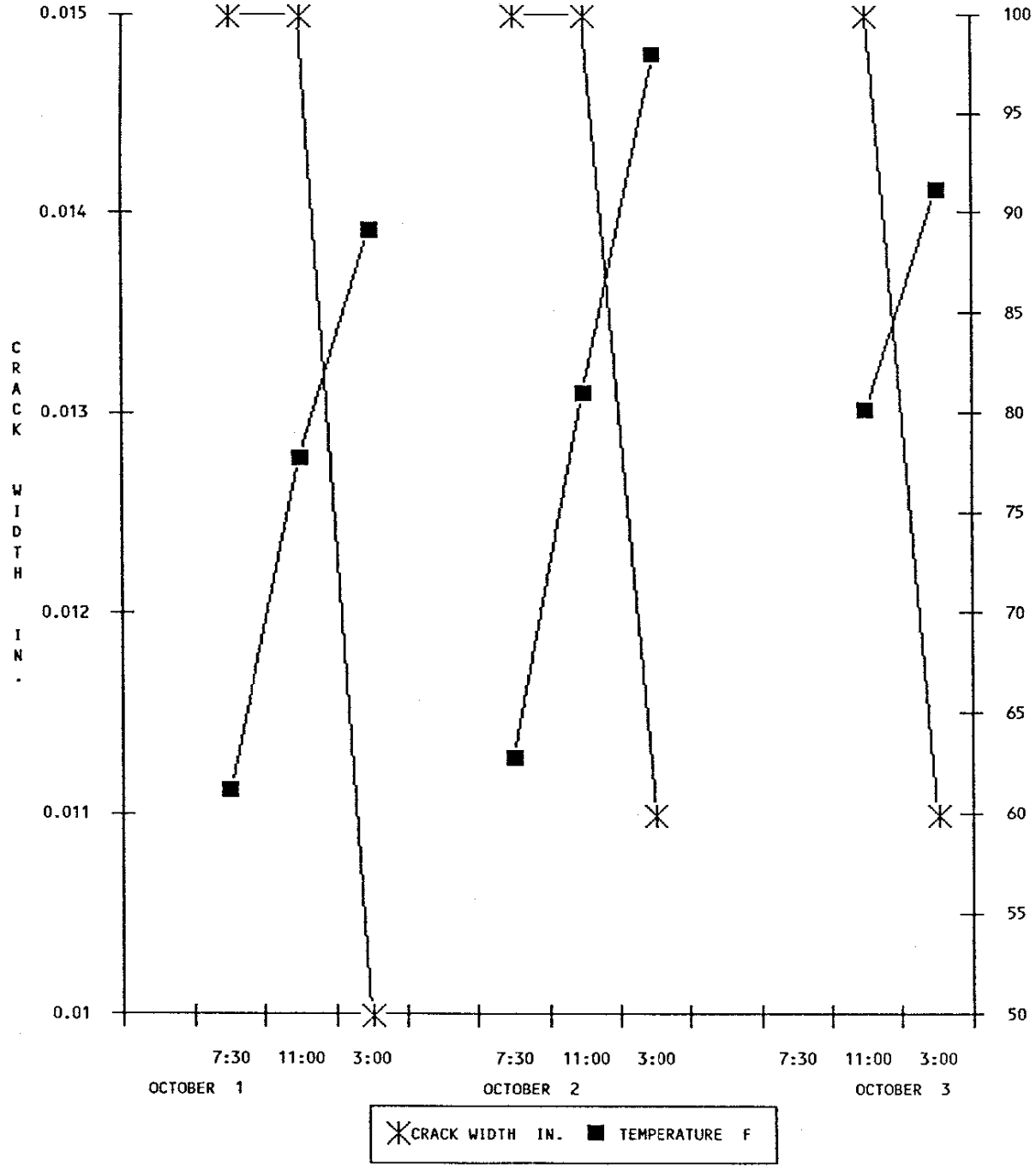


EAST VAULT WALL -- CRACK #3

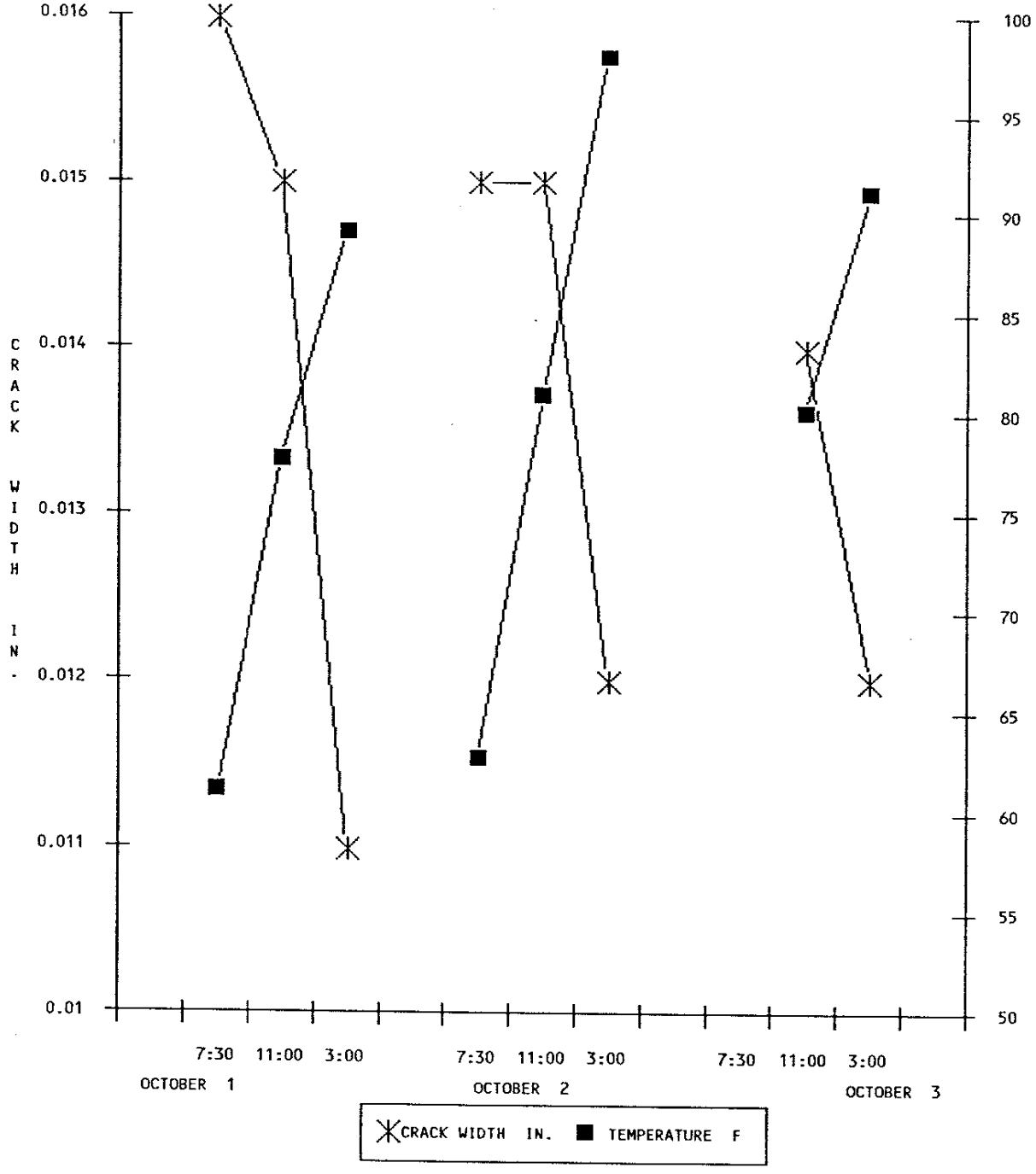



WEST VAULT WALL -- CRACK #1
CRACK WIDTH IN.
0.02
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.01
100
95
90
85
80
75
70
65
60
55
50
7:30
11:00
3:00
OCTOBER 1
OCTOBER 2
OCTOBER 3
CRACK WIDTH IN.
TEMPERATURE F

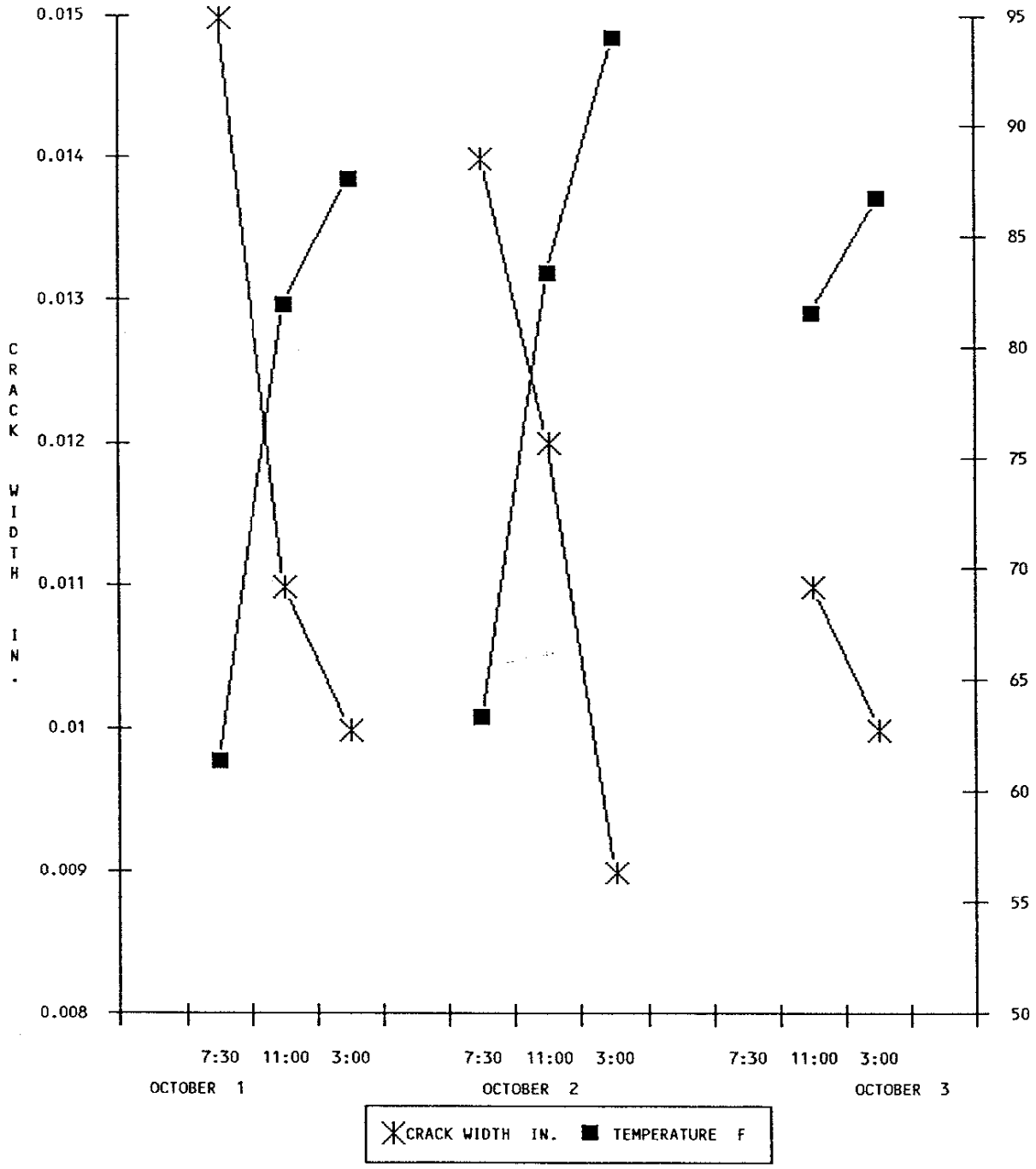
WEST VAULT WALL -- CRACK #2

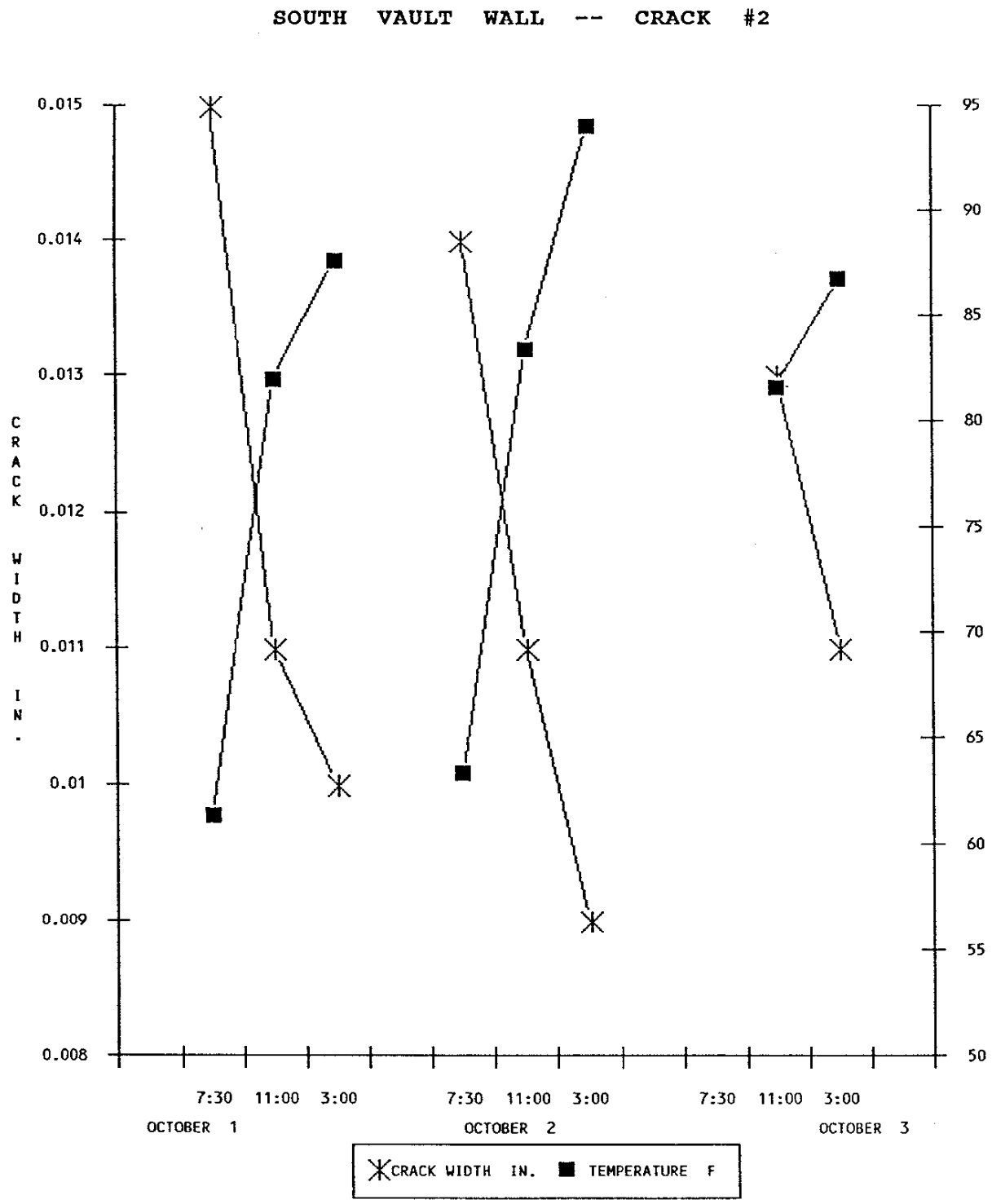


WEST VAULT WALL -- CRACK #3

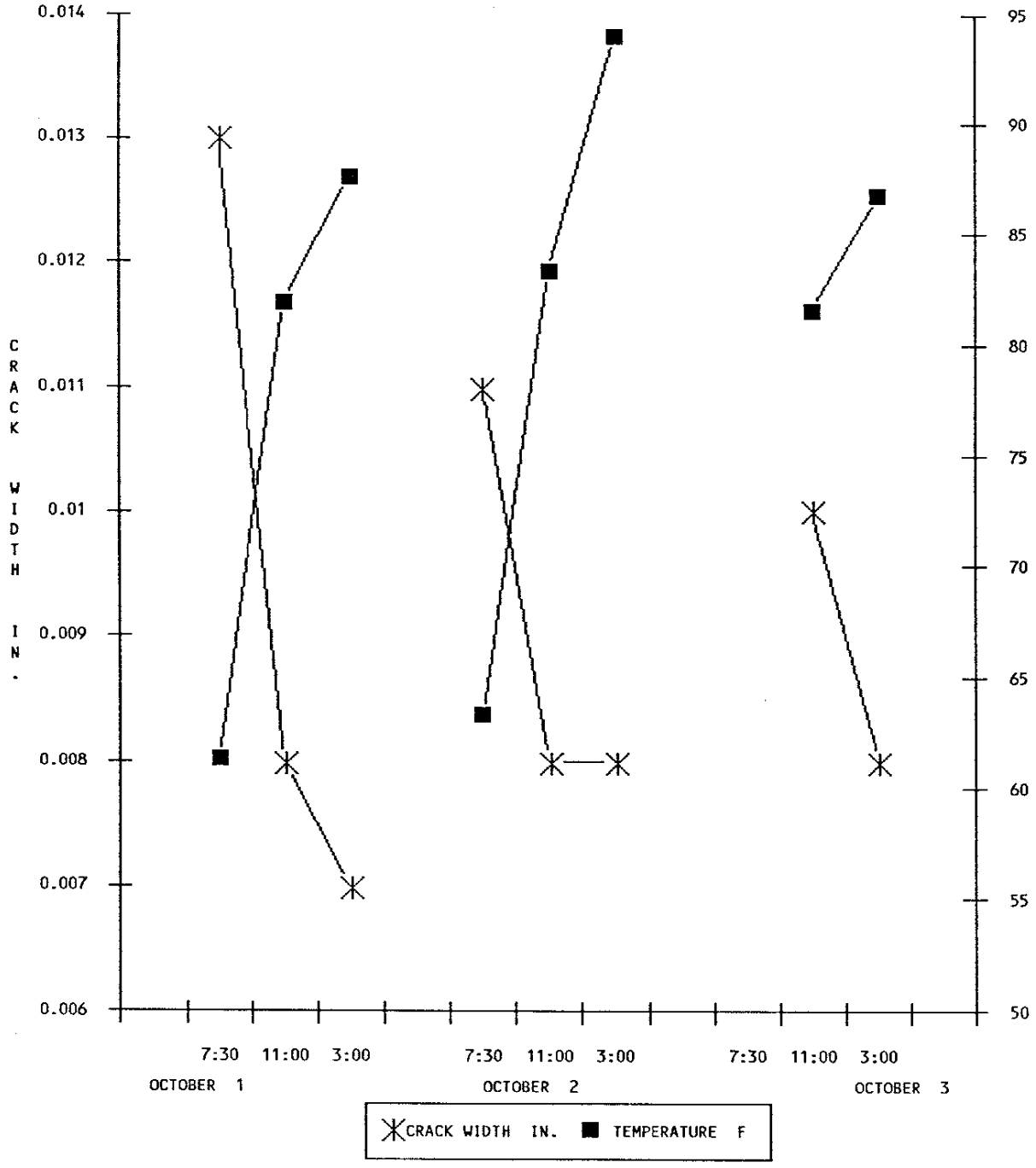


SOUTH VAULT WALL -- CRACK #1




SOUTH VAULT WALL -- CRACK #2
CRACK WIDTH IN.
0.015
0.014
0.013
0.012
0.011
0.01
0.009
0.008
95
90
85
80
75
70
65
60
55
50
7:30
11:00
3:00
OCTOBER 1
OCTOBER 2
OCTOBER 3
CRACK WIDTH IN.
TEMPERATURE F

SOUTH VAULT WALL -- CRACK #3



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ADDRESSEE
STEVEL GEBLER

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