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TITANIUM RESPONSE TO SIMULATED NUCLEAR CLOUD PARTICLE ENVIRONME--ETC(U)
AUG 77 L E DUNBAR, R M CLEVER, G H BURGHART DNA001-76-C-0366
UNCLASSIFIED SAI-78-561-LA-VOL-2 DNA-4404F-2 NL

1 OF 4
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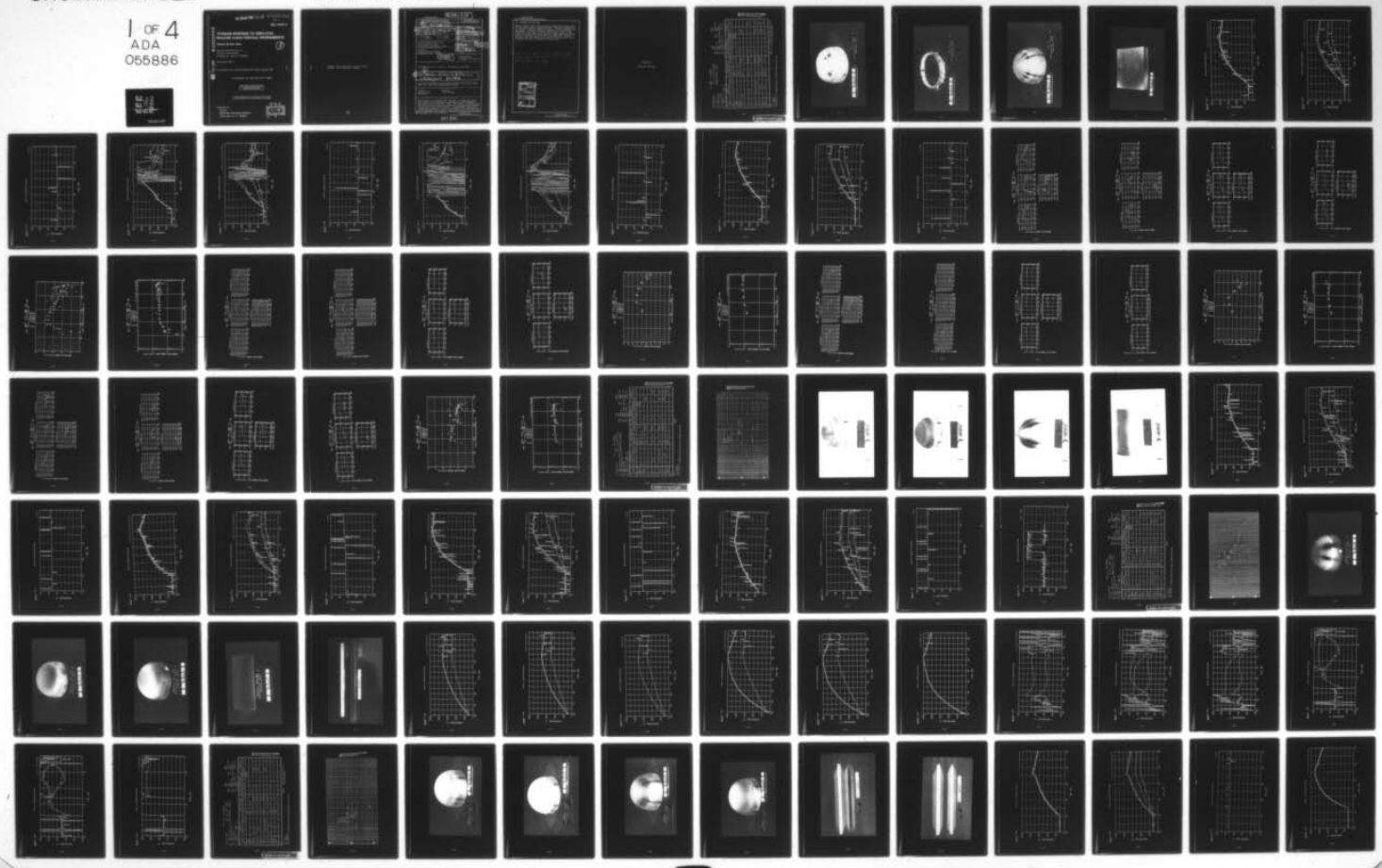

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DNA 4404F-2

TITANIUM RESPONSE TO SIMULATED NUCLEAR CLOUD PARTICLE ENVIRONMENTS

Volume II-Test Data

2
B.S.

Science Applications, Inc.
101 Continental Blvd.
El Segundo, California 90245

31 August 1977

Final Report for Period September 1976—August 1977

CONTRACT No. DNA 001-76-C-0366

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(6) 4. TITLE *(and Subtitle)* TITANIUM RESPONSE TO SIMULATED NUCLEAR CLOUD PARTICLE ENVIRONMENTS, Volume II - Test Data. (Vol. I Russian)	(9) 5. TYPE OF REPORT & PERIOD COVERED Final Report, for Period Sep 76 - Aug 77
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18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B342077464 N99QAXAA12942 H2590D.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Titanium
Nuclear Cloud
Oxidation
Erosion
Heat Transfer

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The response of titanium alloy (6Al-4V) to simulated nuclear cloud particle environments is addressed in this combined experimental and analytical study. The results are applicable for ascent vehicles with hot titanium structures flying through nuclear burst ice or dust clouds. A three-phase exploratory program was conducted: An initial oxidation test series using an SAI-designed test fixture, a test series using the AEDC Dust

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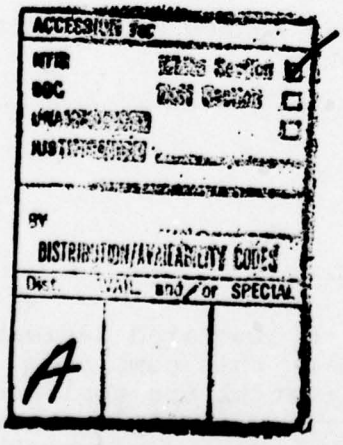
20. ABSTRACT (Continued)

Erosion Tunnel (DET), and a particle impact test series using the SAI hypervelocity impact facility. Analytical modeling of titanium oxidation produced results in close agreement with experiment. Although increased oxidation of titanium was confirmed in H_2O vapor versus O_2 environment tests, no net effect of liquid H_2O and O_2 oxidation under combined particle erosion conditions was observed in the AEDC DET. This is believed to be the result of the heat of vaporization of H_2O exceeding the heat of oxidation of H_2O vapor.

See Volume I for complete abstract. This volume contain AEDC DET test data and SAI oxidation test data.

A

1473B



APPENDIX A

AEDC DET TEST DATA

TABLE A-1 RUN SUMMARY

RUN 2 DATE 11-23-76

NOZZLE STATION 127.5

TUNNEL CONDITIONS

P_o = 994 psia

H_{o_B} = 765 Btu/lbm

H_o = _____ Btu/lbm

T_{o_B} = 2890 °R, T_o = _____ °R

M = 7.1 p_o' = 10 psia

DUST			WATER	
TYPE	MgO		Flow	0.13 gpm
SIZE	100 μm		C.F.	14.1
VEL	4600 ft/sec		Orifice	0.016 in.
Flow	11.49 gm/sec		ΔP	741 psi
C.F.	33.7			

STRING	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANSDUCER TYPE	PRERUN	POSTRUN
1	P_o' probe	3					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_o probe	4					See Fig. 3	0.25		R	1					
3	T_i-5	5.52					Hemi	2.0	6Al-4V-T_i	S	8				6835	
4																
5	T_i-1		4.29				Hemi	2.0	6Al-4V-T_i	S	8					7925
6																
7	T_i-6		3.83	6.41	x 3.83		Hemi	2.0	6Al-4V-T_i	S	8				6835	7922
8	T_i-7			5.63			Hemi	2.0	6Al-4V-T_i	S	8				6835	7924
9	WB-2			5.67			See Fig. 2		Al						7009	7923
10																

KEY -

PH - PREHEAT
POH - POSTHEAT
DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

NOTES: 1. T_o probe did not reach equilibrium.
2. Ti-1 and Ti-6 burned through.

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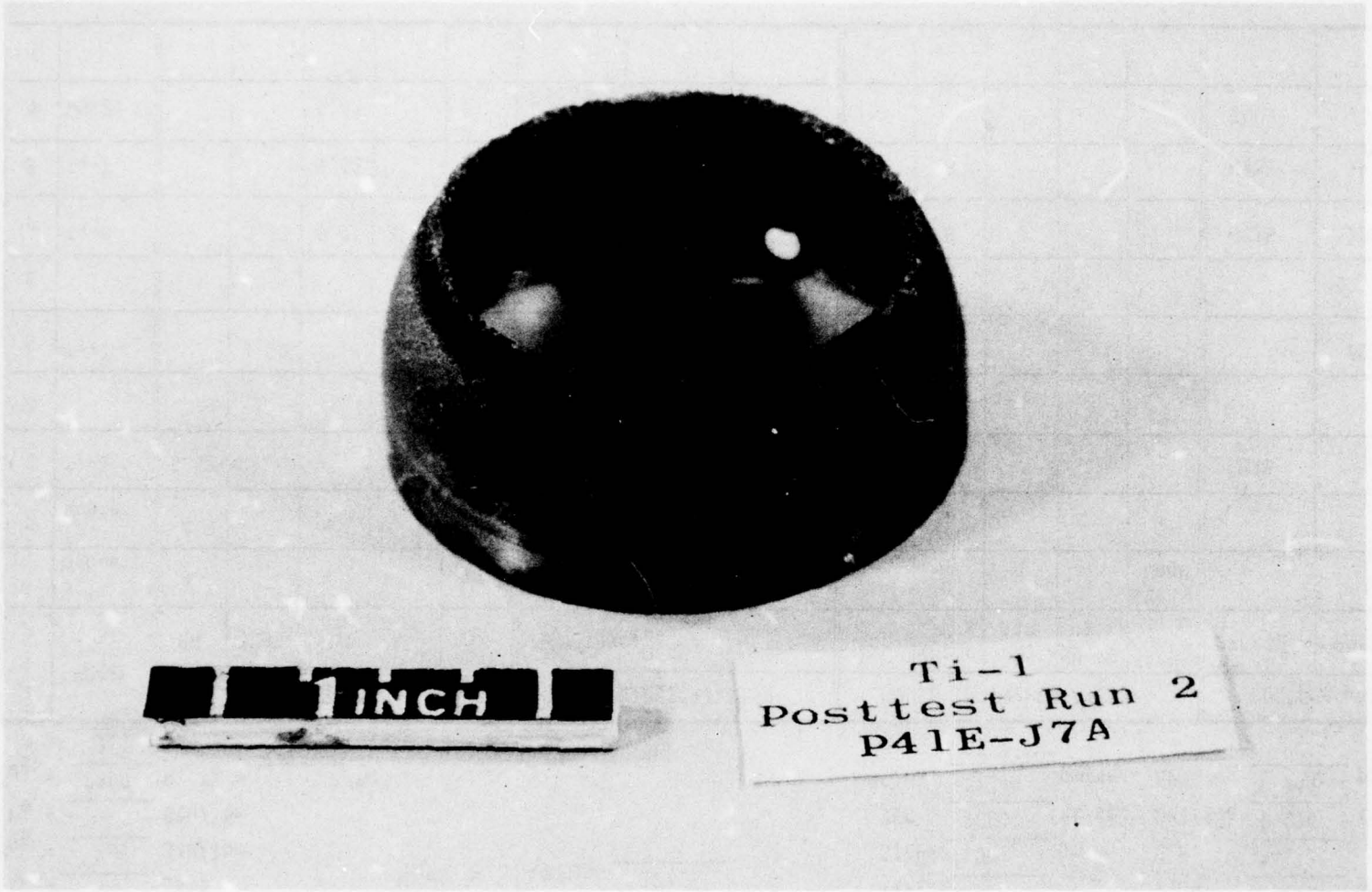
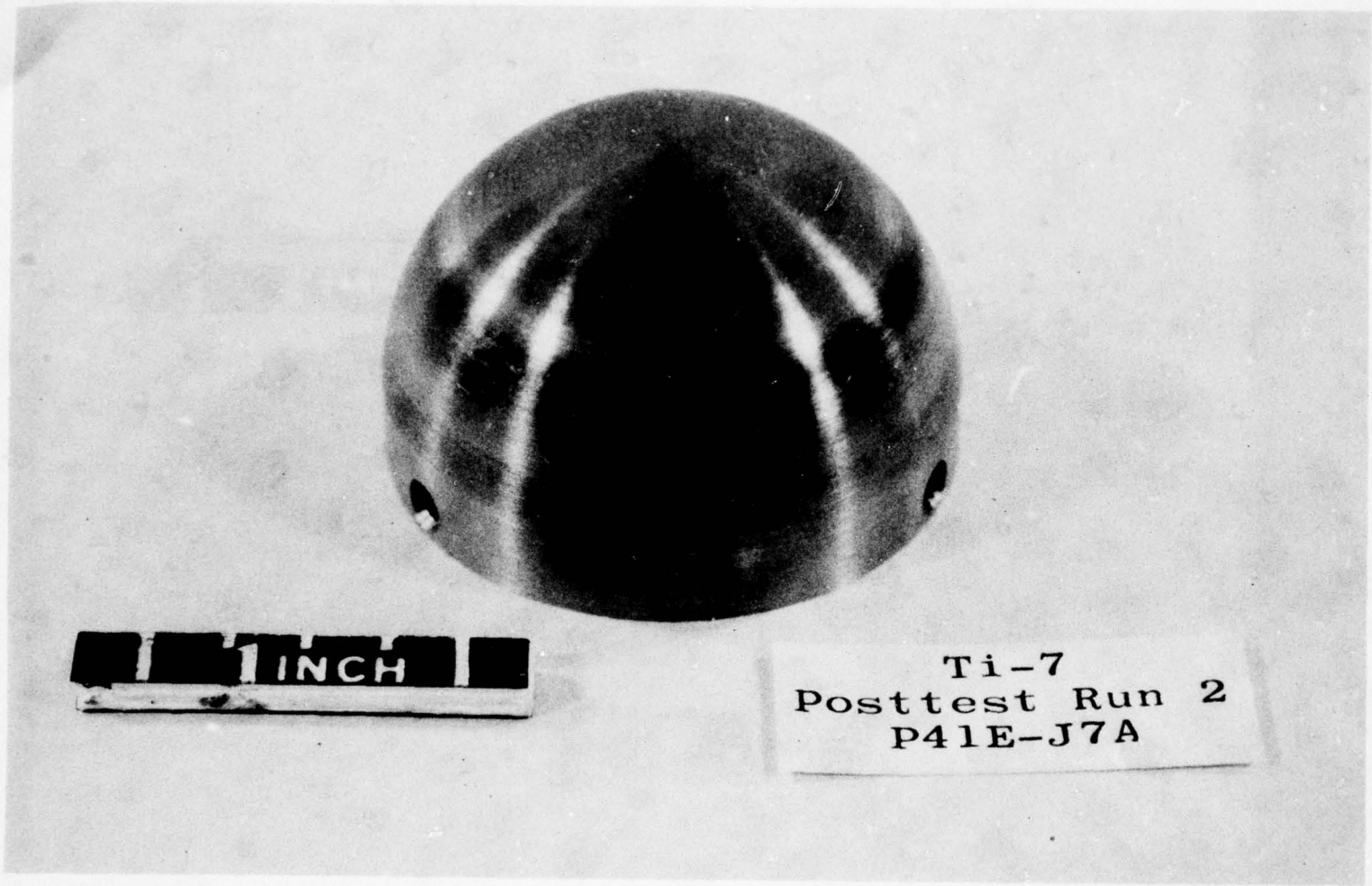
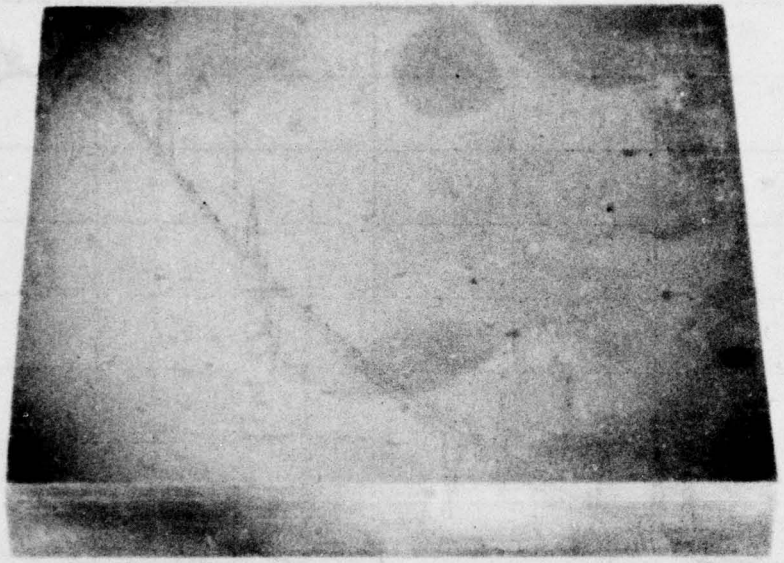

1 INCH
Ti-1
Posttest Run 2
P41E-J7A

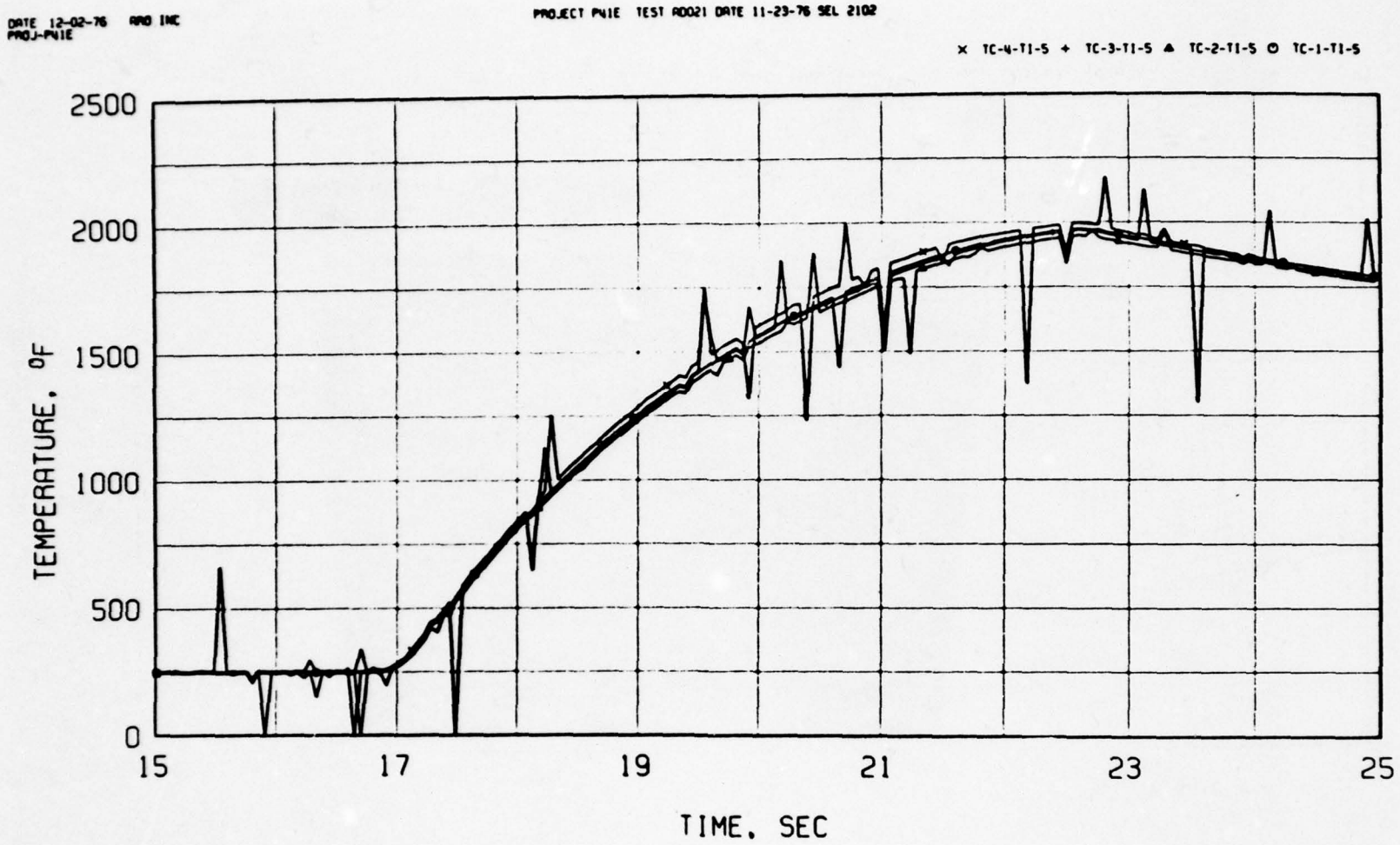
1 INCH
Ti-6
Posttest Run 2
P41E-J7A

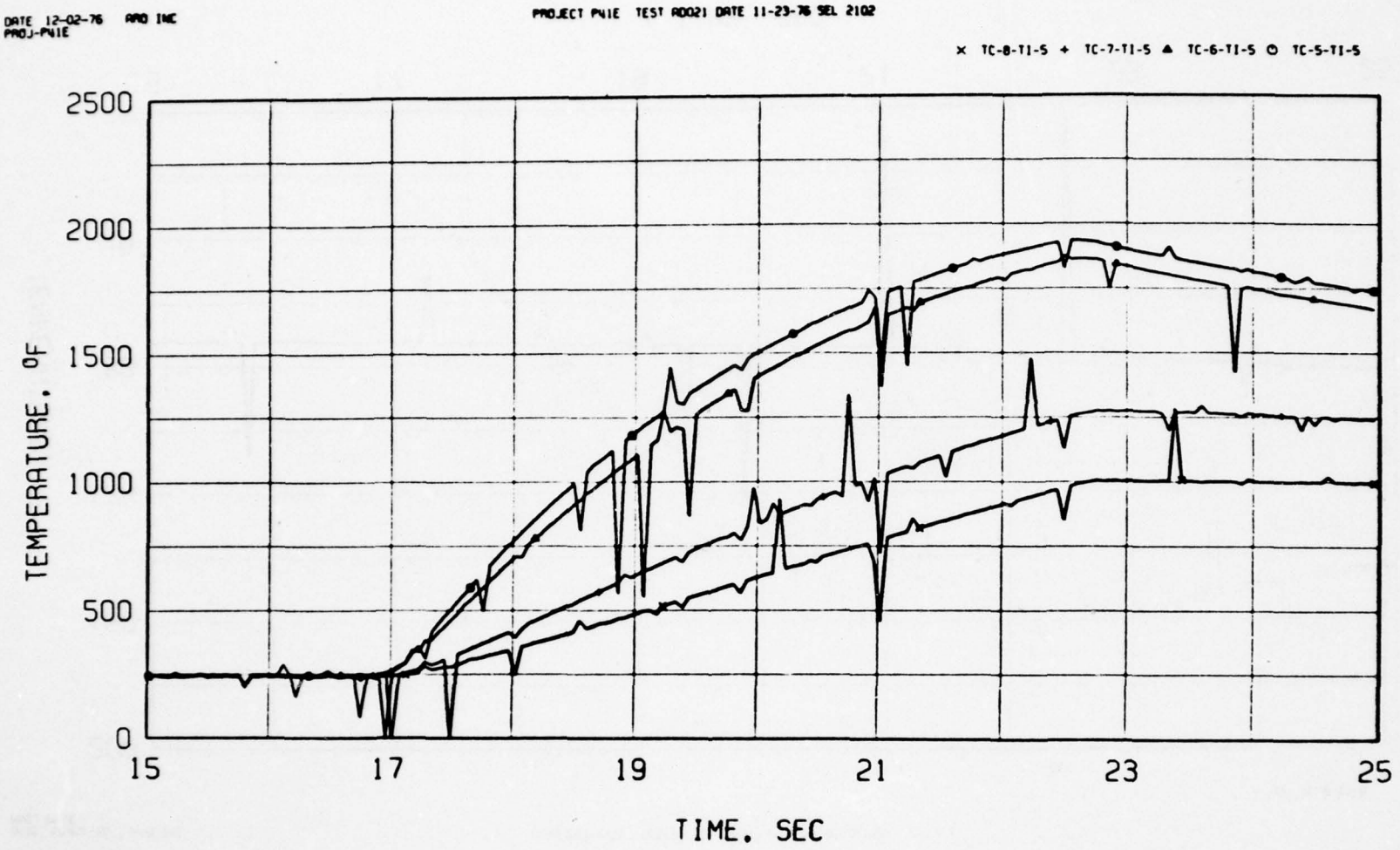

1 INCH
Ti-7
Posttest Run 2
P41E-J7A



1 INCH

WB-2
Posttest Run 2
P41E-J7A

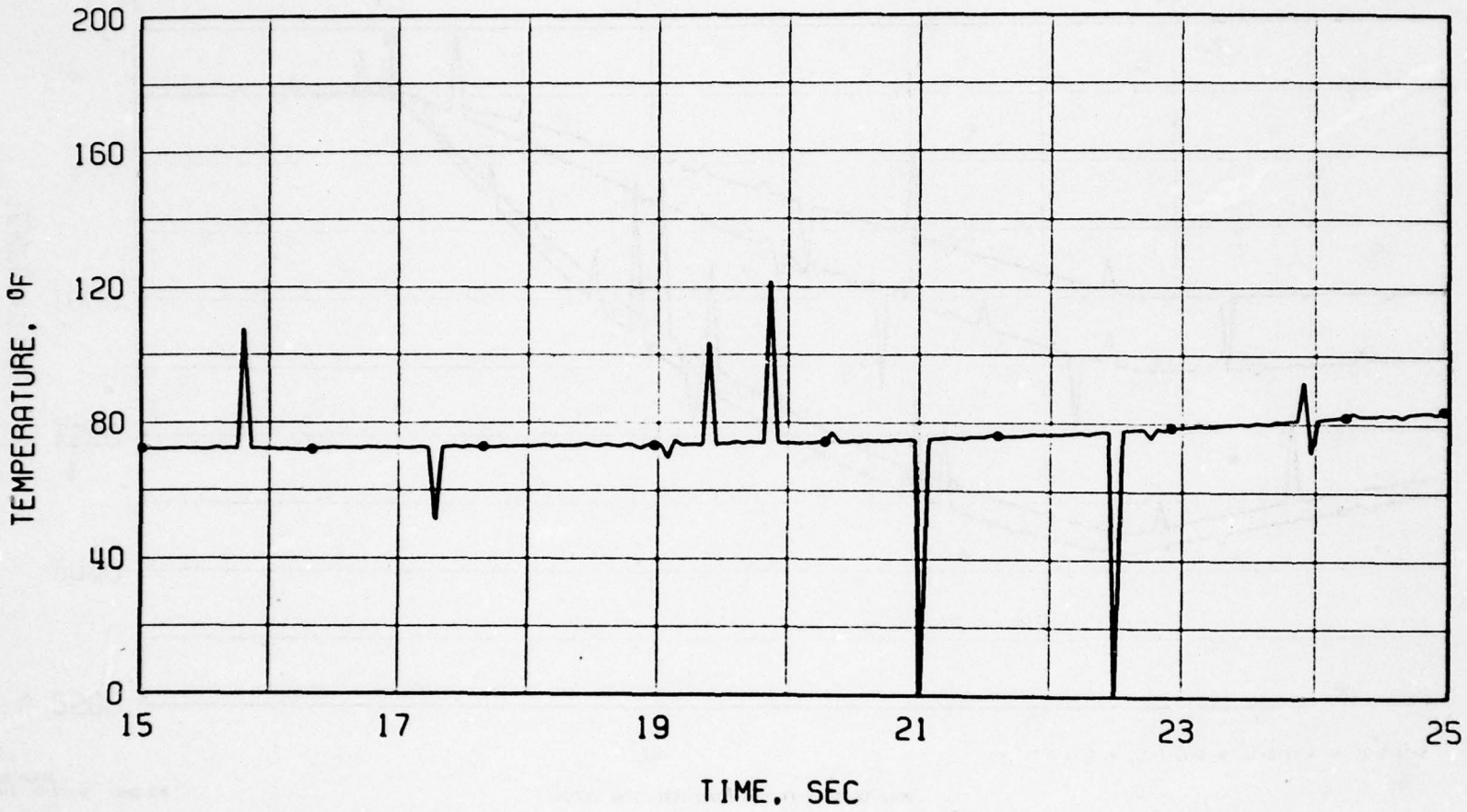

DATE 12-02-76 AND INC
PROJ-PNIE
PROJECT PNIE TEST A0021 DATE 11-23-76 SEL 2102
× TC-4-TI-5 + TC-3-TI-5 ▲ TC-2-TI-5 ⊙ TC-1-TI-5
TEMPERATURE, °F
2500
2000
1500
1000
500
0
15
17
19
21
23
25
TIME, SEC

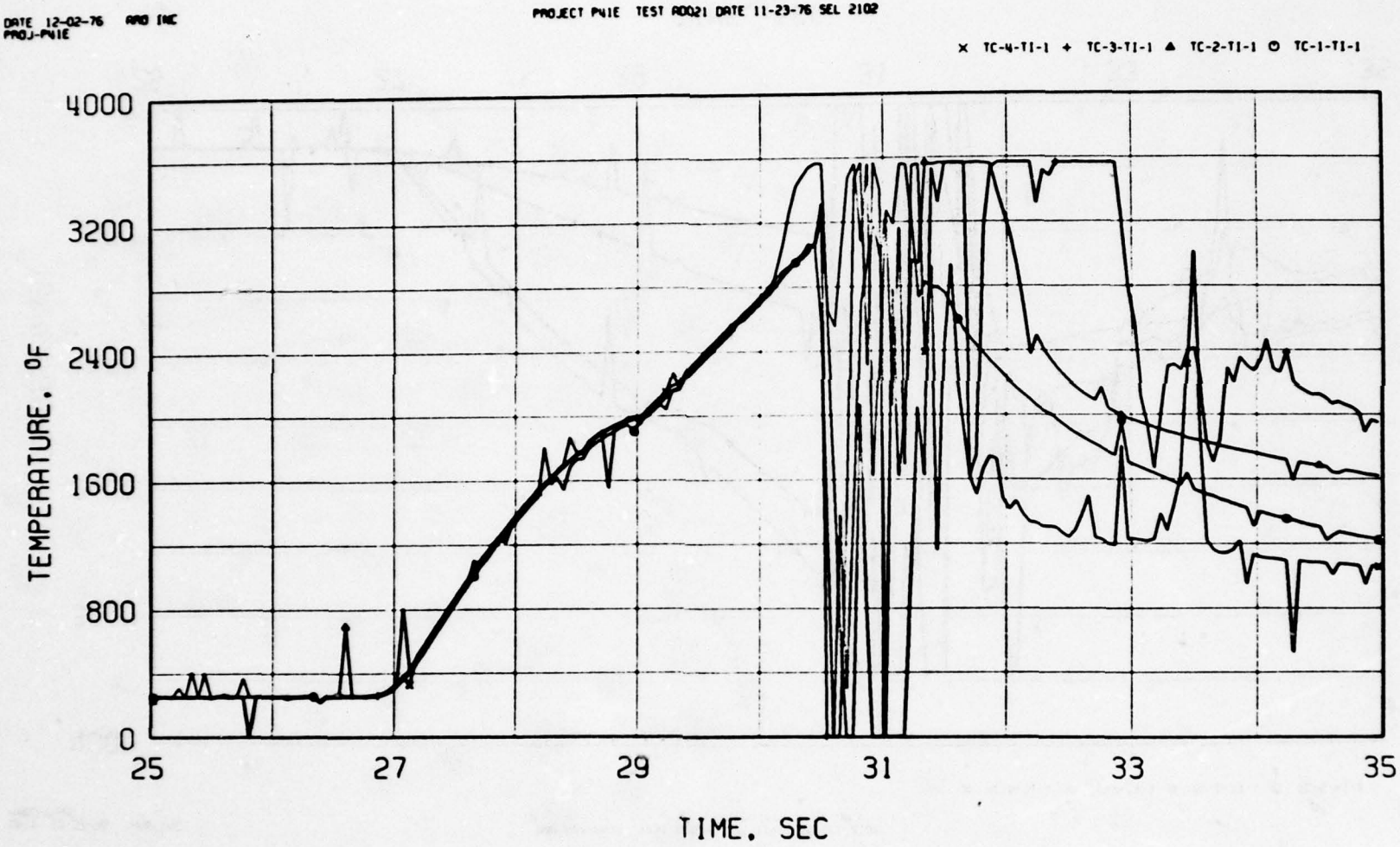

DATE 12-02-76 ARO INC
PROJ-PN1E
PROJECT PN1E TEST AD021 DATE 11-23-76 SEL 2102
× TC-8-TI-5 + TC-7-TI-5 ▲ TC-6-TI-5 ⊙ TC-5-TI-5
2500
2000
1500
1000
500
0
TEMPERATURE, °F
15
17
19
21
23
25
TIME, SEC

DATE 12-02-76 ARO INC
PROJ-PW1E

PROJECT PW1E TEST A0021 DATE 11-23-76 SEL 2102

© TC-9-T1-5

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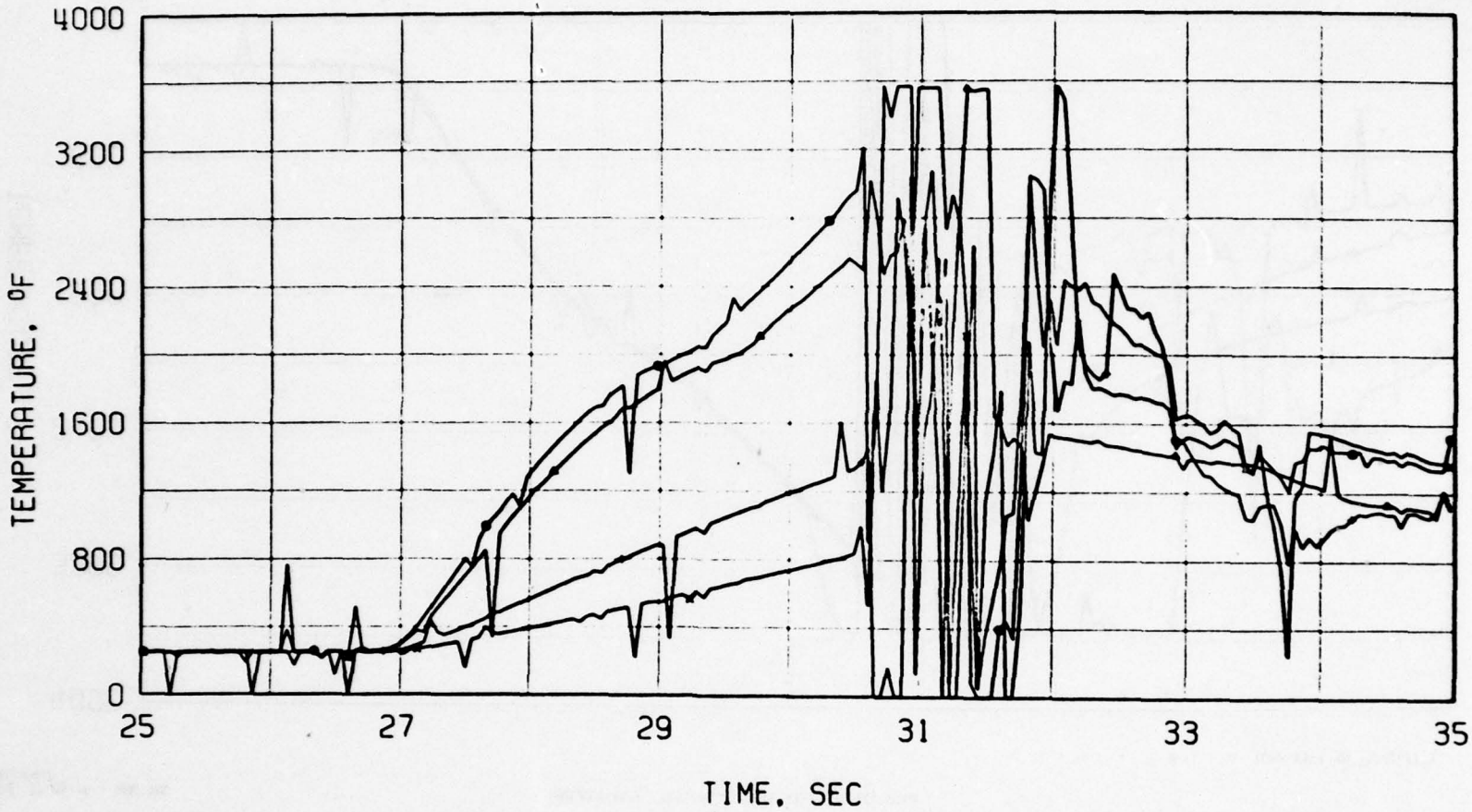
PROJ-PN1E
PROJECT PN1E TEST AD021 DATE 11-23-76 SEL 2102
× TC-4-TI-1 + TC-3-TI-1 ▲ TC-2-TI-1 ⊙ TC-1-TI-1
4000
3200
2400
1600
800
0
TEMPERATURE, °F
25
27
29
31
33
35
TIME, SEC

DATE 12-02-76 ARO INC
PROJ-PW1E

PROJECT PW1E TEST R0021 DATE 11-23-76 SEL 2102

× TC-8-TI-1 + TC-7-TI-1 ▲ TC-6-TI-1 ○ TC-5-TI-1



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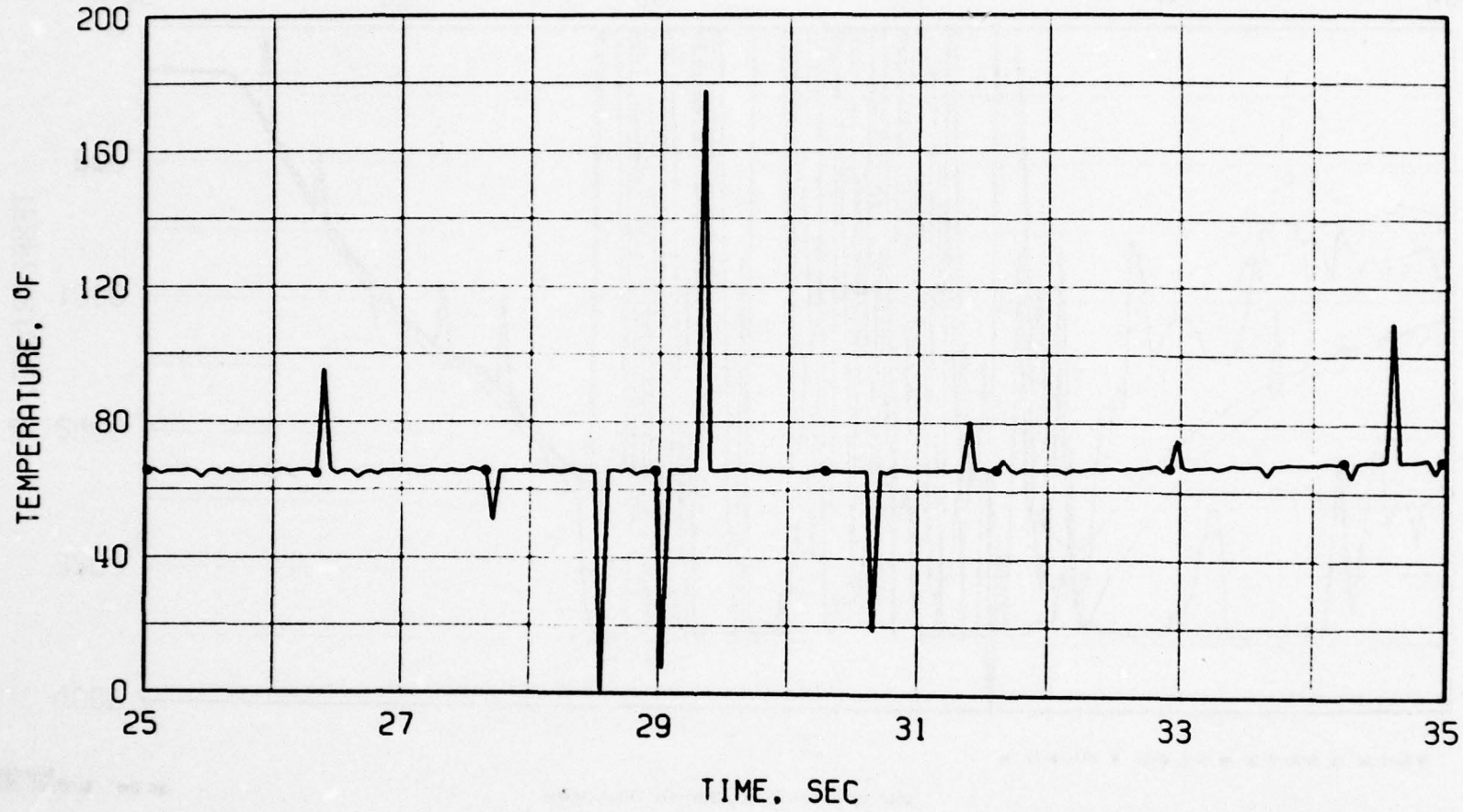
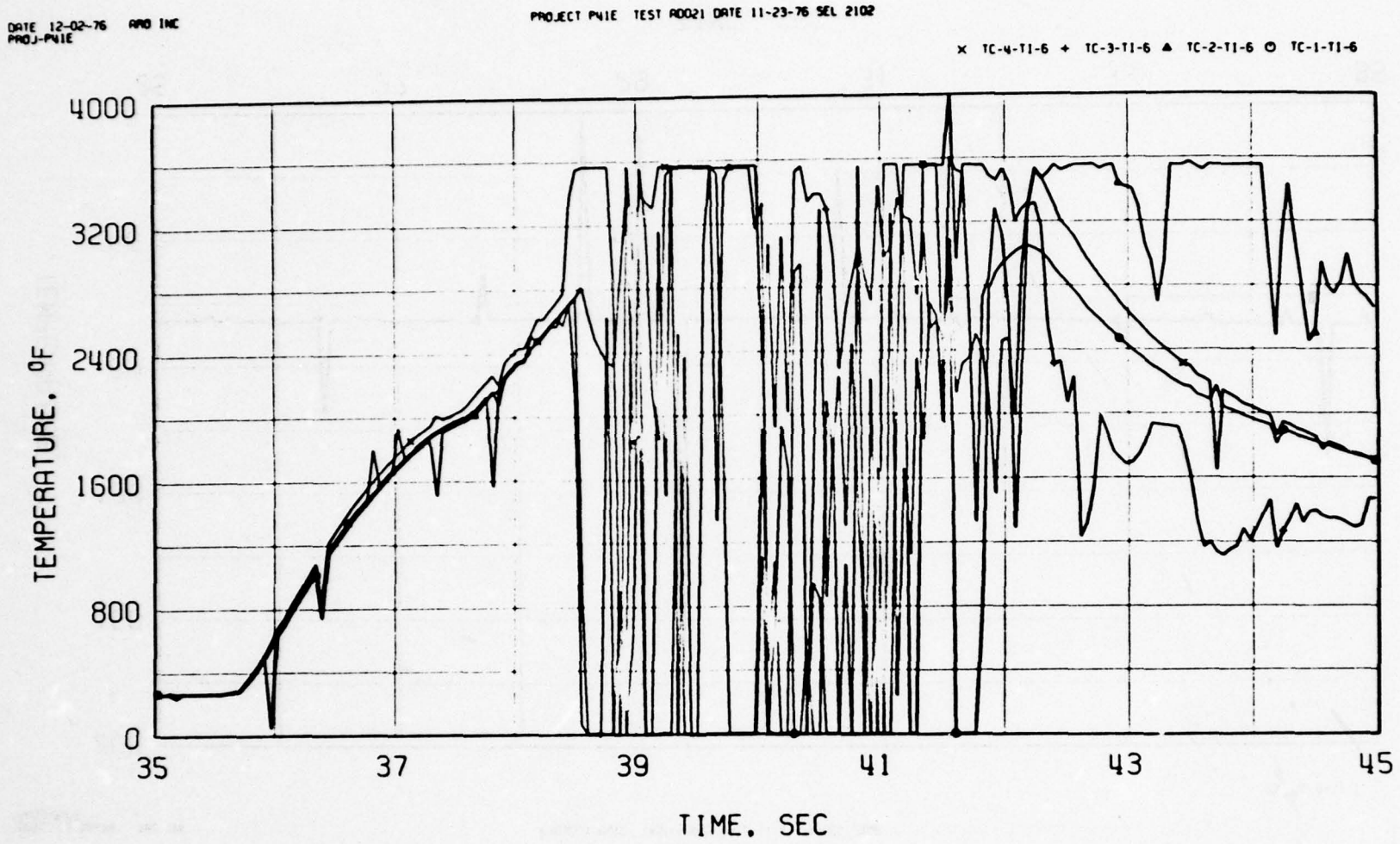
○ TC-9-T1-1

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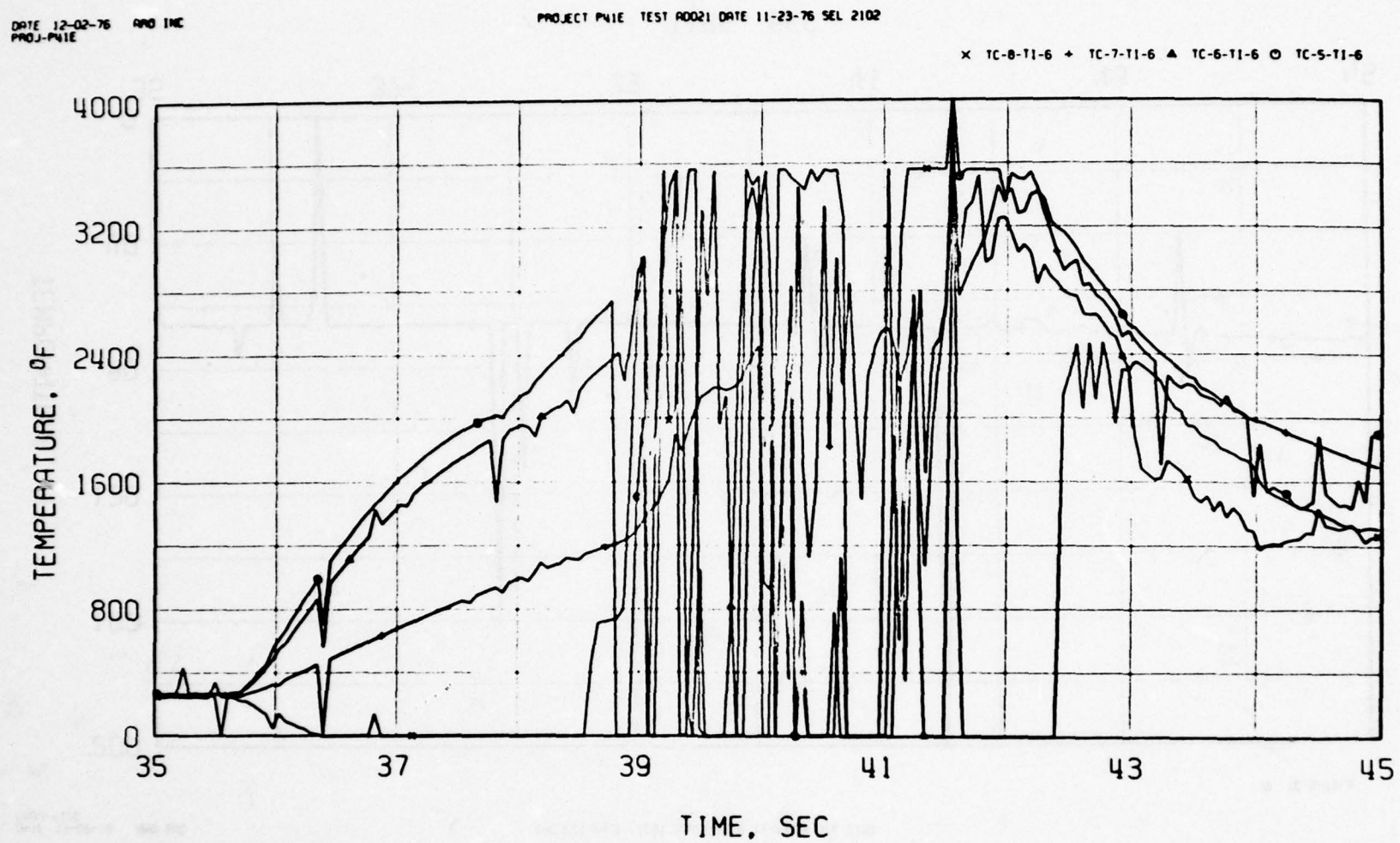
PROJ-PWIE
PROJECT PWIE TEST A0021 DATE 11-23-76 SEL 2102
× TC-4-TI-6 + TC-3-TI-6 ▲ TC-2-TI-6 ⊙ TC-1-TI-6
4000
3200
2400
1600
800
0
TEMPERATURE, °F
35
37
39
41
43
45
TIME, SEC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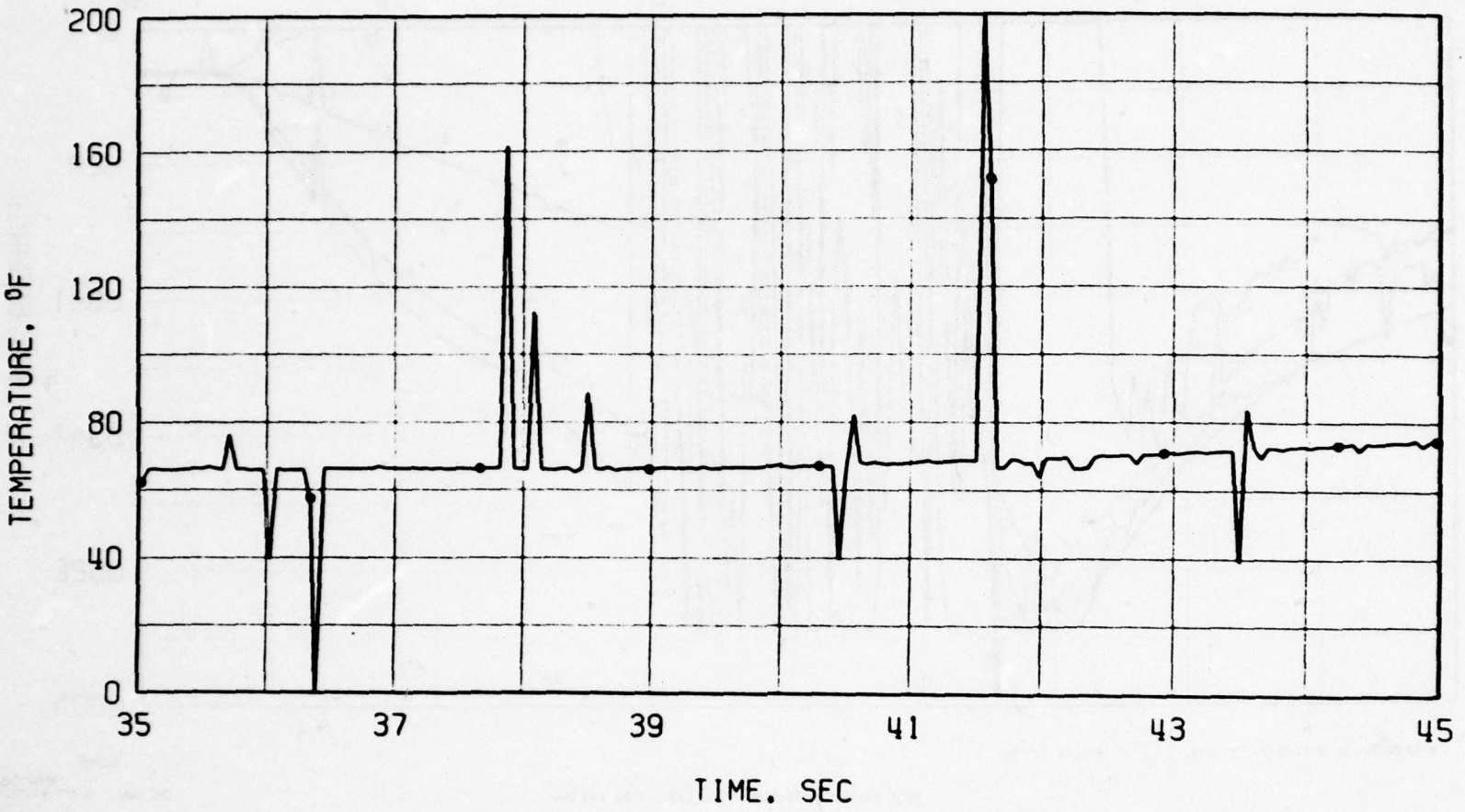
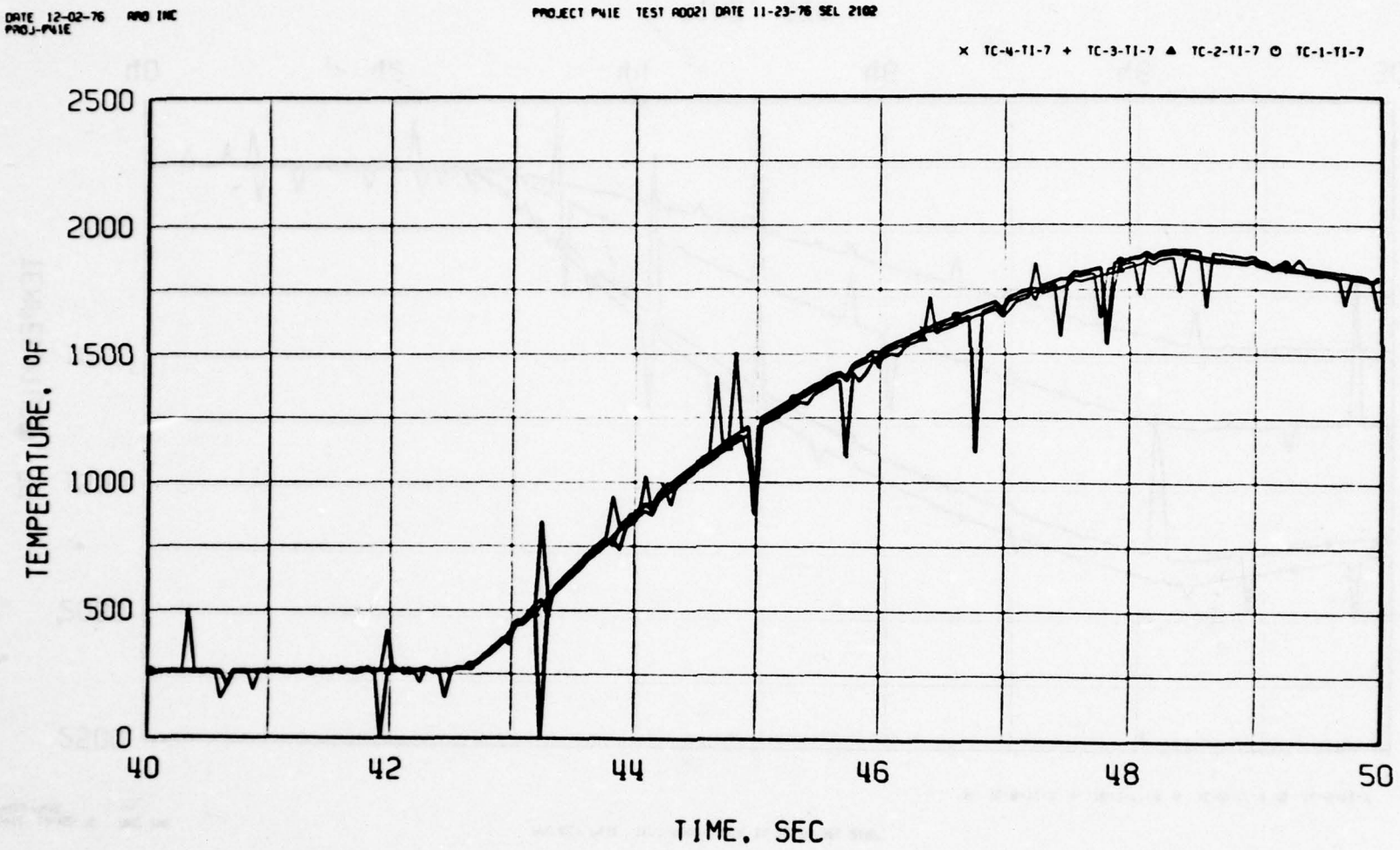
× TC-8-T1-6 + TC-7-T1-6 ▲ TC-6-T1-6 ○ TC-5-T1-6
4000
3200
2400
1600
800
0
TEMPERATURE, °F
35
37
39
41
43
45
TIME, SEC

DATE 12-02-76 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 11-23-76 SEL 2102

○ TC-9-T1-6

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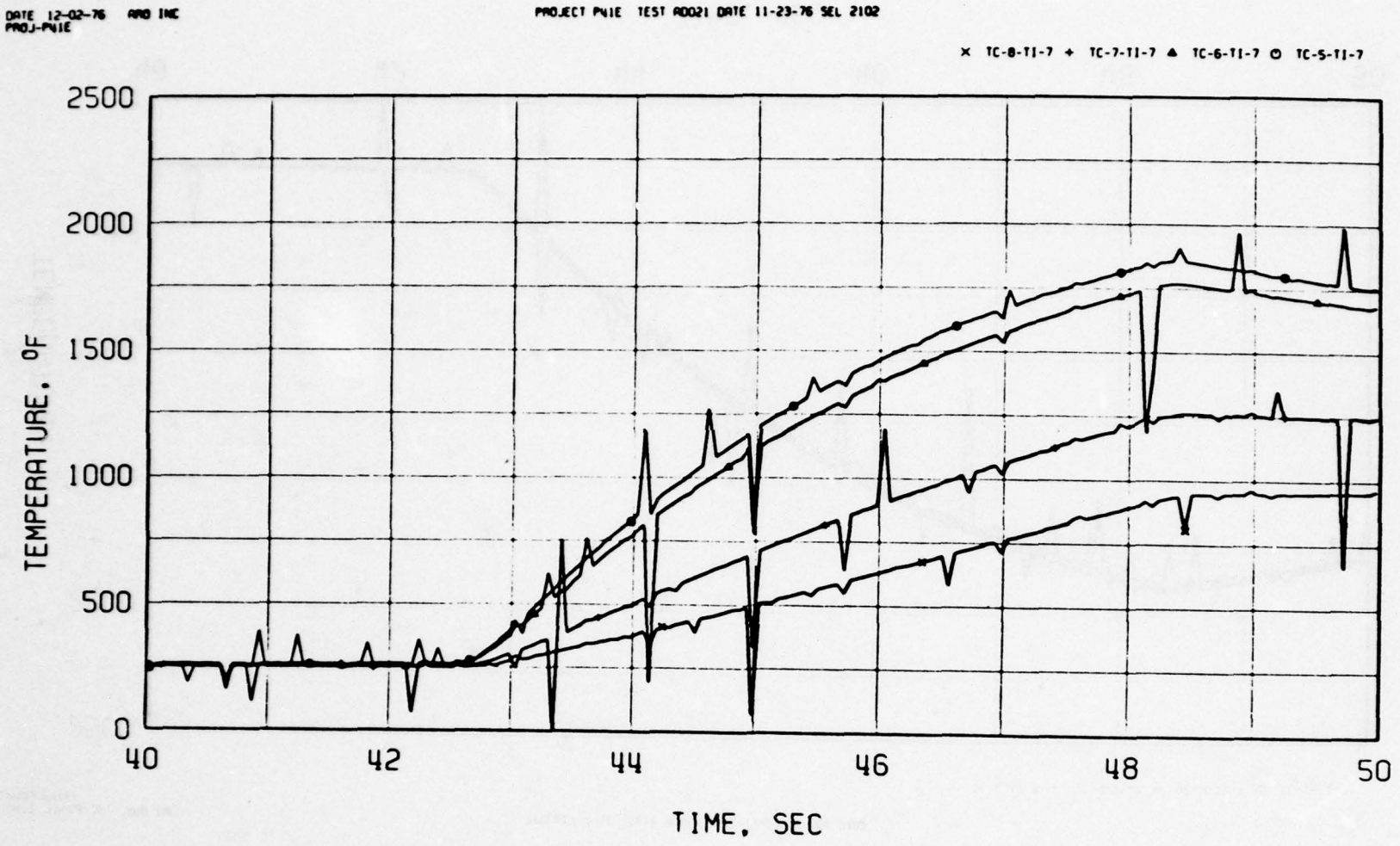
× TC-4-TI-7 + TC-3-TI-7 ▲ TC-2-TI-7 ⊙ TC-1-TI-7
2500
2000
1500
1000
500
0
TEMPERATURE, °F
40
42
44
46
48
50
TIME, SEC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2500
2000
1500
1000
500
0
TEMPERATURE, °F
40
42
44
46
48
50
TIME, SEC

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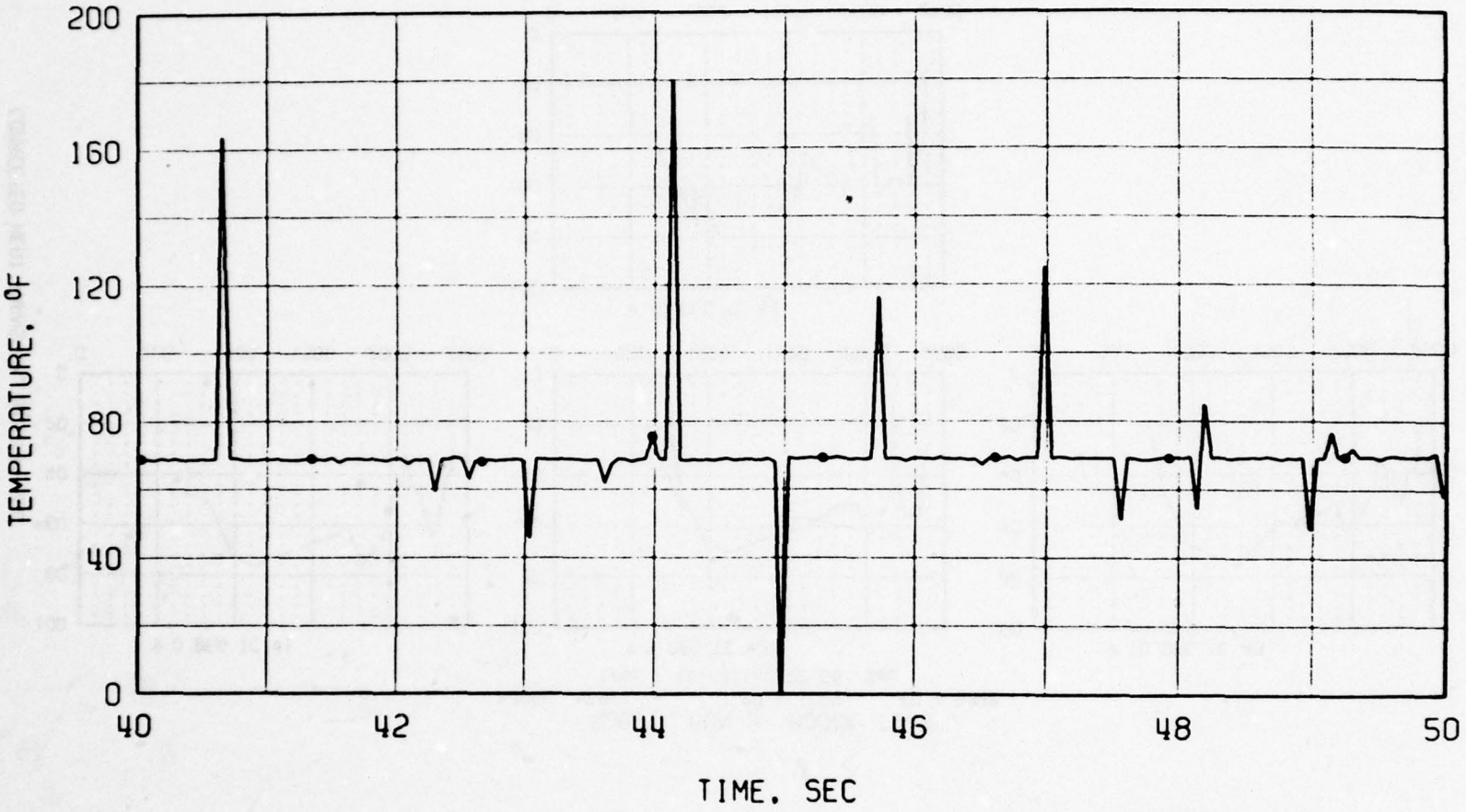
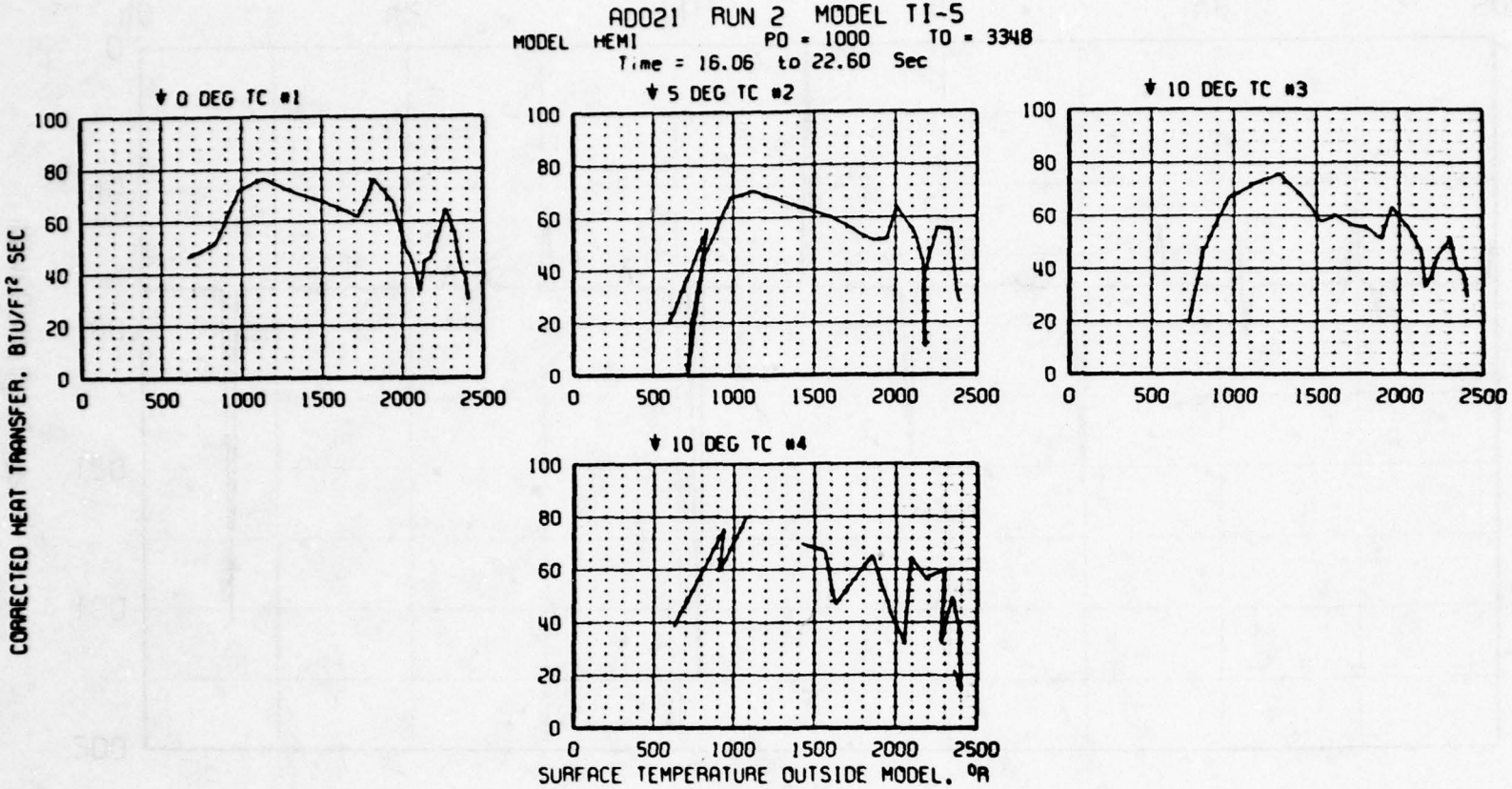
PROJECT PWIE TEST R0021 DATE 11-23-76 SEL 2102

○ TC-9-T1-7

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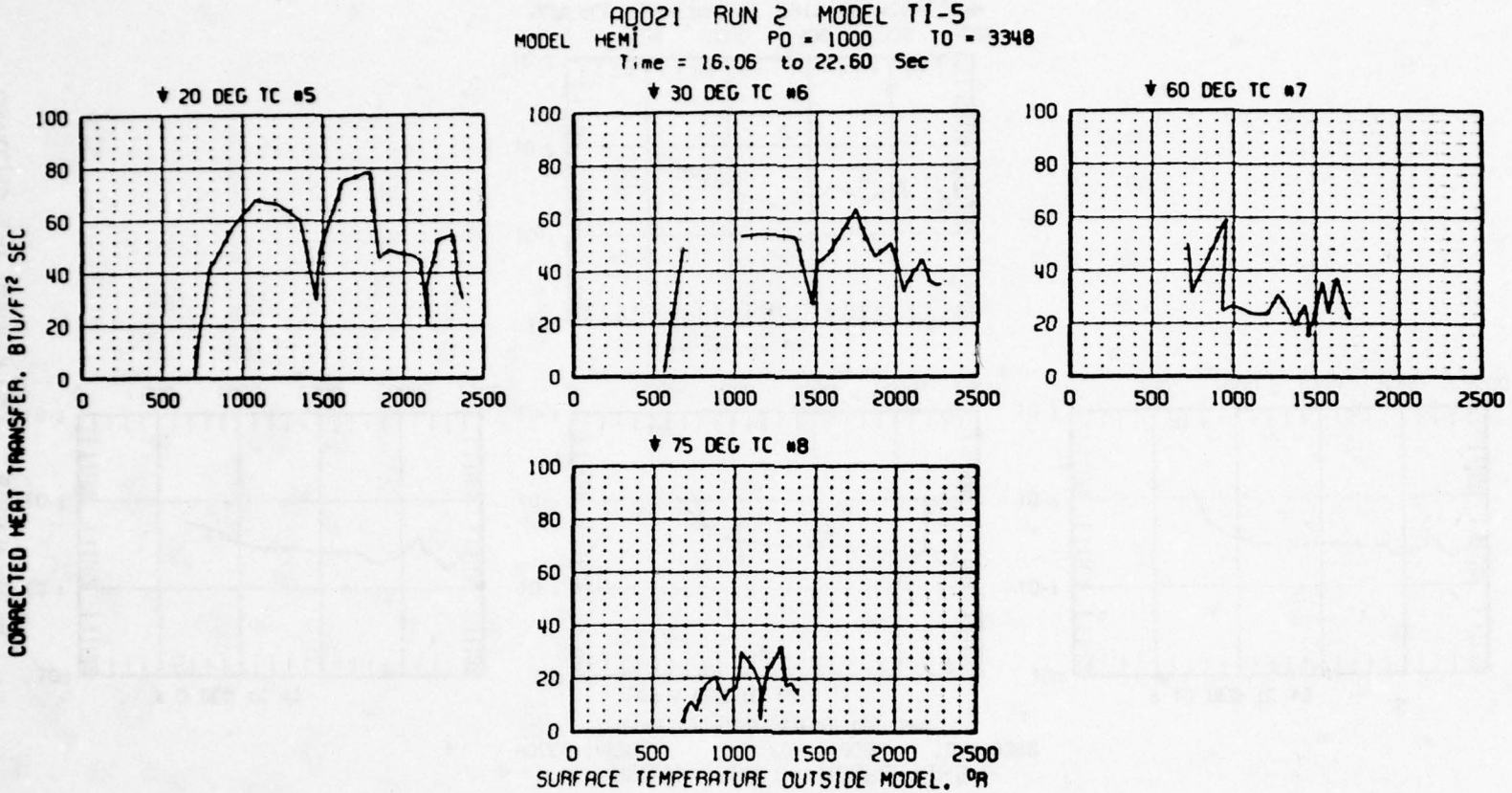
MODEL HEMI PO = 1000 TO = 3348
Time = 16.06 to 22.60 Sec
0 DEG TC #1
5 DEG TC #2
10 DEG TC #3
10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
500
1000
1500
2000
2500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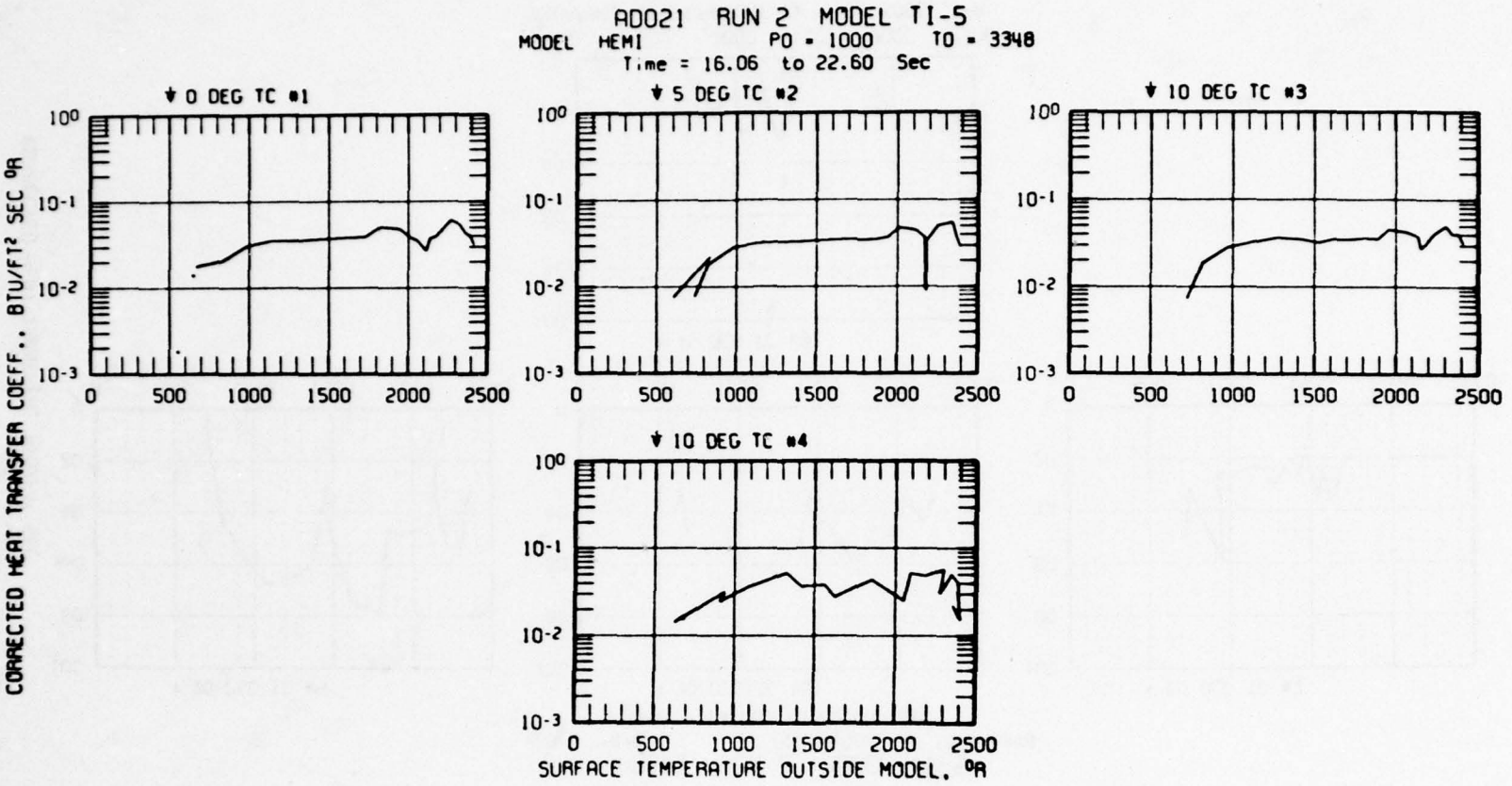
MODEL HEMI PO = 1000 TO = 3348
Time = 16.06 to 22.60 Sec
▼ 20 DEG TC #5
▼ 30 DEG TC #6
▼ 60 DEG TC #7
▼ 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
500
1000
1500
2000
2500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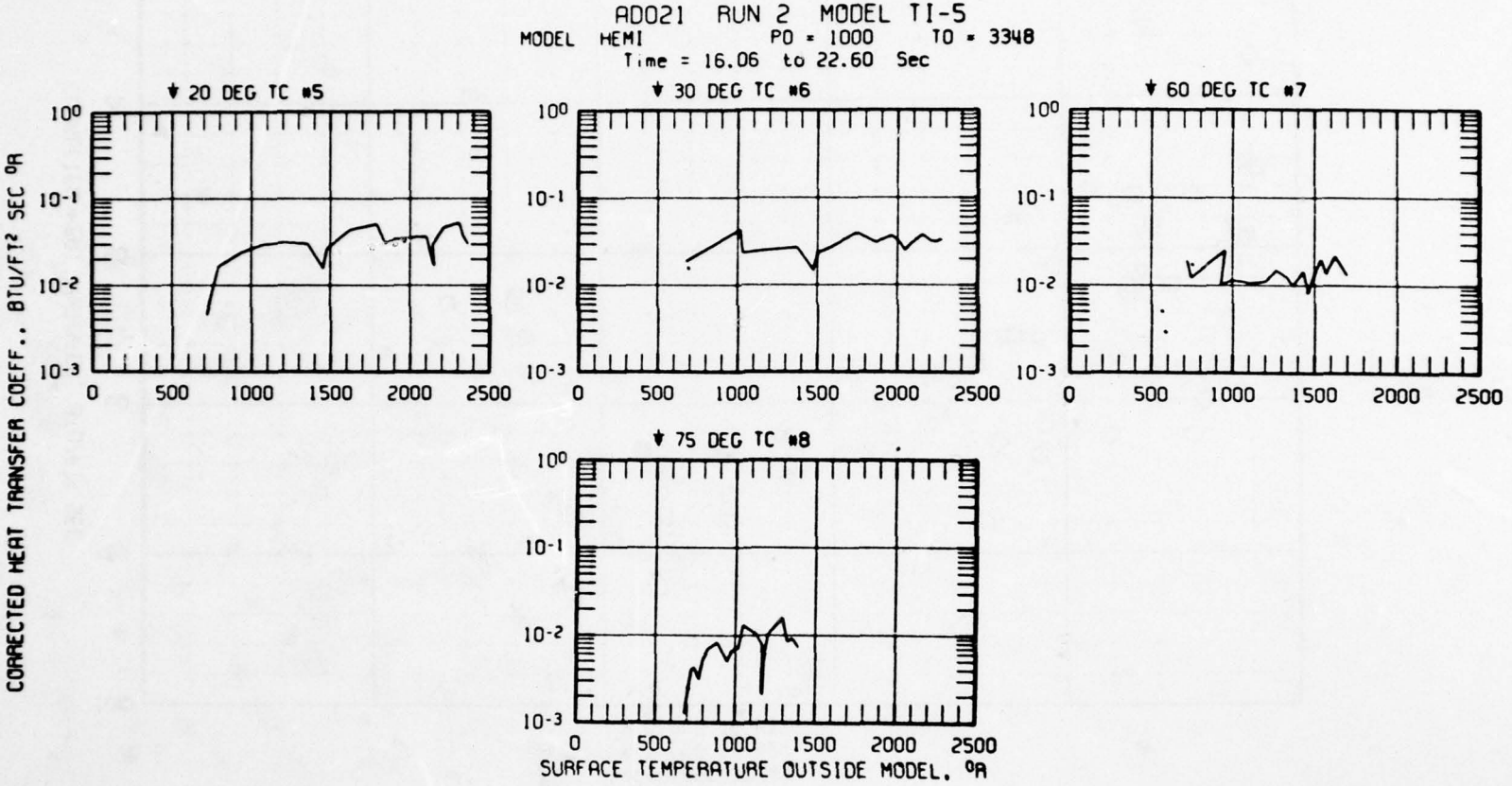
MODEL HEMI PO = 1000 TO = 3348
Time = 16.06 to 22.60 Sec
ψ 0 DEG TC #1
ψ 5 DEG TC #2
ψ 10 DEG TC #3
ψ 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500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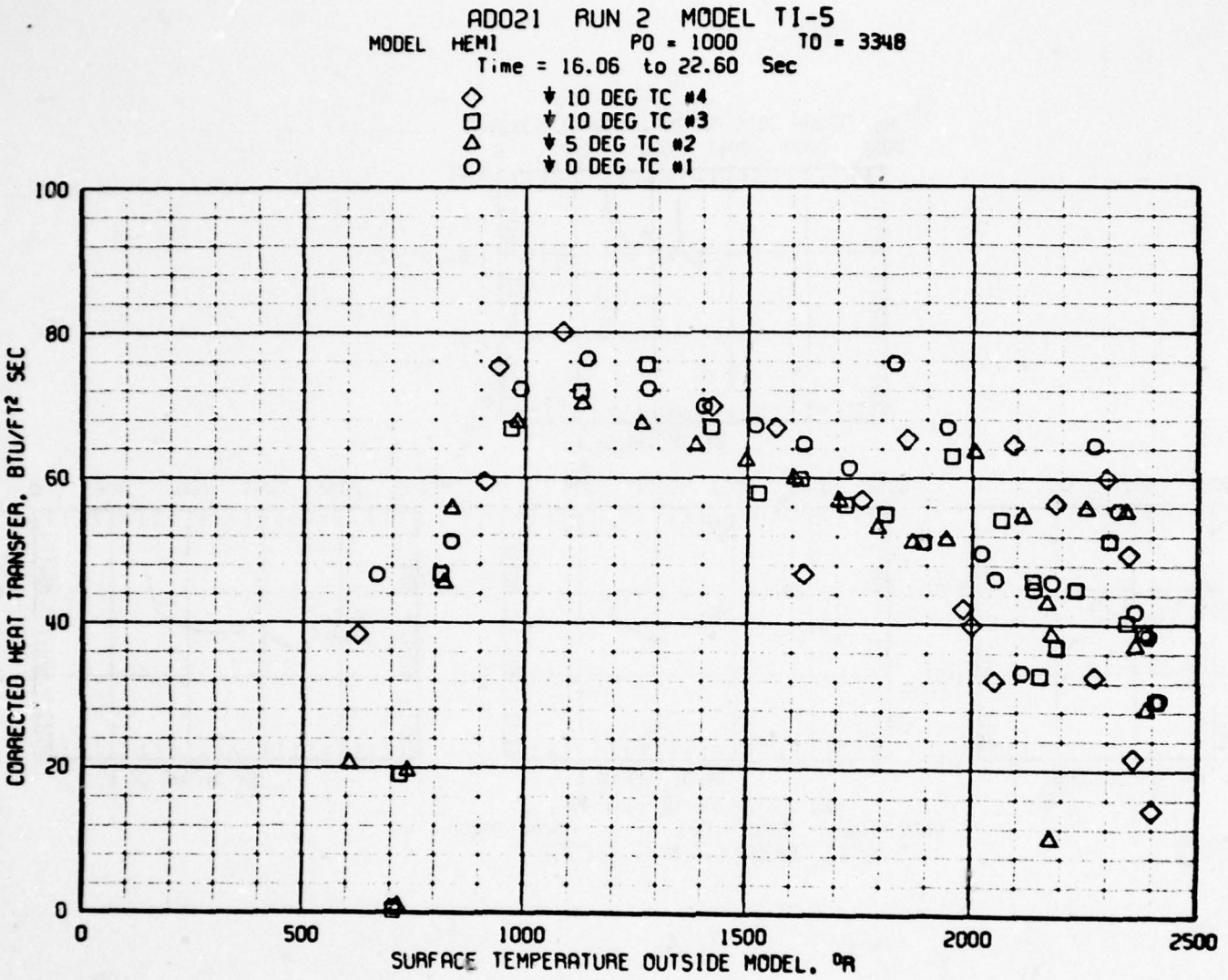
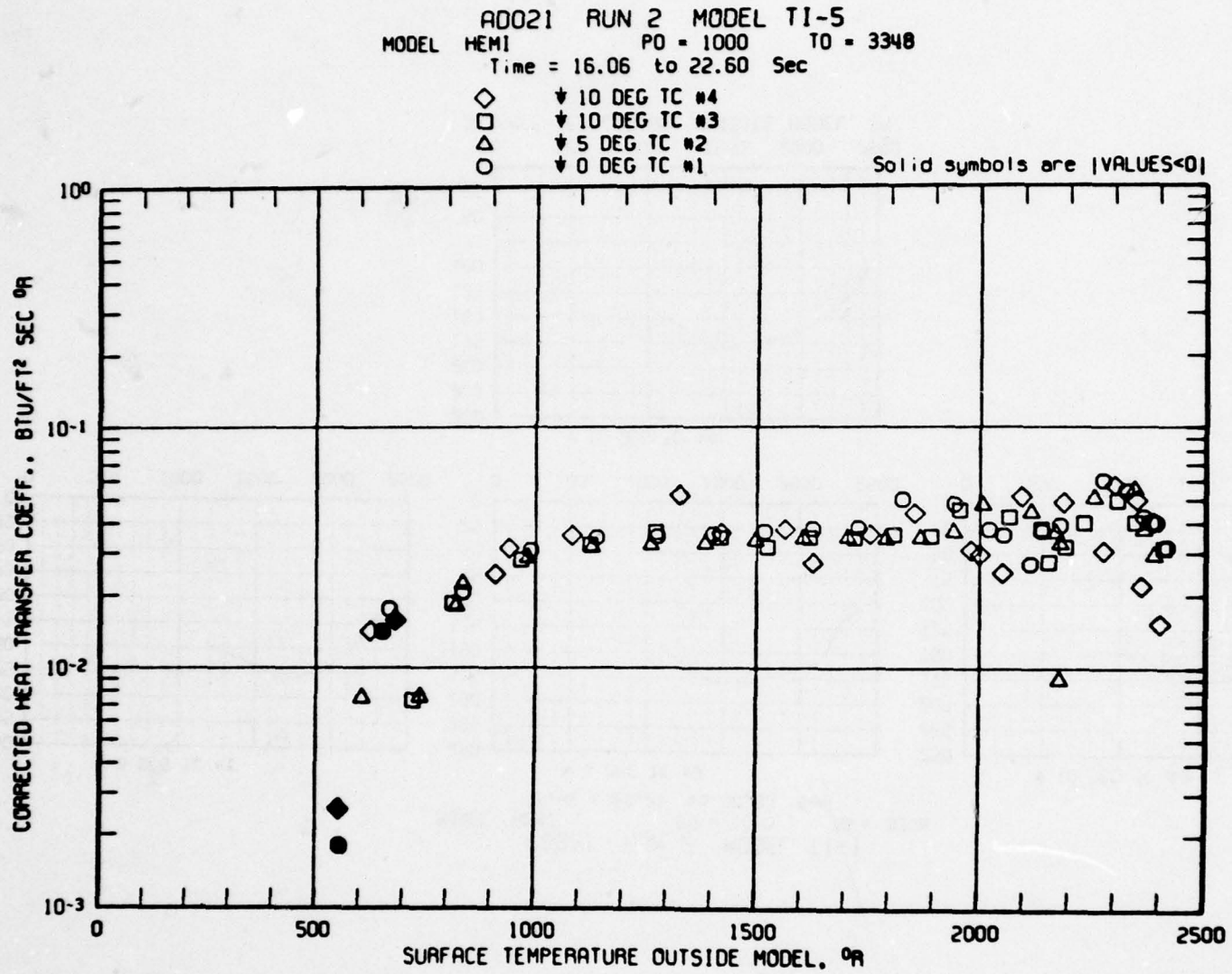
MODEL HEMI PO = 1000 TO = 3348
Time = 16.06 to 22.60 Sec
20 DEG TC #5
30 DEG TC #6
60 DEG TC #7
75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500


AD021 RUN 2 MODEL TI-5
MODEL HEMI PO = 1000 TO = 3348
Time = 16.06 to 22.60 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500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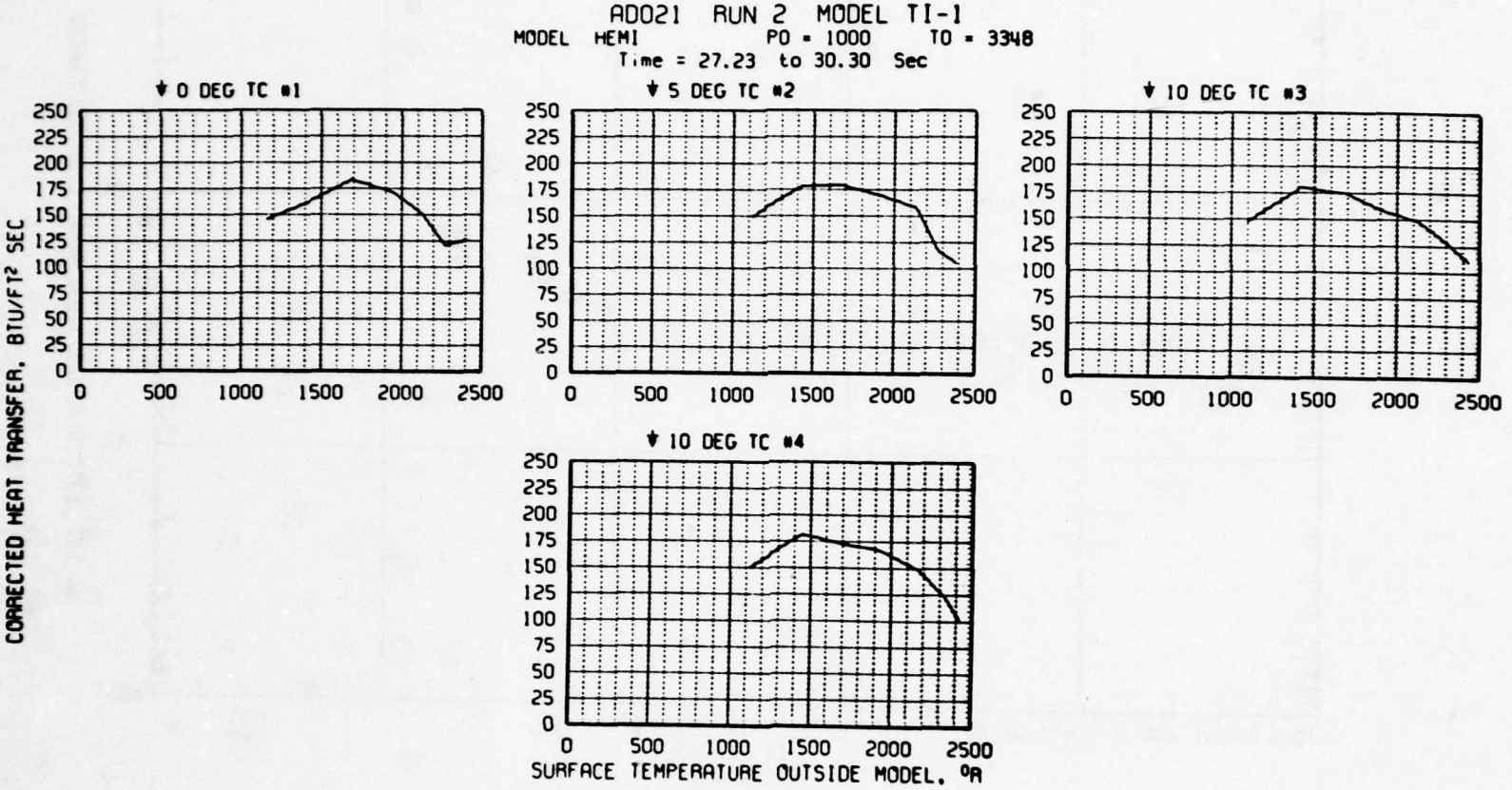
MODEL HEMI PO = 1000 TO = 3348
Time = 16.06 to 22.60 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R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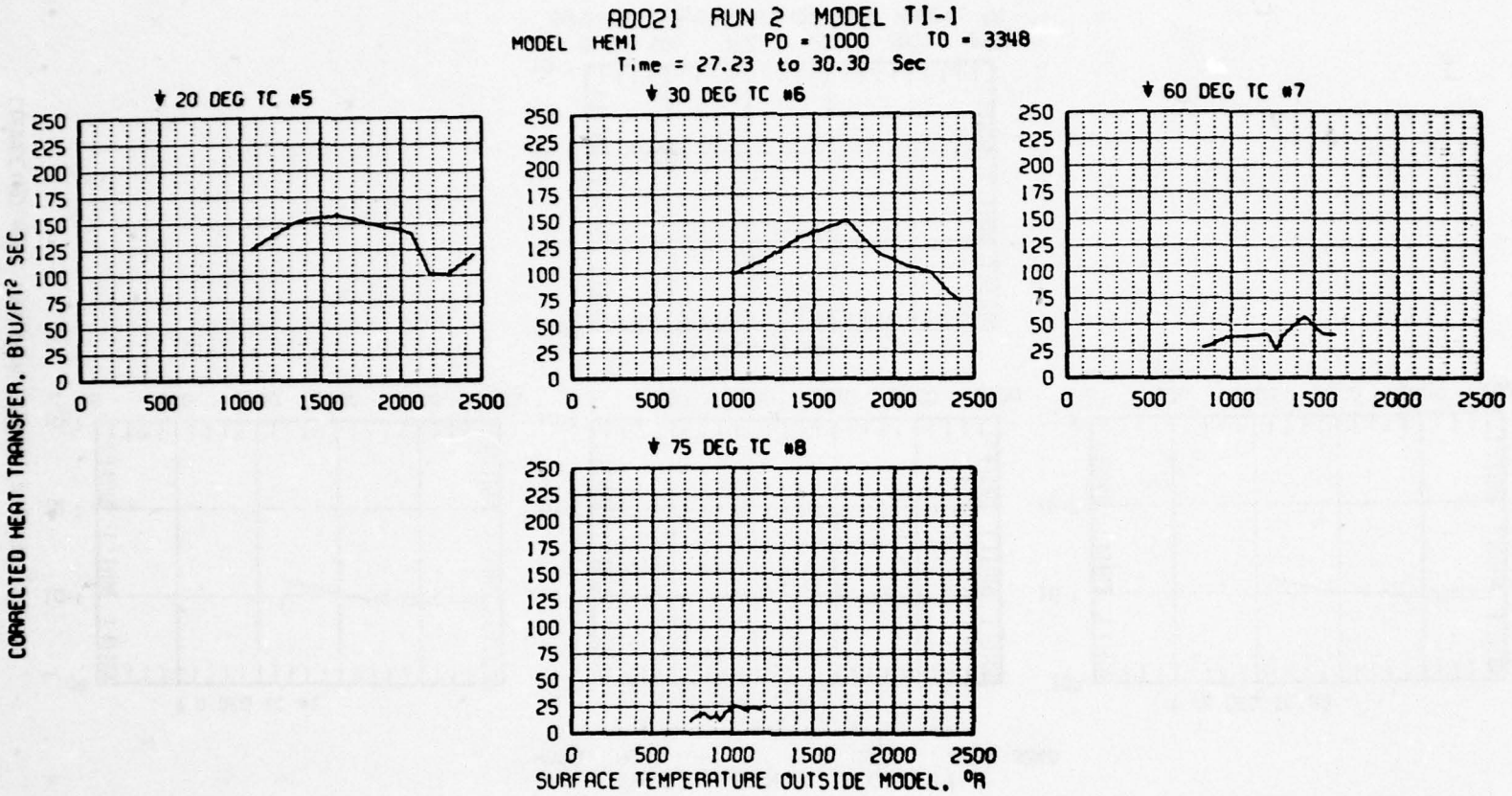
MODEL HEMI PO = 1000 TO = 3348
Time = 27.23 to 30.30 Sec
0 DEG TC #1
5 DEG TC #2
10 DEG TC #3
10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
175
200
225
250
500
1000
1500
2000
2500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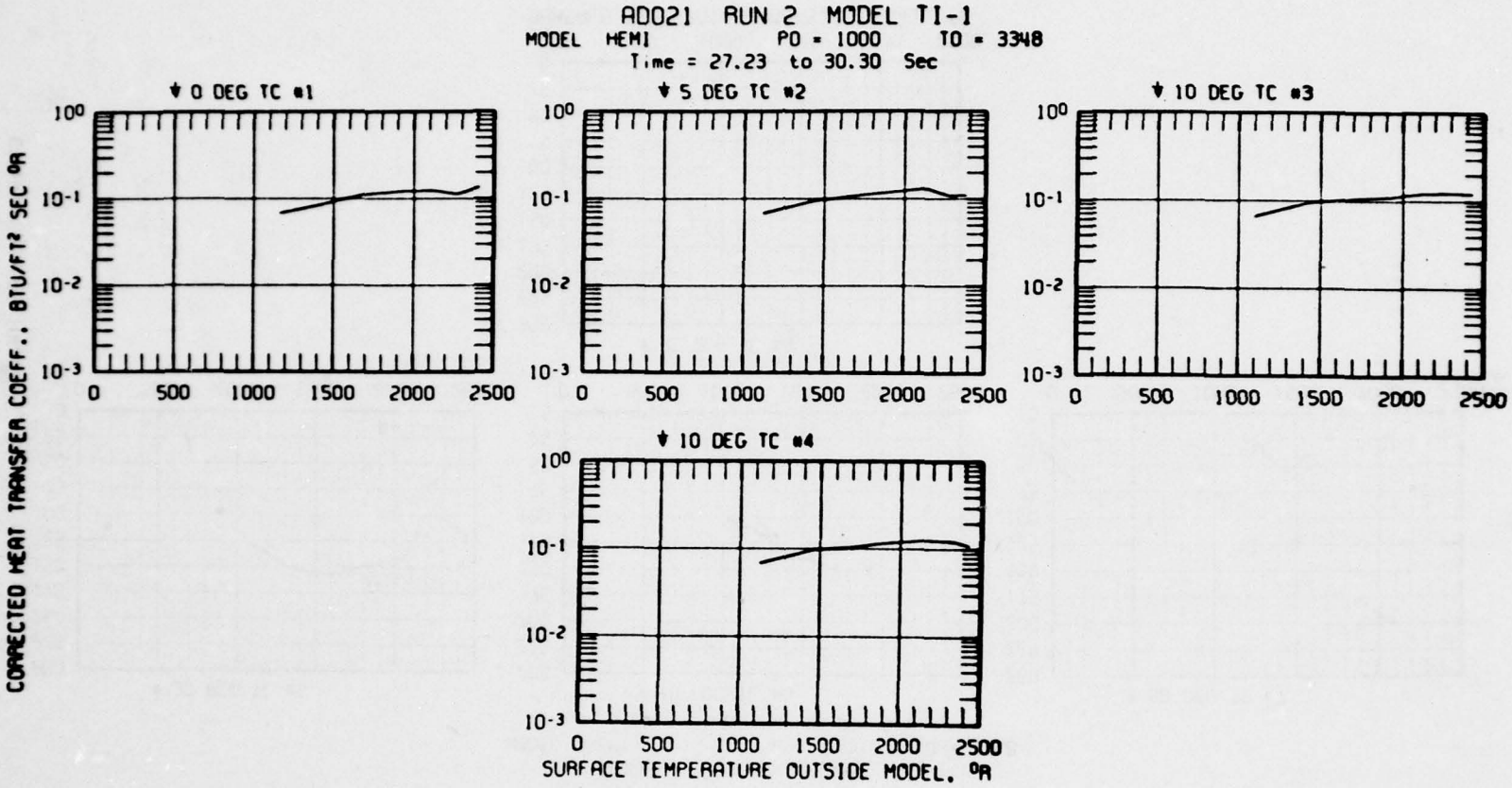
MODEL HEMI PO = 1000 TO = 3348
Time = 27.23 to 30.30 Sec
ϕ 20 DEG TC #5
ϕ 30 DEG TC #6
ϕ 60 DEG TC #7
ϕ 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0 25 50 75 100 125 150 175 200 225 250
0 500 1000 1500 2000 2500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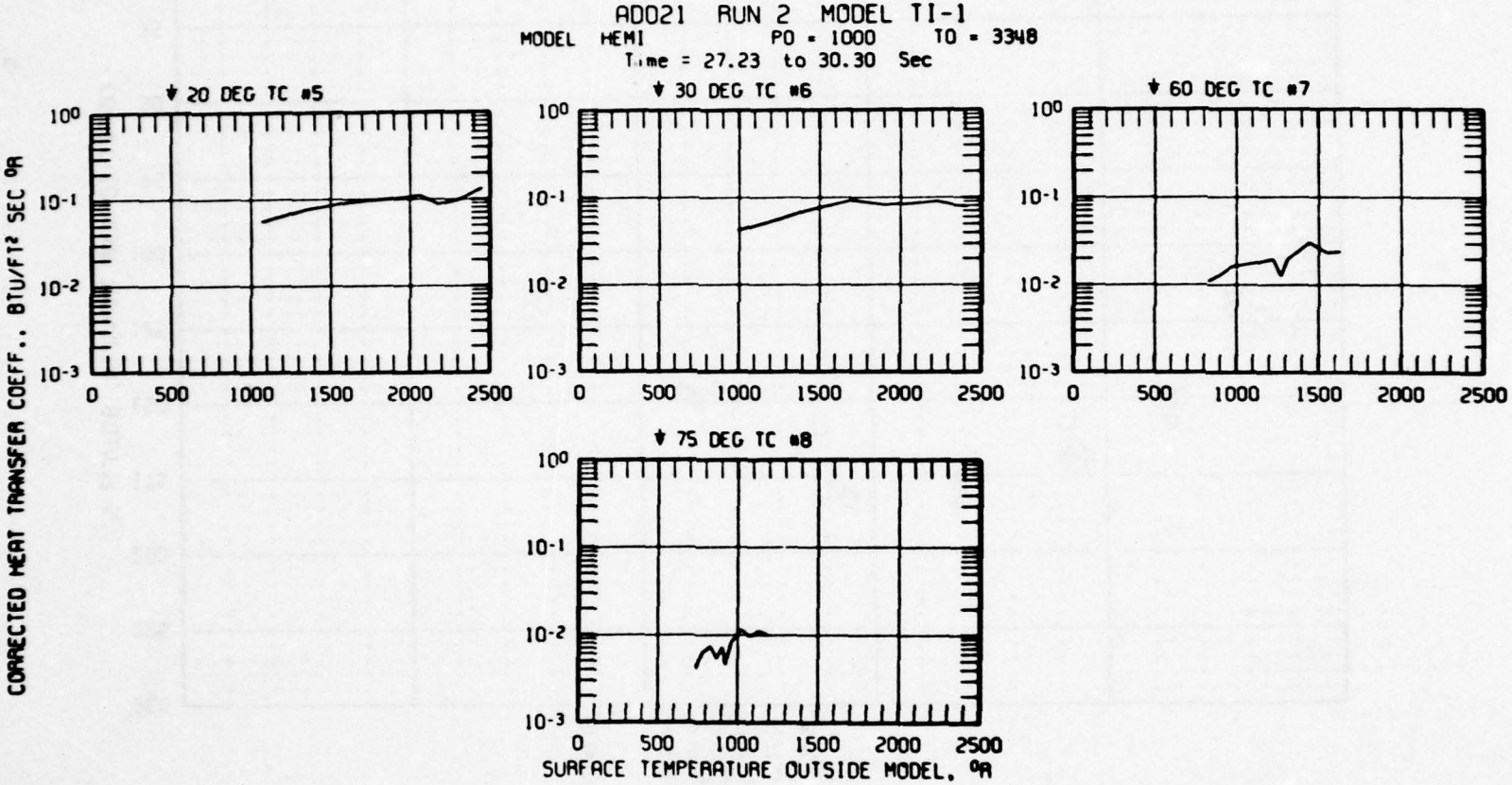
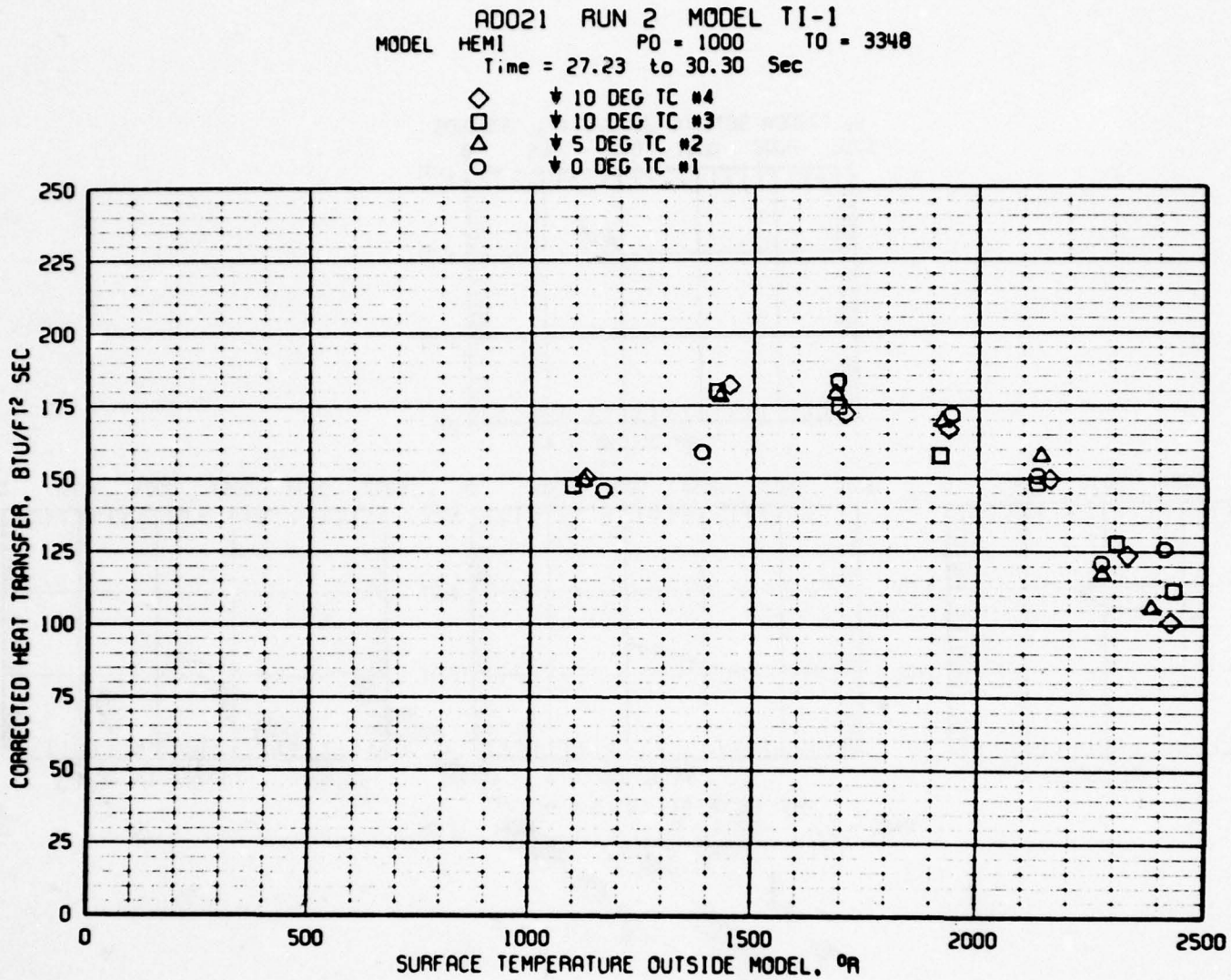
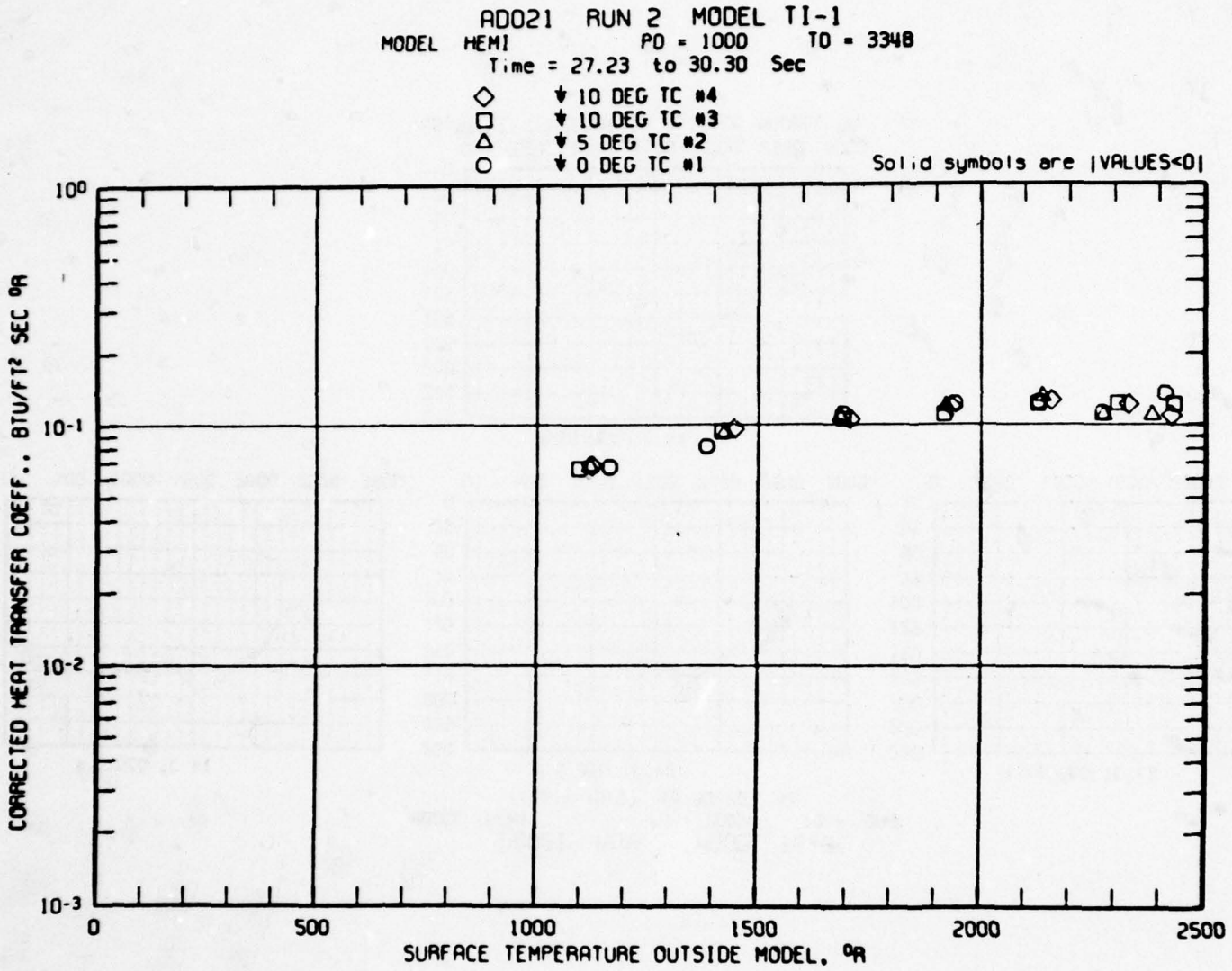
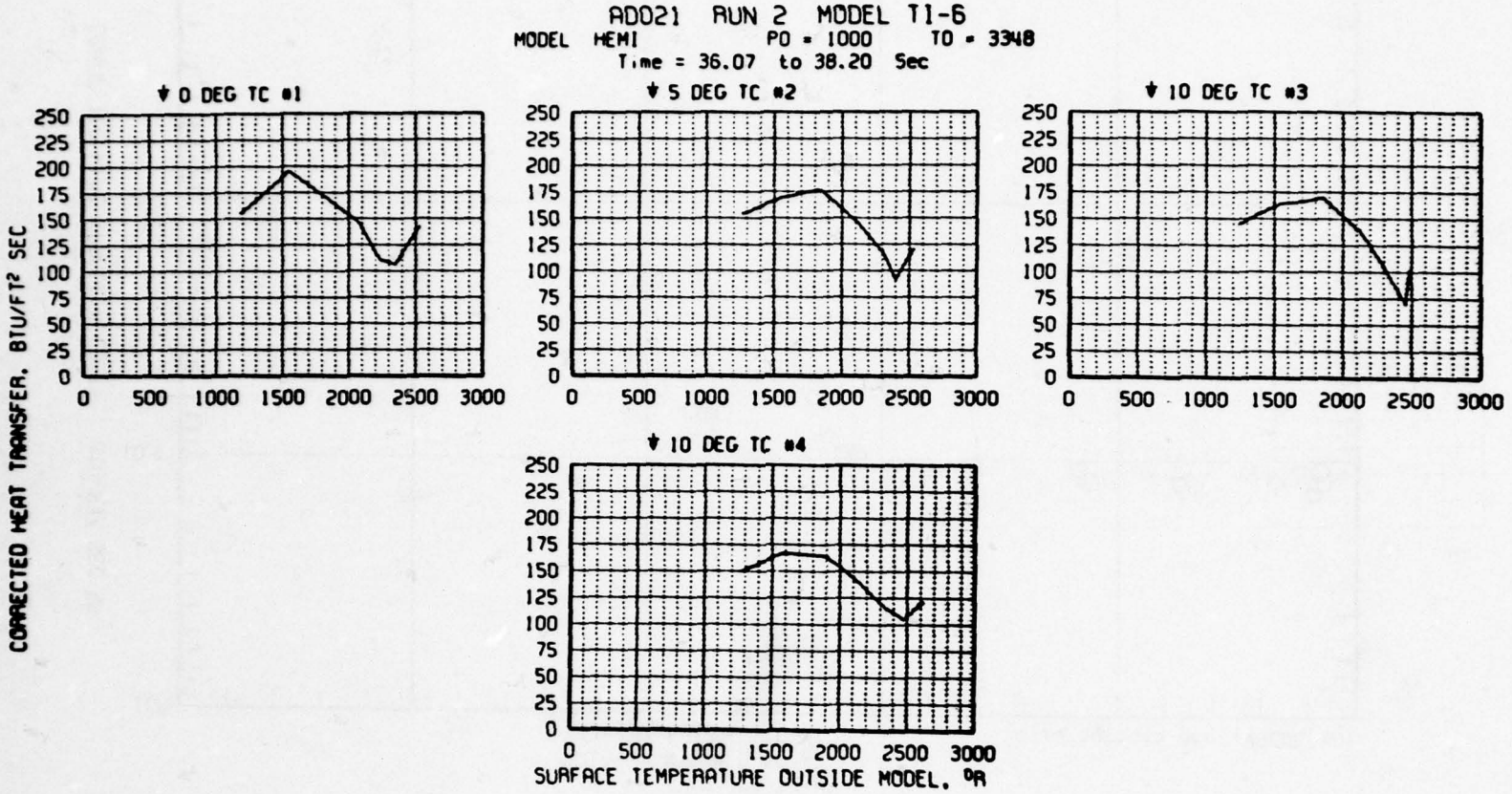
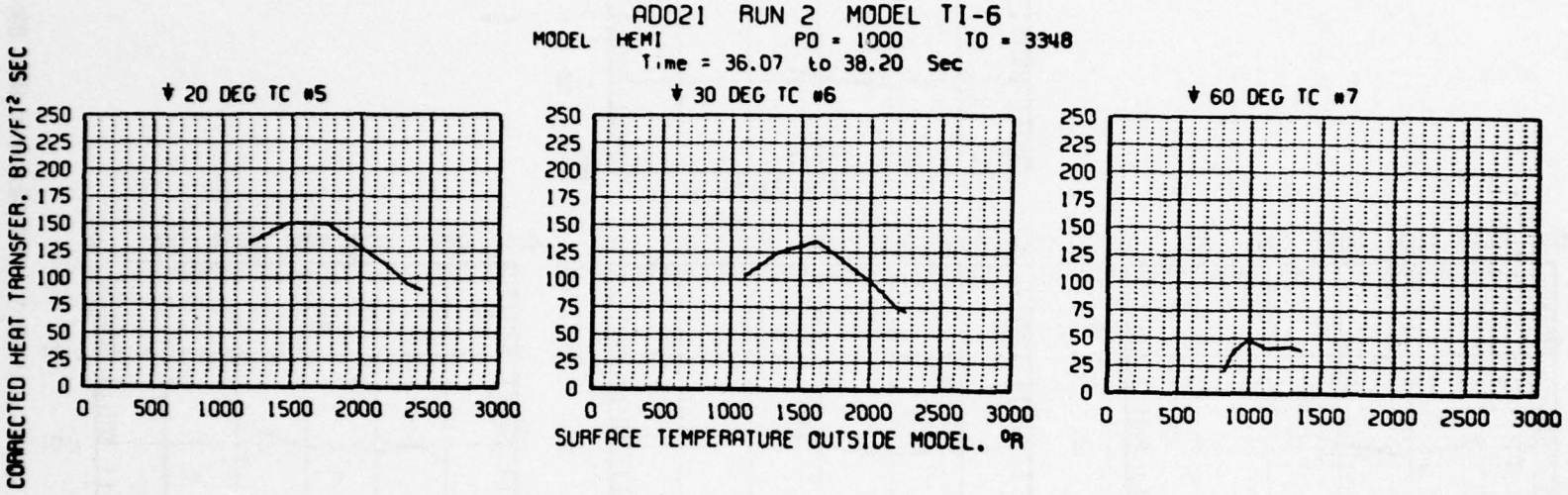
ψ 5 DEG TC #2
ψ 10 DEG TC #3
ψ 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500

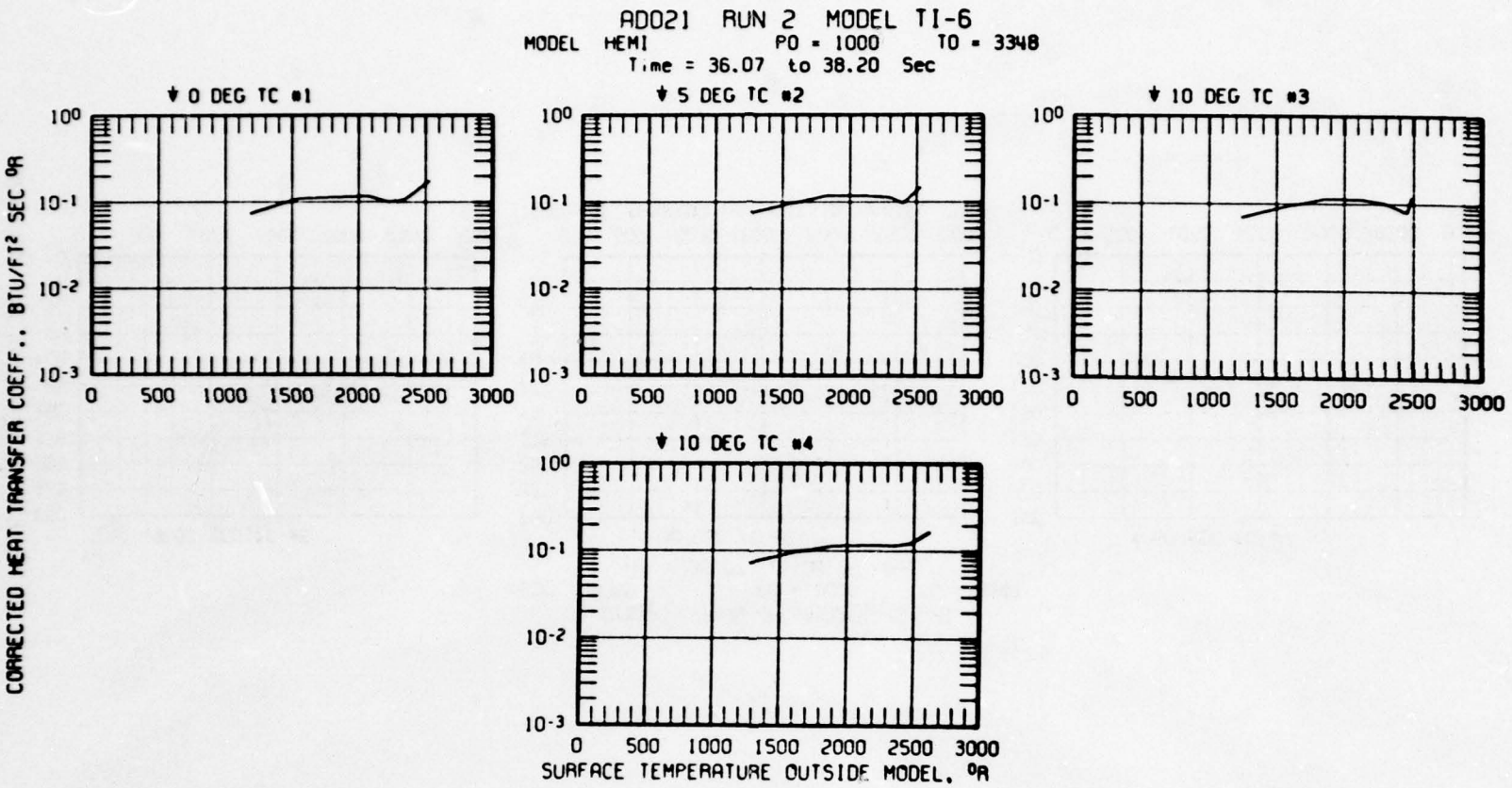

AD021 RUN 2 MODEL TI-1
MODEL HEMI PO = 1000 TO = 3348
Time = 27.23 to 30.30 Sec
ϕ 20 DEG TC #5
ϕ 30 DEG TC #6
ϕ 60 DEG TC #7
ϕ 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500

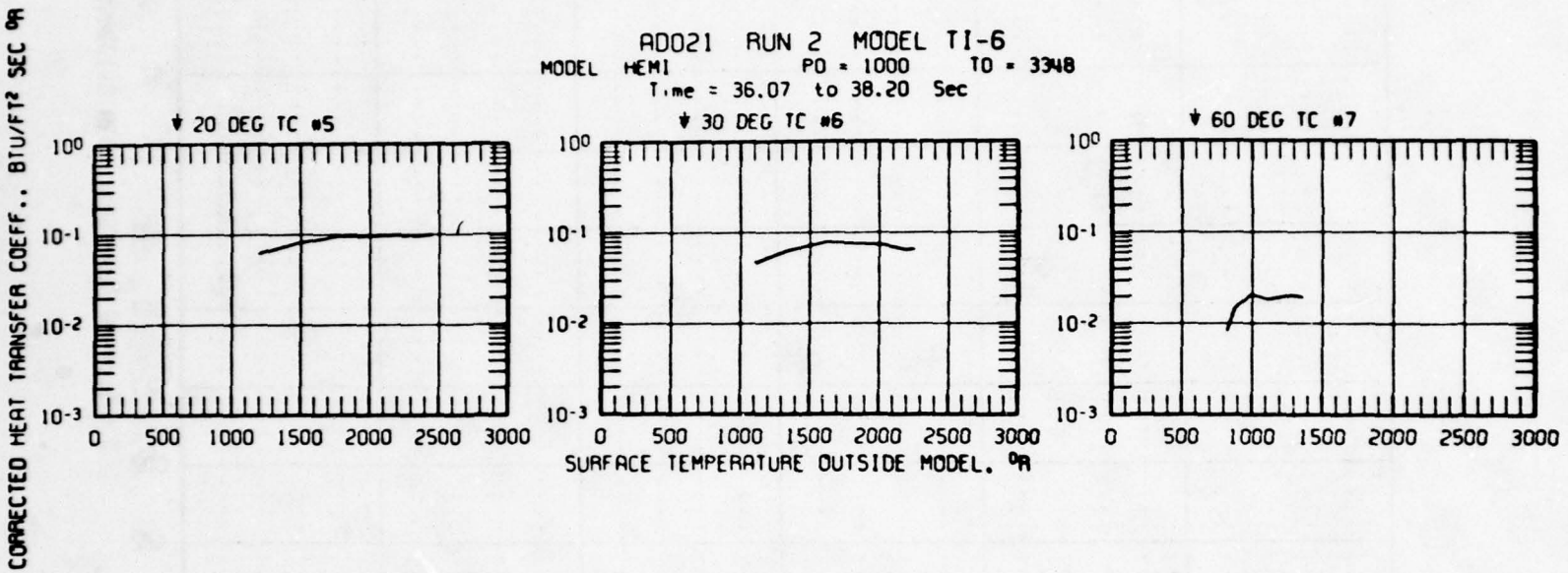

AD021 RUN 2 MODEL TI-1
MODEL HEMI PO = 1000 TO = 3348
Time = 27.23 to 30.30 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
250
225
200
175
150
125
100
75
50
25
0
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R

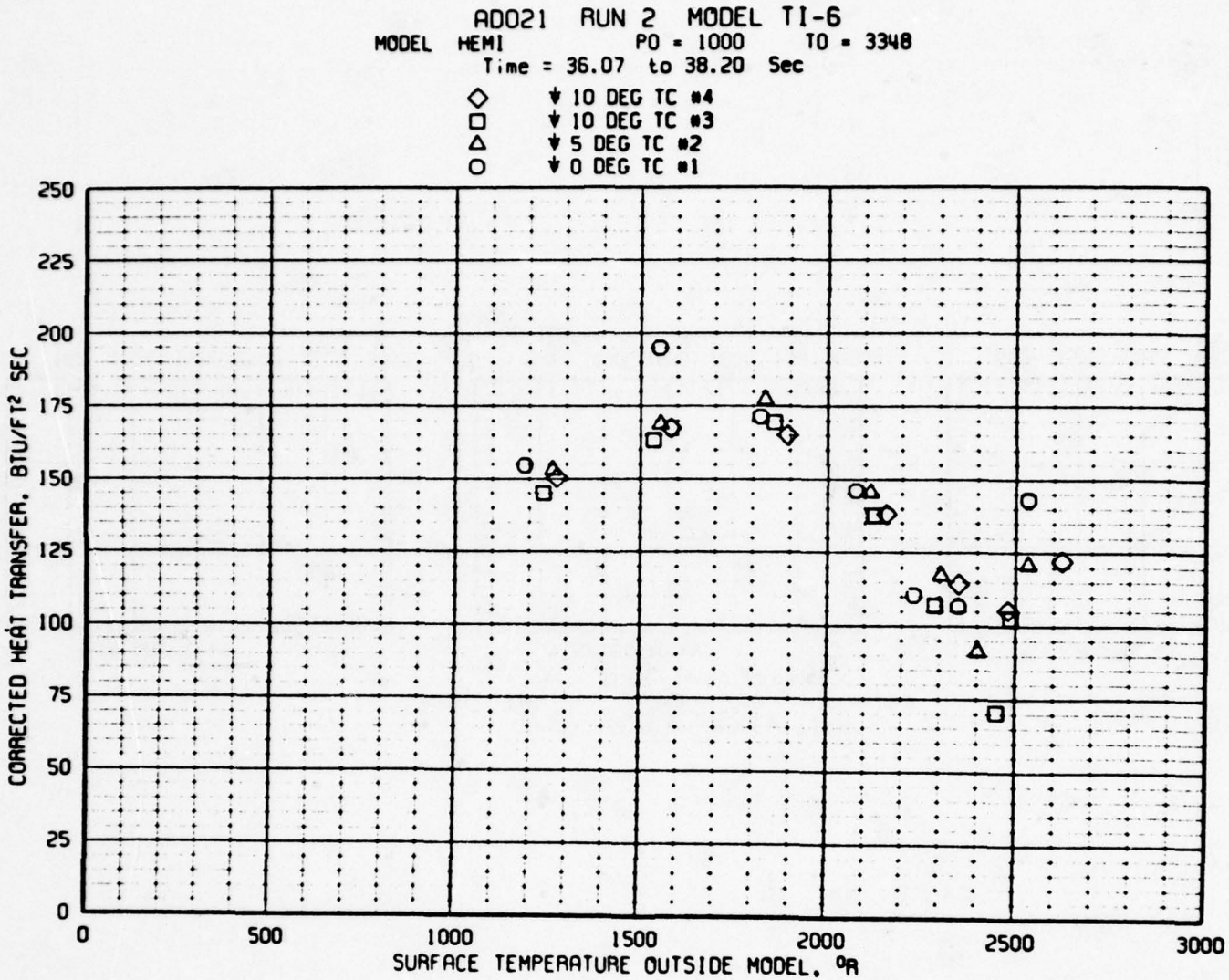

AD021 RUN 2 MODEL TI-1
MODEL HEMI PD = 1000 TD = 3348
Time = 27.23 to 30.30 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R

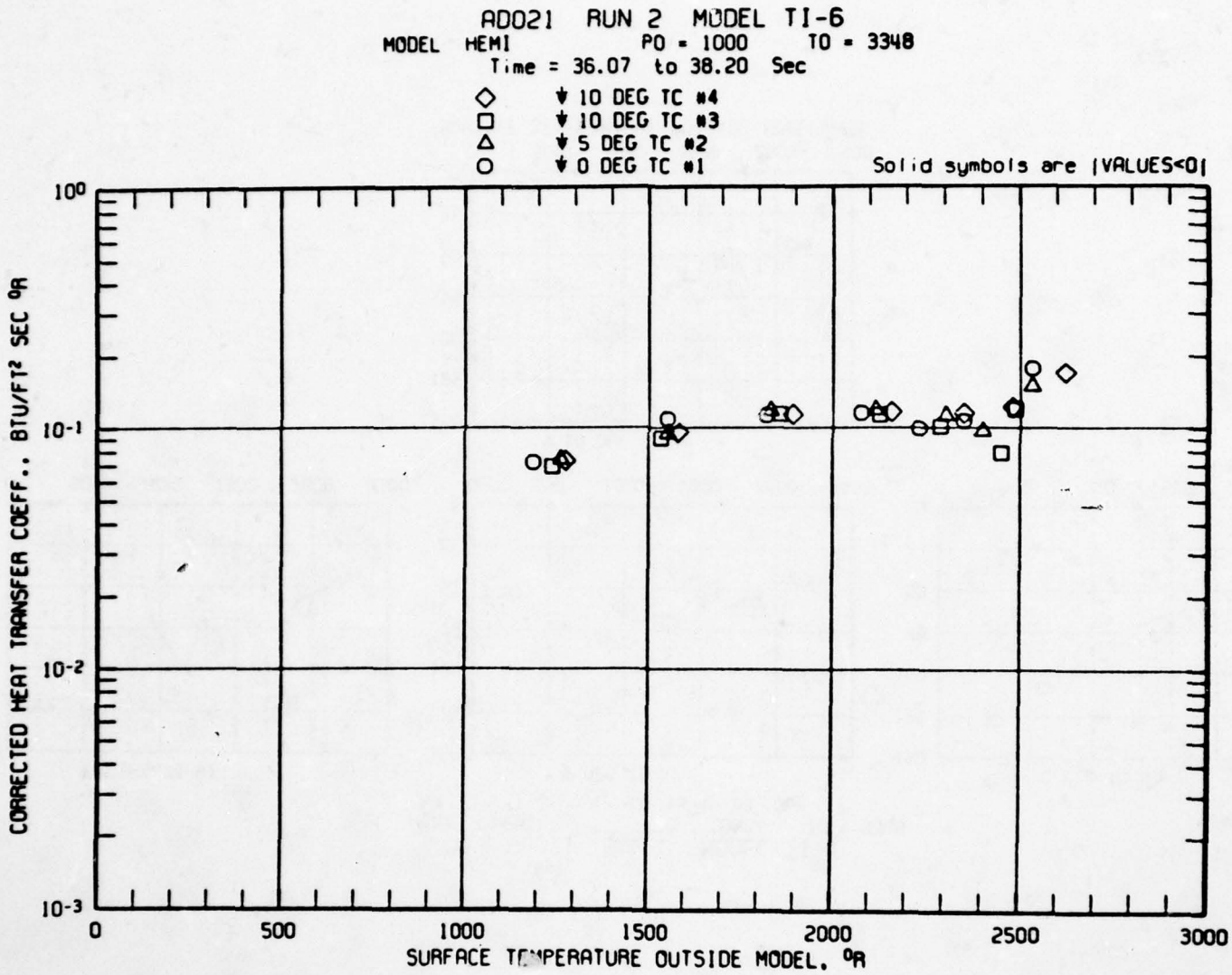

AD021 RUN 2 MODEL T1-6
MODEL HEMI PO = 1000 TO = 3348
Time = 36.07 to 38.20 Sec
ϕ 0 DEG TC #1
ϕ 5 DEG TC #2
ϕ 10 DEG TC #3
ϕ 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0 25 50 75 100 125 150 175 200 225 250
0 500 1000 1500 2000 2500 3000

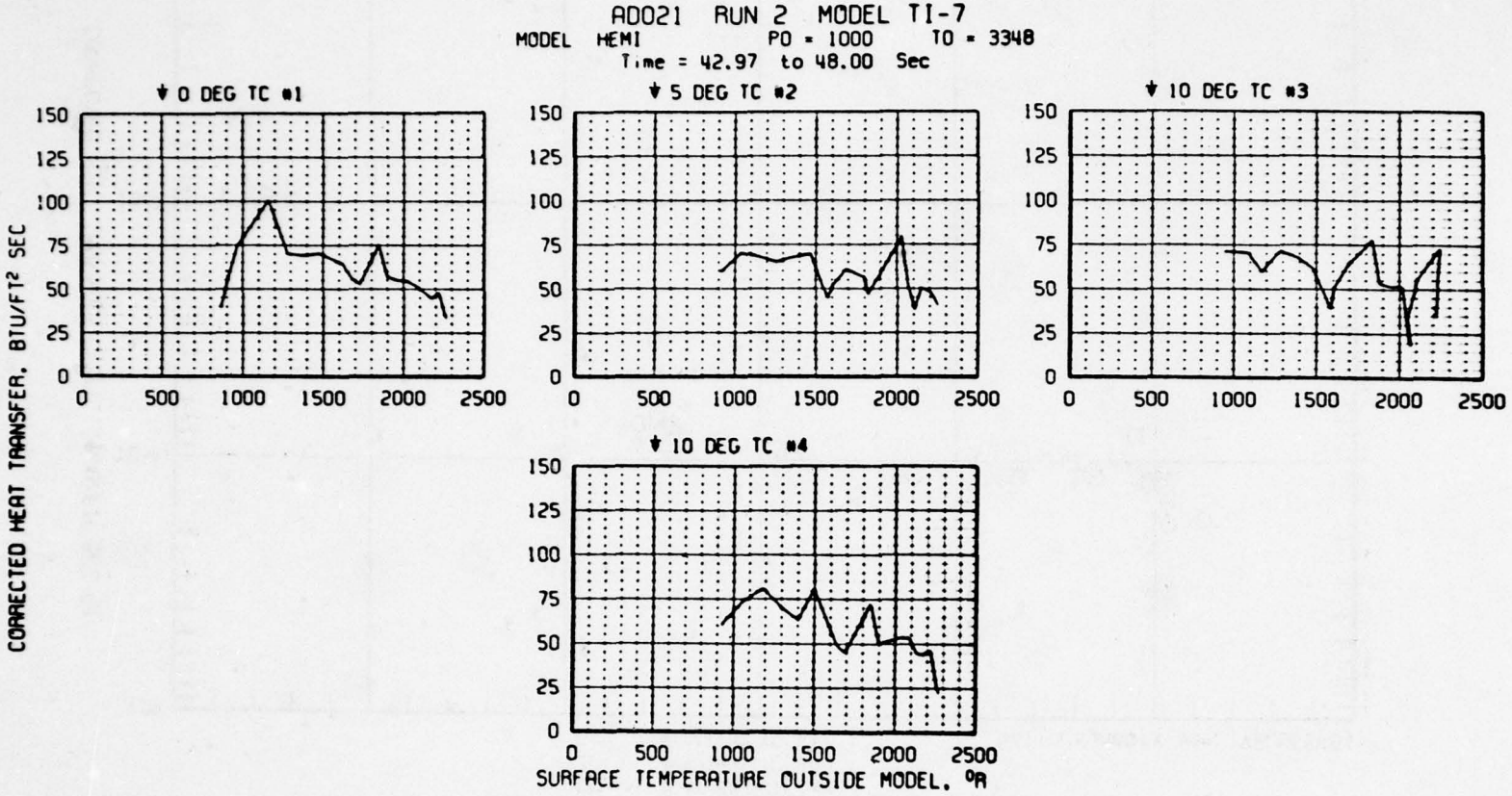

A0021 RUN 2 MODEL TI-6
MODEL HEMI PO = 1000 TO = 3348
Time = 36.07 to 38.20 Sec
CORRECTED HEAT TRANSFER, BTU/FT² SEC
ψ 20 DEG TC #5
ψ 30 DEG TC #6
ψ 60 DEG TC #7
0 25 50 75 100 125 150 175 200 225 250
0 500 1000 1500 2000 2500 3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

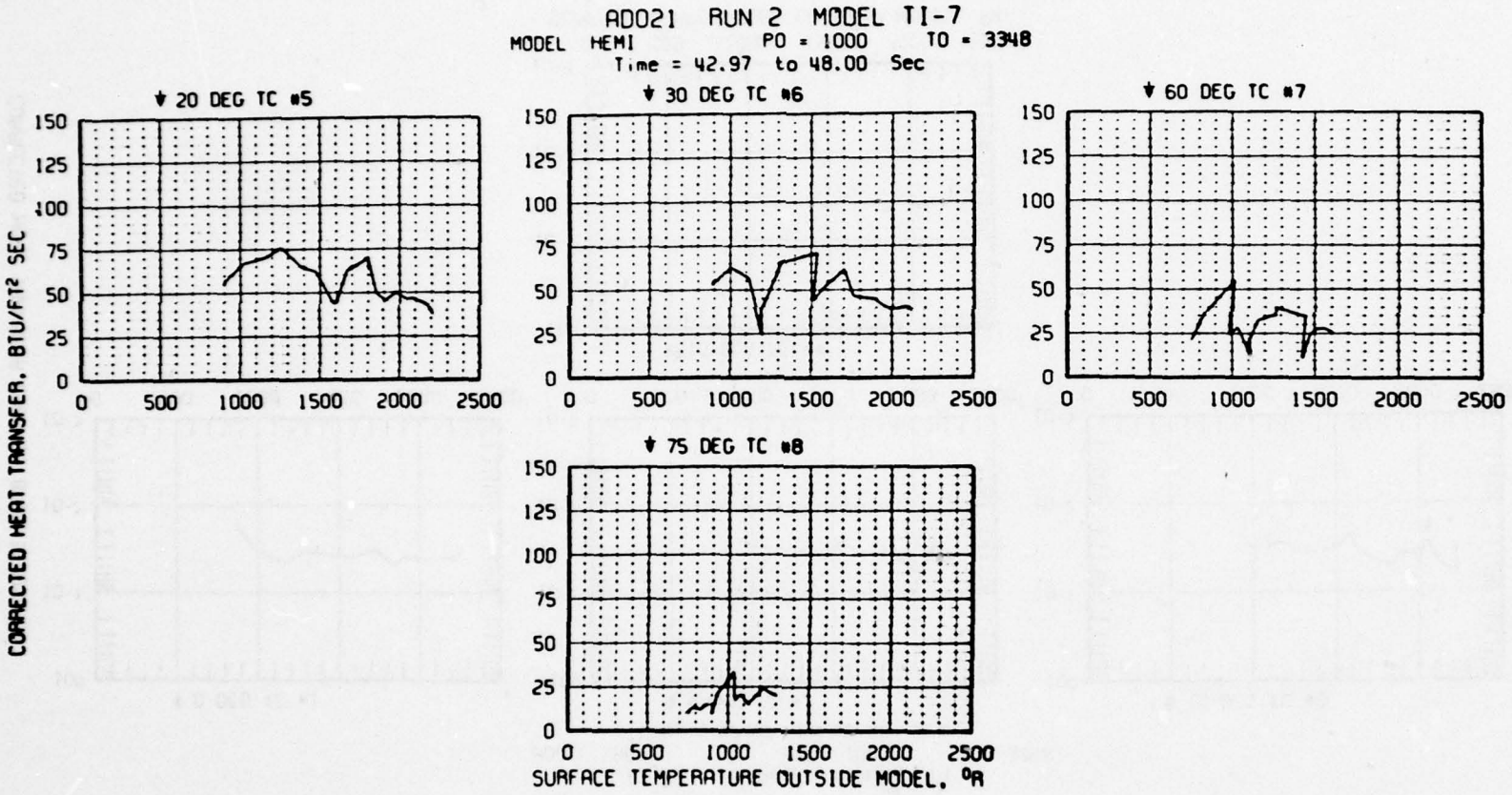

AD021 RUN 2 MODEL TI-6
MODEL HEMI PO = 1000 TO = 3348
Time = 36.07 to 38.20 Sec
ϕ 0 DEG TC #1
ϕ 5 DEG TC #2
ϕ 10 DEG TC #3
ϕ 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

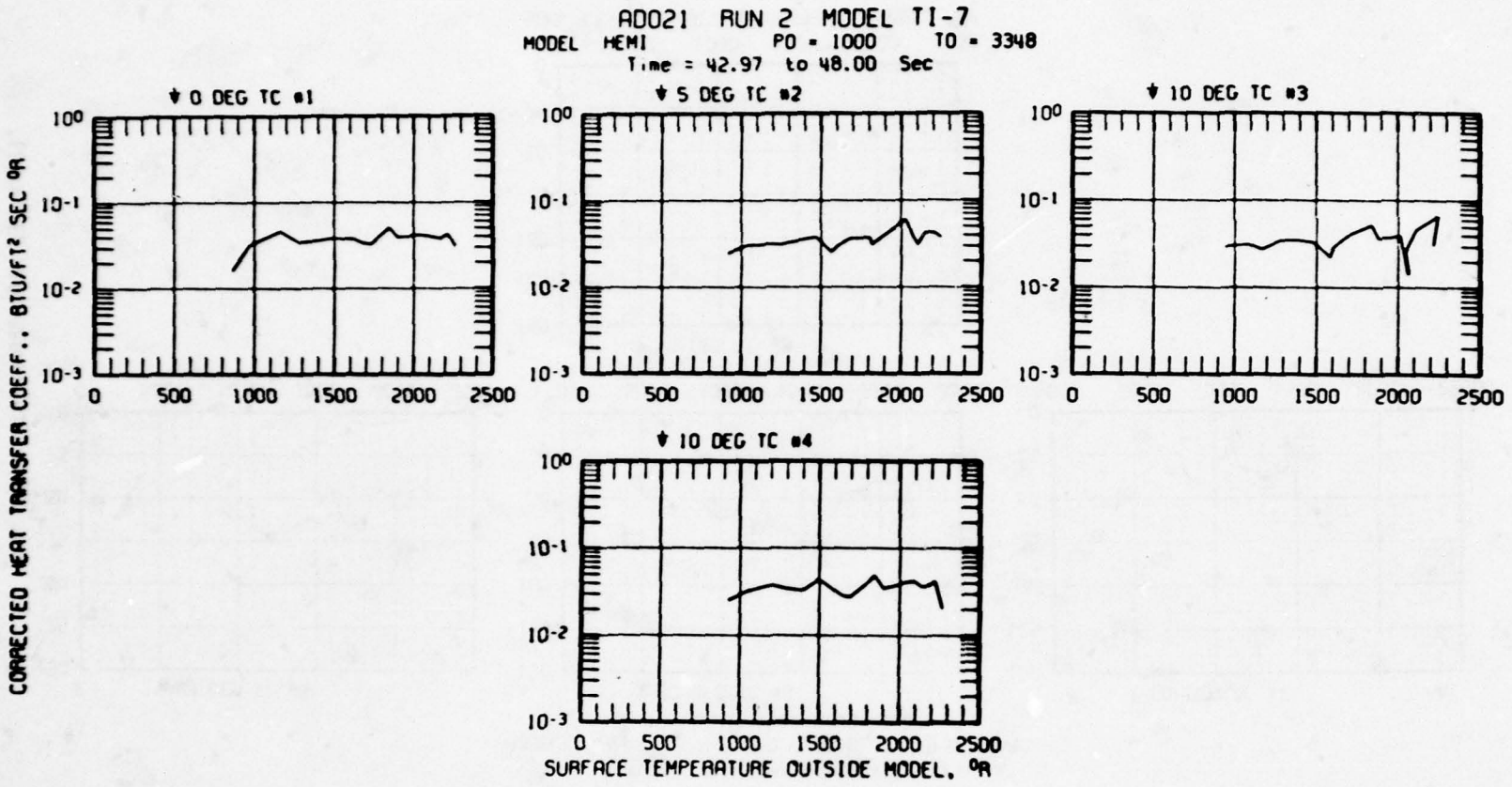

AD021 RUN 2 MODEL TI-6
MODEL HEMI PO = 1000 TO = 3348
Time = 36.07 to 38.20 Sec
ψ 20 DEG TC #5
ψ 30 DEG TC #6
ψ 60 DEG TC #7
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

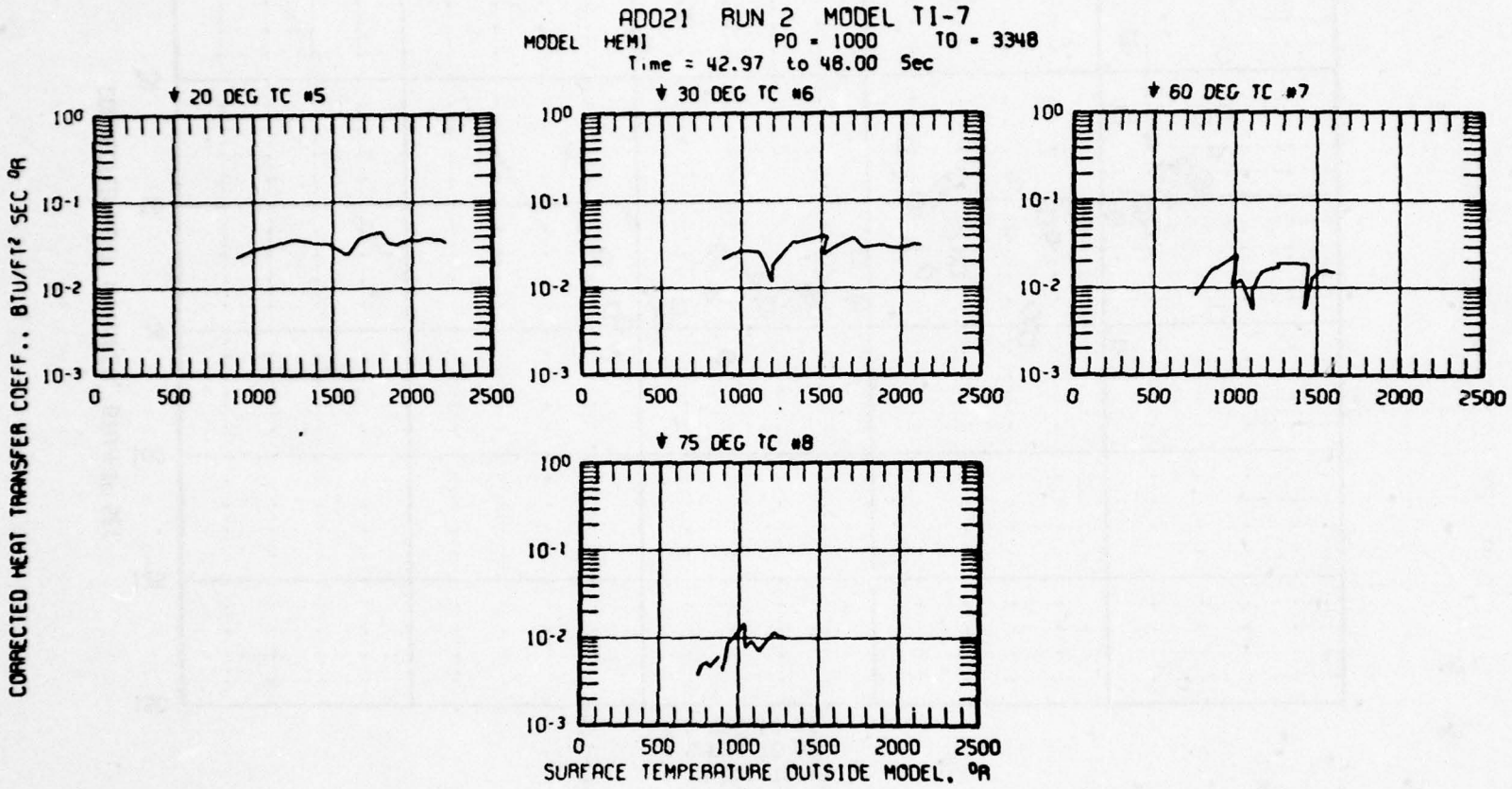

AD021 RUN 2 MODEL TI-6
MODEL HEMI PO = 1000 TO = 3348
Time = 36.07 to 38.20 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
175
200
225
250
0
500
1000
1500
2000
2500
3000

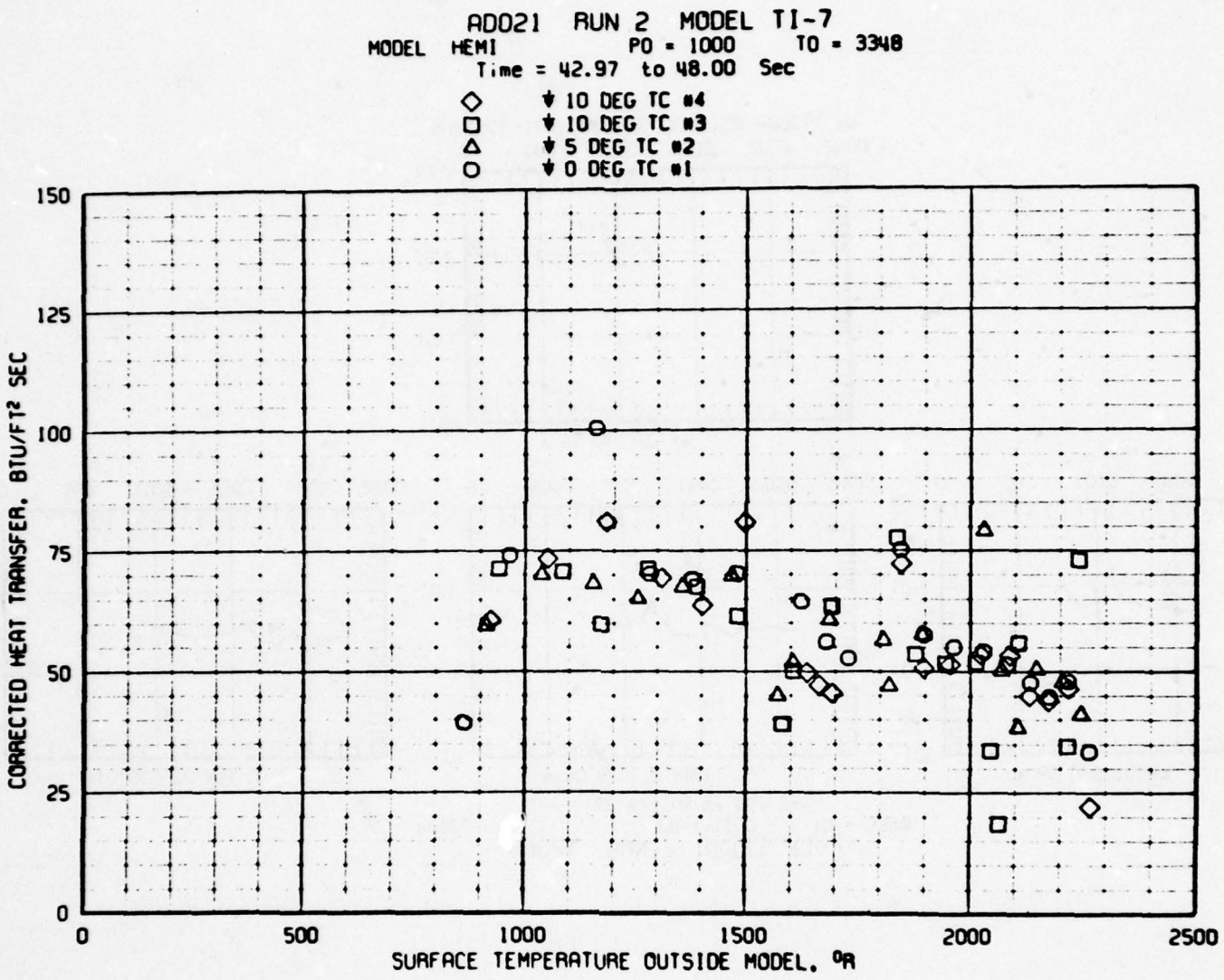

AD021 RUN 2 MODEL TI-6
MODEL HEMI PO = 1000 TO = 3348
Time = 36.07 to 38.20 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R


AD021 RUN 2 MODEL TI-7
MODEL HEMI PO = 1000 TO = 3348
Time = 42.97 to 48.00 Sec
ϕ 0 DEG TC #1
ϕ 5 DEG TC #2
ϕ 10 DEG TC #3
ϕ 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
500
1000
1500
2000
2500


AD021 RUN 2 MODEL TI-7
MODEL HEMI PO = 1000 TO = 3348
Time = 42.97 to 48.00 Sec
20 DEG TC #5
30 DEG TC #6
60 DEG TC #7
75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
500
1000
1500
2000
2500


AD021 RUN 2 MODEL TI-7
MODEL HEMI PO = 1000 TO = 3348
Time = 42.97 to 48.00 Sec
φ 0 DEG TC #1
φ 5 DEG TC #2
φ 10 DEG TC #3
φ 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500


AD021 RUN 2 MODEL TI-7
MODEL HEMI PO = 1000 TO = 3348
Time = 42.97 to 48.00 Sec
φ 20 DEG TC #5
φ 30 DEG TC #6
φ 60 DEG TC #7
φ 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500


AD021 RUN 2 MODEL TI-7
MODEL HEMI PO = 1000 TO = 3348
Time = 42.97 to 48.00 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
0
500
1000
1500
2000
2500

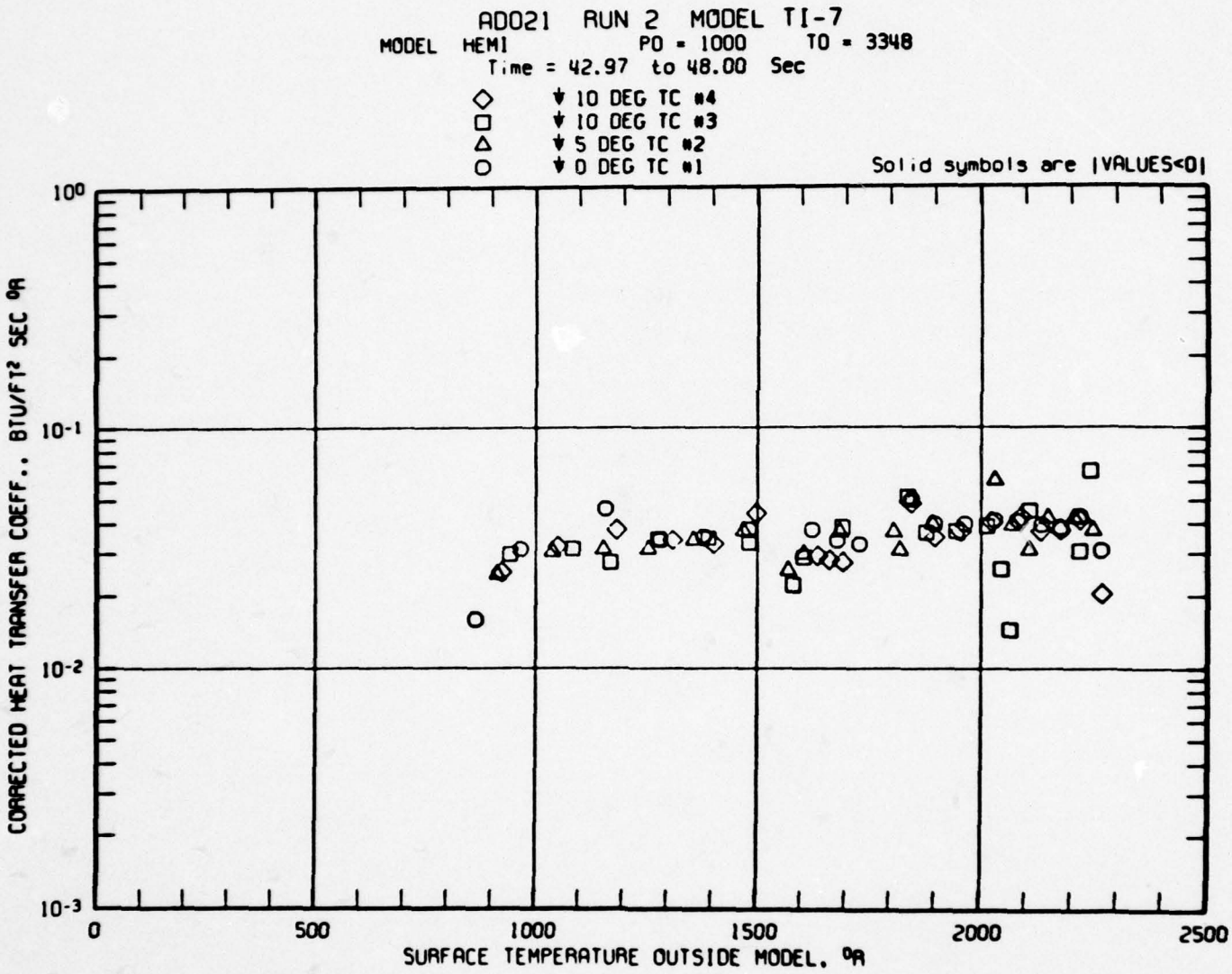

AD021 RUN 2 MODEL TI-7
MODEL HEMI PO = 1000 TO = 3348
Time = 42.97 to 48.00 Sec
10 DEG TC #4
10 DEG TC #3
5 DEG TC #2
0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R

TABLE 1 RUN SUMMARY

TUNNEL CONDITIONS

RUN 3 DATE 12-1-76

NOZZLE STATION 127.5

P_o = 1000 psia, P_{o_m} = 1000.5

H_{o_B} = 592 Btu/lbm, H_{o_m} = 576

H_o = 580 Btu/lbm

T_{o_B} = 2300 °R, T_o = 2269 °R

M = 7.3 P_o' = 10 psia

DUST		WATER	
TYPE	MgO	Flow	0.305 gpm
SIZE	100 μm	C.F.	36.2
VEL	4200 ft/sec	Orifice	0.20 in.
Flow	13.93 gm/sec	ΔP	804 psi
C.F.	44.7		

STRING	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANS-DUCER TYPE	PRERUN	POSTRUN
1	P_o' probe	5					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_o probe	15					See Fig. 3	0.25		R	1					
3	T_i-10	6.1					Hemi	2.0	6Al-4V-T_i	S	8				6838	
4																
5	T_i-5		5.77				Hemi	2.0	6Al-4V-T_i	S	8					8008
6																
7	T_i-8		5.07	7.00	X 5.07		Hemi	2.0	6Al-4V-T_i	S	8				6835	8007
8	T_i-11			5.85			Hemi	2.0	6Al-4V-T_i	S	8				6838	8005
9	WB-4R			6			See Fig. 2	2.0	Al							8006
10																

KEY -

PH - PREHEAT
POH - POSTHEAT
DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

NOTES:

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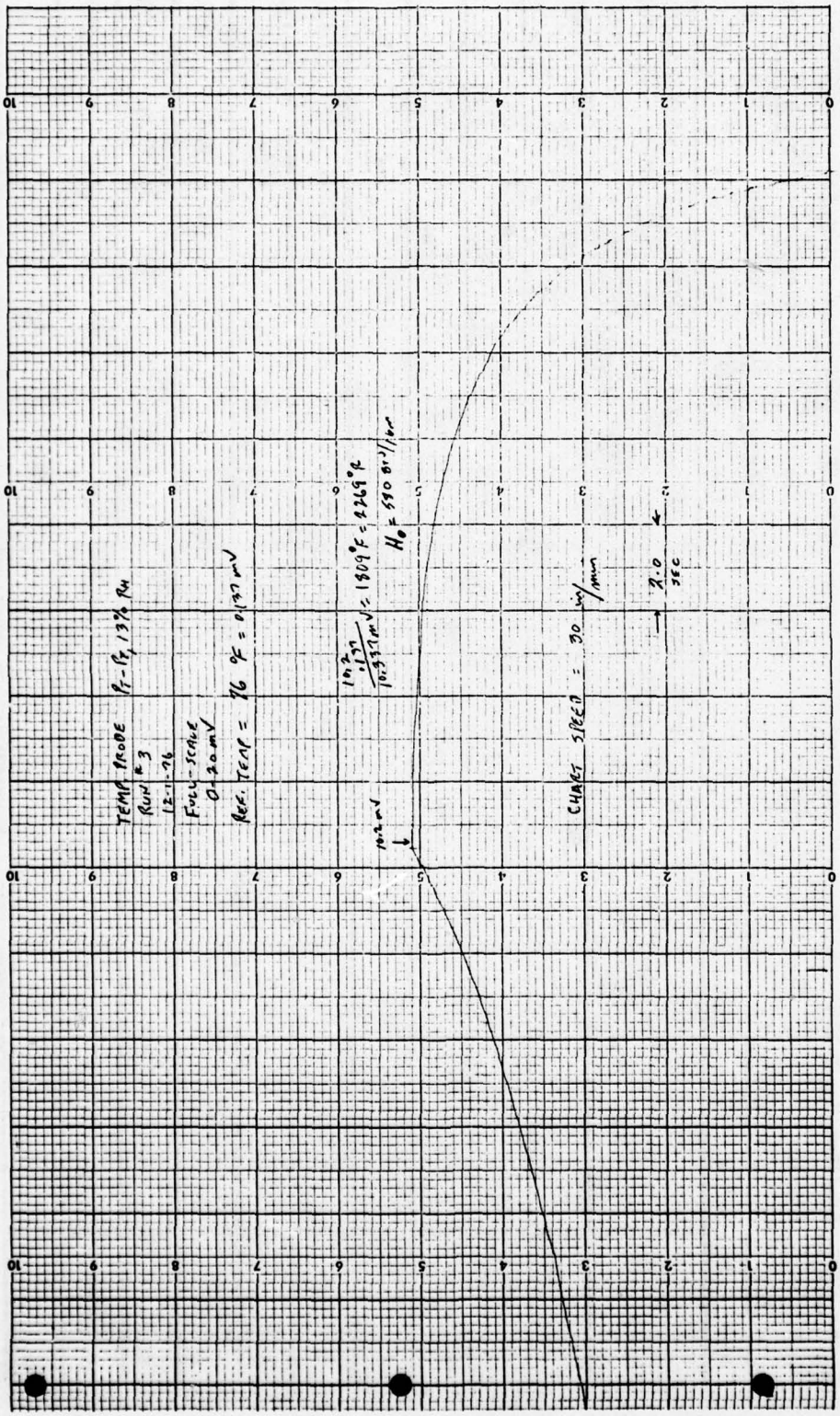
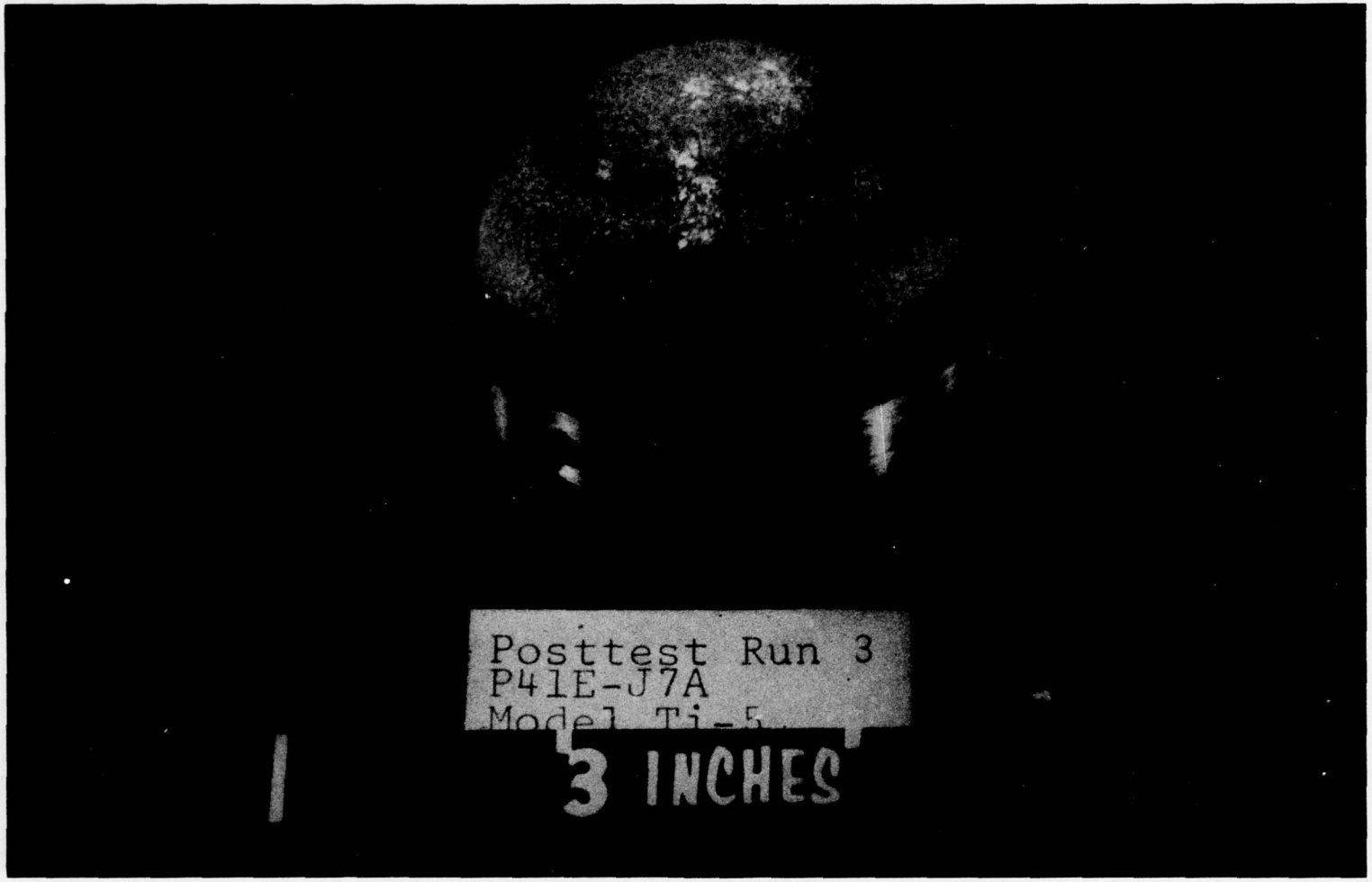
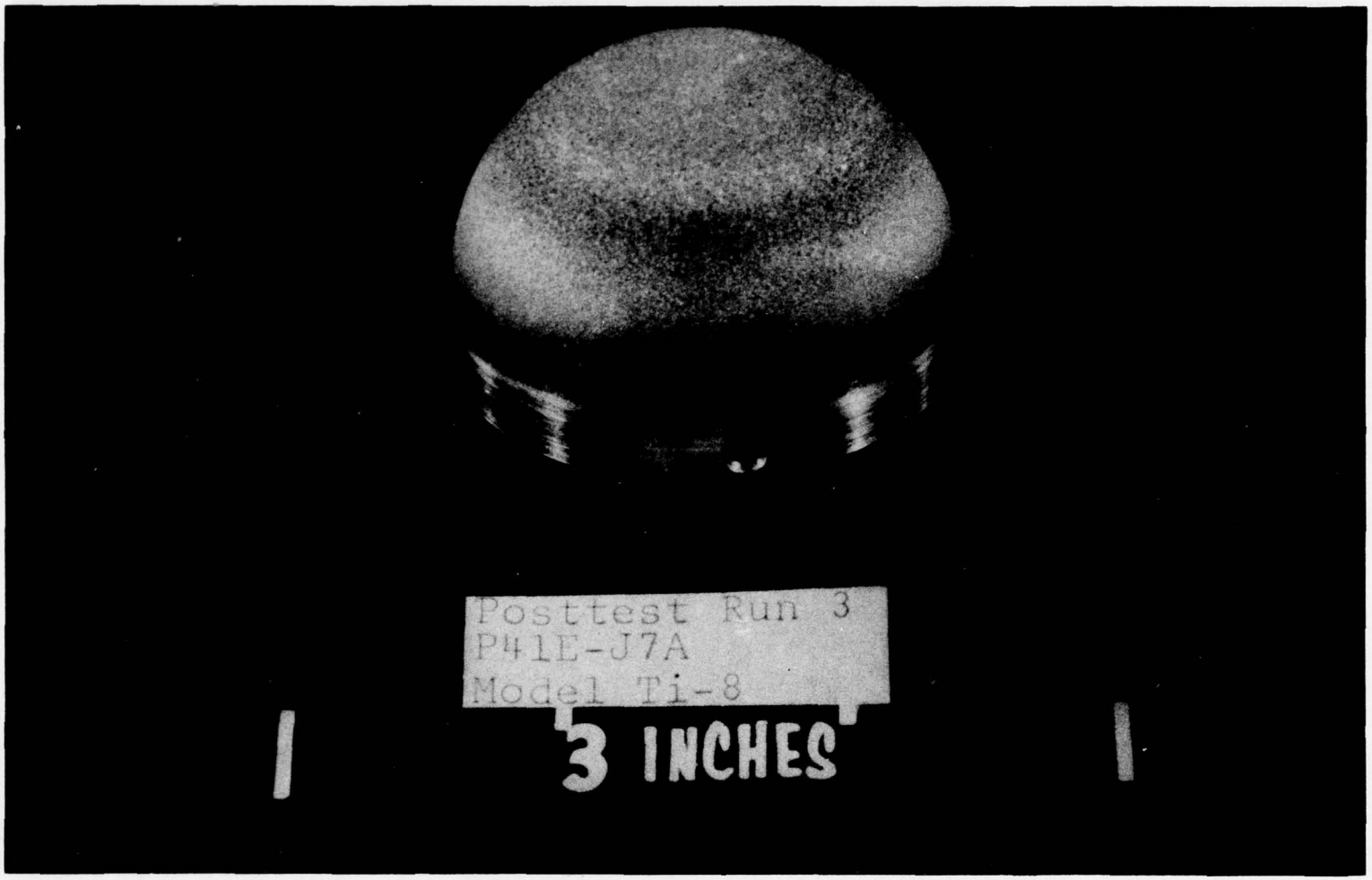
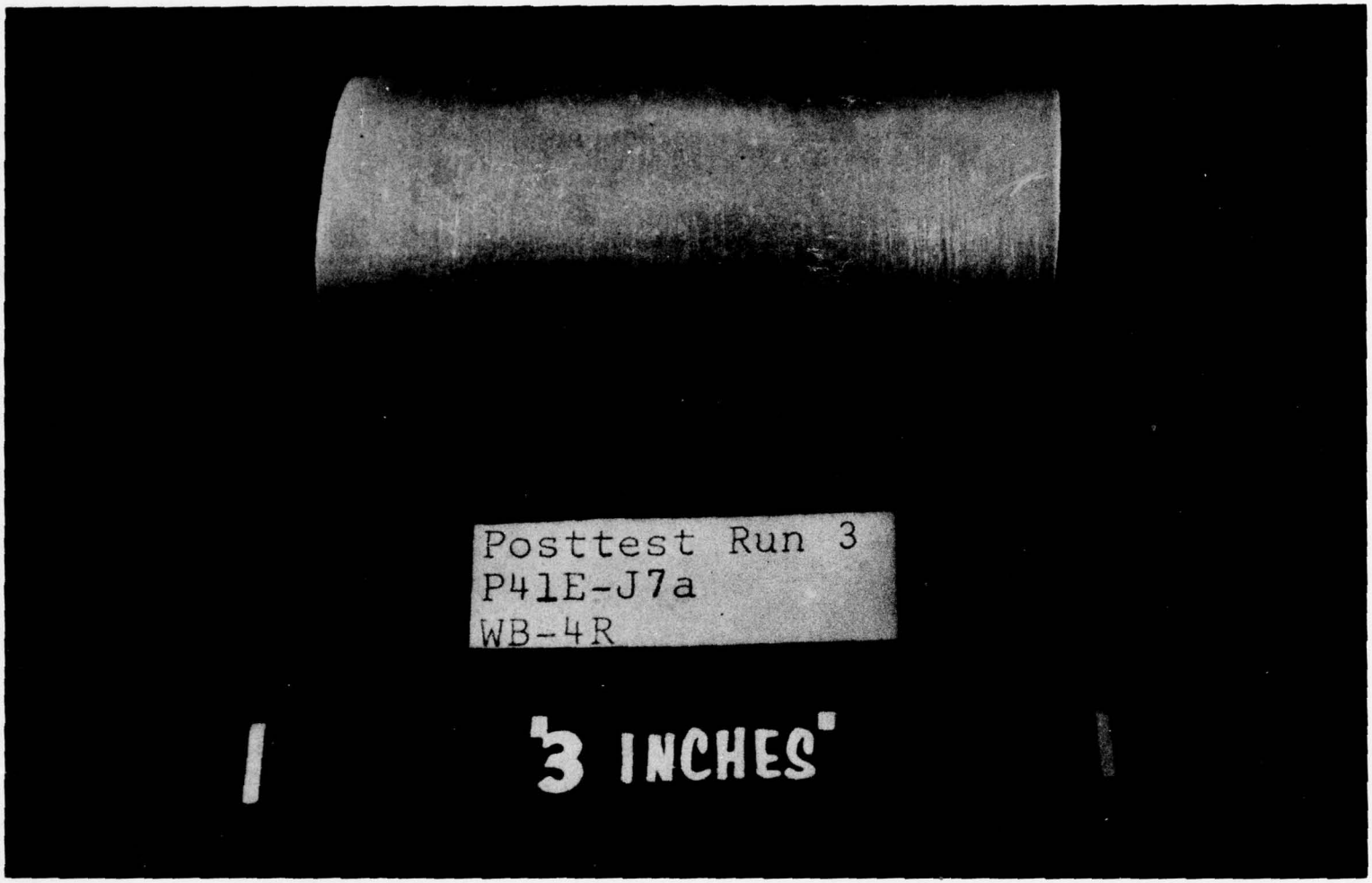



Posttest Run 3
P41E-J7A
Model Ti-5
3 INCHES


Posttest Run 3
P41E-J7A
Model Ti-8
3 INCHES

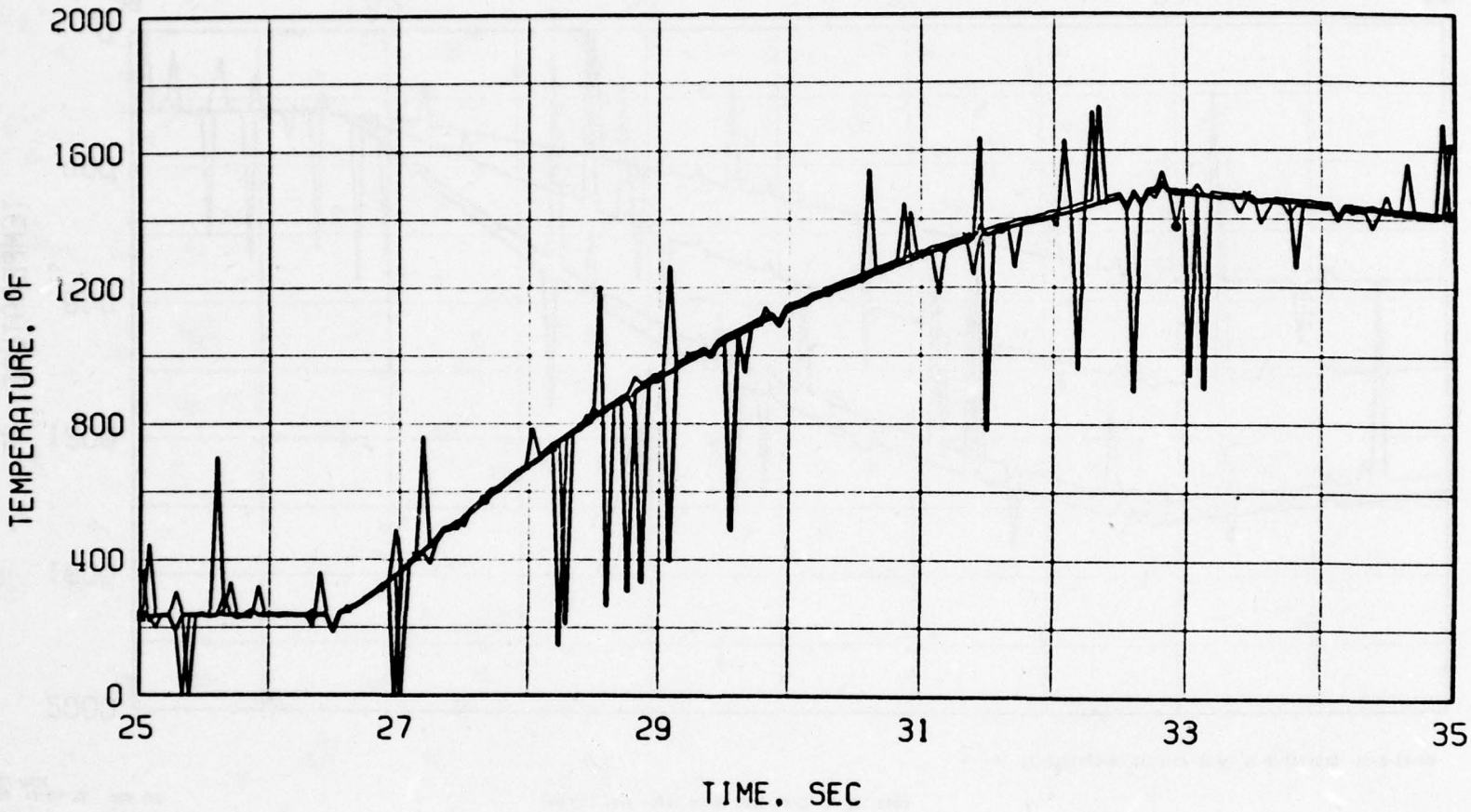
Posttest Run 3
P41E-J7A
3 INCHES


Posttest Run 3
P41E-J7a
WB-4R
3 INCHES

DATE 12-03-76 ARO INC
PROJ-PWIE

PROJECT PWIE TEST A0021 DATE 12-01-76 SEL 2103

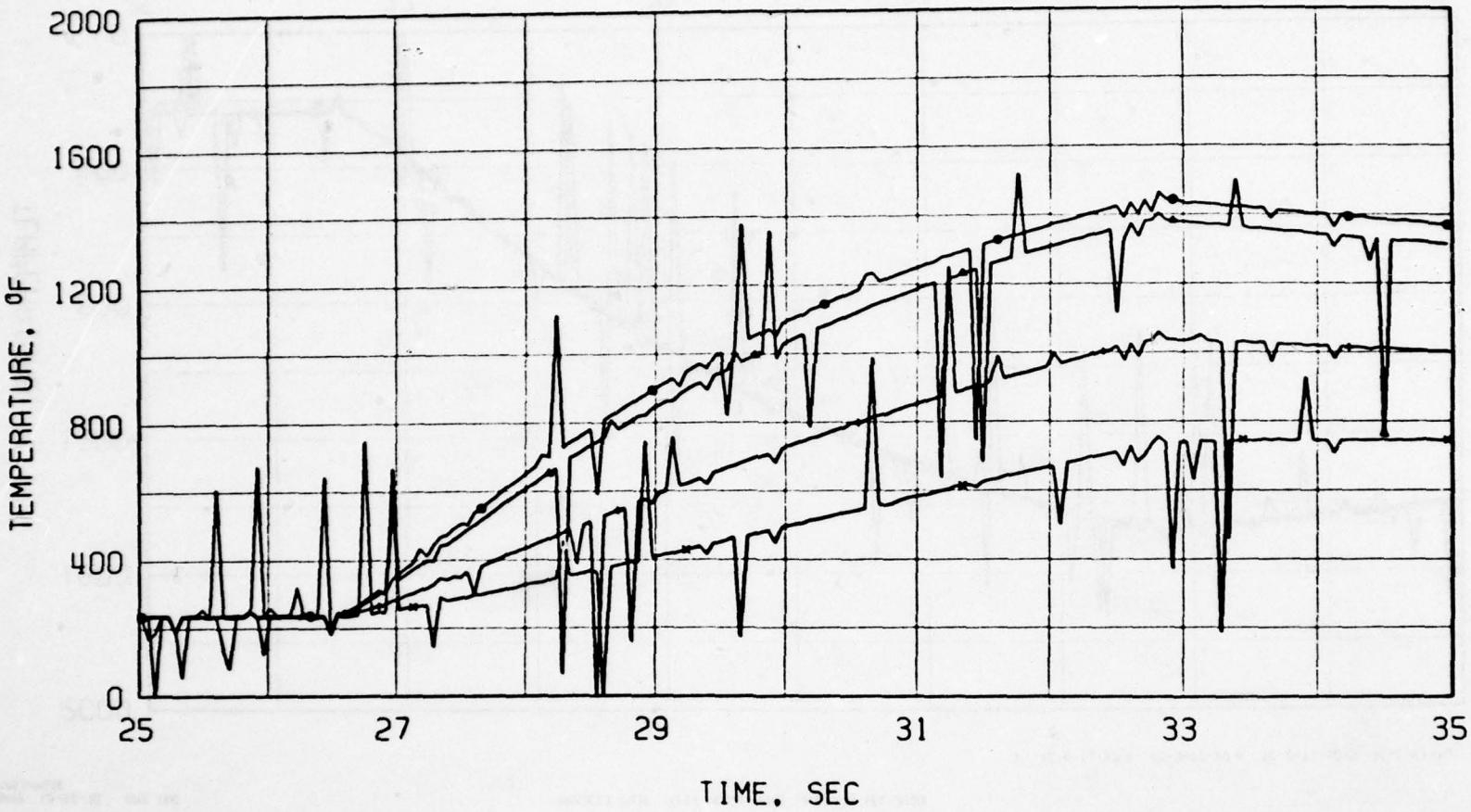
× TC-4-TI-10 + TC-3-TI-10 ▲ TC-2-TI-10 ⊙ TC-1-TI-10



DATE 12-03-76 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 12-01-76 SEL 2103

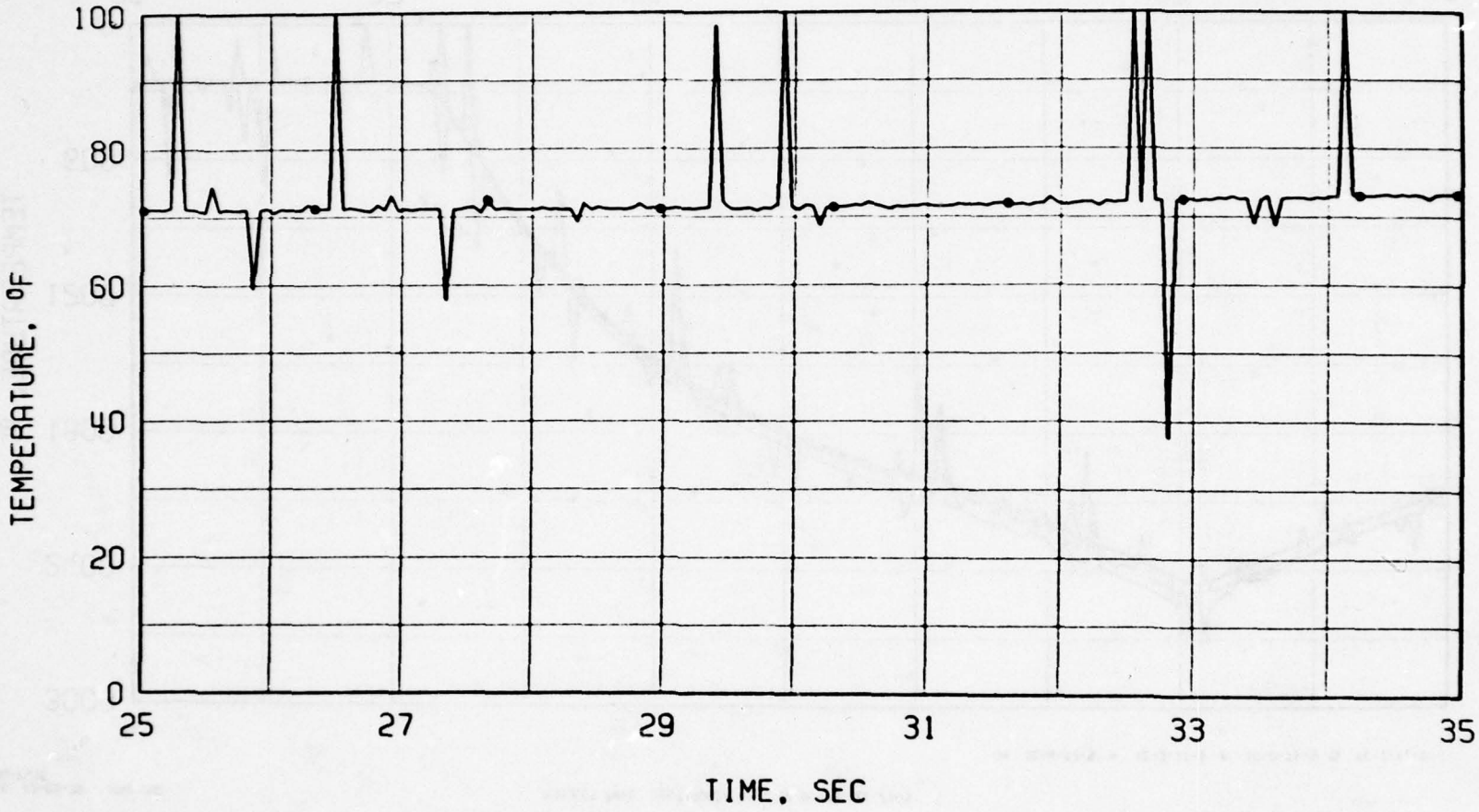
× TC-8-T1-10 + TC-7-T1-10 ▲ TC-6-T1-10 ○ TC-5-T1-10

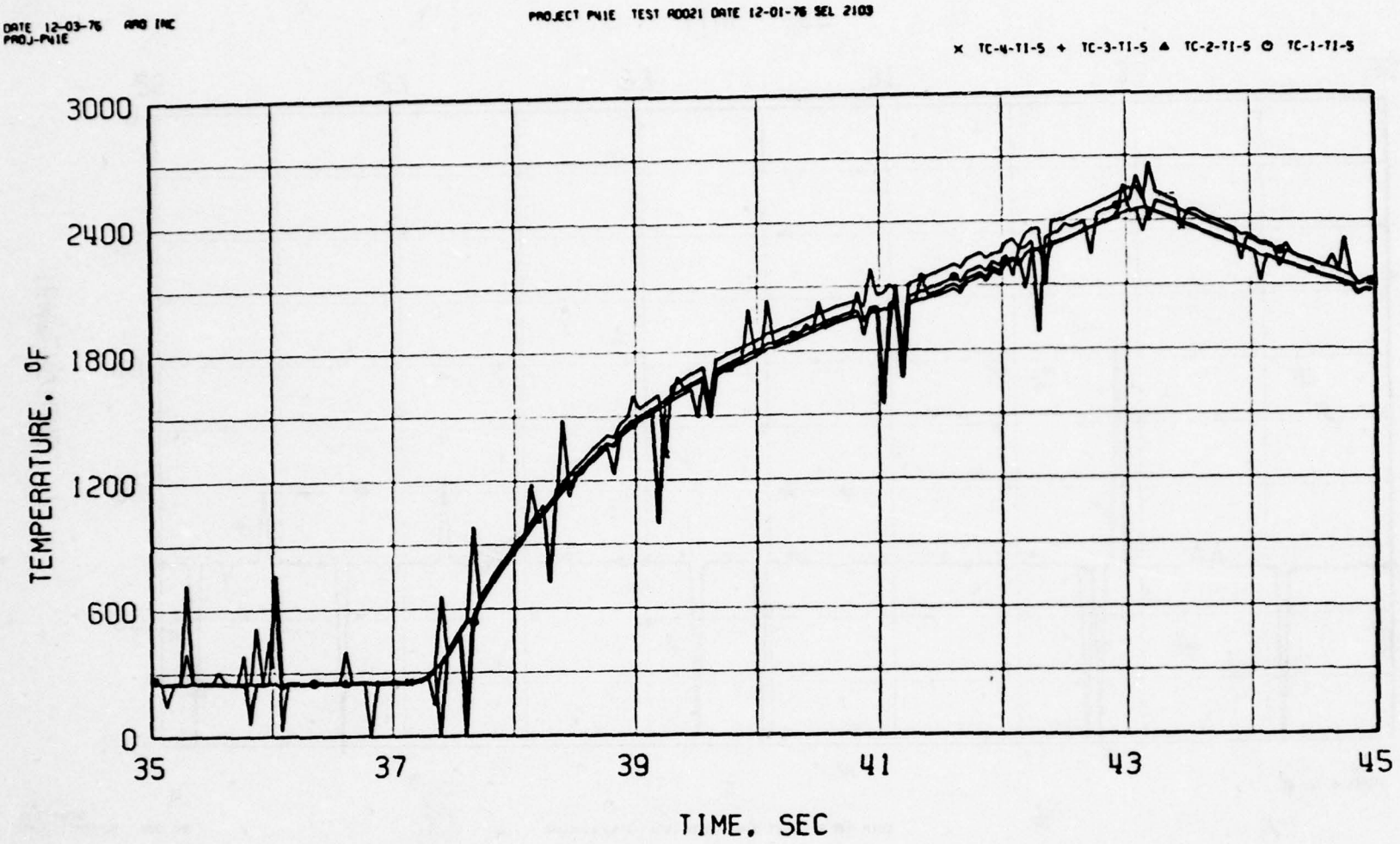


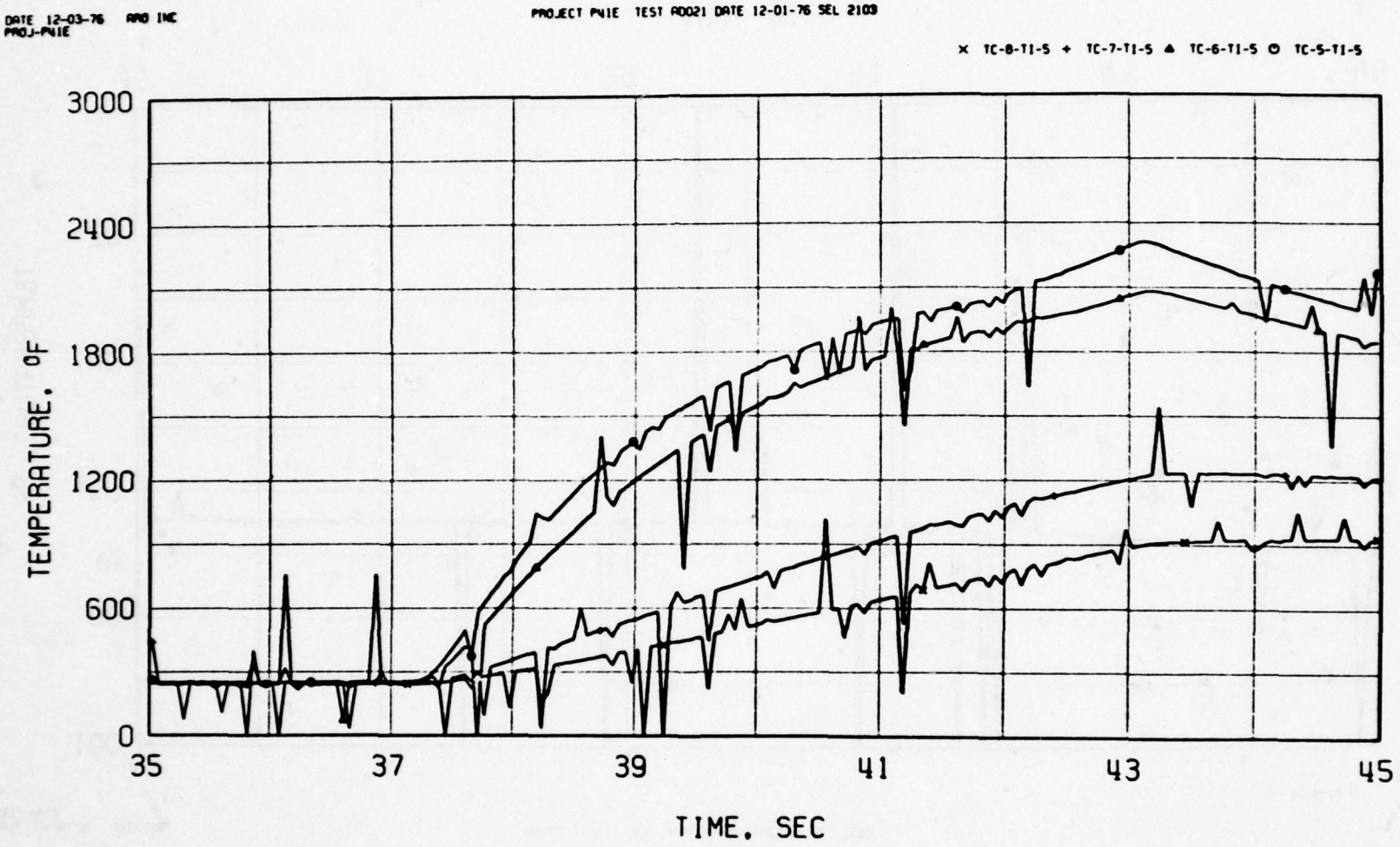
DATE 12-03-76 ARO INC
PROJ-PN1E

PROJECT PN1E TEST A0021 DATE 12-01-76 SEL 2103

○ TC-9-T1-10



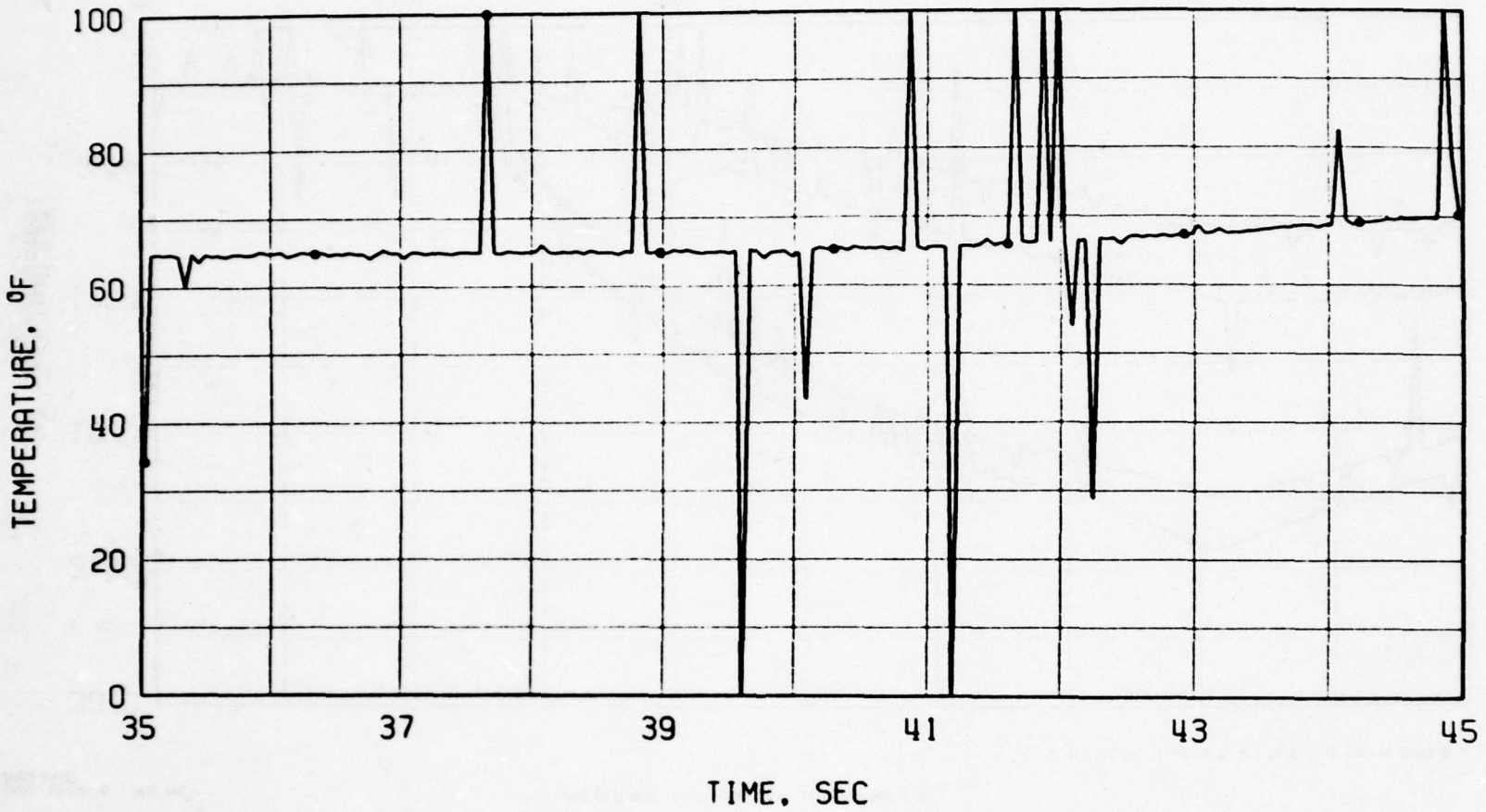

DATE 12-03-76 ARO INC
PROJ-PN1E
PROJECT PN1E TEST A0021 DATE 12-01-76 SEL 2103
× TC-4-TI-5 + TC-3-TI-5 ▲ TC-2-TI-5 ⊙ TC-1-TI-5
3000
2400
1800
1200
600
0
TEMPERATURE, °F
35
37
39
41
43
45
TIME, SEC


DATE 12-03-76 ARO INC
PROJ-PWIE
PROJECT PWIE TEST A0021 DATE 12-01-76 SEL 2103
× TC-8-TI-5 + TC-7-TI-5 ▲ TC-6-TI-5 ⊙ TC-5-TI-5
3000
2400
1800
1200
600
0
TEMPERATURE, °F
35
37
39
41
43
45
TIME, SEC

DATE 12-03-76 ARO INC
PROJ-PWIE

PROJECT PWIE TEST A0021 DATE 12-01-76 SEL 2103

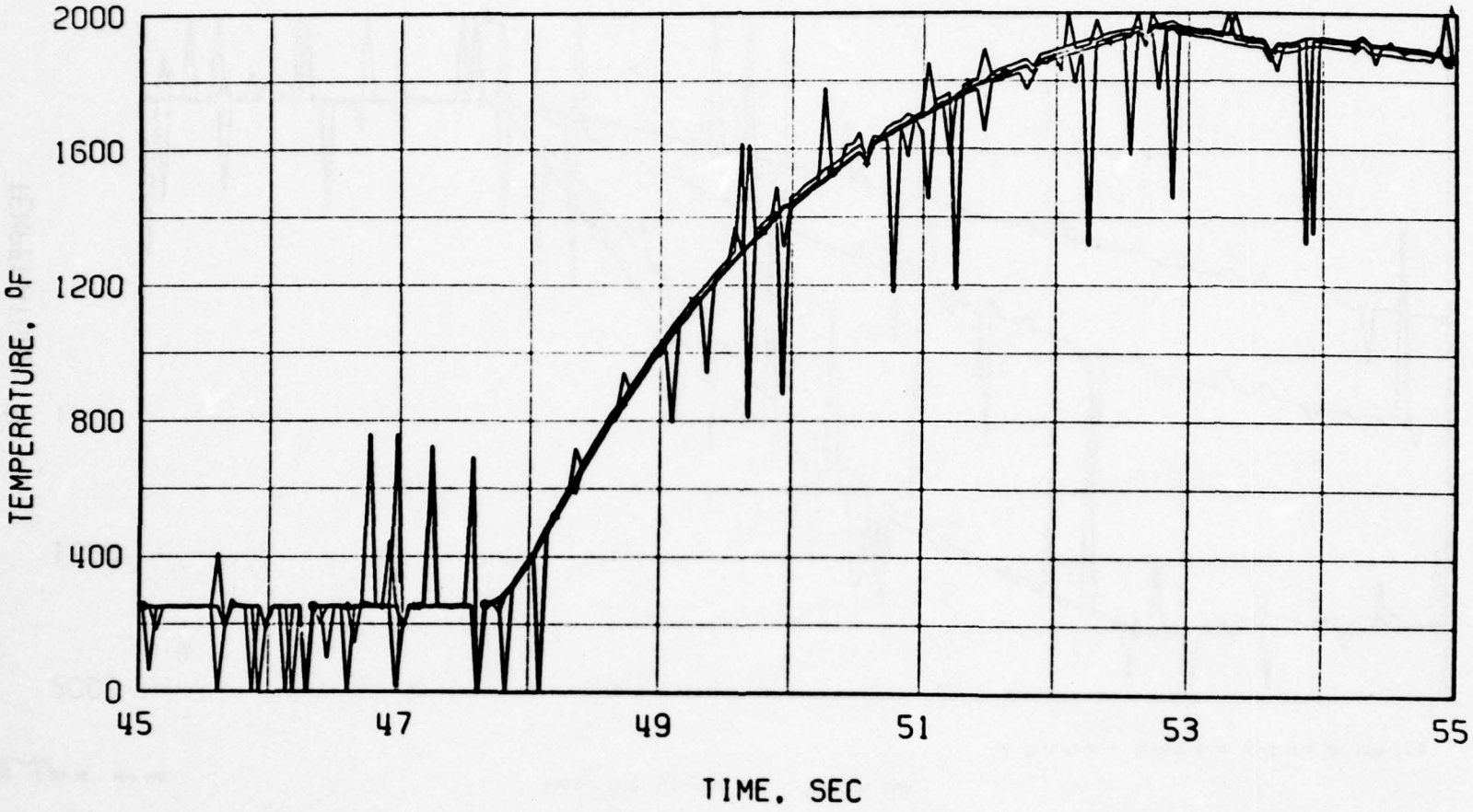
○ TC-9-T1-5

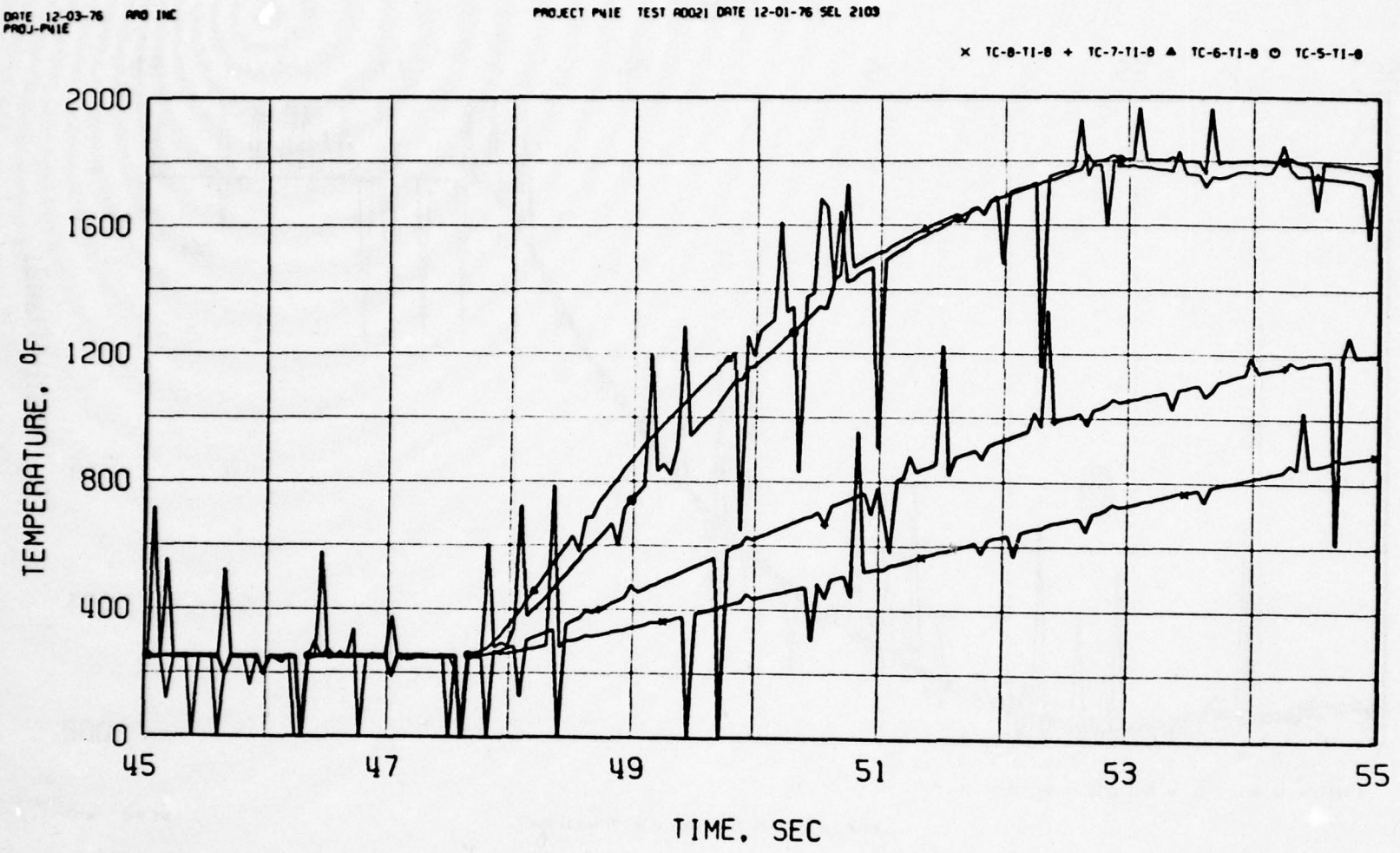


DATE 12-03-76 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 12-01-76 SEL 2103

× TC-4-TI-8 + TC-3-TI-8 ▲ TC-2-TI-8 ○ TC-1-TI-8

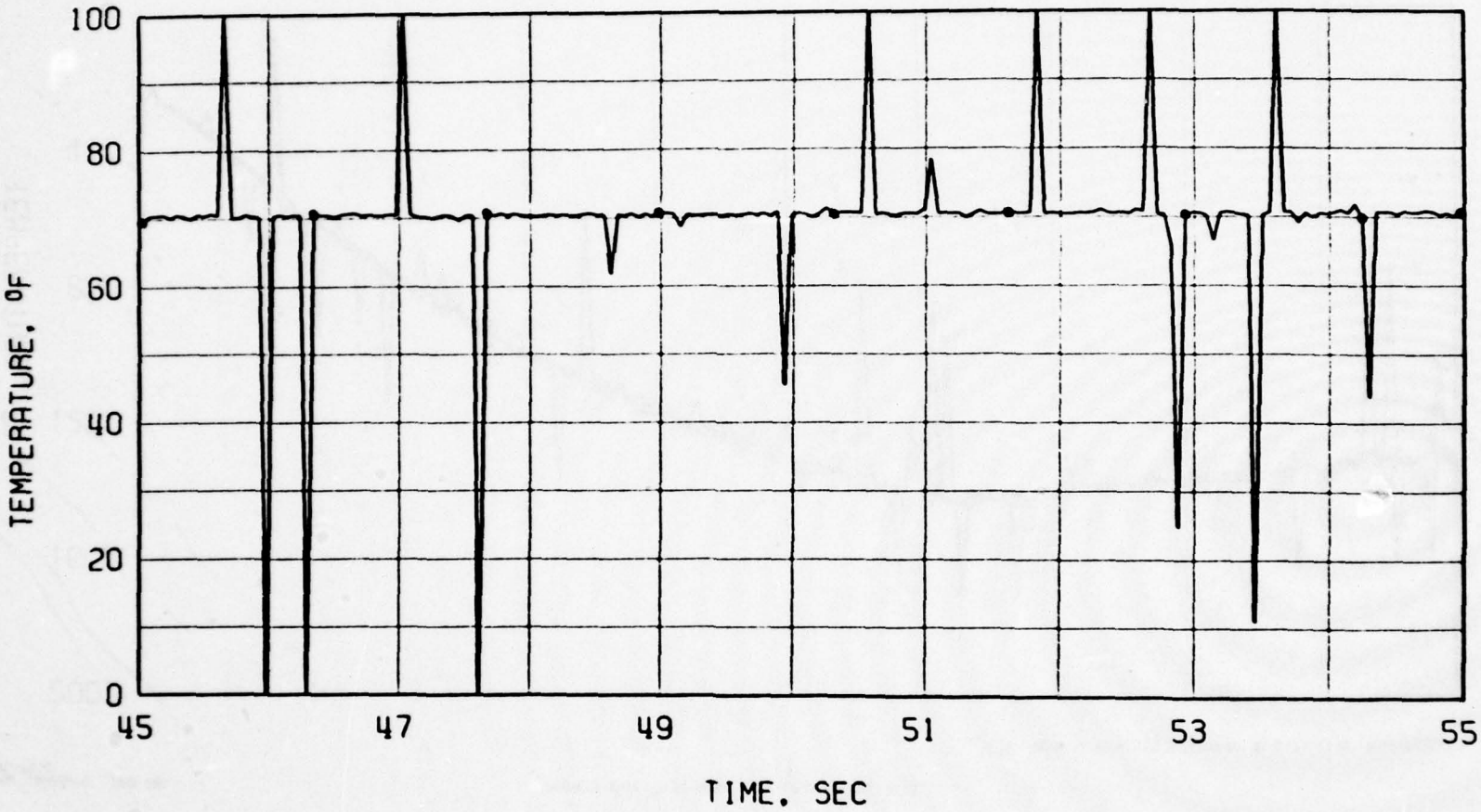


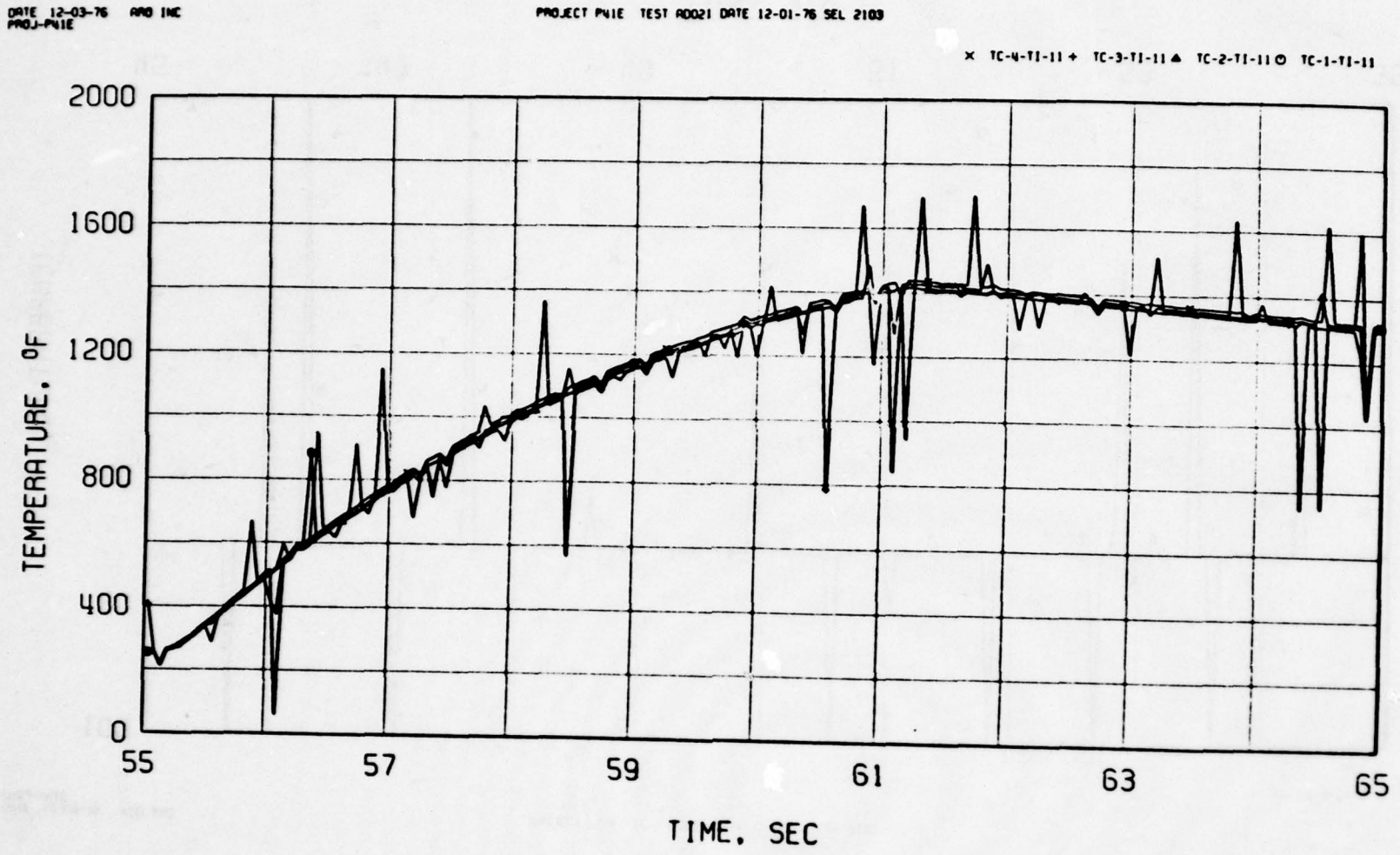

DATE 12-03-76 ARO INC
PROJ-PNIE
PROJECT PNIE TEST A0021 DATE 12-01-76 SEL 2109
× TC-8-TI-8 + TC-7-TI-8 ▲ TC-6-TI-8 ○ TC-5-TI-8
2000
1600
1200
800
400
0
TEMPERATURE, °F
45
47
49
51
53
55
TIME, SEC

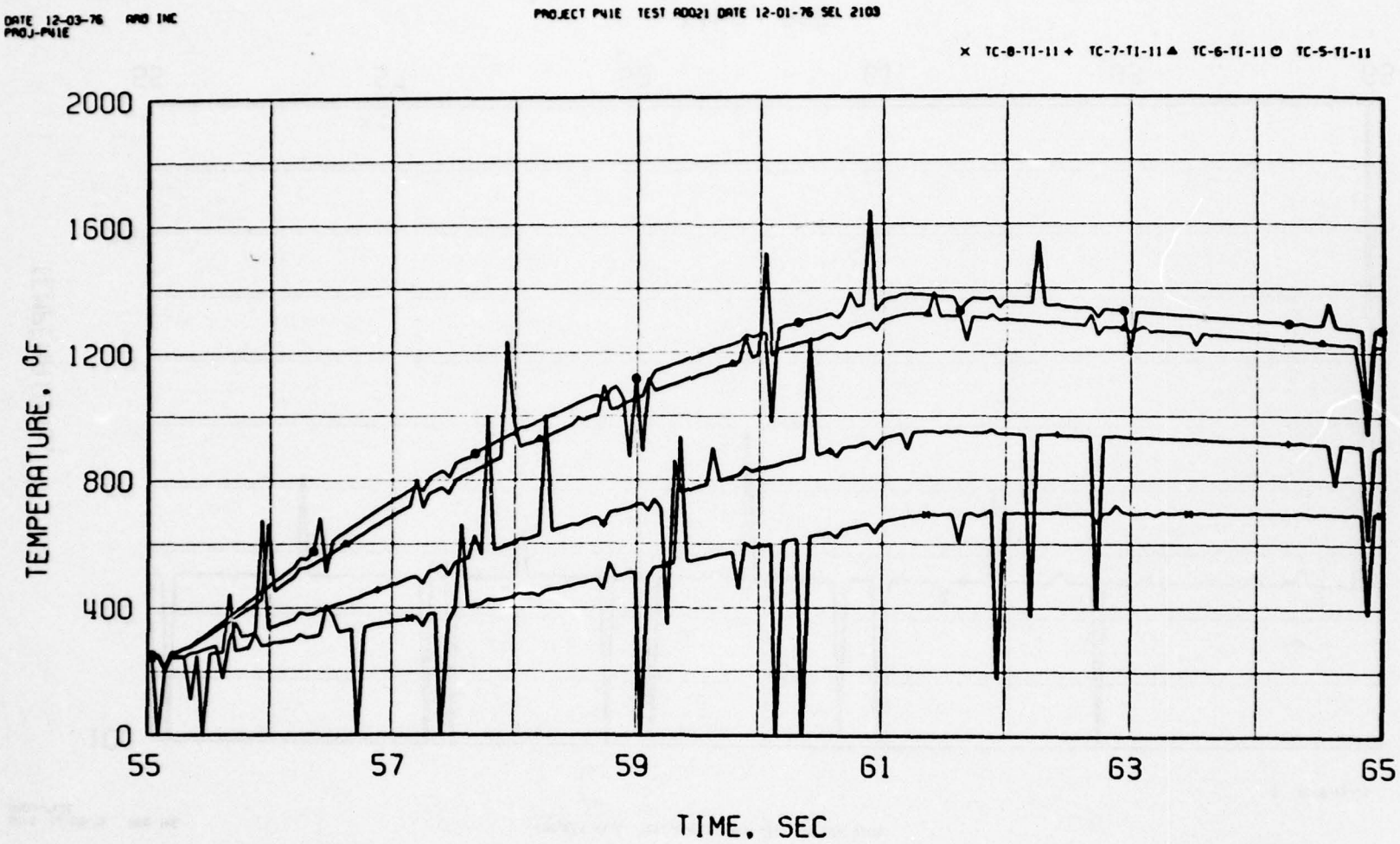
DATE 12-03-76 ARO INC
PROJ-PWIE

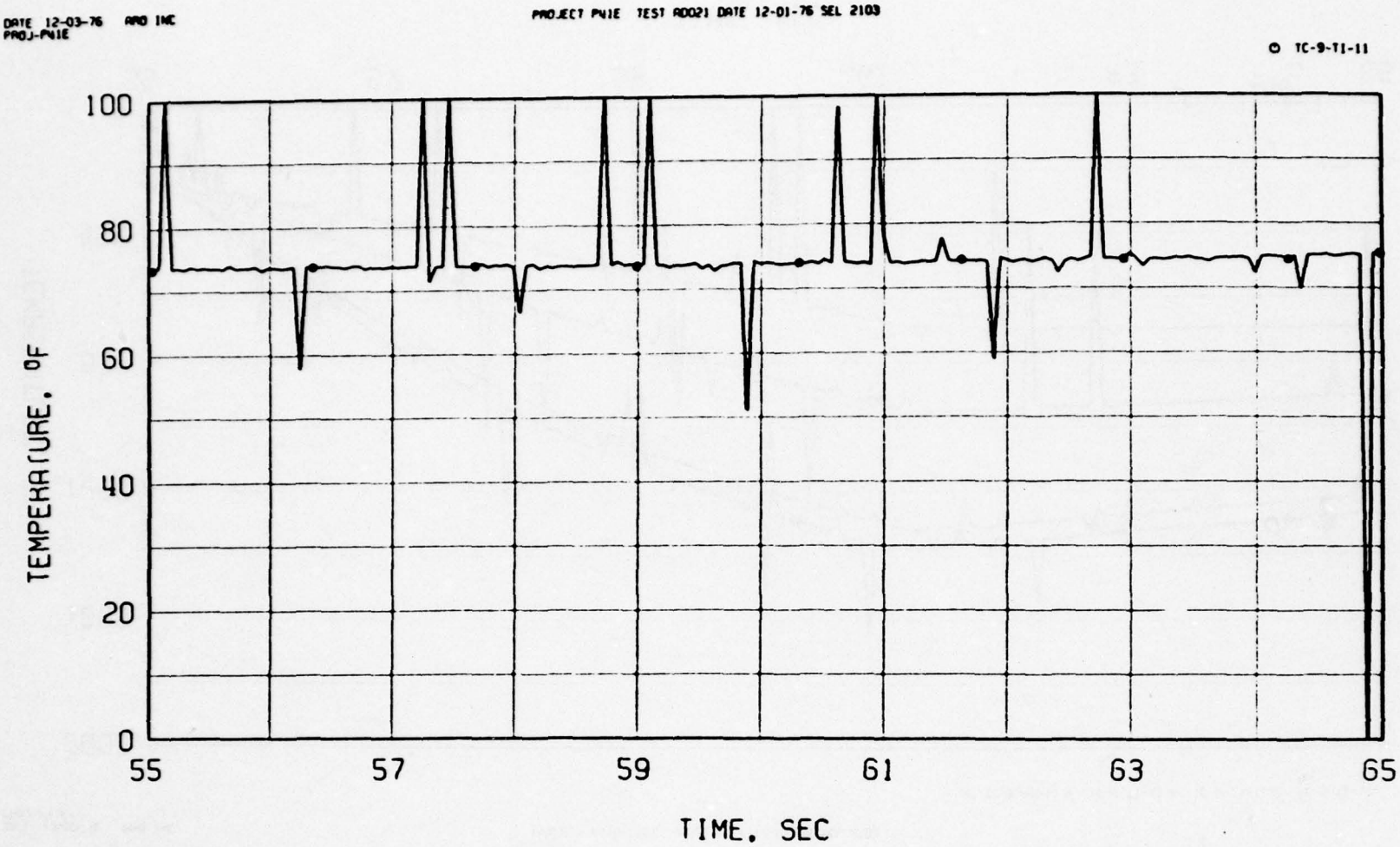
PROJECT PWIE TEST AD021 DATE 12-01-76 SEL 2109

○ TC-9-T1-8




DATE 12-03-76 ARO INC
PROJ-PN1E
PROJECT PN1E TEST A0021 DATE 12-01-76 SEL 2103
× TC-4-TI-11 + TC-3-TI-11 ▲ TC-2-TI-11 ⊙ TC-1-TI-11
2000
1600
1200
800
400
0
TEMPERATURE, °F
55
57
59
61
63
65
TIME, SEC


DATE 12-03-76 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 12-01-76 SEL 2109
× TC-8-TI-11 + TC-7-TI-11 ▲ TC-6-TI-11 ⊙ TC-5-TI-11
2000
1600
1200
800
400
0
TEMPERATURE, °F
55
57
59
61
63
65
TIME, SEC


DATE 12-03-76 ARO INC
PROJ-PWIE
PROJECT PWIE TEST AD021 DATE 12-01-76 SEL 2103
© TC-9-T1-11
100
80
60
40
20
0
TEMPERATURE, °F
55
57
59
61
63
65
TIME, SEC

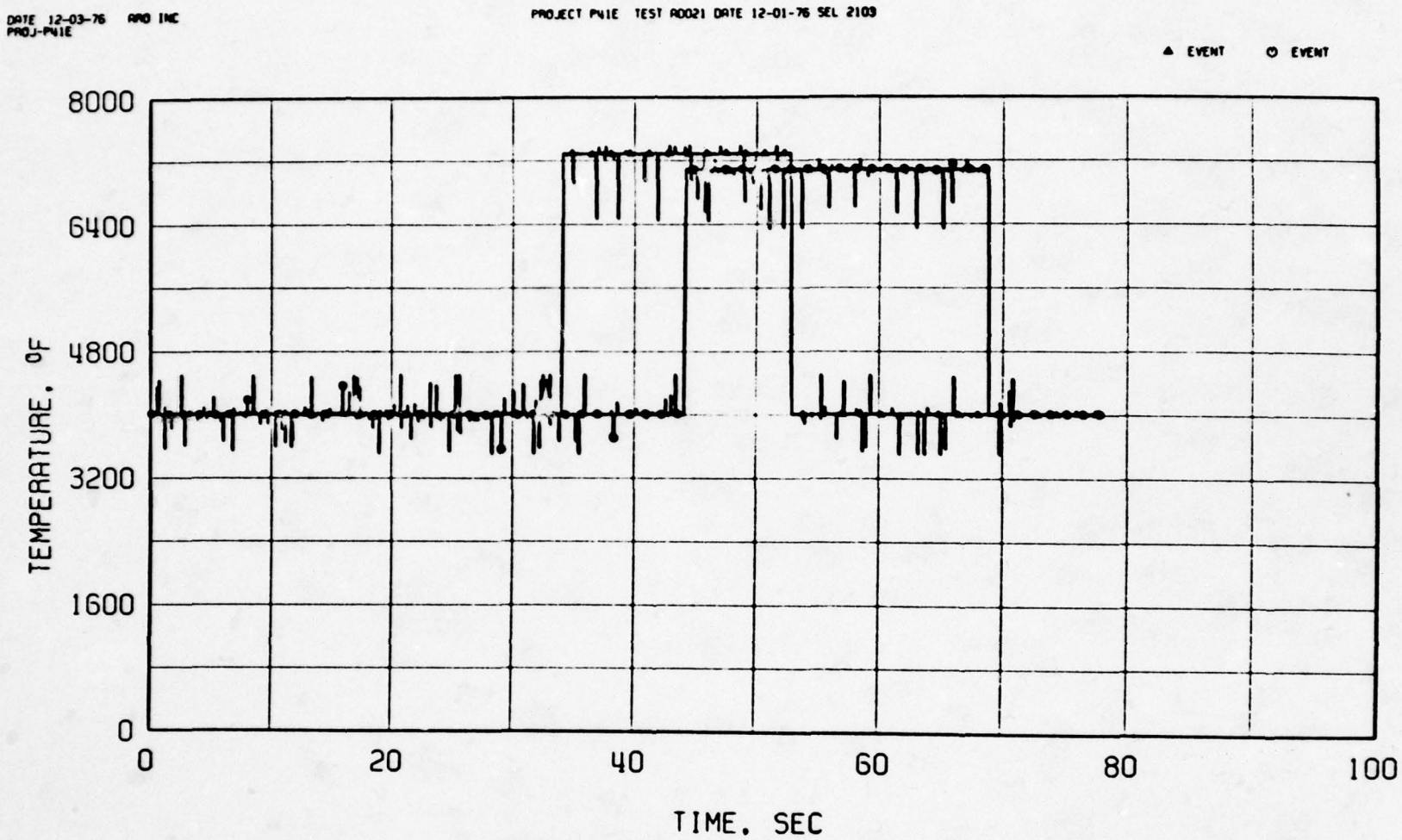

DATE 12-03-76 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 12-01-76 SEL 2109
▲ EVENT
⊙ EVENT
8000
6400
4800
3200
1600
0
TEMPERATURE, °F
0
20
40
60
80
100
TIME, SEC

TABLE 1 RUN SUMMARY

TUNNEL CONDITIONS

RUN 4 DATE 12-3-76

NOZZLE STATION 127.5

P_o = 506 psia, P_{o_m} = 475

H_{o_B} = 487 Btu/lbm, H_{o_m} = 286

H_o = 550 Btu/lbm

T_{o_B} = 1940 °R, T_o = 2162 °R

M = 7.4 p_o' = 5.3 psia

DUST

TYPE MgO

SIZE 100 µm

VEL 4130 ft/sec

Flow 10.37 gm/sec

C.F. 33.9

WATER

Flow 2.49 gpm

C.F. 302

Orifice 0.062 in.

ΔP 452 psi

STING	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANS-DUCER TYPE	PRERUN	POSTRUN
1	P_o' Probe	4					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_o Probe	25					See Fig. 3	0.25		R	1					
3	T_i-7	10.15					Hemi	2.0	6Al-4V-T_i	S	8				7924	
4	WB9-2		4				See Fig. 2	0.5	Al							8035
5	T_i-10		10				Hemi	2.0	6Al-4V-T_i	S	8					8032
6	WB-6R		4	4	x 4		See Fig. 2	2.0	Al							8033
7	T_i-16		8.90	10.51	x 8.90		Hemi	2.0	6Al-4V-T_i	S	8				6837	8034
8	T_i-2			9.76			Hemi	2.0	6Al-4V-T_i	S	8				7733	8031
9	WB9-1			6			See Fig. 2	2.0	Al							8035
10																

KEY -

PH - PREHEAT

POH - POSTHEAT

DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

NOTES:

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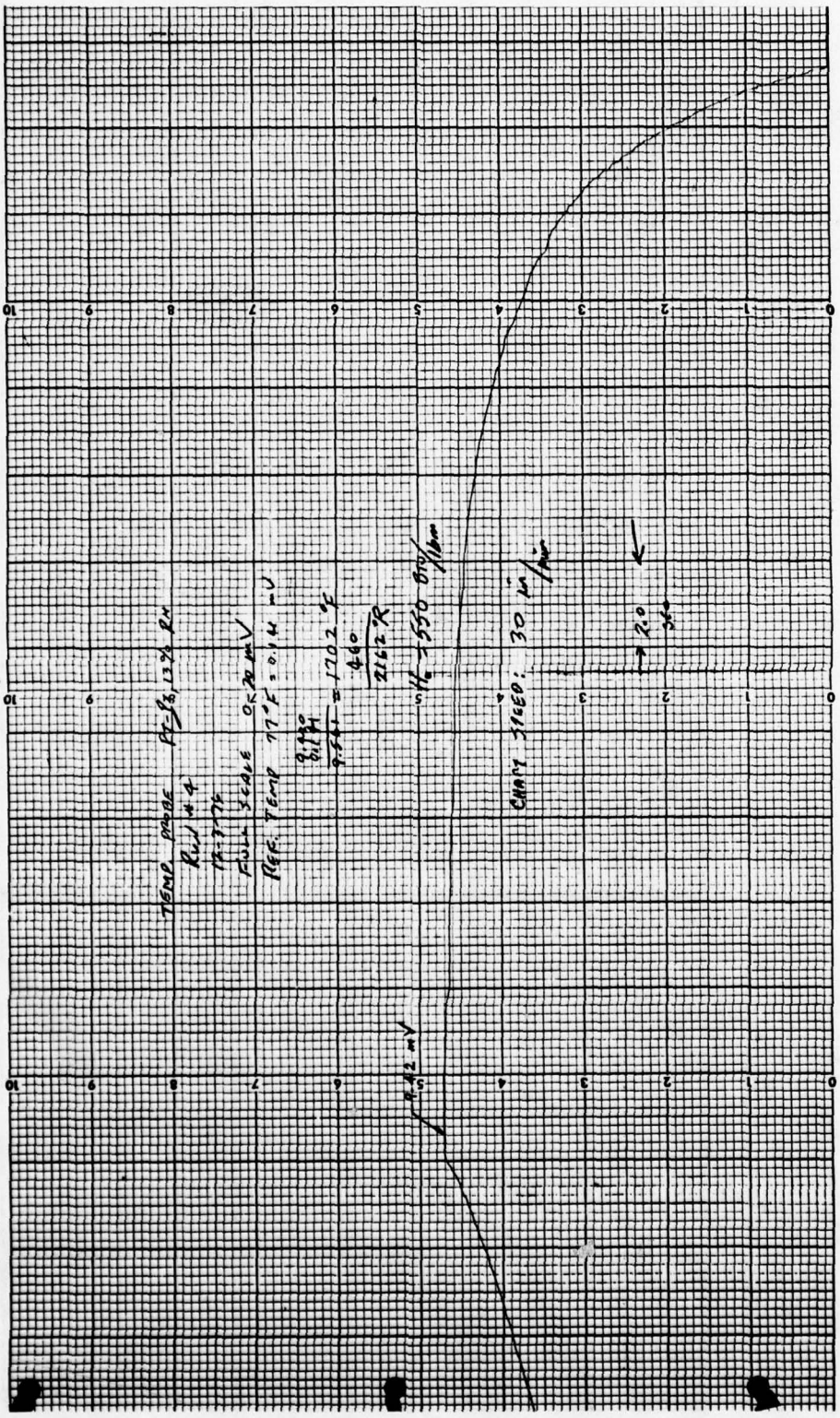
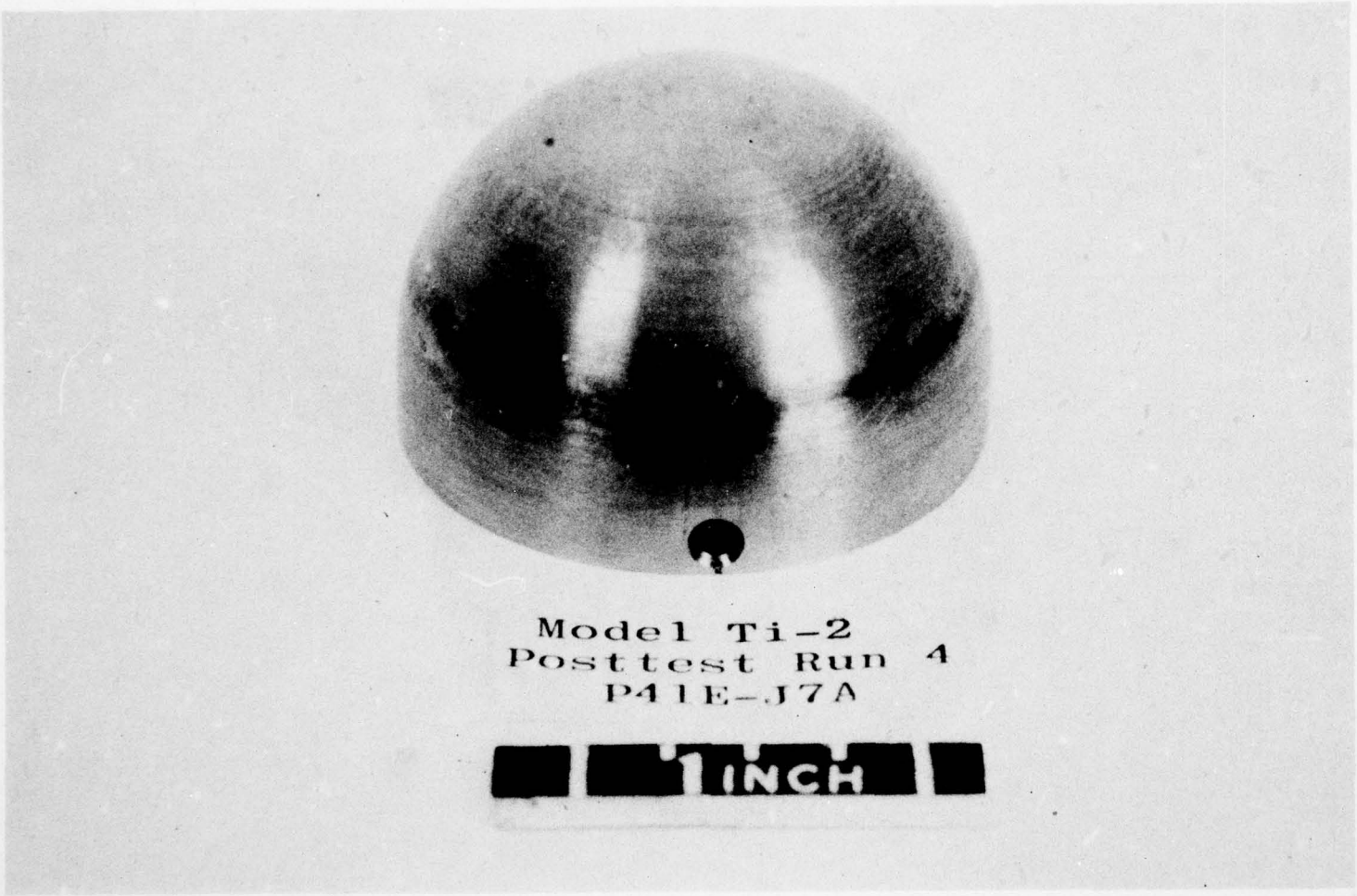
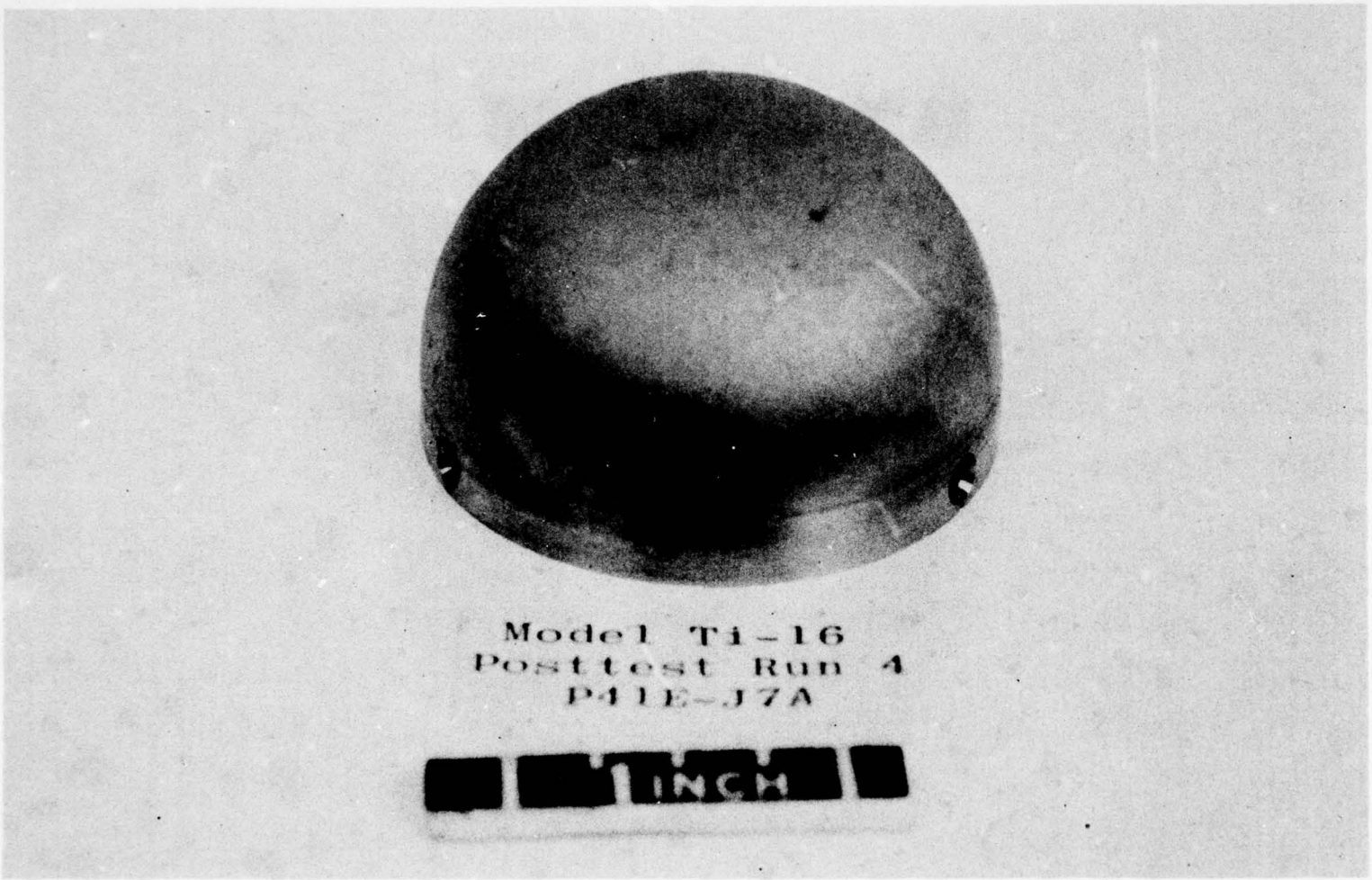
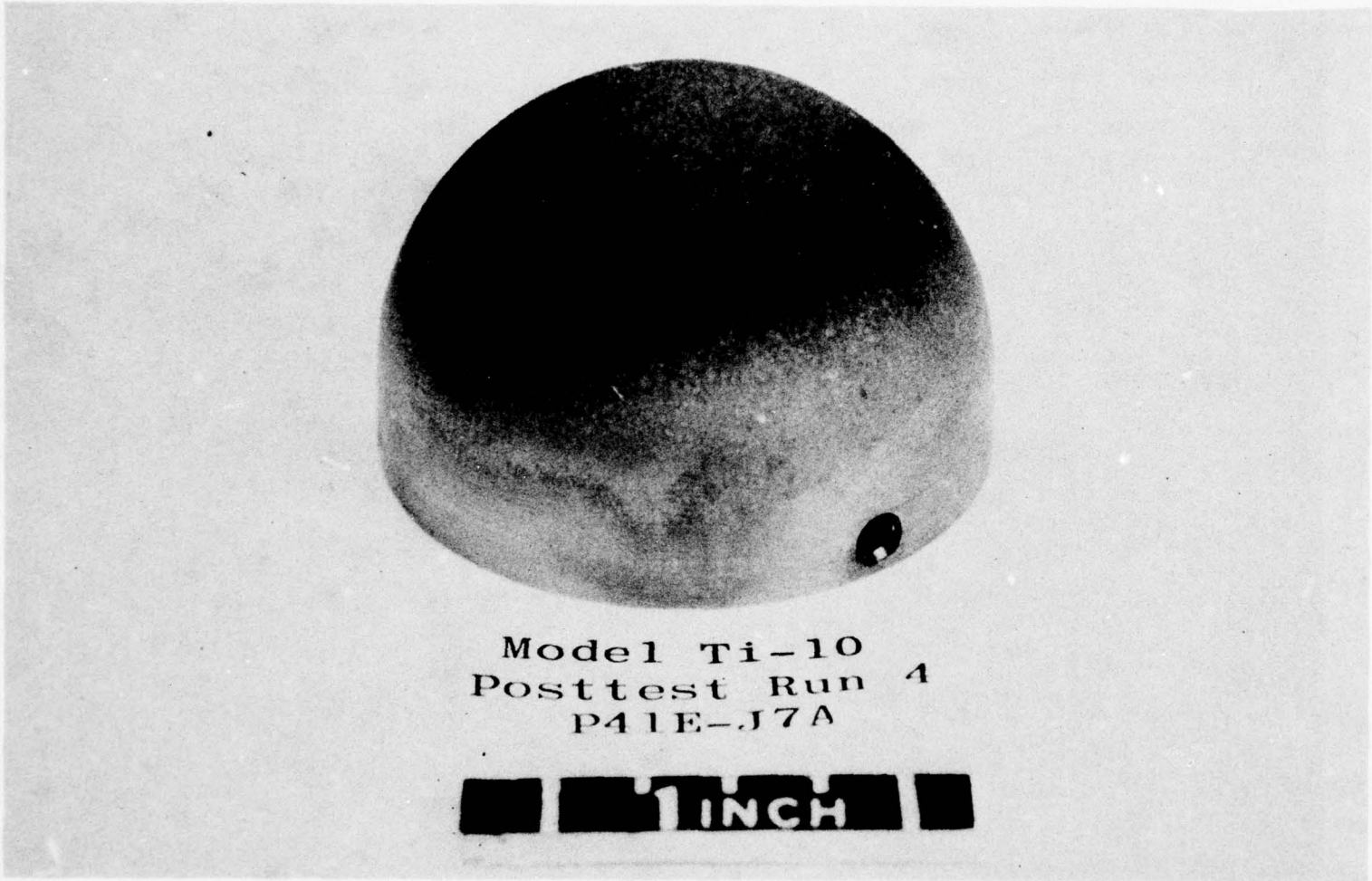
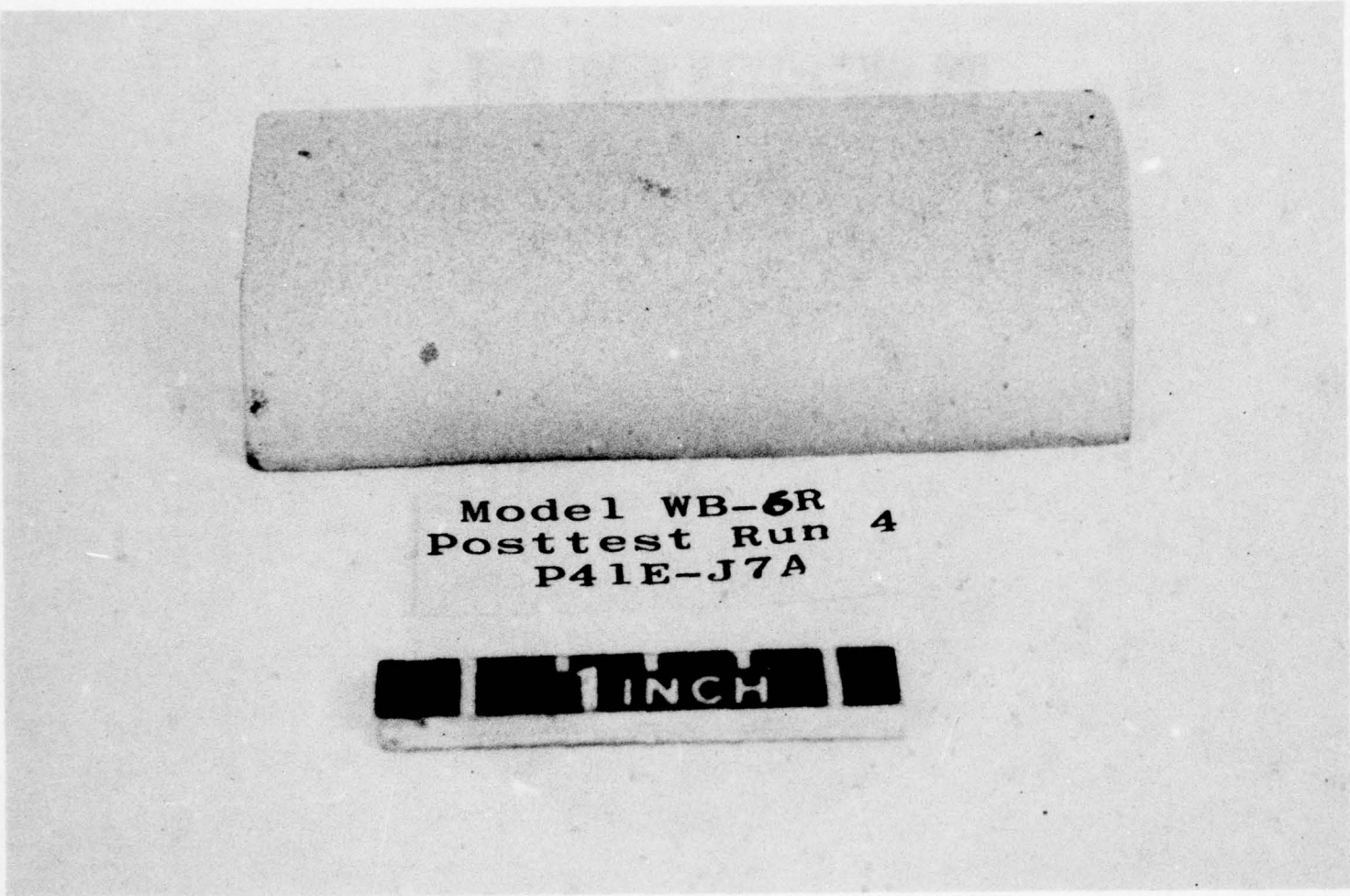

TEMP MODE
Run #4
12-7-76
FULL SCALE 0 to 20 mV
REF. TEMP 77°F = 0.14 mV
9.170 / 8.542 = 1702 °F
460
2162 °R
H = 550 BTU/lbm
CHART SPEED: 30 in/min
2.0 sec
8.42 mV

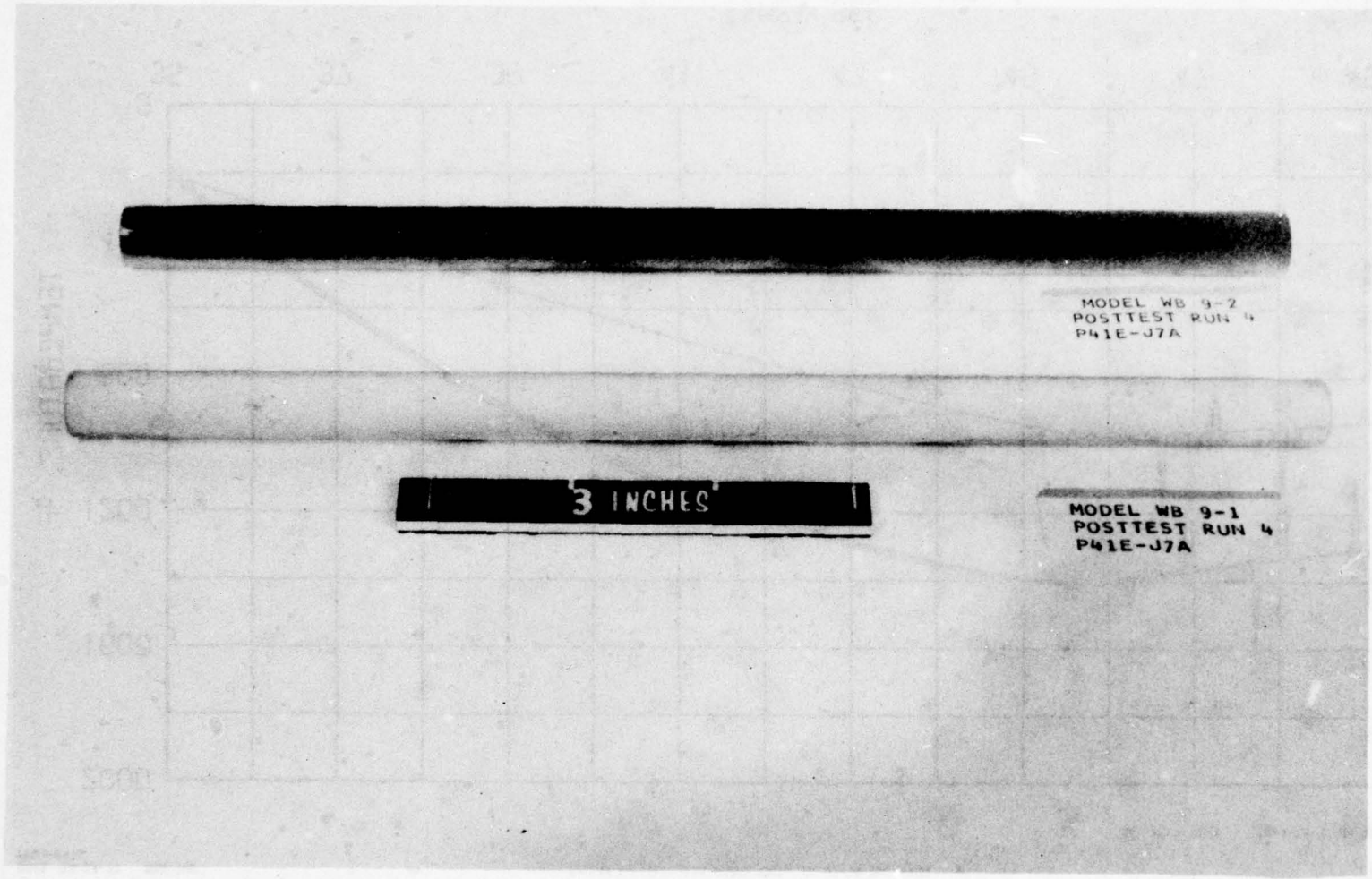


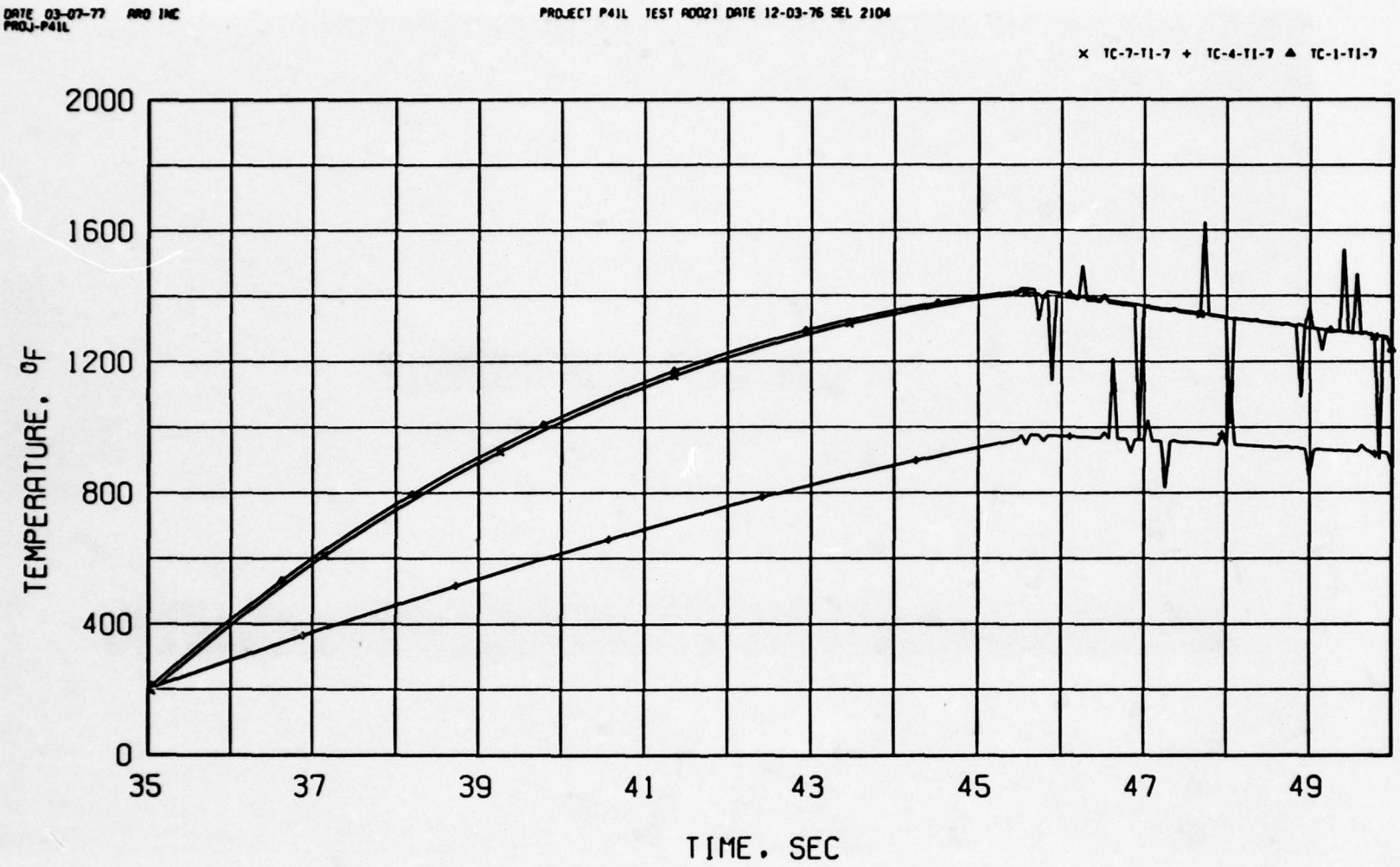
Model Ti-2
Posttest Run 4
P41E-J7A


Model Ti-16
Posttest Run 4
P41E-J7A
INCH


Model Ti-10
Posttest Run 4
P41E-J7A
1 INCH


Model WB-6R
Posttest Run 4
P41E-J7A
1 INCH

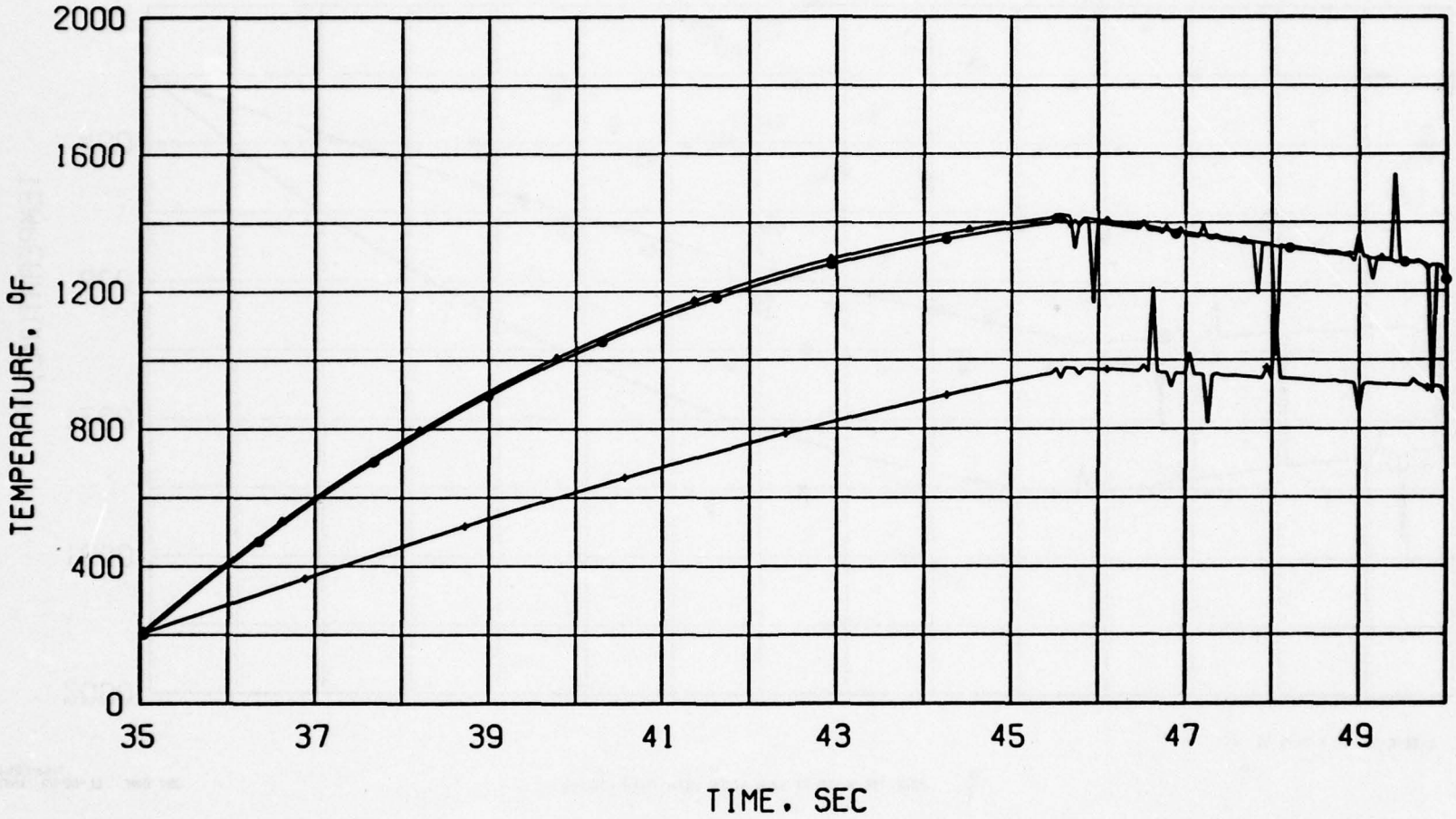

MODEL WB 9-2
POSTTEST RUN 4
P41E-J7A
3 INCHES
MODEL WB 9-1
POSTTEST RUN 4
P41E-J7A


DATE 03-07-77 ARO INC
PROJ-P41L
PROJECT P41L TEST R0021 DATE 12-03-76 SEL 2104
× TC-7-T1-7 + TC-4-T1-7 ▲ TC-1-T1-7
2000
1600
1200
800
400
0
TEMPERATURE, °F
35
37
39
41
43
45
47
49
TIME, SEC

DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST R0021 DATE 12-03-76 SEL 2104

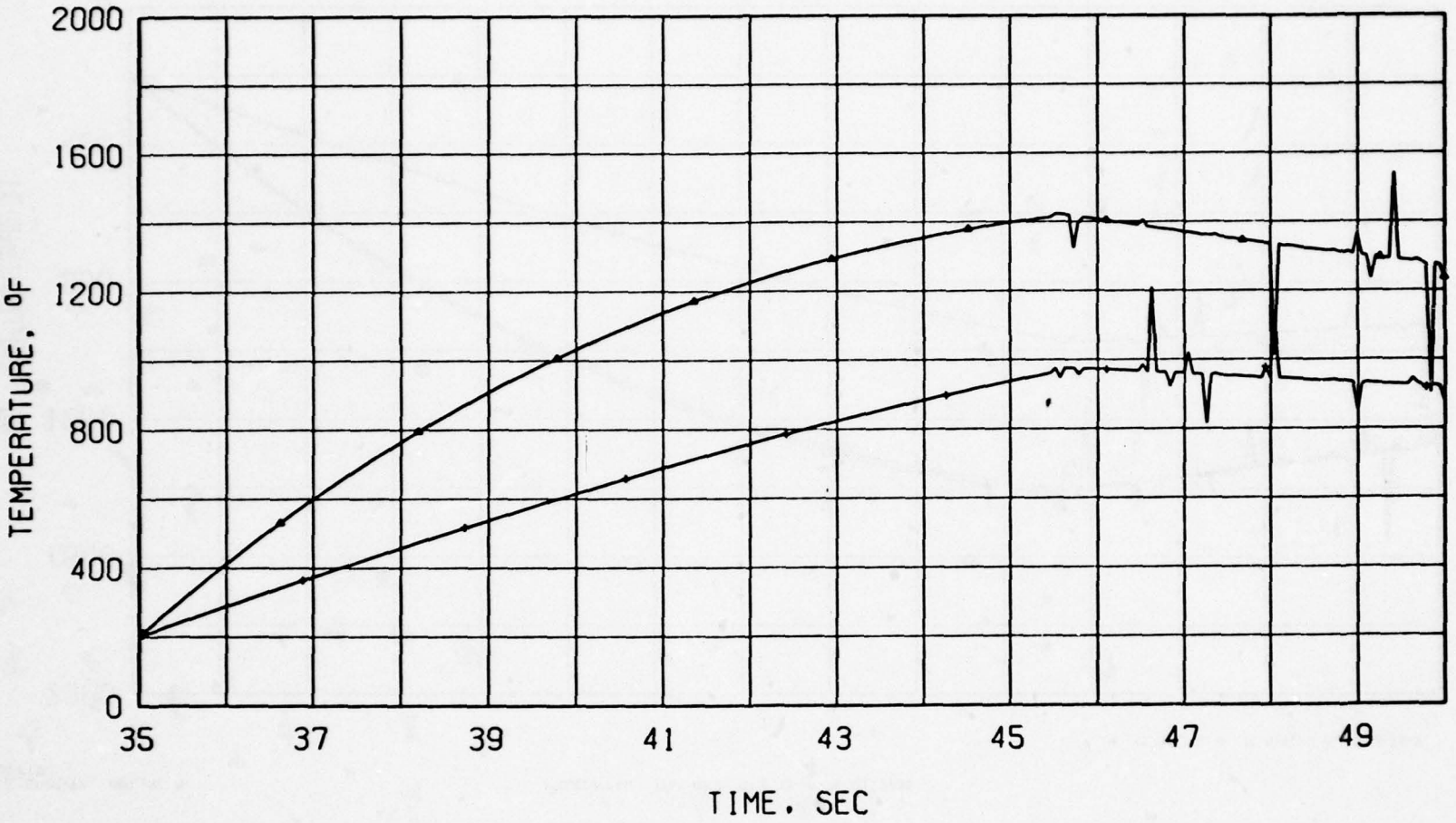
+ TC-8-T1-7 ▲ TC-5-T1-7 ⊙ TC-2-T1-7

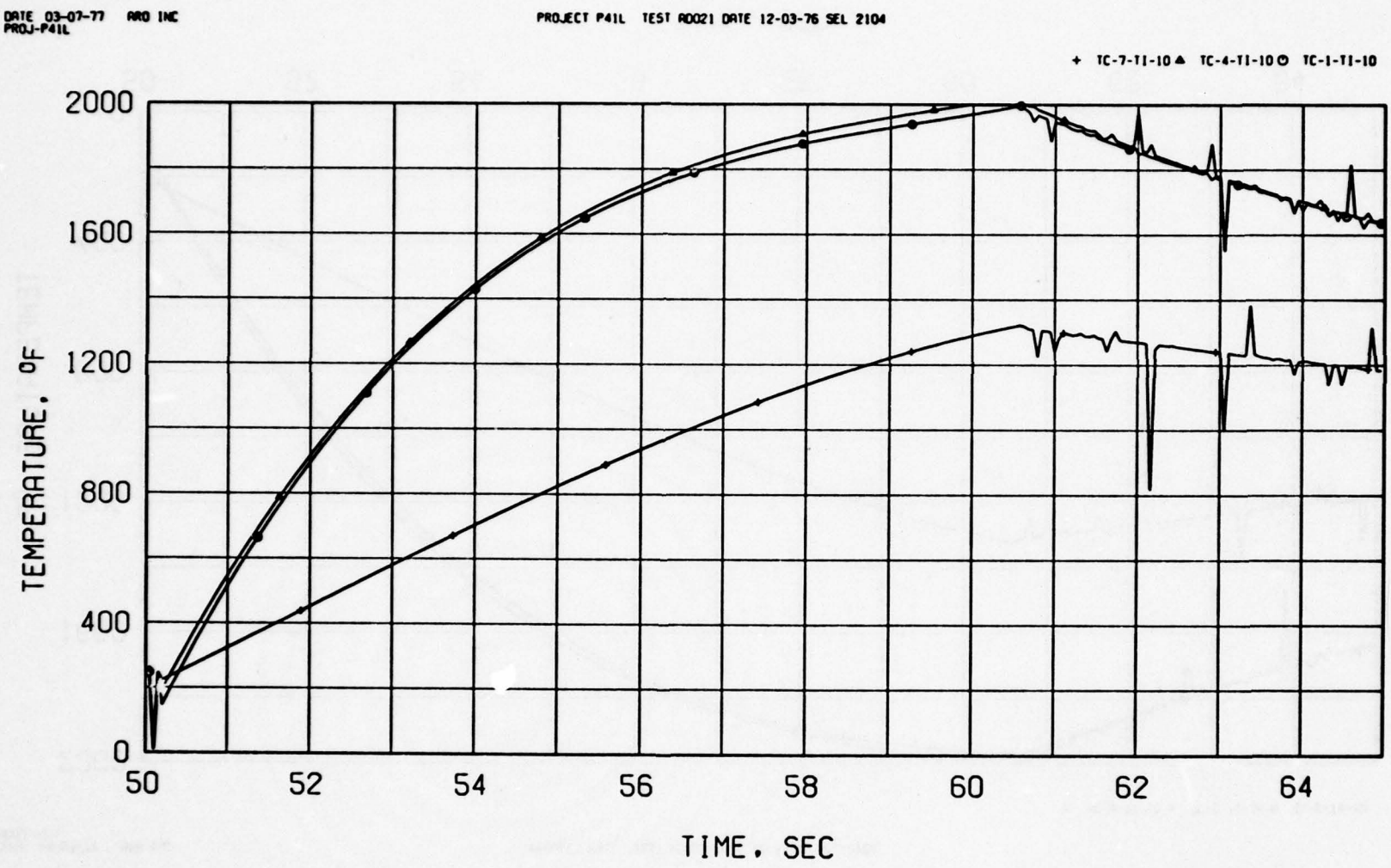


DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST R0021 DATE 12-03-76 SEL 2104

+ TC-6-T1-7 ▲ TC-3-T1-7

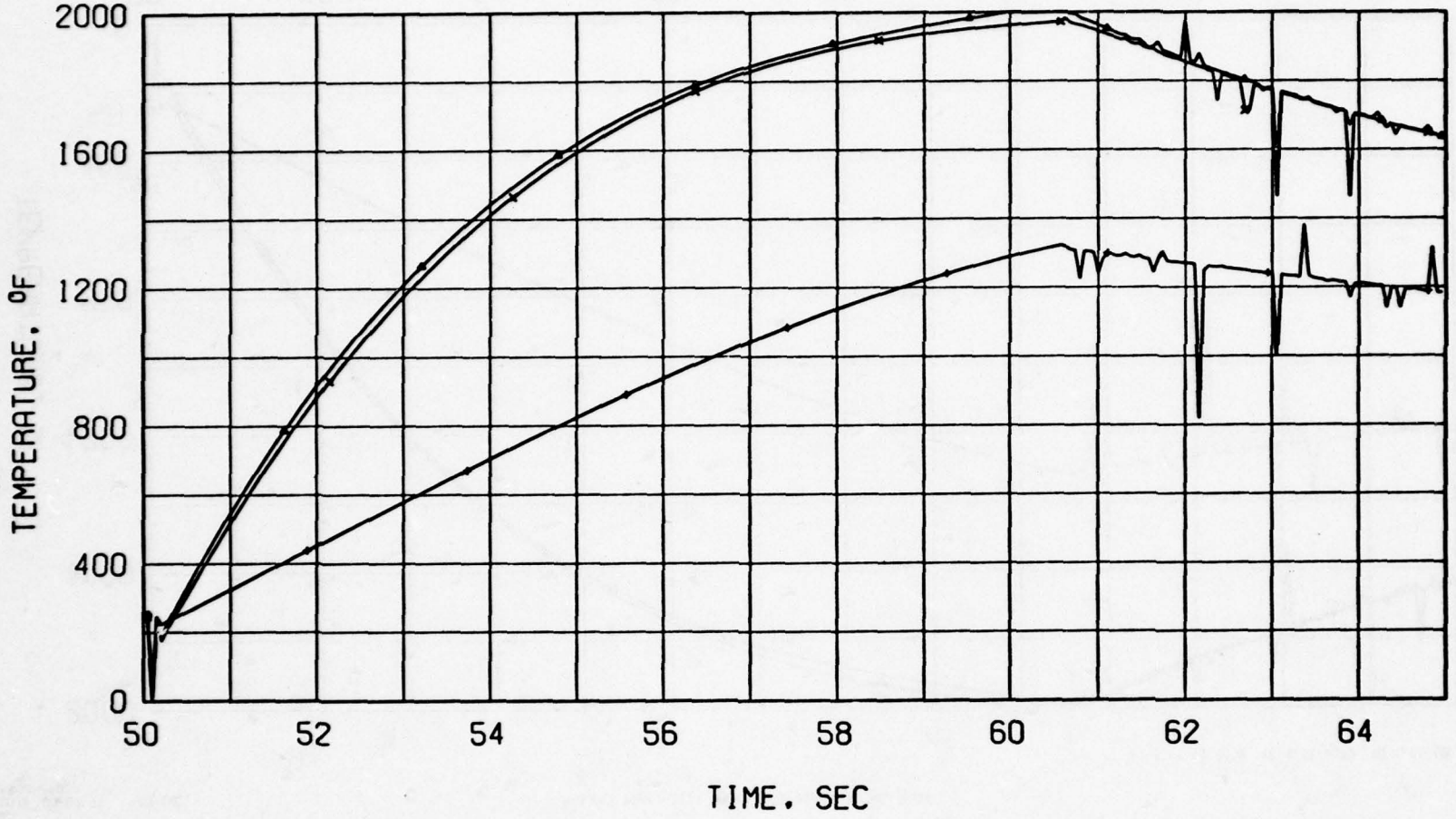



DATE 03-07-77 ARO INC
PROJ-P41L
PROJECT P41L TEST R0021 DATE 12-03-76 SEL 2104
+ TC-7-T1-10 ▲ TC-4-T1-10 ○ TC-1-T1-10
2000
1600
1200
800
400
0
TEMPERATURE, °F
50
52
54
56
58
60
62
64
TIME, SEC

DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST R0021 DATE 12-03-76 SEL 2104

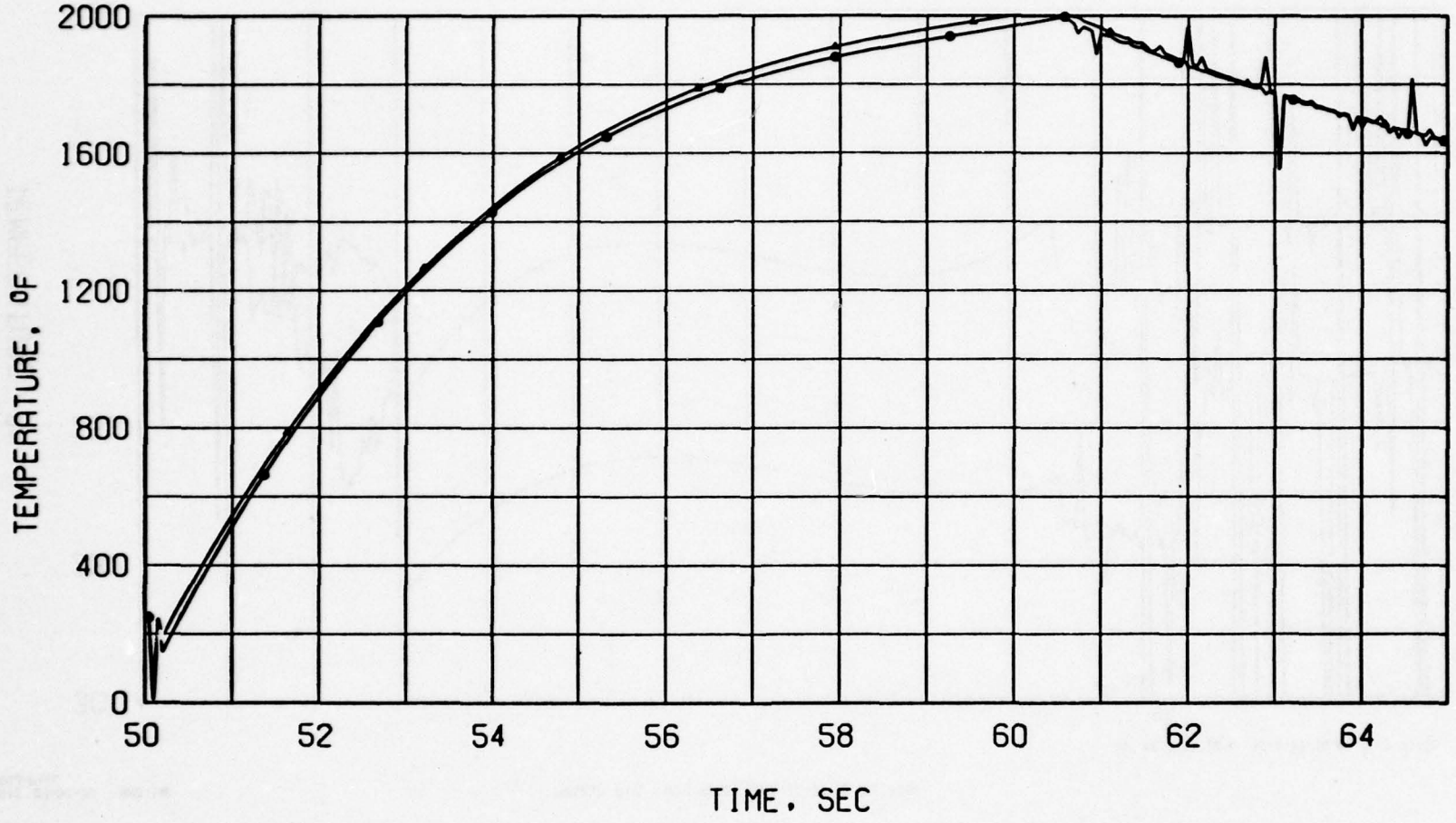
× TC-8-T1-10 + TC-5-T1-10 ▲ TC-2-T1-10

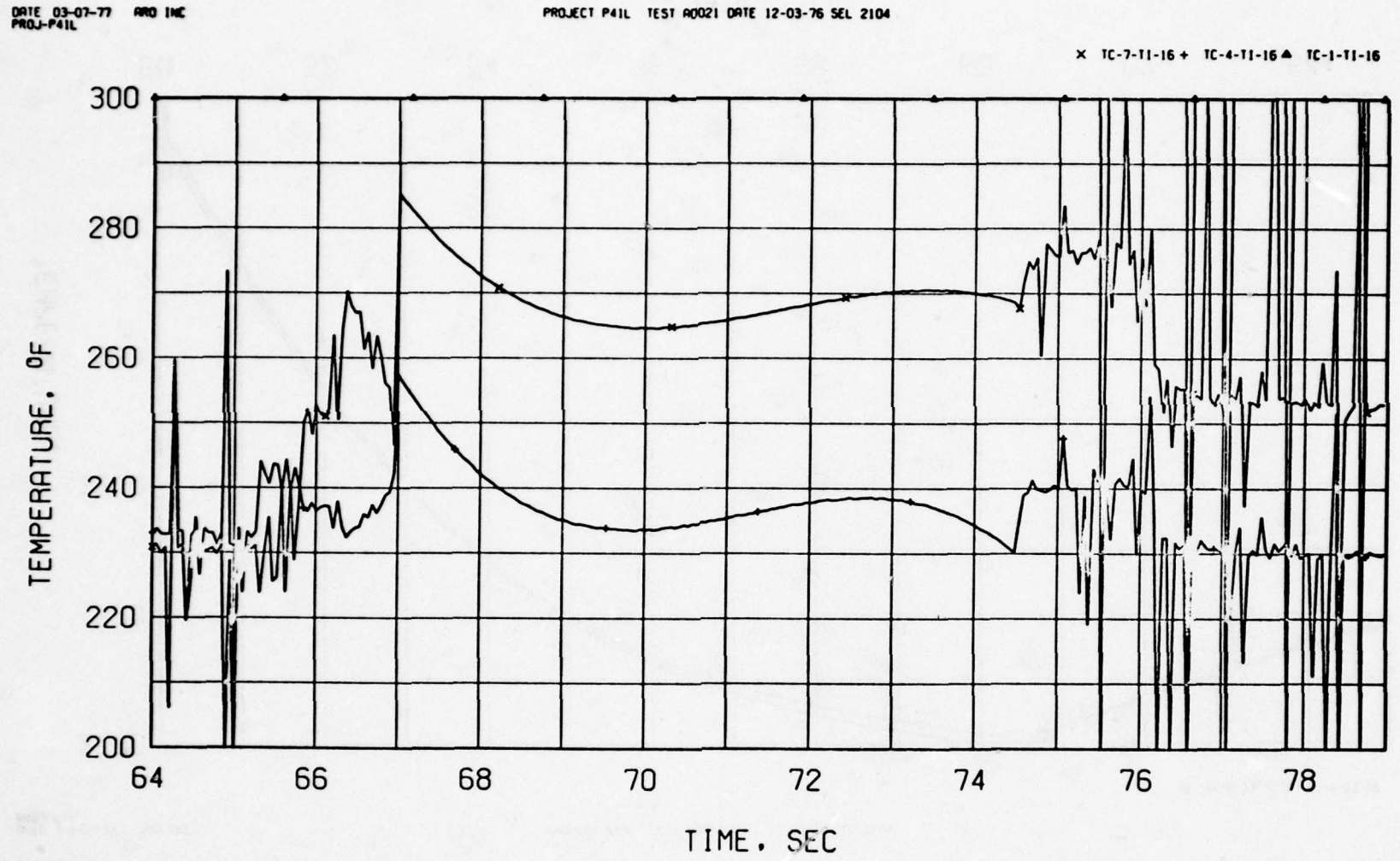


DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST A0021 DATE 12-03-76 SEL 2104

▲ TC-6-T1-10 ⊙ TC-3-T1-10

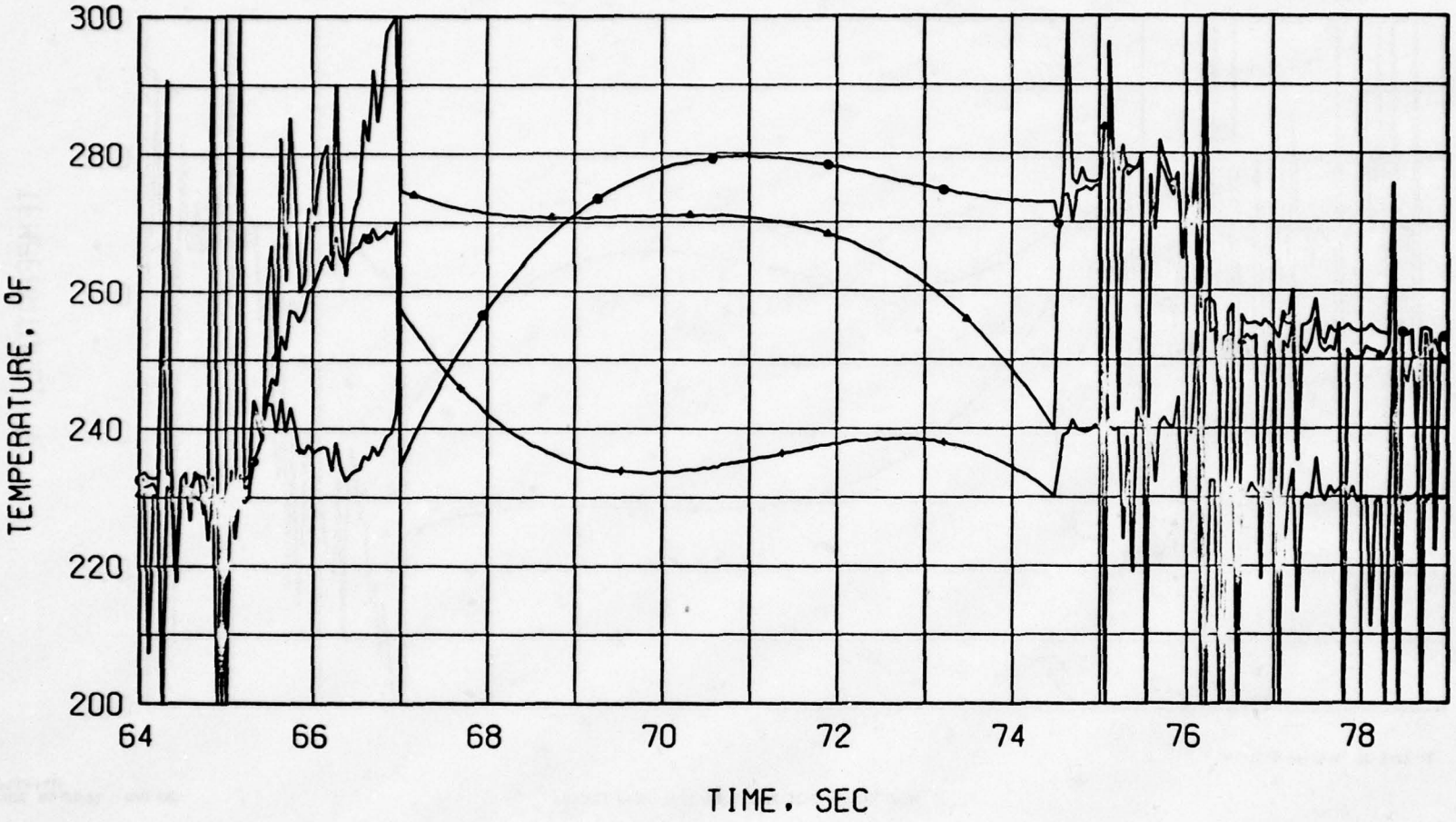


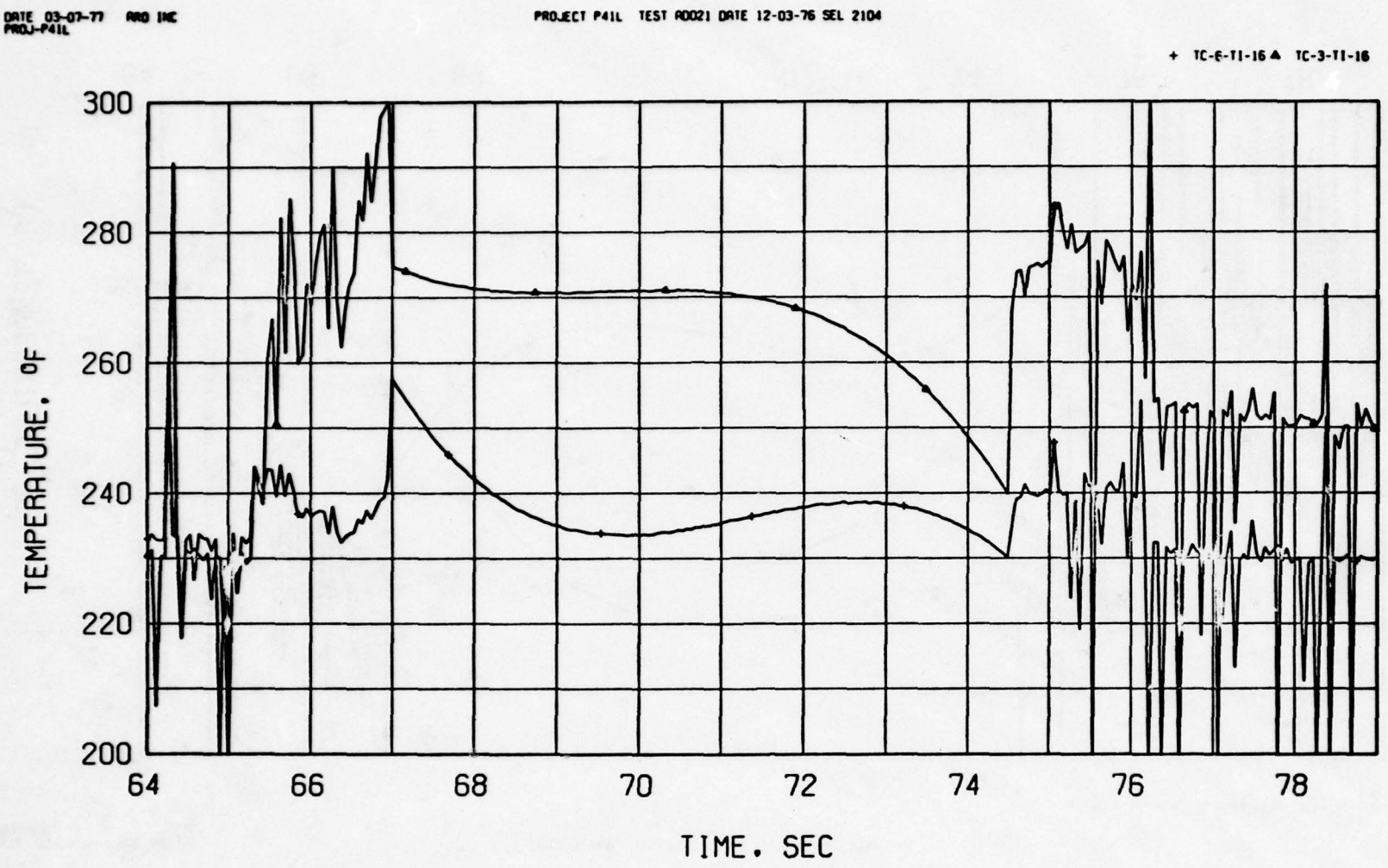

DATE 03-07-77 ARO INC
PROJ-P41L
PROJECT P41L TEST A0021 DATE 12-03-76 SEL 2104
× TC-7-T1-16 + TC-4-T1-16 ▲ TC-1-T1-16
300
280
260
240
220
200
TEMPERATURE, °F
64
66
68
70
72
74
76
78
TIME, SEC

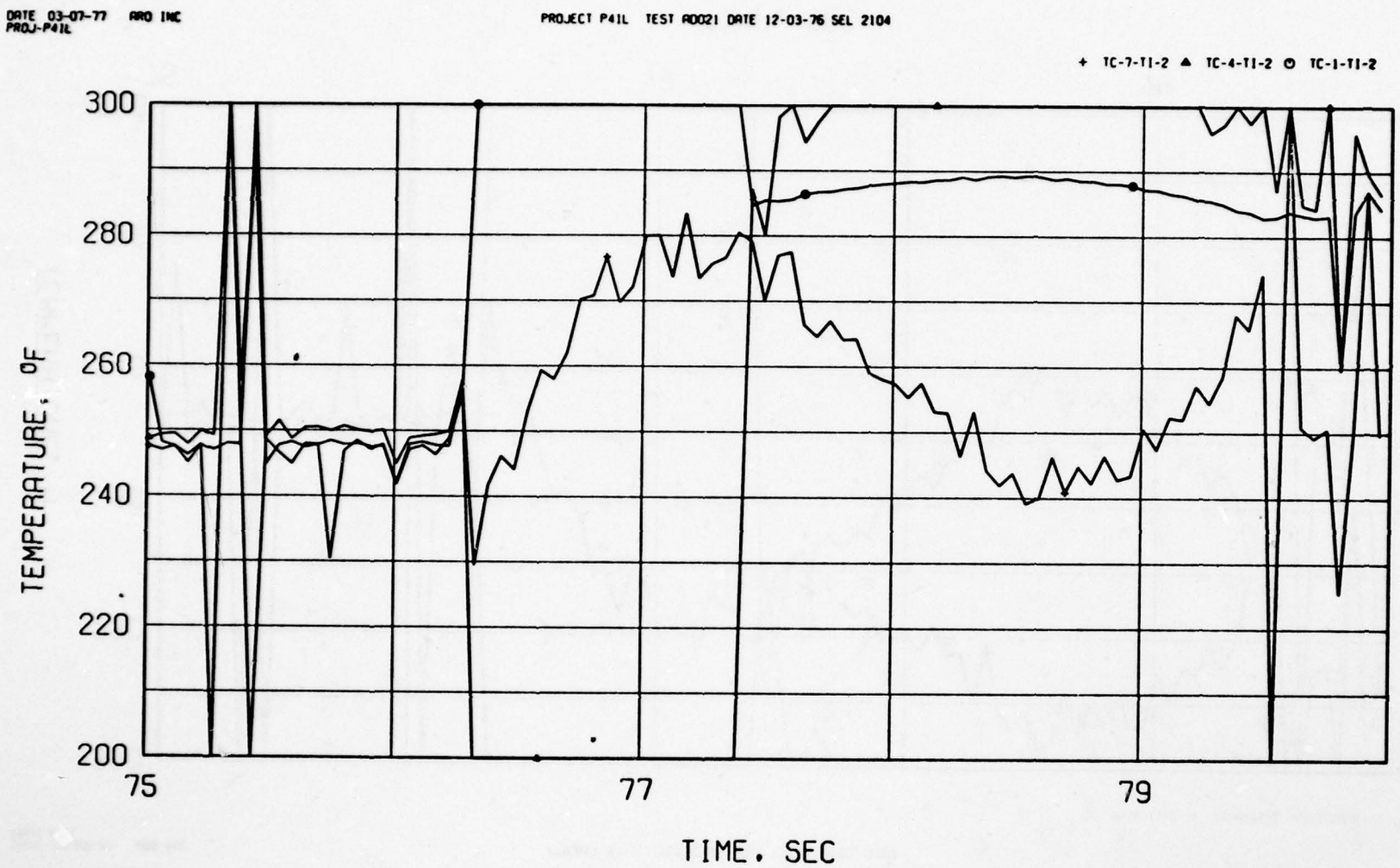
DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST A0021 DATE 12-03-76 SEL 2104

+ TC-8-T1-16 ▲ TC-5-T1-16 ⊙ TC-2-T1-16



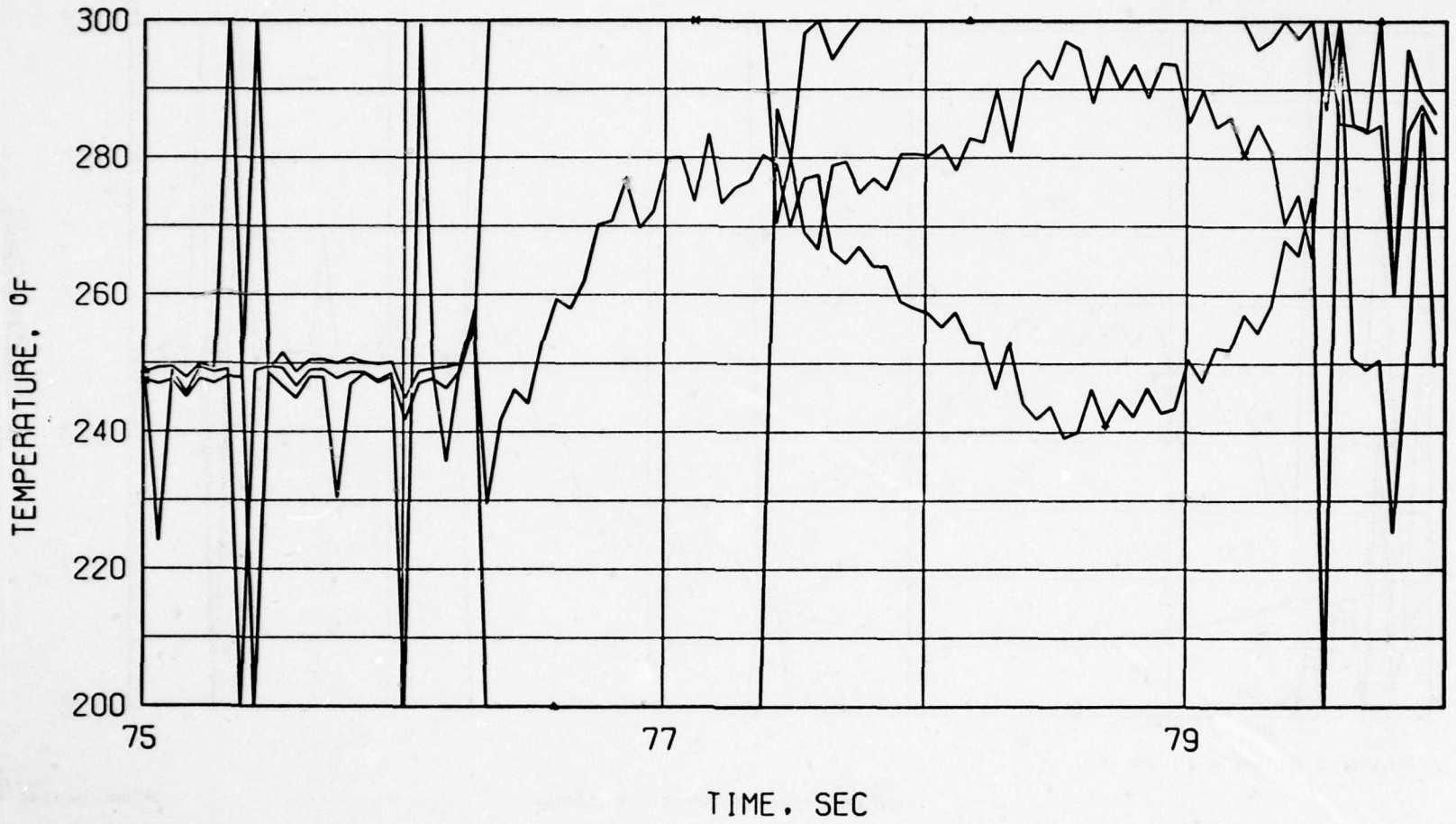

DATE 03-07-77 ARO INC
PROJ-P41L
PROJECT P41L TEST A0021 DATE 12-03-76 SEL 2104
+ TC-6-TI-16 ▲ TC-3-TI-16
300
280
260
240
220
200
64
66
68
70
72
74
76
78
TEMPERATURE, °F
TIME, SEC


DATE 03-07-77 ARO INC
PROJ-P41L
PROJECT P41L TEST A0021 DATE 12-03-76 SEL 2104
+ TC-7-T1-2 ▲ TC-4-T1-2 ⊙ TC-1-T1-2
300
280
260
240
220
200
TEMPERATURE, °F
75
77
79
TIME. SEC

DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST AD021 DATE 12-03-76 SEL 2104

× TC-8-T1-2 + TC-5-T1-2 ▲ TC-2-T1-2



DATE 03-07-77 ARO INC
PROJ-P41L

PROJECT P41L TEST R0021 DATE 12-03-76 SEL 2104

▲ TC-6-T1-2 ⊙ TC-3-T1-2

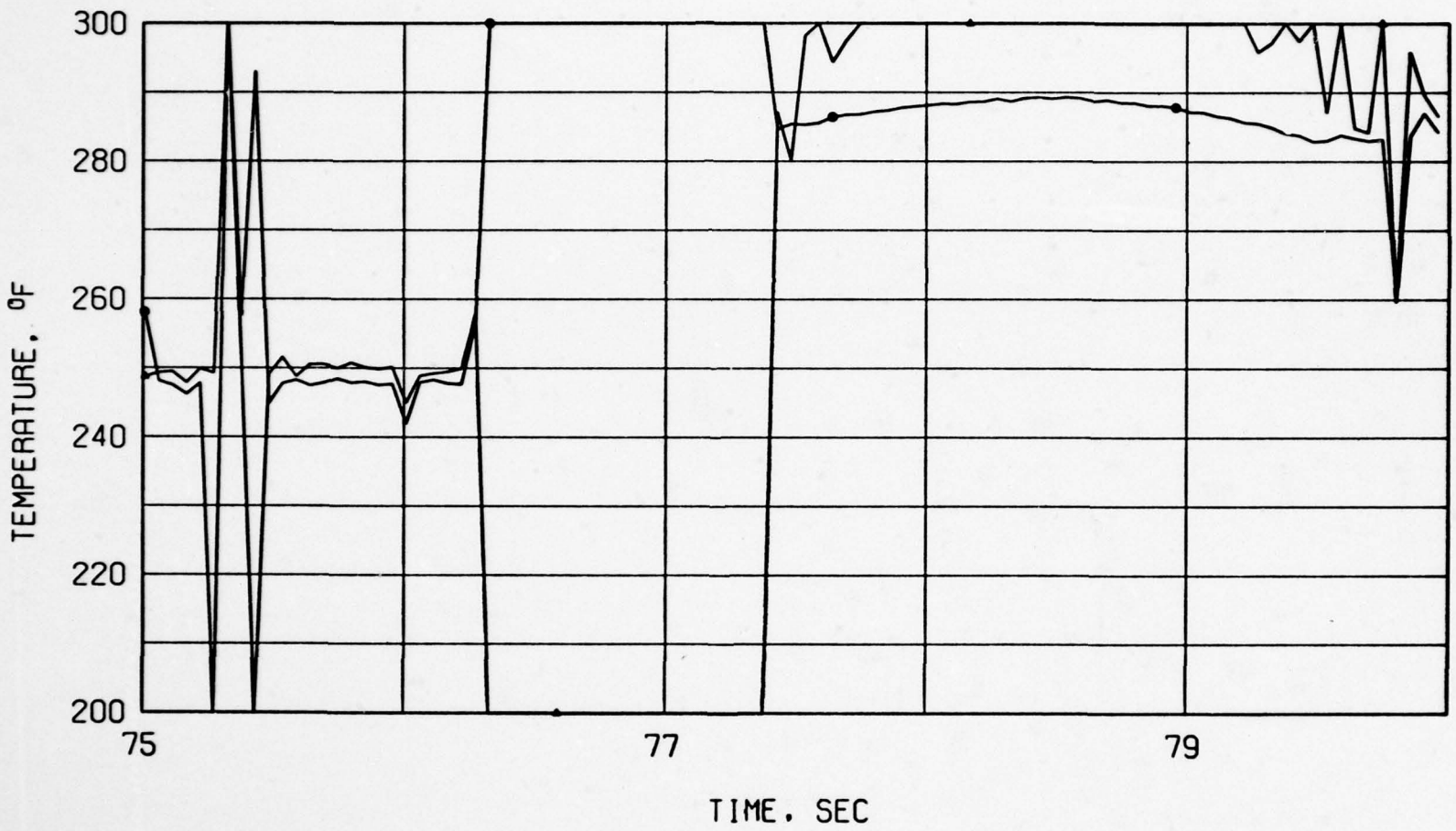


TABLE 1 RUN SUMMARY

TUNNEL CONDITIONS

RUN 5 DATE 1-6-77

NOZZLE STATION 127.5

P_o = 500 psia, P_{om} = 499

H_{oB} = 496 Btu/lbm, H_{om} = 476

H_o = 515 Btu/lbm

T_{oB} = 1960 °R, T_o = 2028 °R

M = 7.5 p_o' = 5.3 psia

DUST			WATER	
TYPE	MgO		Flow	0.228 gpm
SIZE	100	μm	C.F.	28.2
VEL	4050	ft/sec	Orifice	0.020 in.
Flow	10.89	gm/sec	ΔP	894 psi
C.F.	26.6			

STING	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANS-DUCER TYPE	PRERUN	POSTRUN
1	p_o' probe	3					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_o probe	25					See Fig. 3	0.25		R	1					
3	T_i-12	8.59	1.19				Hemi	2.0	6Al-4V-T_i	S	8				6838	102
4	T_i-14		9.97				Hemi	2.0	6Al-4V-T_i	S	8				6837	103
5	WB-1S WB-1A		10	10	x 10		See Fig. 2		SS Al							99
6	T_i-15		10.28	5.49	x 5.49		Hemi	2.0	6Al-4V-T_i	S	8				6837	100
7	T_i-7	4.47		5.49			Hemi	2.0	6Al-4V-T_i	S	8					101
8	WB-2S WB-2A			10			See Fig. 2		SS Al							98
9	GS			25			See Fig. 4	2.0	SS							
10																

KEY -

PH - PREHEAT

POH - POSTHEAT

DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

NOTES: 1. Model GS on Sting No. 9 is a gas sampling model.

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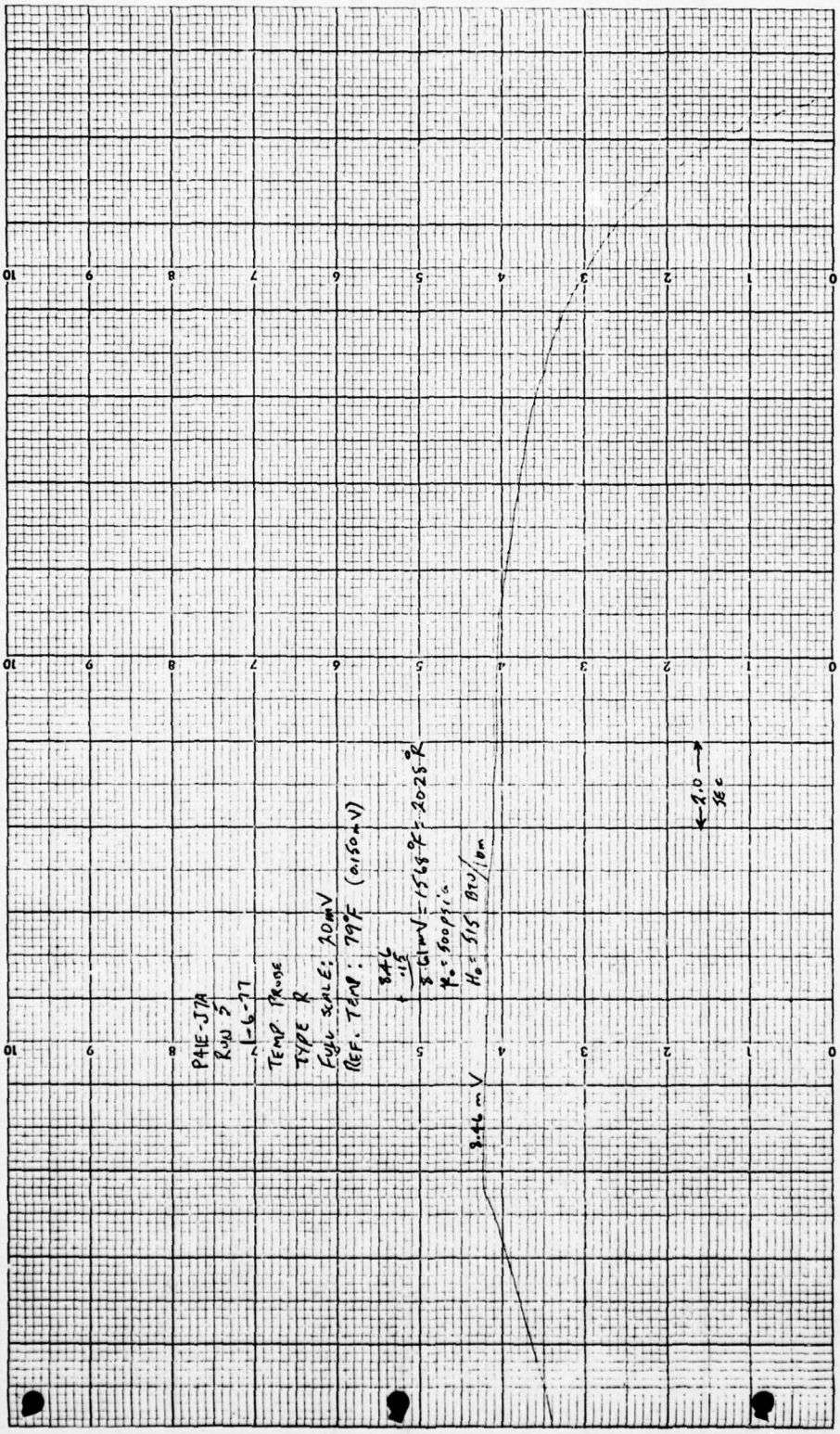
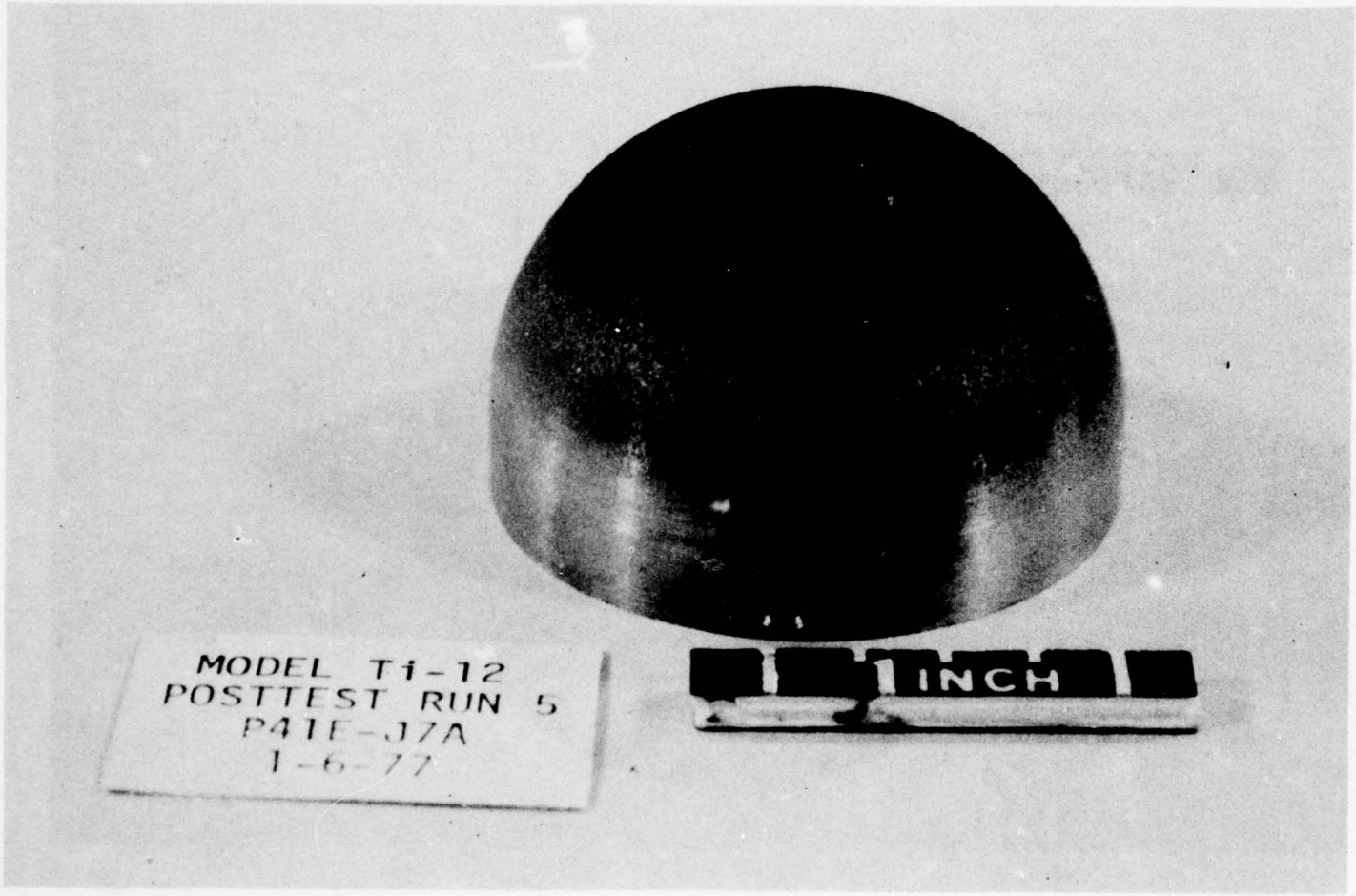
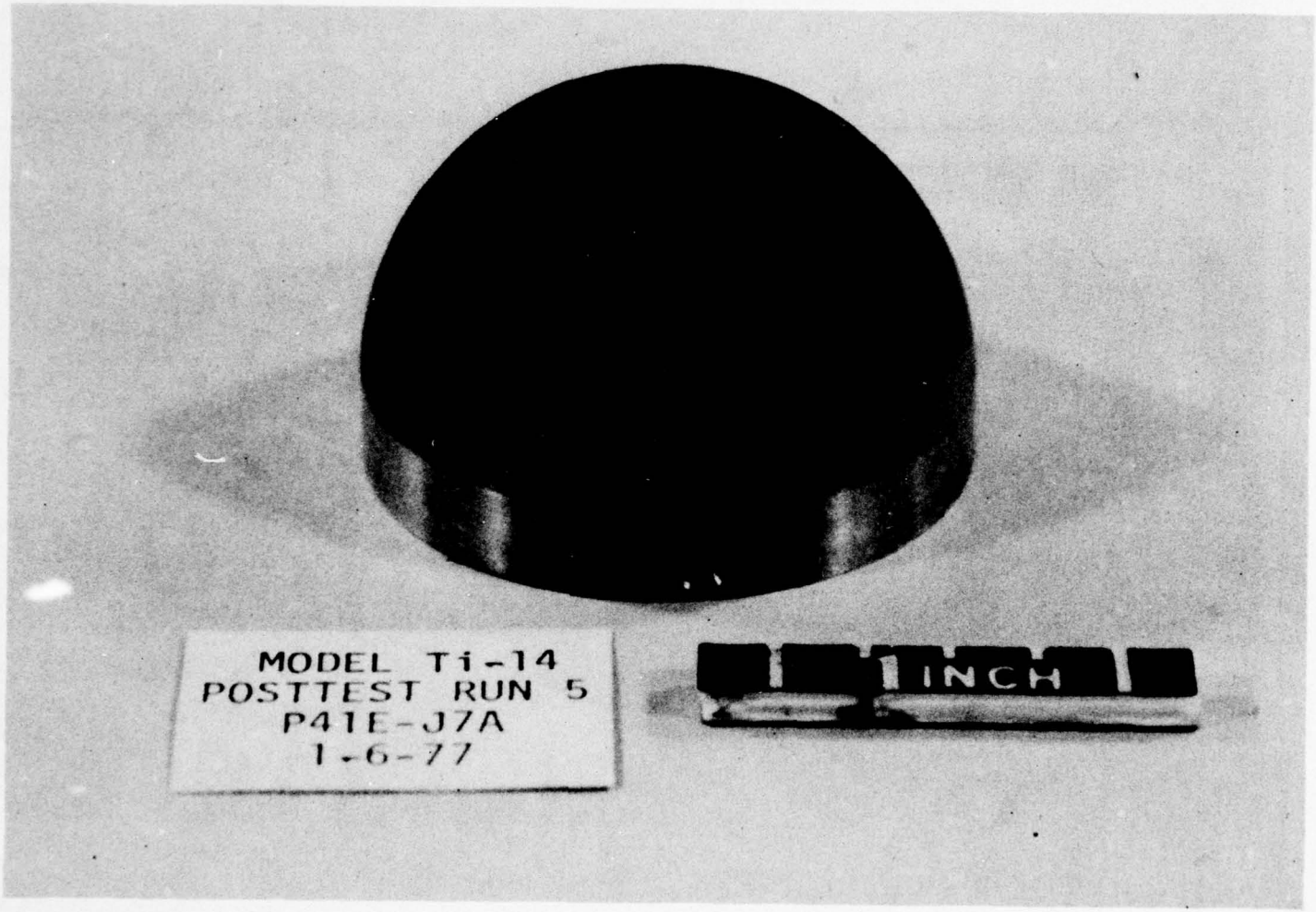
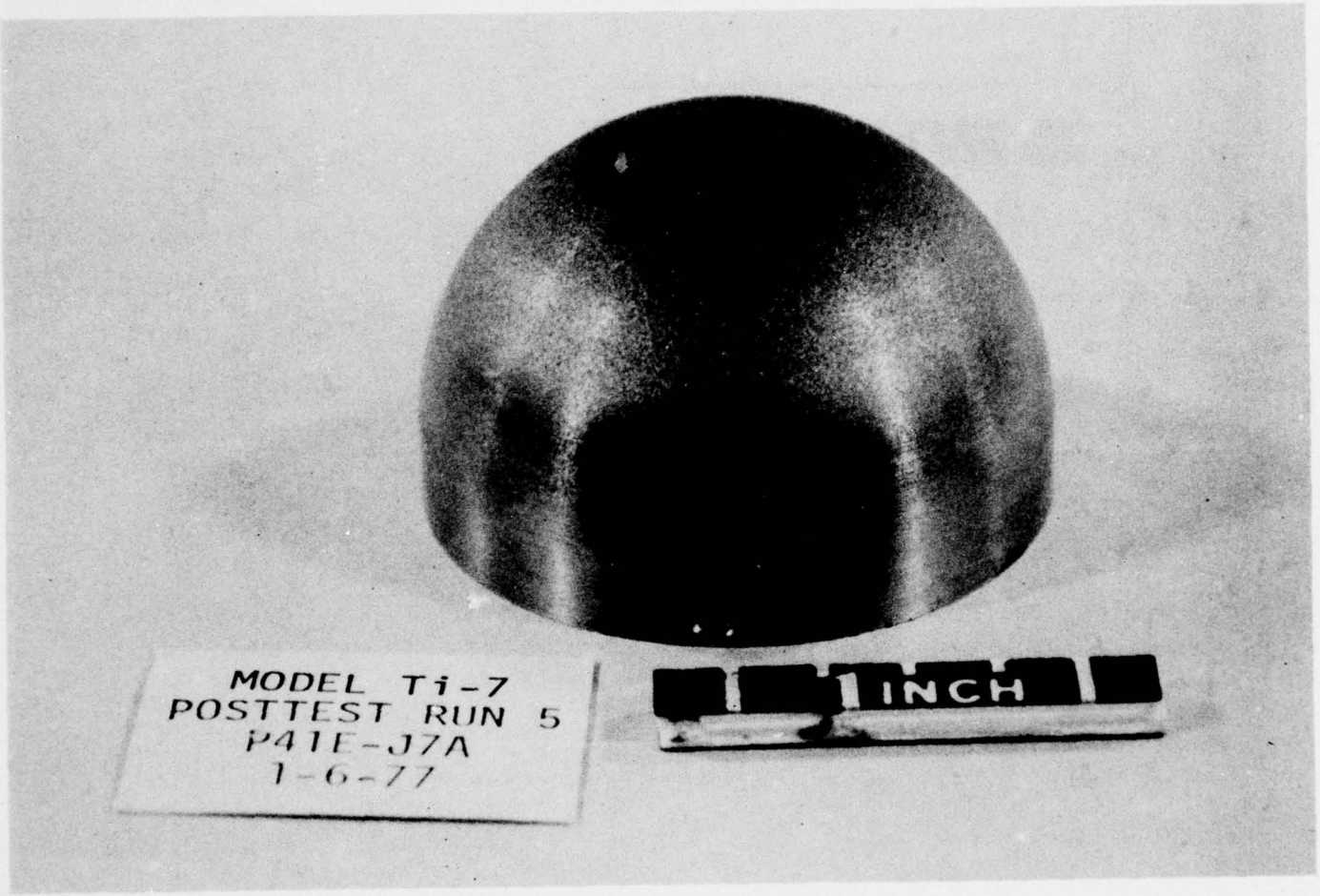
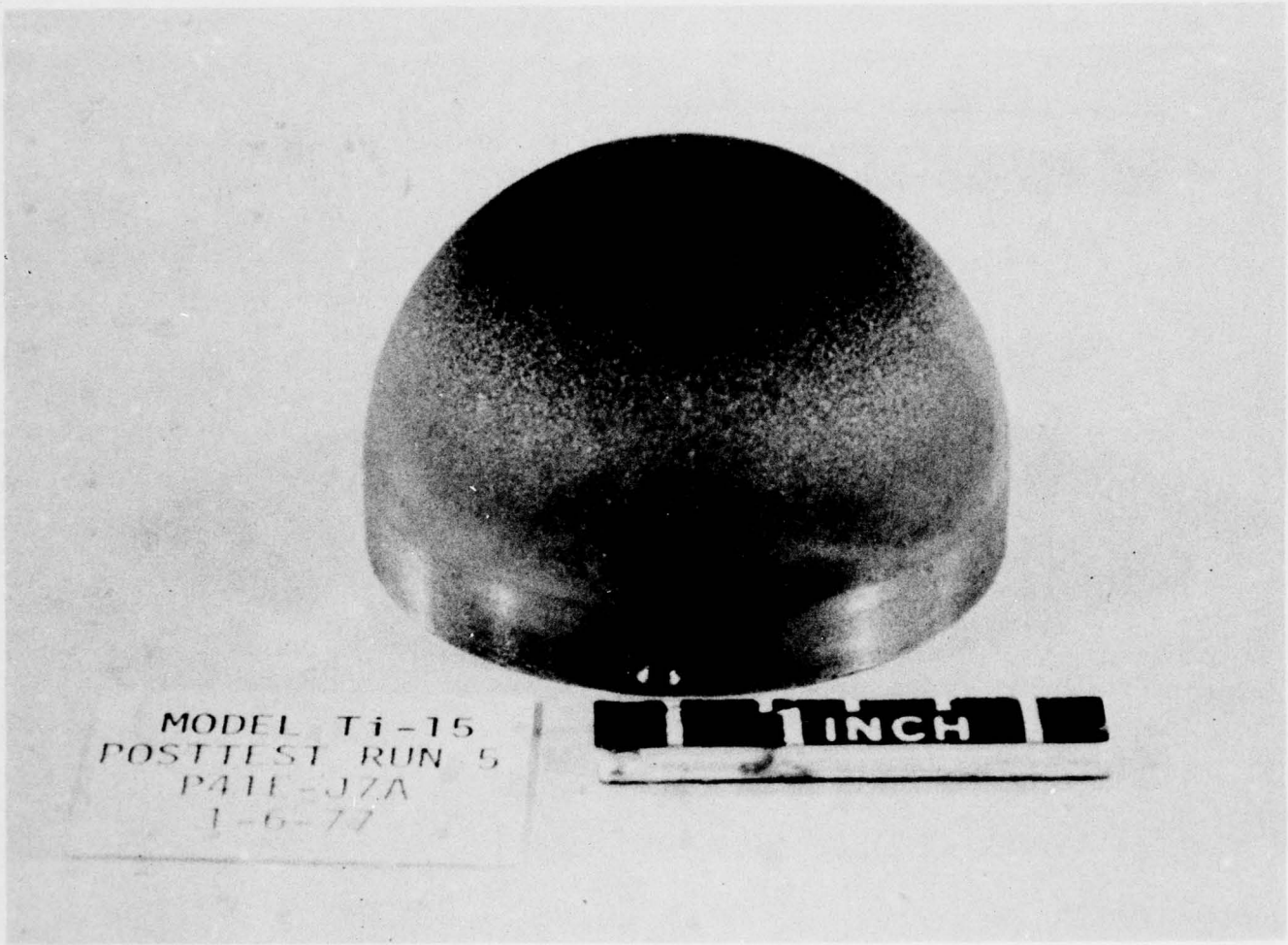
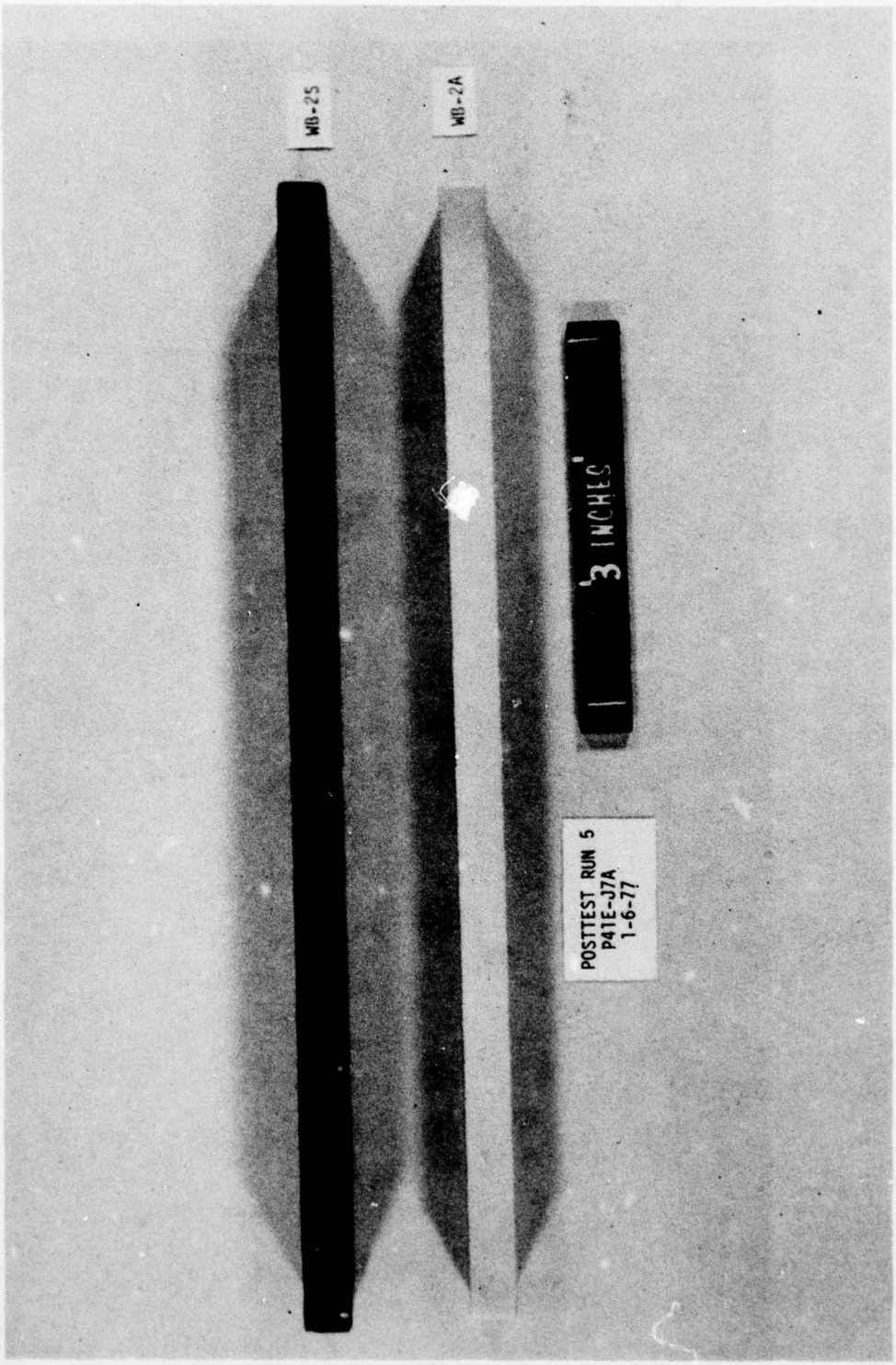


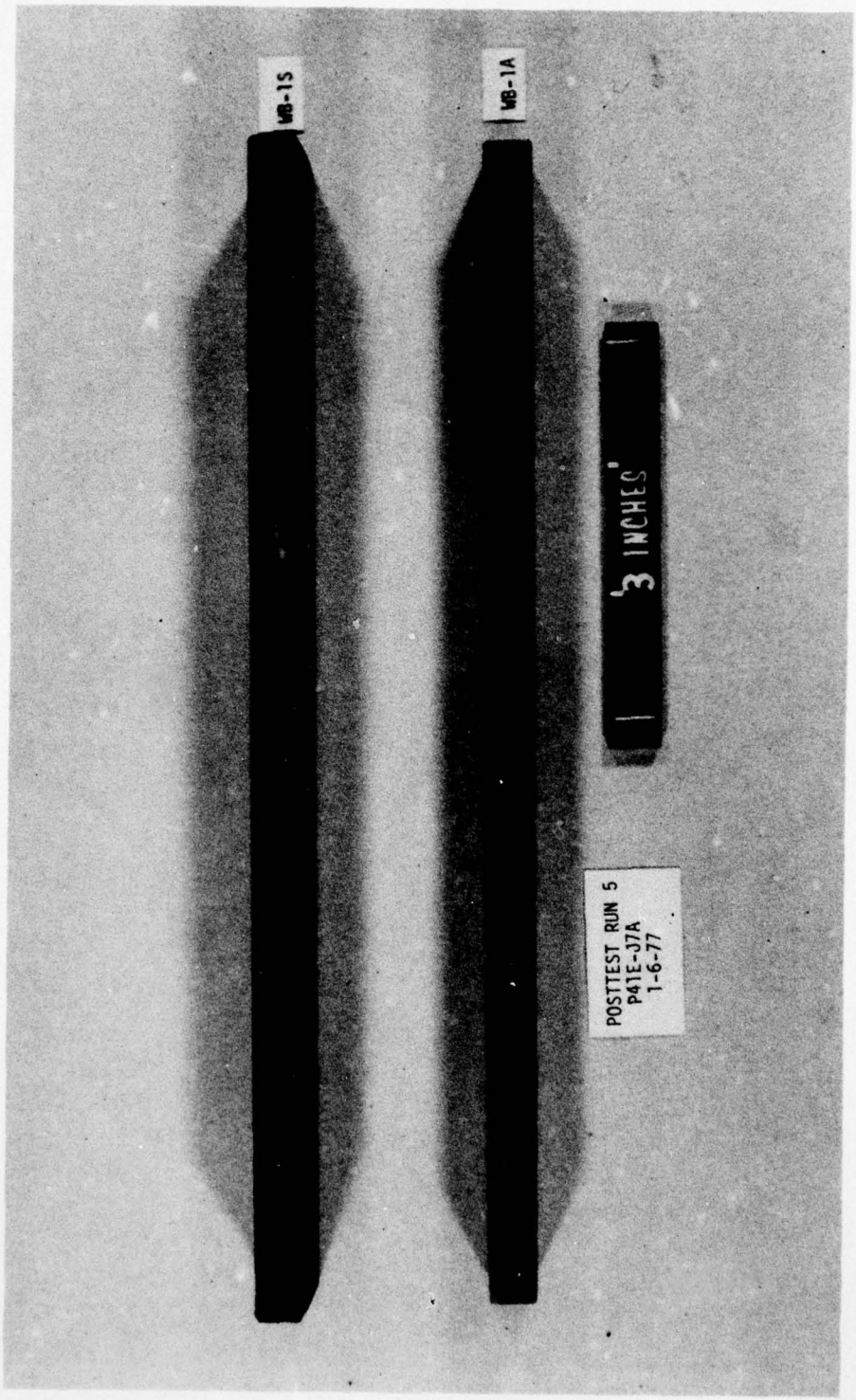

MODEL T1-12
POSTTEST RUN 5
P41E-J7A
1-6-77
1 INCH

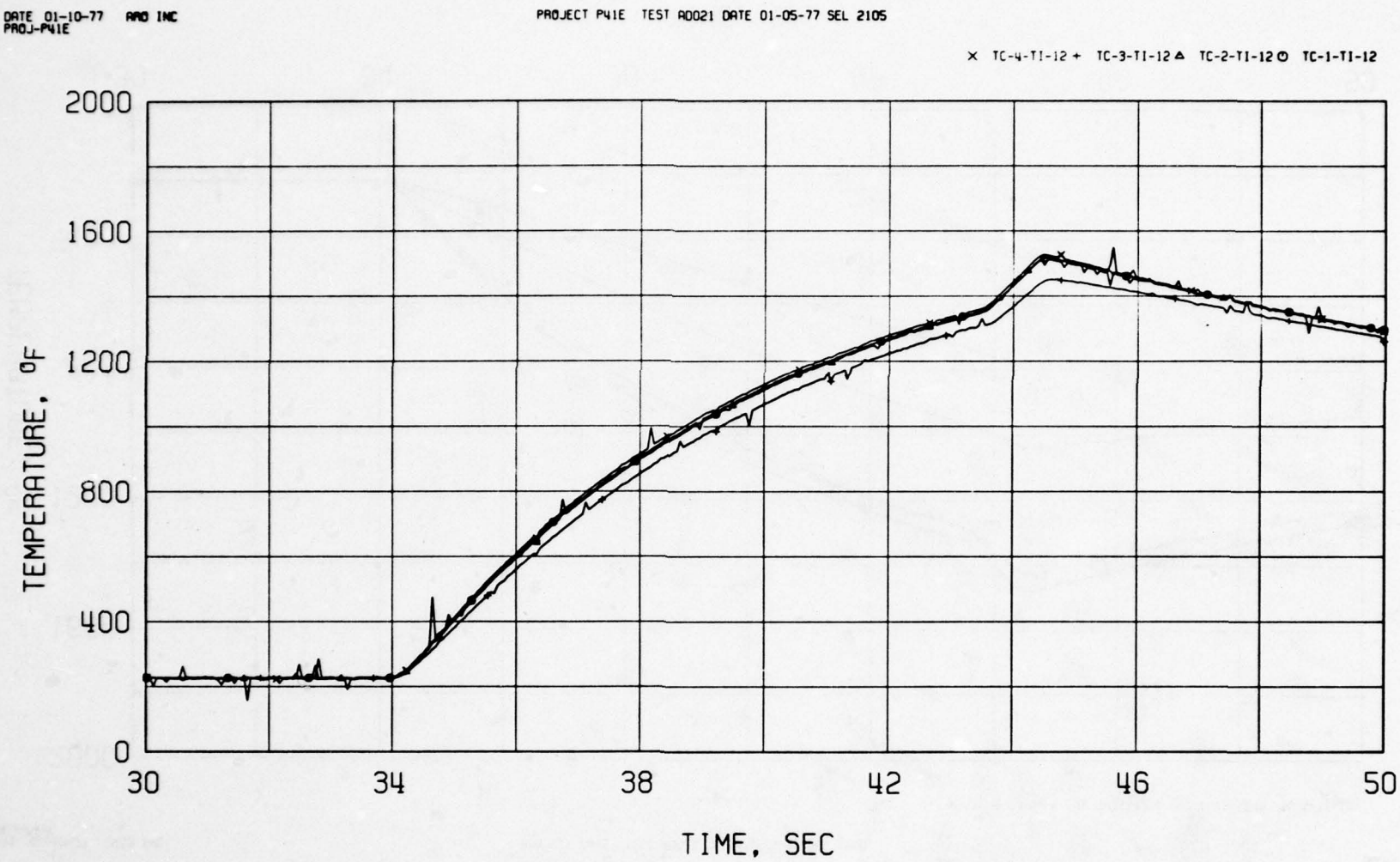

MODEL Ti-14
POSTTEST RUN 5
P41E-J7A
1-6-77
1 INCH


MODEL Ti-7
POSTTEST RUN 5
P41E-J7A
1-6-77
1 INCH


MODEL Ti-15
POSTTEST RUN 5
P4II-3ZA
1-6-77
1 INCH


WB-2S
WB-2A
3 INCHES
POSTTEST RUN 5
P41E-J7A
1-6-77

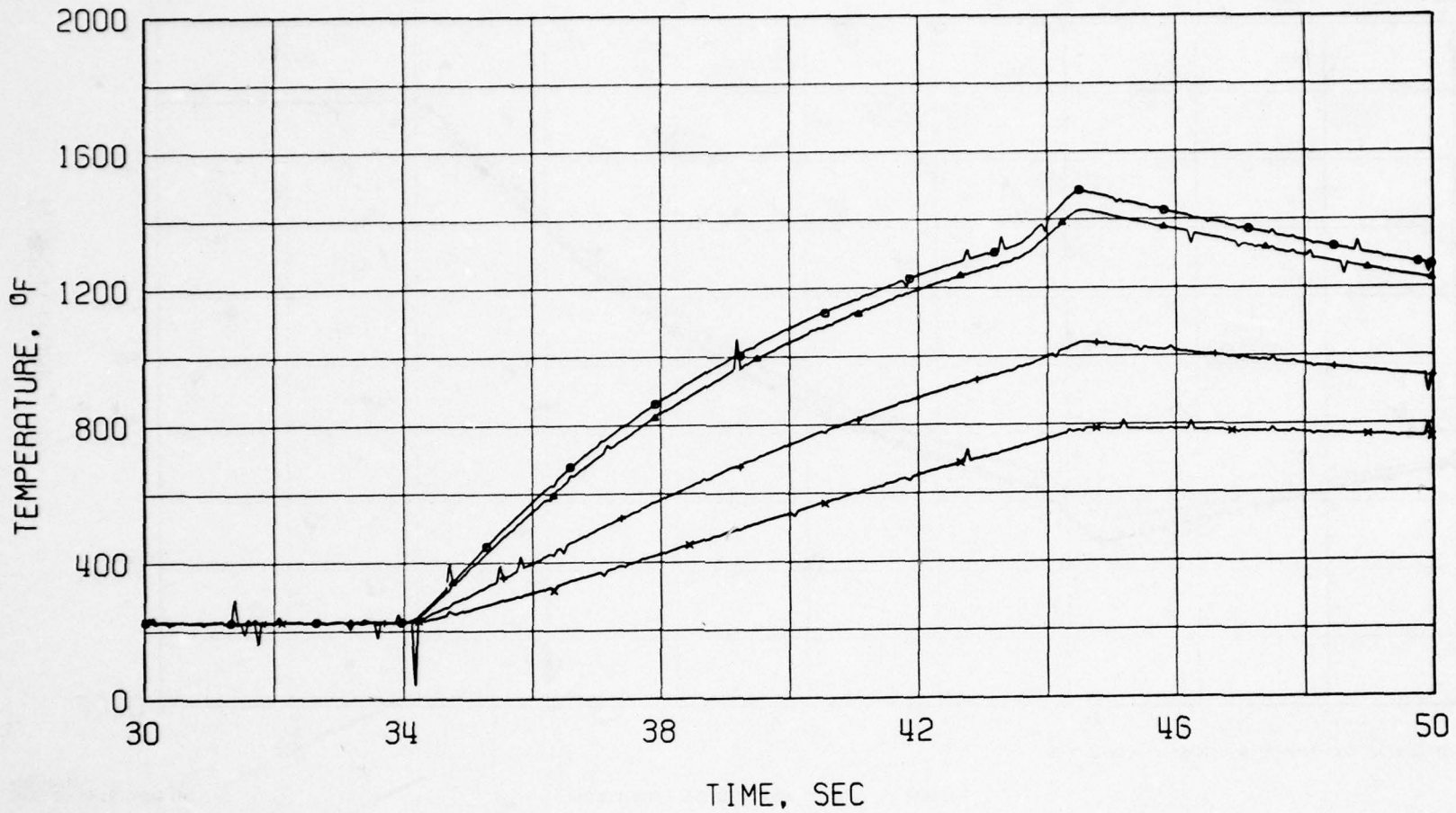

WB-1S
WB-1A
3 INCHES
POSTTEST RUN 5
P41E-J7A
1-6-77


DATE 01-10-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105
× TC-4-TI-12 + TC-3-TI-12 △ TC-2-TI-12 ⊙ TC-1-TI-12
2000
1600
1200
800
400
0
TEMPERATURE, °F
30
34
38
42
46
50
TIME, SEC

DATE 01-10-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-05-77 SEL 2105

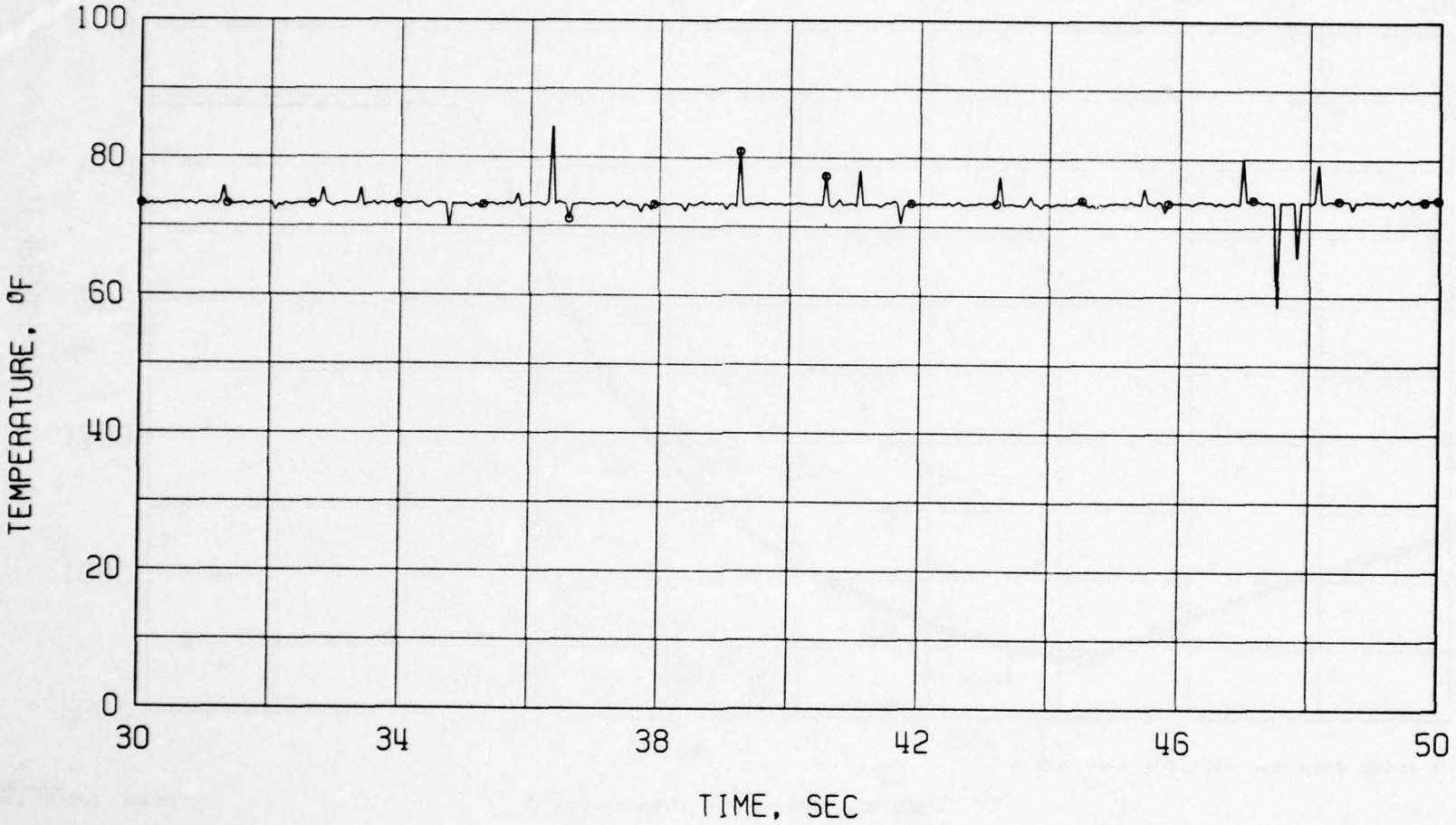
× TC-8-TI-12 + TC-7-TI-12 △ TC-6-TI-12 ○ TC-5-TI-12



DATE 01-10-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105

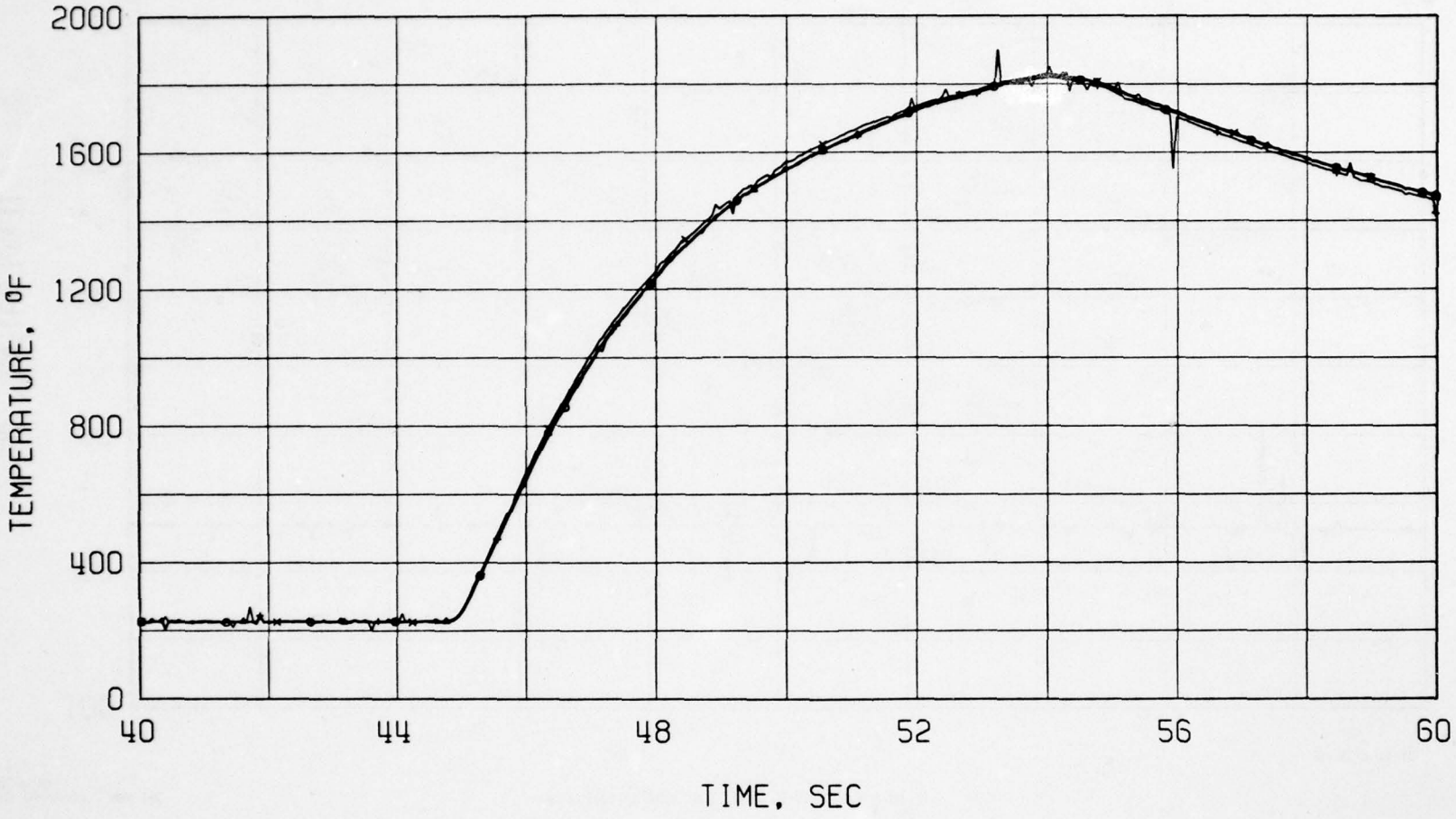
TC-9-T1-12



DATE 01-10-77 ARO INC
PROJ-P41E

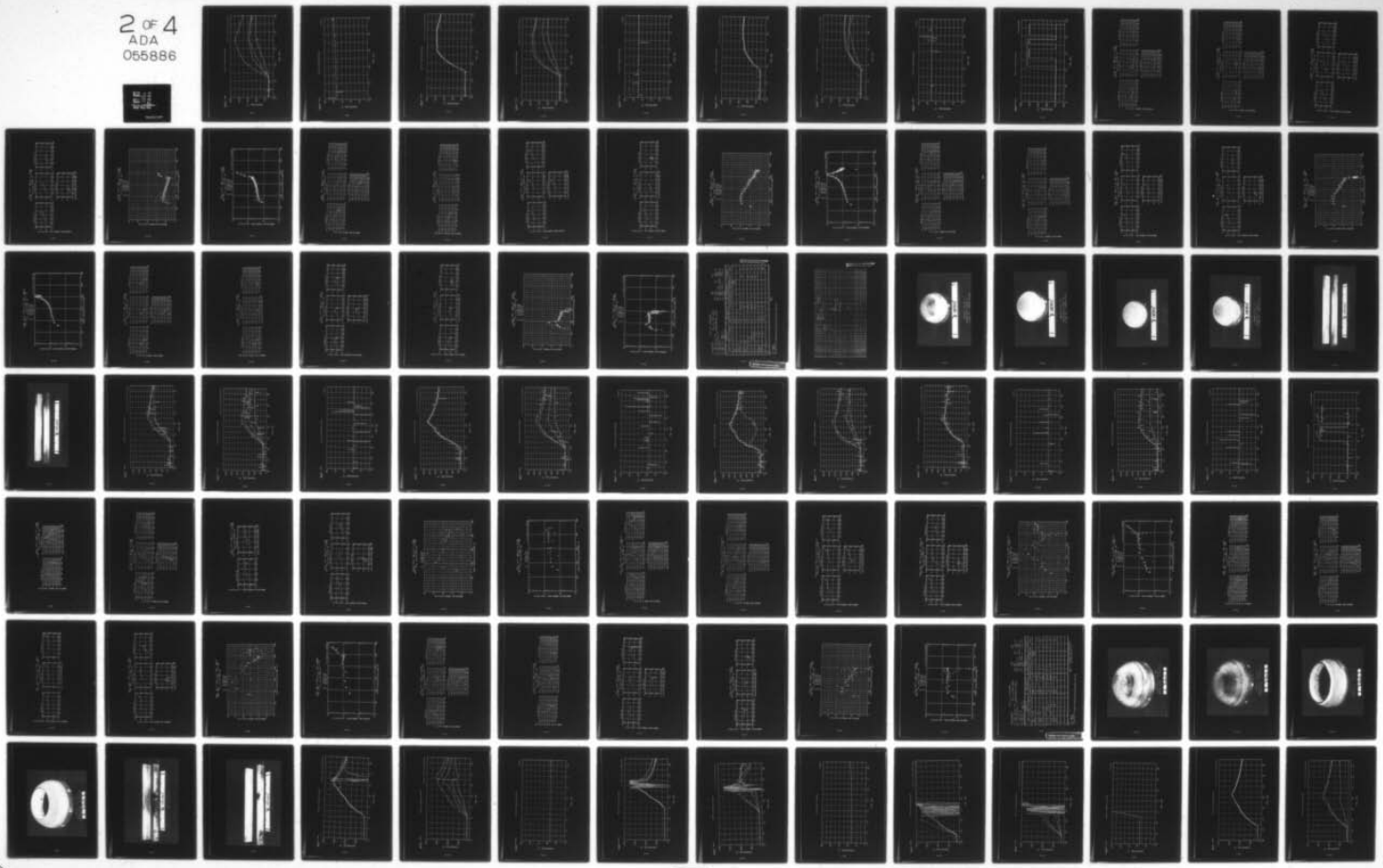
PROJECT P41E TEST AD021 DATE 01-05-77 SEL 2105

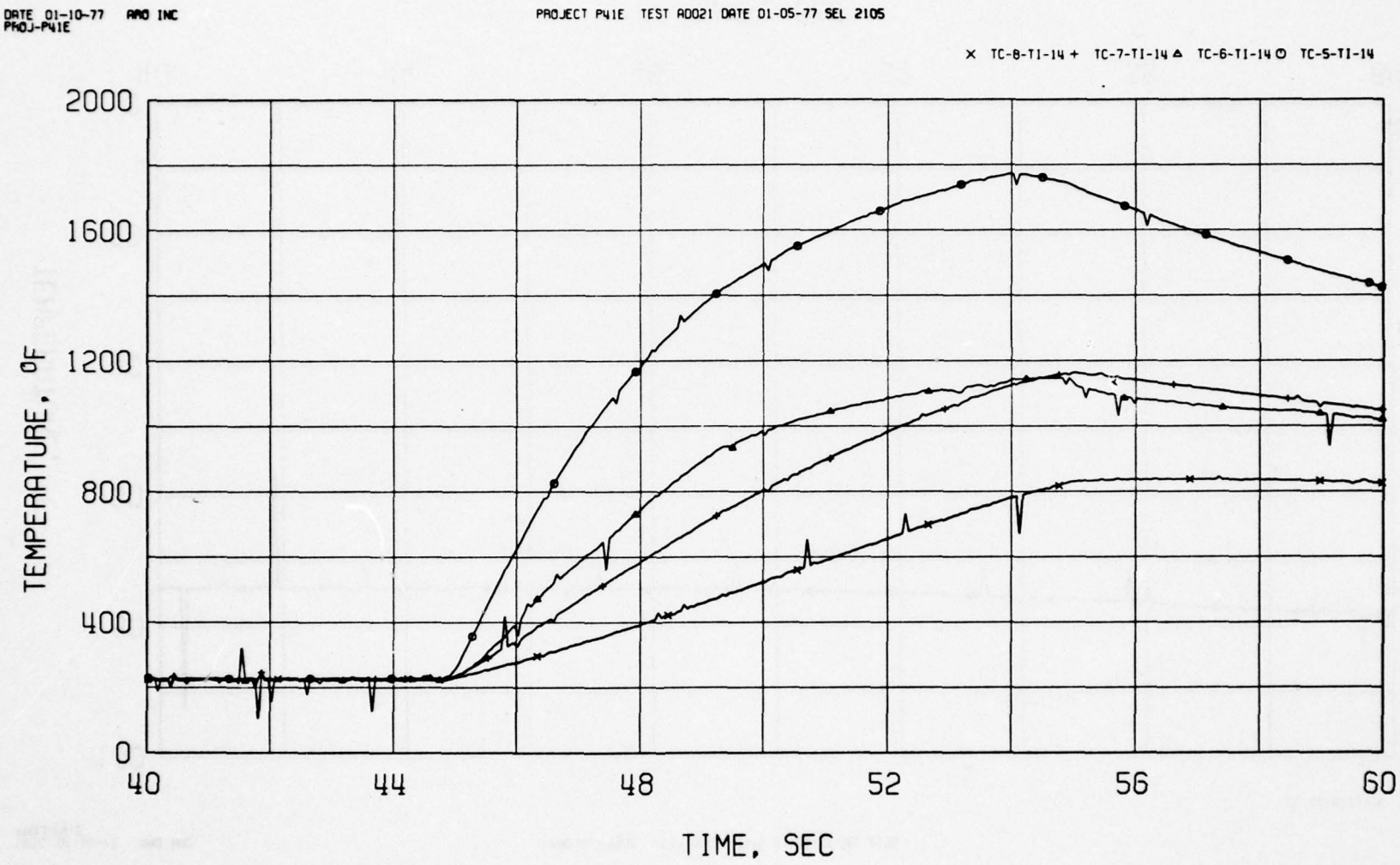
× TC-4-TI-14 + TC-3-TI-14 △ TC-2-TI-14 ⊙ TC-1-TI-14



AD-A055 886 SCIENCE APPLICATIONS INC EL SEGUNDO CALIF F/G 11/6
TITANIUM RESPONSE TO SIMULATED NUCLEAR CLOUD PARTICLE ENVIRONME--ETC(U)
AUG 77 L E DUNBAR, R M CLEVER, G H BURGHART DNA001-76-C-0366
UNCLASSIFIED SAI-78-561-LA-VOL-2 DNA-4404F-2 NL

2 OF 4
ADA
055886

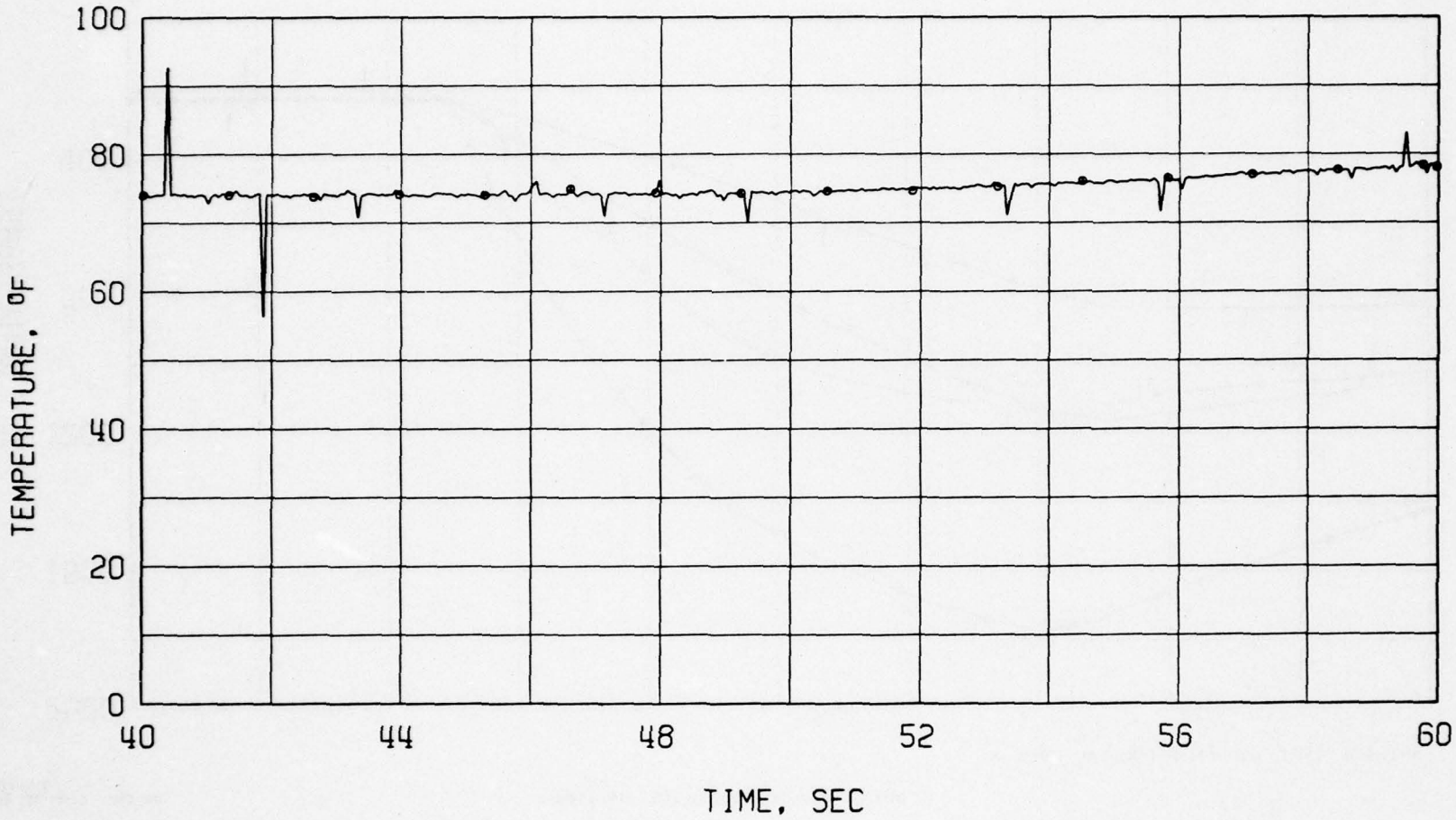



DATE 01-10-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105
× TC-8-TI-14 + TC-7-TI-14 △ TC-6-TI-14 ○ TC-5-TI-14
2000
1600
1200
800
400
0
TEMPERATURE, °F
40
44
48
52
56
60
TIME, SEC

DATE 01-10-77 AMD INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105

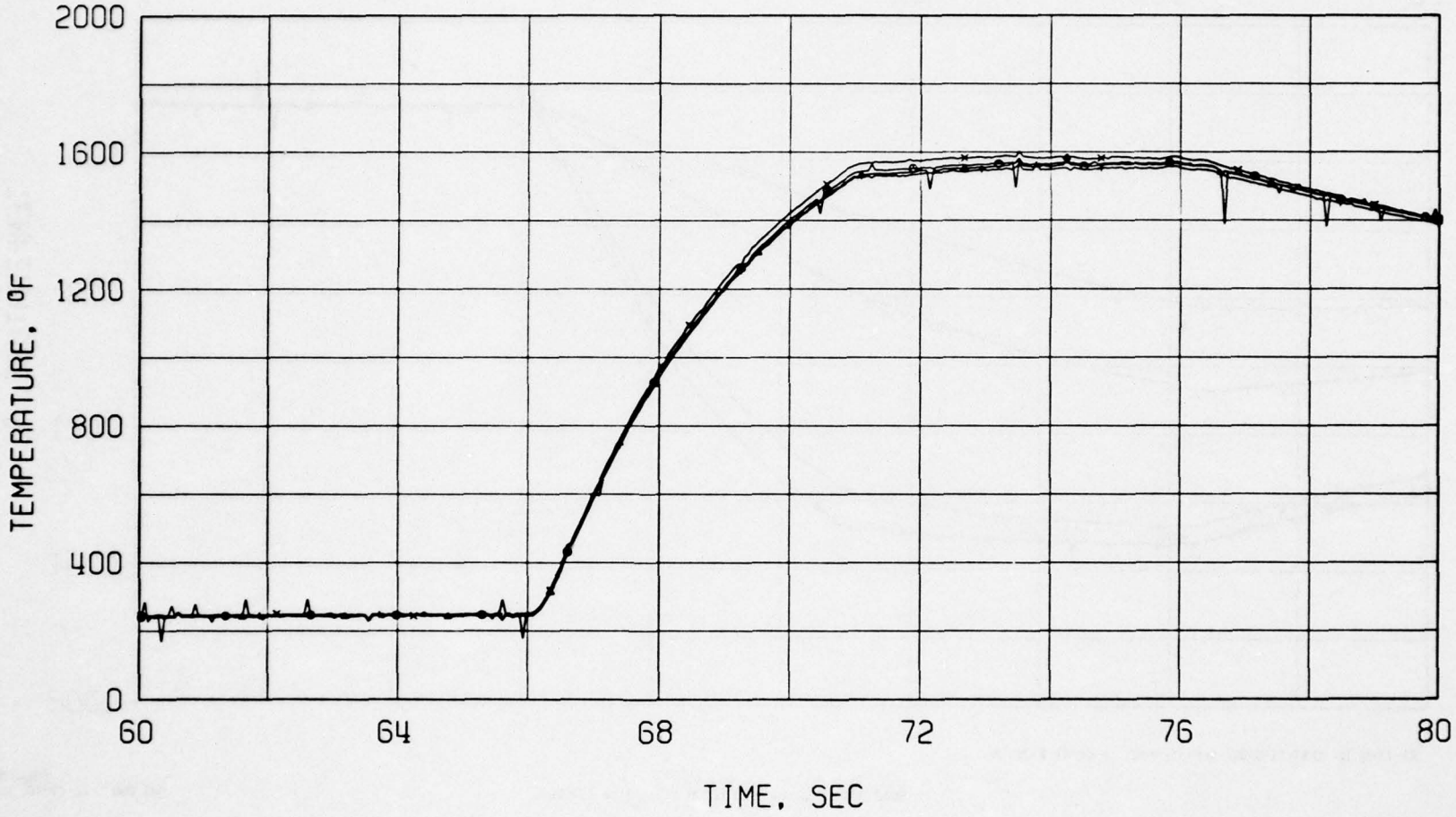
⊙ TC-9-TI-14

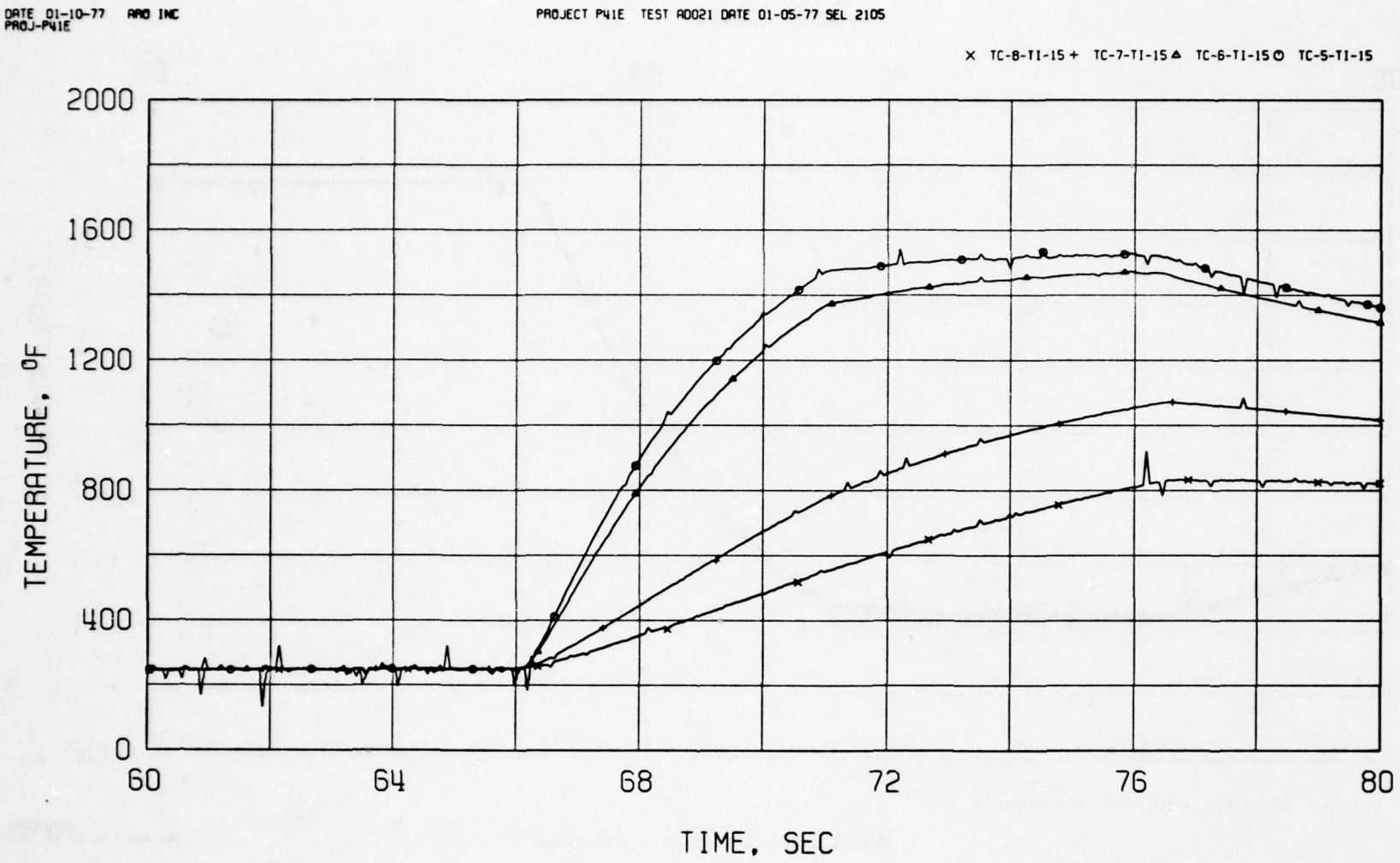


DATE 01-10-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-05-77 SEL 2105

× TC-4-TI-15 + TC-3-TI-15 △ TC-2-TI-15 ⊙ TC-1-TI-15

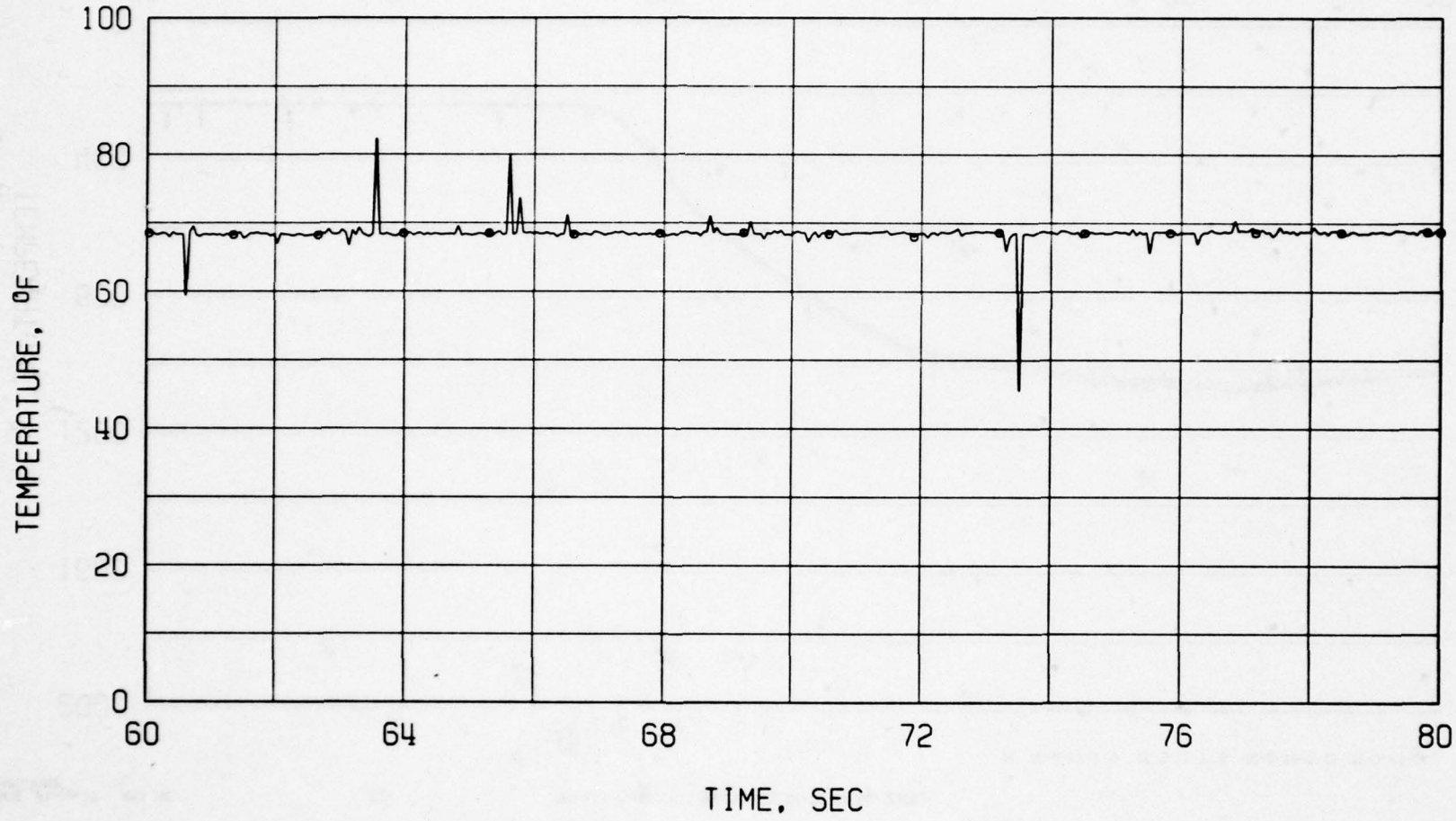


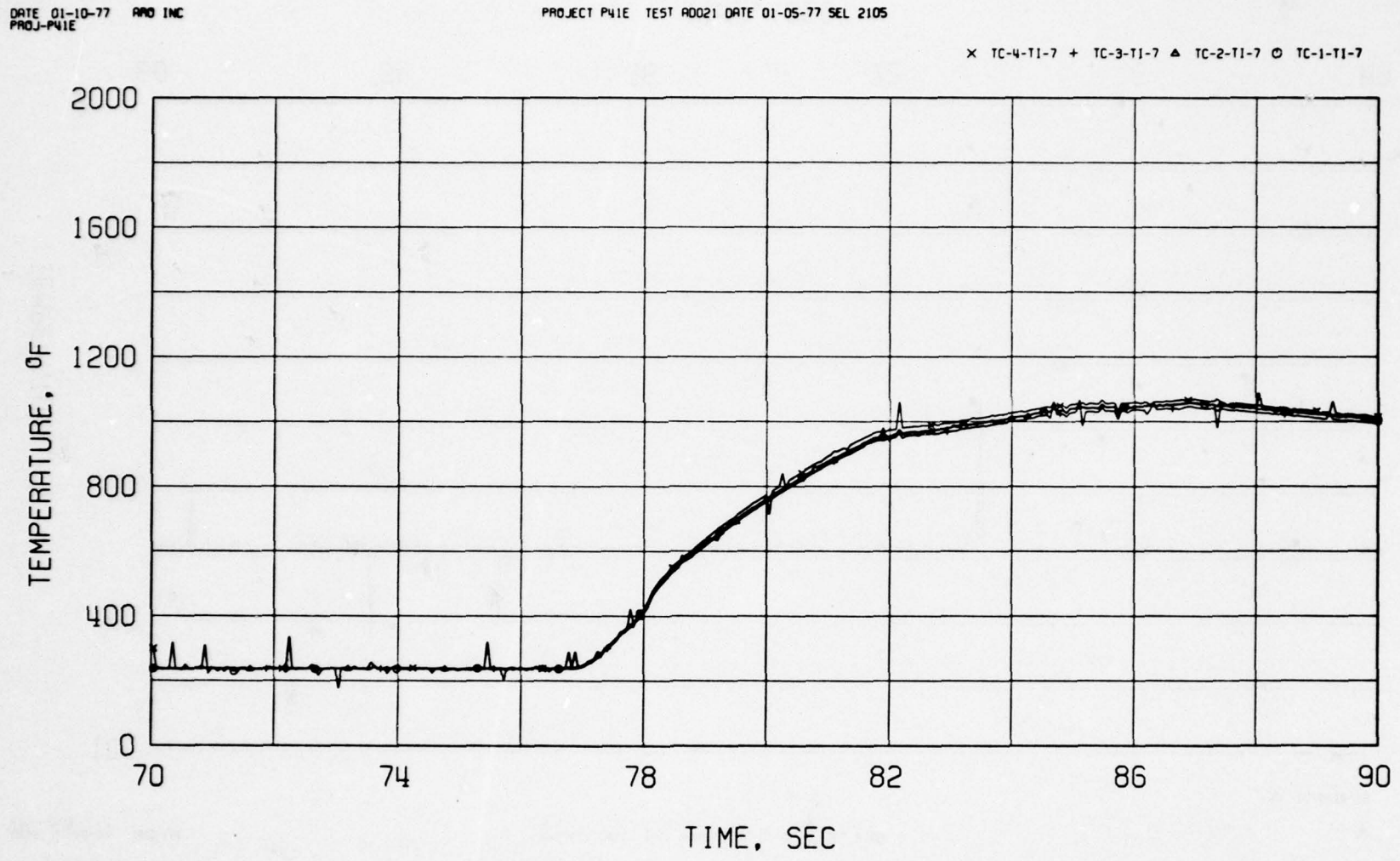

DATE 01-10-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105
× TC-8-TI-15 + TC-7-TI-15 △ TC-6-TI-15 ○ TC-5-TI-15
2000
1600
1200
800
400
0
TEMPERATURE, °F
60
64
68
72
76
80
TIME, SEC

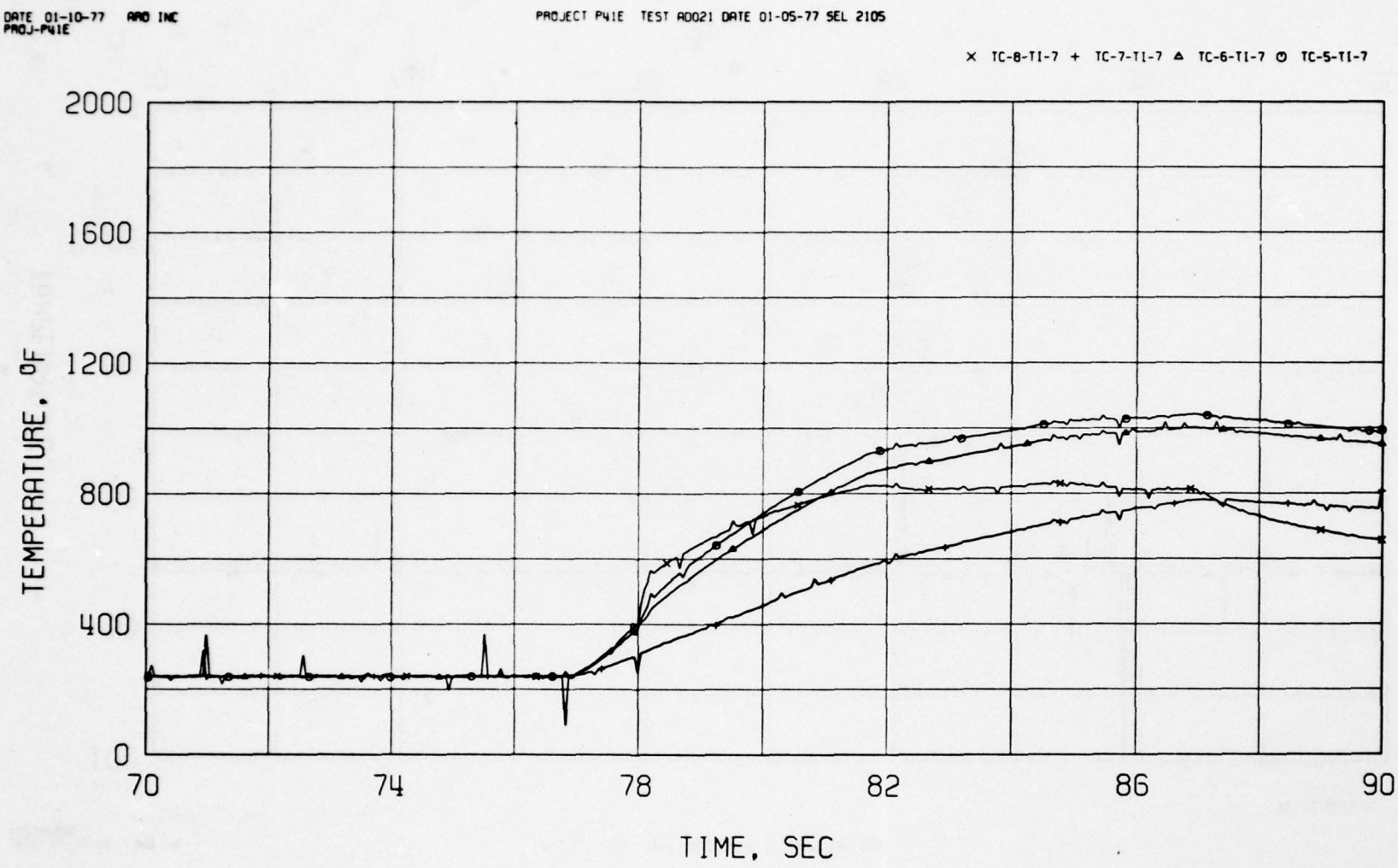
DATE 01-10-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105

© TC-9-TI-15



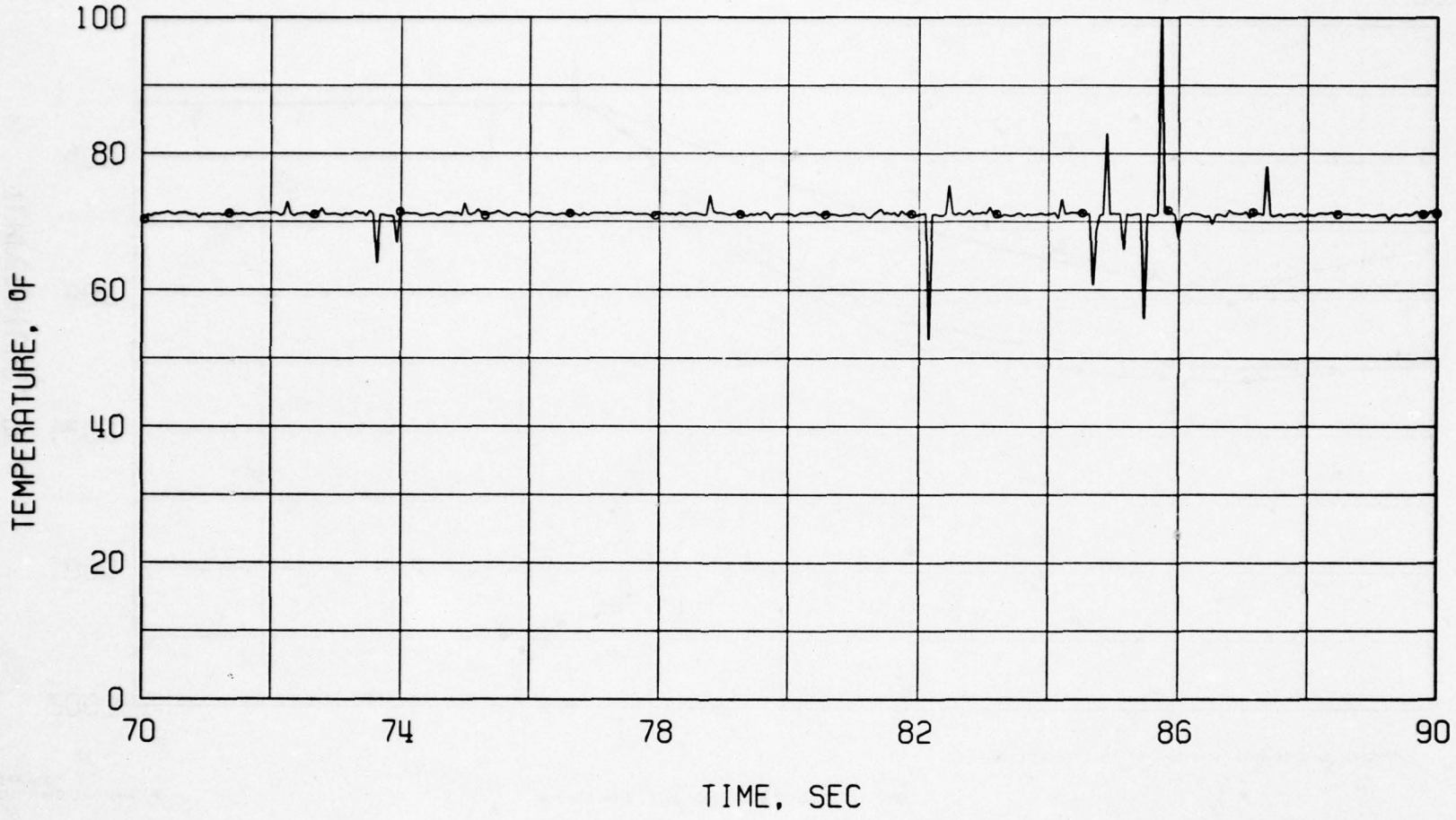

DATE 01-10-77 AND INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105
× TC-4-TI-7 + TC-3-TI-7 △ TC-2-TI-7 ⊙ TC-1-TI-7
2000
1600
1200
800
400
0
TEMPERATURE, °F
70
74
78
82
86
90
TIME, SEC

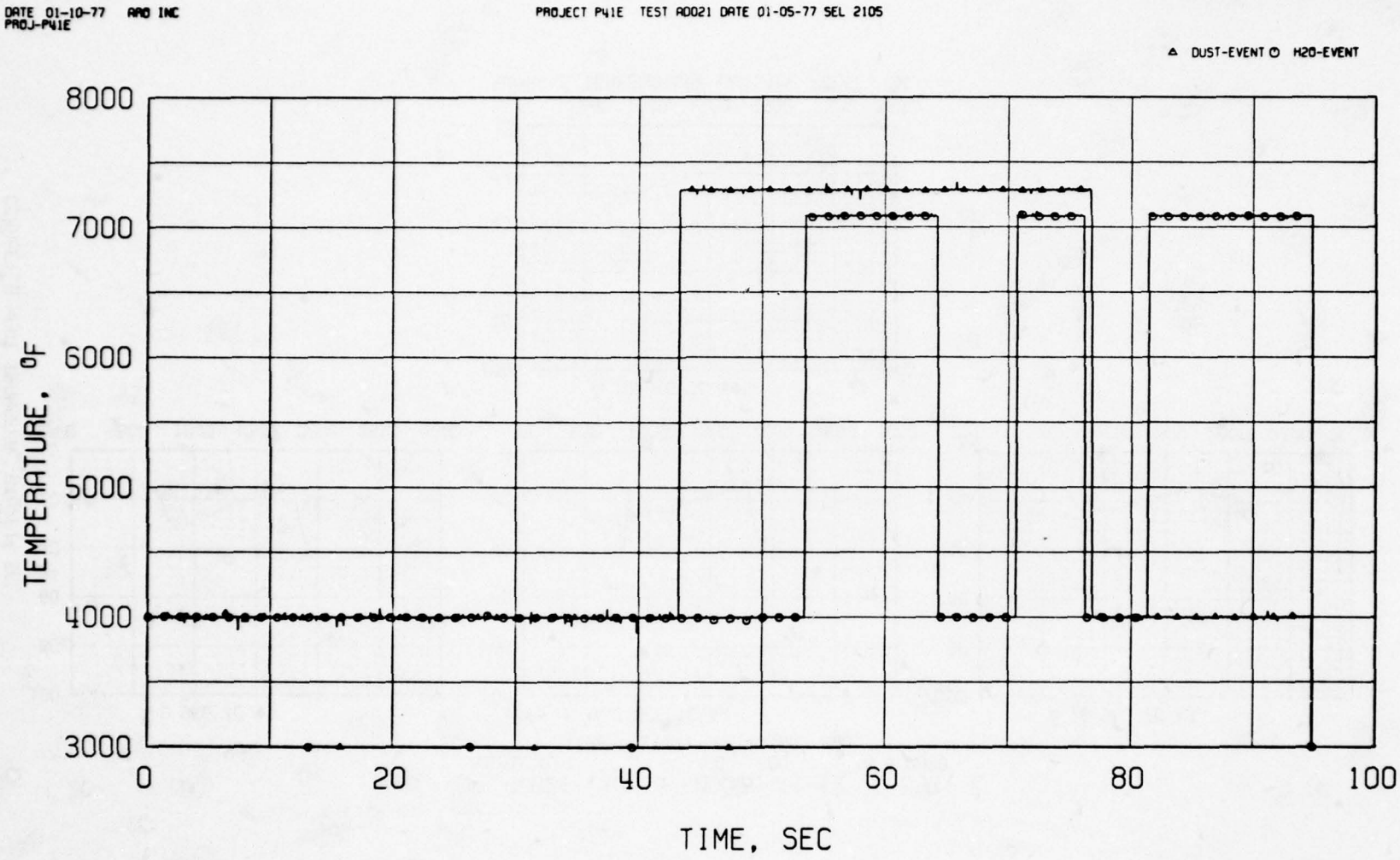

DATE 01-10-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105
× TC-8-TI-7 + TC-7-TI-7 △ TC-6-TI-7 ⊙ TC-5-TI-7
2000
1600
1200
800
400
0
TEMPERATURE, °F
70
74
78
82
86
90
TIME, SEC

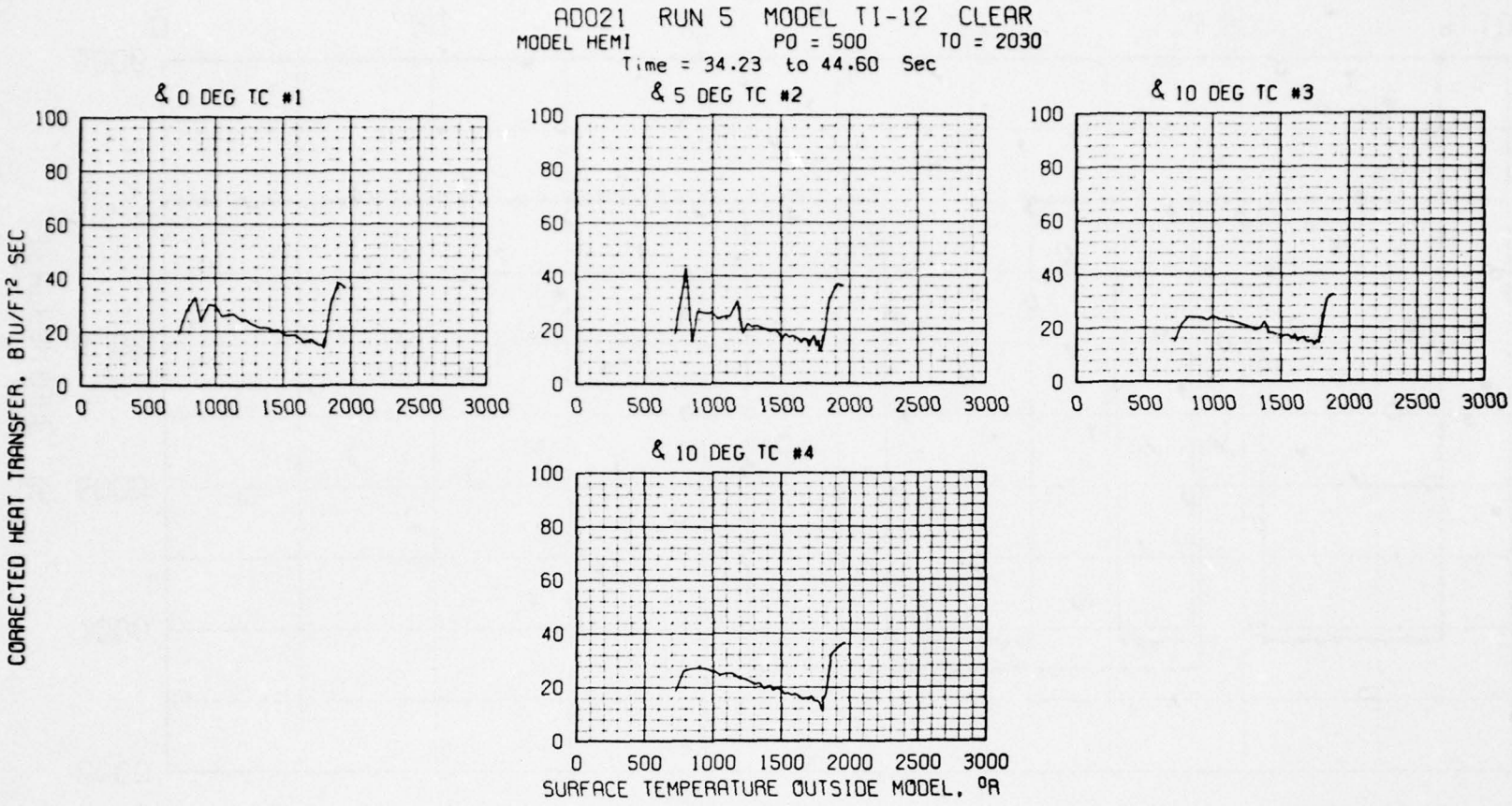
DATE 01-10-77 ARO INC
PROJ-P41E

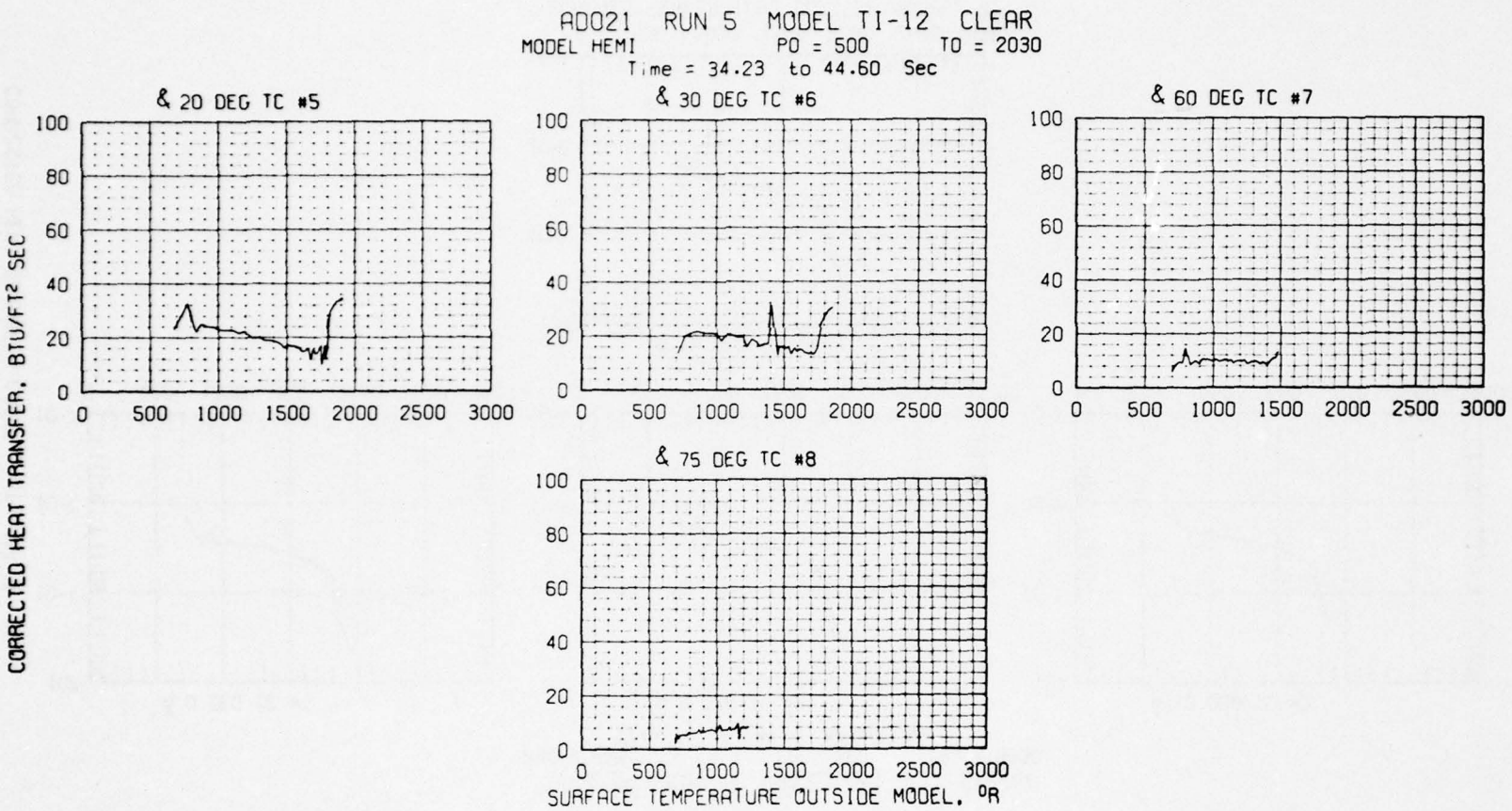
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105

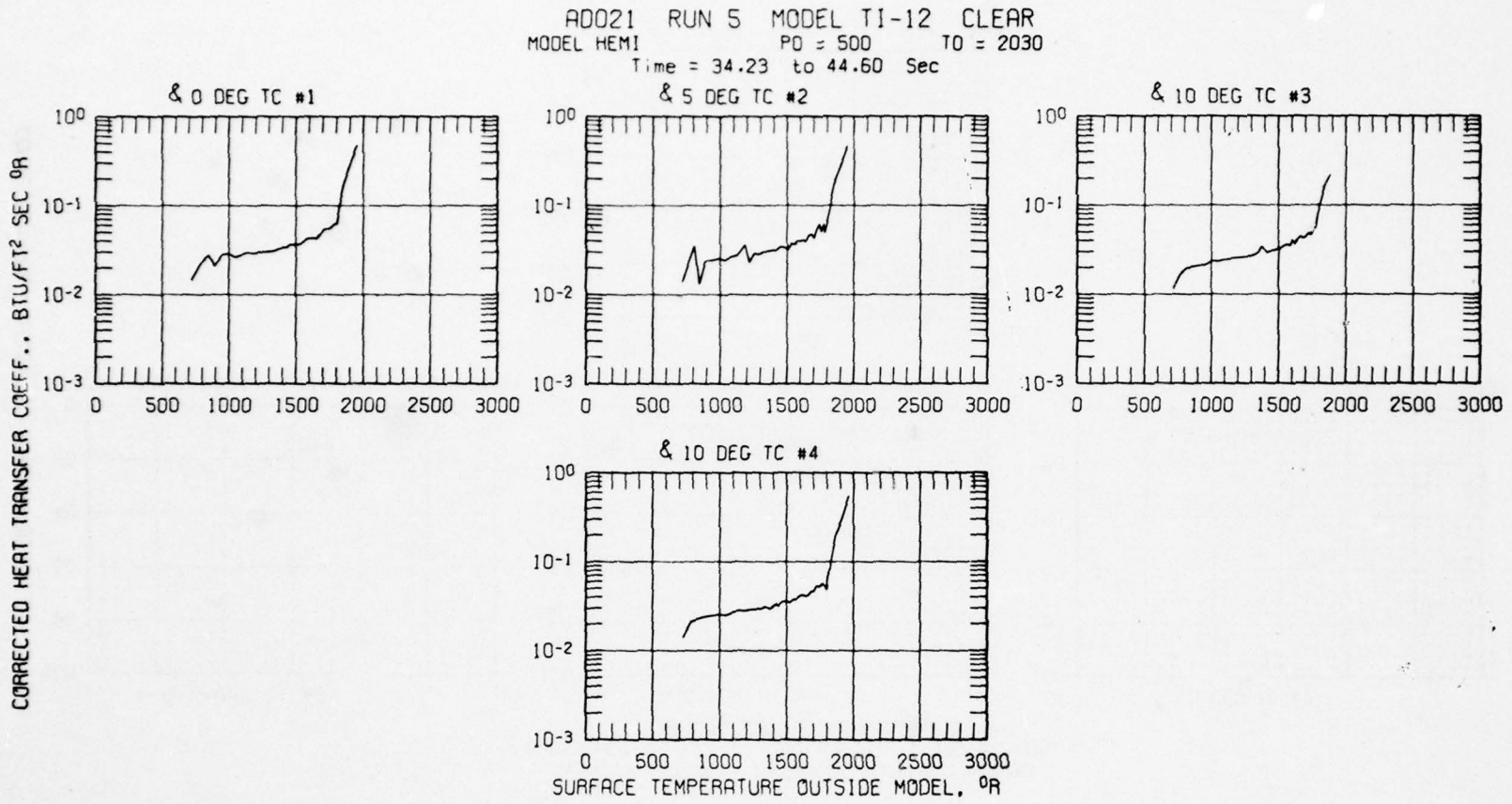
© TC-9-TI-7

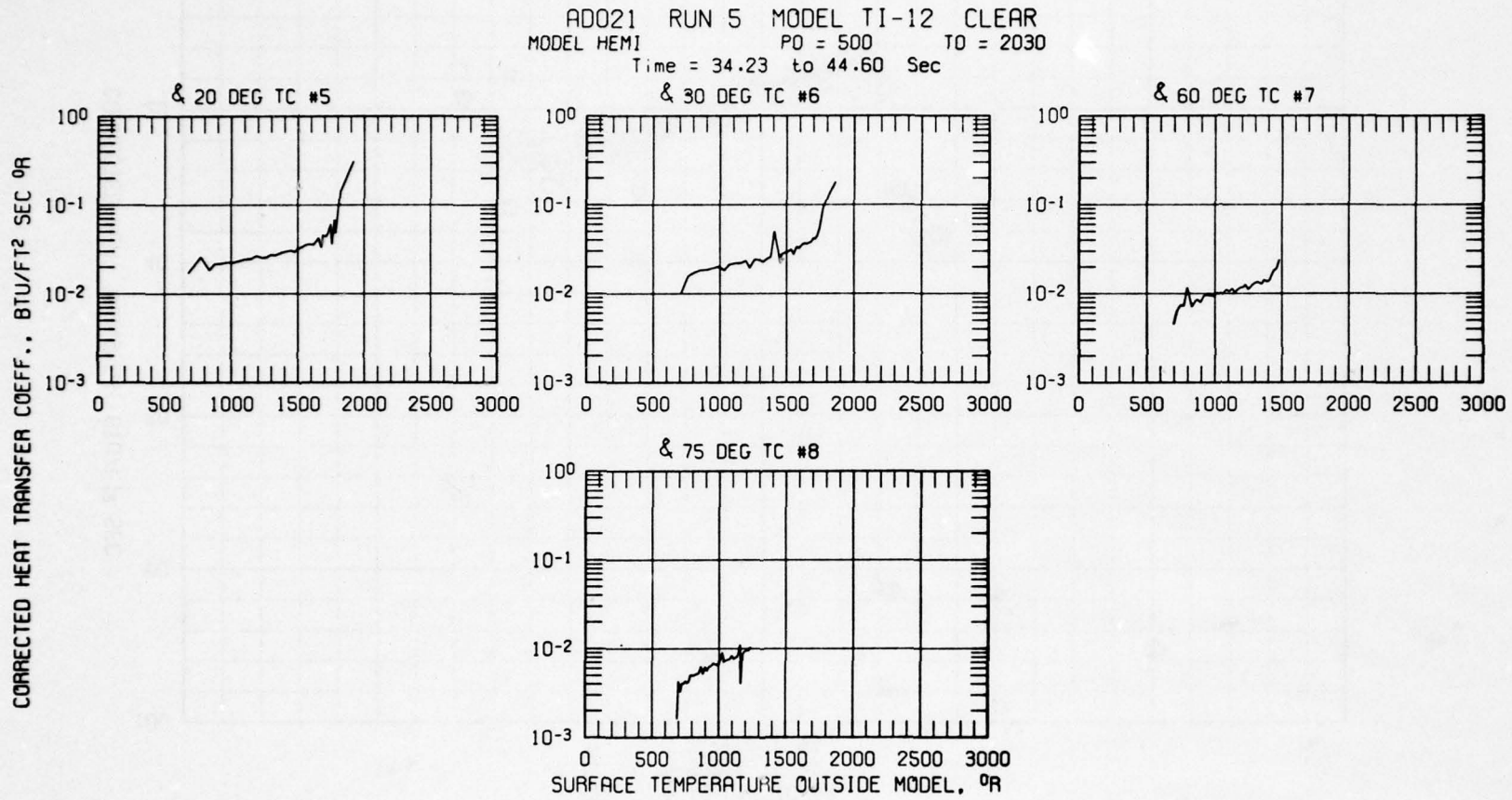


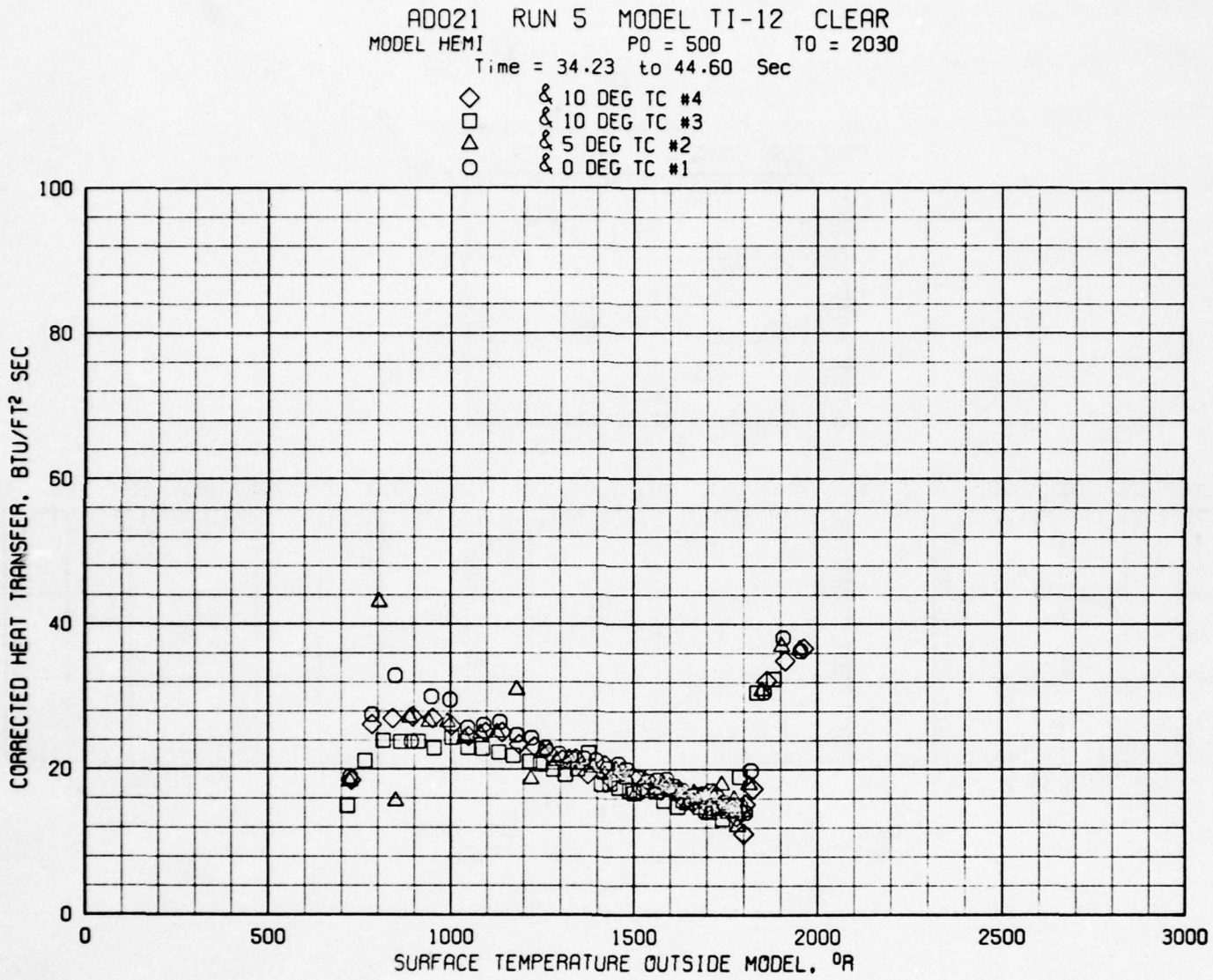

DATE 01-10-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-05-77 SEL 2105
▲ DUST-EVENT ⊙ H20-EVENT
8000
7000
6000
5000
4000
3000
TEMPERATURE, °F
0
20
40
60
80
100
TIME, SEC

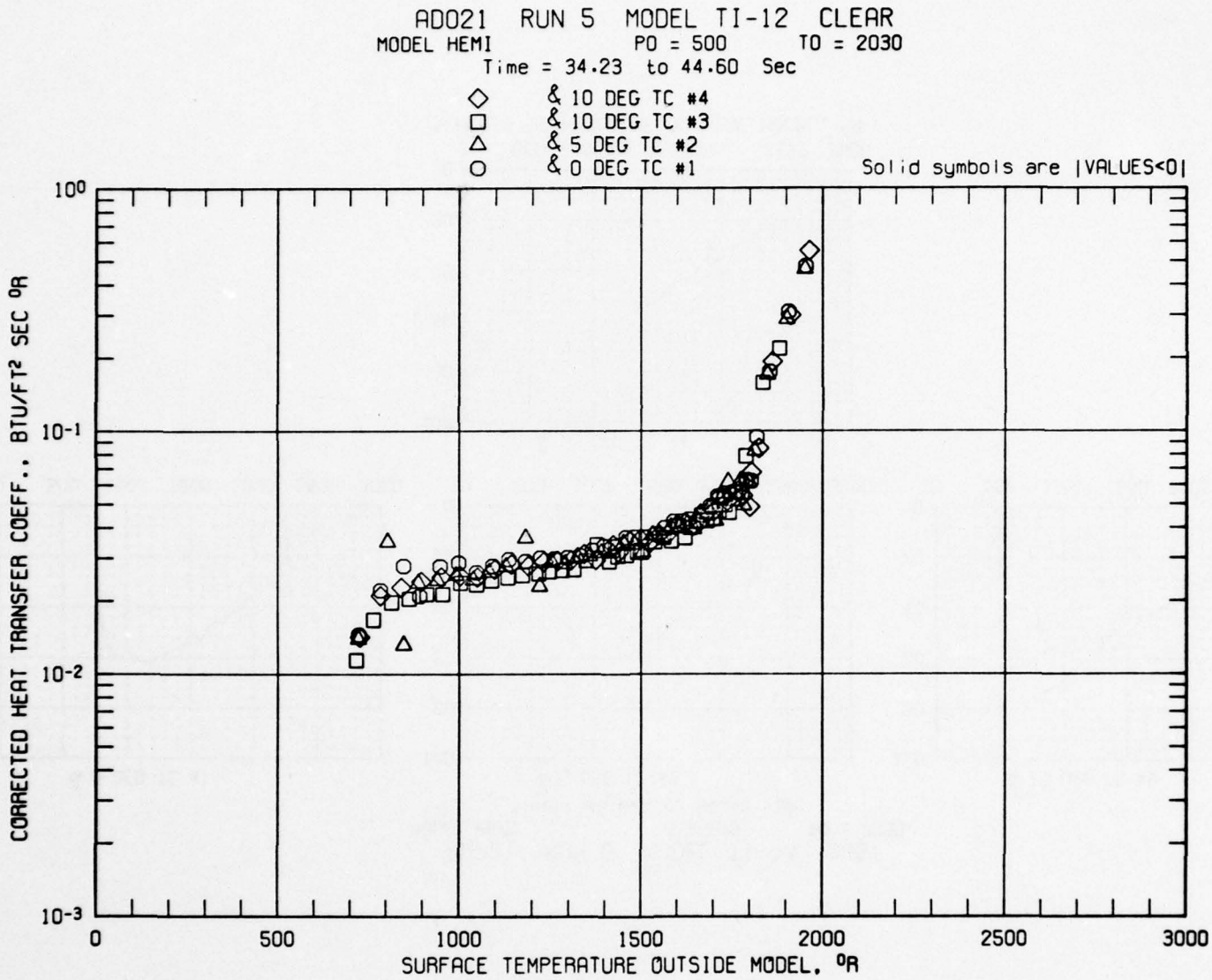

AD021 RUN 5 MODEL TI-12 CLEAR
MODEL HEMI
PO = 500
TO = 2030
Time = 34.23 to 44.60 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000

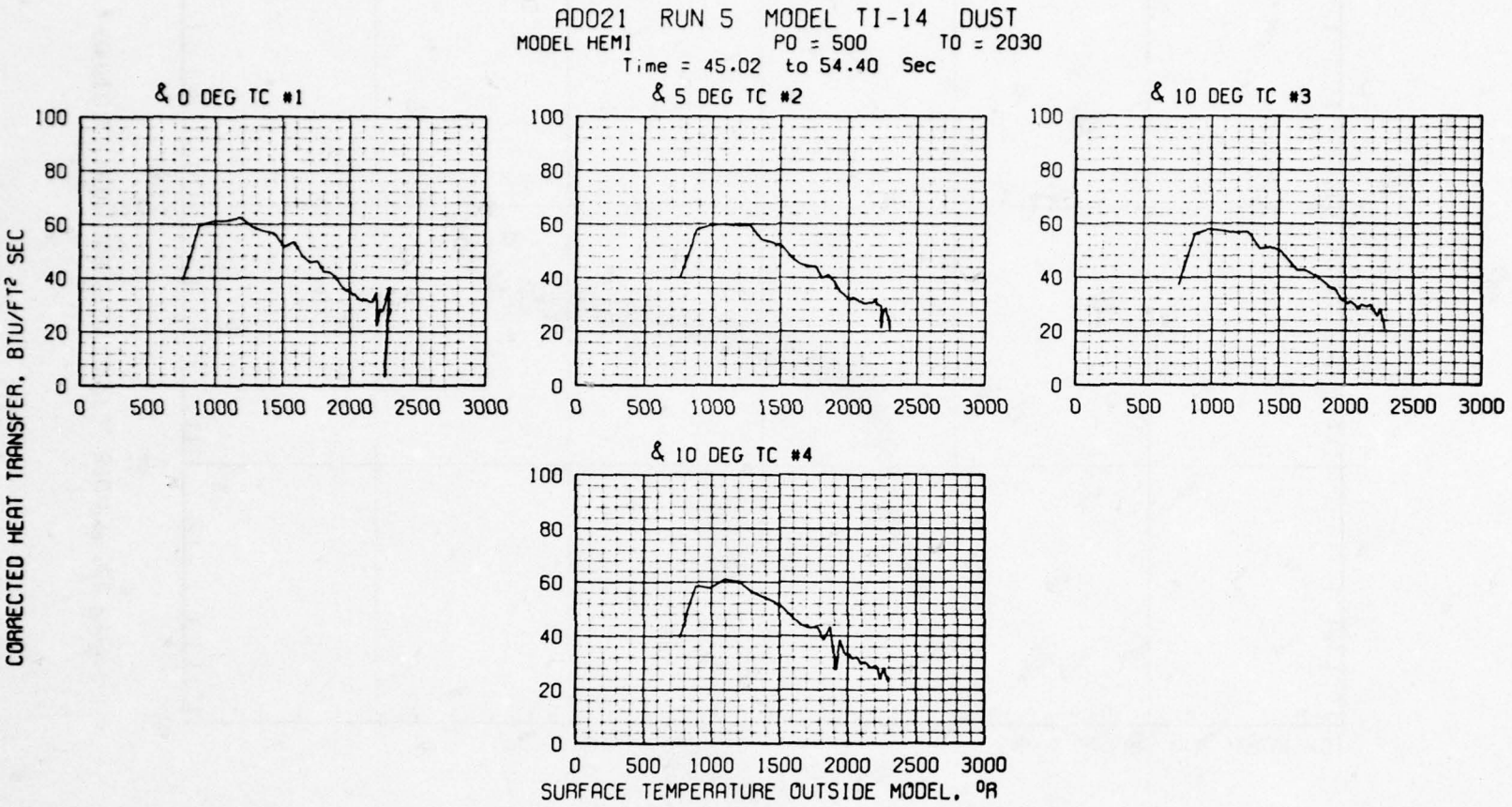

A0021 RUN 5 MODEL TI-12 CLEAR
MODEL HEMI
PO = 500
TO = 2030
Time = 34.23 to 44.60 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
500
1000
1500
2000
2500
3000

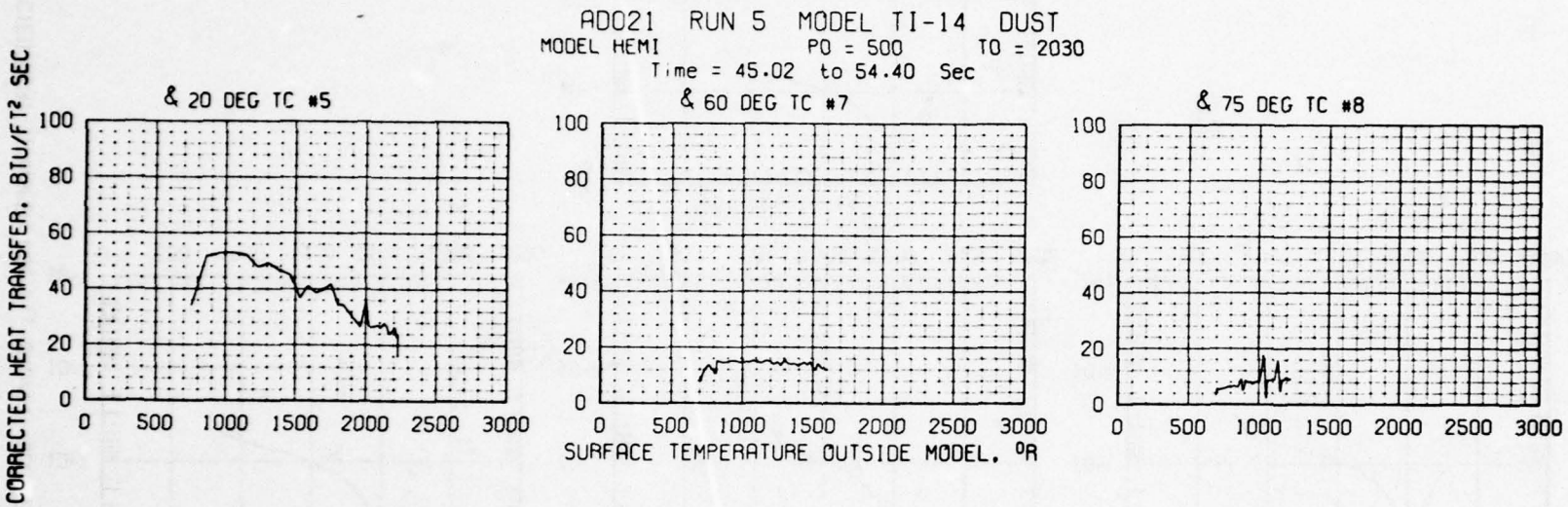

A0021 RUN 5 MODEL TI-12 CLEAR
MODEL HEMI PO = 500 TO = 2030
Time = 34.23 to 44.60 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

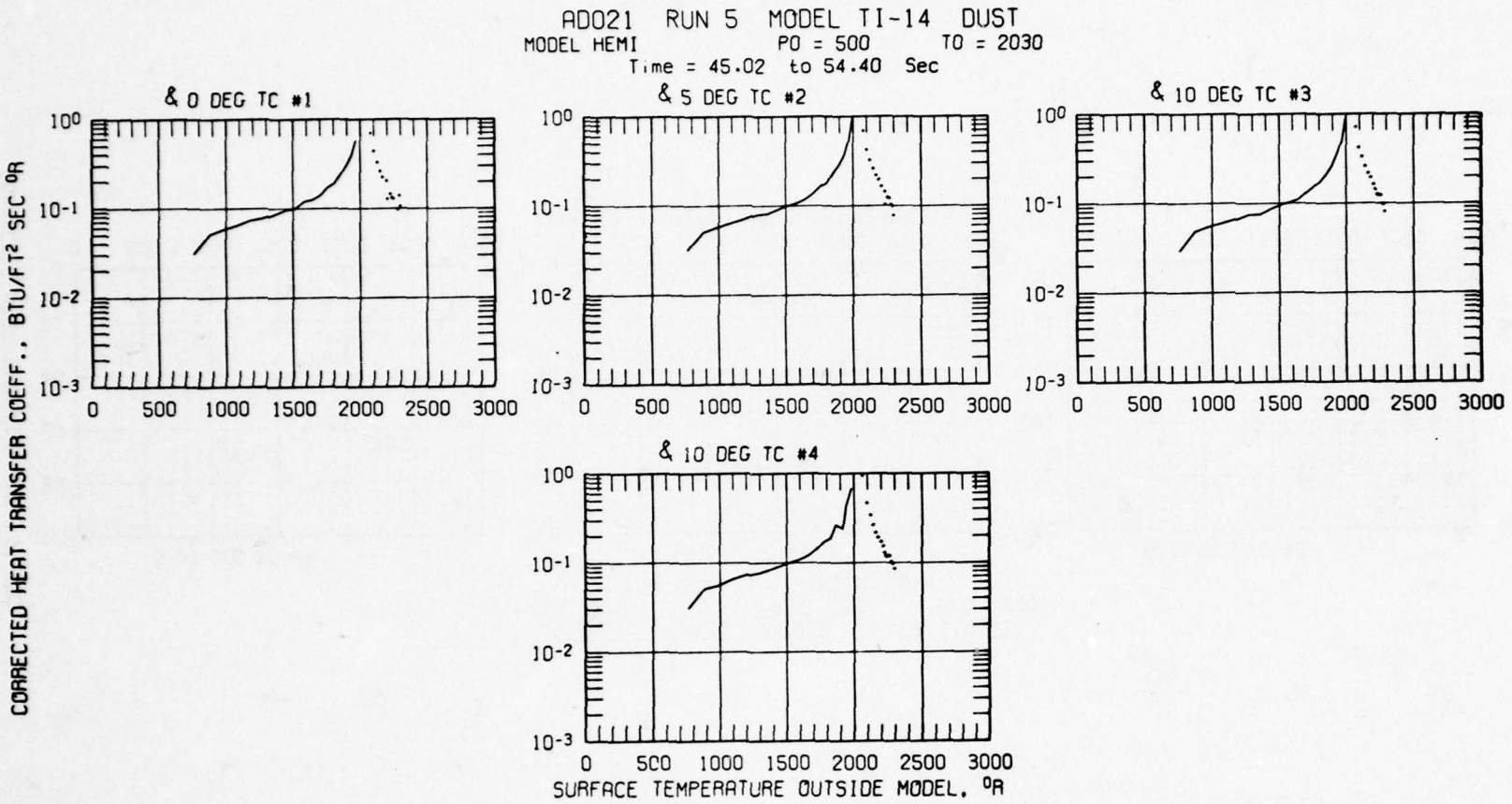

AD021 RUN 5 MODEL TI-12 CLEAR
MODEL HEMI PO = 500 TO = 2030
Time = 34.23 to 44.60 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

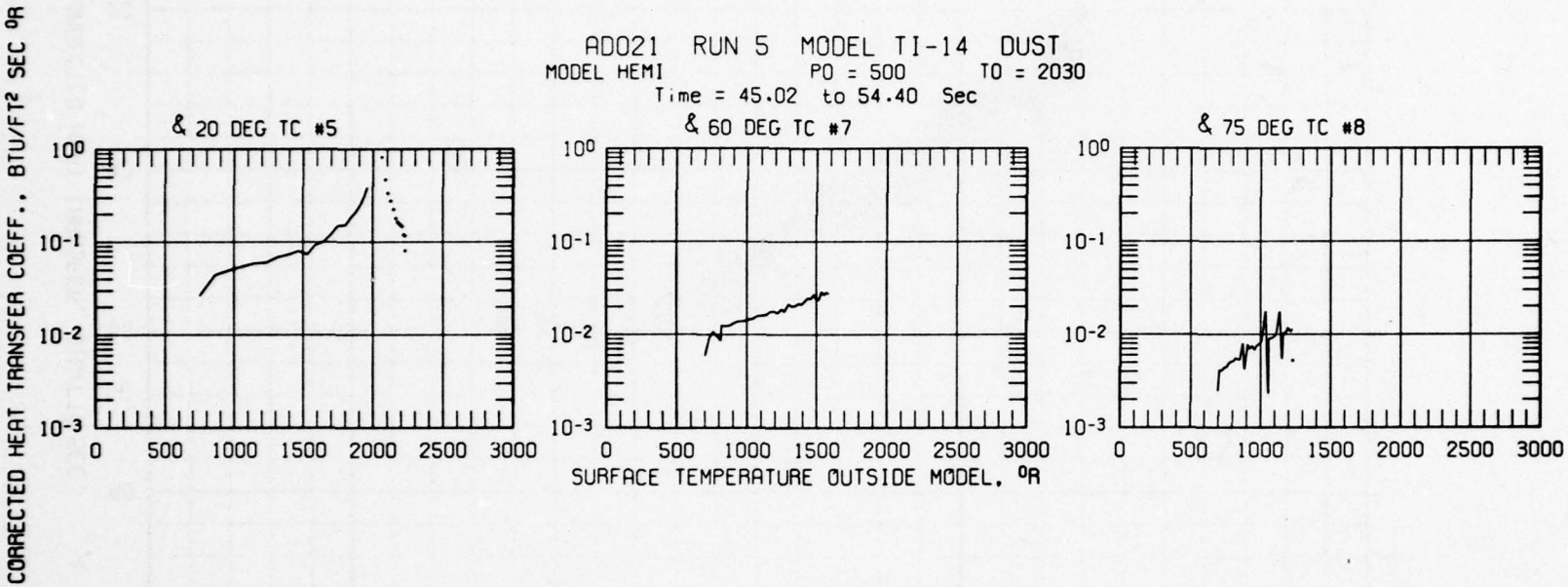

AD021 RUN 5 MODEL TI-12 CLEAR
MODEL HEMI
PO = 500
TO = 2030
Time = 34.23 to 44.60 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000

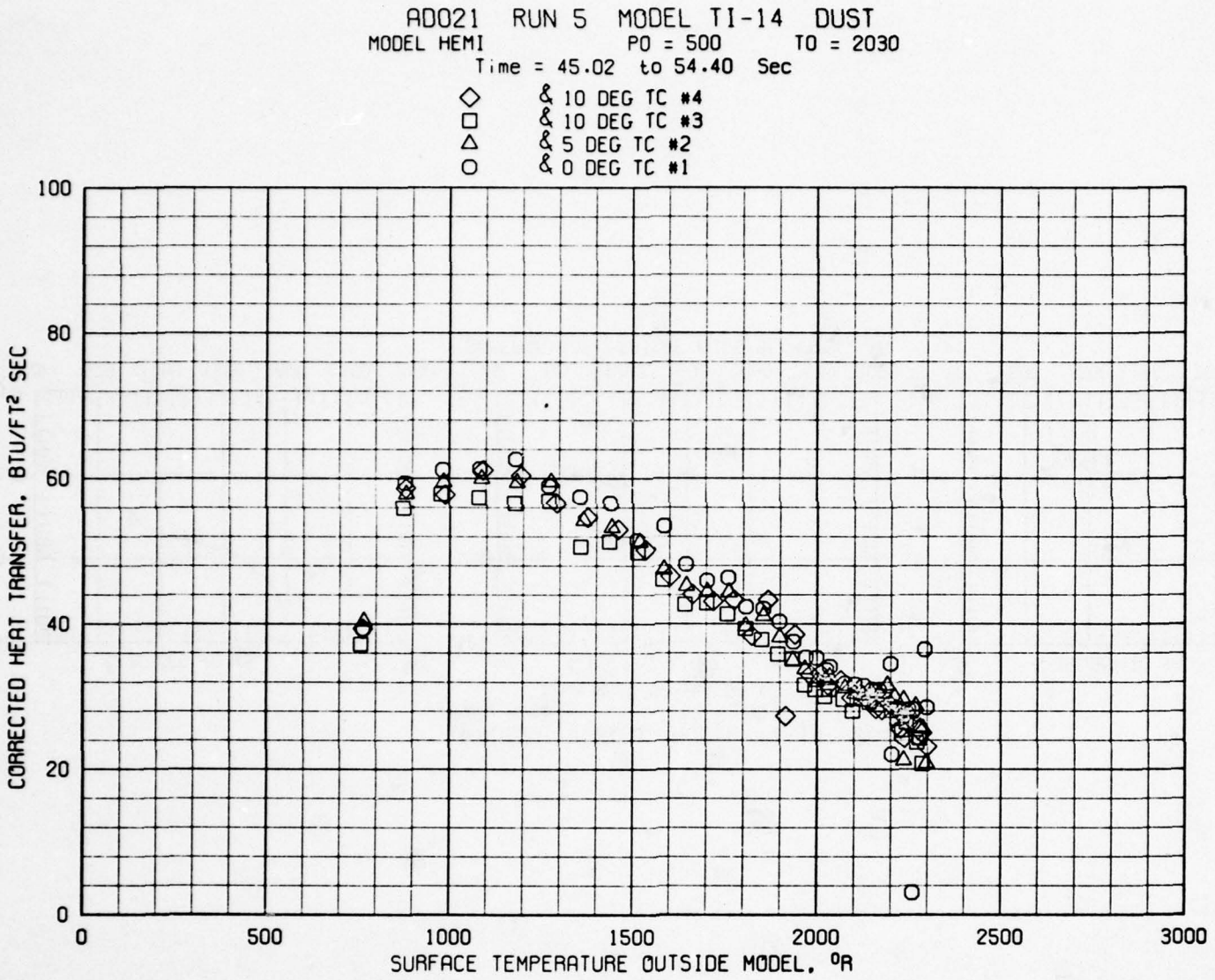

AD021 RUN 5 MODEL TI-12 CLEAR
MODEL HEMI
PO = 500
TO = 2030
Time = 34.23 to 44.60 Sec
& 10 DEG TC #4
& 10 DEG TC #3
& 5 DEG TC #2
& 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

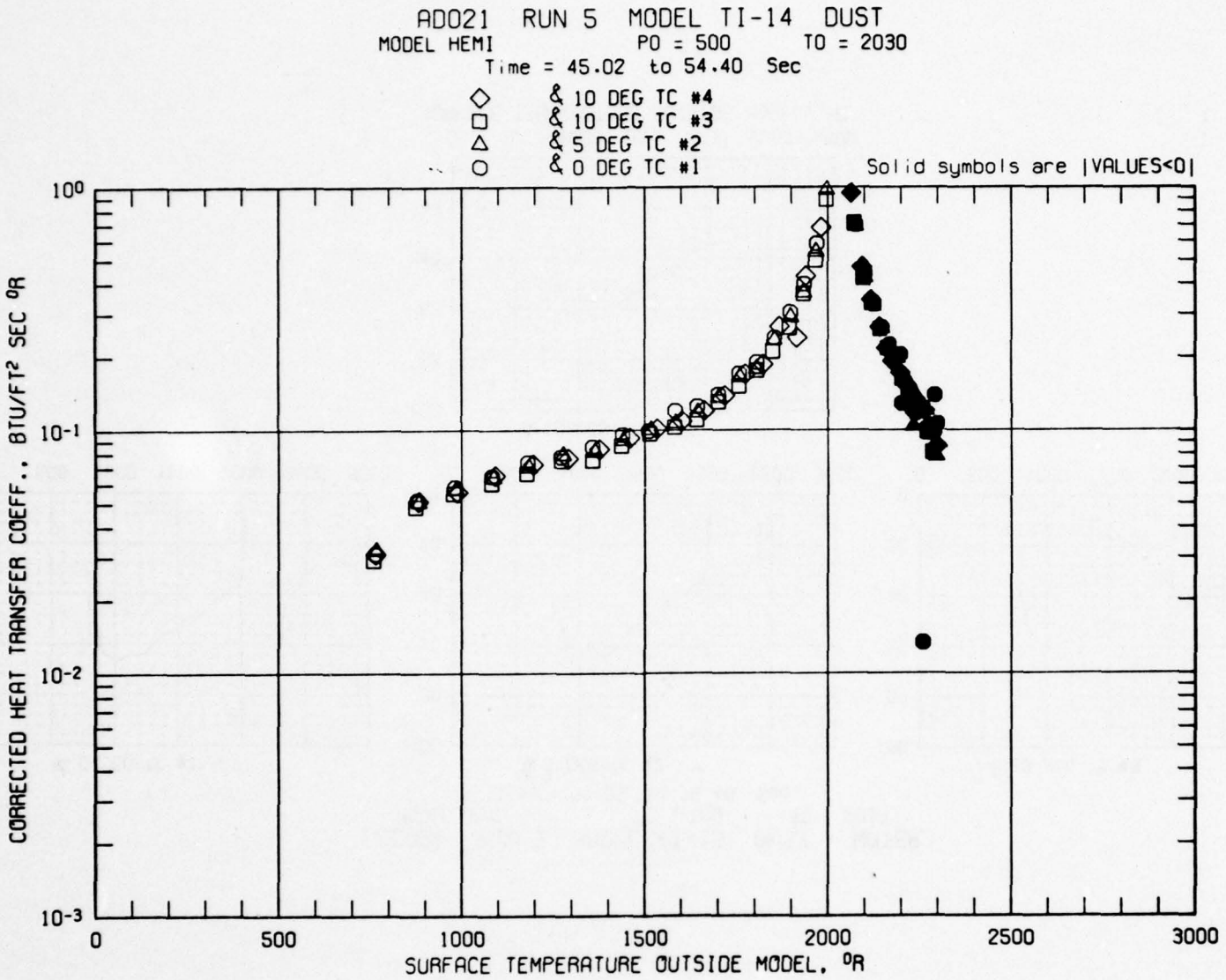

AD021 RUN 5 MODEL TI-14 DUST
MODEL HEMI PO = 500 TO = 2030
Time = 45.02 to 54.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000


AD021 RUN 5 MODEL TI-14 DUST
MODEL HEMI PO = 500 TO = 2030
Time = 45.02 to 54.40 Sec
& 20 DEG TC #5
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000

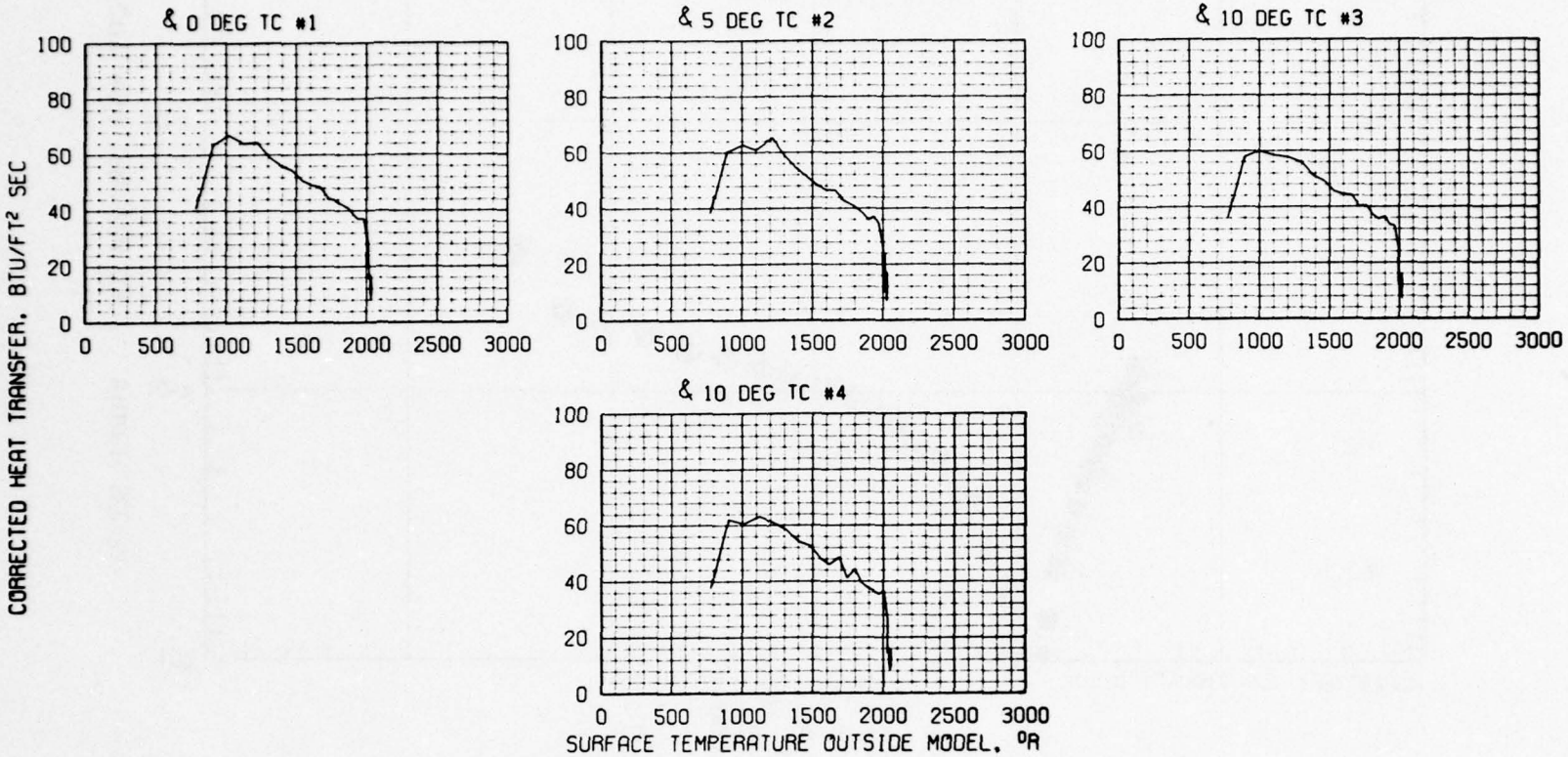

AD021 RUN 5 MODEL TI-14 DUST
MODEL HEMI PO = 500 TO = 2030
Time = 45.02 to 54.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

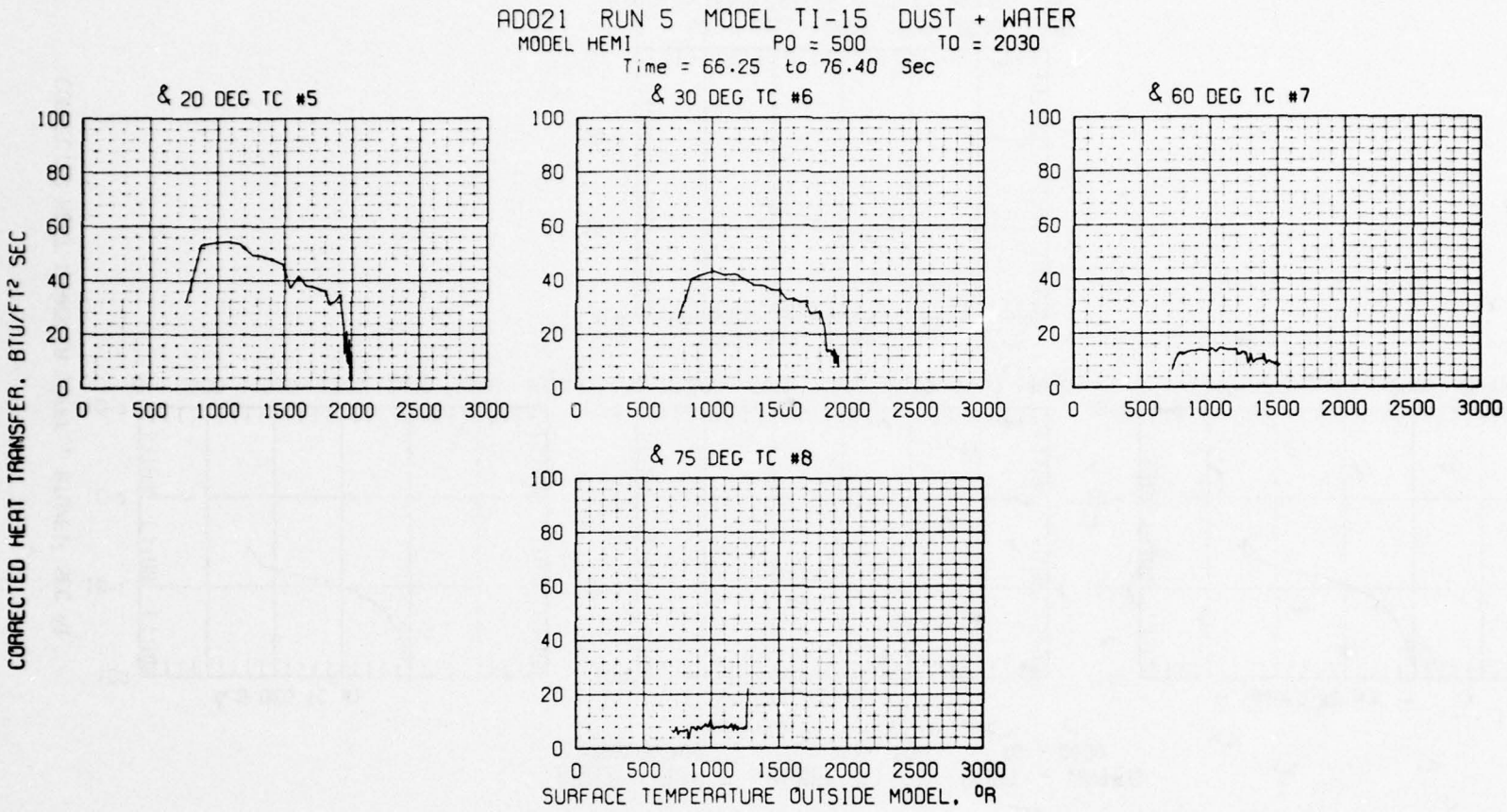

AD021 RUN 5 MODEL TI-14 DUST
MODEL HEMI PO = 500 TO = 2030
Time = 45.02 to 54.40 Sec
& 20 DEG TC #5
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

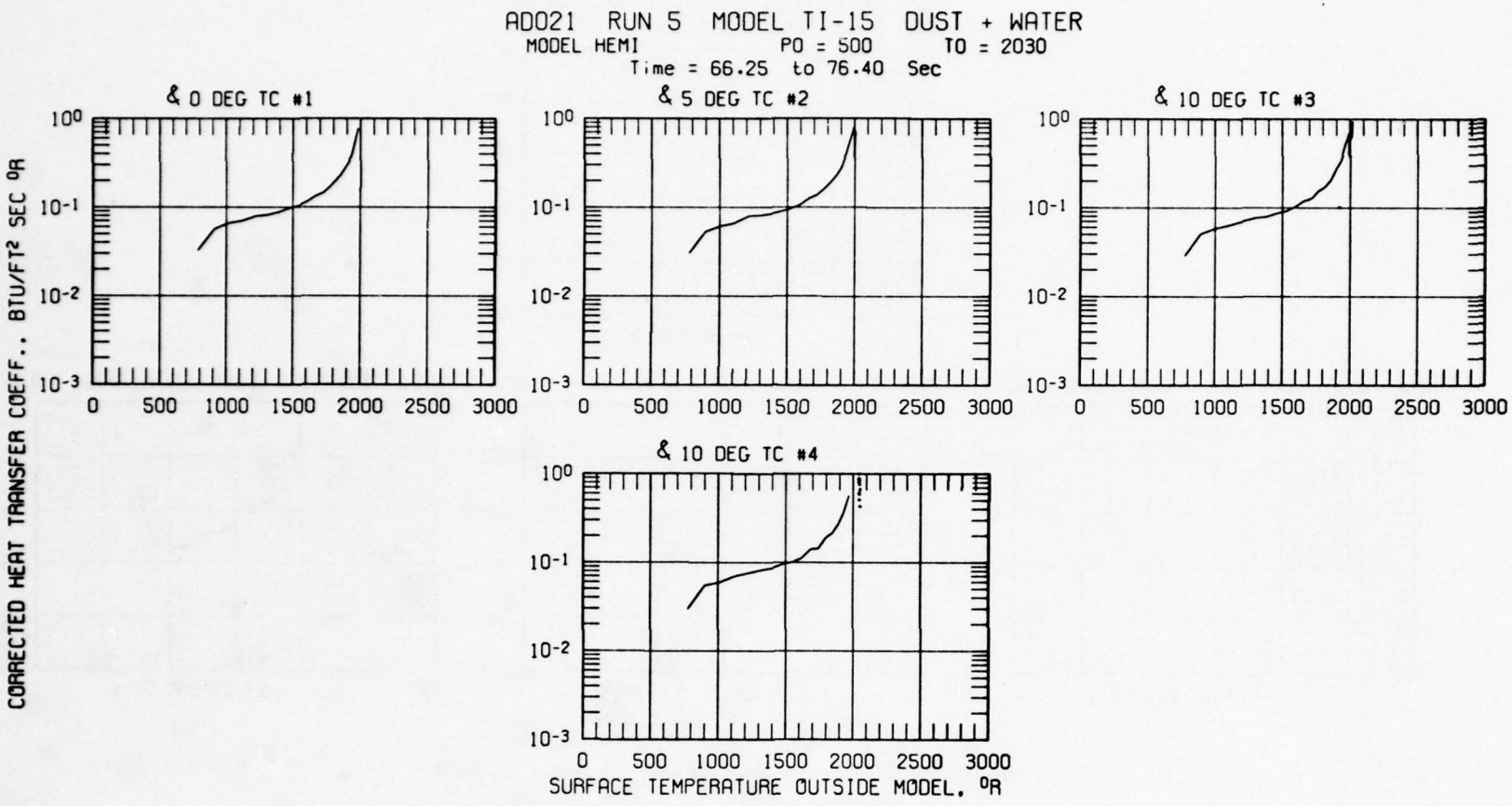

AD021 RUN 5 MODEL TI-14 DUST
MODEL HEMI
PO = 500
TO = 2030
Time = 45.02 to 54.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000

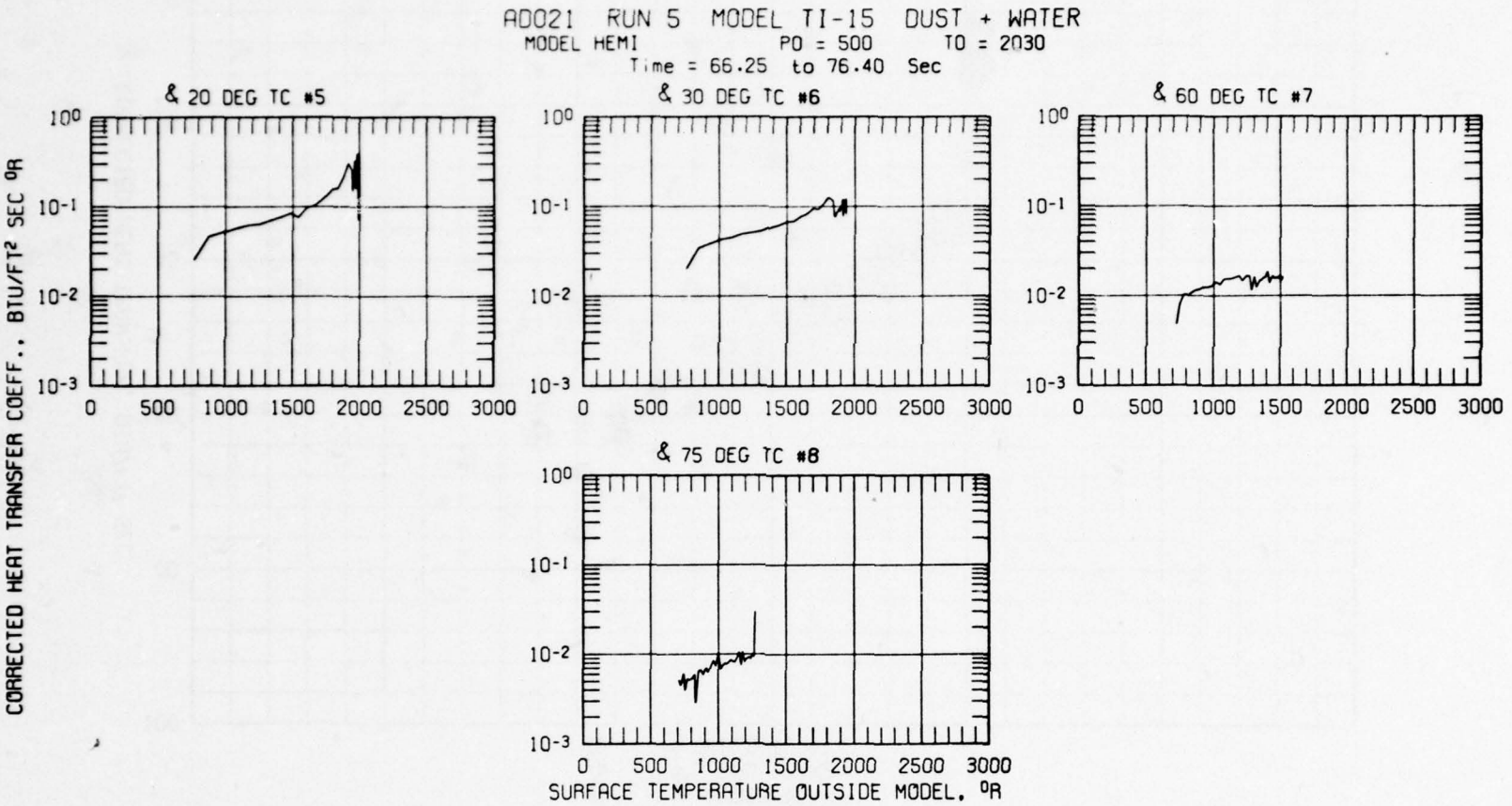

AD021 RUN 5 MODEL TI-14 DUST
MODEL HEMI
PO = 500
TO = 2030
Time = 45.02 to 54.40 Sec
& 10 DEG TC #4
& 10 DEG TC #3
& 5 DEG TC #2
& 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

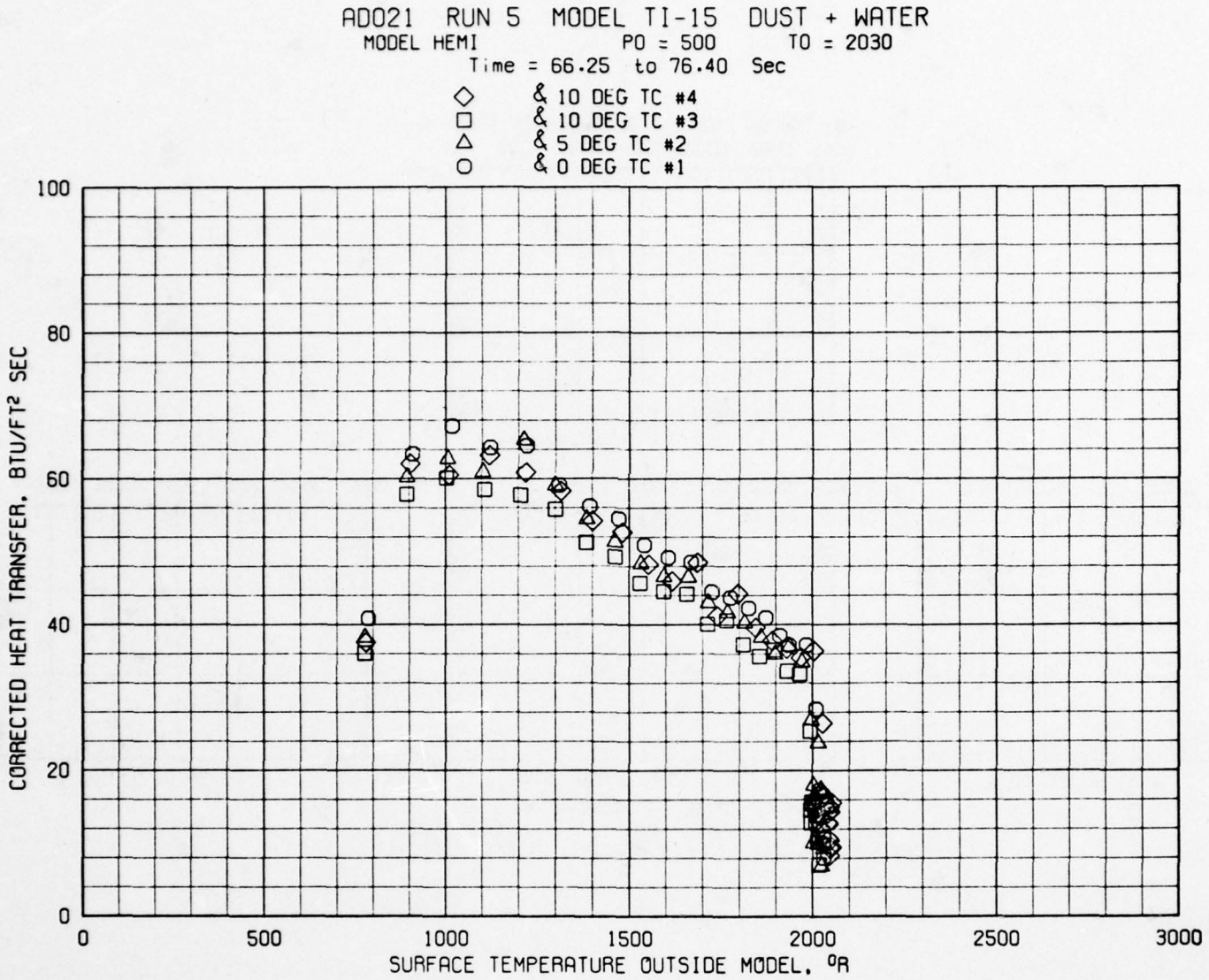
AD021 RUN 5 MODEL TI-15 DUST + WATER
MODEL HEMI PO = 500 TO = 2030
Time = 66.25 to 76.40 Sec

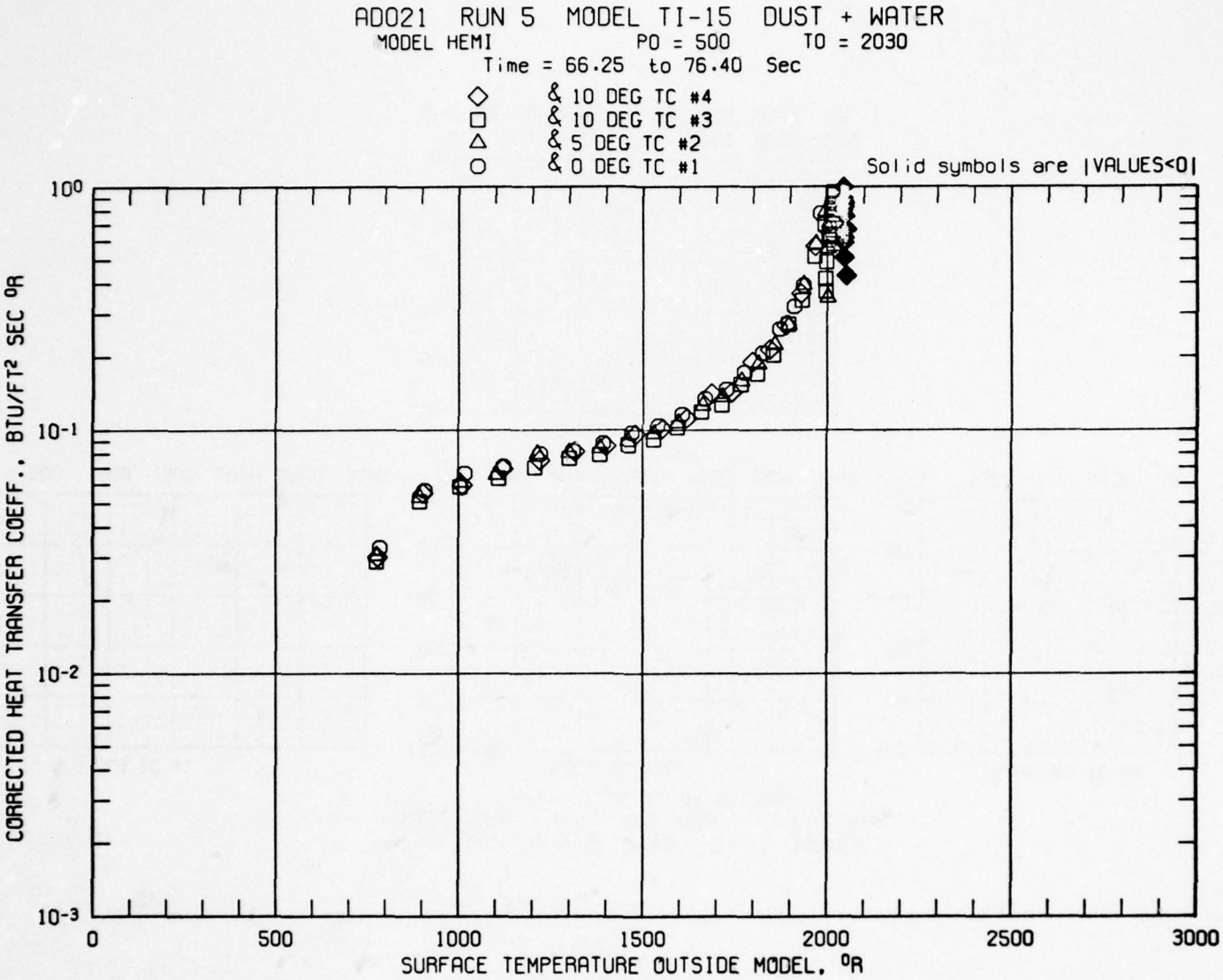


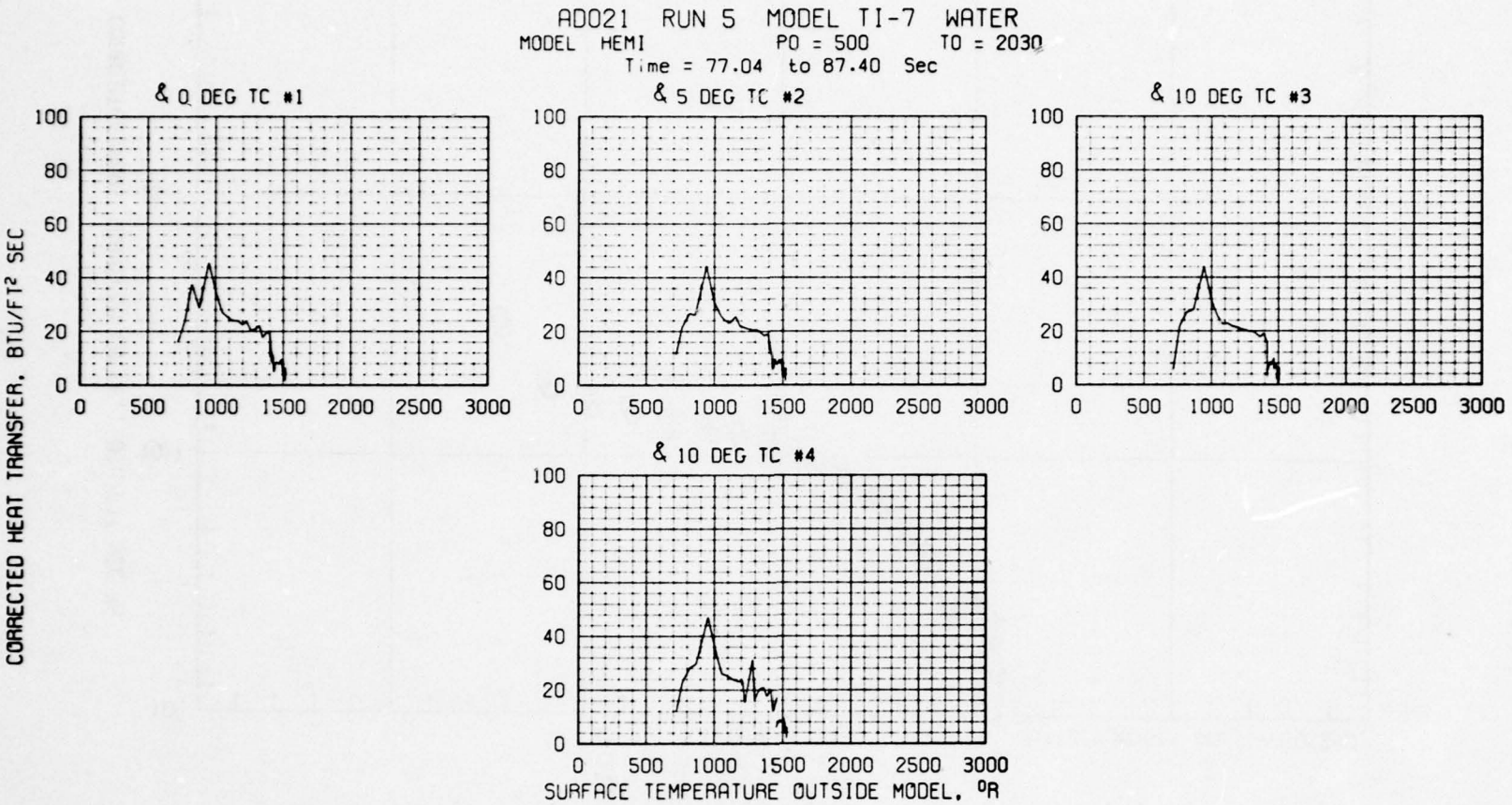

AD021 RUN 5 MODEL TI-15 DUST + WATER
MODEL HEMI PO = 500 TO = 2030
Time = 66.25 to 76.40 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
500
1000
1500
2000
2500
3000

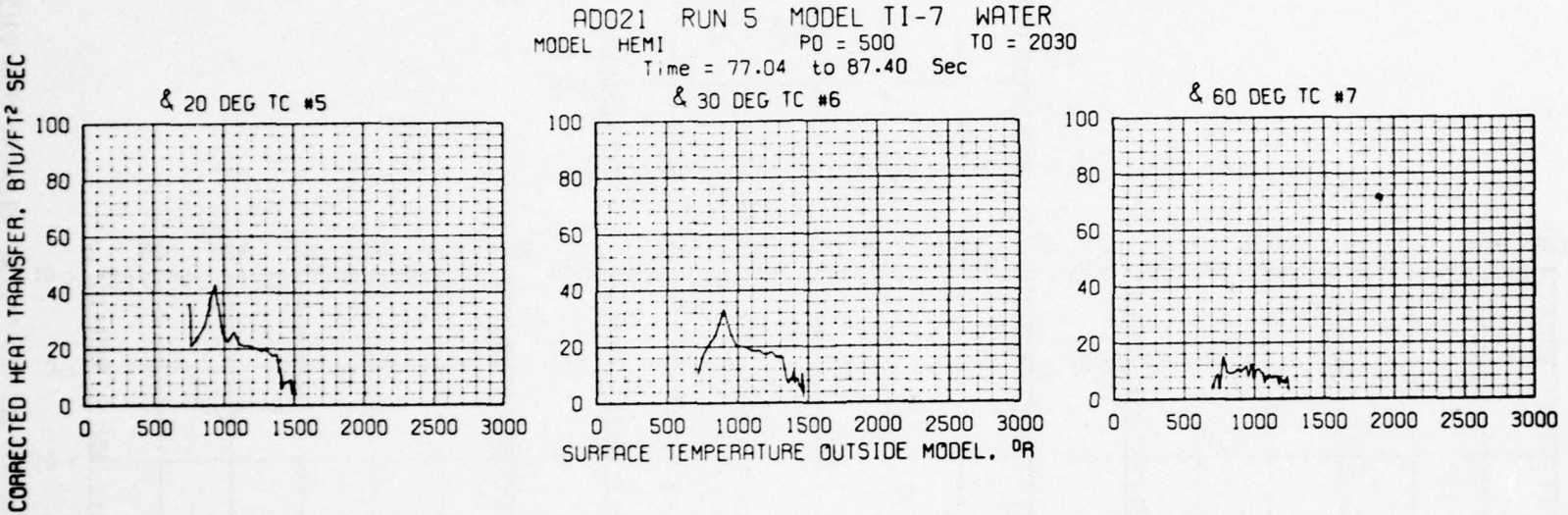

AD021 RUN 5 MODEL TI-15 DUST + WATER
MODEL HEMI PO = 500 TO = 2030
Time = 66.25 to 76.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

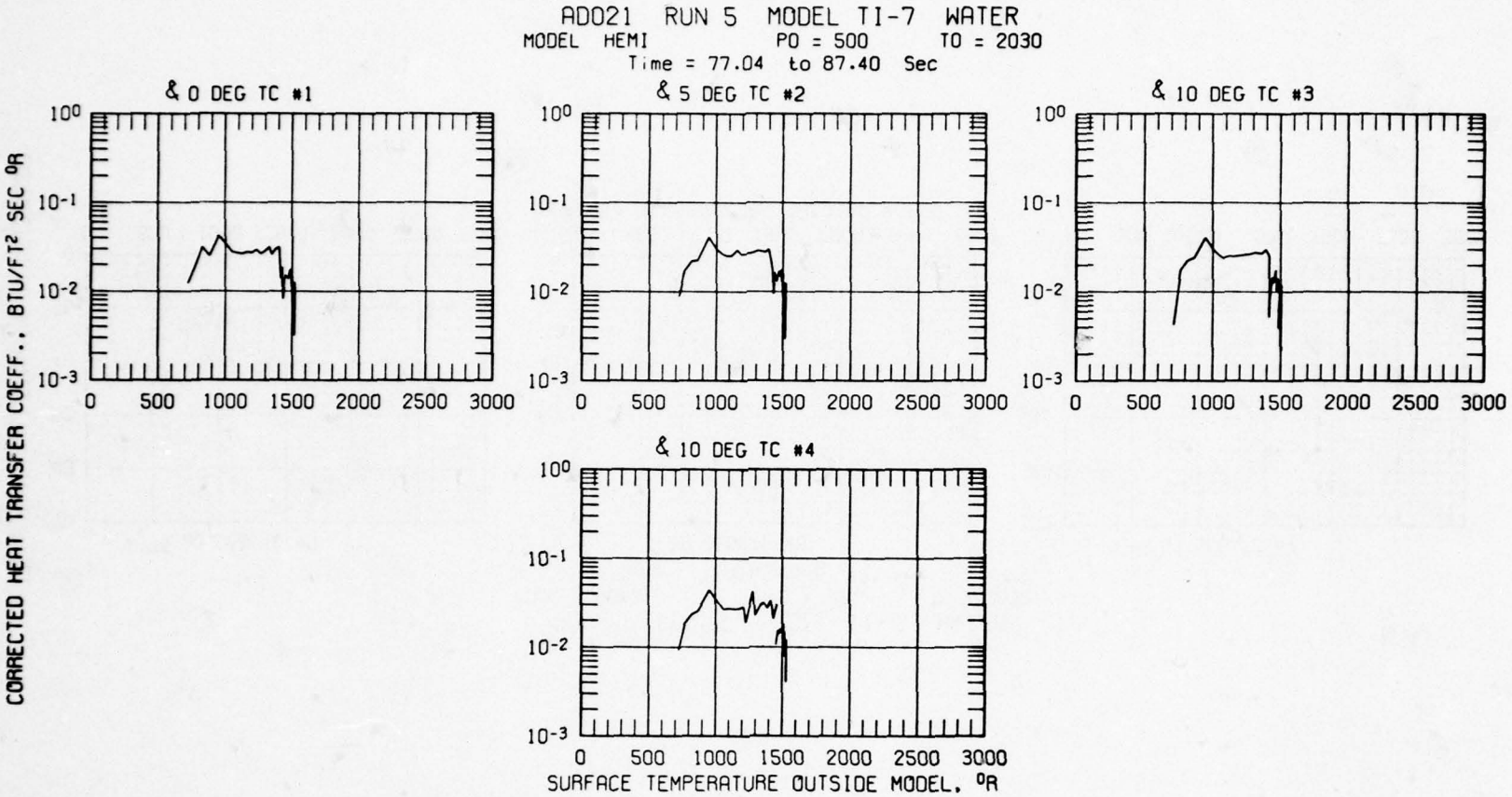

AD021 RUN 5 MODEL TI-15 DUST + WATER
MODEL HEMI PO = 500 TO = 2030
Time = 66.25 to 76.40 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

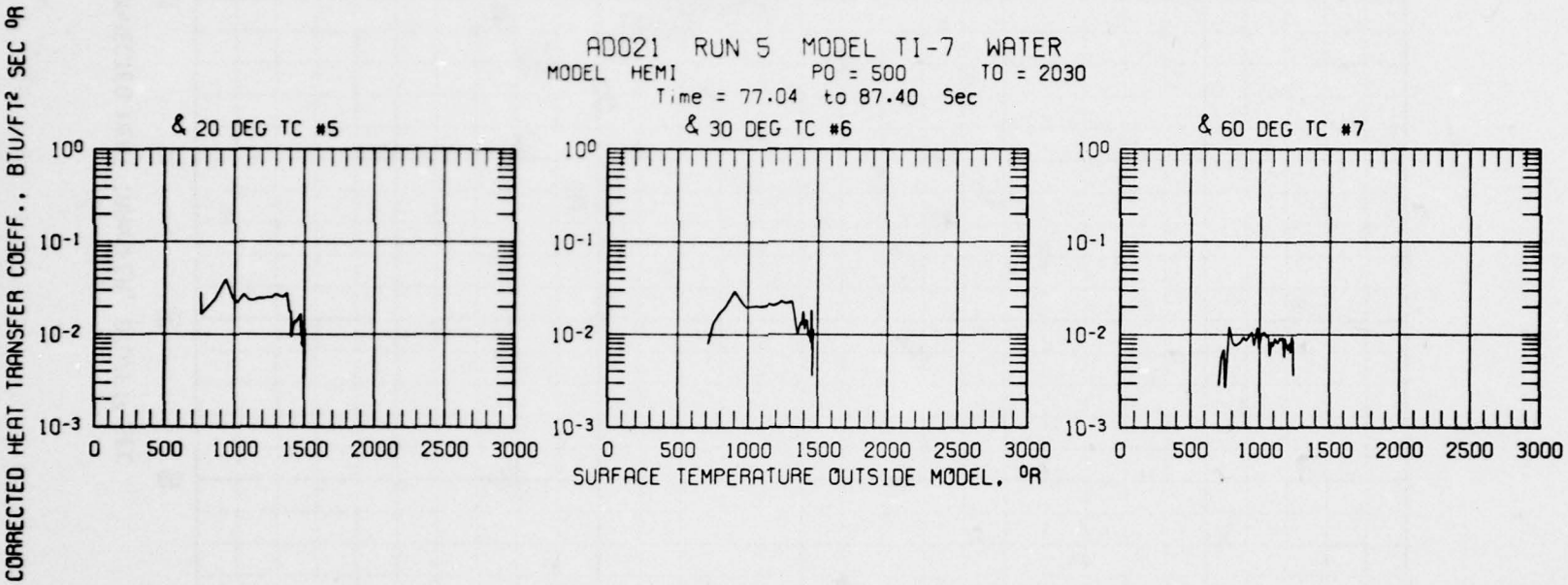

AD021 RUN 5 MODEL TI-15 DUST + WATER
MODEL HEMI
PO = 500
TO = 2030
Time = 66.25 to 76.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000

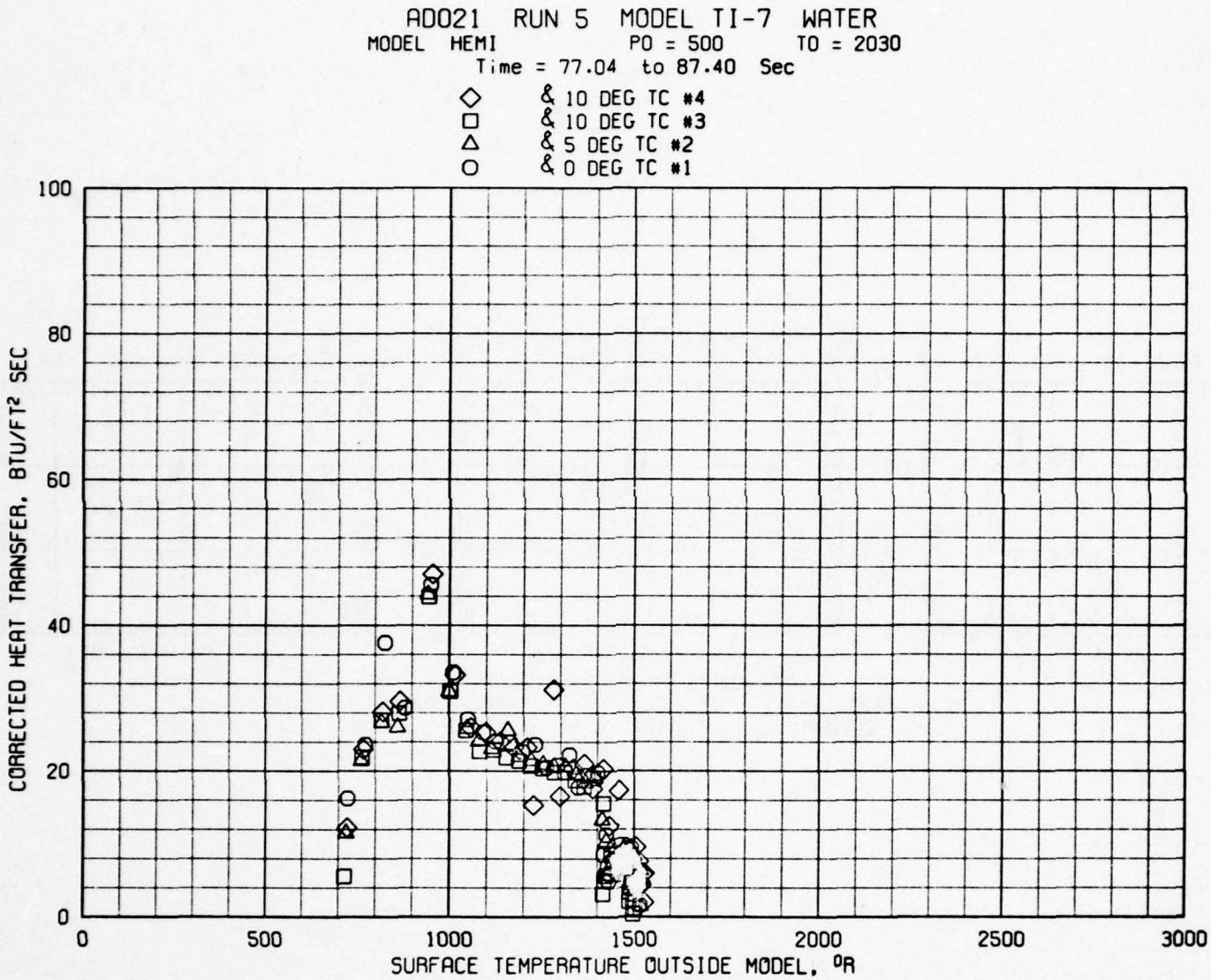

AD021 RUN 5 MODEL TI-15 DUST + WATER
MODEL HEMI
PO = 500
TO = 2030
Time = 66.25 to 76.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R


AD021 RUN 5 MODEL TI-7 WATER
MODEL HEMI PO = 500 TO = 2030
Time = 77.04 to 87.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000


AD021 RUN 5 MODEL TI-7 WATER
MODEL HEMI PO = 500 TO = 2030
Time = 77.04 to 87.40 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0 500 1000 1500 2000 2500 3000


AD021 RUN 5 MODEL TI-7 WATER
MODEL HEMI PO = 500 TO = 2030
Time = 77.04 to 87.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 5 MODEL TI-7 WATER
MODEL HEMI PO = 500 TO = 2030
Time = 77.04 to 87.40 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 5 MODEL TI-7 WATER
MODEL HEMI
PO = 500
TO = 2030
Time = 77.04 to 87.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500
3000

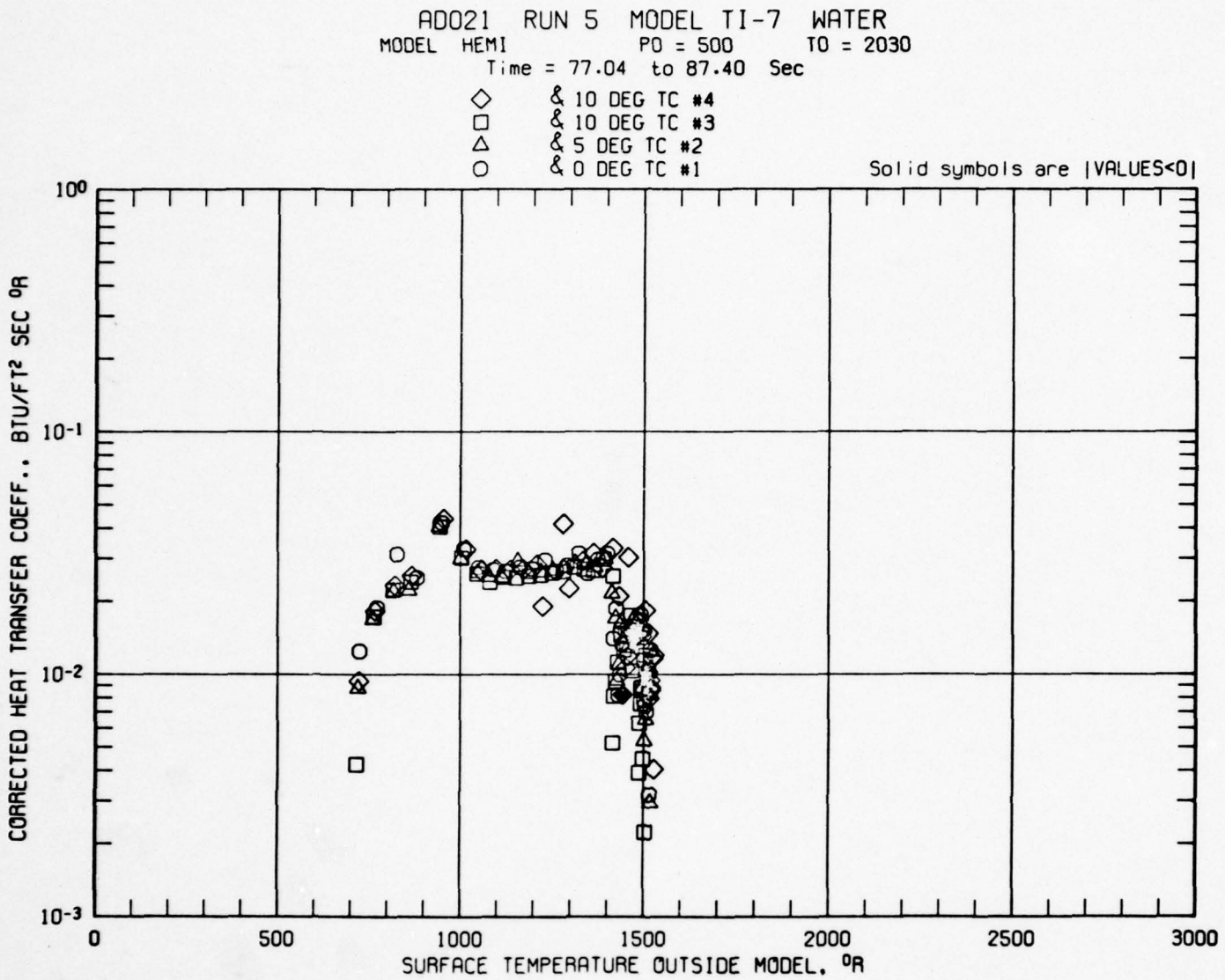

AD021 RUN 5 MODEL TI-7 WATER
MODEL HEMI PO = 500 TO = 2030
Time = 77.04 to 87.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

TABLE 1 RUN SUMMARY

TUNNEL CONDITIONS

RUN 6 DATE 1-12-77

NOZZLE STATION 127.5

p_o = 994 psia, p_{o_m} = 996

H_{o_B} = 756 Btu/lbm, H_{o_m} = 724

H_o = 780 Btu/lbm

T_{o_B} = 2860 °R, T_o = 2924 °R

γ = 7.1 p_o' = 9.43 psia

DUST

TYPE MgO

SIZE 100 µm

VEL 4560 ft/sec

Flow 7.92 gm/sec

C.F. 23.4

WATER

Flow 0.39 gpm

C.F. 42.2

Orifice 0.020 in.

ΔP 930 psi

STING	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANSDUCER TYPE	PRERUN	POSTRUN
1	P_o' probe	3					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_o probe	20					See Fig. 3	0.25		R	1					
3	T_i-12	4.19					Hemi	2.0	6Al-4V-T_i	S	8				102	241
4	WB-4S WB-4A	3.82					See Fig. 2	0.5	SS Al							239
5	T_i-13	0.78	3.78				Hemi	2.0	6Al-4V-T_i	S	8				6837	240
6	T_i-11		2.11 2.40	0 2.40	- x		Hemi	2.0	6Al-4V-T_i	S	8				8005	242
7	T_i-2	1.47		2.49			Hemi	2.0	6Al-4V-T_i	S	8				8031	237
8	WB-3S WB-3A			3.78			See Fig. 2	0.5	SS Al							238
9	GS			20			See Fig. 4	2.0	SS							604 605
10																

KEY -

PH - PREHEAT
POH - POSTHEAT
DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

NOTES:

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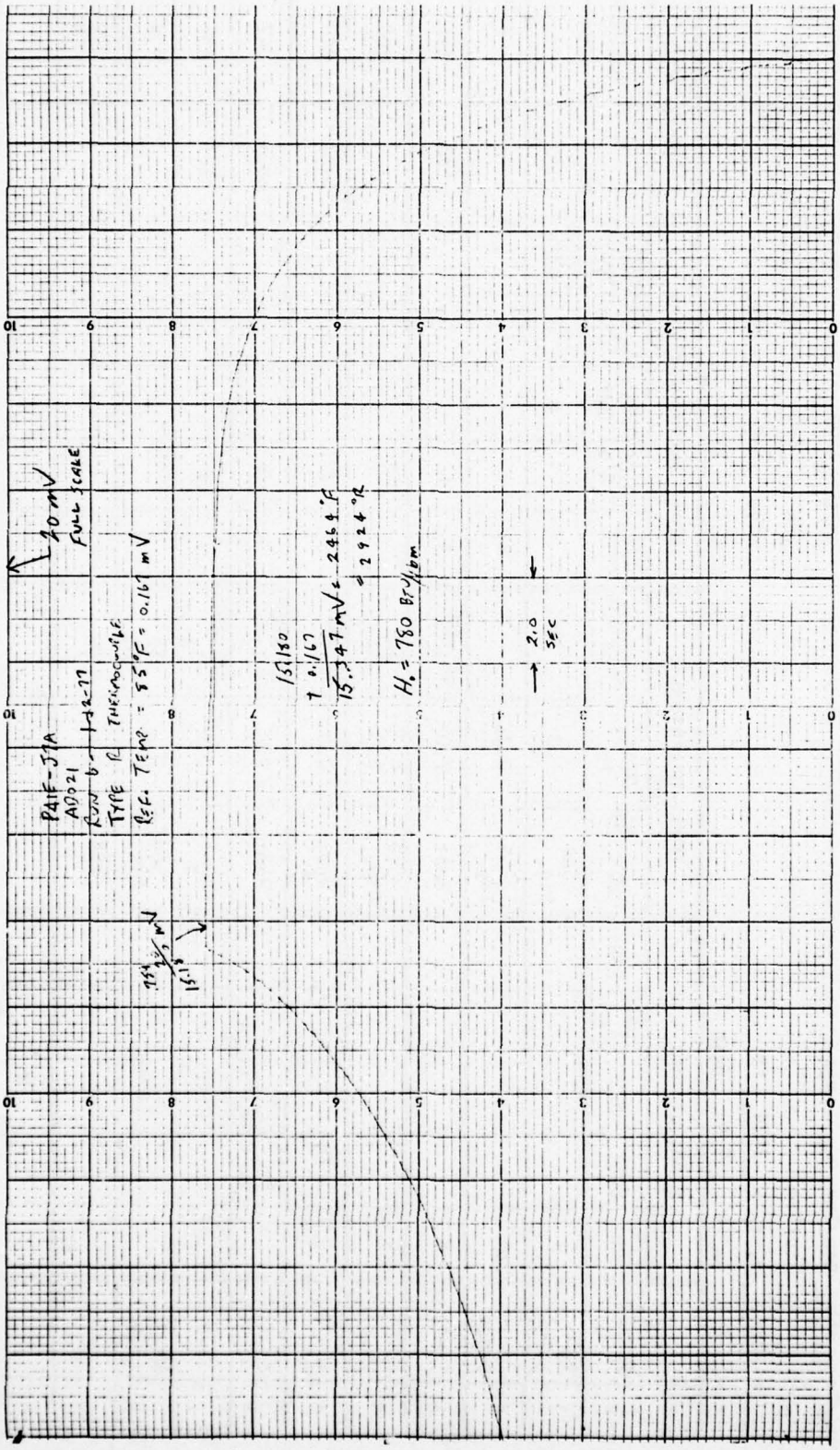
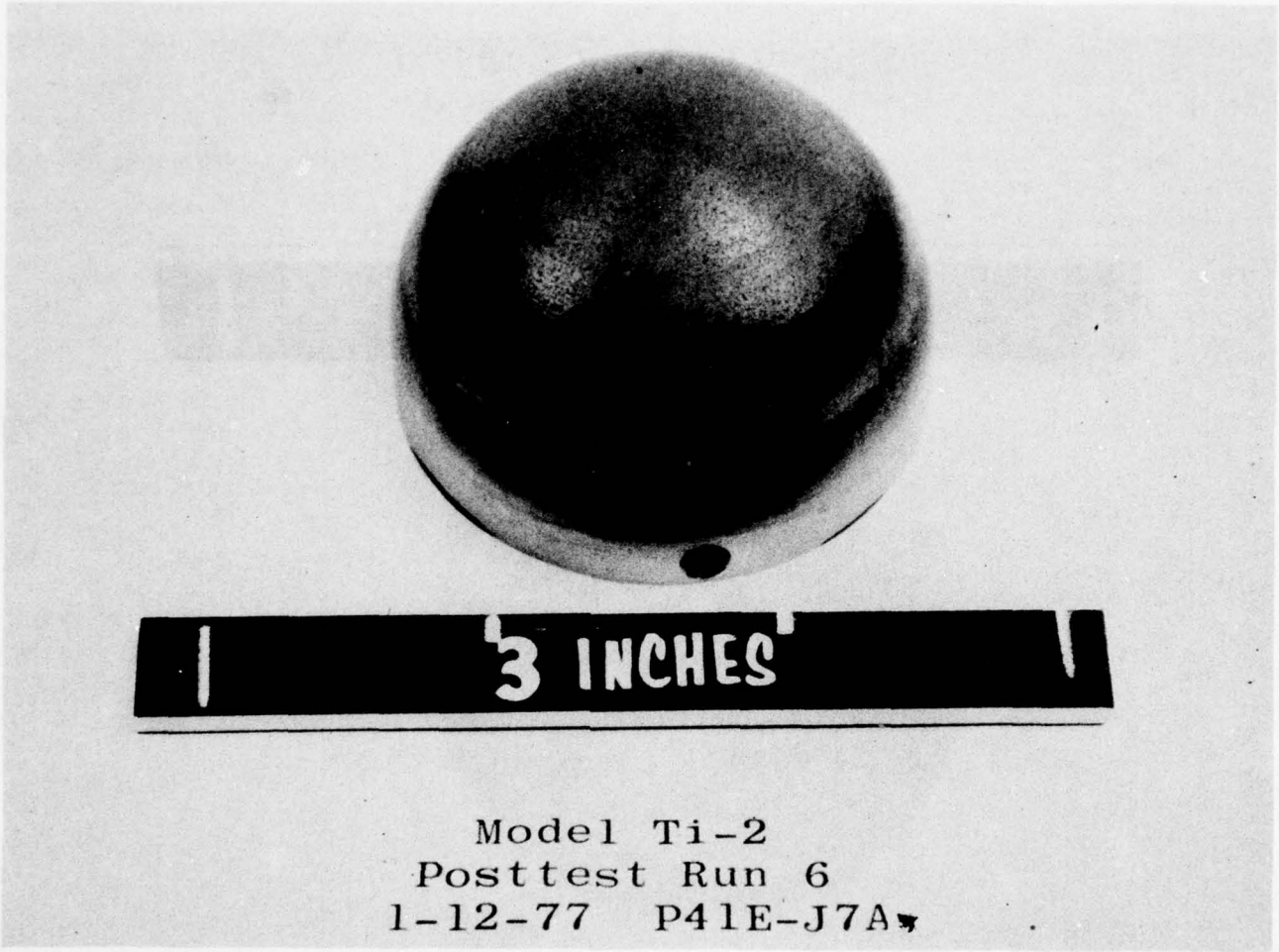
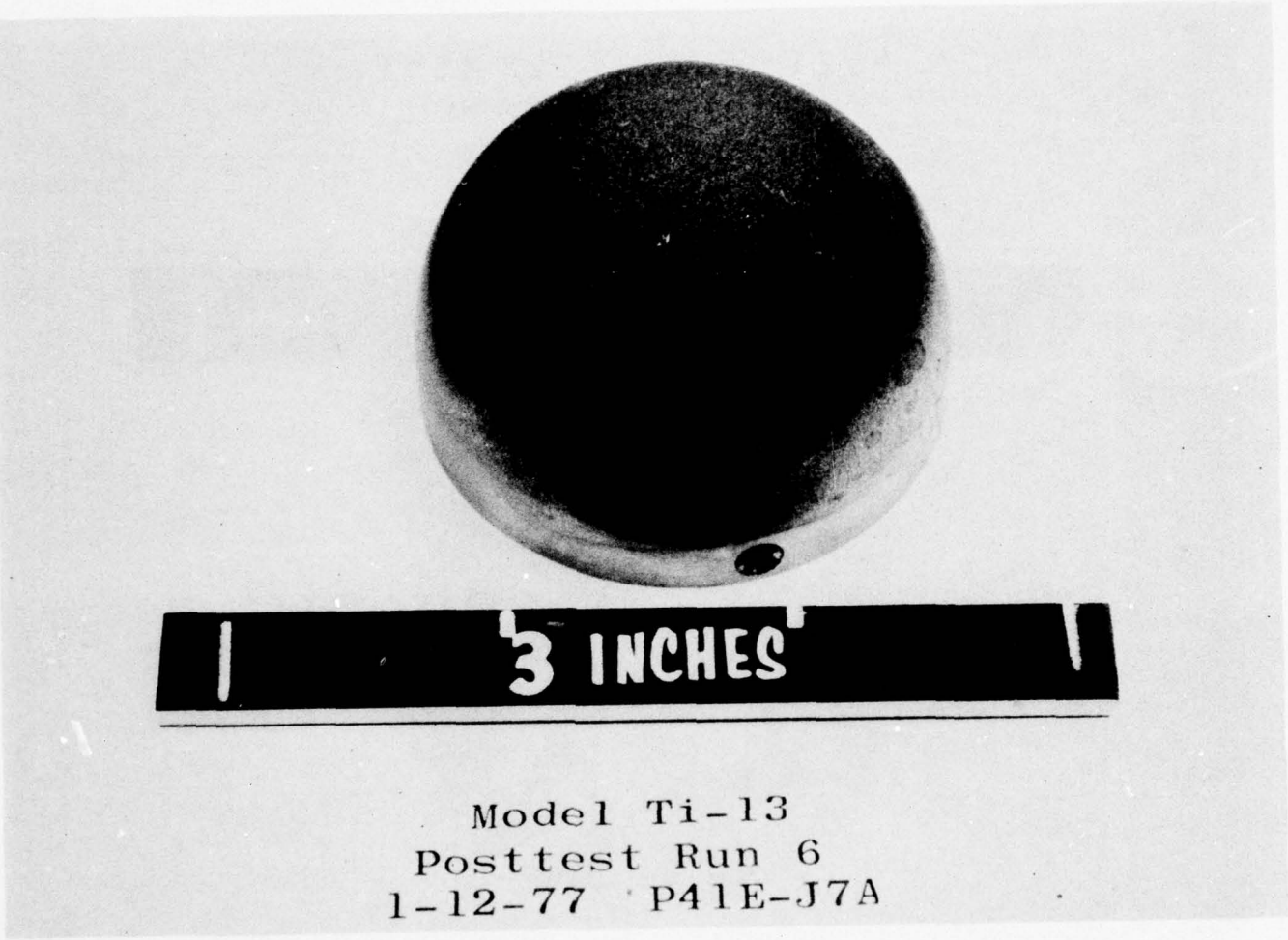
THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

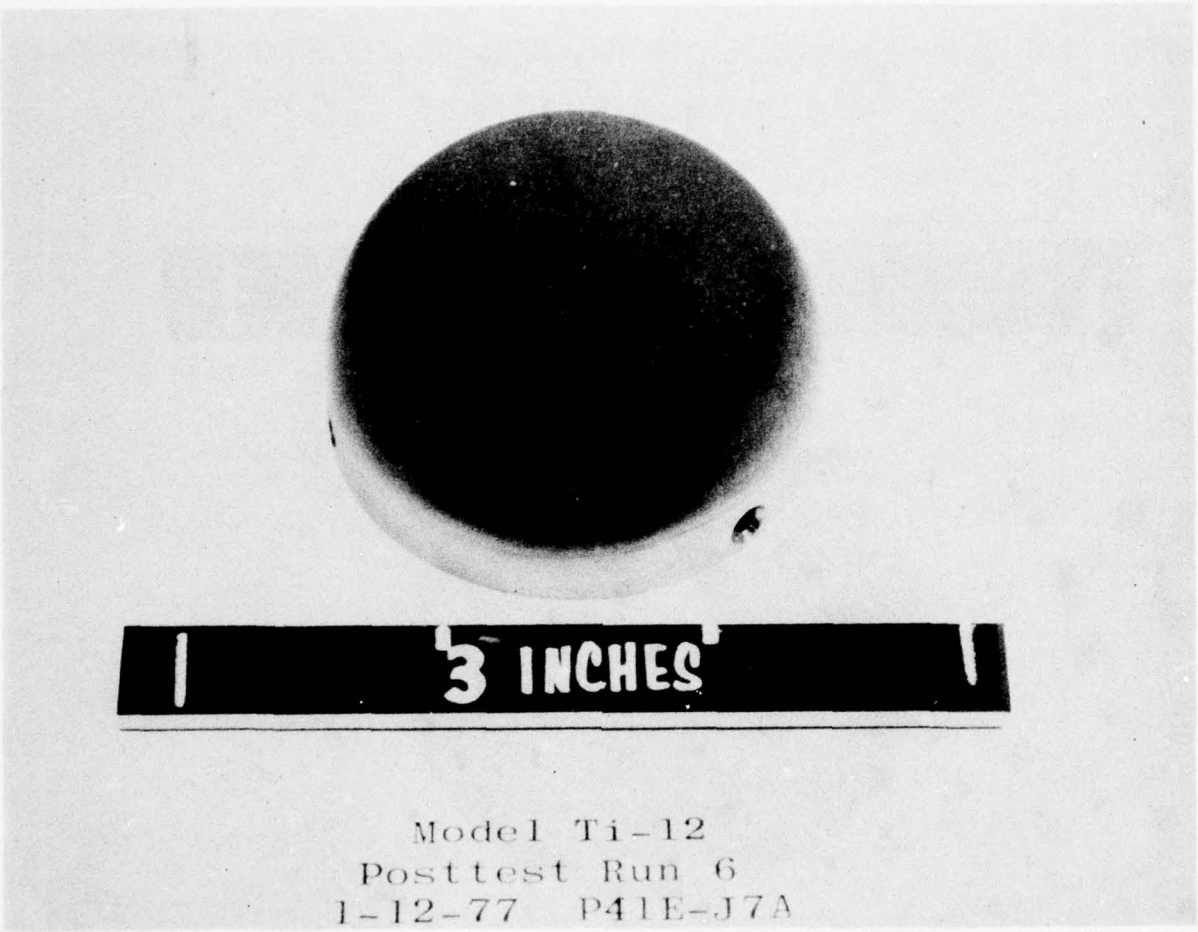




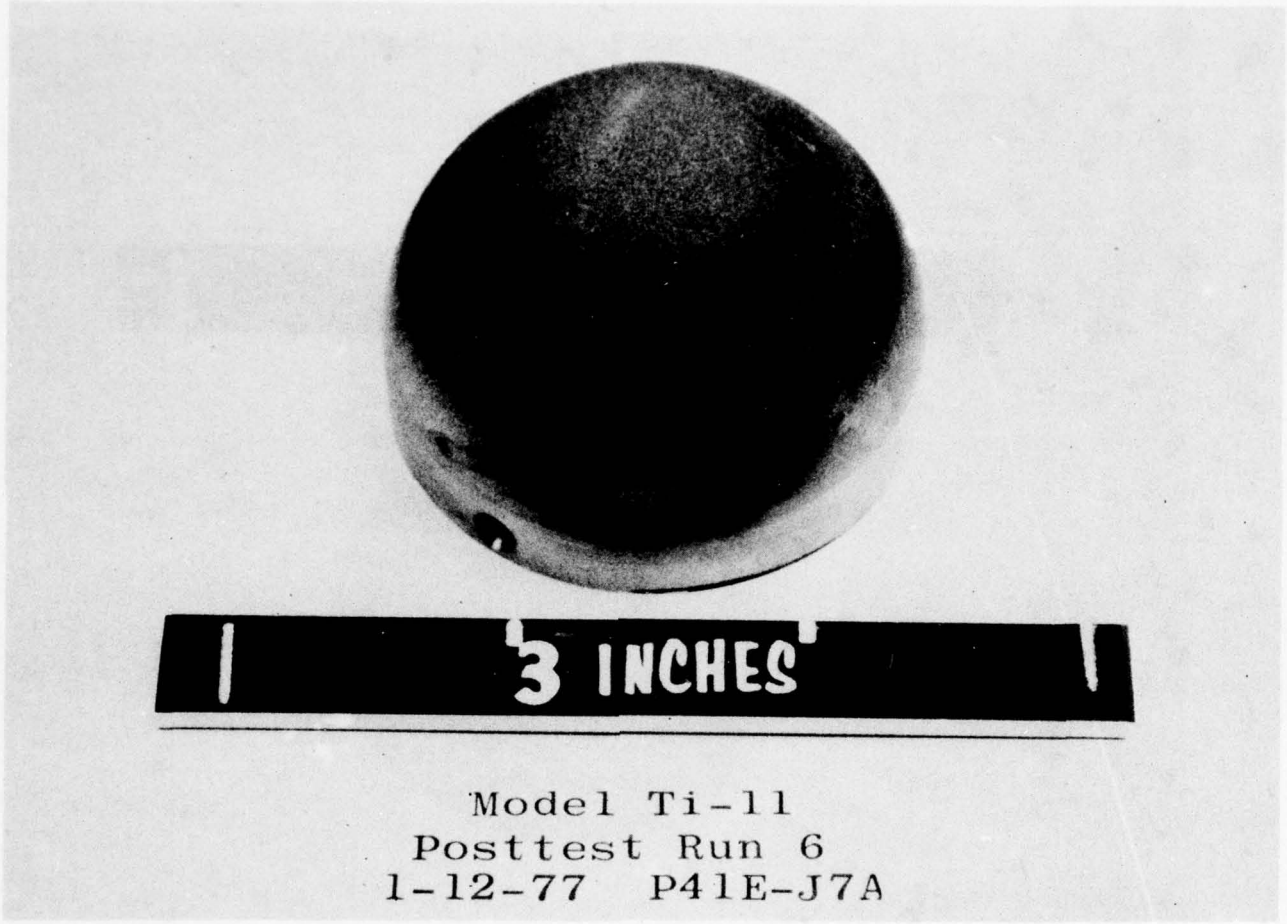
Model Ti-2
Posttest Run 6
1-12-77 P41E-J7A



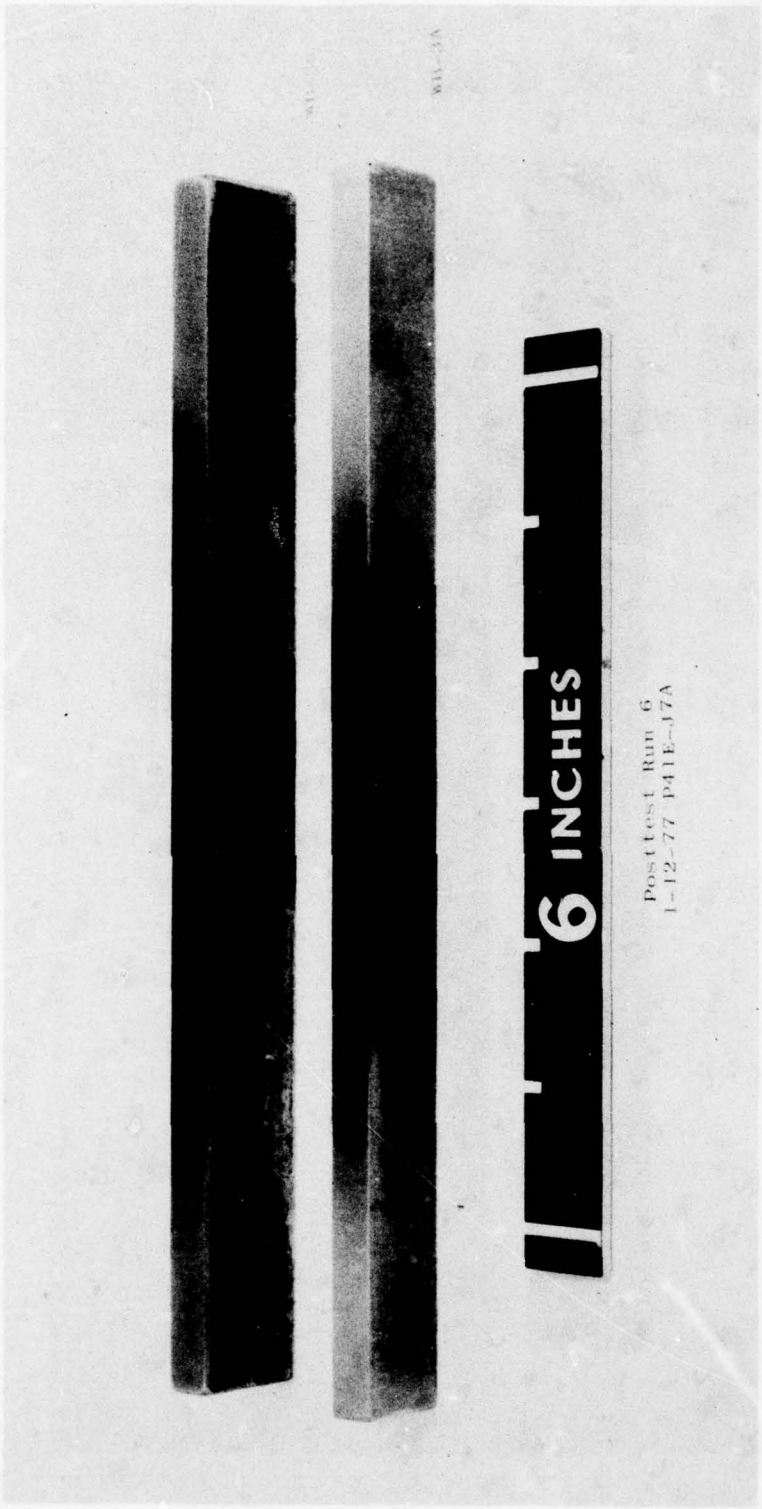
Model Ti-13
Posttest Run 6
1-12-77 P41E-J7A

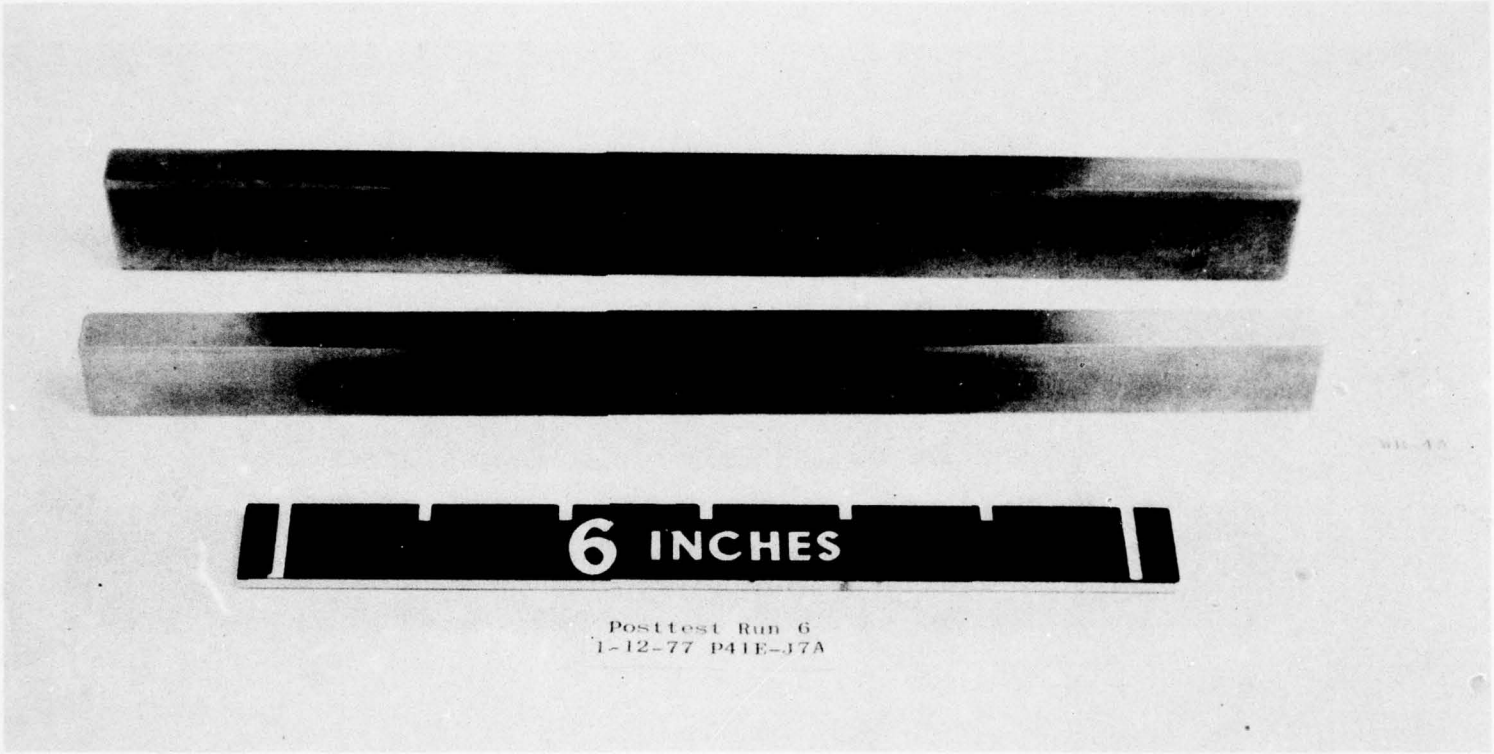


Model Ti-12
Posttest Run 6
1-12-77 P41E-J7A



Model Ti-11
Posttest Run 6
1-12-77 P41E-J7A


6 INCHES
Posttest Run 6
1-12-77 P41E-17A

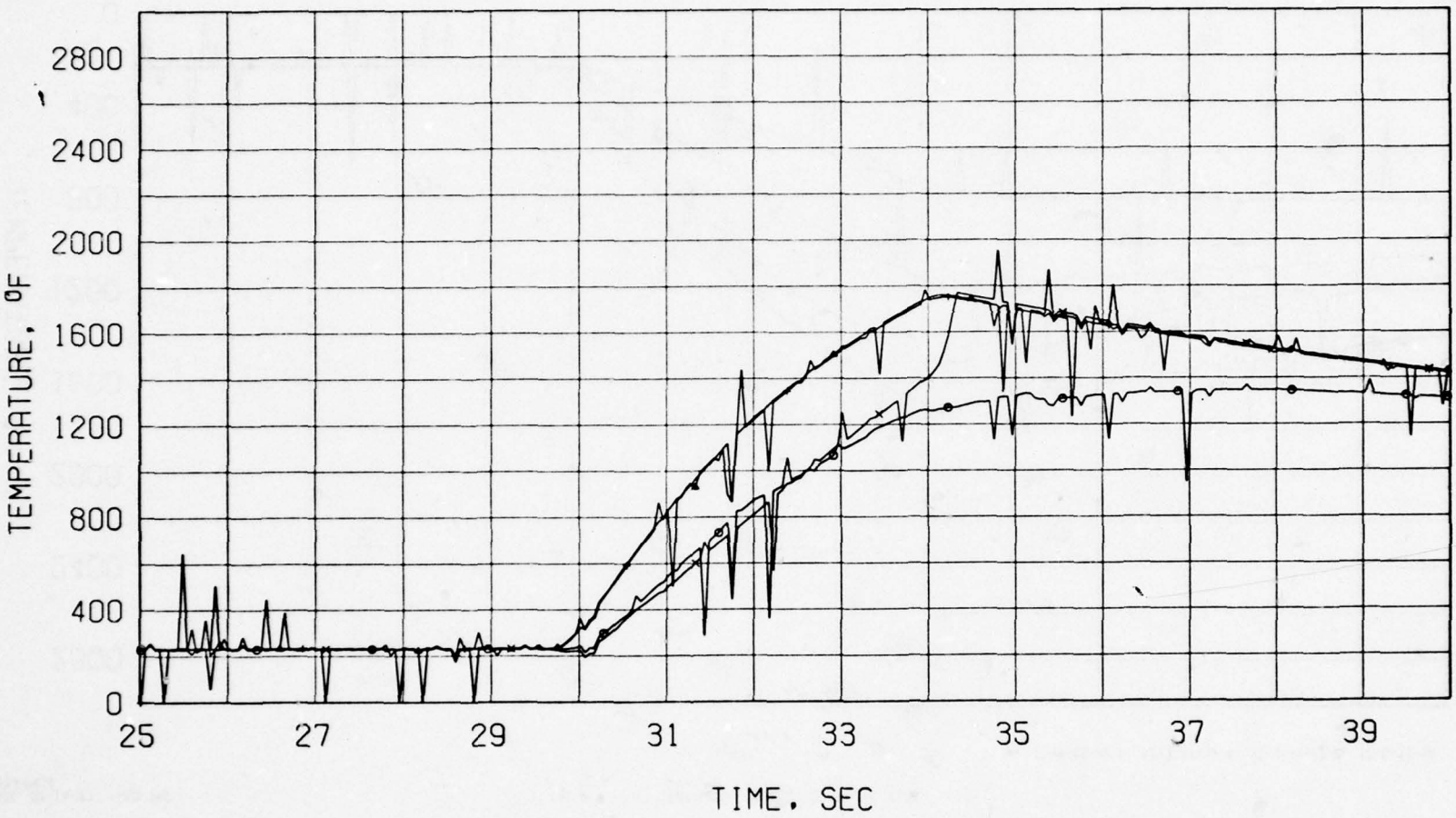


Posttest Run 6
1-12-77 P41E-37A

DATE 01-14-77 ARO INC
PROJ-P41E

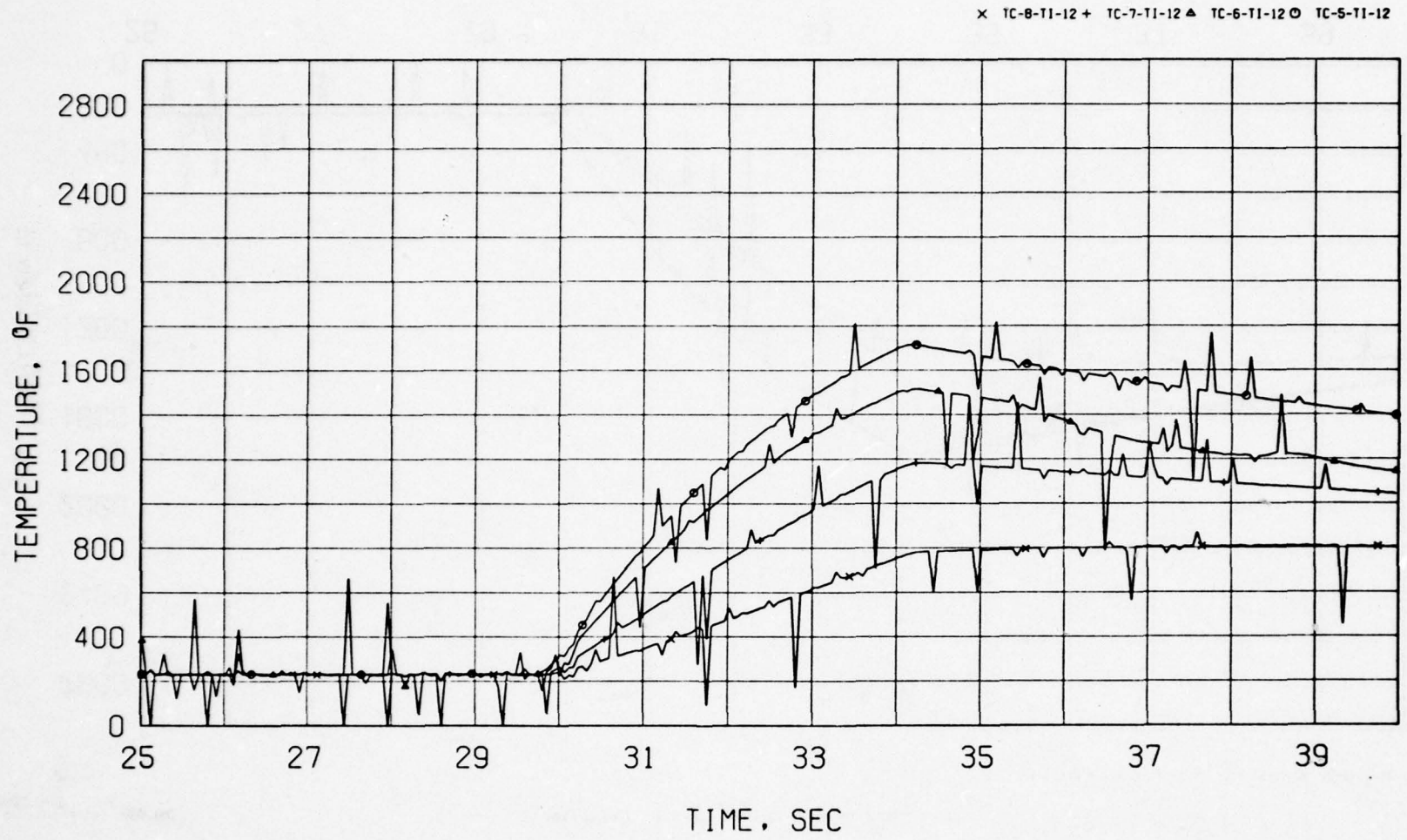
PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

× TC-4-TI-12 + TC-3-TI-12 △ TC-2-TI-12 ○ TC-1-TI-12



DATE 01-14-77 ARO INC
PROJ-P41E

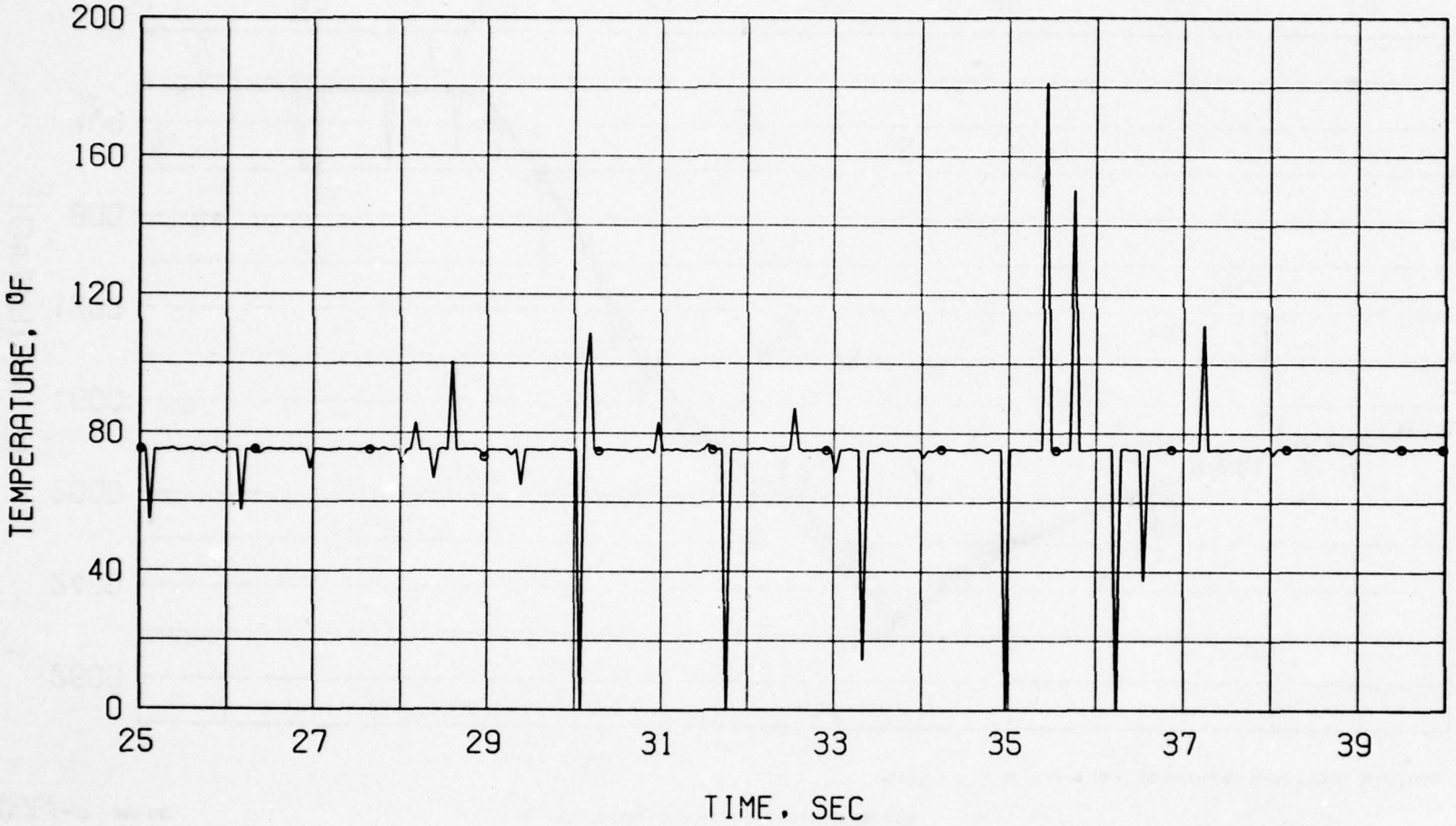
PROJECT P41E TEST A0021 DATE 01-12-77 SEL 2106



DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

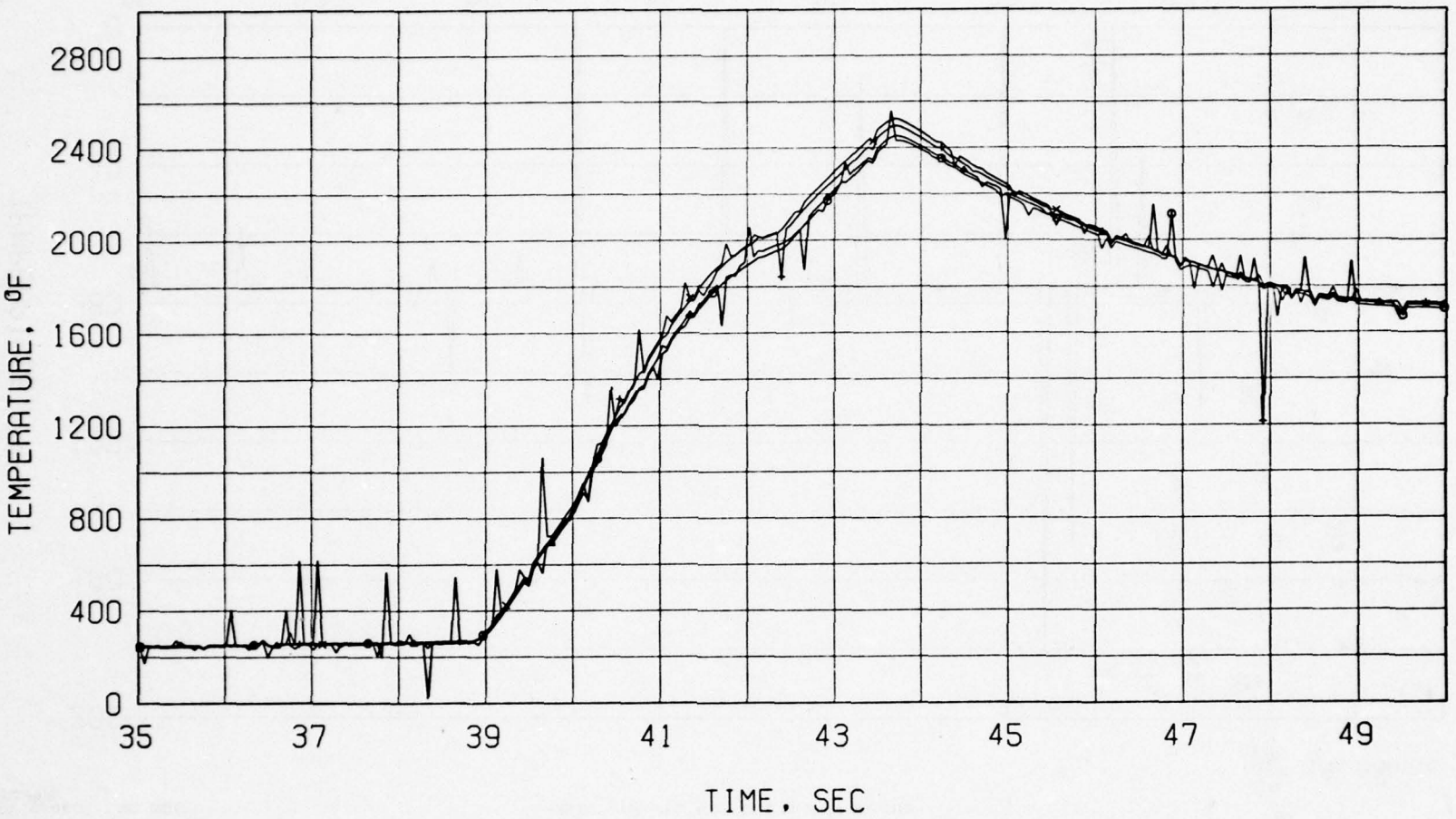
⊙ TC-9-TI-12



DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

× TC-4-TI-13 + TC-3-TI-13 △ TC-2-TI-13 ⊙ TC-1-TI-13



DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-12-77 SEL 2106

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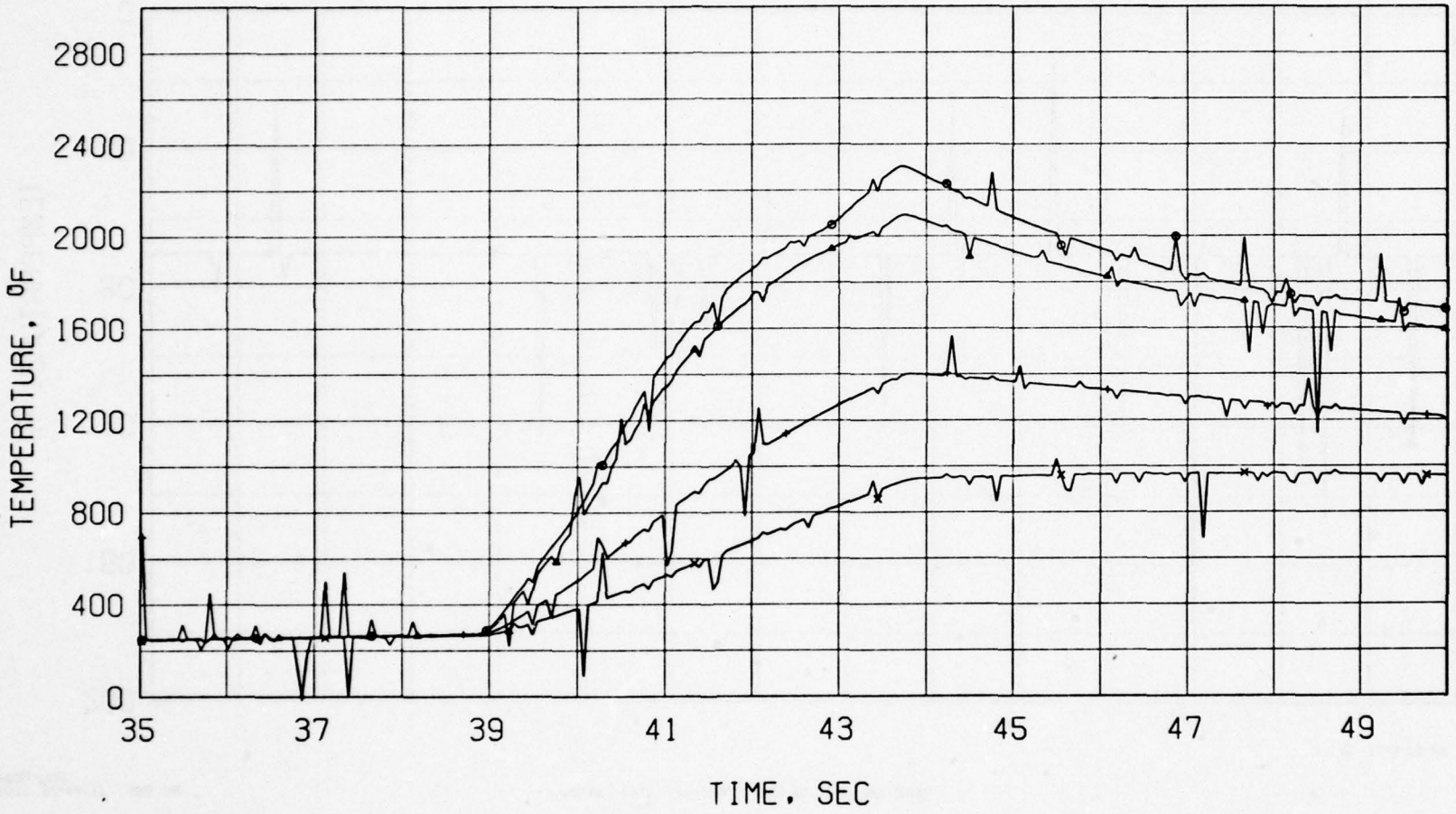

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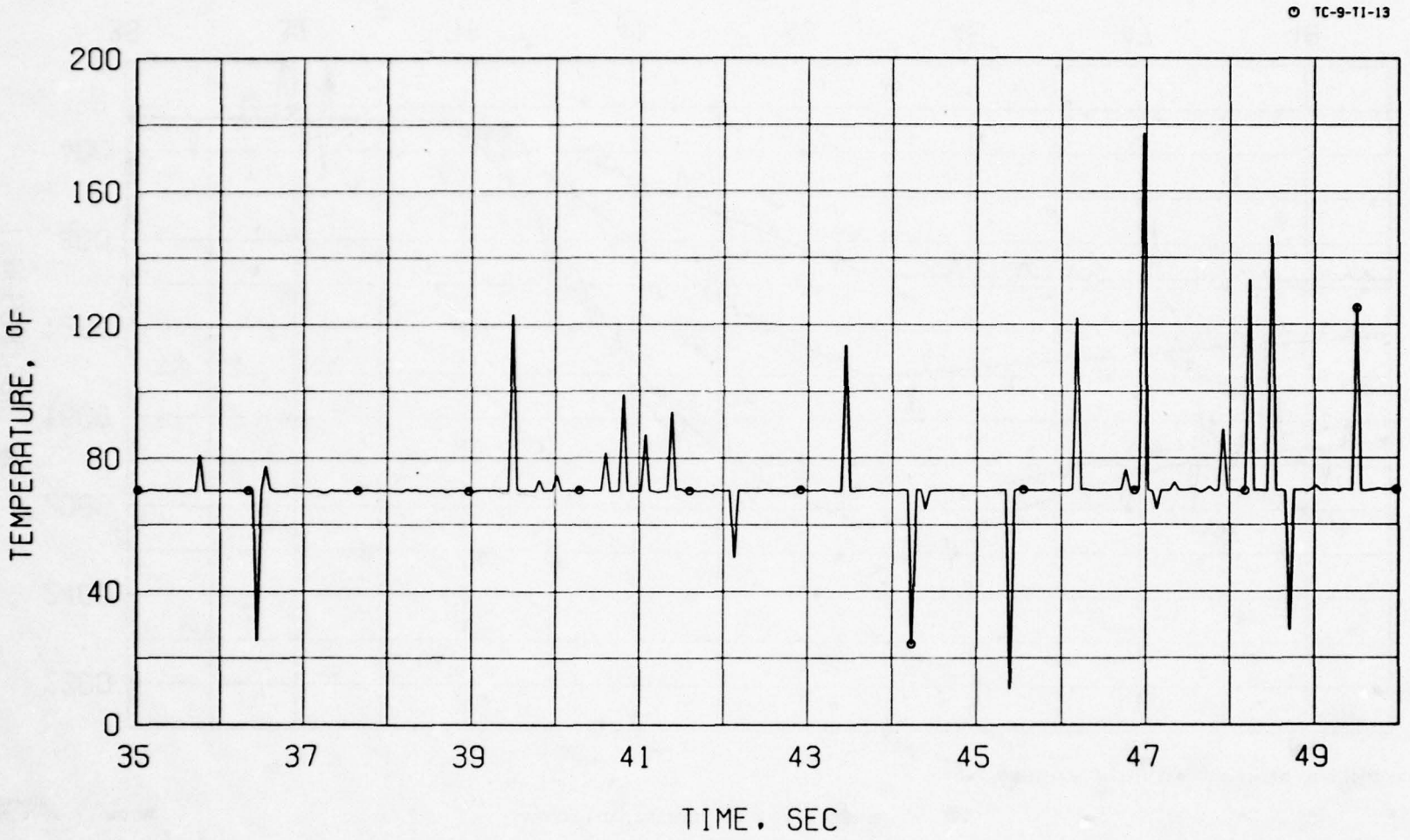
PROJ-P41E

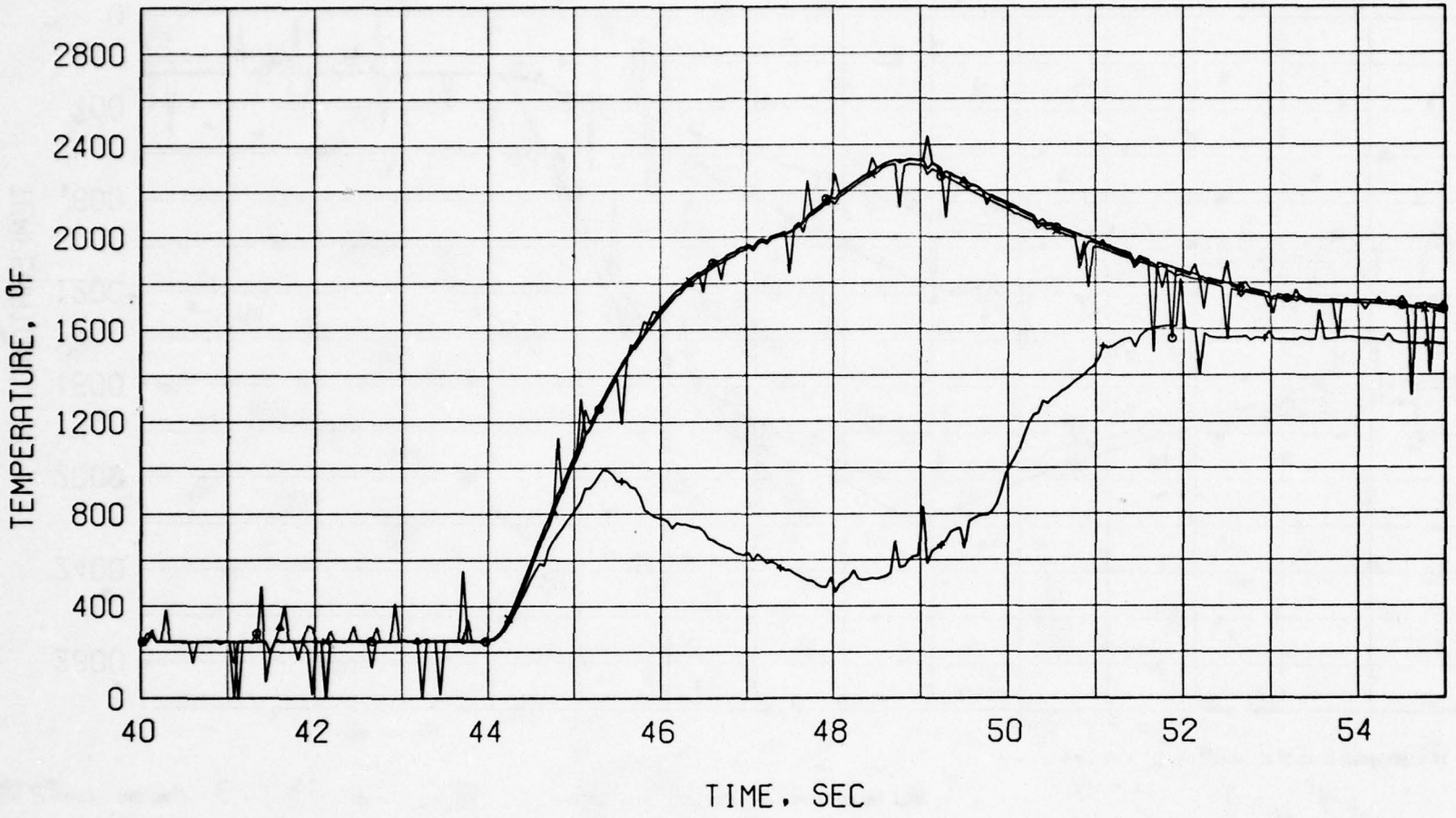
PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

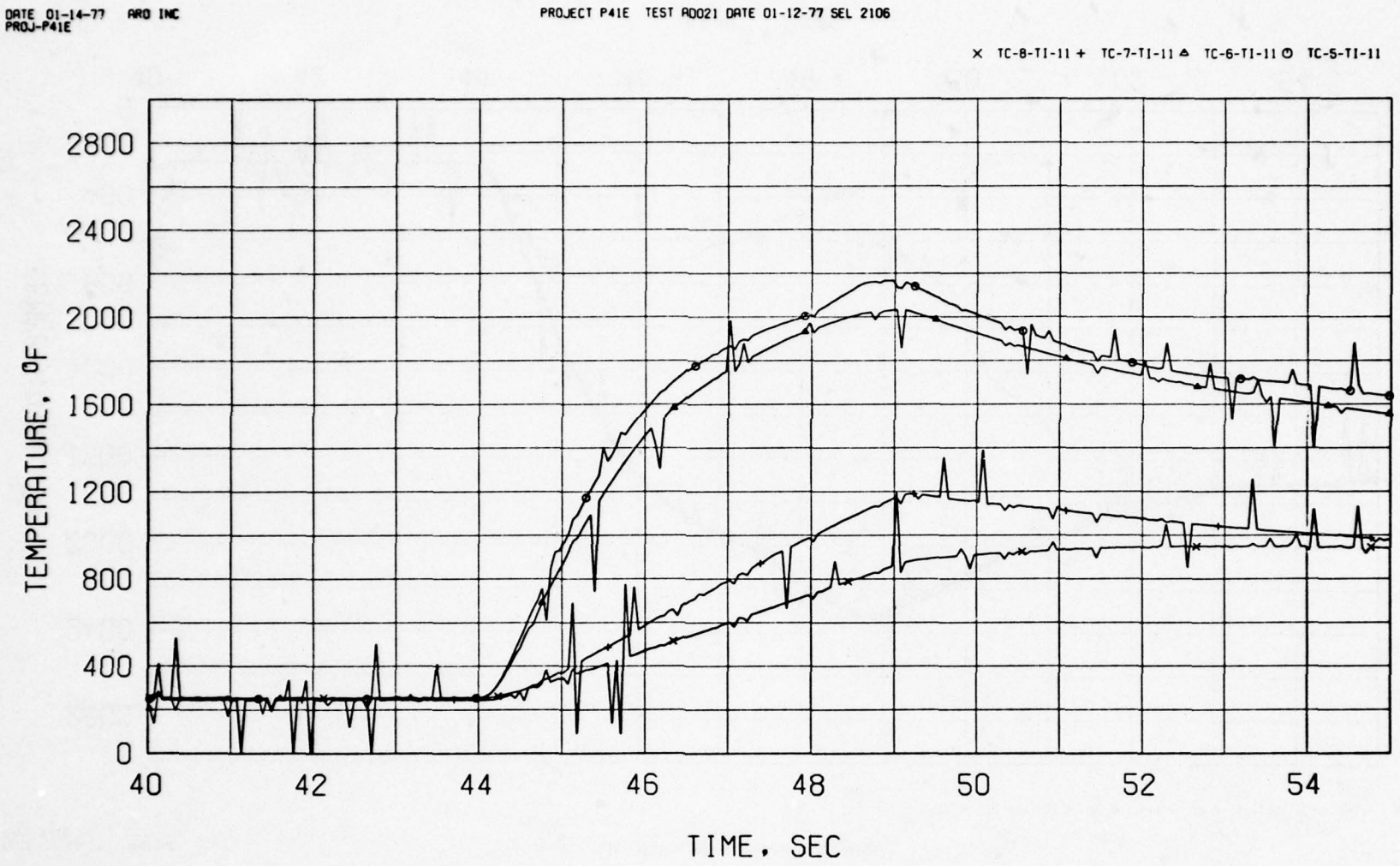


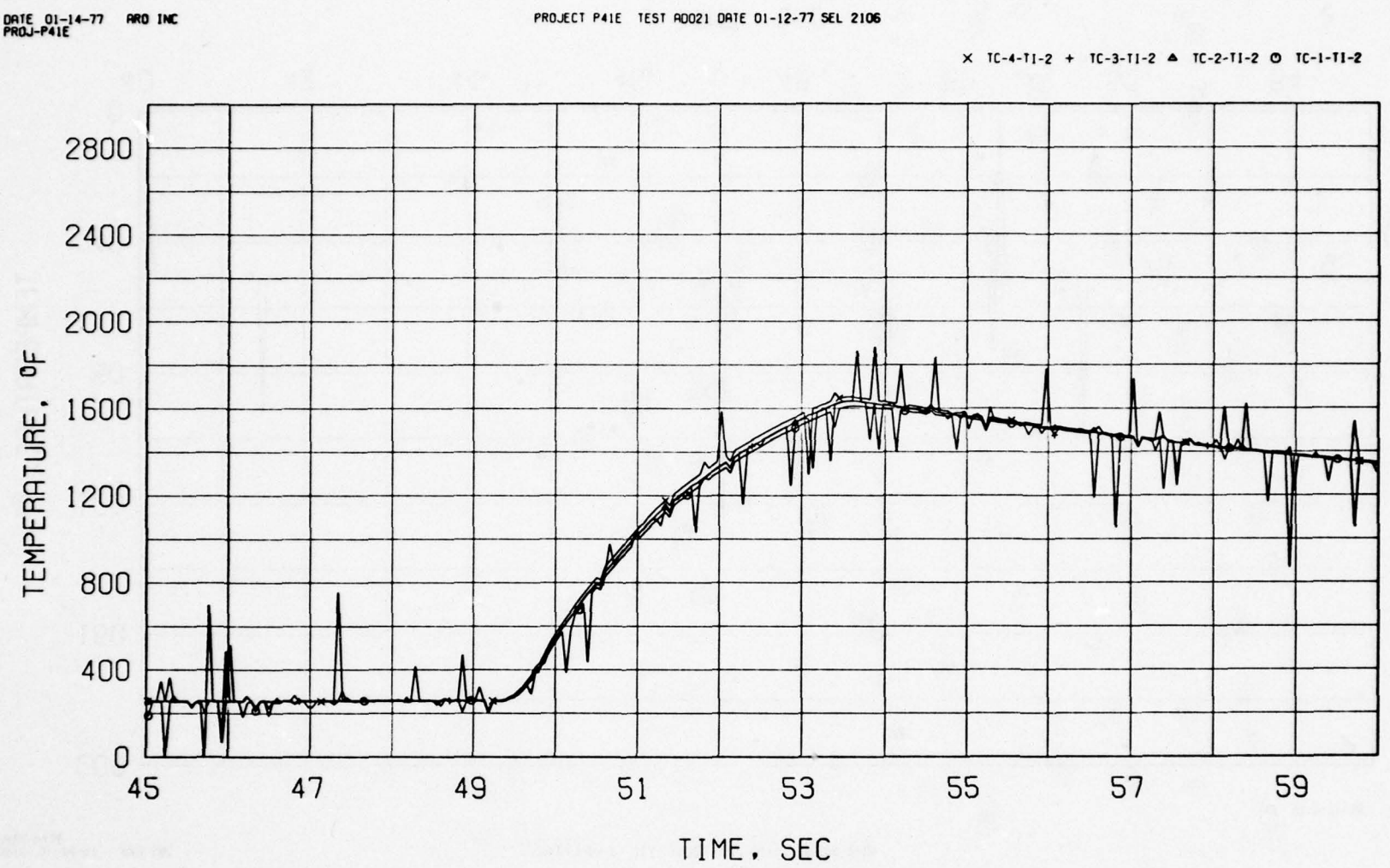
DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-12-77 SEL 2106

× TC-4-TI-11 + TC-3-TI-11 △ TC-2-TI-11 ⊙ TC-1-TI-11



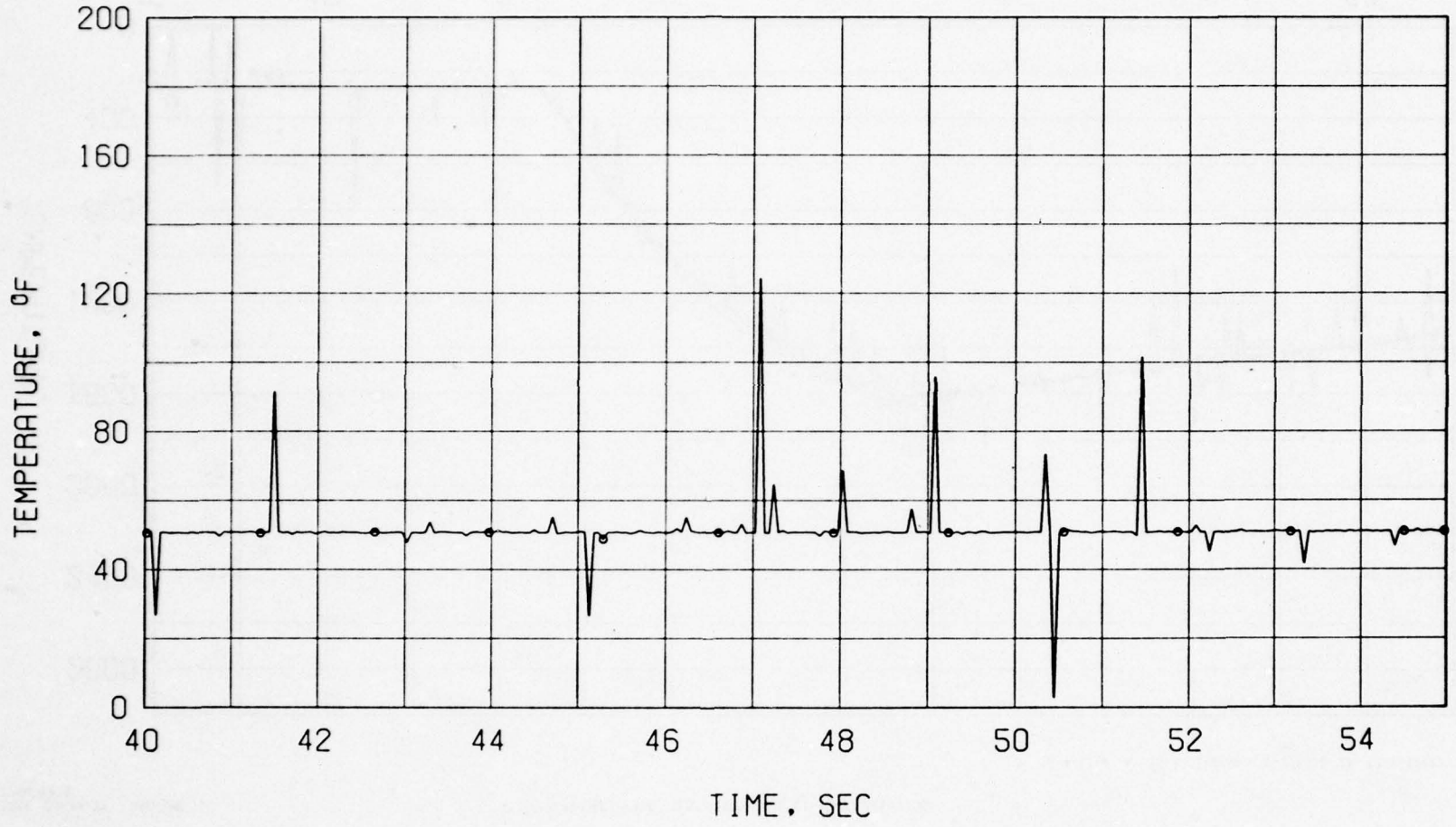

DATE 01-14-77 ARO INC
PROJ-P41E
PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106
× TC-8-TI-11 + TC-7-TI-11 △ TC-6-TI-11 ⊙ TC-5-TI-11
TEMPERATURE, °F
2800
2400
2000
1600
1200
800
400
0
40
42
44
46
48
50
52
54
TIME, SEC


DATE 01-14-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-12-77 SEL 2106
× TC-4-TI-2 + TC-3-TI-2 ▲ TC-2-TI-2 ⊙ TC-1-TI-2
TEMPERATURE, °F
2800
2400
2000
1600
1200
800
400
0
45
47
49
51
53
55
57
59
TIME, SEC

DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

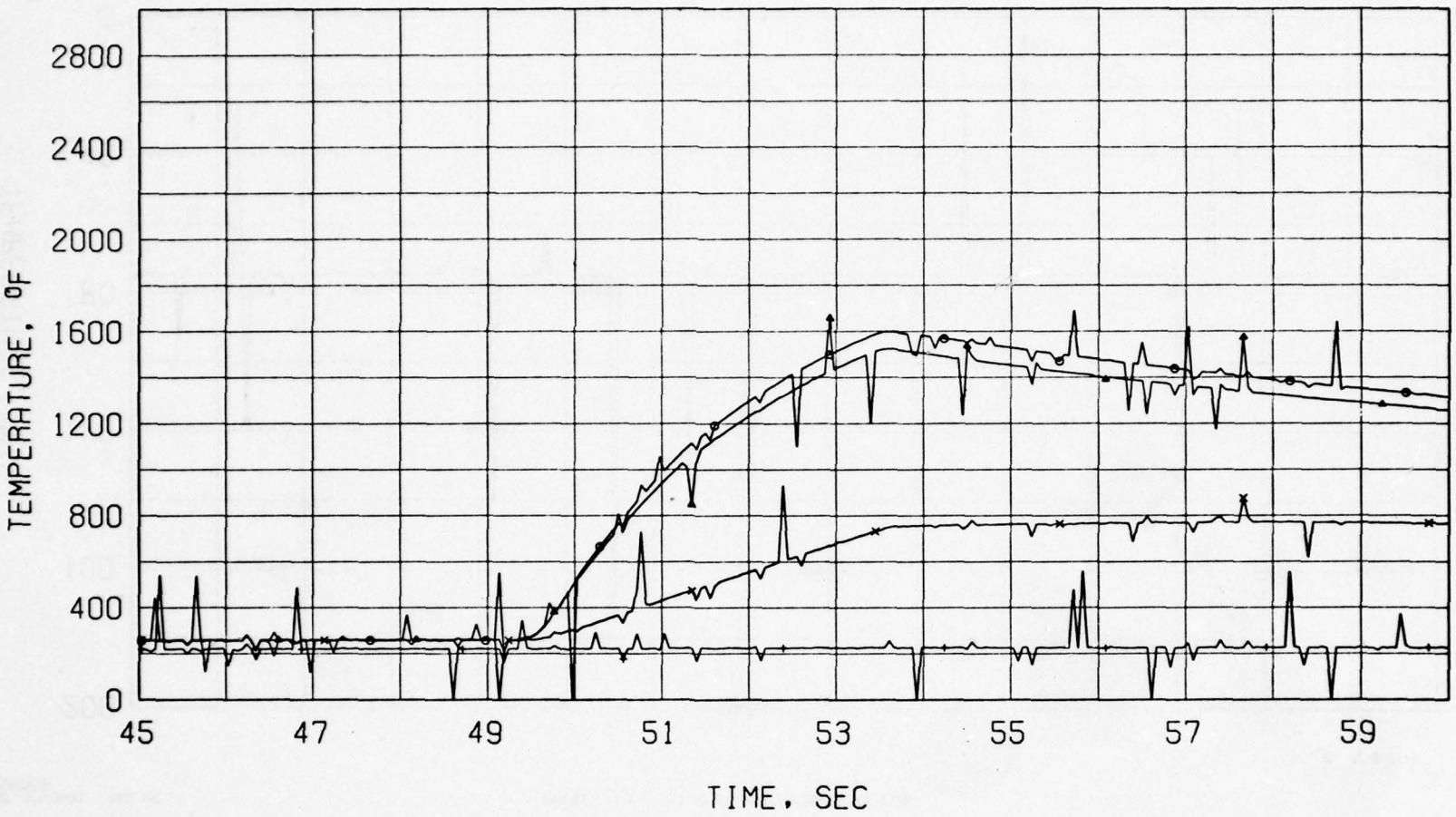
⊙ TC-9-TI-11



DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

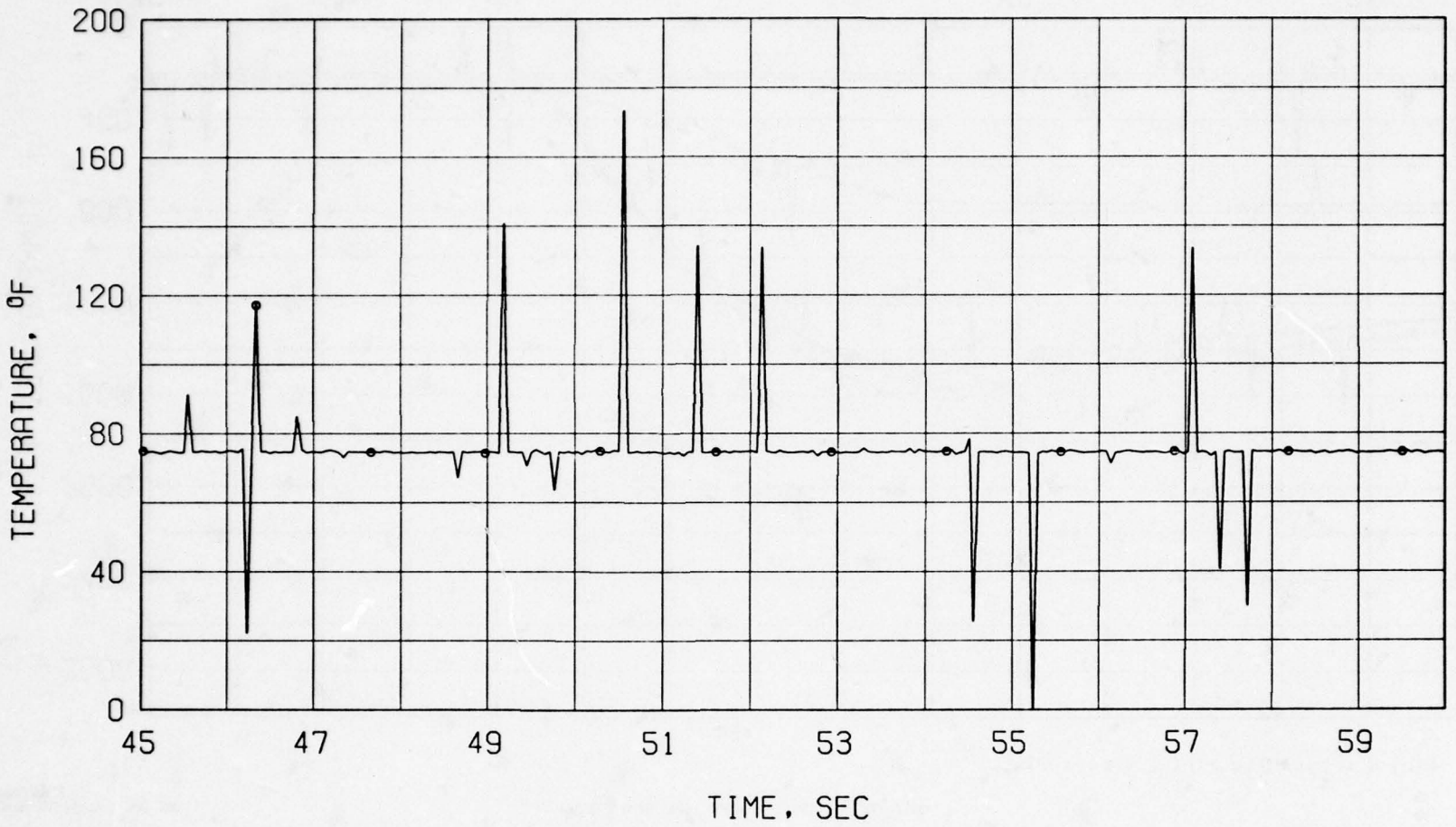
× TC-8-TI-2 + TC-7-TI-2 △ TC-6-TI-2 ⊙ TC-5-TI-2



DATE 01-14-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

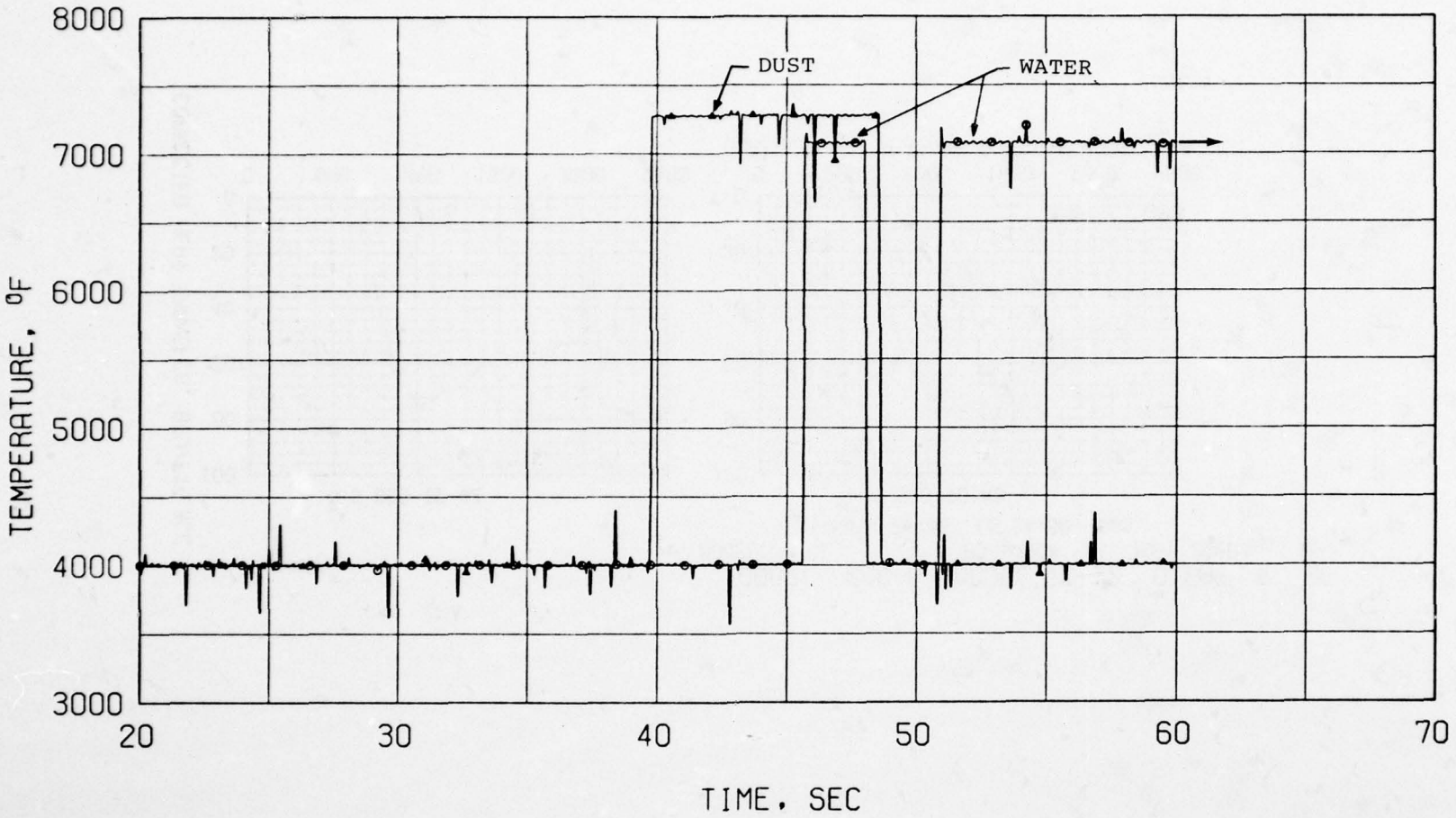
© TC-9-TI-2

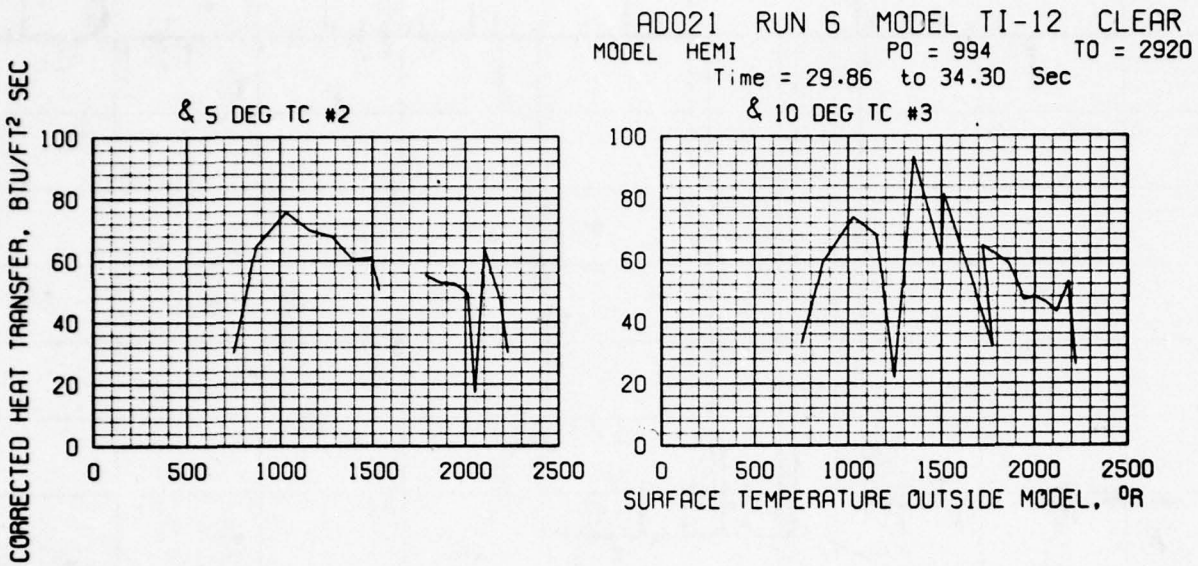


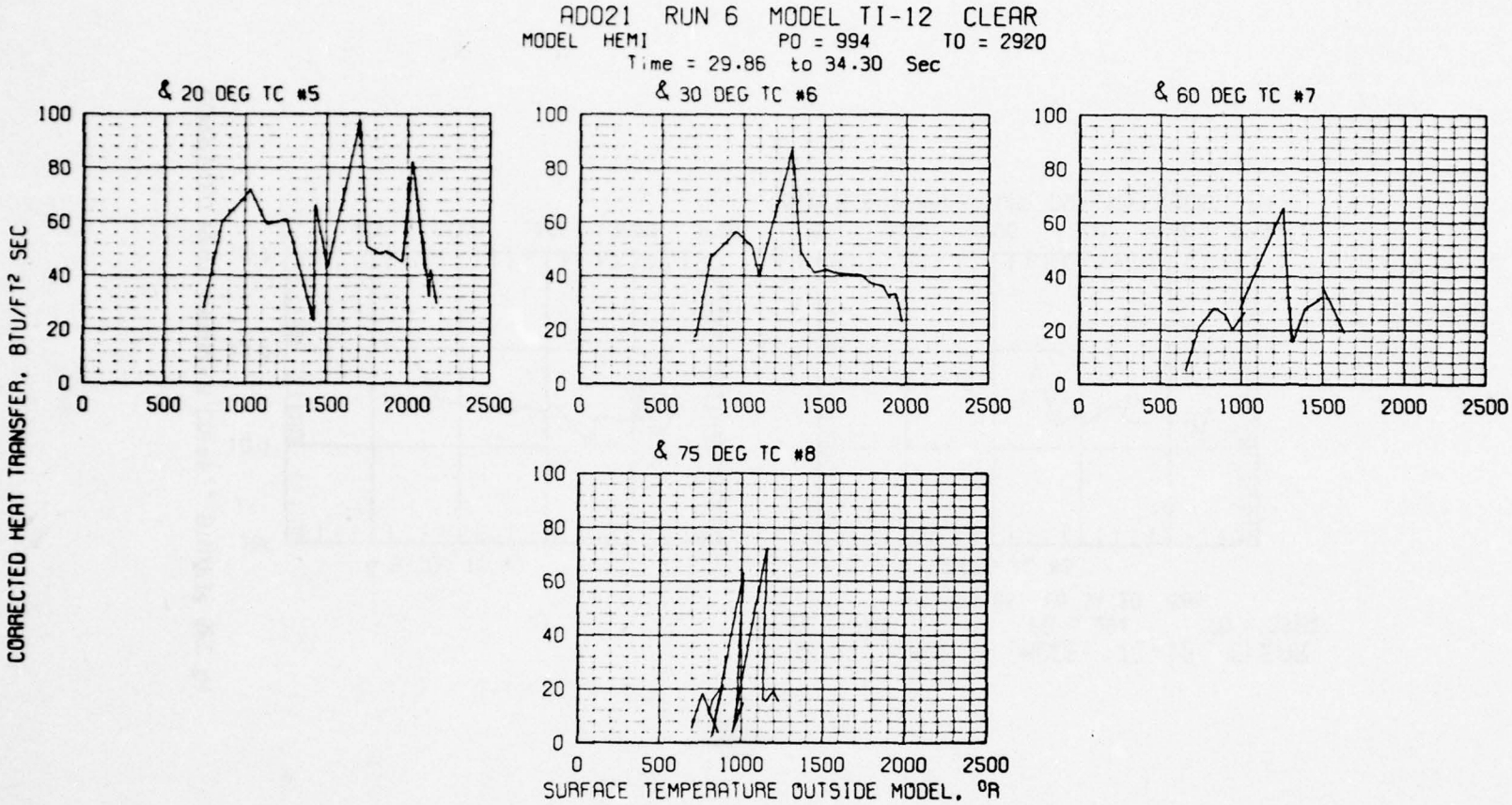
DATE 01-14-77 ARO INC
PROJ-P41E

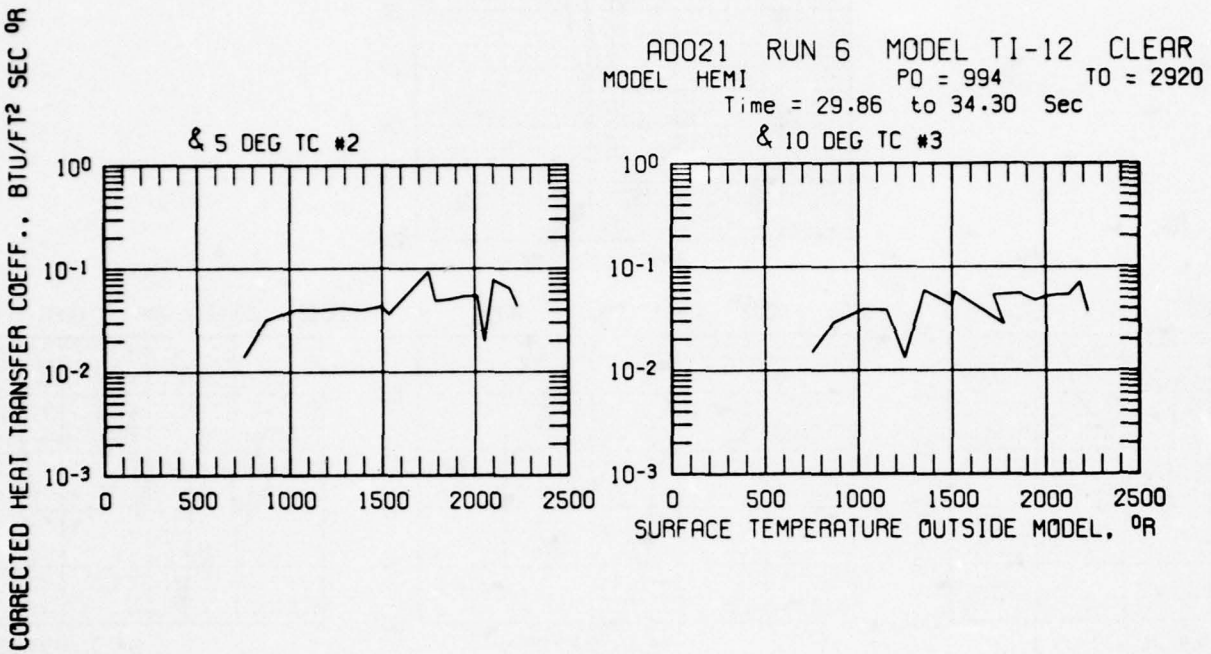
PROJECT P41E TEST AD021 DATE 01-12-77 SEL 2106

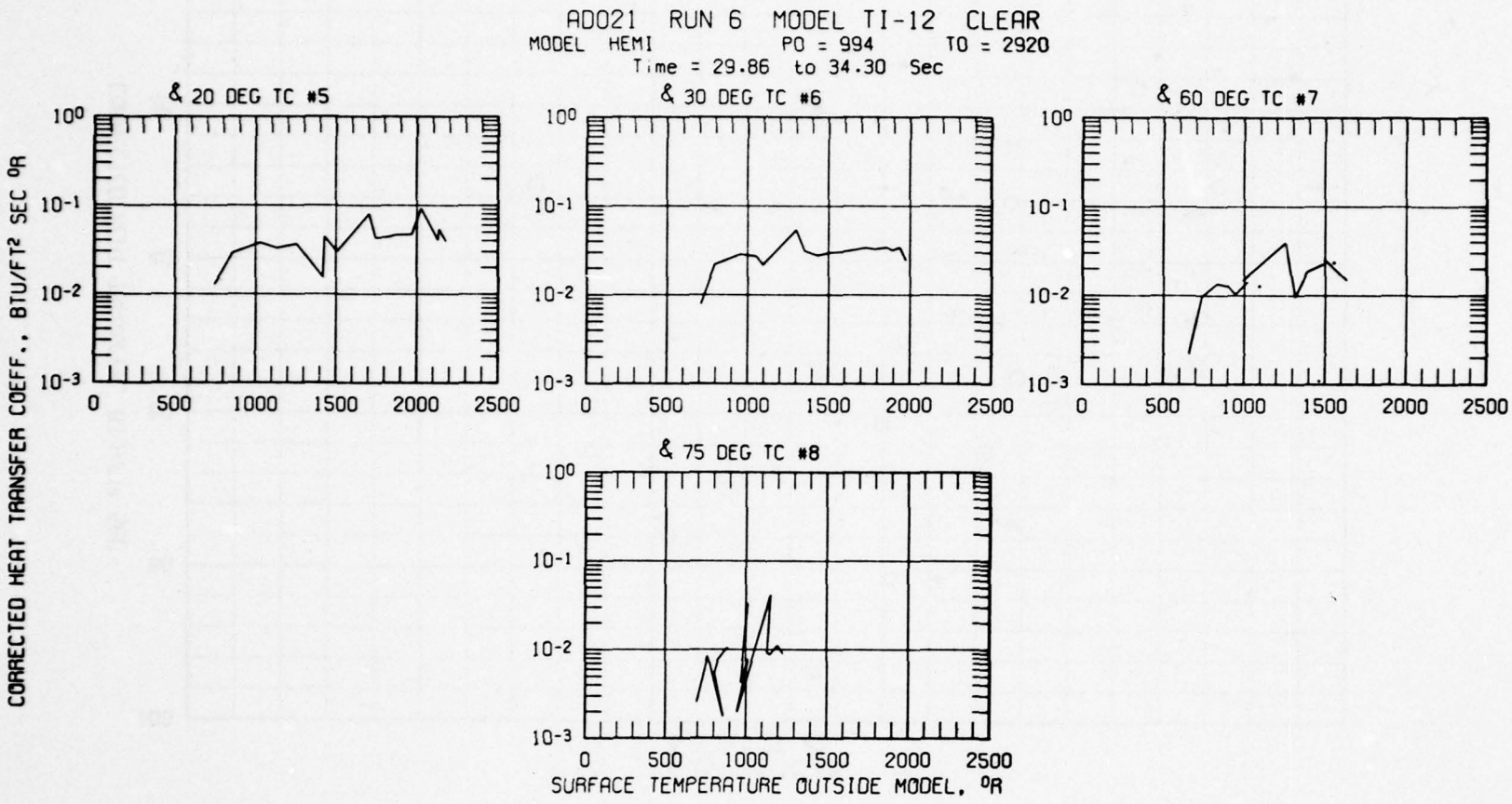
△ DUST-EVENT ⊙ H2O-EVENT

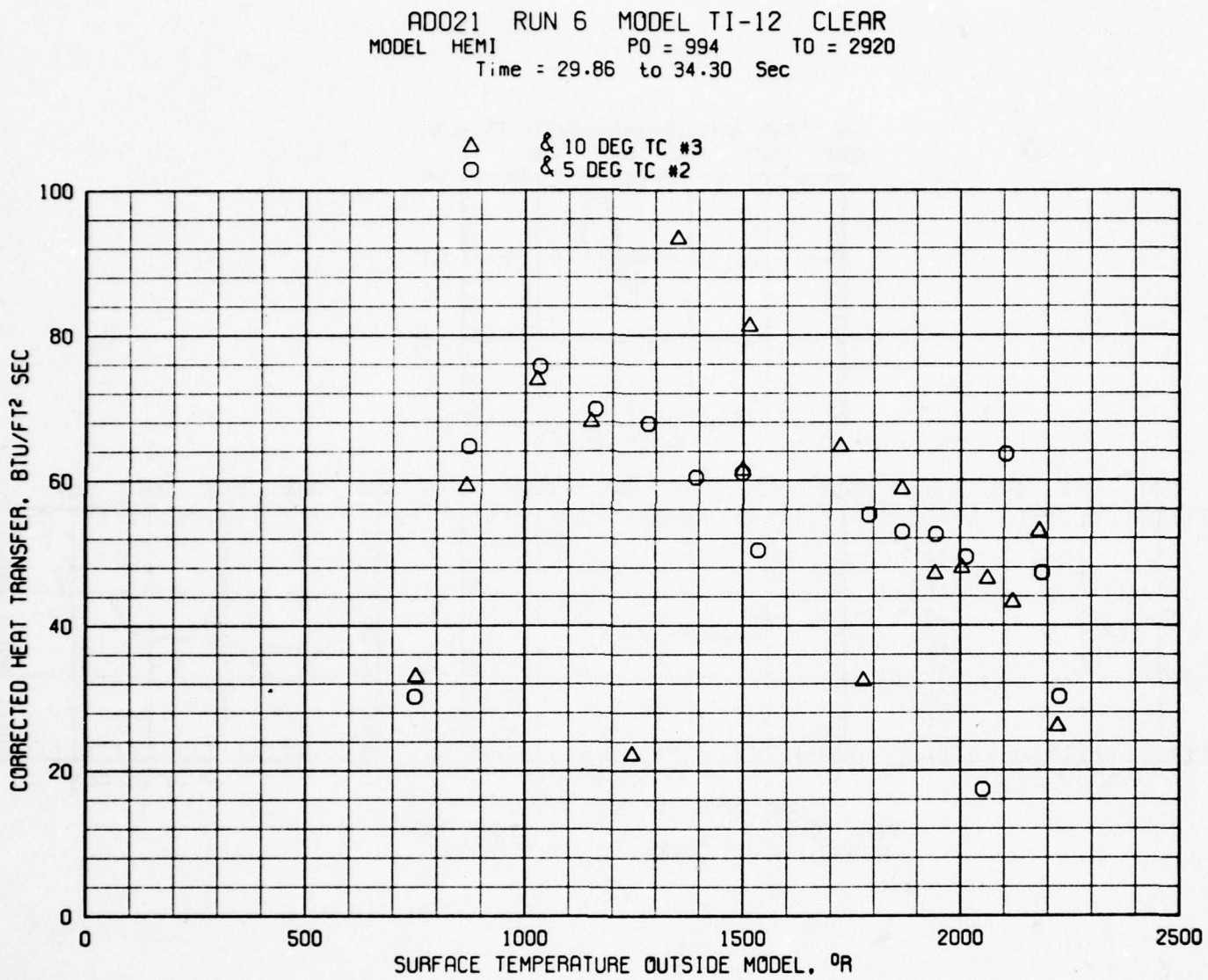


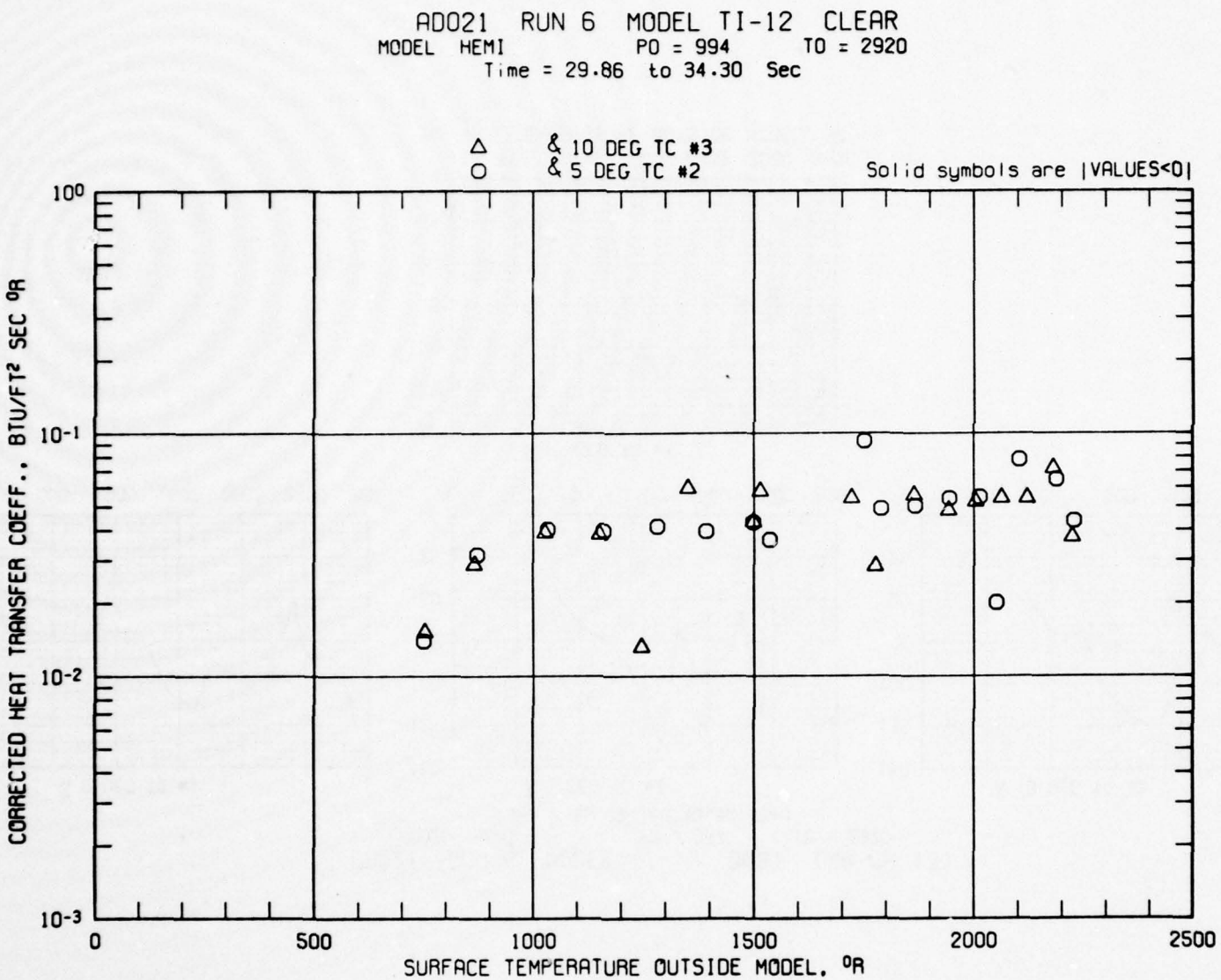

AD021 RUN 6 MODEL TI-12 CLEAR
MODEL HEMI PO = 994 TO = 2920
Time = 29.86 to 34.30 Sec
& 5 DEG TC #2
& 10 DEG TC #3
CORRECTED HEAT TRANSFER, BTU/FT² SEC
0
20
40
60
80
100
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R

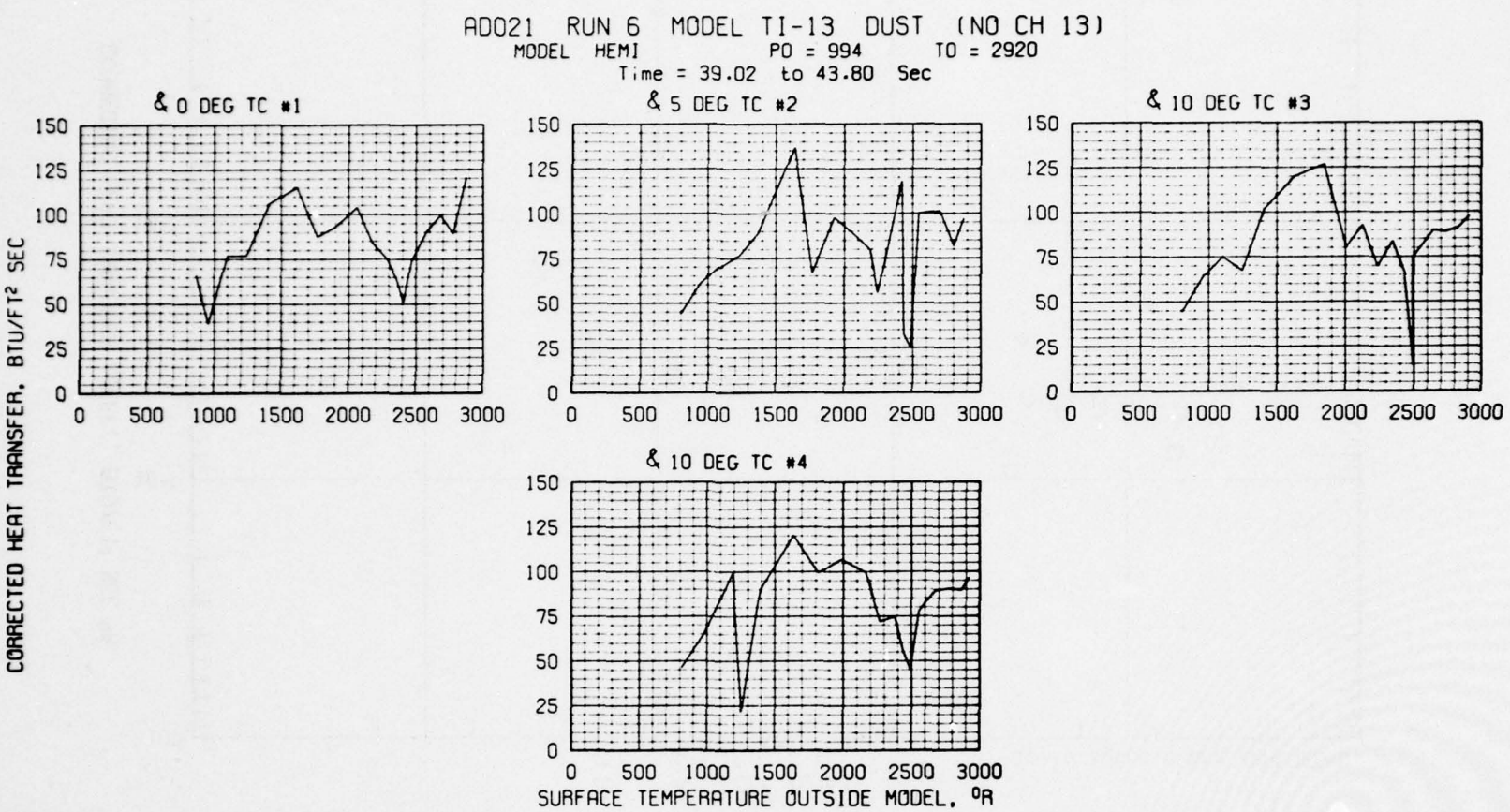

AD021 RUN 6 MODEL TI-12 CLEAR
MODEL HEMI PO = 994 TO = 2920
Time = 29.86 to 34.30 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
500
1000
1500
2000
2500


AD021 RUN 6 MODEL TI-12 CLEAR
MODEL HEMI PO = 994 TO = 2920
Time = 29.86 to 34.30 Sec
& 5 DEG TC #2
& 10 DEG TC #3
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10-1
10-2
10-3
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R

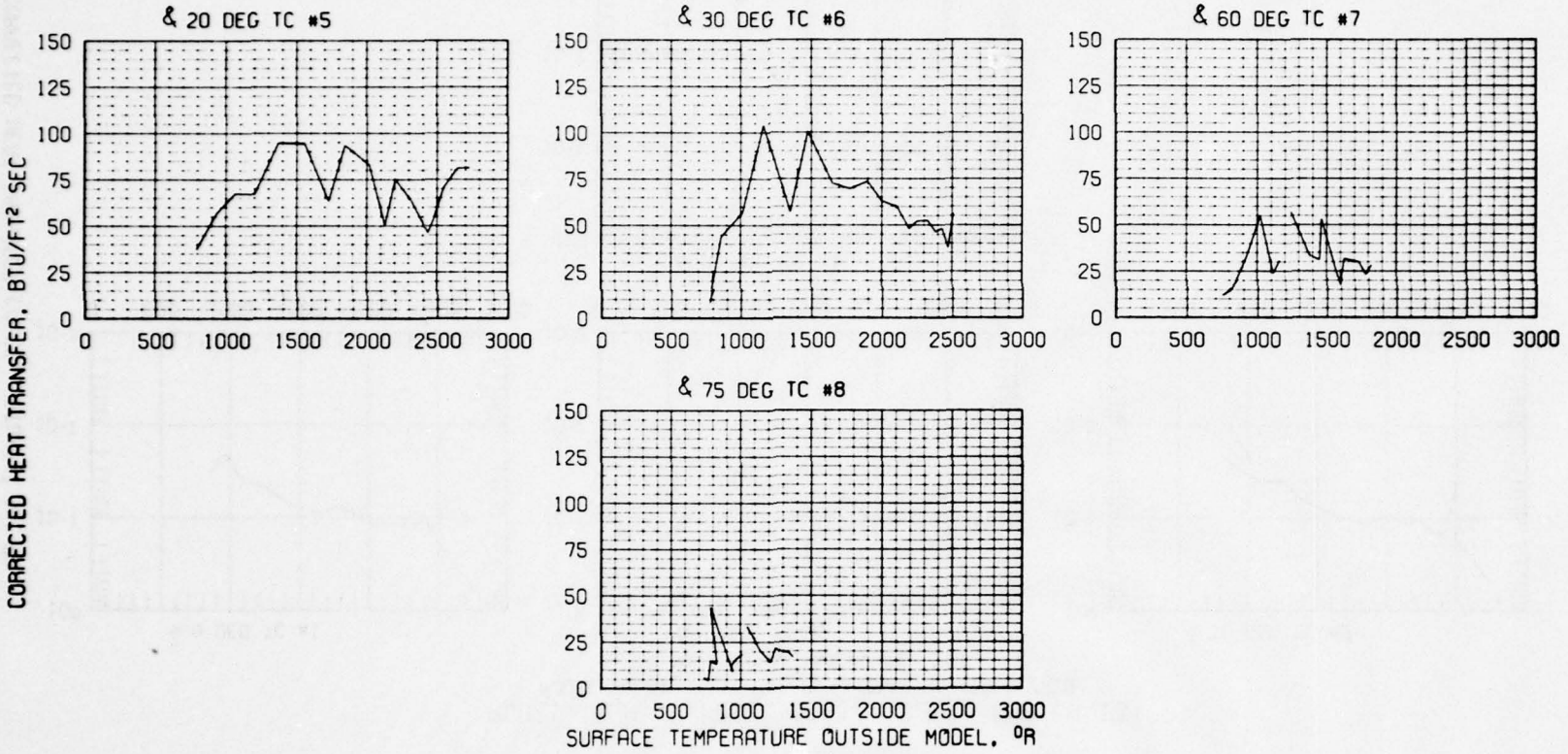

AD021 RUN 6 MODEL TI-12 CLEAR
MODEL HEMI PO = 994 TO = 2920
Time = 29.86 to 34.30 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10-1
10-2
10-3
0
500
1000
1500
2000
2500


AD021 RUN 6 MODEL TI-12 CLEAR
MODEL HEMI PO = 994 TO = 2920
Time = 29.86 to 34.30 Sec
△ & 10 DEG TC #3
○ & 5 DEG TC #2
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
20
40
60
80
100
0
500
1000
1500
2000
2500

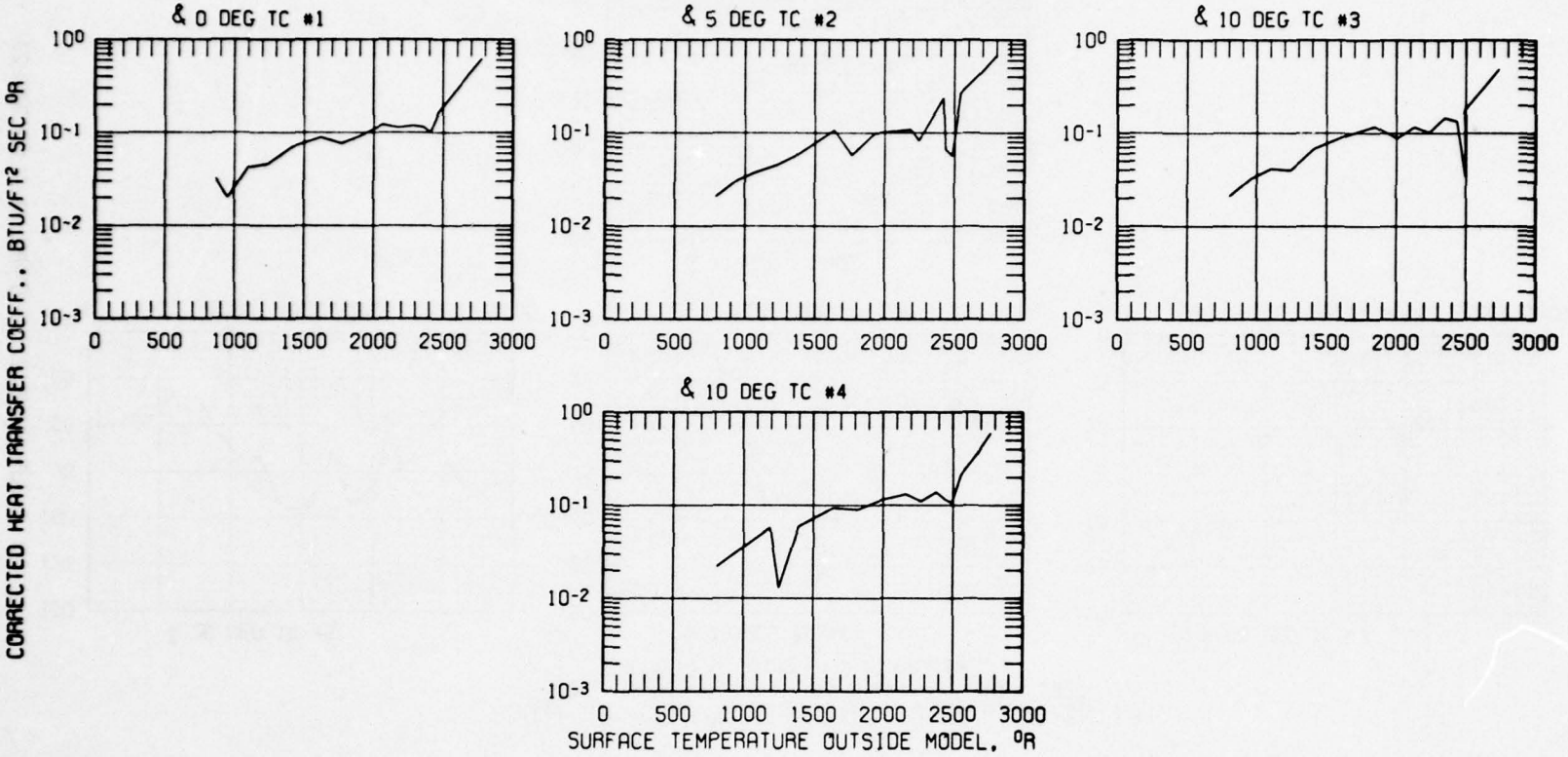

AD021 RUN 6 MODEL TI-12 CLEAR
MODEL HEMI PO = 994 TO = 2920
Time = 29.86 to 34.30 Sec
△ & 10 DEG TC #3
○ & 5 DEG TC #2
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
SURFACE TEMPERATURE OUTSIDE MODEL, °R

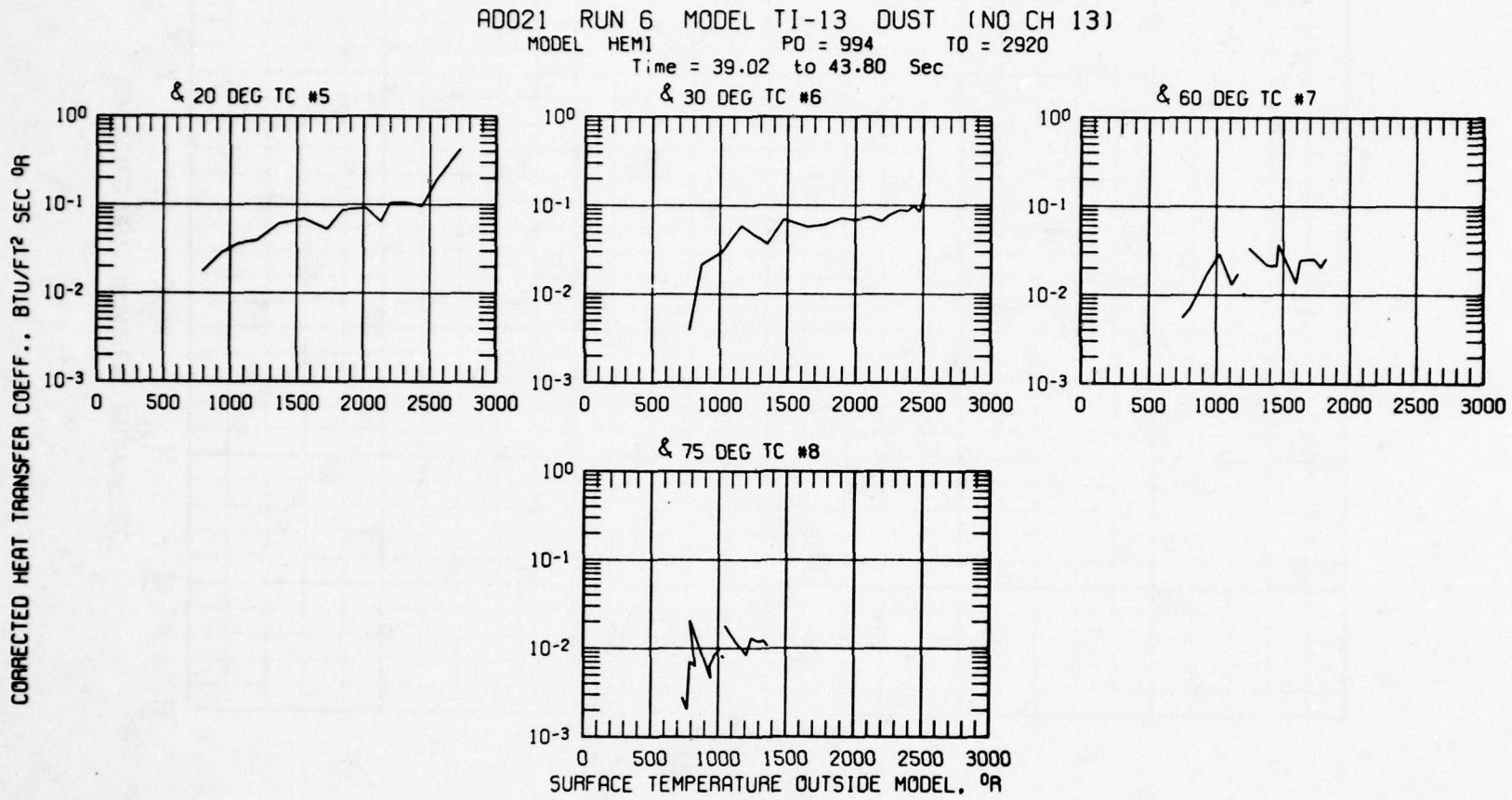

AD021 RUN 6 MODEL TI-13 DUST (NO CH 13)
MODEL HEMI PO = 994 TO = 2920
Time = 39.02 to 43.80 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
0
500
1000
1500
2000
2500
3000

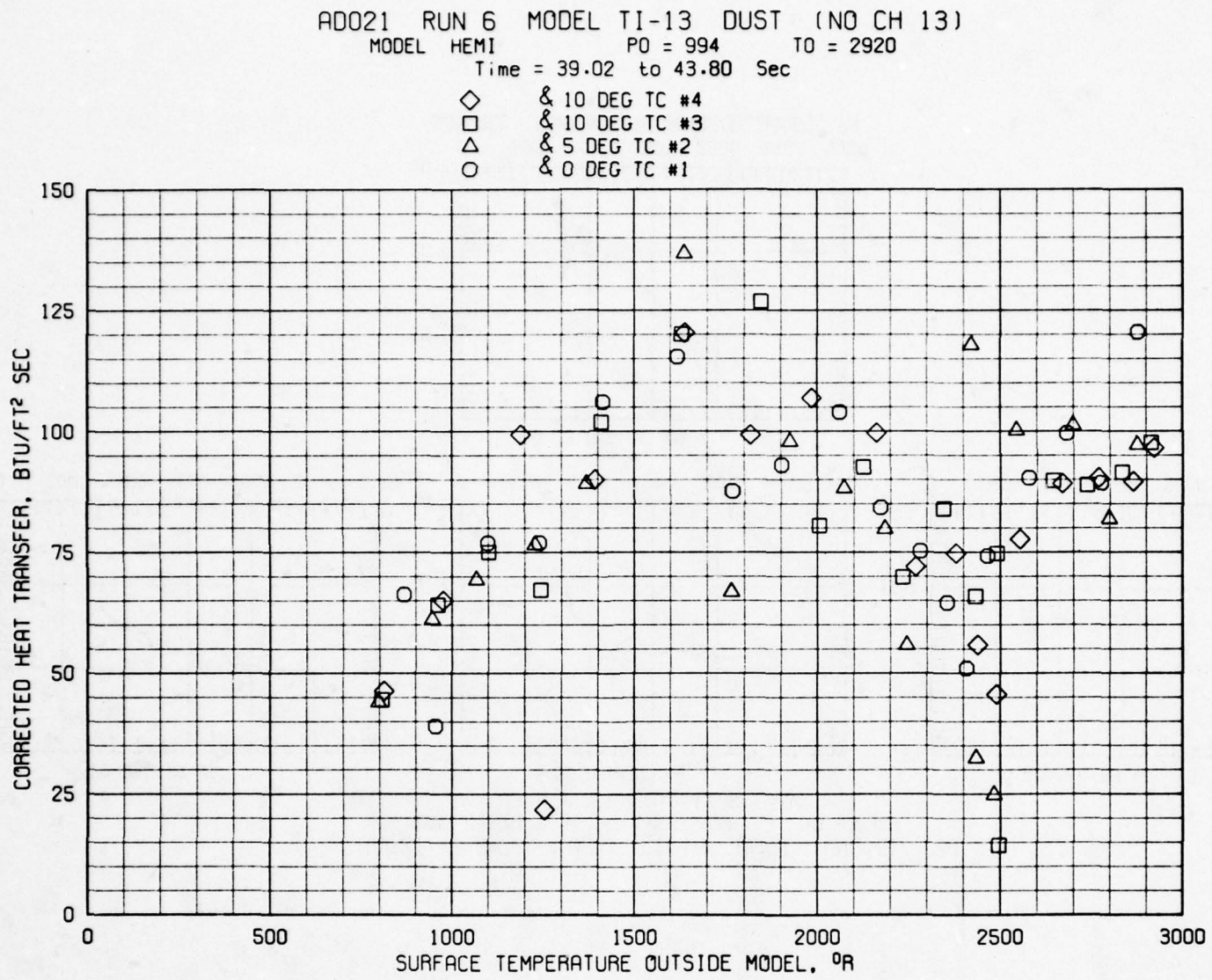
AD021 RUN 6 MODEL TI-13 DUST (NO CH 13)
MODEL HEMI PO = 994 TO = 2920
Time = 39.02 to 43.80 Sec

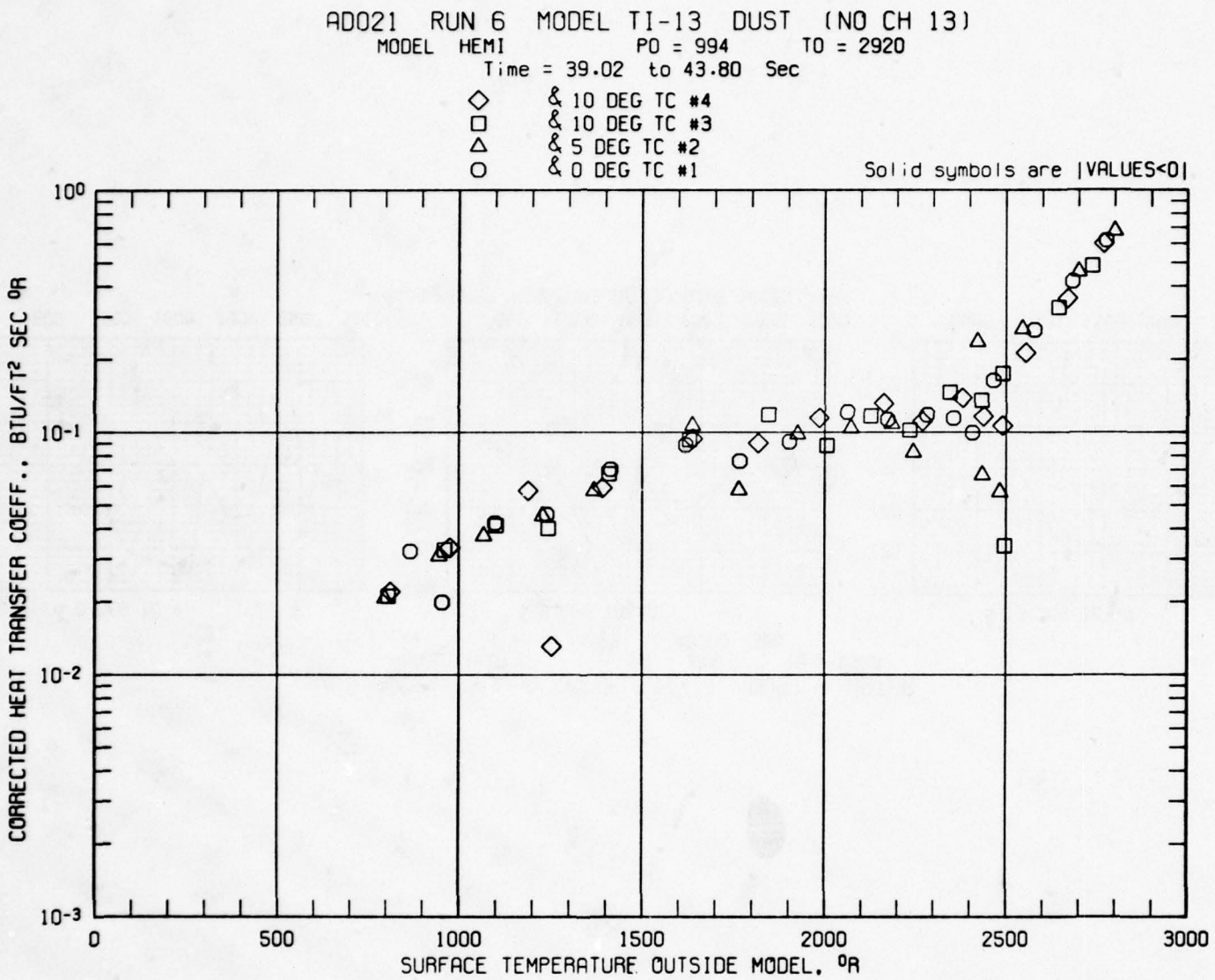


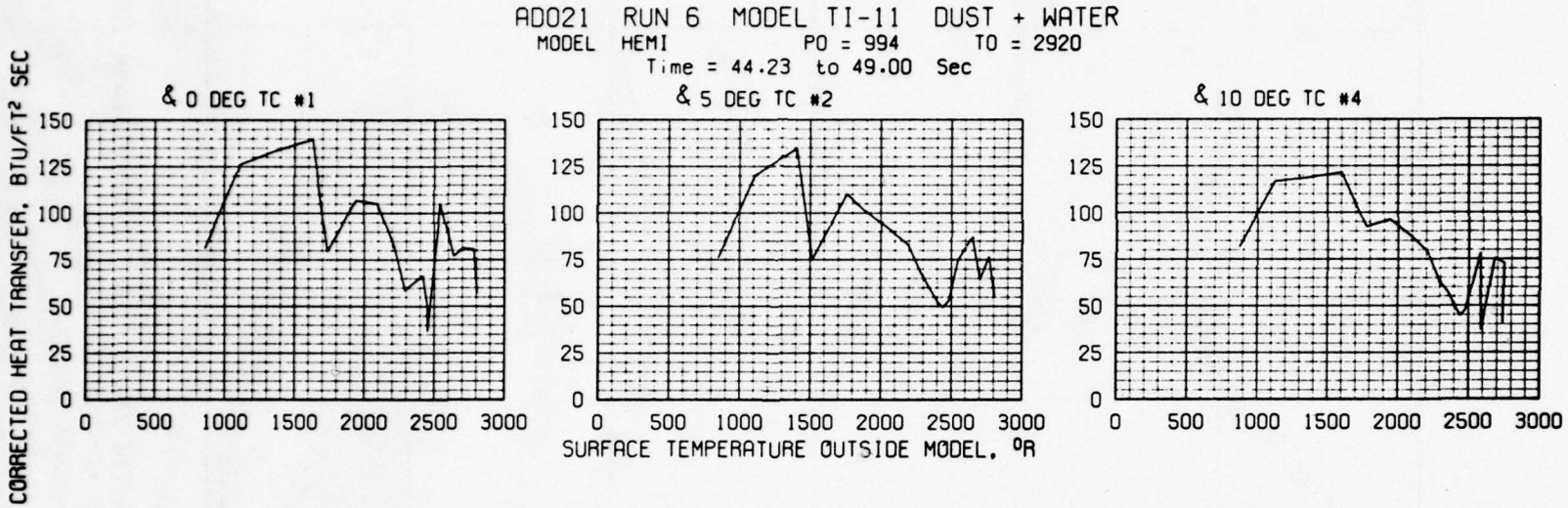
AD021 RUN 6 MODEL TI-13 DUST (NO CH 13)
MODEL HEMI PO = 994 TO = 2920
Time = 39.02 to 43.80 Sec

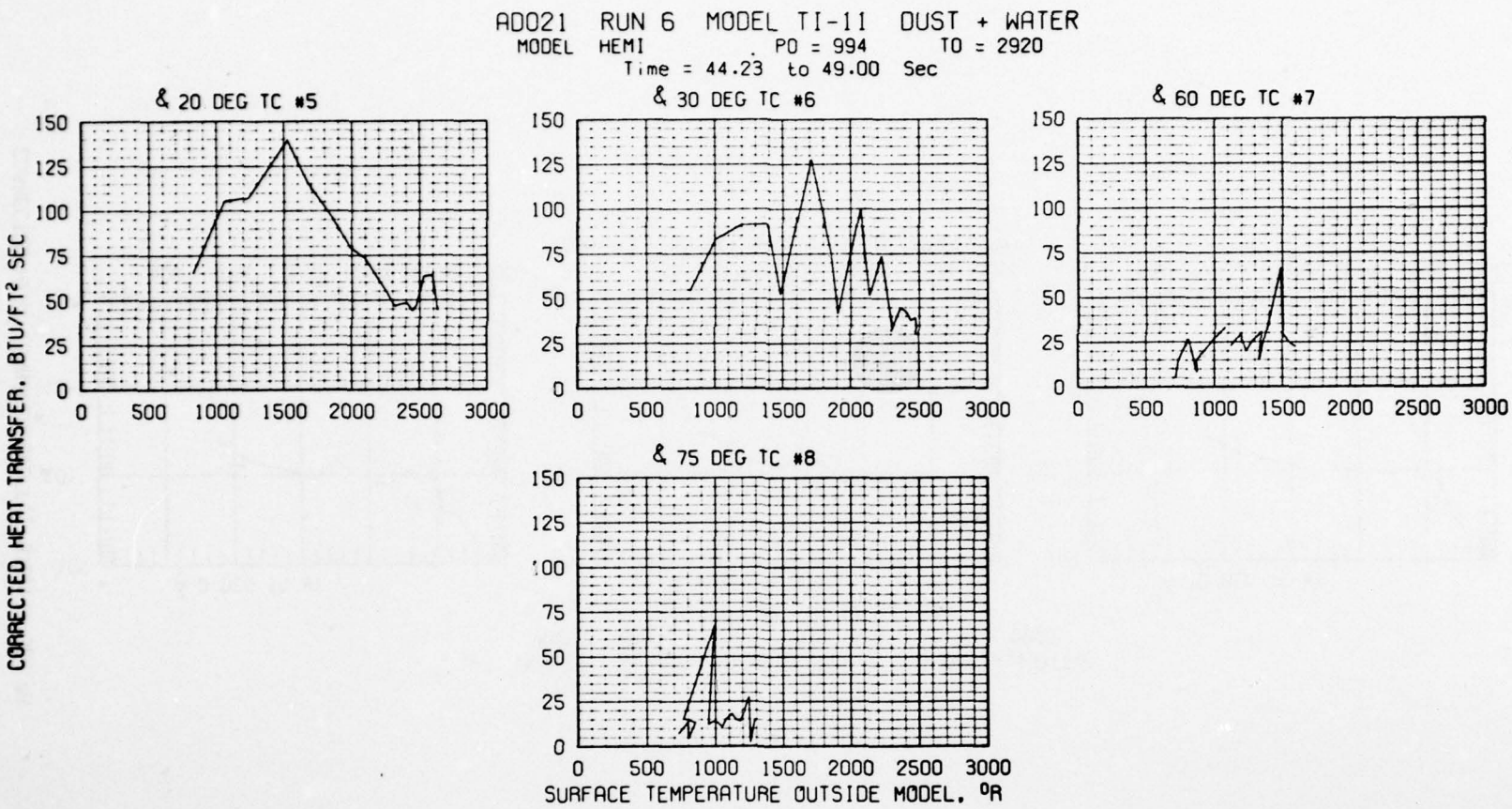


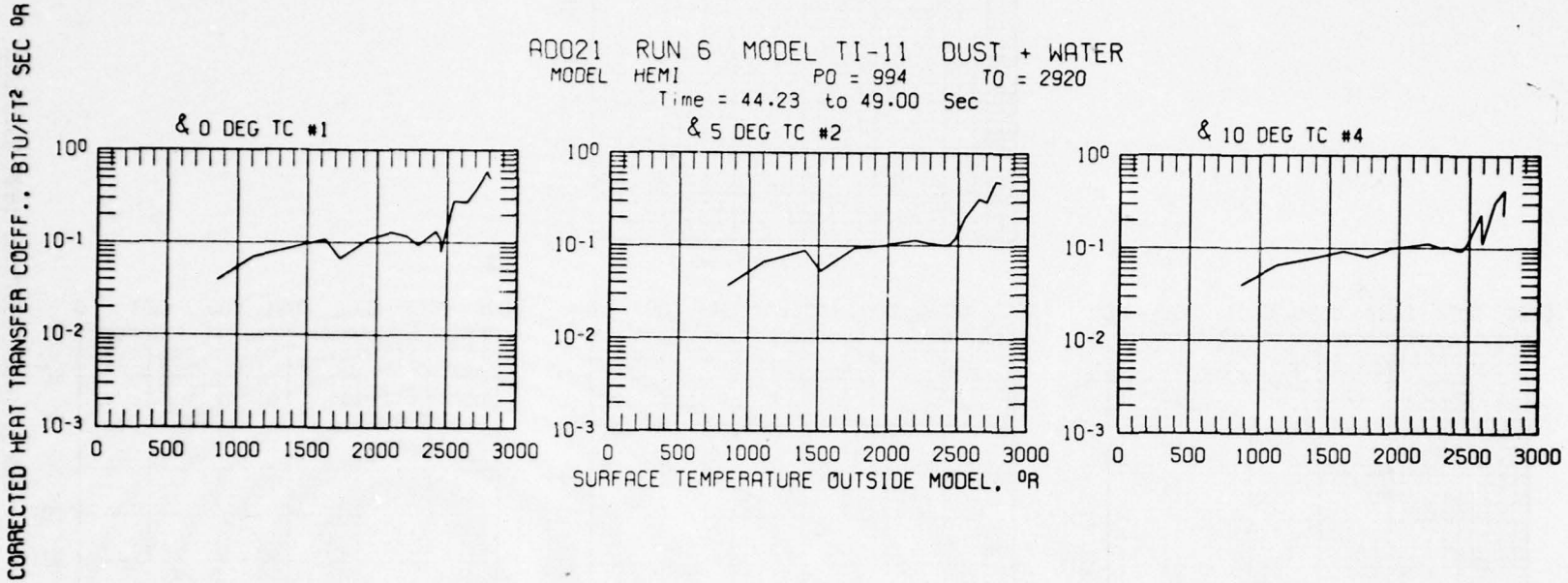

AD021 RUN 6 MODEL TI-13 DUST (NO CH 13)
MODEL HEMI PO = 994 TO = 2920
Time = 39.02 to 43.80 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

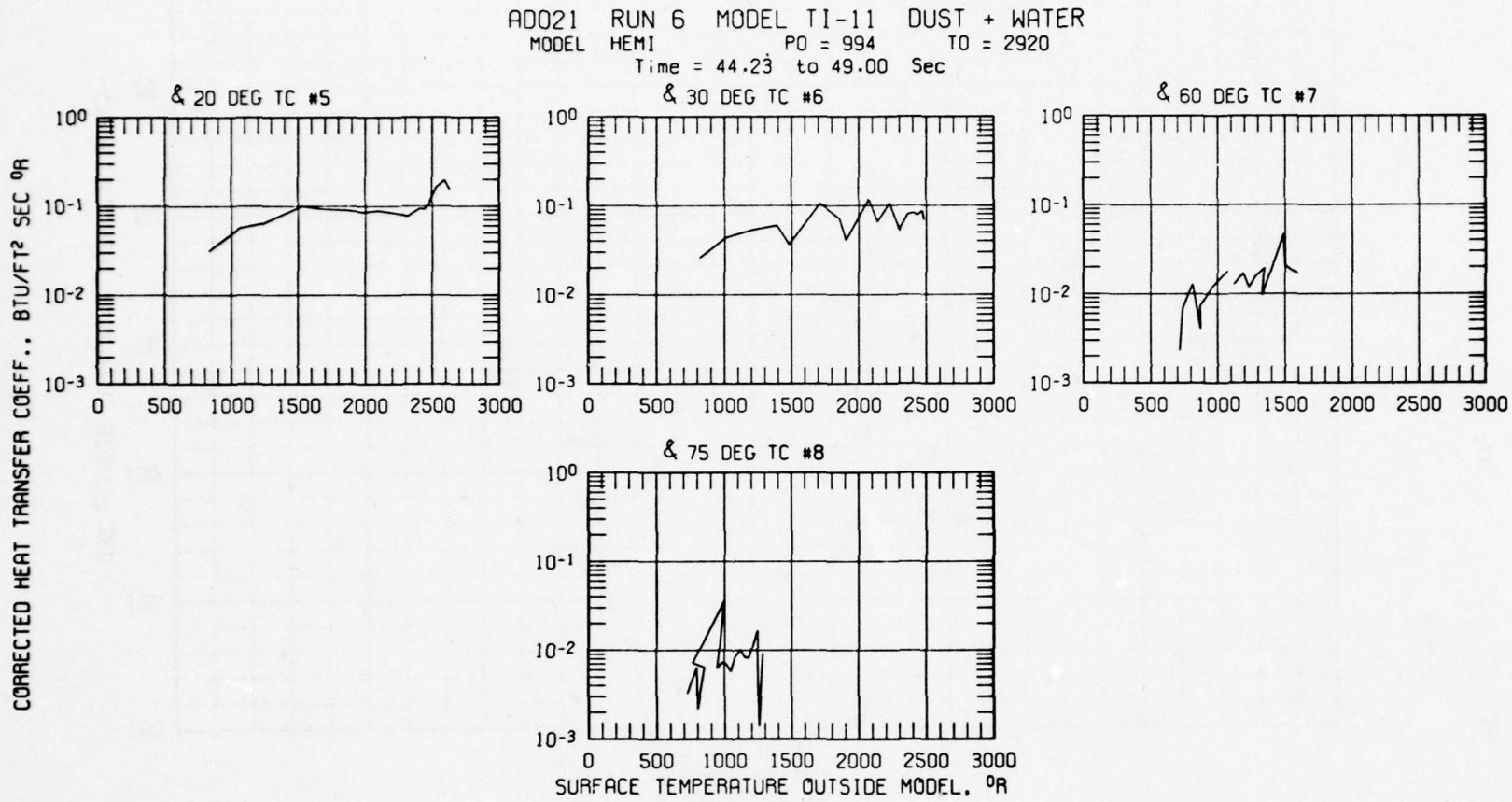

AD021 RUN 6 MODEL TI-13 DUST (NO CH 13)
MODEL HEMI PO = 994 TO = 2920
Time = 39.02 to 43.80 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
0
500
1000
1500
2000
2500
3000

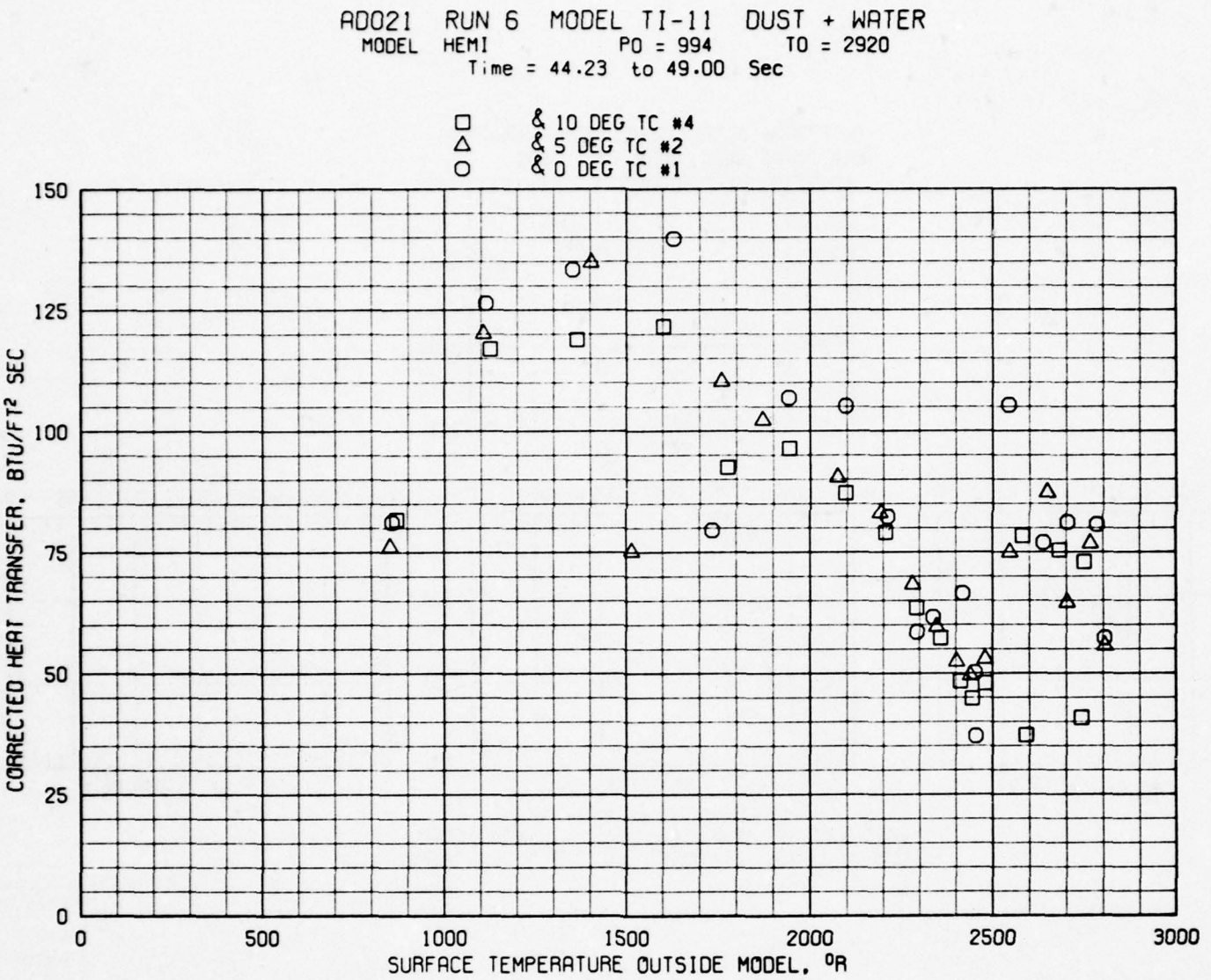

AD021 RUN 6 MODEL TI-13 DUST (NO CH 13)
MODEL HEMI PO = 994 TO = 2920
Time = 39.02 to 43.80 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

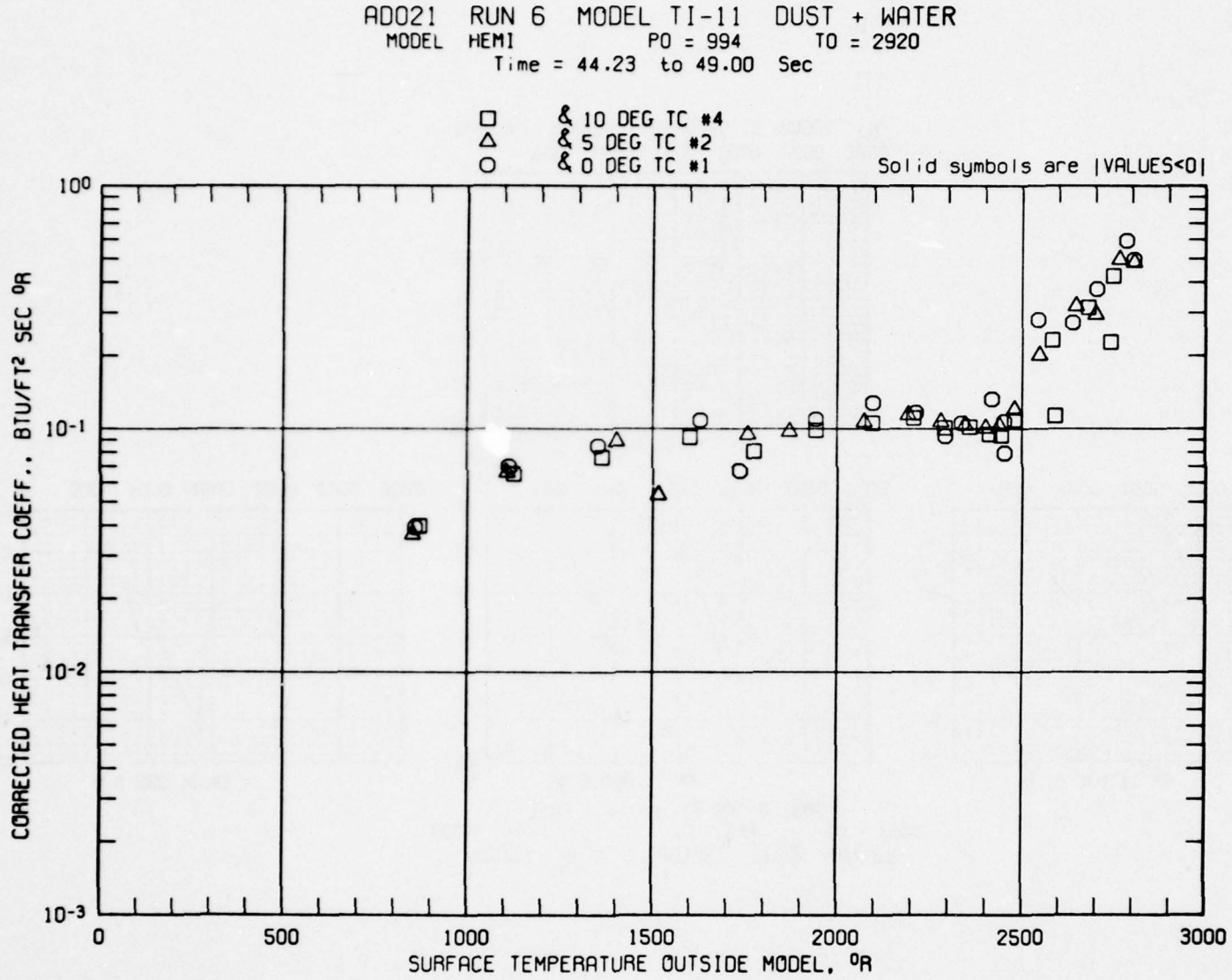

AD021 RUN 6 MODEL TI-11 DUST + WATER
MODEL HEMI PO = 994 TO = 2920
Time = 44.23 to 49.00 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
500
1000
1500
2000
2500
3000

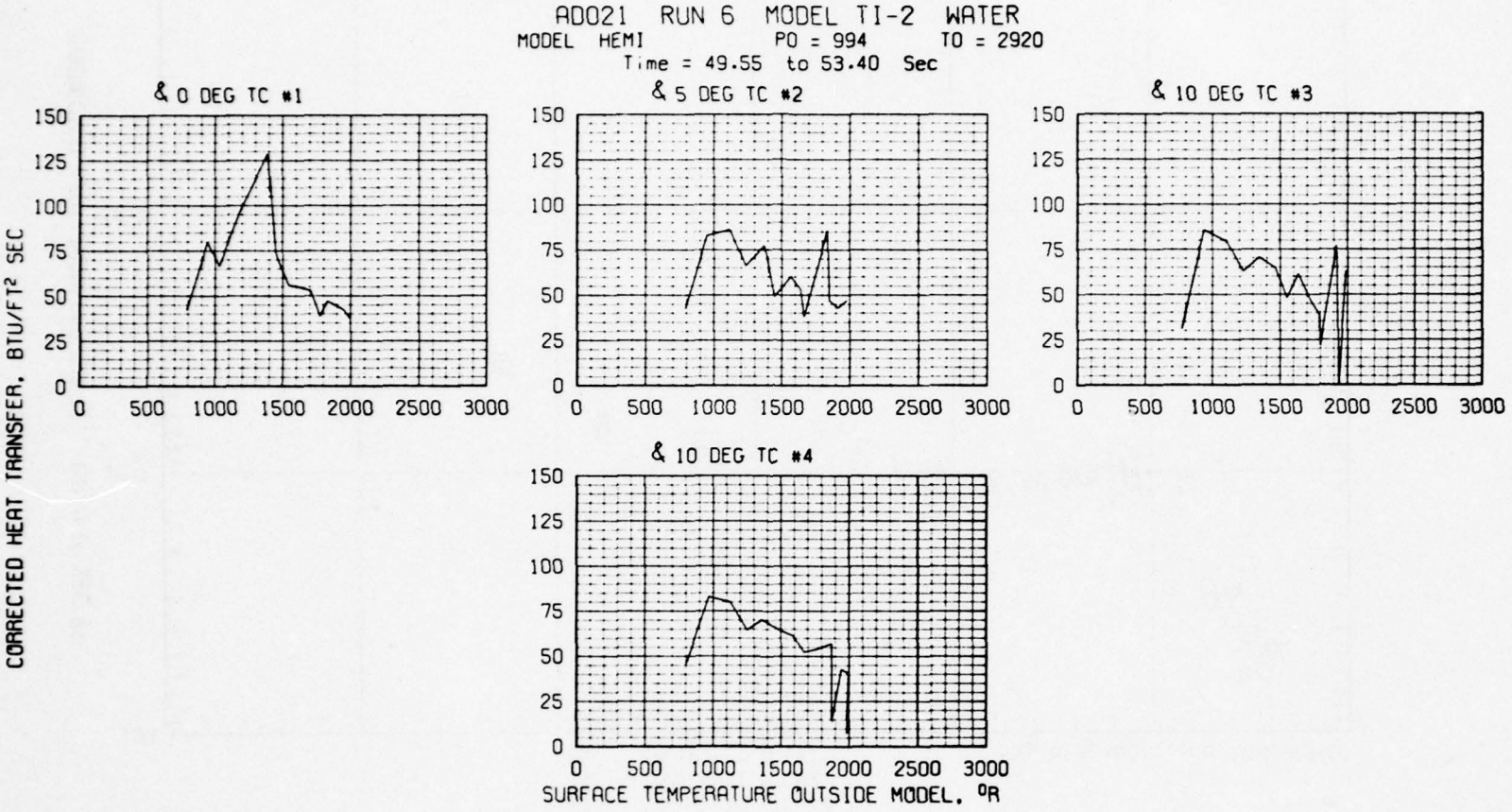

AD021 RUN 6 MODEL TI-11 DUST + WATER
MODEL HEMI PO = 994 TO = 2920
Time = 44.23 to 49.00 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
500
1000
1500
2000
2500
3000

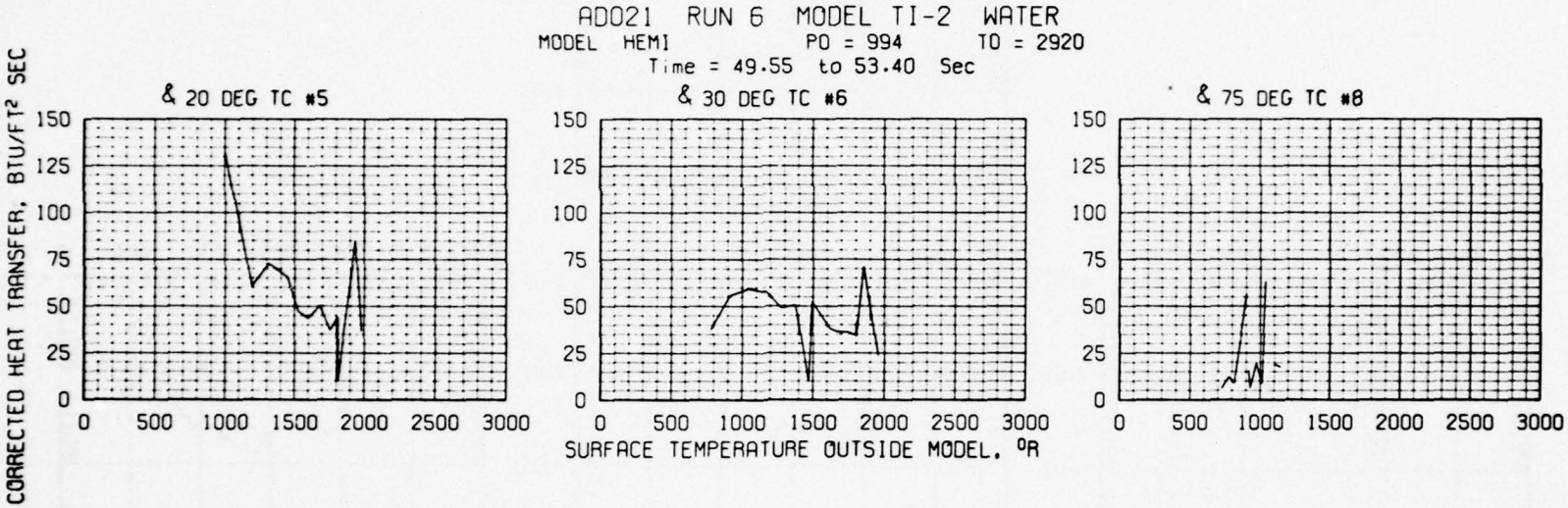

A0021 RUN 6 MODEL TI-11 DUST + WATER
MODEL HEMI PO = 994 TO = 2920
Time = 44.23 to 49.00 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

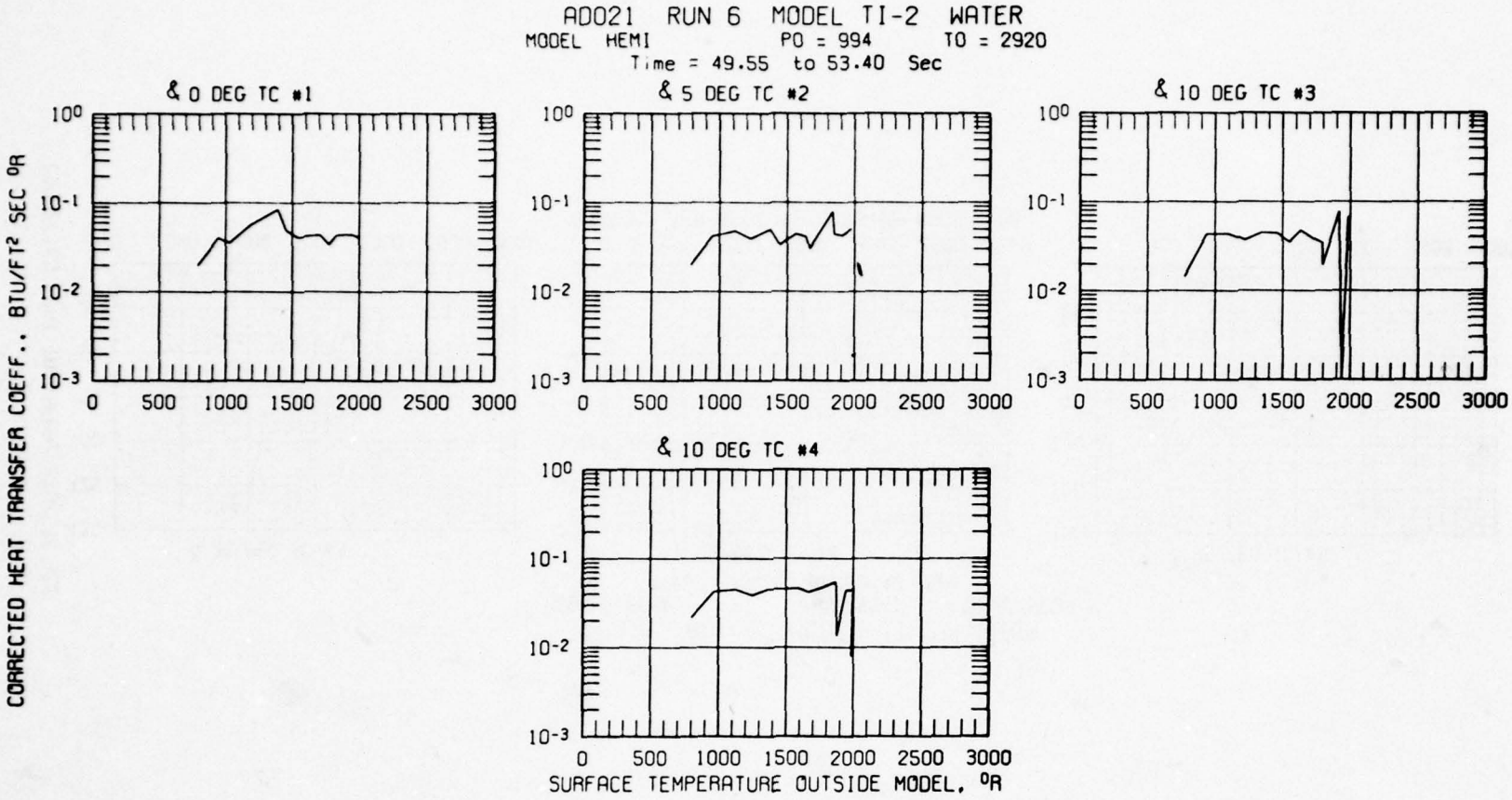

A0021 RUN 6 MODEL TI-11 DUST + WATER
MODEL HEMI PO = 994 TO = 2920
Time = 44.23 to 49.00 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000

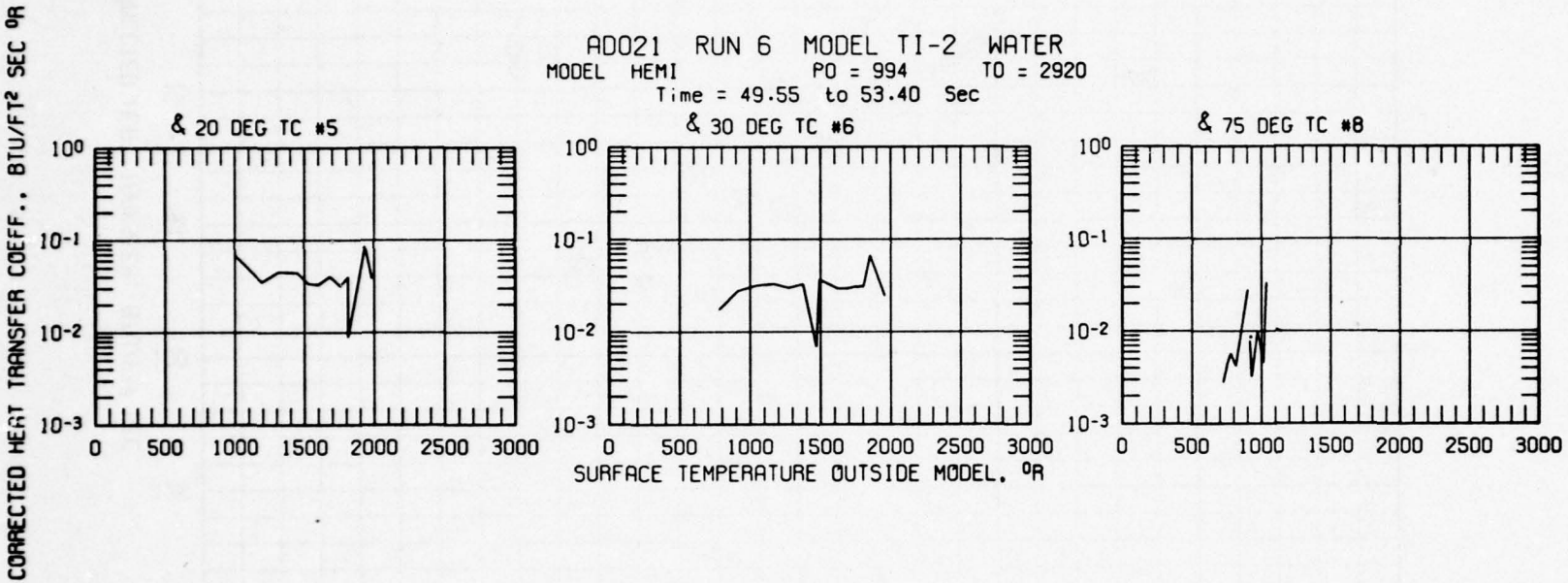

AD021 RUN 6 MODEL TI-11 DUST + WATER
MODEL HEMI PO = 994 TO = 2920
Time = 44.23 to 49.00 Sec
□ & 10 DEG TC #4
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
0
500
1000
1500
2000
2500
3000

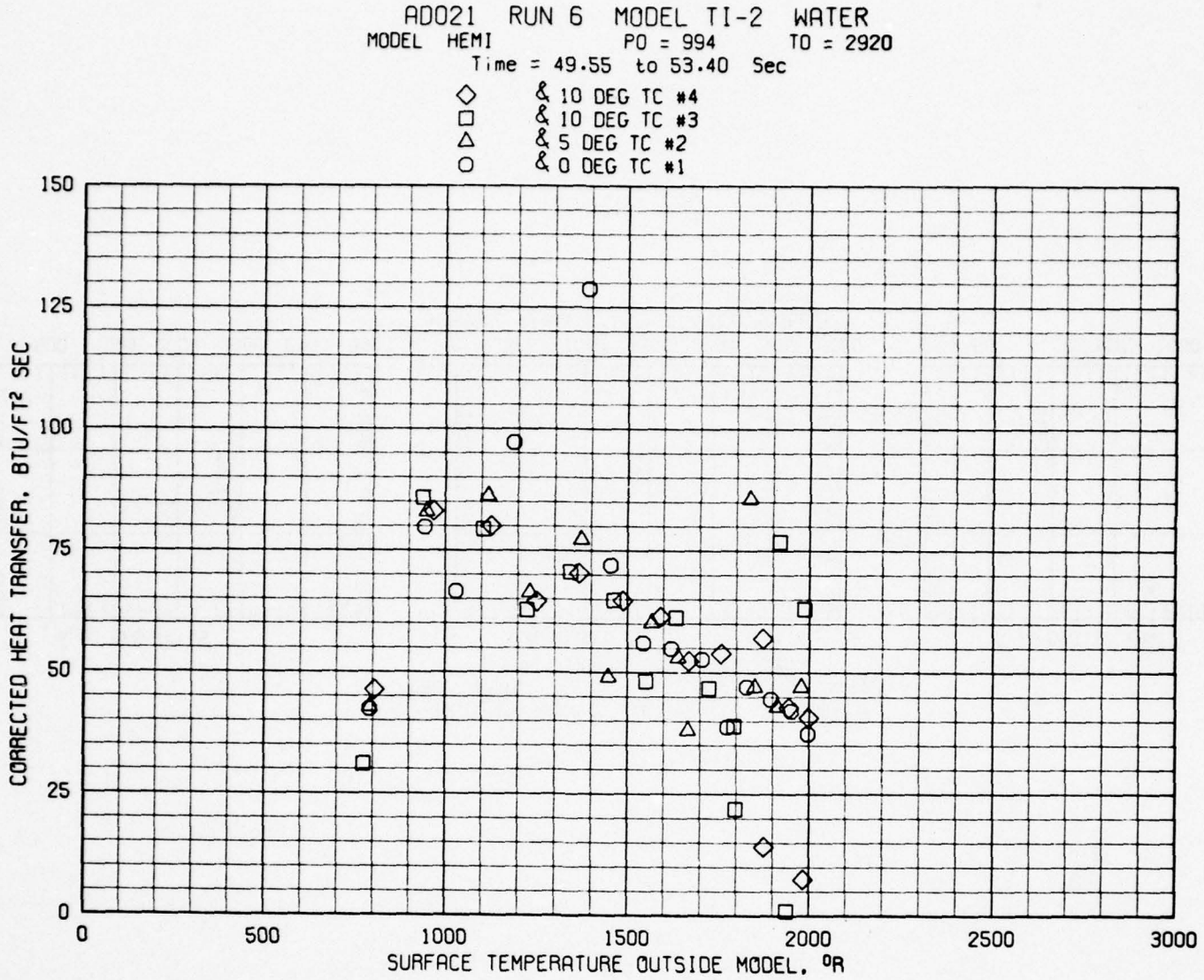

AD021 RUN 6 MODEL TI-11 DUST + WATER
MODEL HEMI PO = 994 TO = 2920
Time = 44.23 to 49.00 Sec
□ & 10 DEG TC #4
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R


AD021 RUN 6 MODEL TI-2 WATER
MODEL HEMI PO = 994 TO = 2920
Time = 49.55 to 53.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
500
1000
1500
2000
2500
3000


AD021 RUN 6 MODEL TI-2 WATER
MODEL HEMI PO = 994 TO = 2920
Time = 49.55 to 53.40 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
25
50
75
100
125
150
500
1000
1500
2000
2500
3000


AD021 RUN 6 MODEL TI-2 WATER
MODEL HEMI PO = 994 TO = 2920
Time = 49.55 to 53.40 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 6 MODEL TI-2 WATER
MODEL HEMI PO = 994 TO = 2920
Time = 49.55 to 53.40 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 6 MODEL TI-2 WATER
MODEL HEMI
PO = 994
TO = 2920
Time = 49.55 to 53.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
150
125
100
75
50
25
0
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

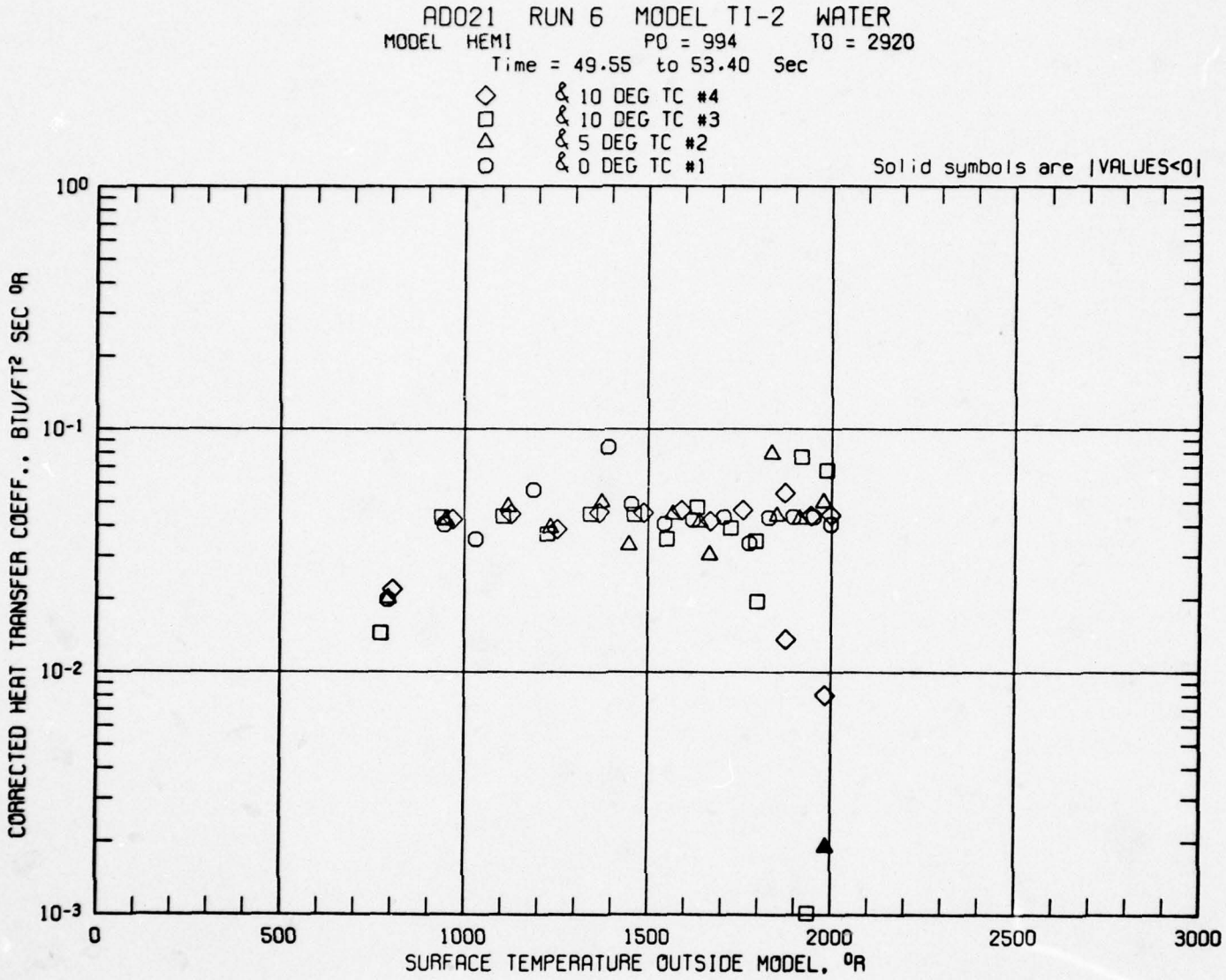

AD021 RUN 6 MODEL TI-2 WATER
MODEL HEMI
PO = 994
TO = 2920
Time = 49.55 to 53.40 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

TABLE 1 RUN SUMMARY

TUNNEL CONDITIONS

RUN 7 DATE 1-14-77

NOZZLE STATION 127.5

P_o = 1002 psia, P_{o_m} = 1018

H_{o_B} = 1806 Btu/lbm, H_{o_m} = 1718

H_o = ____ Btu/lbm

T_{o_B} = 5900 °R, T_o = ____ °R

M = 6.65 p_o' = 9.83 psia

DUST

TYPE MgO

SIZE 100 μm

VEL 5530 ft/sec

Flow 10.89 gm/sec

C.F. 26.6

WATER

Flow 0.42 gpm

C.F. 29.0

Orifice 0.02 in.

ΔP 872 psi

STING	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANSDUCER TYPE	PRERUN	POSTRUN
1	p_o' probe	3.13					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_i-22	6.22					Hemi	3.0	6Al-4V-T_i	S	8				94	276
3	WB-3S WB-3A	4.19					See Fig. 2		SS Al							281
4	T_i-54	0.88	3.82				Hemi	3.0	6Al-4V-T_i	S	8				96	279
5	T_i-53		3.18 2.71	- 2.71	- x		Hemi	3.0	6Al-4V-T_i	S	8				97	278
6	T_i-23	2.95		2.81			Hemi	3.0	6Al-4V-T_i	S	8				93	277
7	WB-4S WB-4A			5.67			See Fig. 2		SS Al							280
8																
9																
10																

KEY -

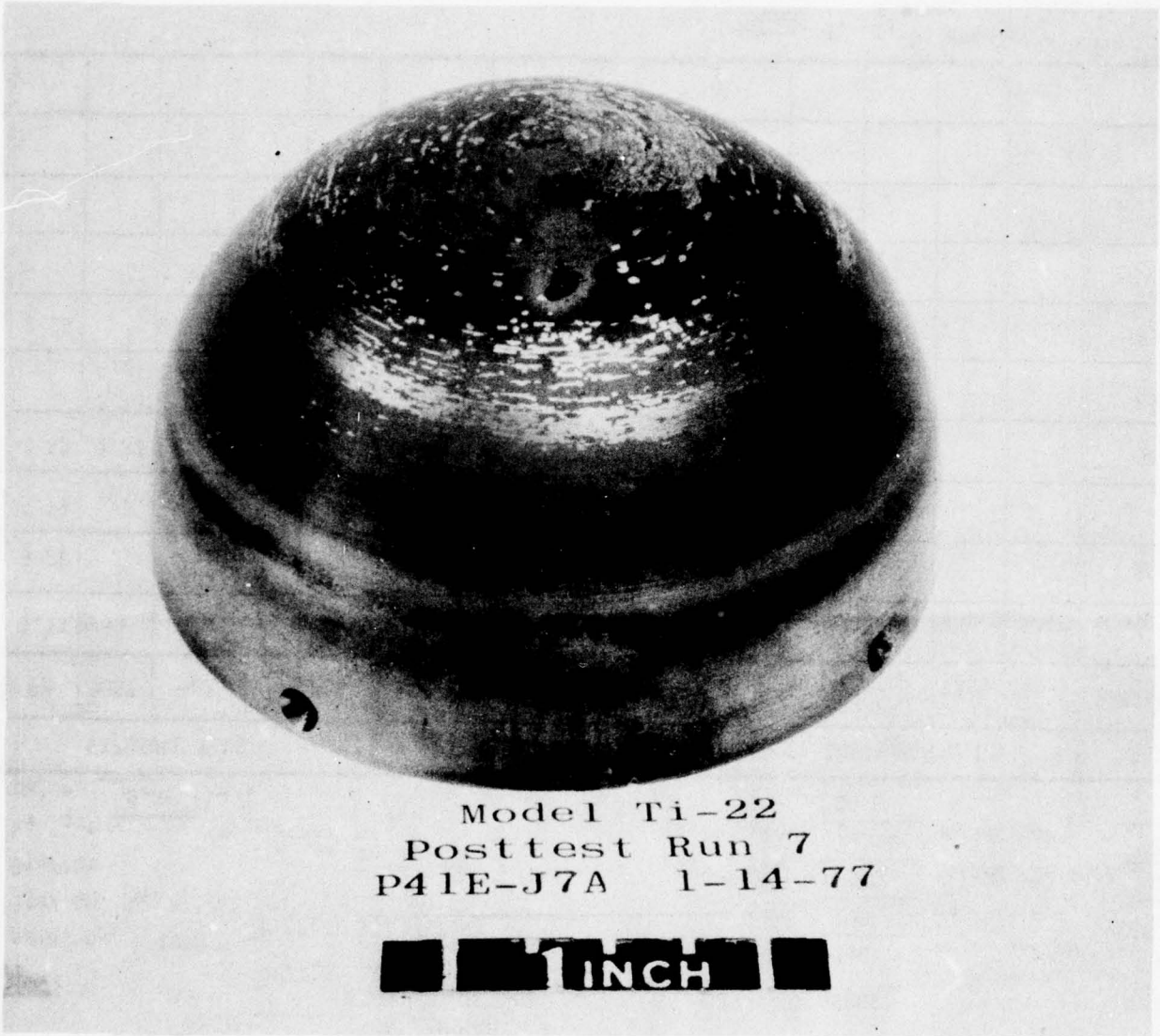
PH - PREHEAT

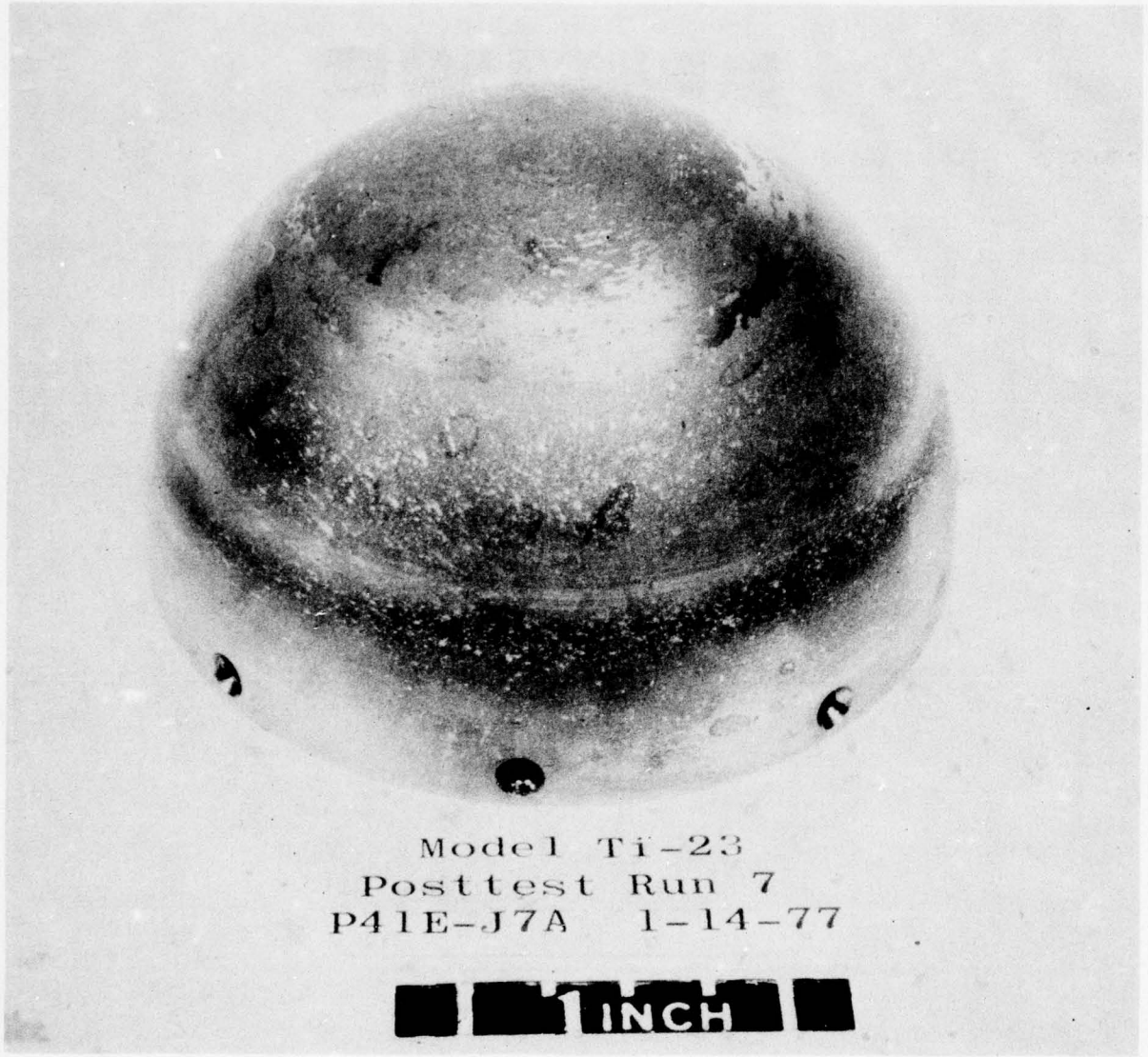
POH - POSTHEAT

DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

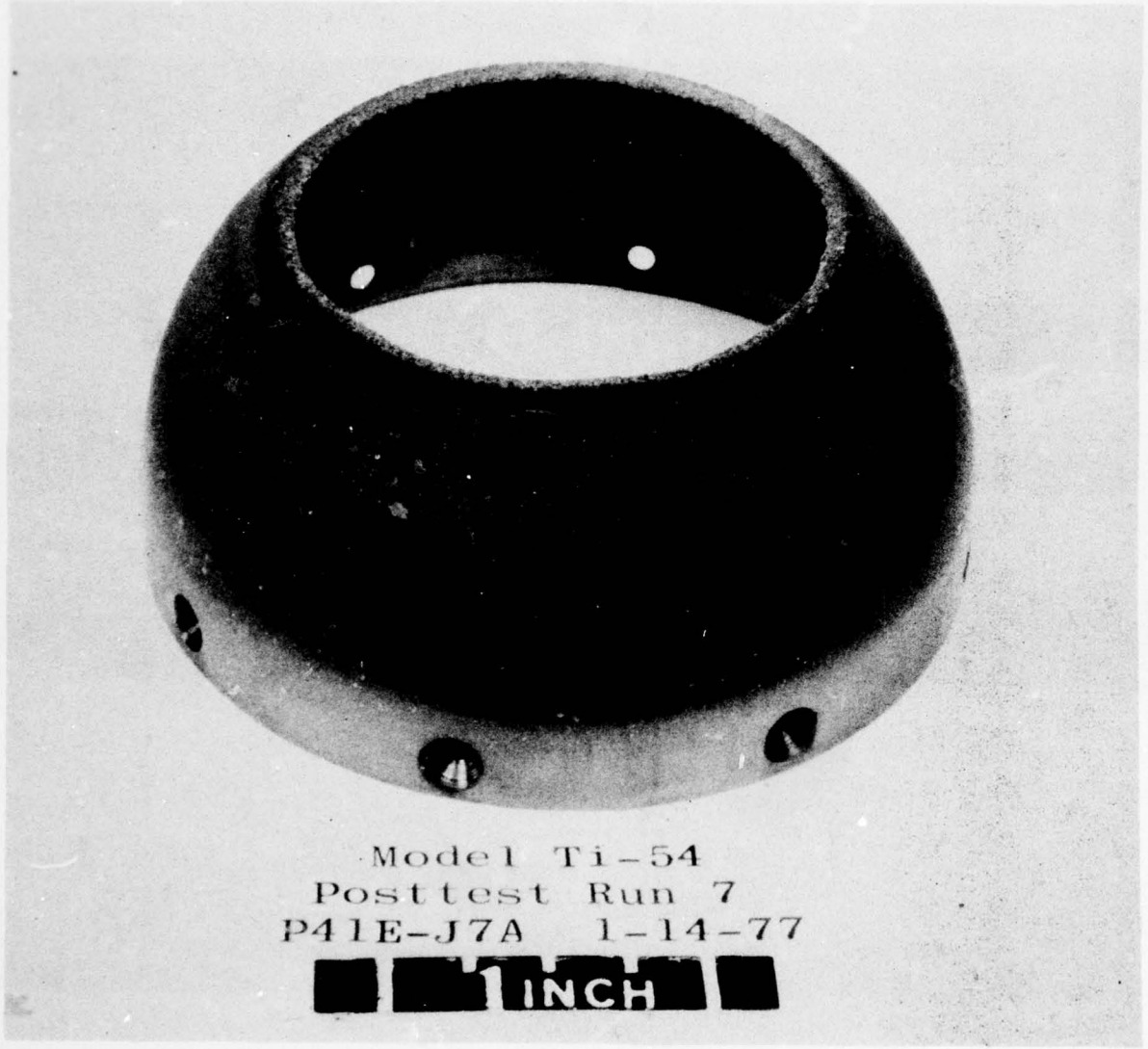
NOTES: 1. T_i-54 and T_i-53 burned through; 2 pinholes burned in T_i-22.

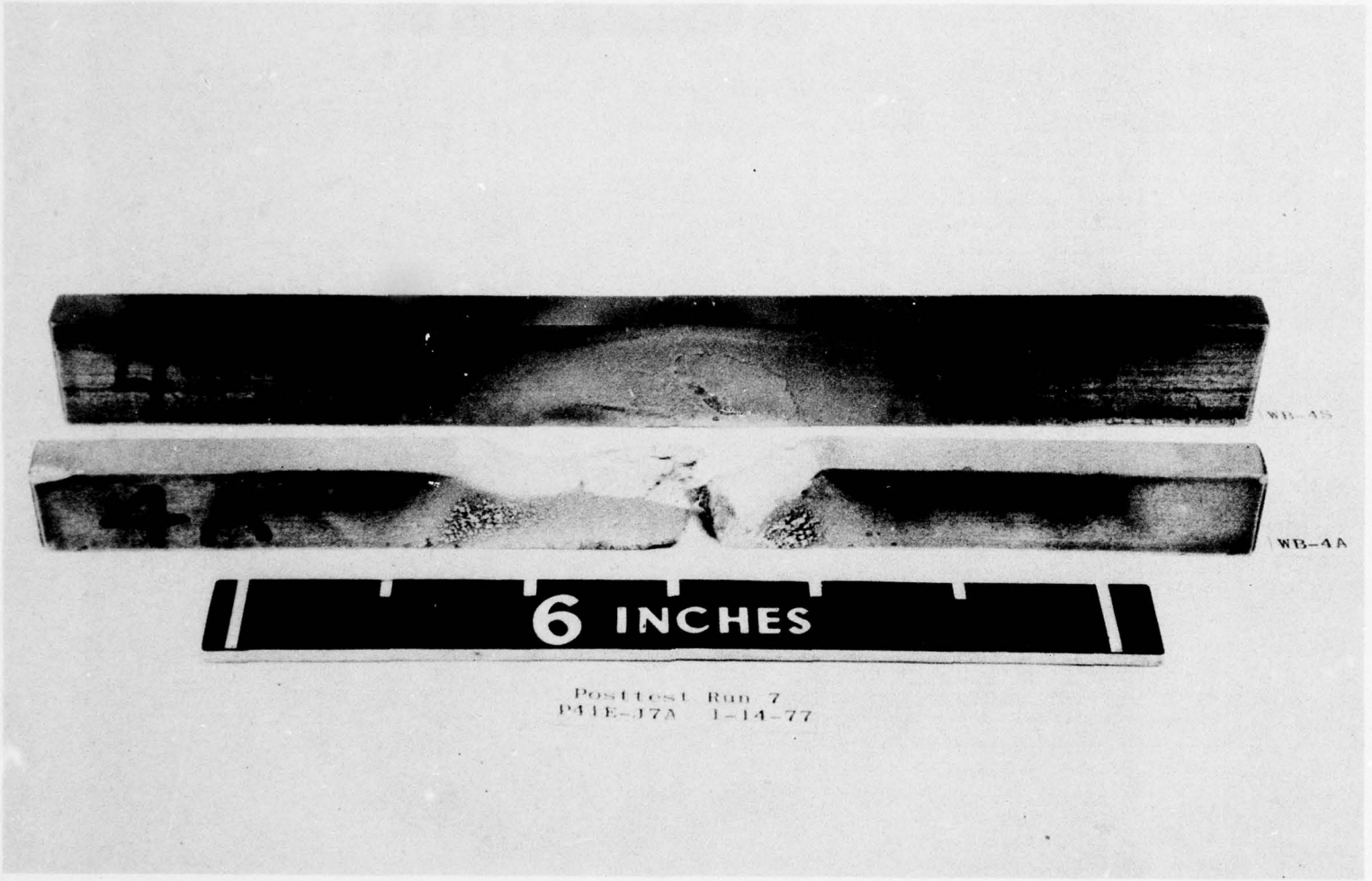
PRECEDING PAGE BLANK-NOT FILMED


Model Ti-22
Posttest Run 7
P41E-J7A 1-14-77
1 INCH

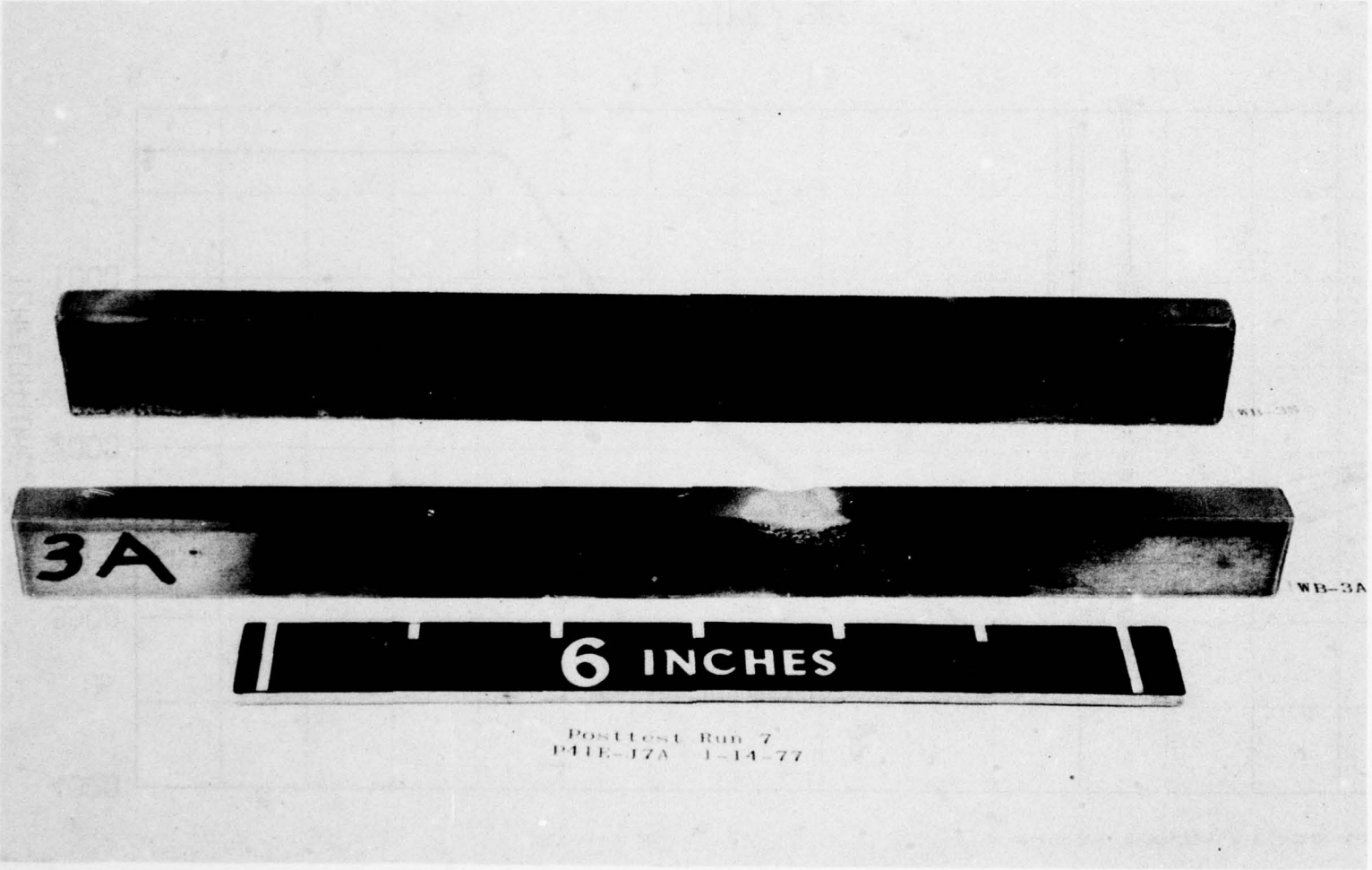

Model Ti-23
Posttest Run 7
P41E-J7A 1-14-77
1 INCH

Model Ti-53
Posttest Run 7
P41E-J7A 1-14-77
1 INCH

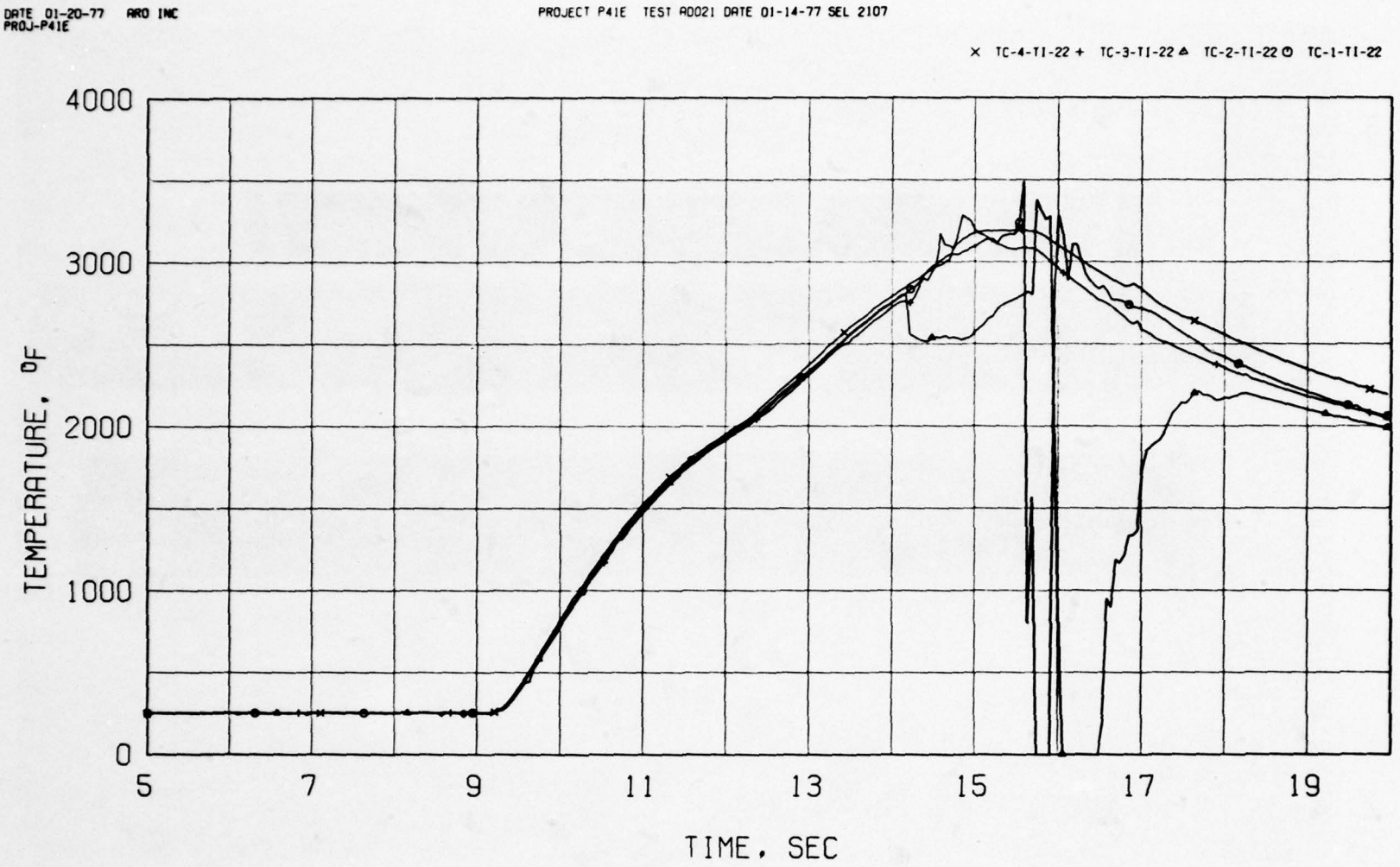

Model Ti-54
Posttest Run 7
P41E-J7A 1-14-77
1 INCH



Post Test Run 7
P41E-17A 1-14-77



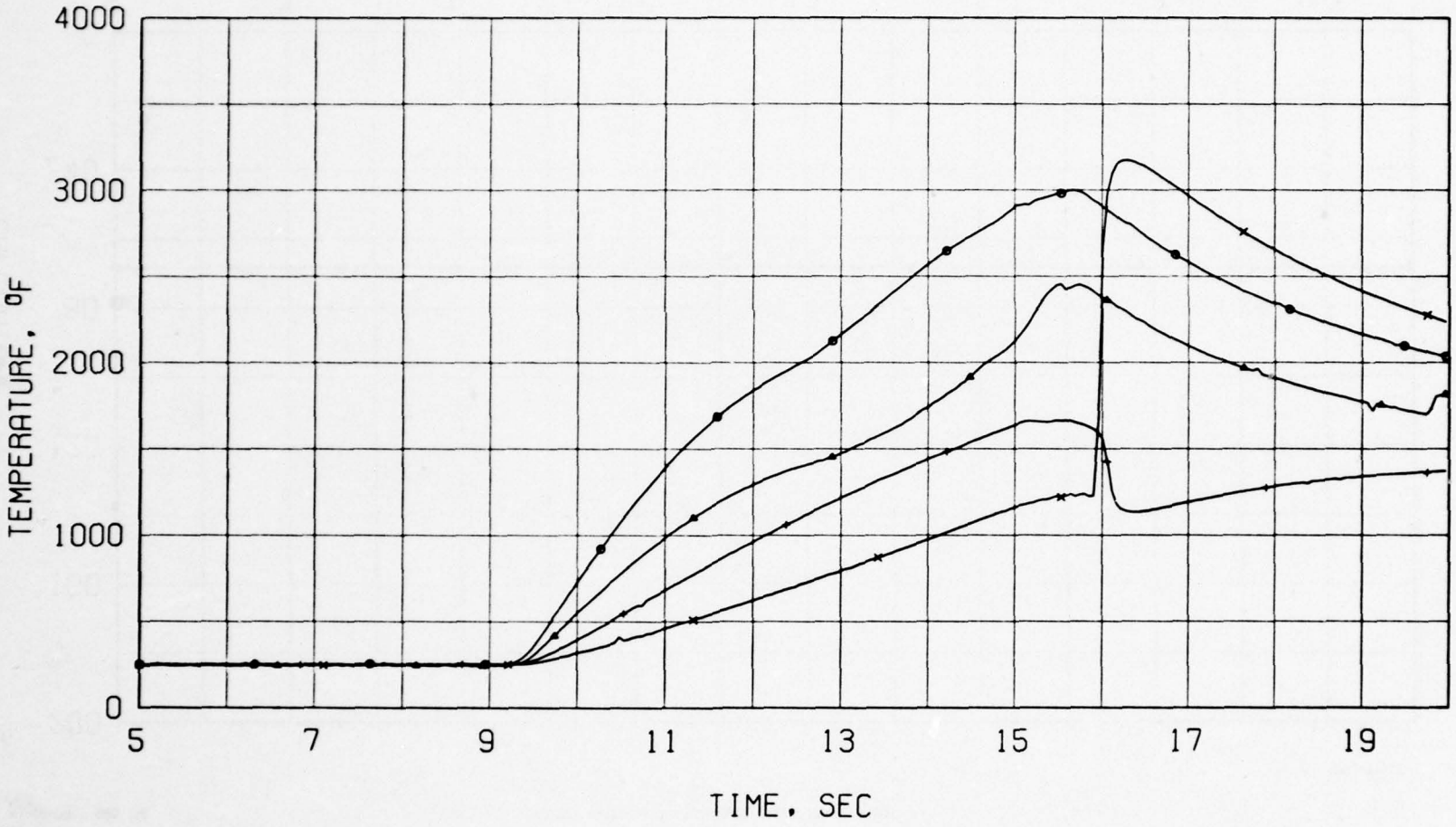
Posttest Run 7
P41E-17A 1-14-77


DATE 01-20-77 ARO INC
PROJ-P41E
PROJECT P41E TEST AD021 DATE 01-14-77 SEL 2107
× TC-4-TI-22 + TC-3-TI-22 △ TC-2-TI-22 ○ TC-1-TI-22
4000
3000
2000
1000
0
TEMPERATURE, °F
5
7
9
11
13
15
17
19
TIME, SEC

DATE 01-20-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107

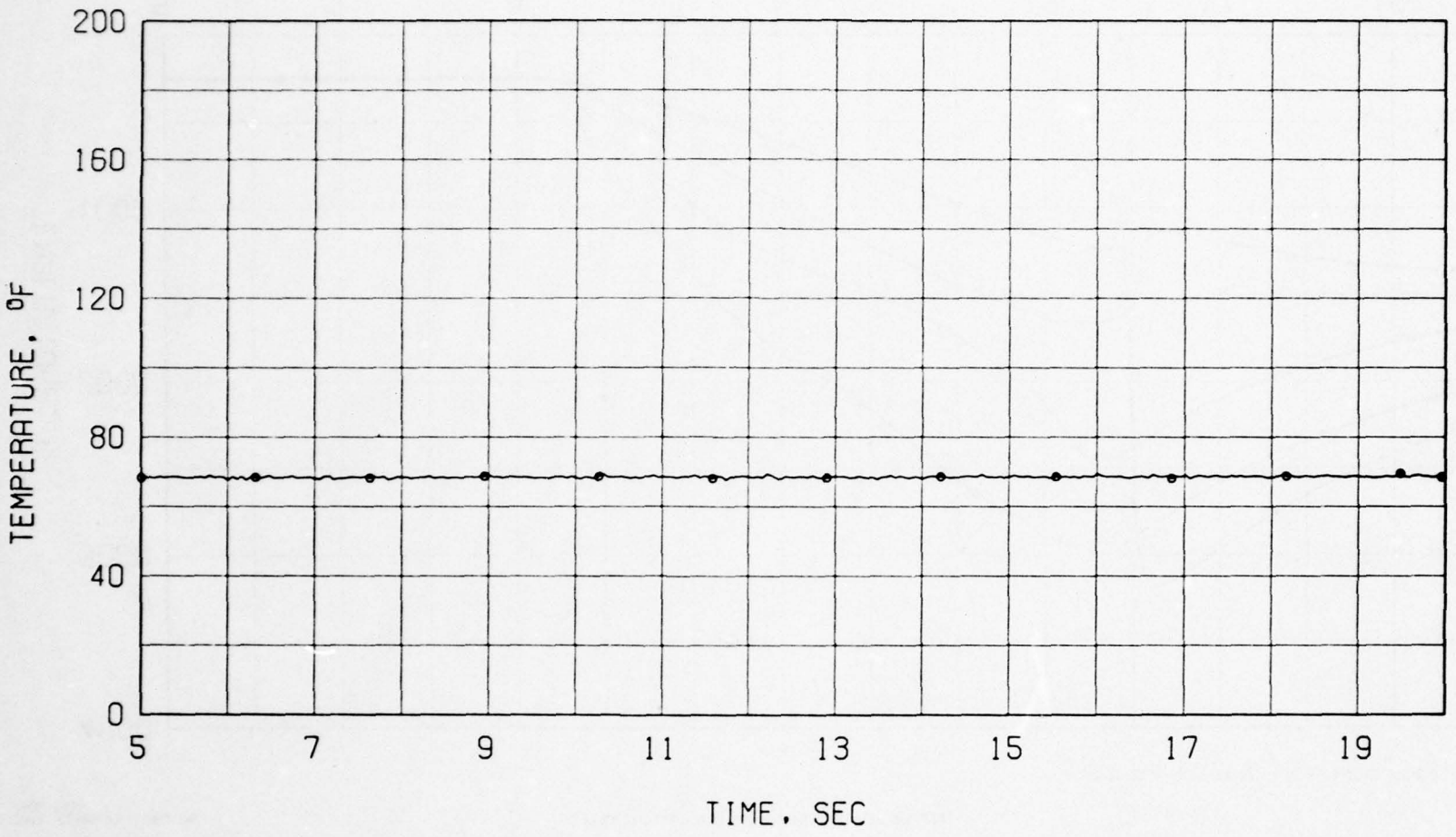
× TC-8-T1-22 + TC-7-T1-22 △ TC-6-T1-22 ⊙ TC-5-T1-22

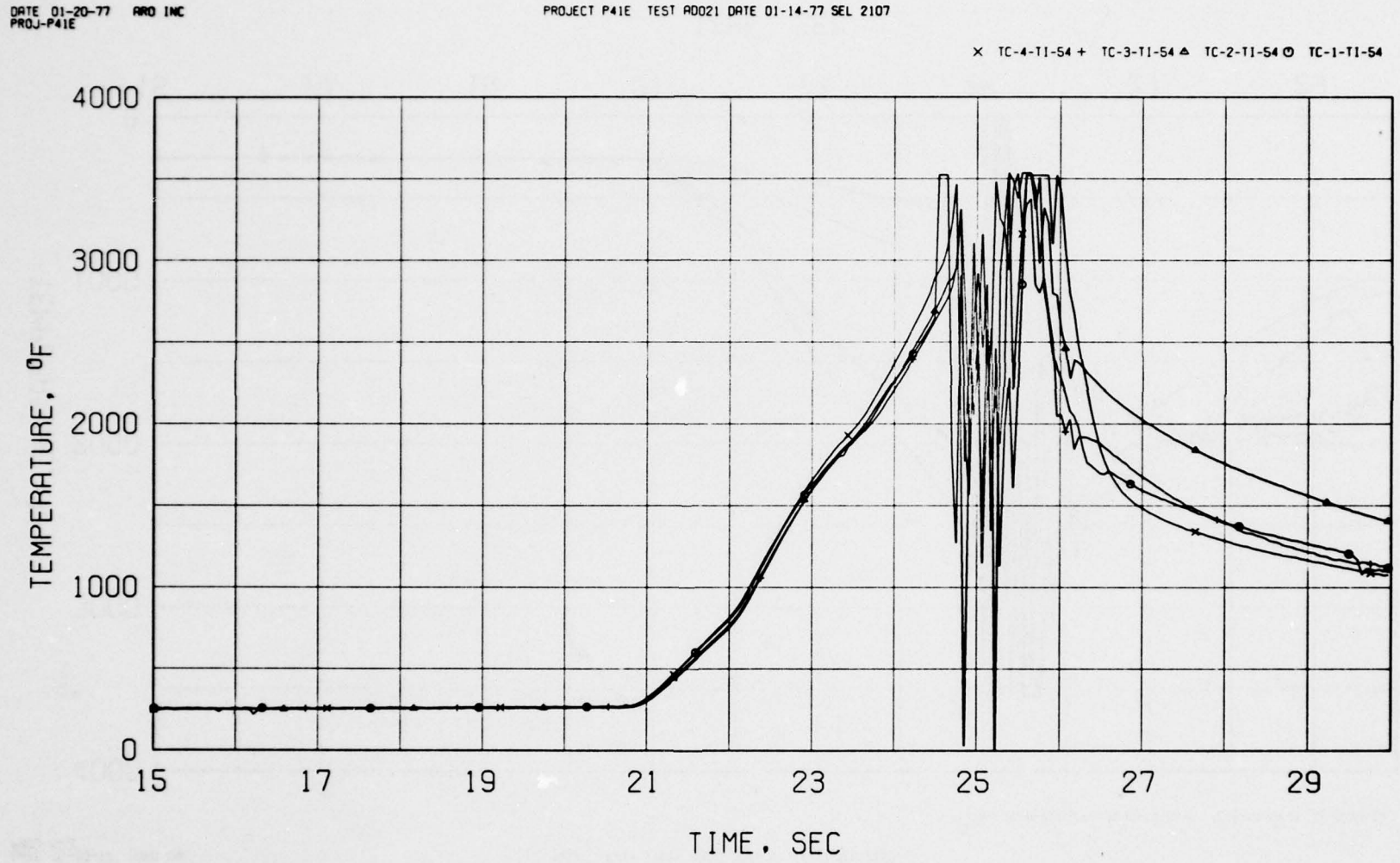


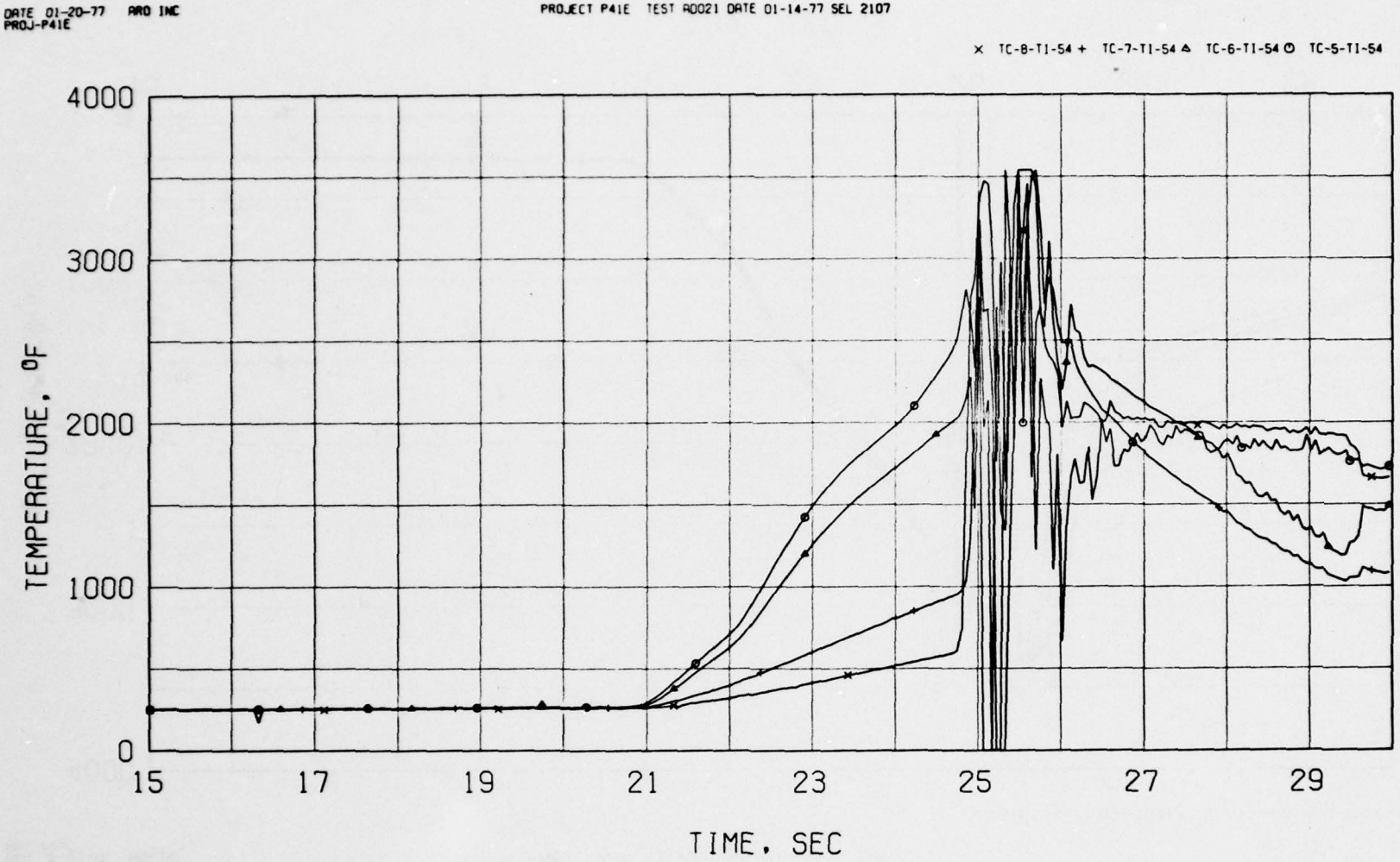
DATE 01-20-77 ARO INC
PROJ-P41E

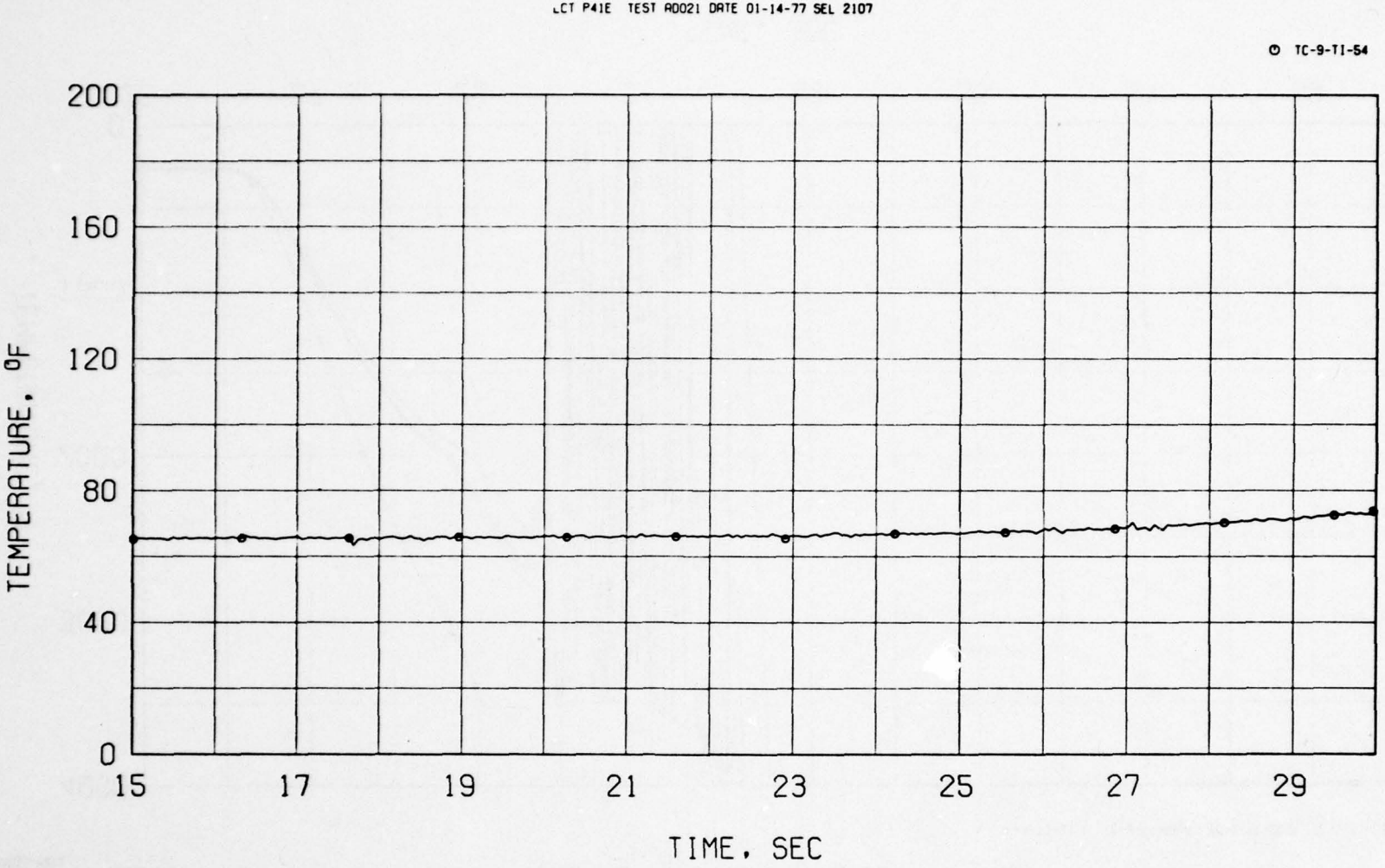
PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107

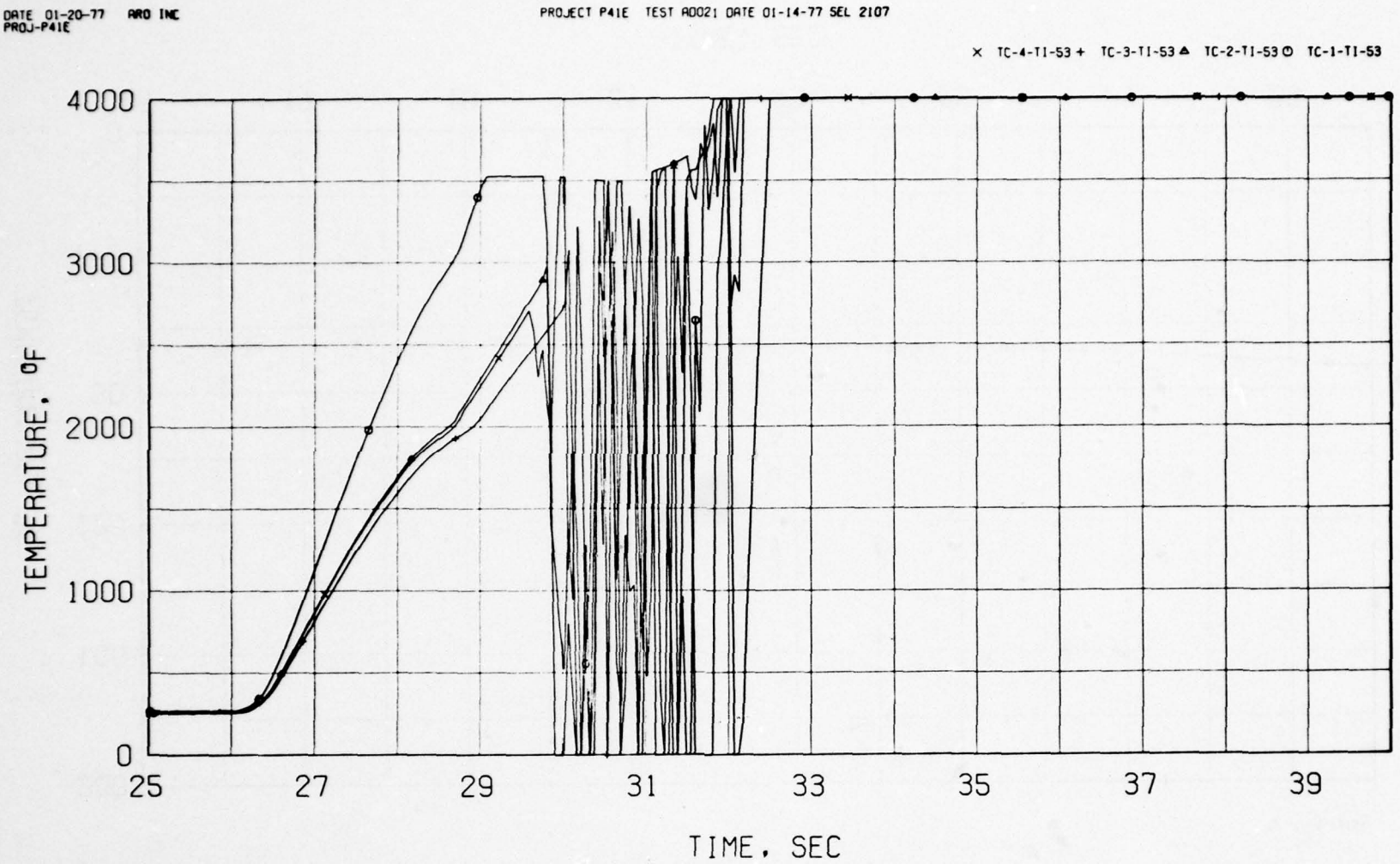
© TC-9-TI-22




DATE 01-20-77 ARO INC
PROJ-P41E
PROJECT P41E TEST AD021 DATE 01-14-77 SEL 2107
× TC-4-TI-54 + TC-3-TI-54 △ TC-2-TI-54 ⊙ TC-1-TI-54
4000
3000
2000
1000
0
TEMPERATURE, °F
15
17
19
21
23
25
27
29
TIME, SEC


DATE 01-20-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107
× TC-8-TI-54 + TC-7-TI-54 △ TC-6-TI-54 ⊙ TC-5-TI-54
4000
3000
2000
1000
0
TEMPERATURE, °F
15
17
19
21
23
25
27
29
TIME, SEC

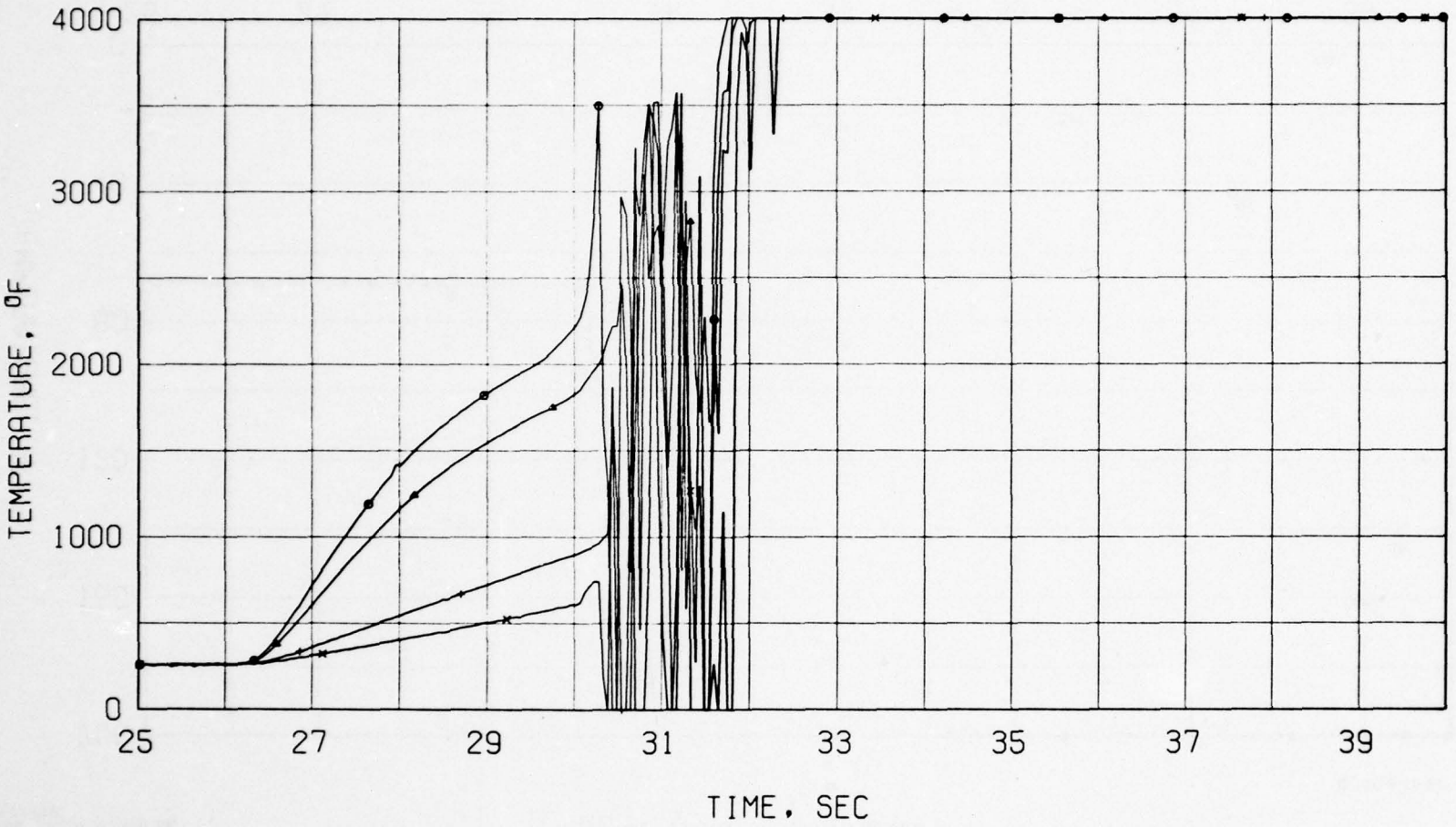

LCT P41E TEST A0021 DATE 01-14-77 SEL 2107
TC-9-TI-54
200
160
120
80
40
0
TEMPERATURE, °F
15
17
19
21
23
25
27
29
TIME, SEC


DATE 01-20-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107
× TC-4-TI-53 + TC-3-TI-53 △ TC-2-TI-53 ⊙ TC-1-TI-53
4000
3000
2000
1000
0
TEMPERATURE, °F
25
27
29
31
33
35
37
39
TIME, SEC

DATE 01-20-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107

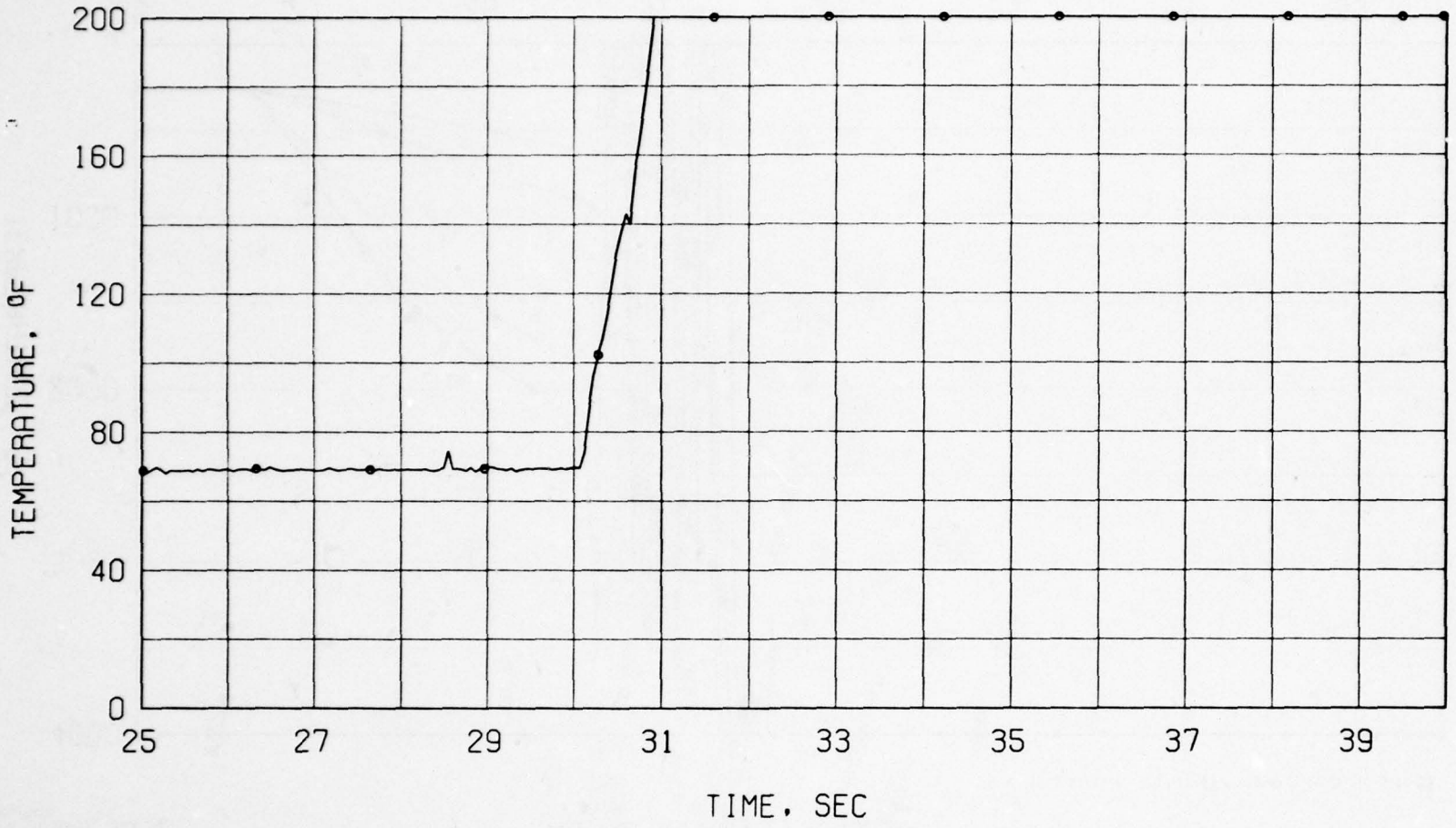
× TC-8-TI-53 + TC-7-TI-53 △ TC-6-TI-53 ⊙ TC-5-TI-53



DATE 01-20-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107

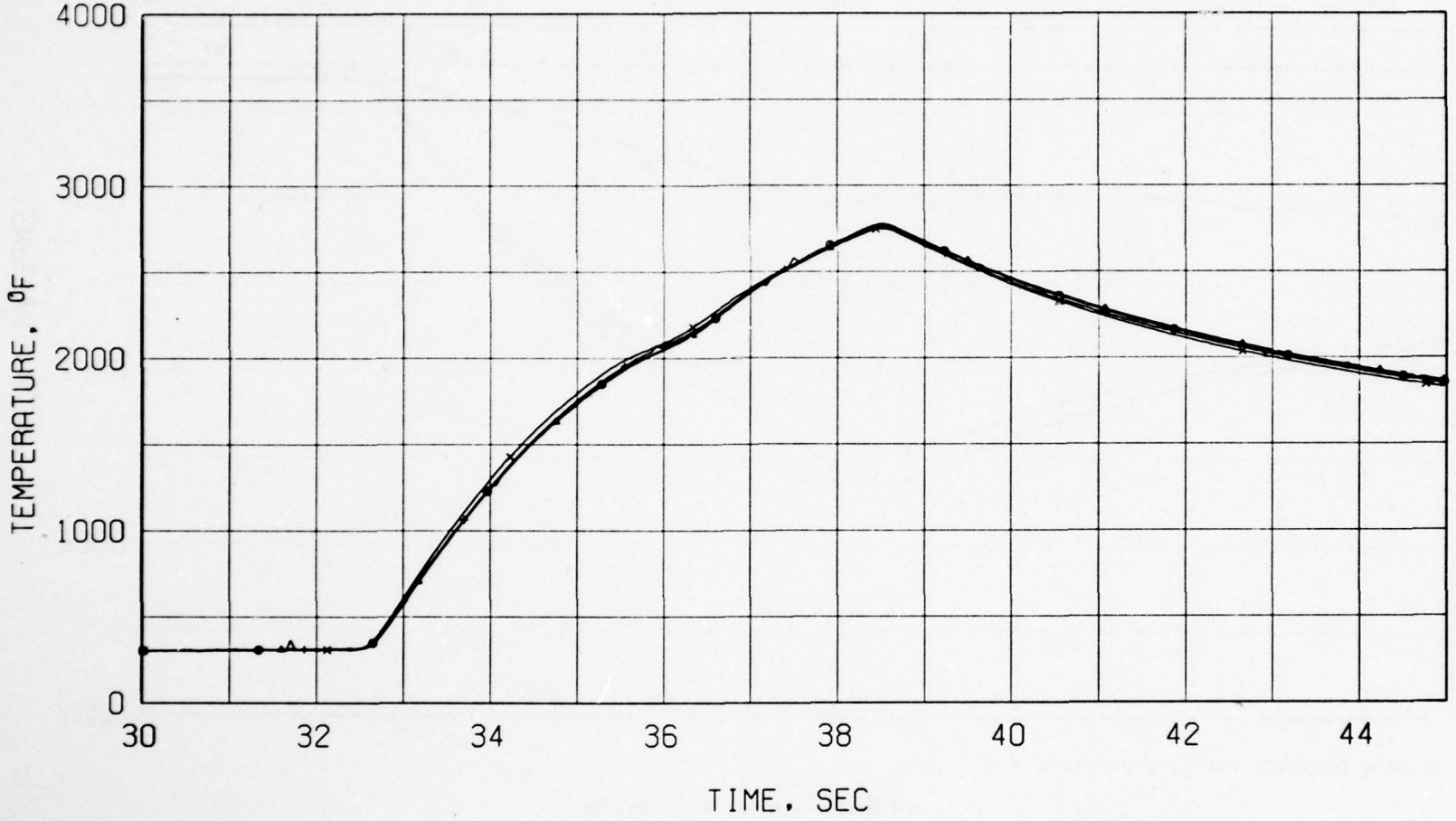
TC-9-TI-53

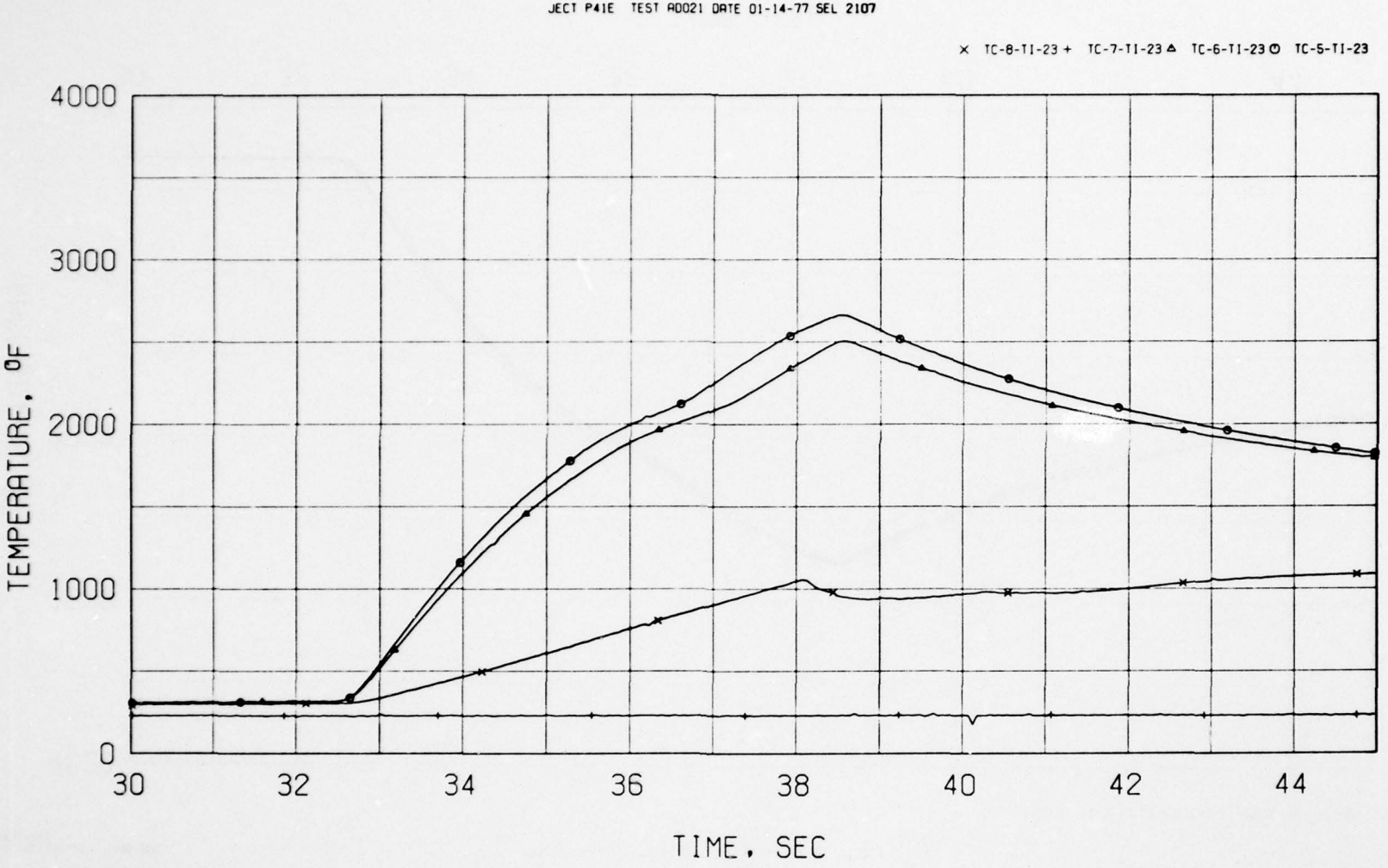


DATE 01-20-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107

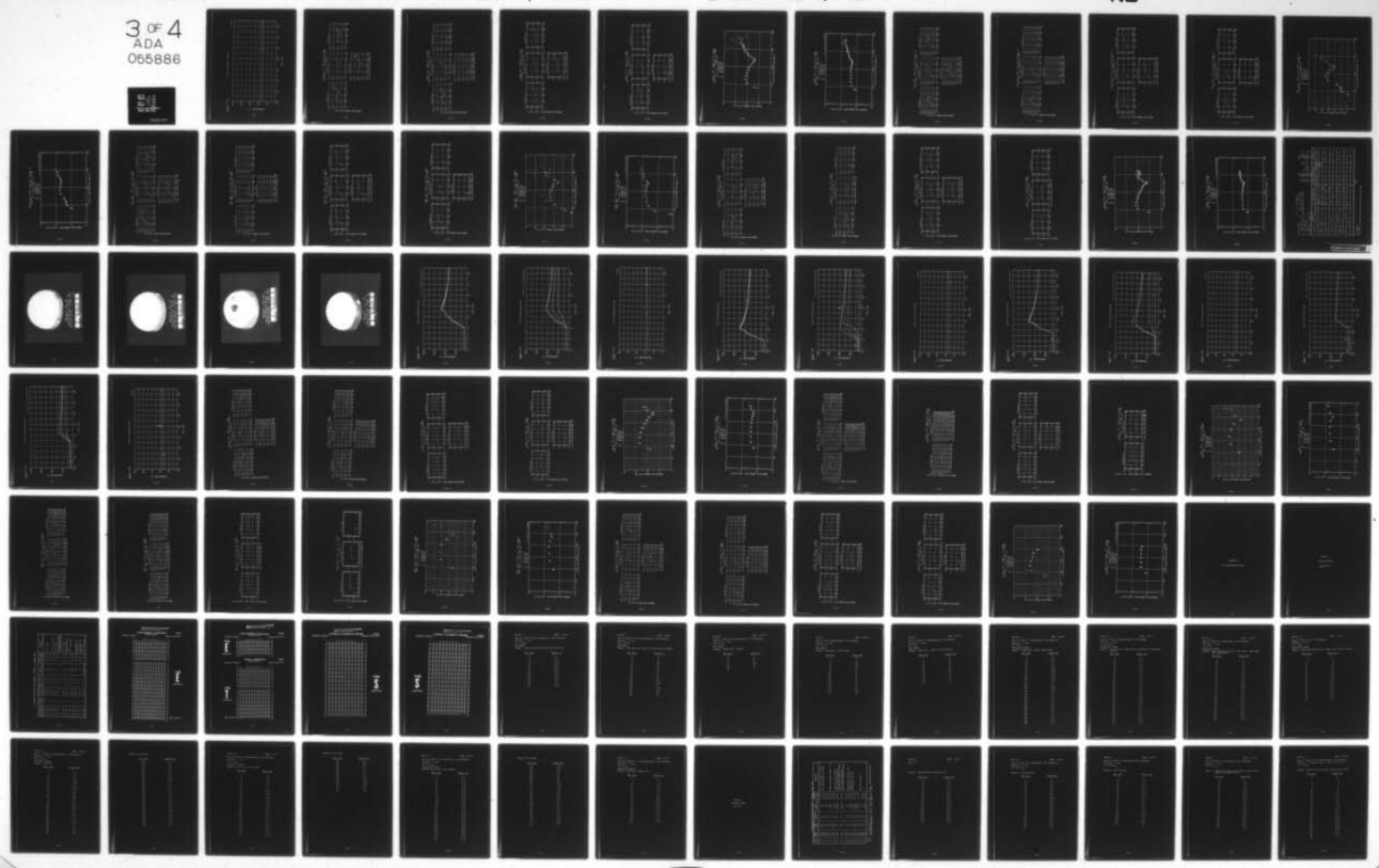
× TC-4-TI-23 + TC-3-TI-23 △ TC-2-TI-23 ⊙ TC-1-TI-23




JECT P41E TEST AD021 DATE 01-14-77 SEL 2107
× TC-8-TI-23 + TC-7-TI-23 △ TC-6-TI-23 ⊙ TC-5-TI-23
4000
3000
2000
1000
0
TEMPERATURE, °F
30
32
34
36
38
40
42
44
TIME, SEC

AD-A055 886 SCIENCE APPLICATIONS INC EL SEGUNDO CALIF F/G 11/6
TITANIUM RESPONSE TO SIMULATED NUCLEAR CLOUD PARTICLE ENVIRONME--ETC(U)
AUG 77 L E DUNBAR, R M CLEVER, G H BURGHART DNA001-76-C-0366
UNCLASSIFIED SAI-78-561-LA-VOL-2 DNA-4404F-2 NL

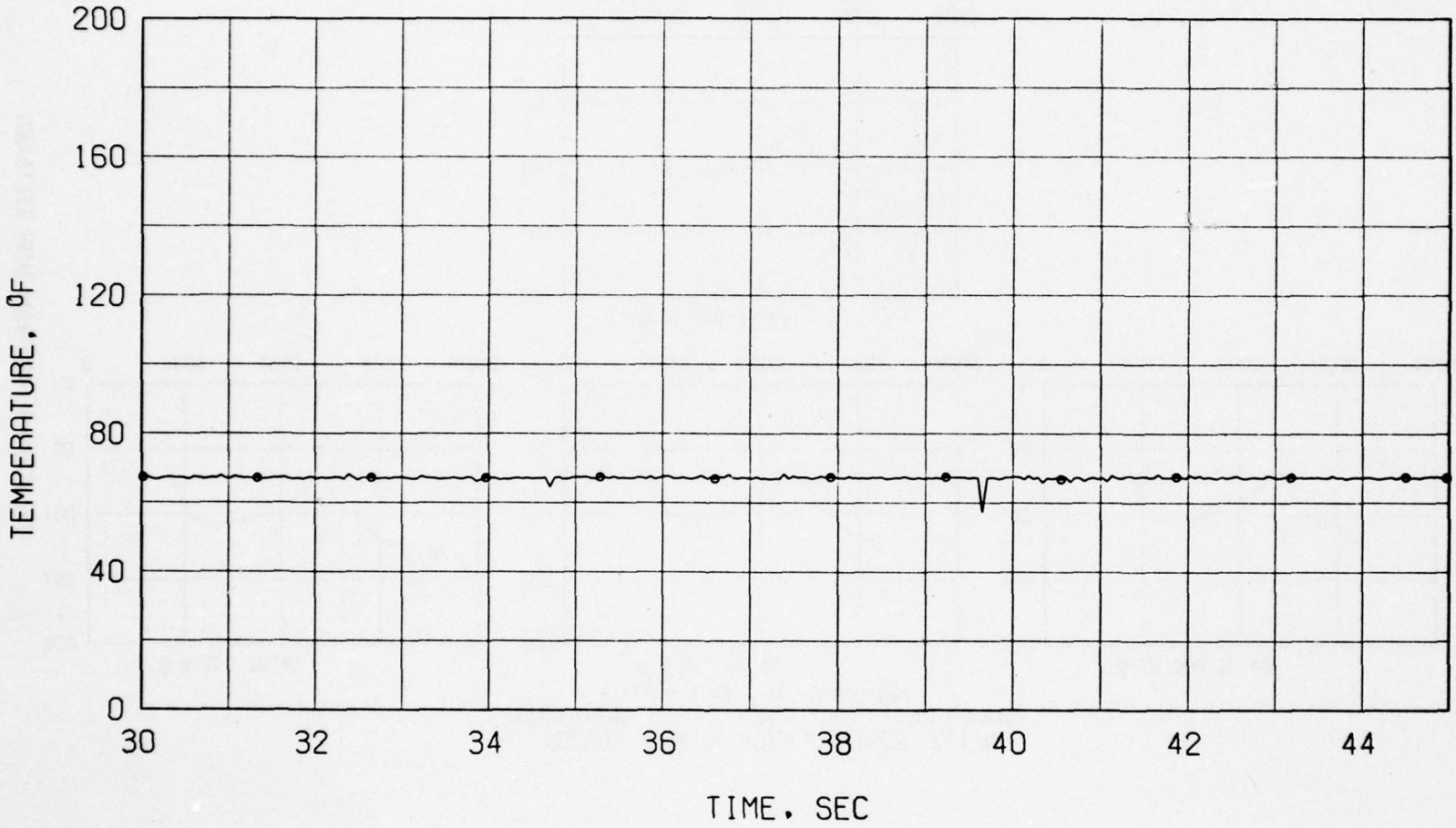
3 OF 4
ADA
055886



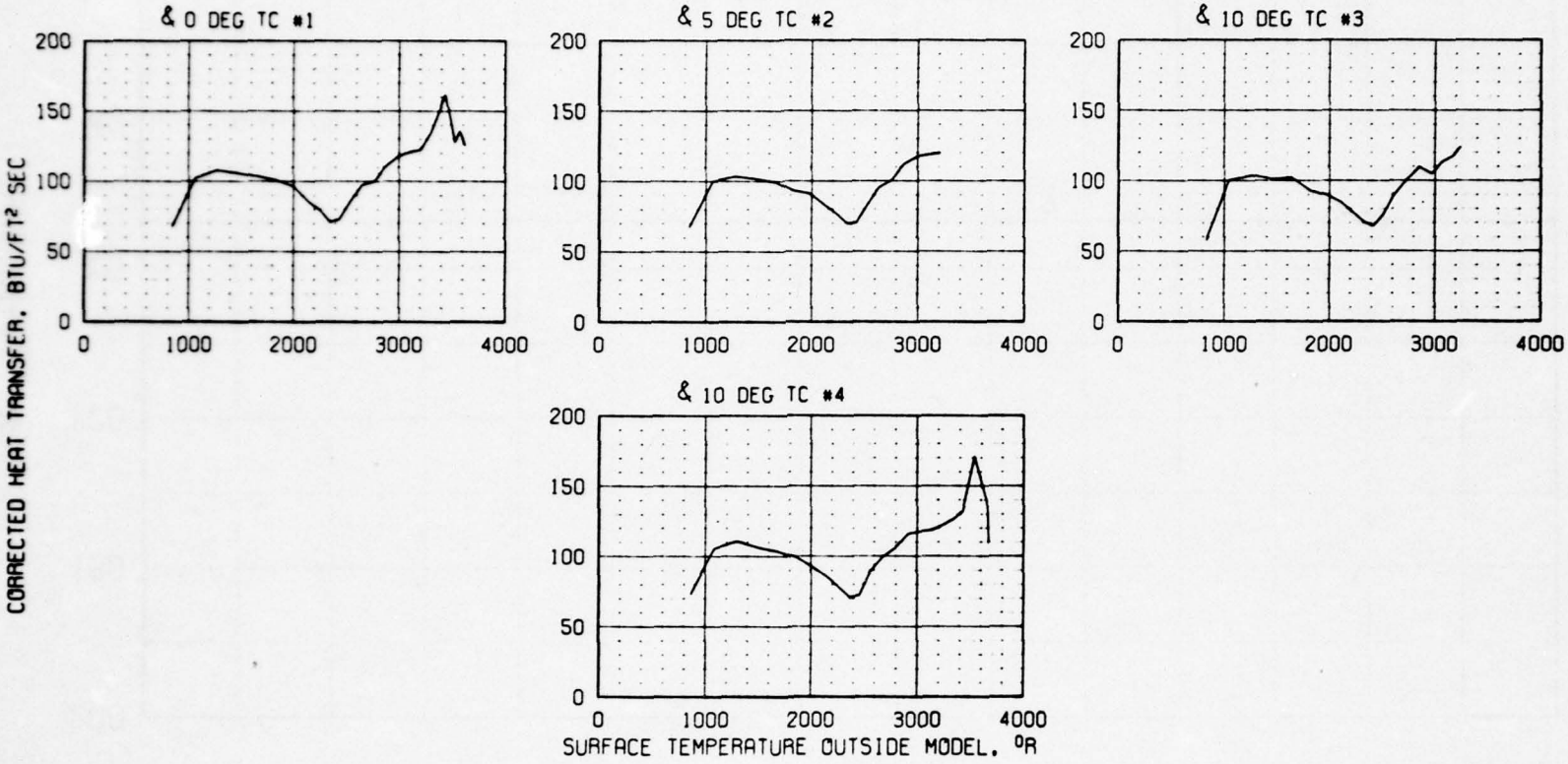
DATE 01-20-77 ARO INC
PROJ-P41E

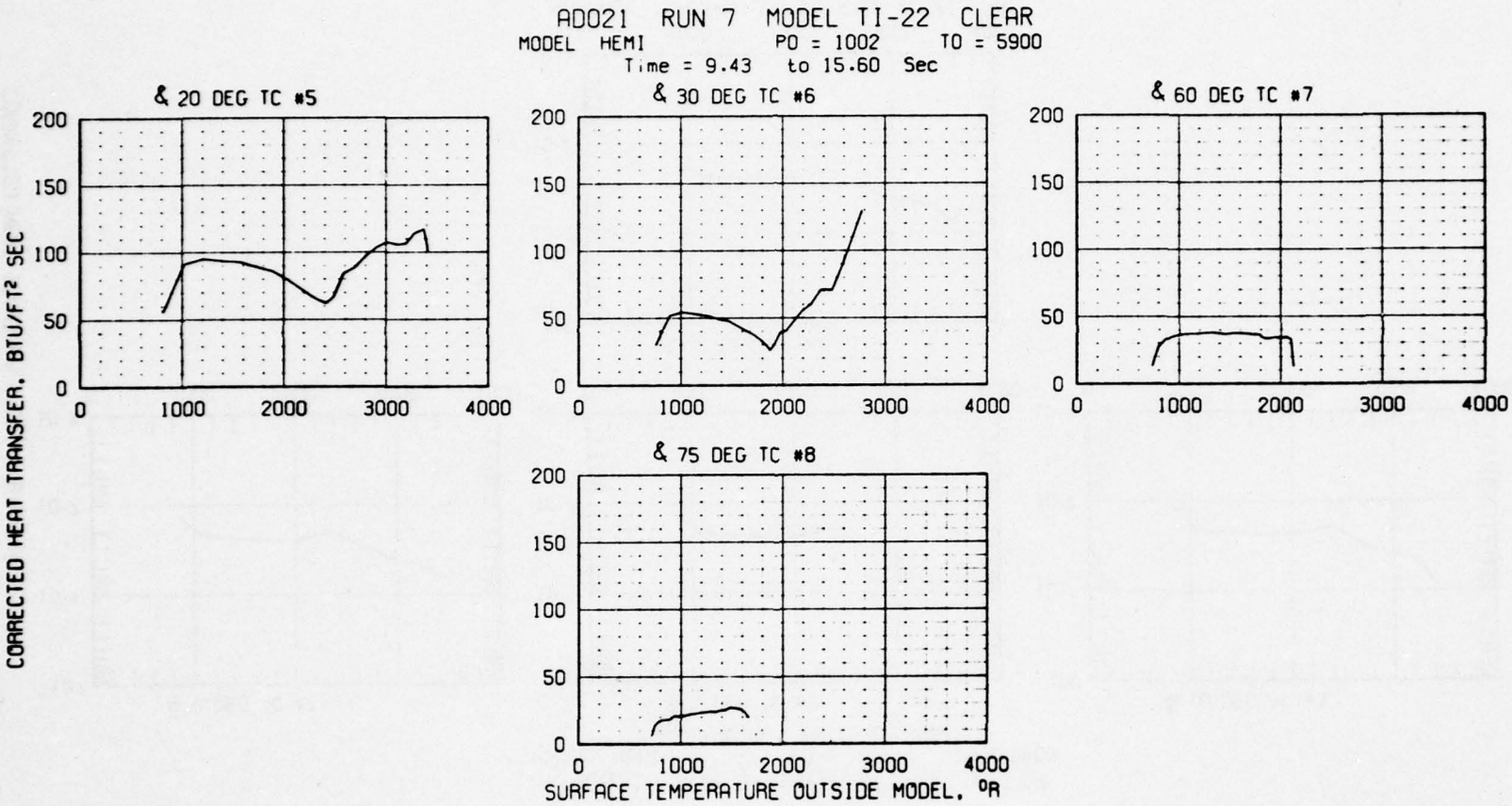
PROJECT P41E TEST A0021 DATE 01-14-77 SEL 2107

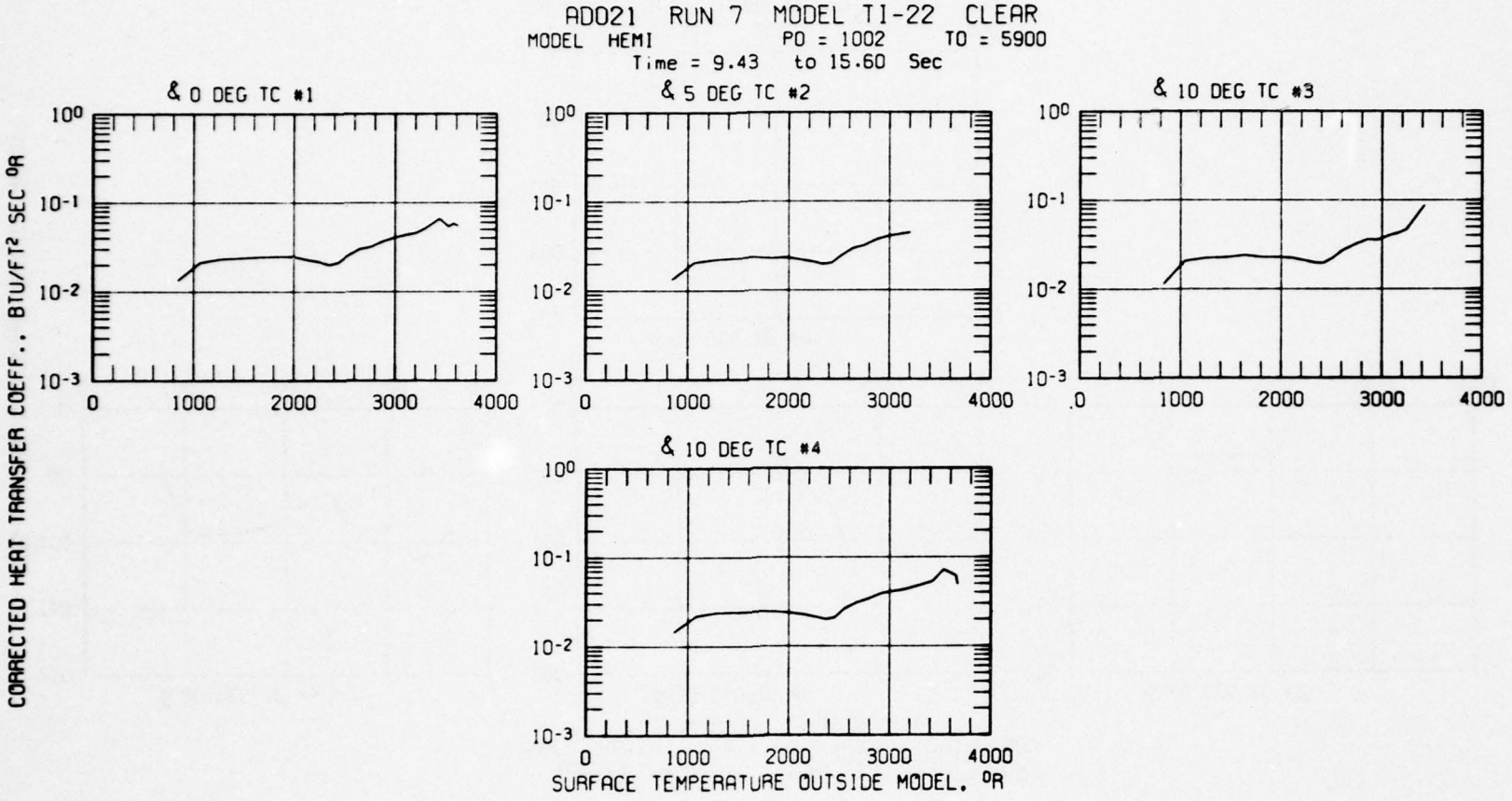
⊙ TC-9-T1-23

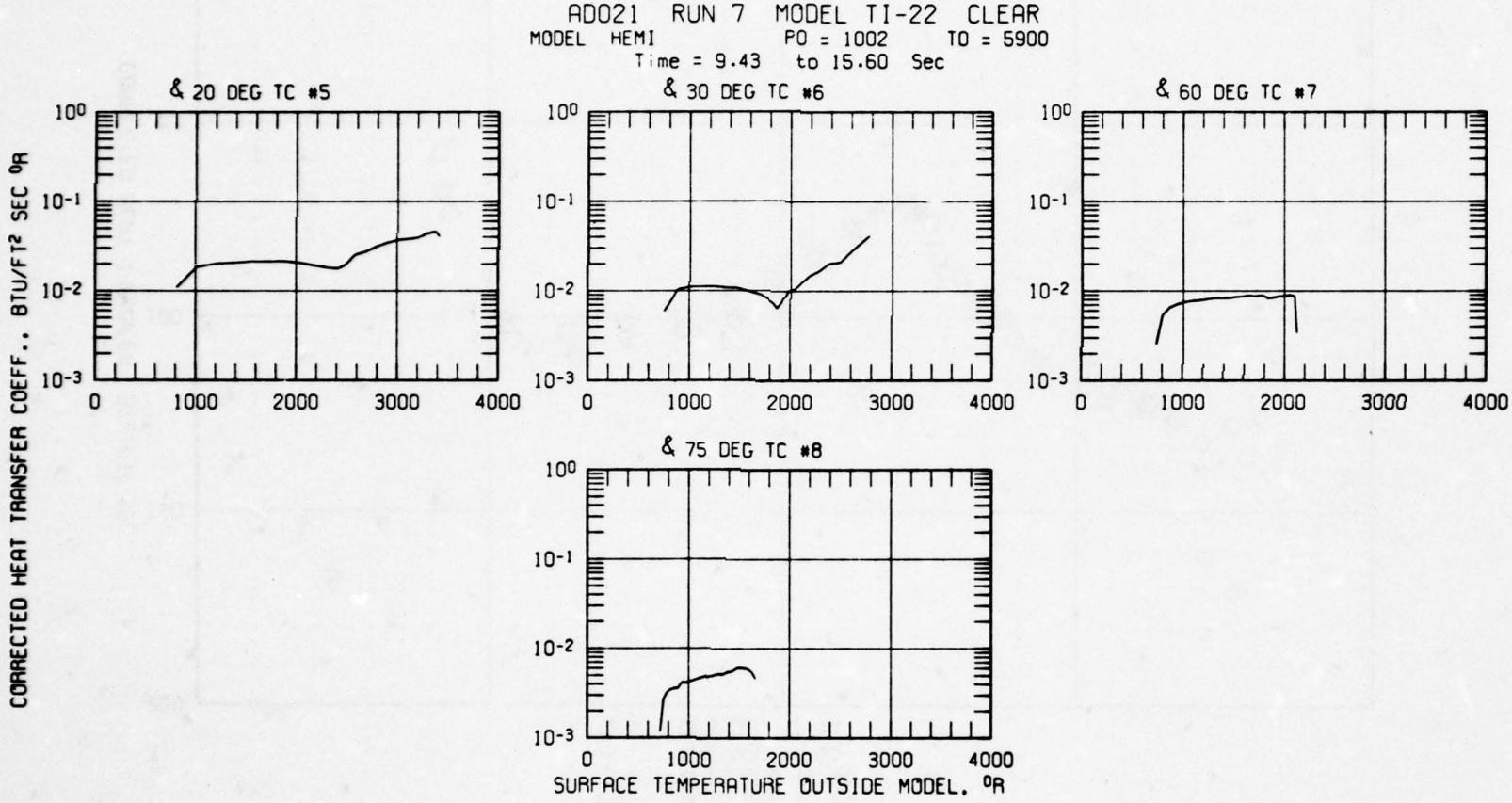


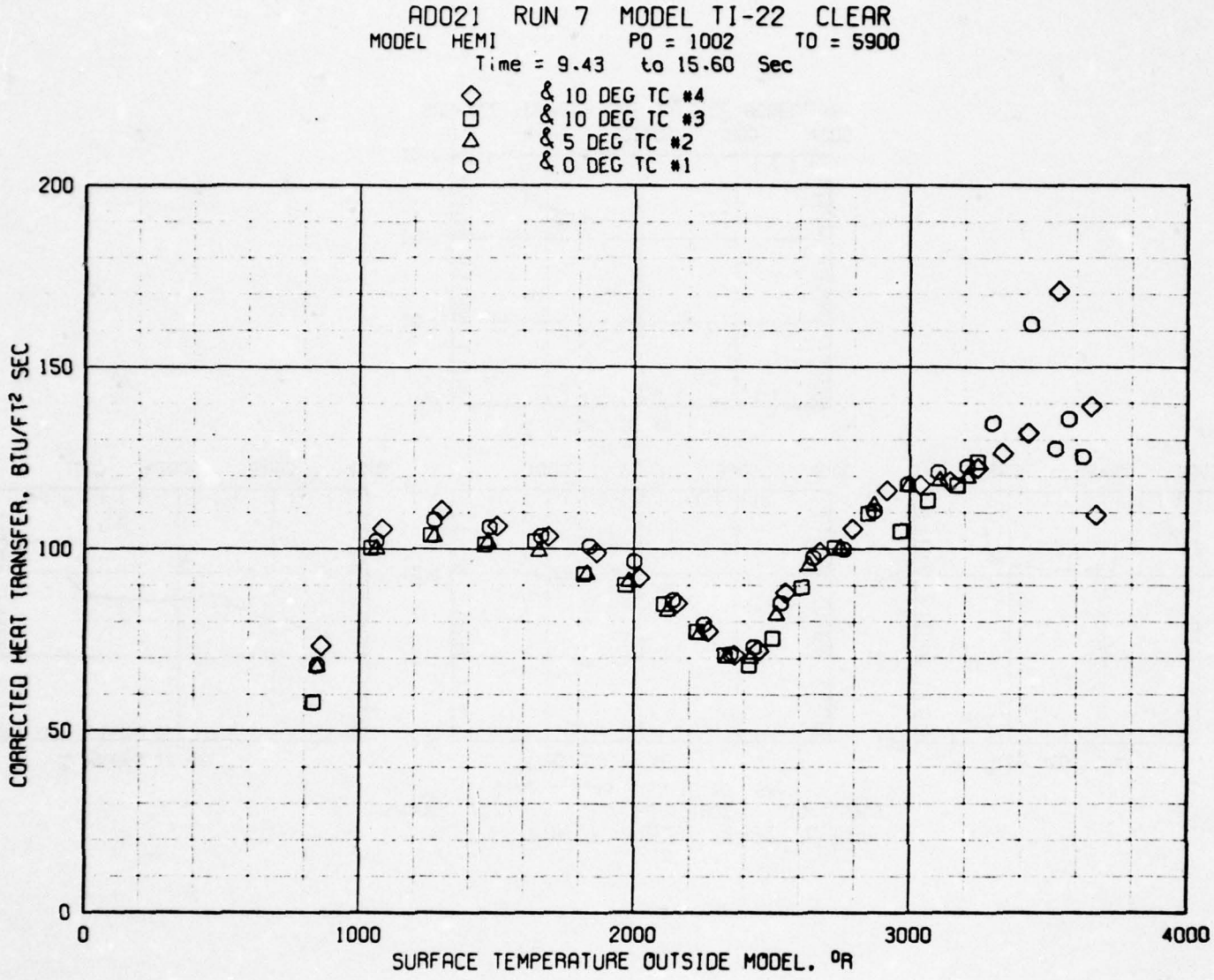
AD021 RUN 7 MODEL TI-22 CLEAR
MODEL HEMI PO = 1002 TO = 5900
Time = 9.43 to 15.60 Sec

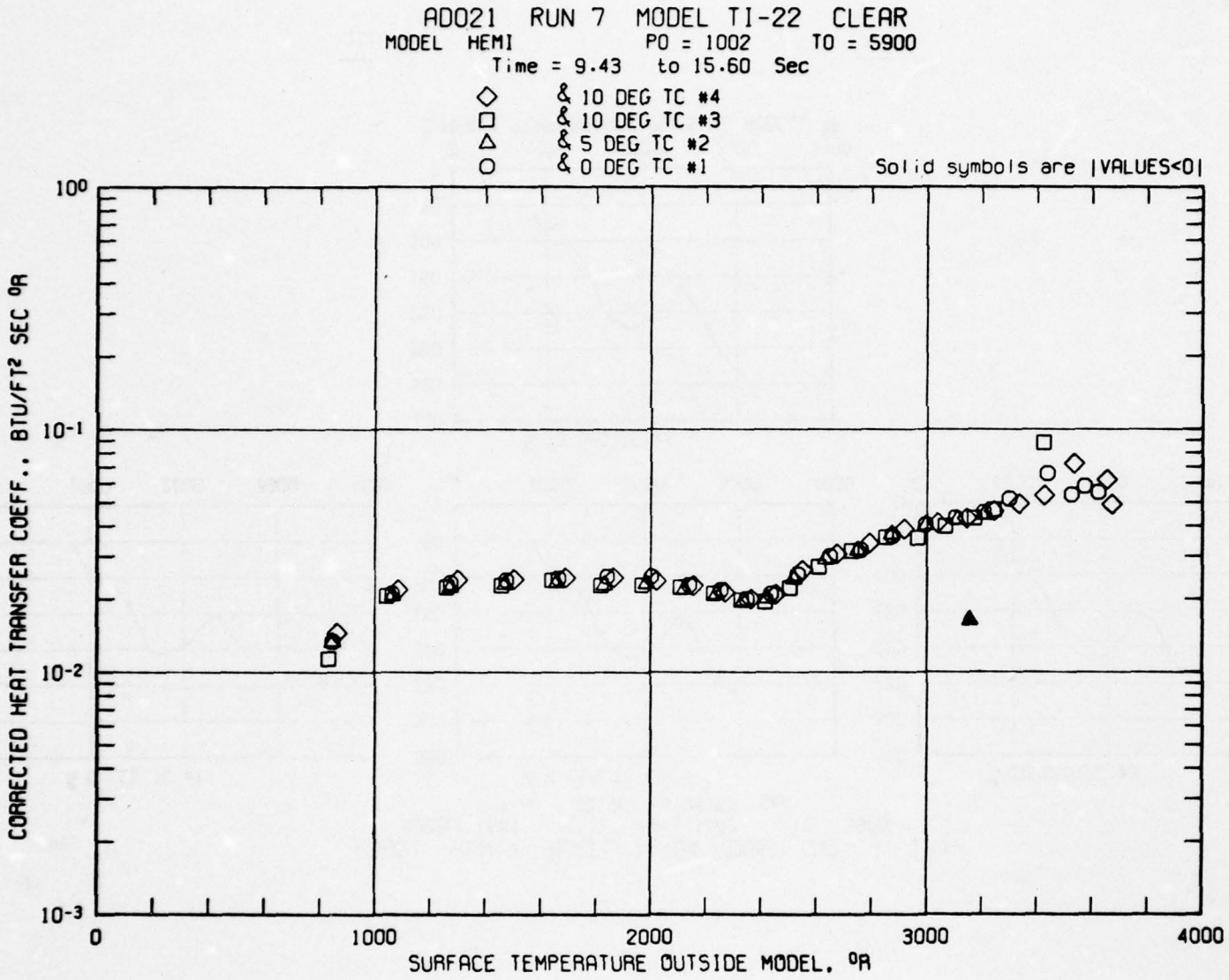


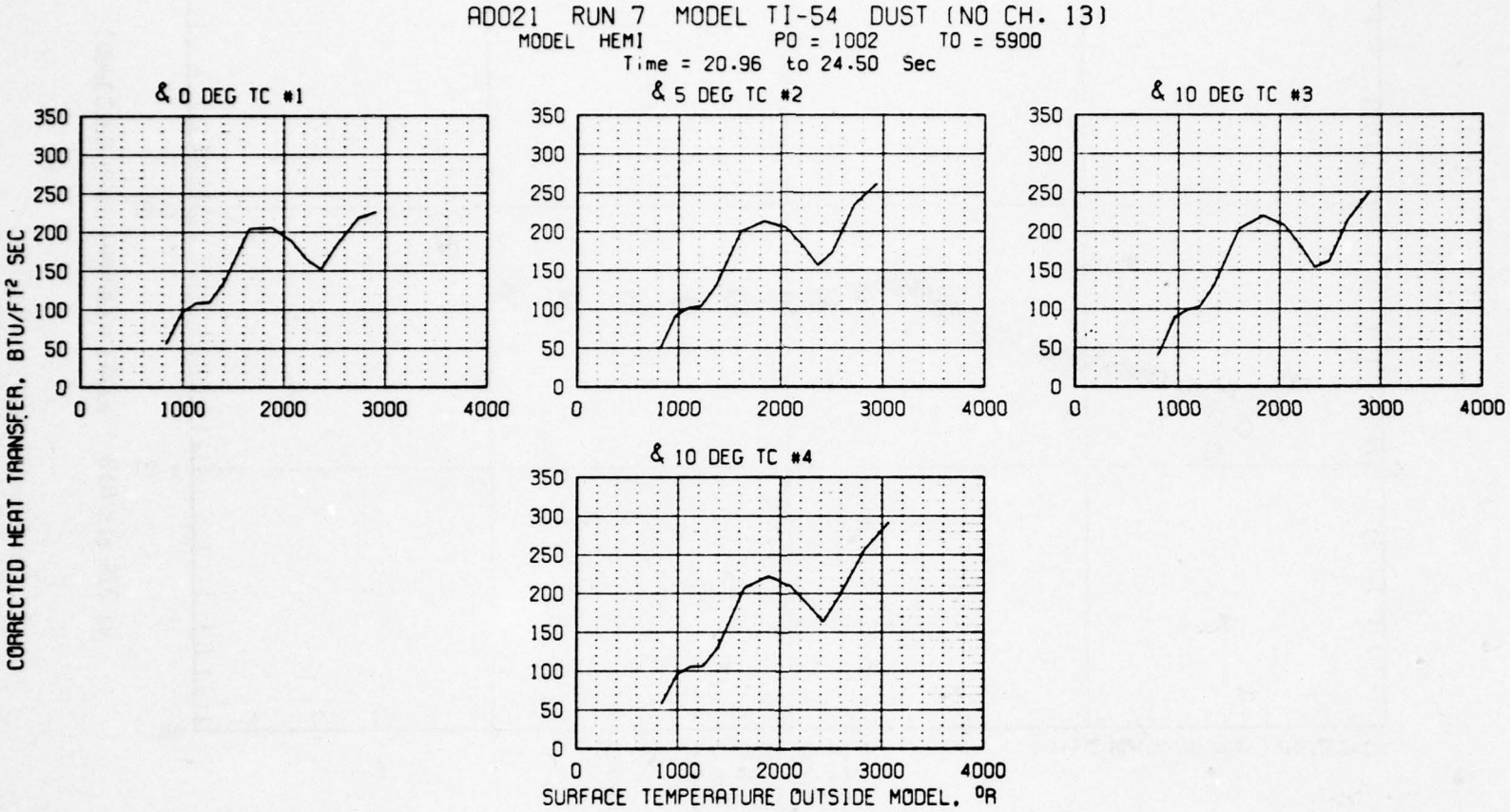

AD021 RUN 7 MODEL TI-22 CLEAR
MODEL HEMI PO = 1002 TO = 5900
Time = 9.43 to 15.60 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
1000
2000
3000
4000

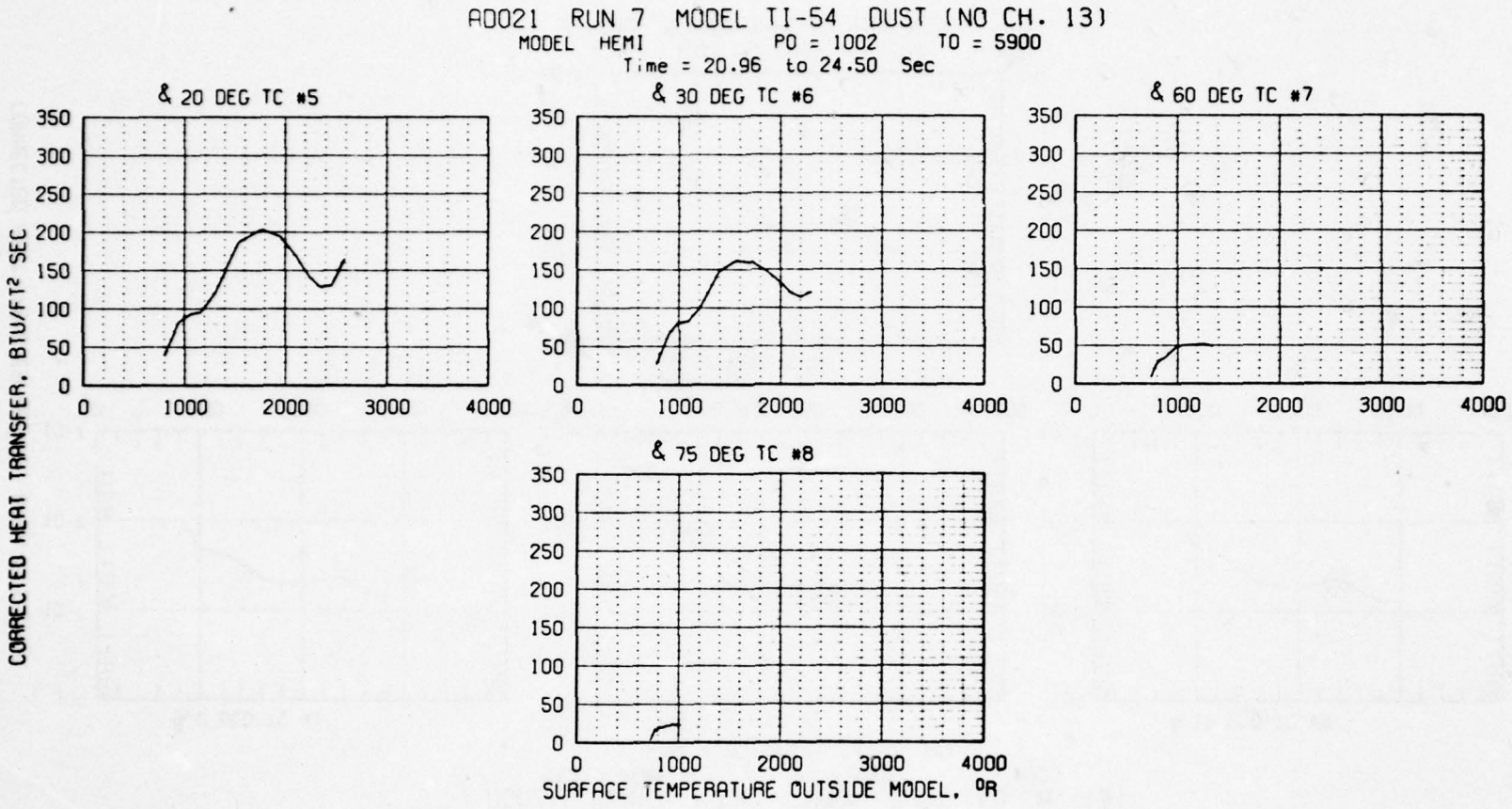

AD021 RUN 7 MODEL TI-22 CLEAR
MODEL HEMI PO = 1002 TO = 5900
Time = 9.43 to 15.60 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000

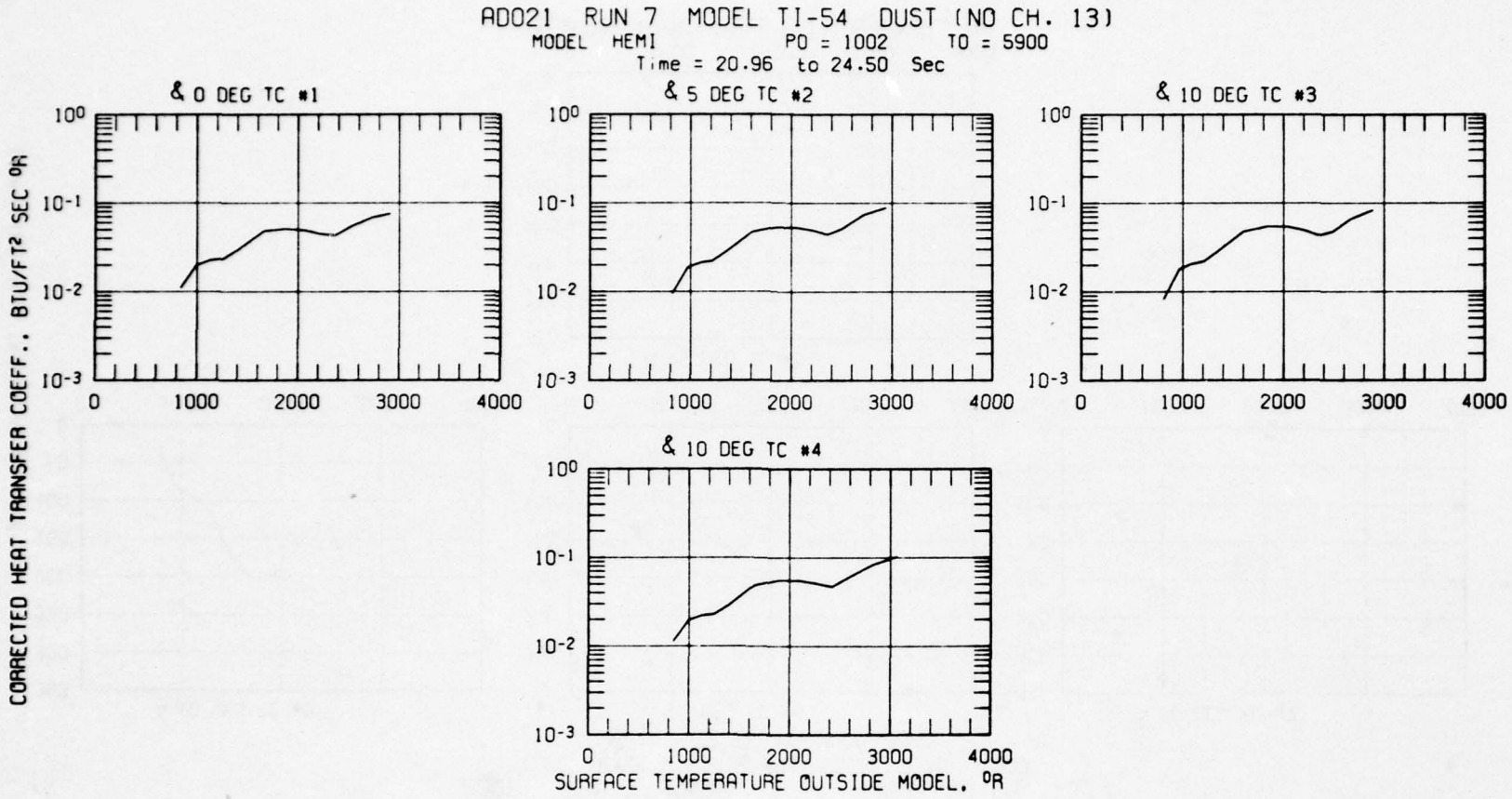

AD021 RUN 7 MODEL TI-22 CLEAR
MODEL HEMI PO = 1002 TO = 5900
Time = 9.43 to 15.60 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000

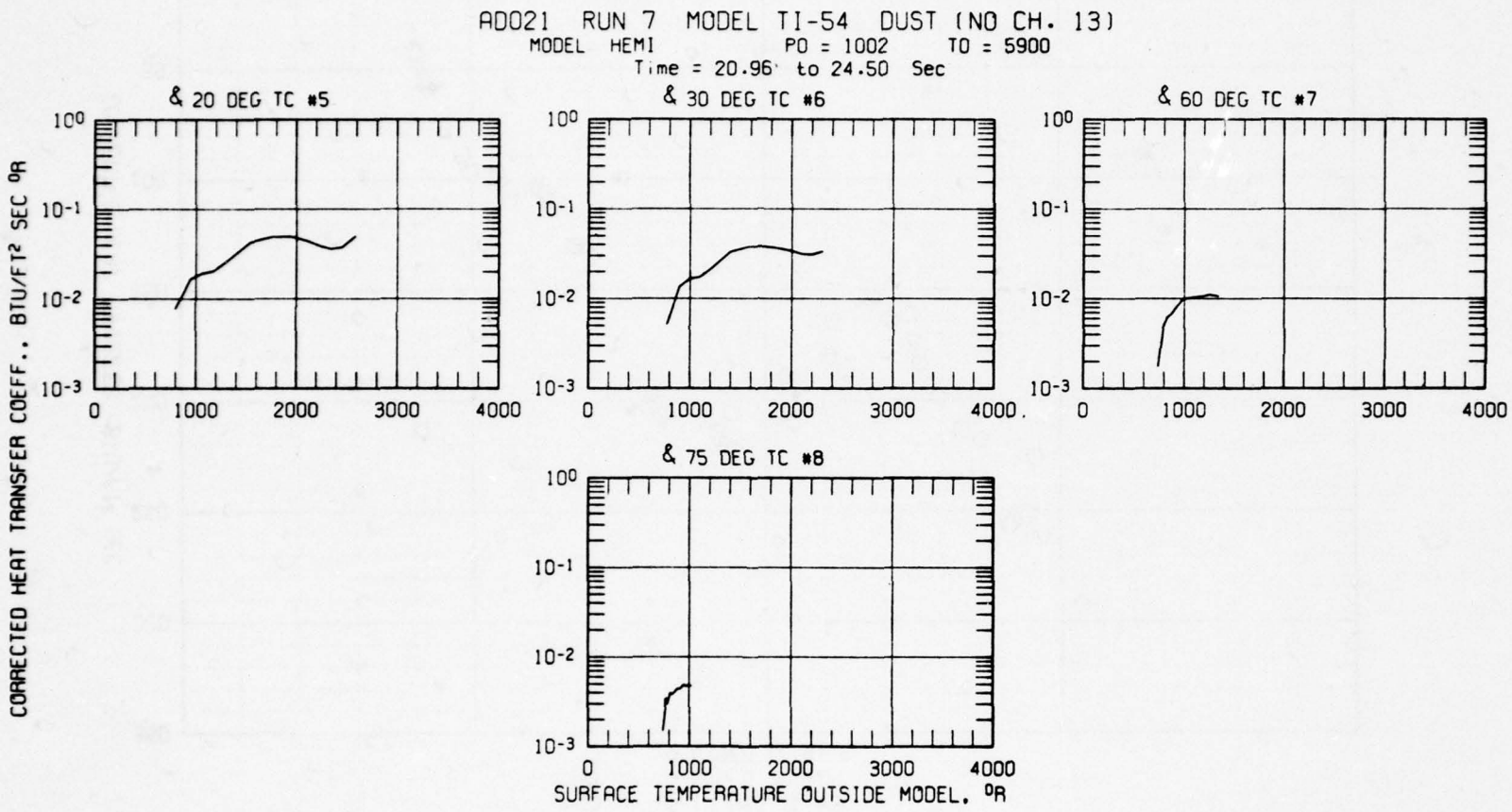

AD021 RUN 7 MODEL TI-22 CLEAR
MODEL HEMI
PO = 1002
TO = 5900
Time = 9.43 to 15.60 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
200
150
100
50
0
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

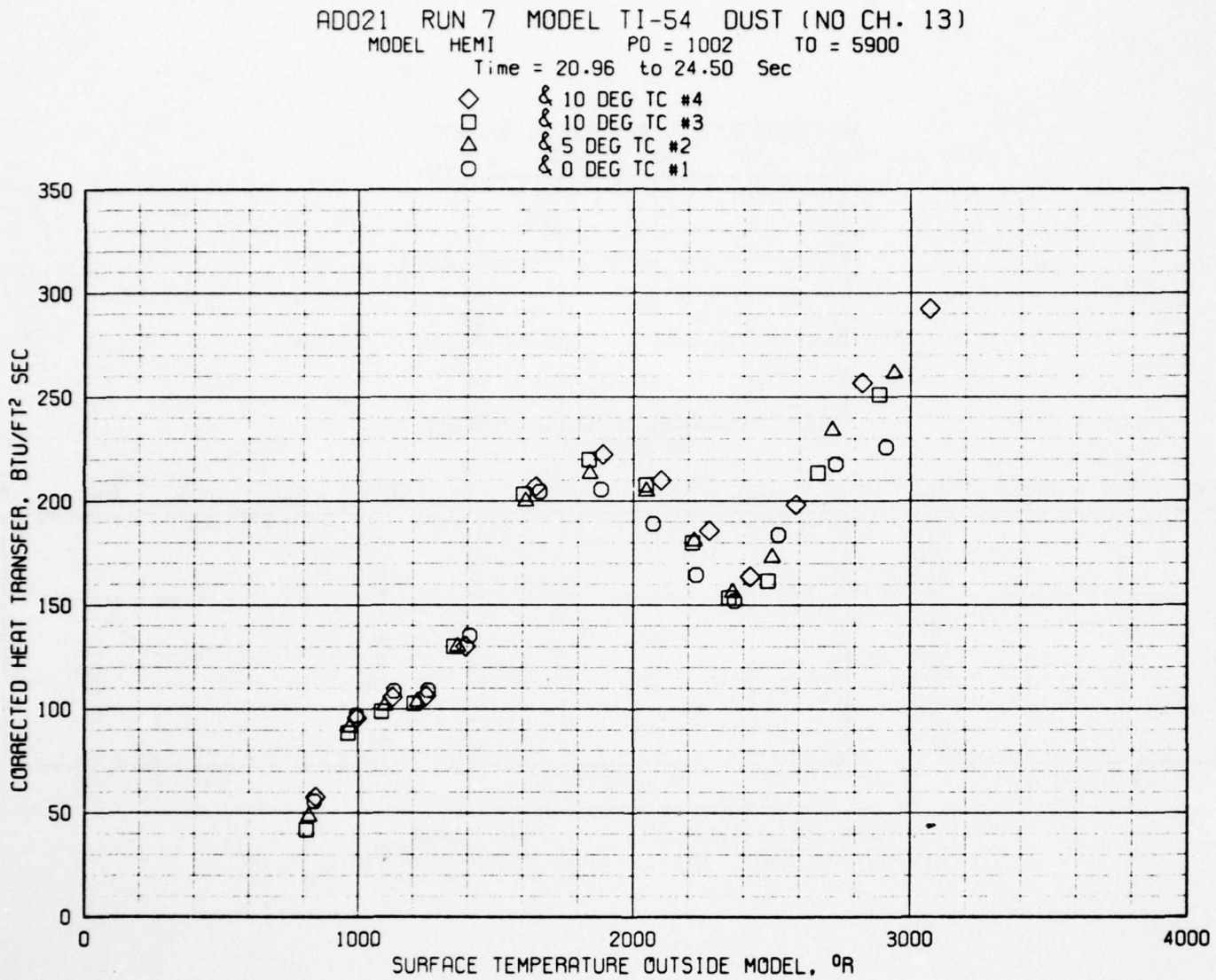

AD021 RUN 7 MODEL TI-22 CLEAR
MODEL HEMI PO = 1002 TO = 5900
Time = 9.43 to 15.60 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

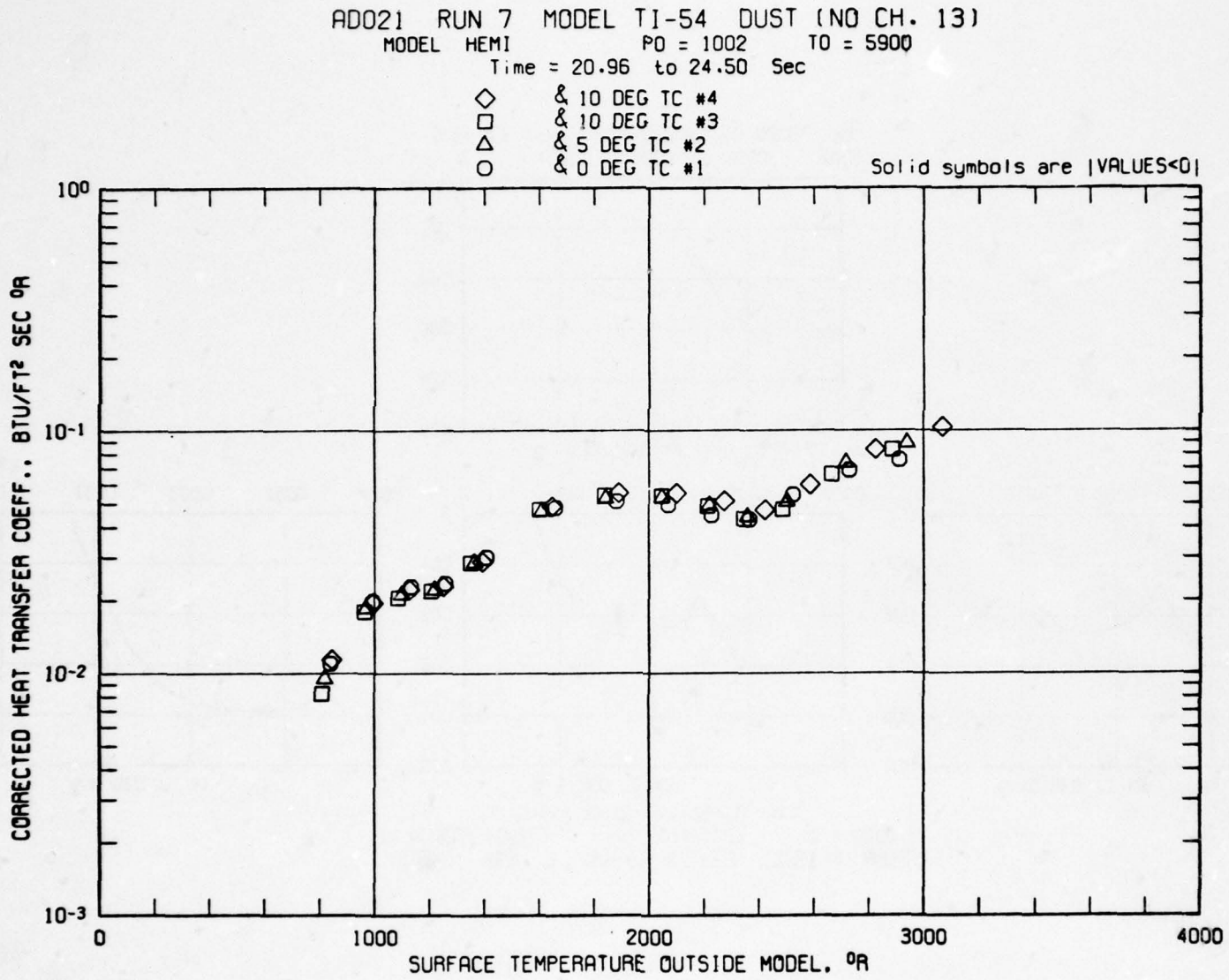

AD021 RUN 7 MODEL TI-54 DUST (NO CH. 13)
MODEL HEMI PO = 1002 TO = 5900
Time = 20.96 to 24.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
350
1000
2000
3000
4000

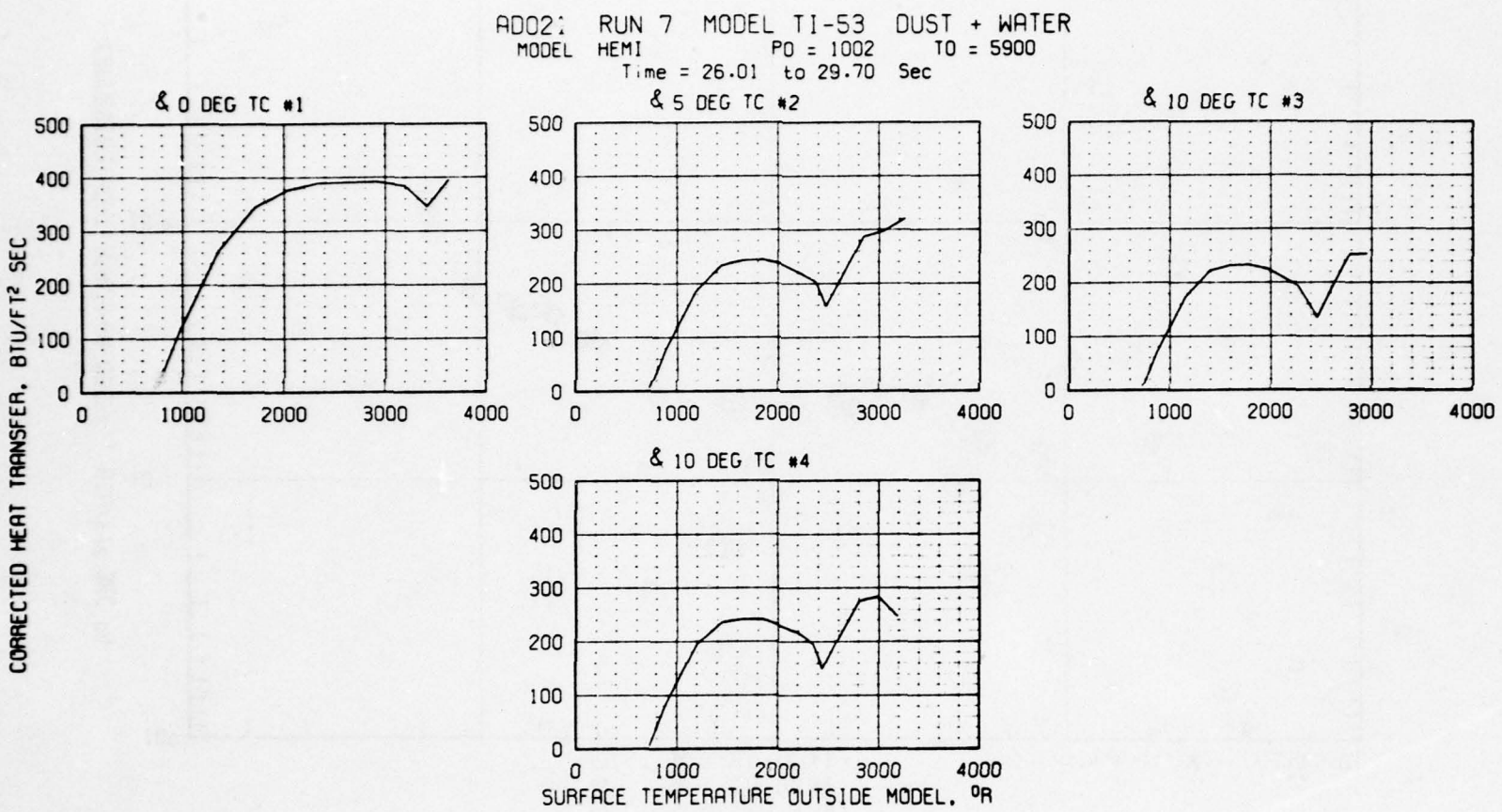

A0021 RUN 7 MODEL TI-54 DUST (NO CH. 13)
MODEL HEMI
P0 = 1002
T0 = 5900
Time = 20.96 to 24.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
350
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-54 DUST (NO CH. 13)
MODEL HEMI PO = 1002 TO = 5900
Time = 20.96 to 24.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-54 DUST (NO CH. 13)
MODEL HEMI PO = 1002 TO = 5900
Time = 20.96 to 24.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-54 DUST (NO CH. 13)
MODEL HEMI
PO = 1002
TO = 5900
Time = 20.96 to 24.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
350
300
250
200
150
100
50
0
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

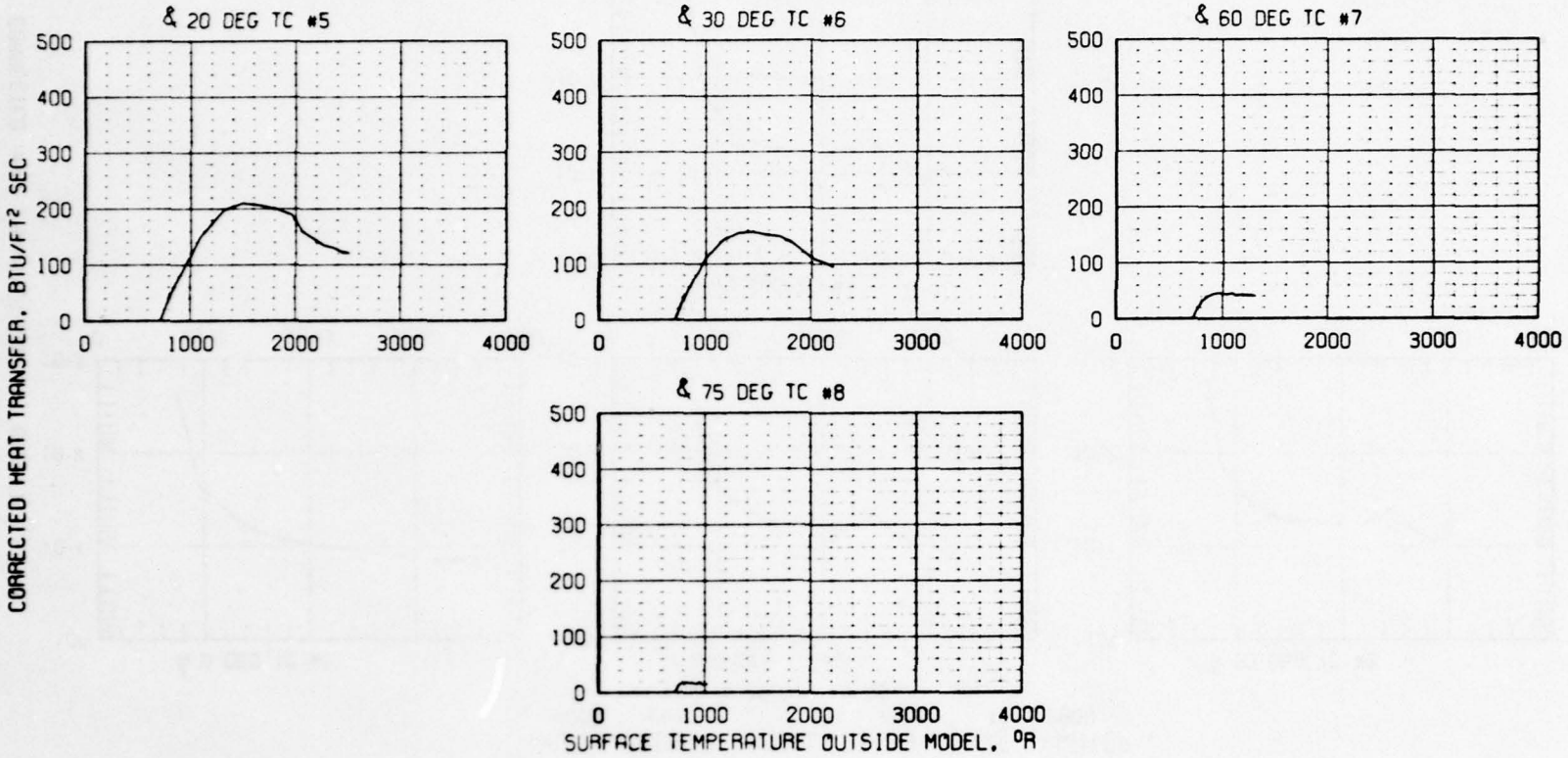

AD021 RUN 7 MODEL TI-54 DUST (NO CH. 13)
MODEL HEMI PO = 1002 TO = 5900
Time = 20.96 to 24.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

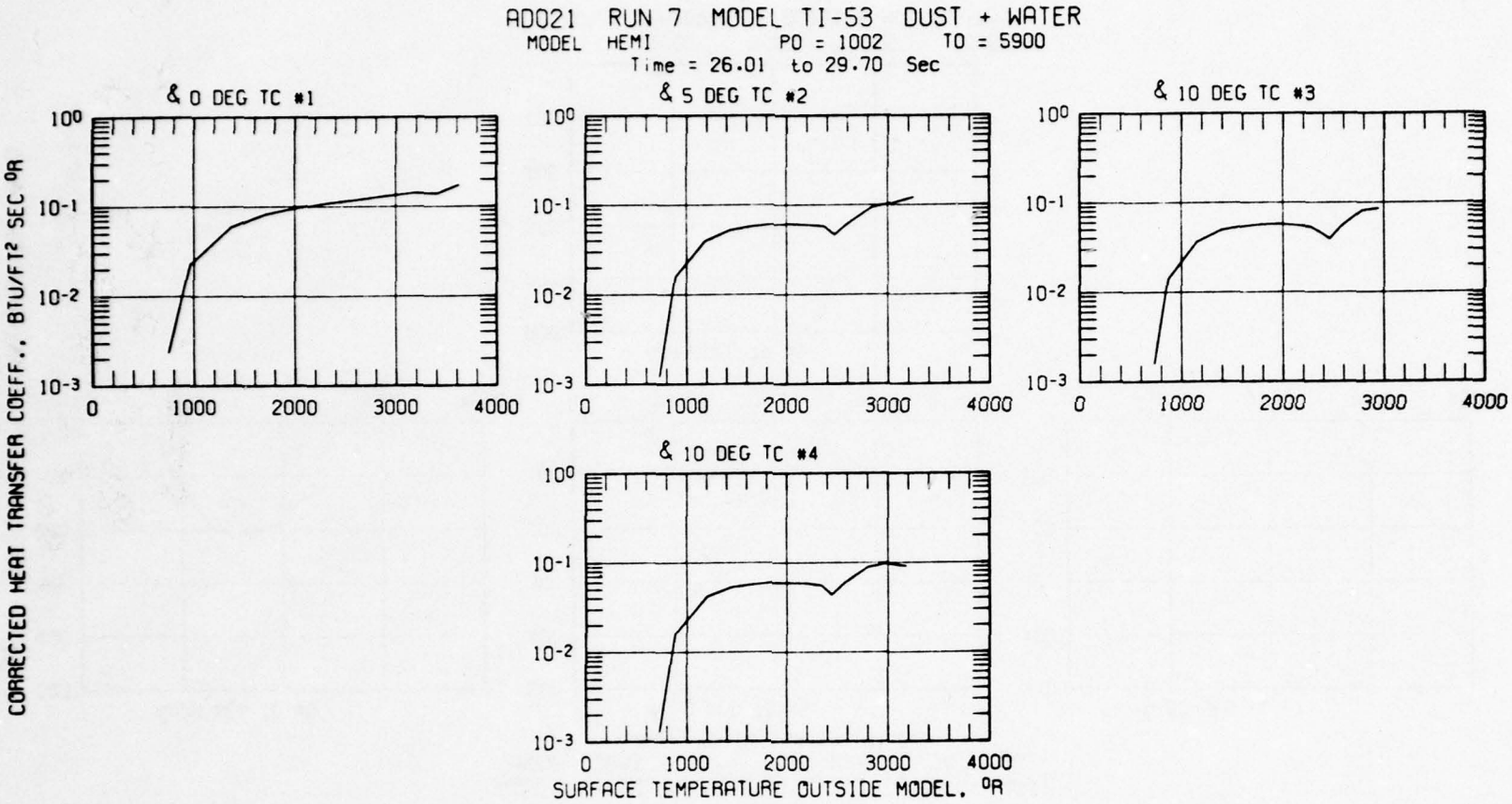

AD02: RUN 7 MODEL TI-53 DUST + WATER
MODEL HEMI P0 = 1002 T0 = 5900
Time = 26.01 to 29.70 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
100
200
300
400
500
1000
2000
3000
4000

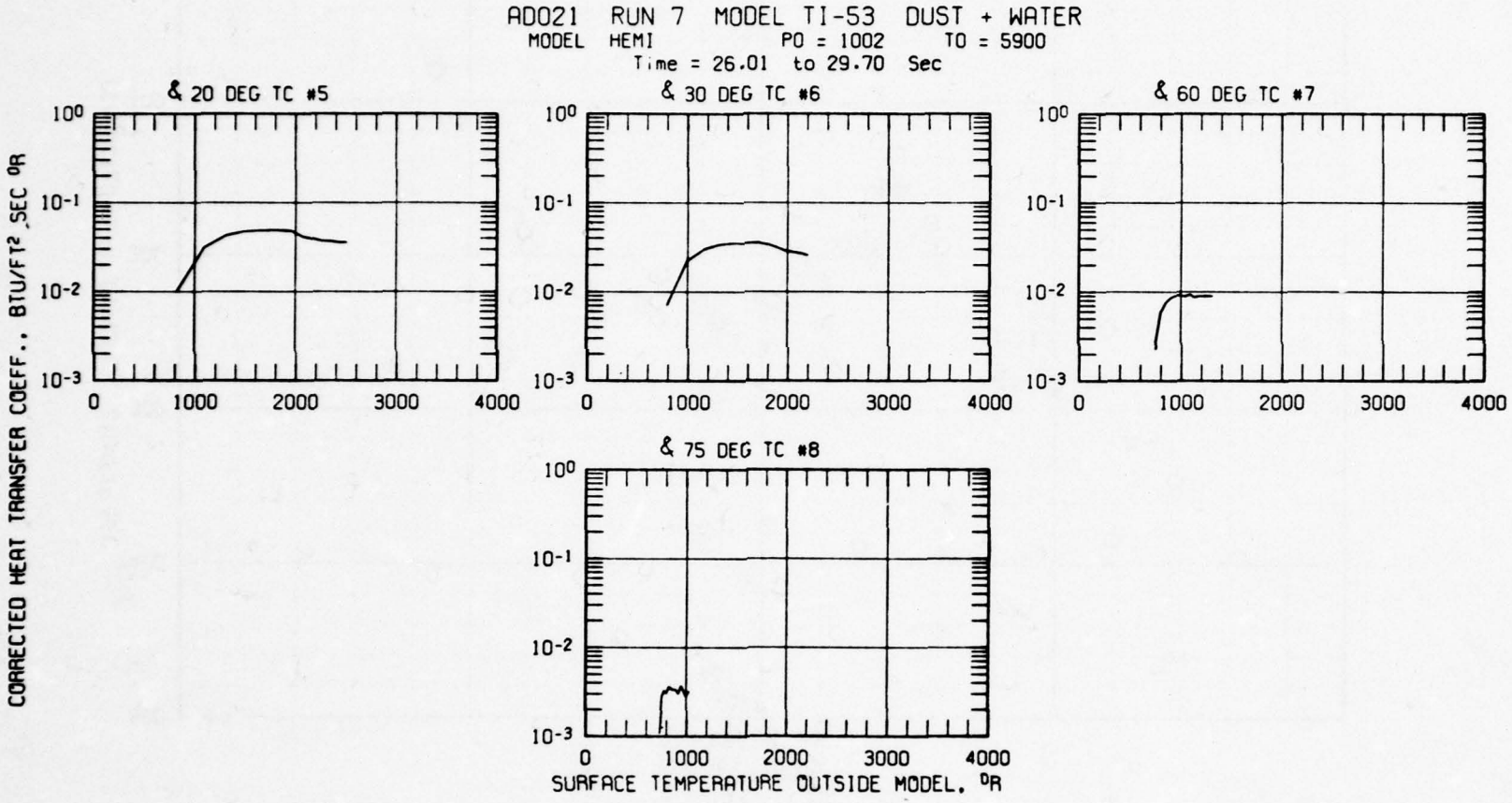
AD021 RUN 7 MODEL TI-53 DUST + WATER

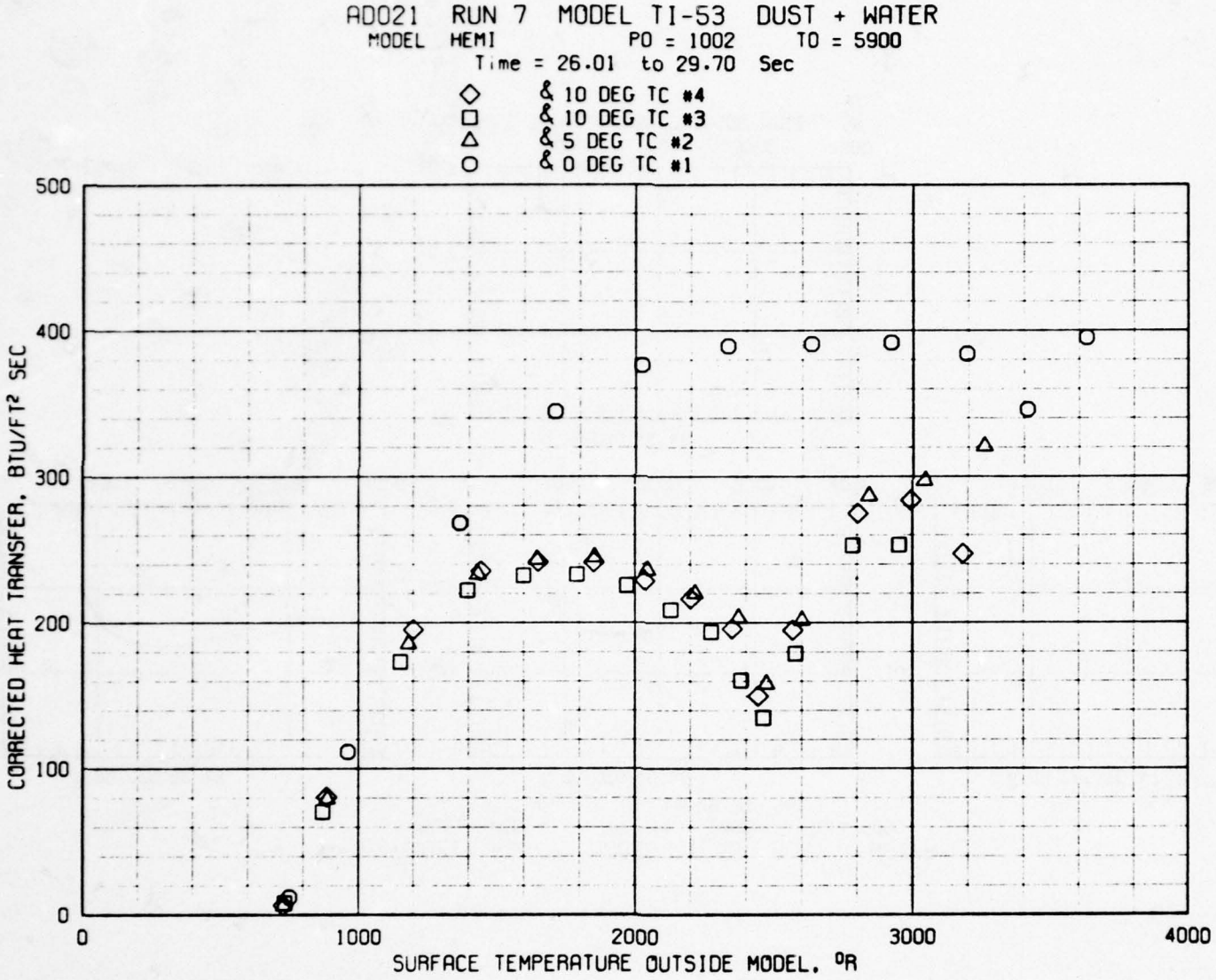
MODEL HEMI P0 = 1002 T0 = 5900

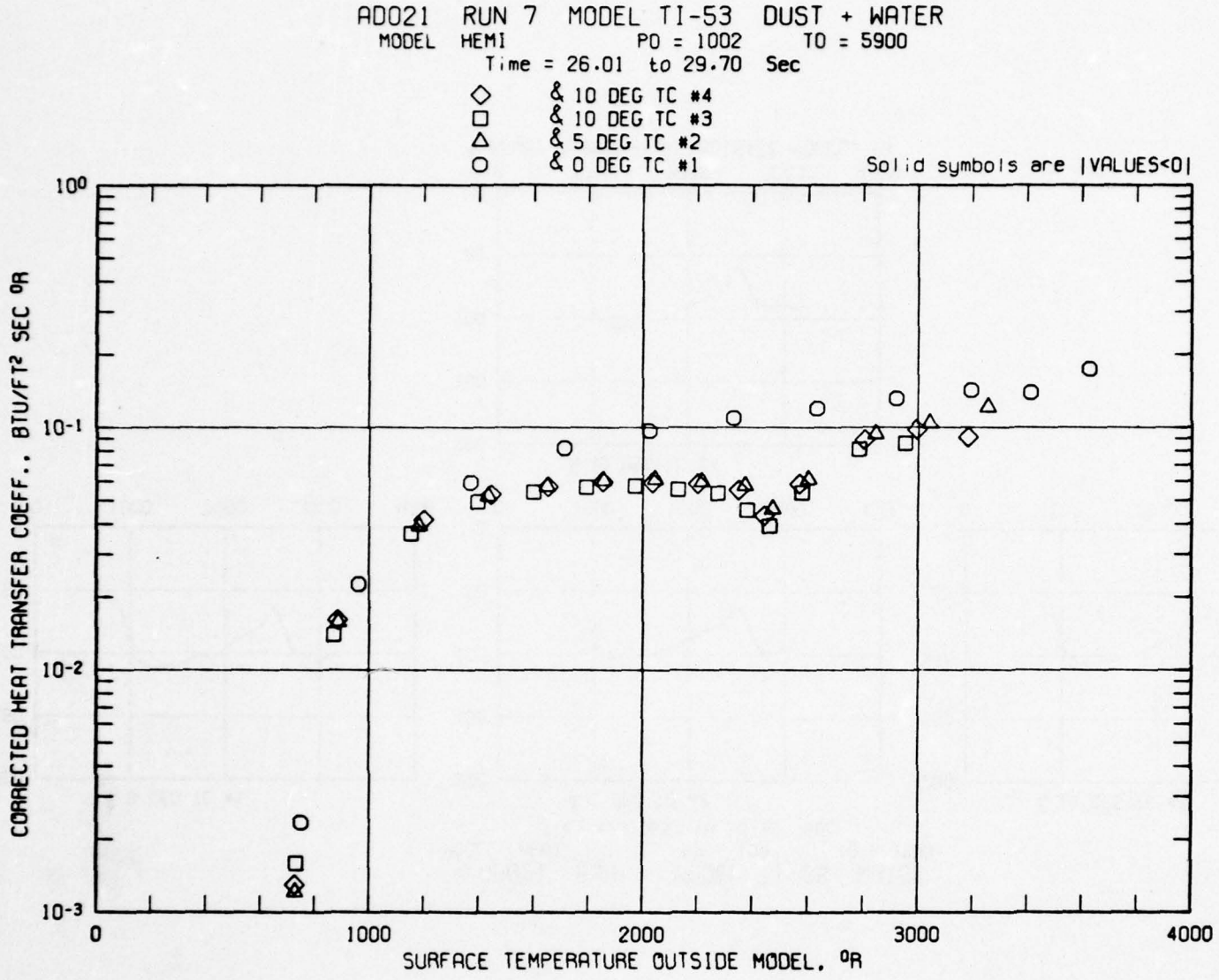
Time = 26.01 to 29.70 Sec

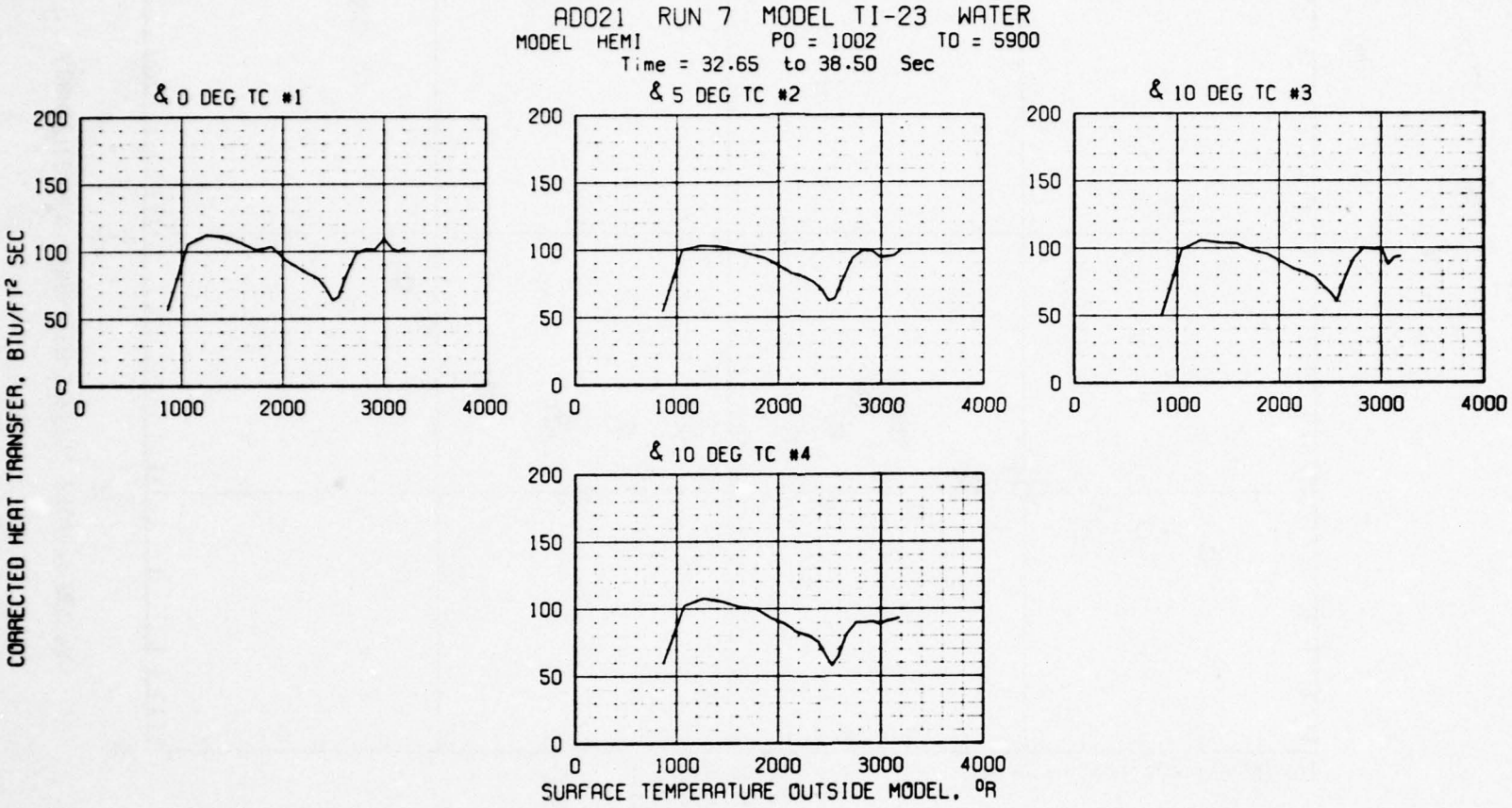


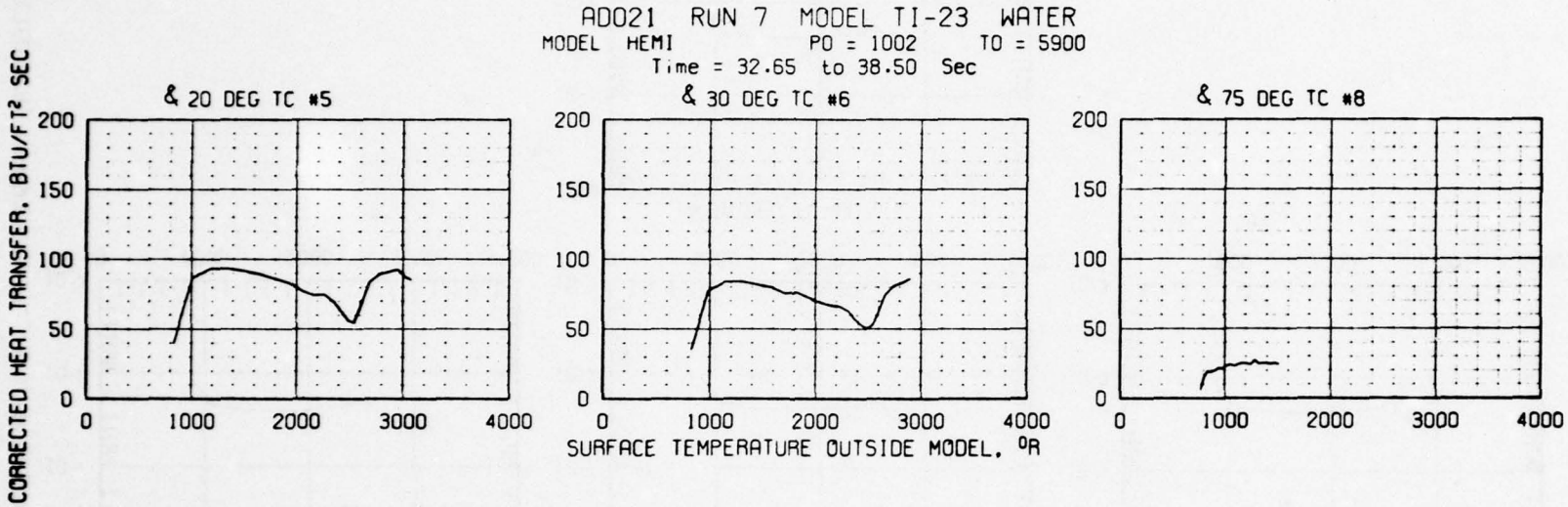

AD021 RUN 7 MODEL TI-53 DUST + WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 26.01 to 29.70 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000

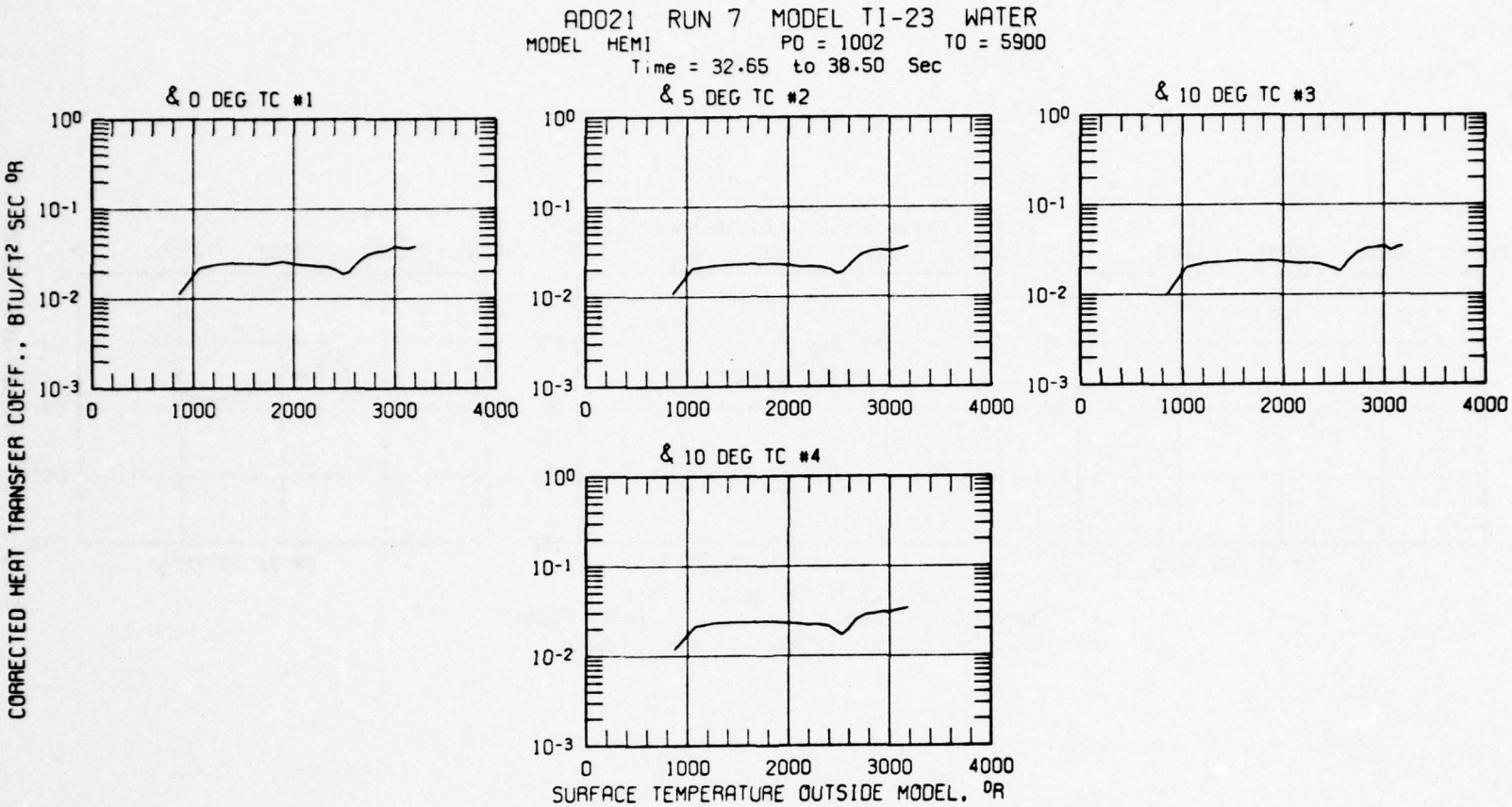

AD021 RUN 7 MODEL TI-53 DUST + WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 26.01 to 29.70 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT²_SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10-1
10-2
10-3
0
1000
2000
3000
4000

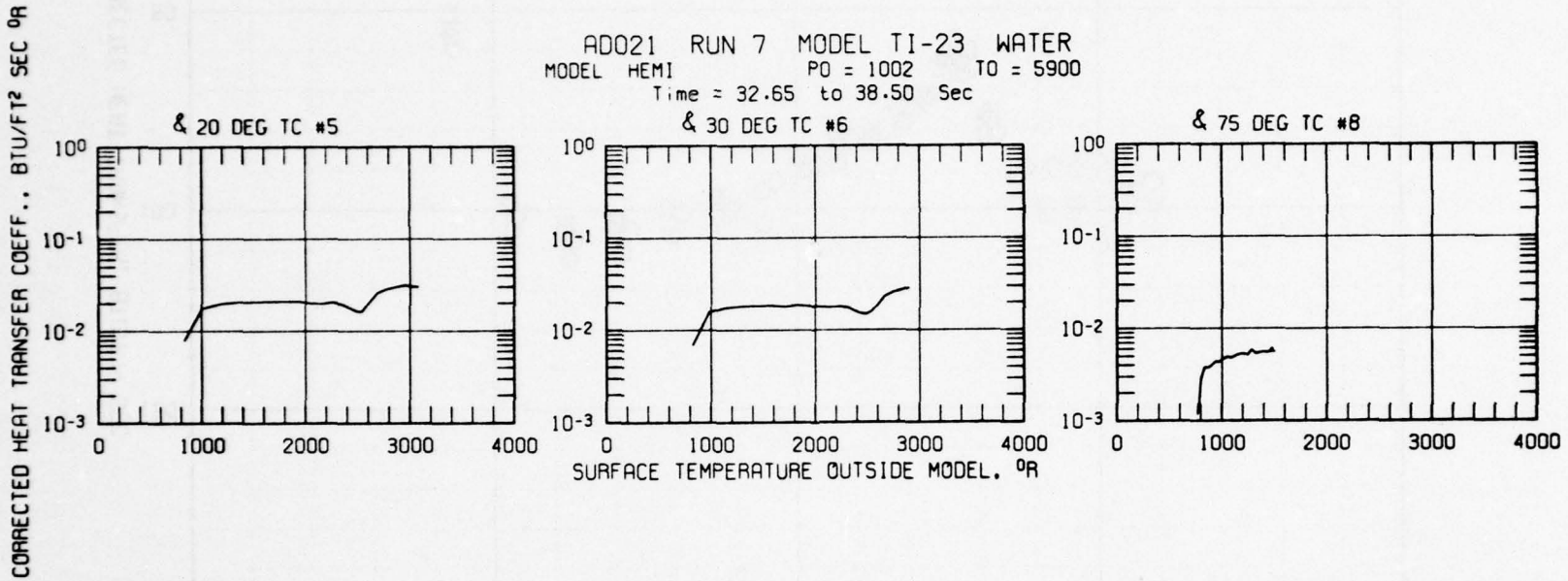

AD021 RUN 7 MODEL TI-53 DUST + WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 26.01 to 29.70 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
0
100
200
300
400
500
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

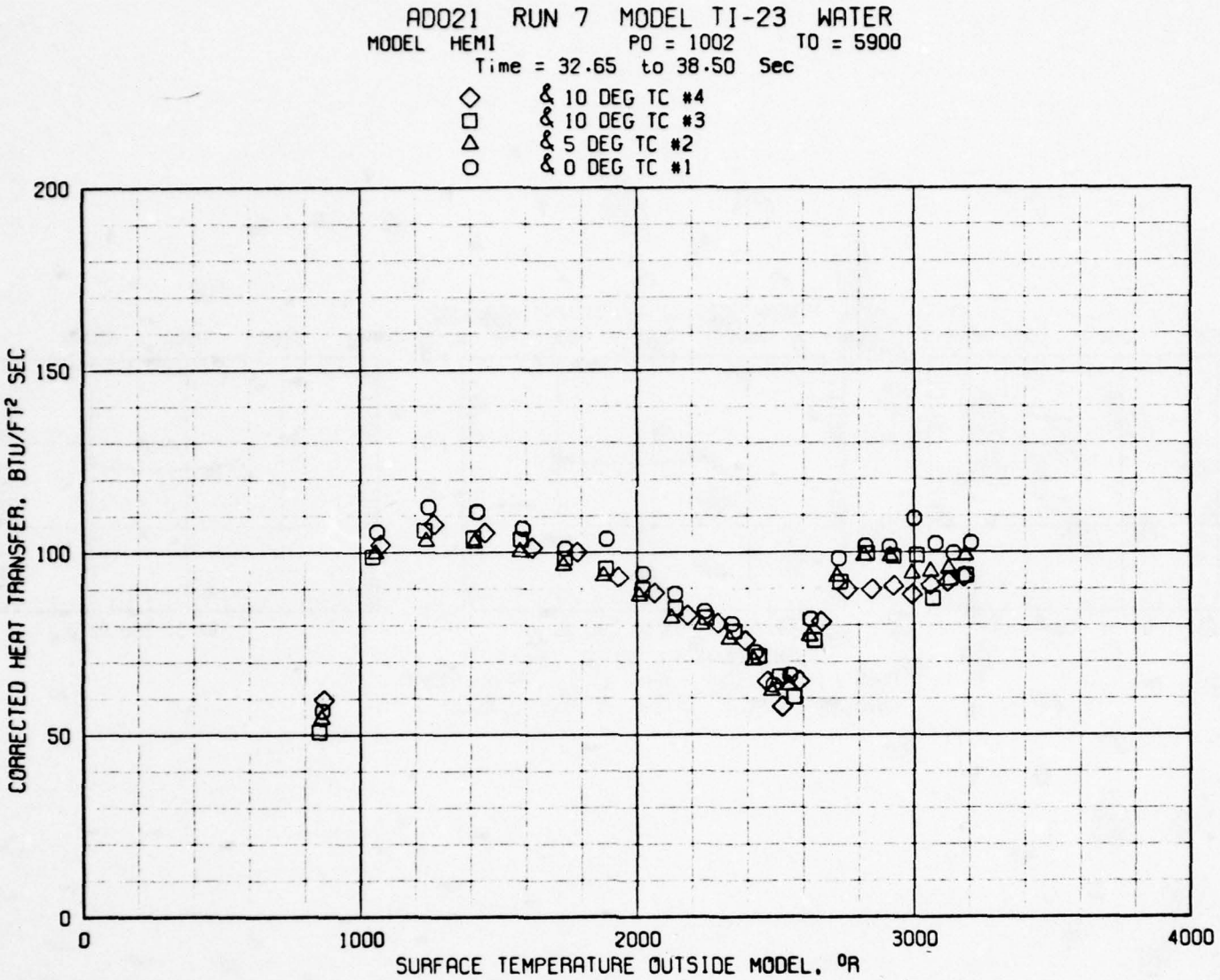

AD021 RUN 7 MODEL TI-53 DUST + WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 26.01 to 29.70 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10-1
10-2
10-3
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R


AD021 RUN 7 MODEL TI-23 WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 32.65 to 38.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-23 WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 32.65 to 38.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-23 WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 32.65 to 38.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-23 WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 32.65 to 38.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000


AD021 RUN 7 MODEL TI-23 WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 32.65 to 38.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
200
150
100
50
0
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

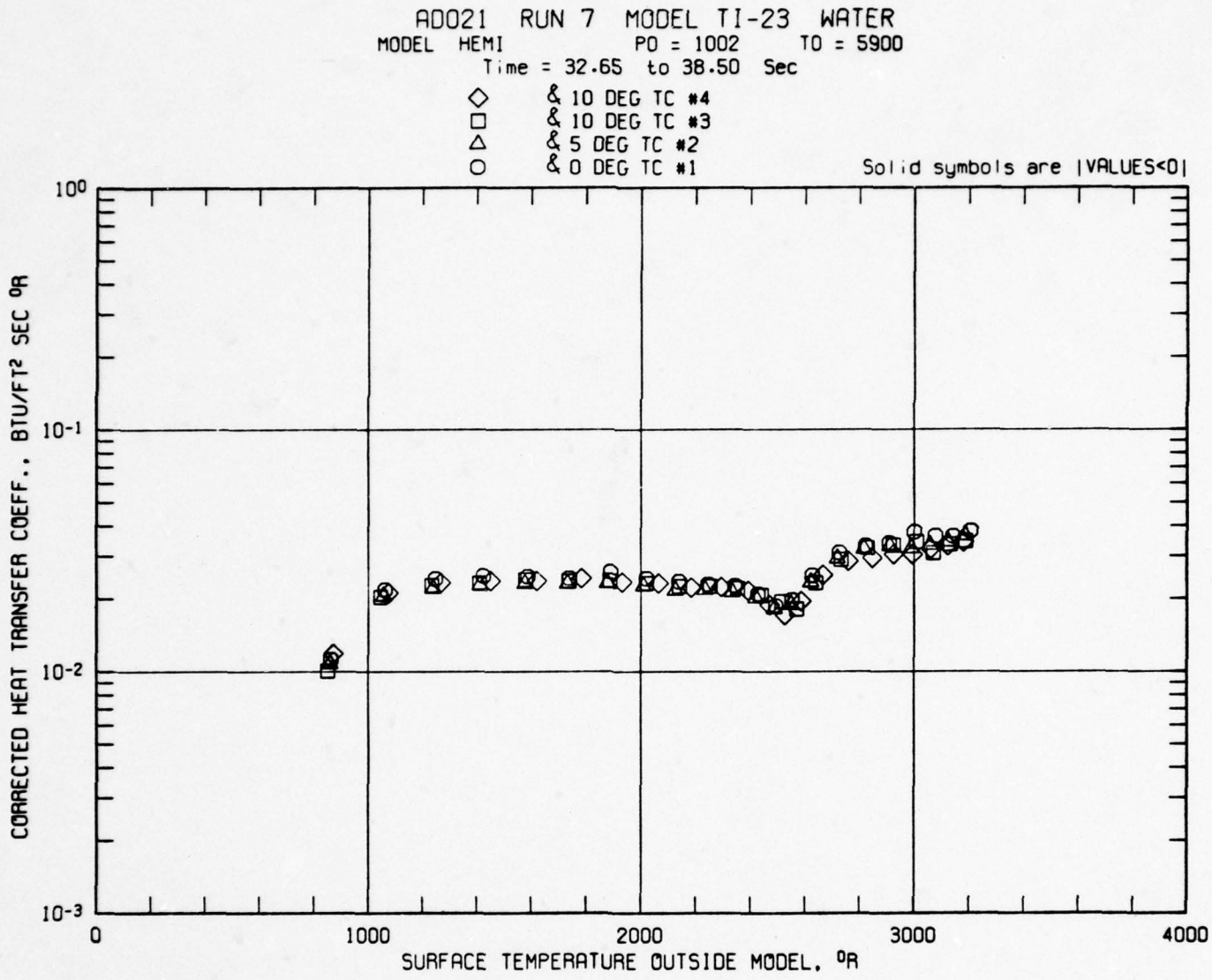

AD021 RUN 7 MODEL TI-23 WATER
MODEL HEMI PO = 1002 TO = 5900
Time = 32.65 to 38.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
1000
2000
3000
4000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

TABLE 1 RUN SUMMARY

TUNNEL CONDITIONS

RUN 8 DATE 1-21-77

P_o = 1004 psia, P_{o_m} = 1016

H_{c_B} = 1865 Btu/lbm, H_{o_m} = 1804

NOZZLE STATION 127.5

H_o = _____ Btu/lbm

T_{o_B} = 6020 °R, T_o = _____ °R

M = 6.6 p_o' = 9.9 psia

DUST

TYPE MgO

SIZE 100 μm

VEL 5560 ft/sec

Flow 7.26 gm/sec

C.F. 17.6

WATER

Flow 0.287 gpm

C.F. 19.0

Orifice 0.020 in.

ΔP 214 psi

RUNS	MODEL NUMBER	EXPOSURE TIME					MODEL DESCRIPTION			MODEL INSTRUMENTATION					PHOTOGRAPHS	
		PH	DUST	H_2O	DUST & H_2O	POH	GEOMETRY	DIAM, In.	MATERIAL	T/C TYPE	NO. OF T/C's	PR. TAP	NO. OF TAPS	TRANS-DUCER TYPE	PRERUN	POSTRUN
1	P_o' probe	3.04					See Fig. 3	1.0	SS			x	1	Strain Gage		
2	T_i-2	3.32					Hemi	2.0	6A-4V-T_i	S	8				237	600
3	Empty															
4	T_i-18		1.94				Hemi	2.0	6A-4V-T_i	S	8				95	603
5	Empty															
6	T_i-7		2.17	2.17	x		Hemi	2.0	6A-4V-T_i	S	8				101	601
7	Empty															
8	T_i-17			2.03		1.11	Hemi	2.0	6A-4V-T_i	S	8				92	602
9																
10																

KEY -

PH - PREHEAT
POH - POSTHEAT
DUST AND H_2O - IF CHECKED, MEANS DUST AND WATER FLOWING AT SAME TIME

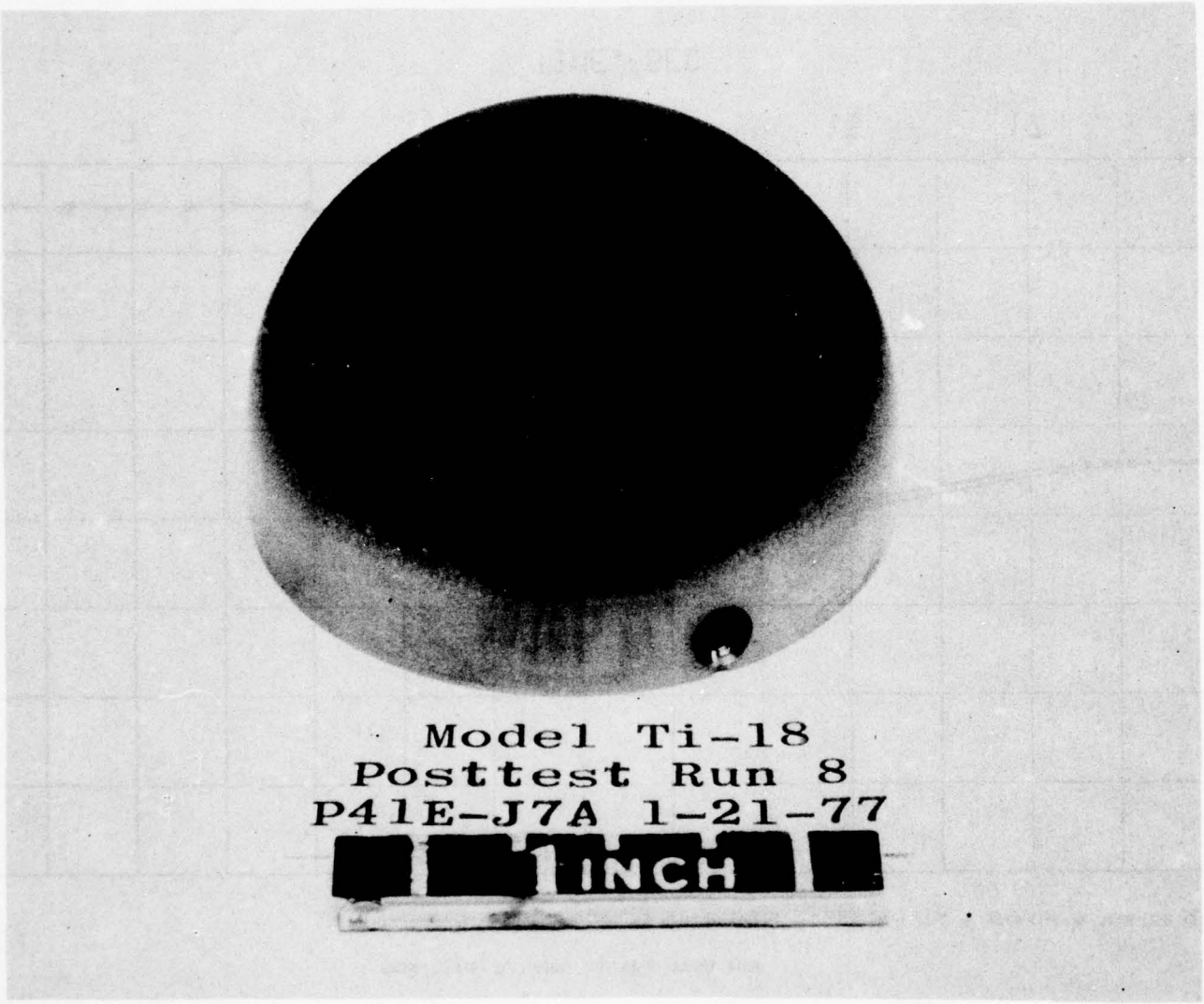
NOTES:

PRECEDING PAGE BLANK-NOT FILMED

Model Ti-2
Posttest Run 8
P41E-J7A 1-21-77
1 INCH

Model Ti-7
Posttest Run 8
P41E-J7A 1-21-77
1 INCH

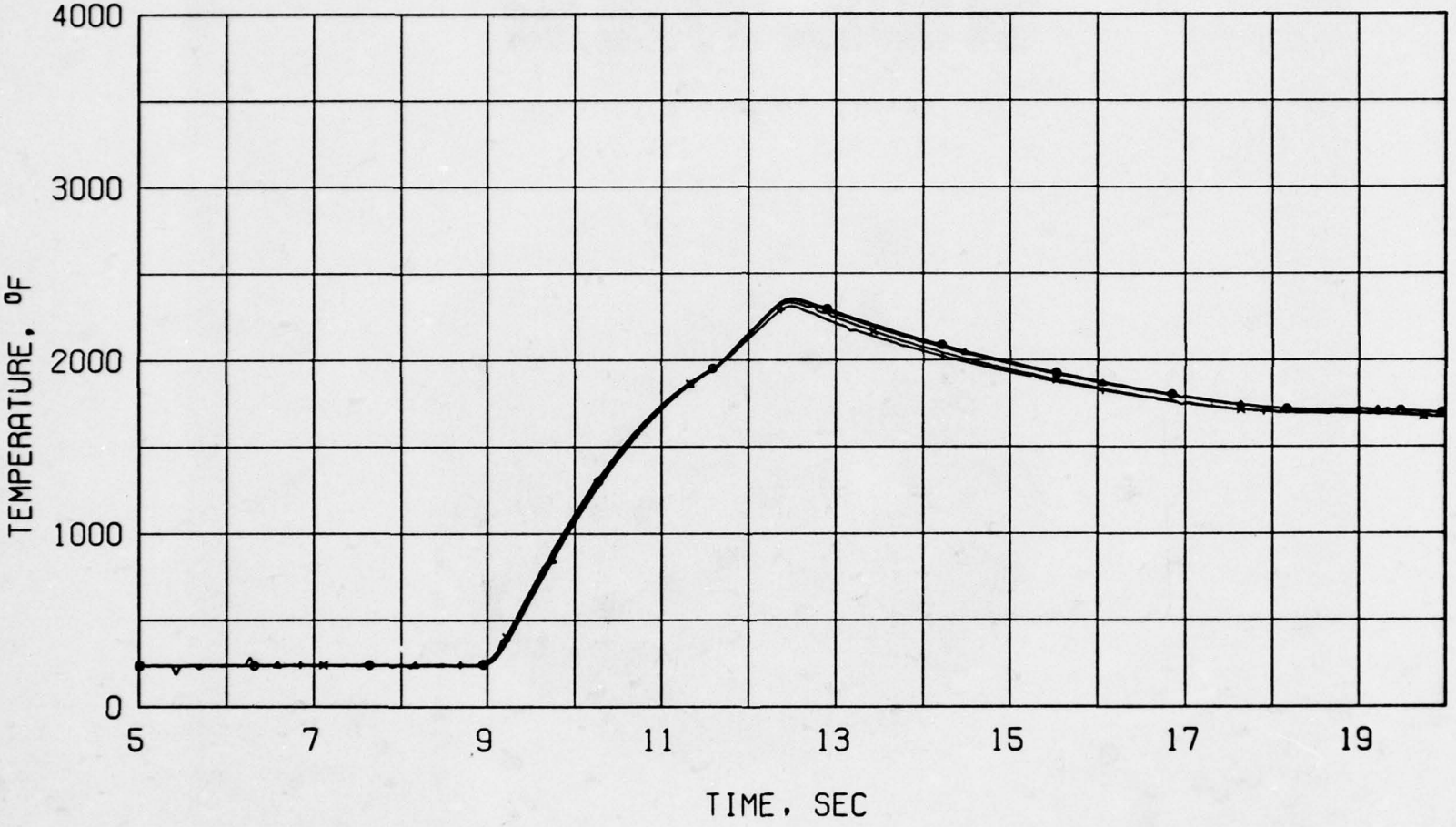
Model Ti-17
Posttest Run 8
P41E-J7A 1-21-77
1 INCH


Model Ti-18
Posttest Run 8
P41E-J7A 1-21-77
1 INCH

DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

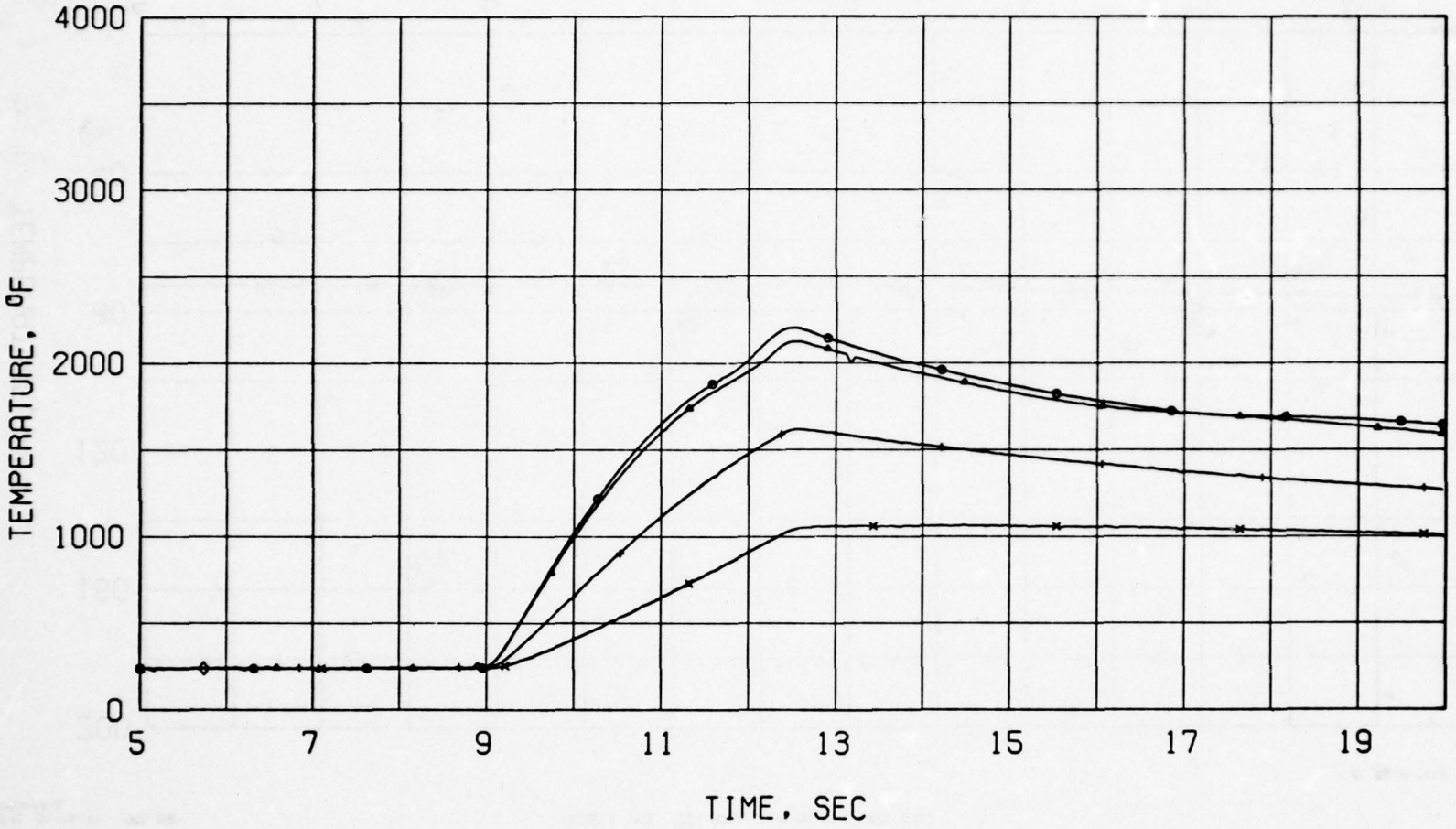
× TC-4-TI-2 + TC-3-TI-2 ▲ TC-2-TI-2 ⊙ TC-1-TI-2



DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

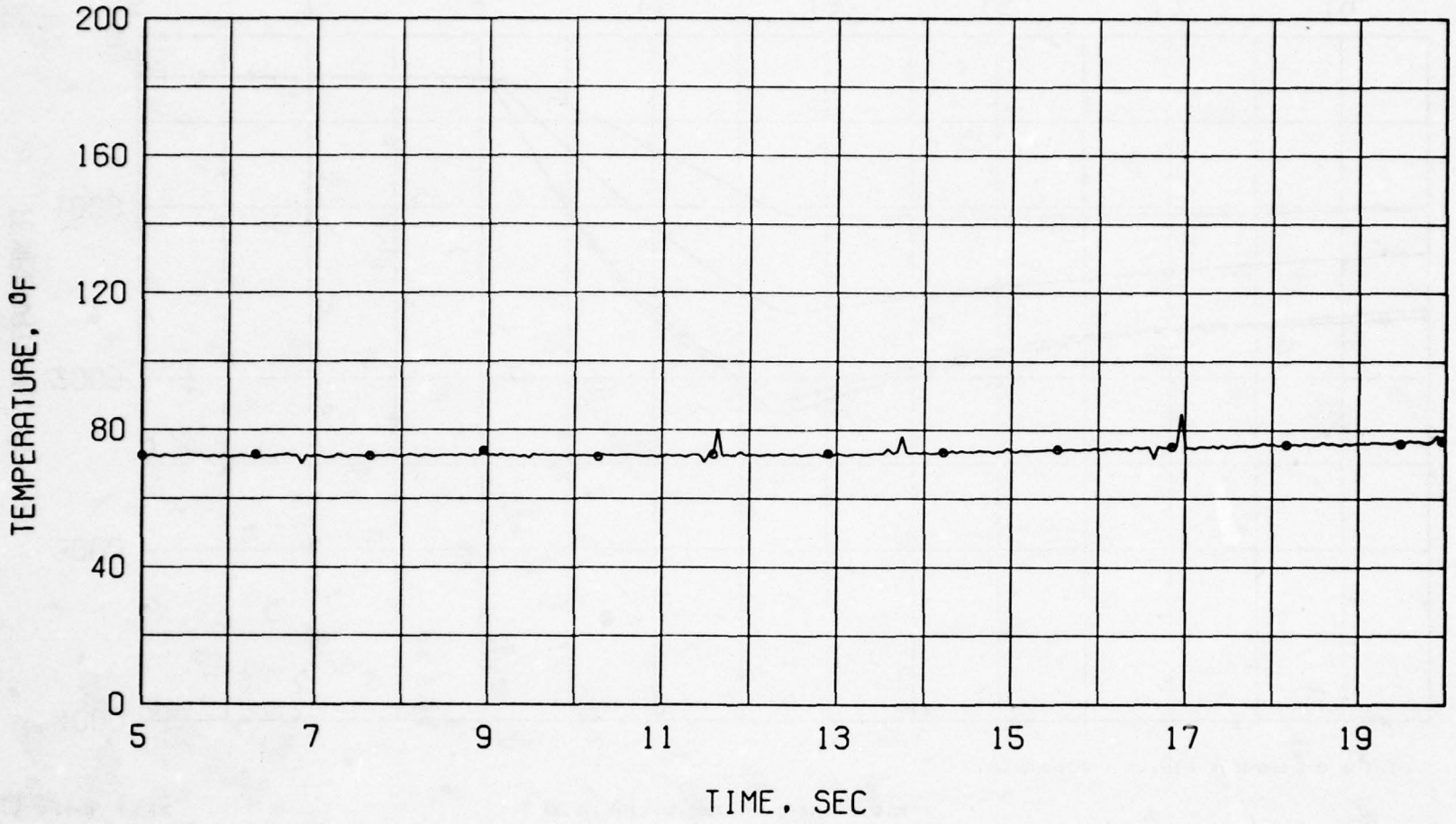
× TC-8-TI-2 + TC-7-TI-2 ▲ TC-6-TI-2 ⊙ TC-5-TI-2



DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

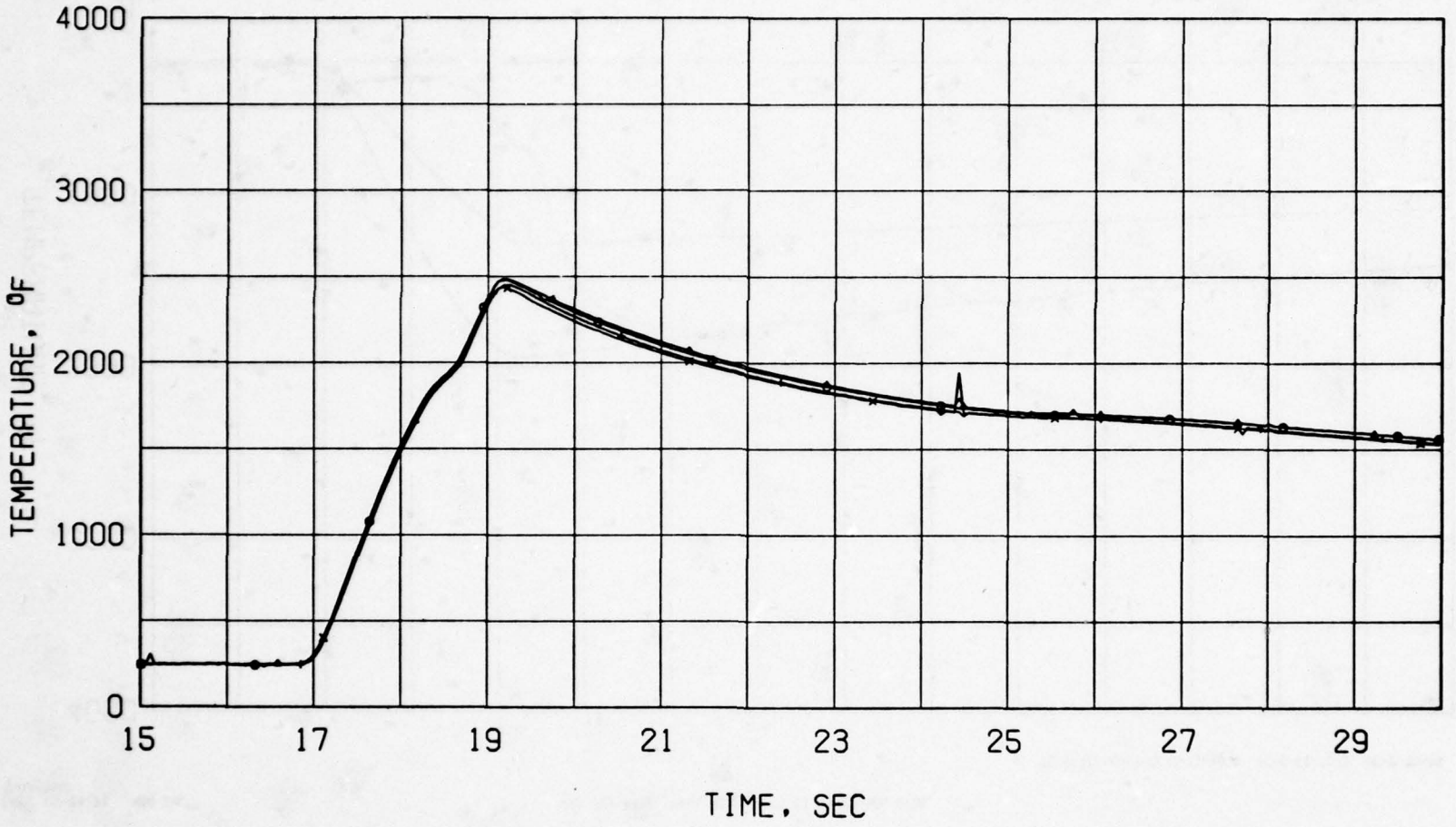
© TC-9-T1-2

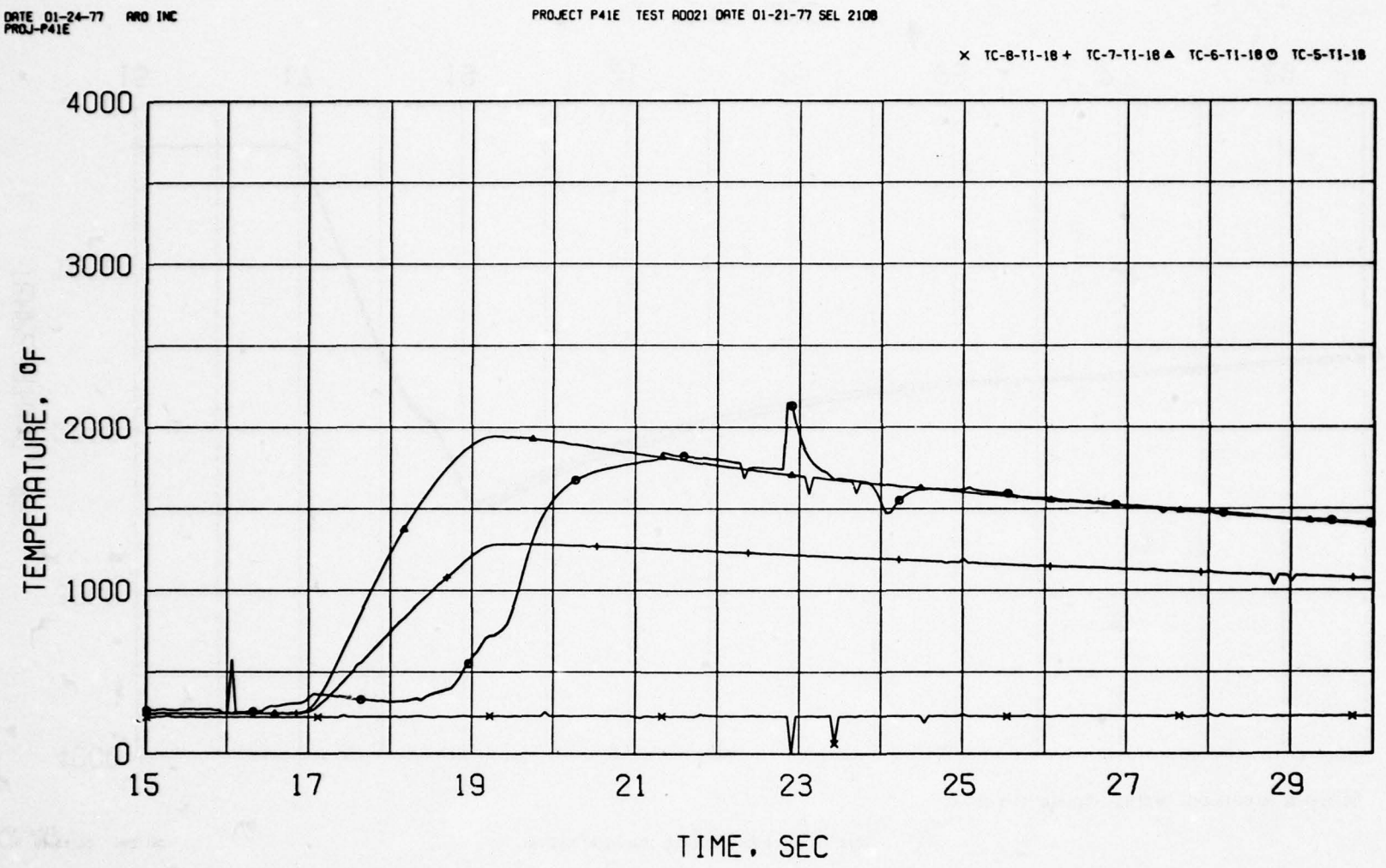


DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

× TC-4-TI-18 + TC-3-TI-18 ▲ TC-2-TI-18 ⊙ TC-1-TI-18

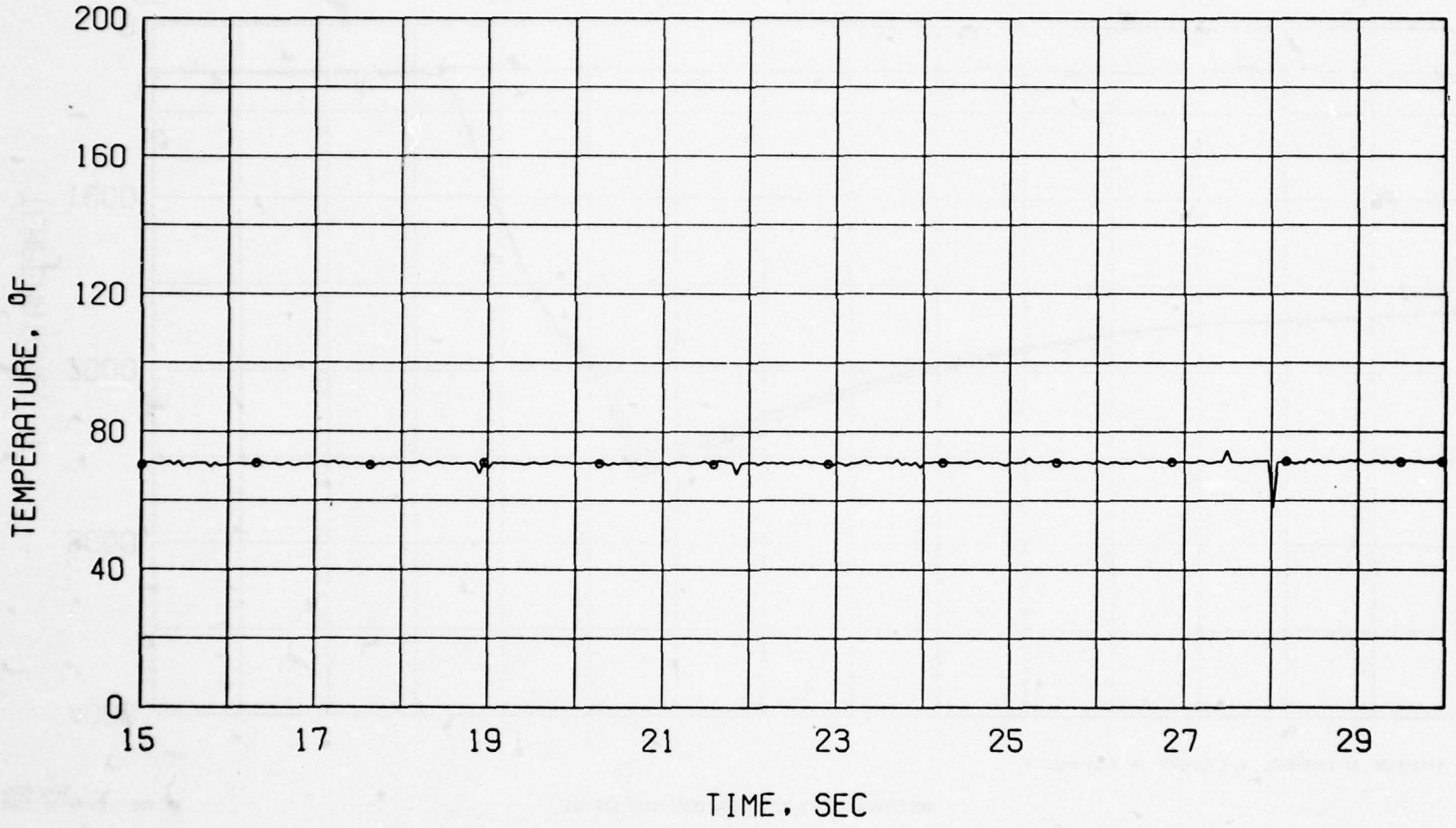



DATE 01-24-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108
× TC-8-T1-18 + TC-7-T1-18 ▲ TC-6-T1-18 ⊙ TC-5-T1-18
4000
3000
2000
1000
0
TEMPERATURE, °F
15
17
19
21
23
25
27
29
TIME, SEC

DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

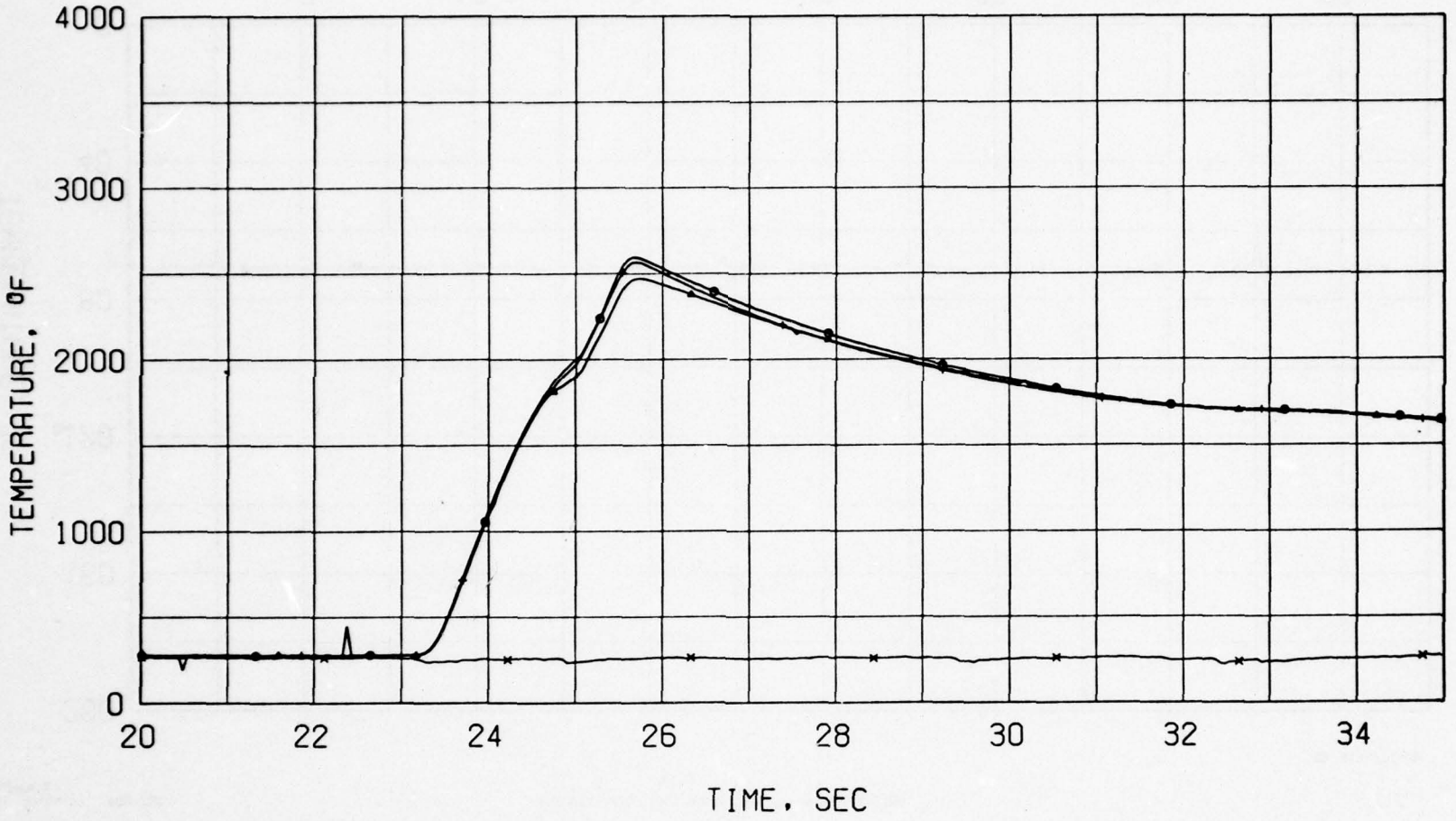
⊙ TC-9-TI-18



DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST AD021 DATE 01-21-77 SEL 2108

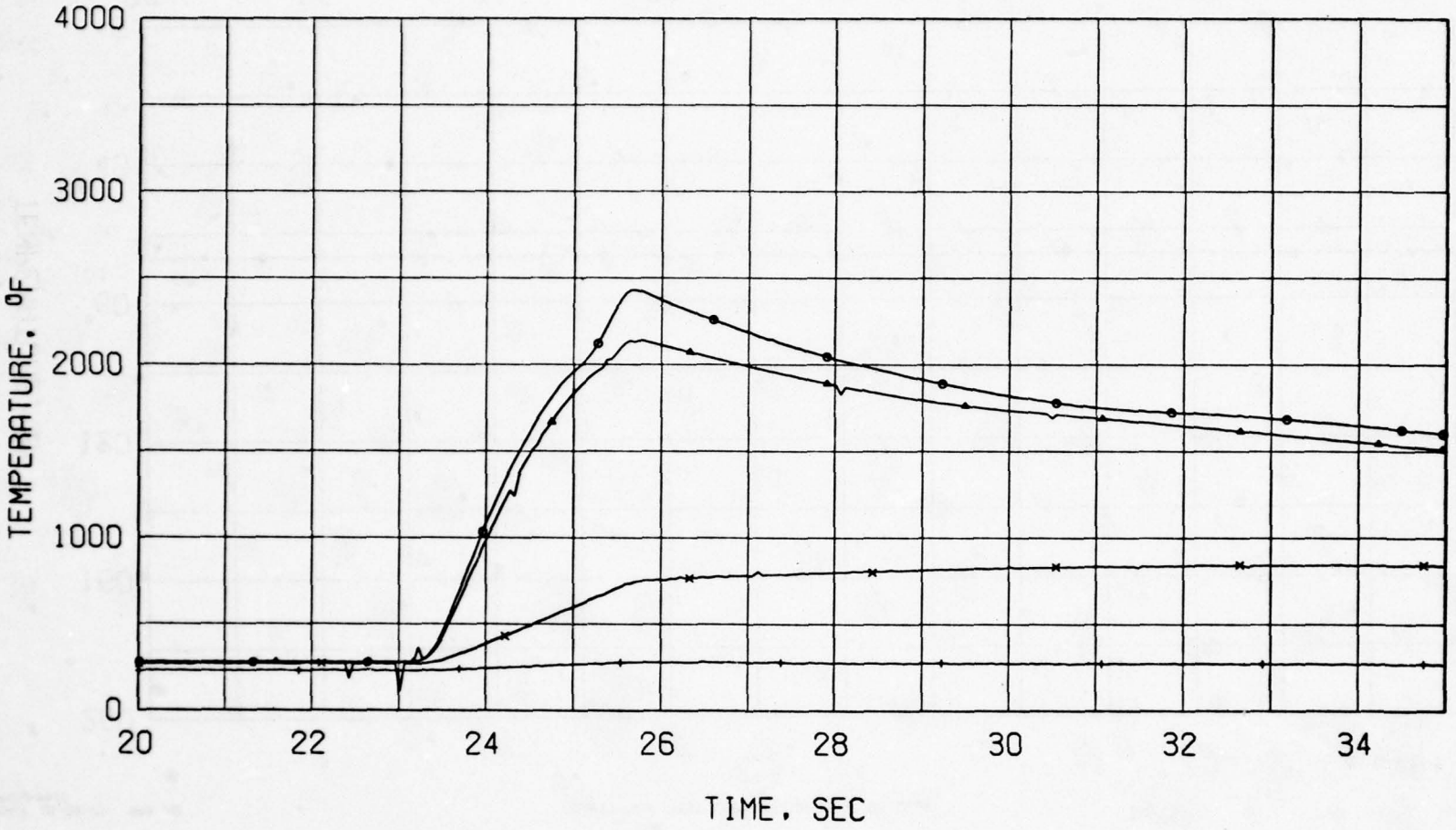
× TC-4-TI-7 + TC-3-TI-7 ▲ TC-2-TI-7 ⊙ TC-1-TI-7



DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

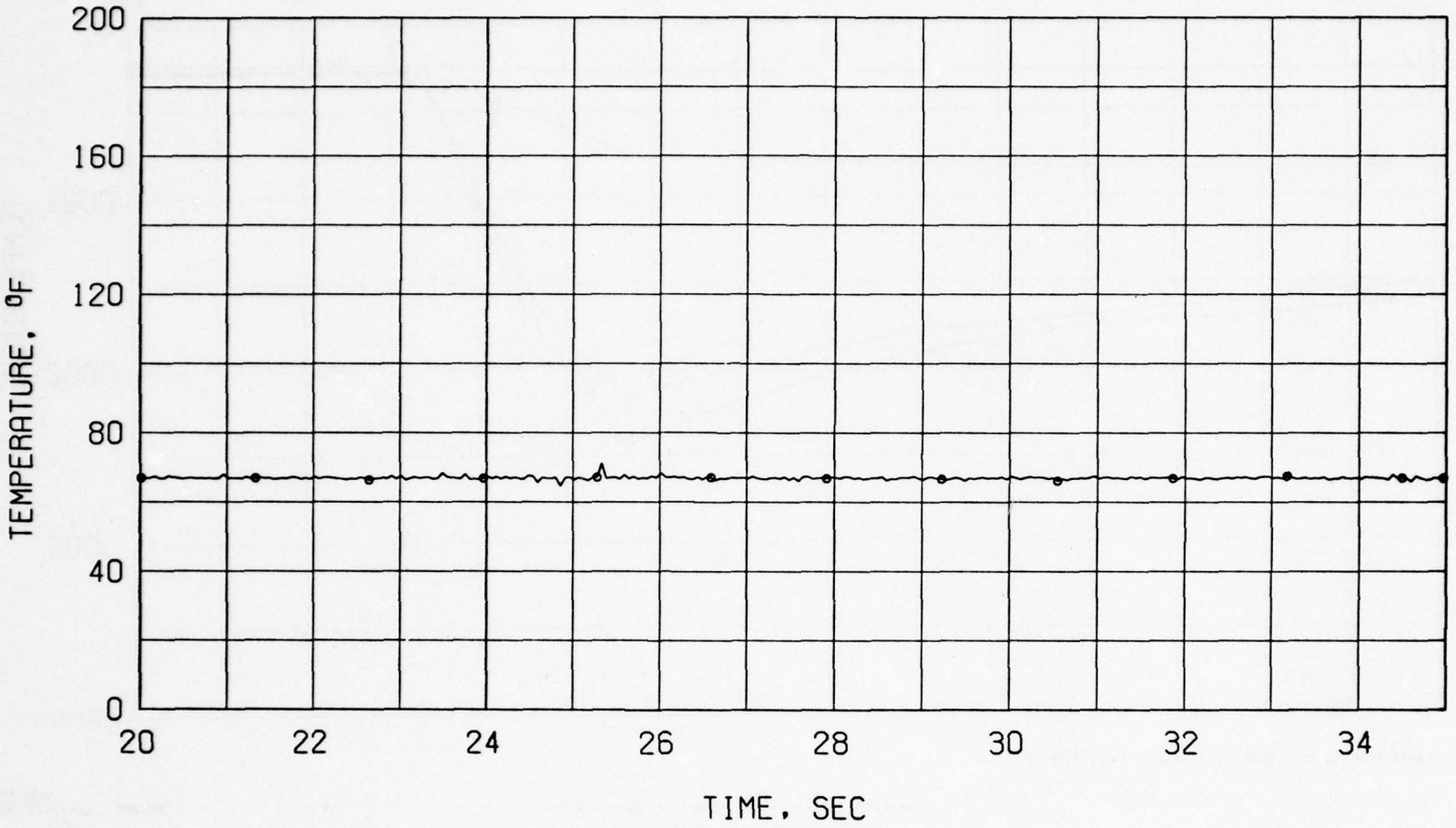
× TC-8-TI-7 + TC-7-TI-7 ▲ TC-6-TI-7 ⊙ TC-5-TI-7



DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

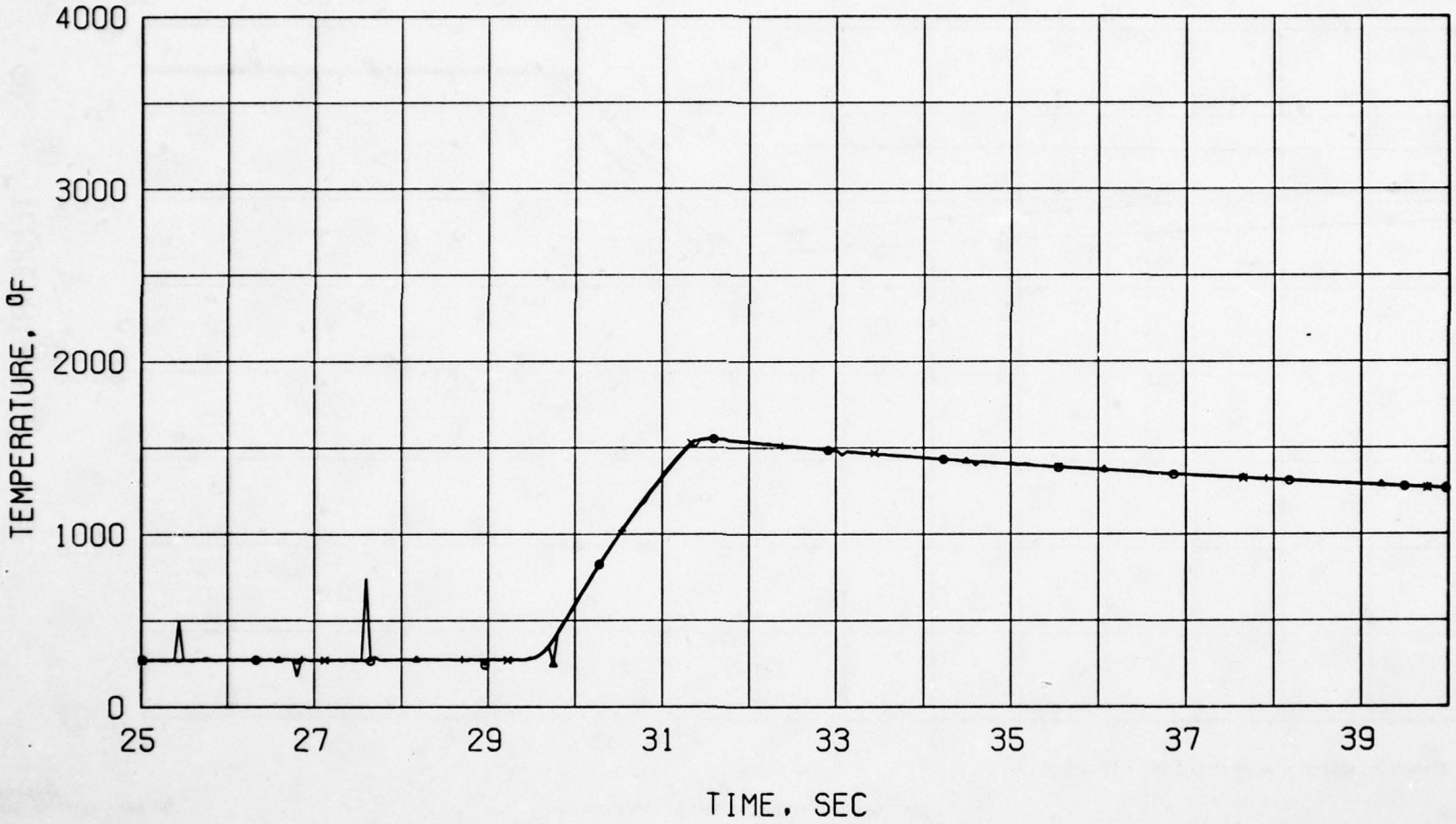
© TC-9-T1-7

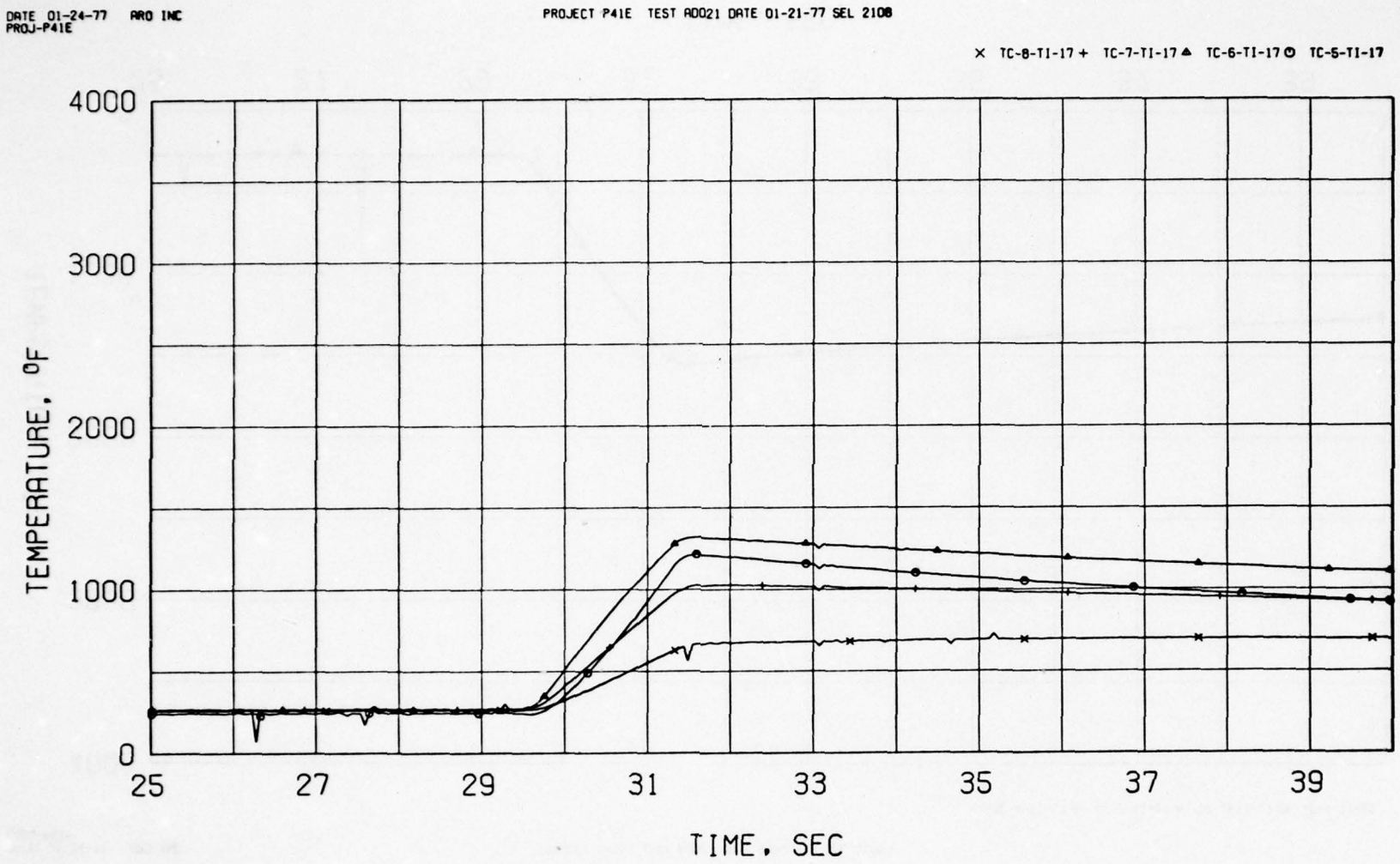


DATE 01-24-77 ARO INC
PROJ-P41E

PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

× TC-4-TI-17 + TC-3-TI-17 △ TC-2-TI-17 ⊙ TC-1-TI-17

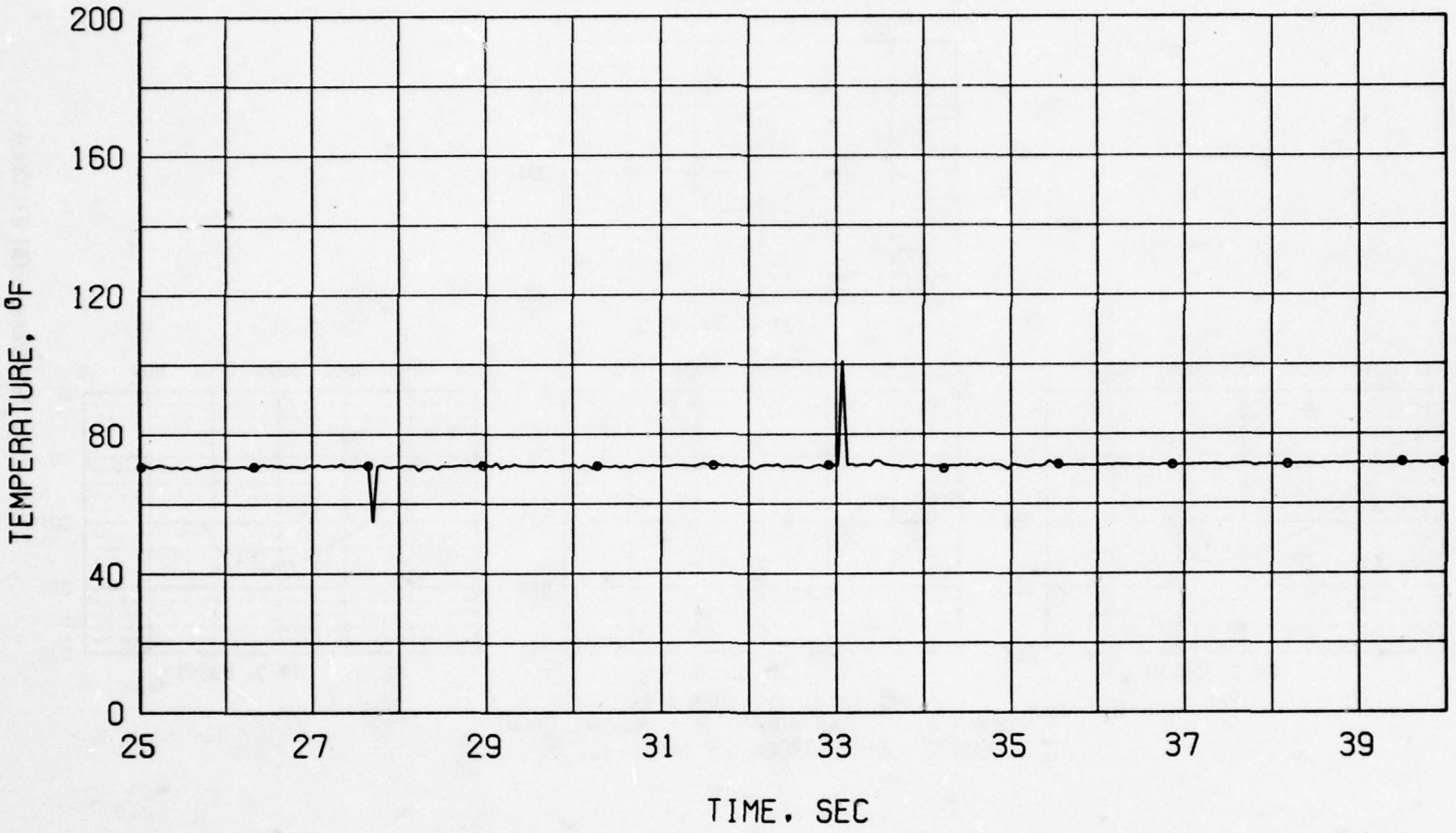


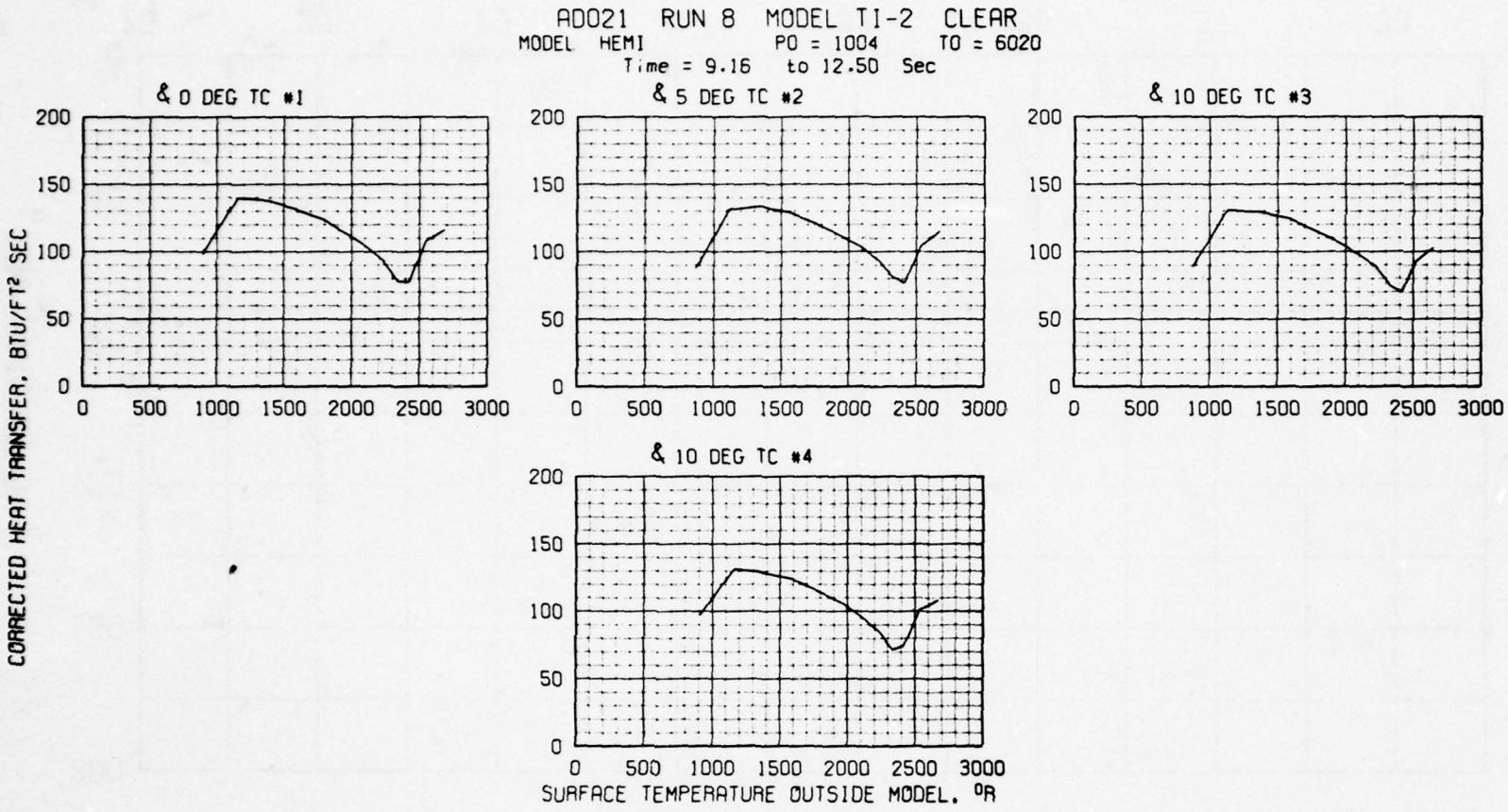

DATE 01-24-77 ARO INC
PROJ-P41E
PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108
× TC-8-TI-17 + TC-7-TI-17 ▲ TC-6-TI-17 ⊙ TC-5-TI-17
4000
3000
2000
1000
0
TEMPERATURE, °F
25
27
29
31
33
35
37
39
TIME, SEC

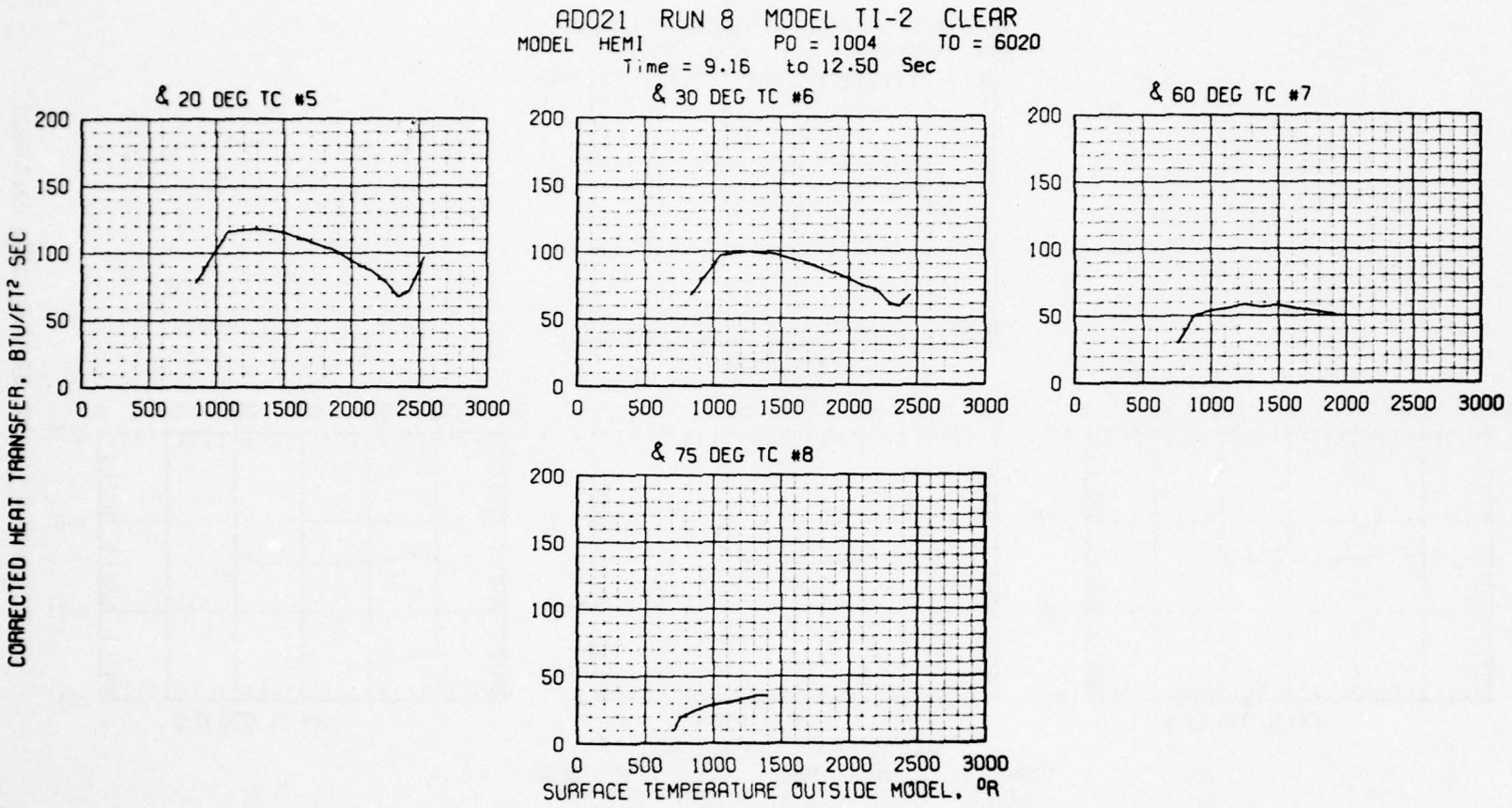
DATE 01-24-77 ARO INC
PROJ-P41E

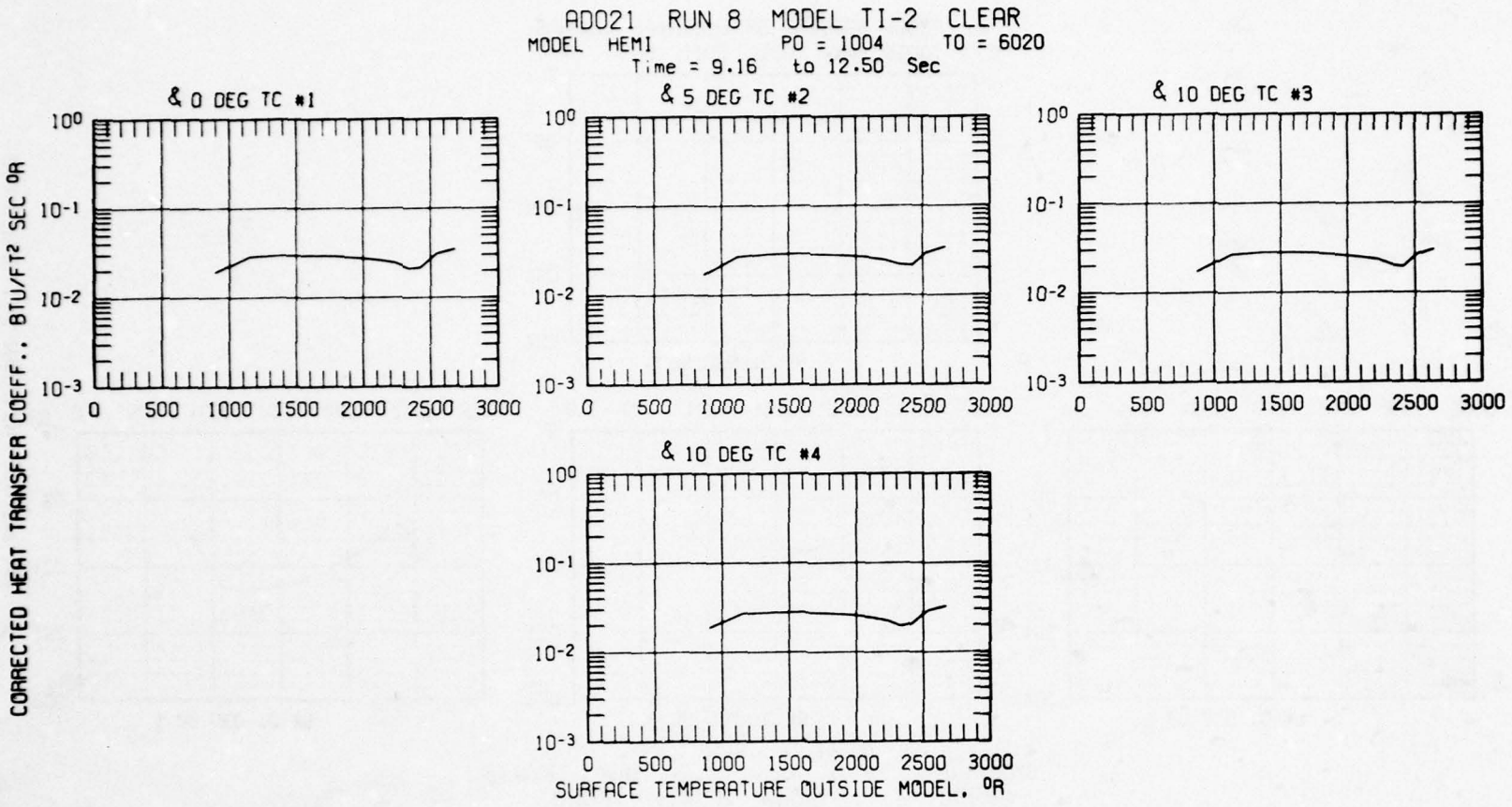
PROJECT P41E TEST A0021 DATE 01-21-77 SEL 2108

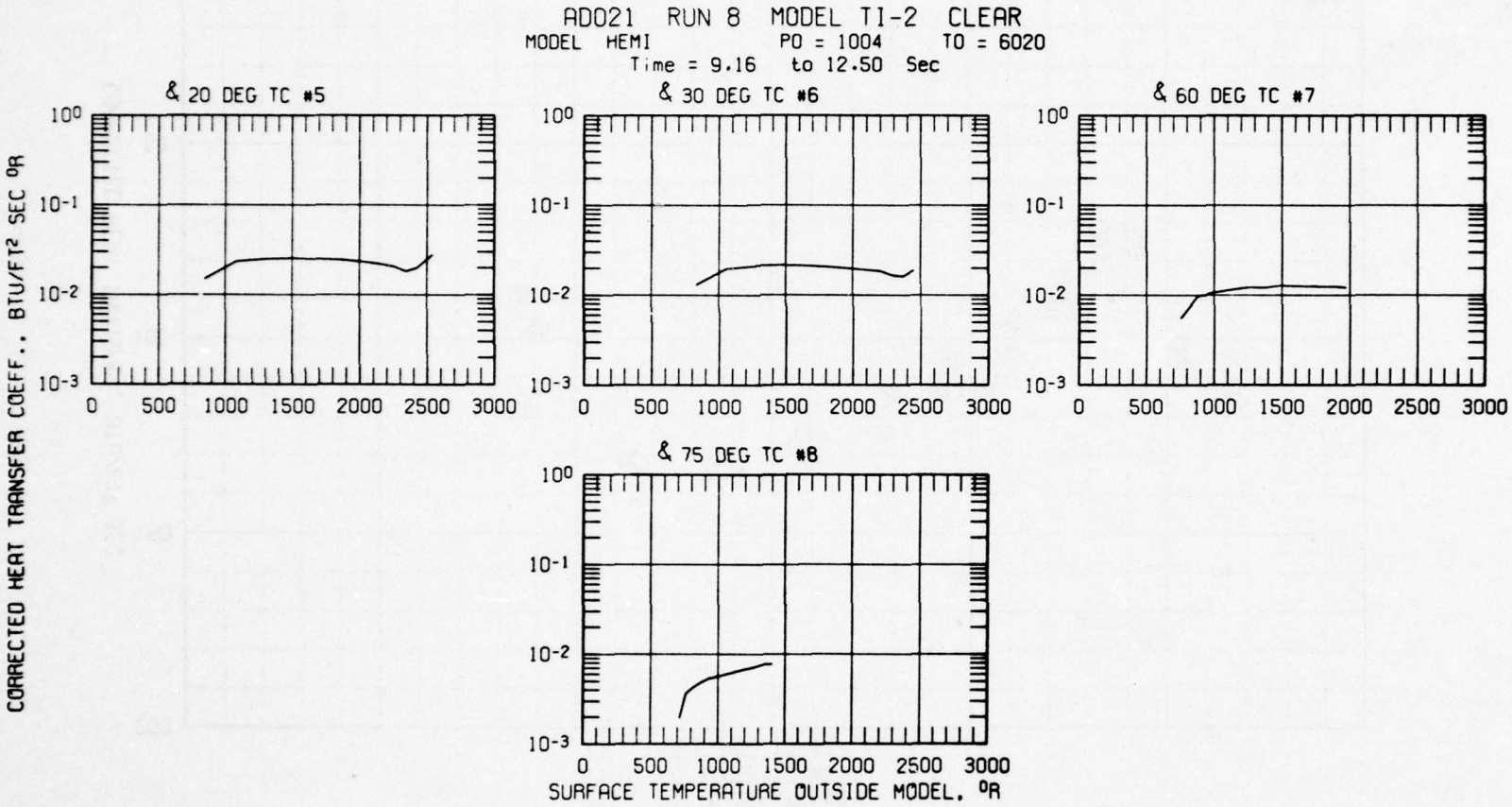
⊙ TC-9-TI-17

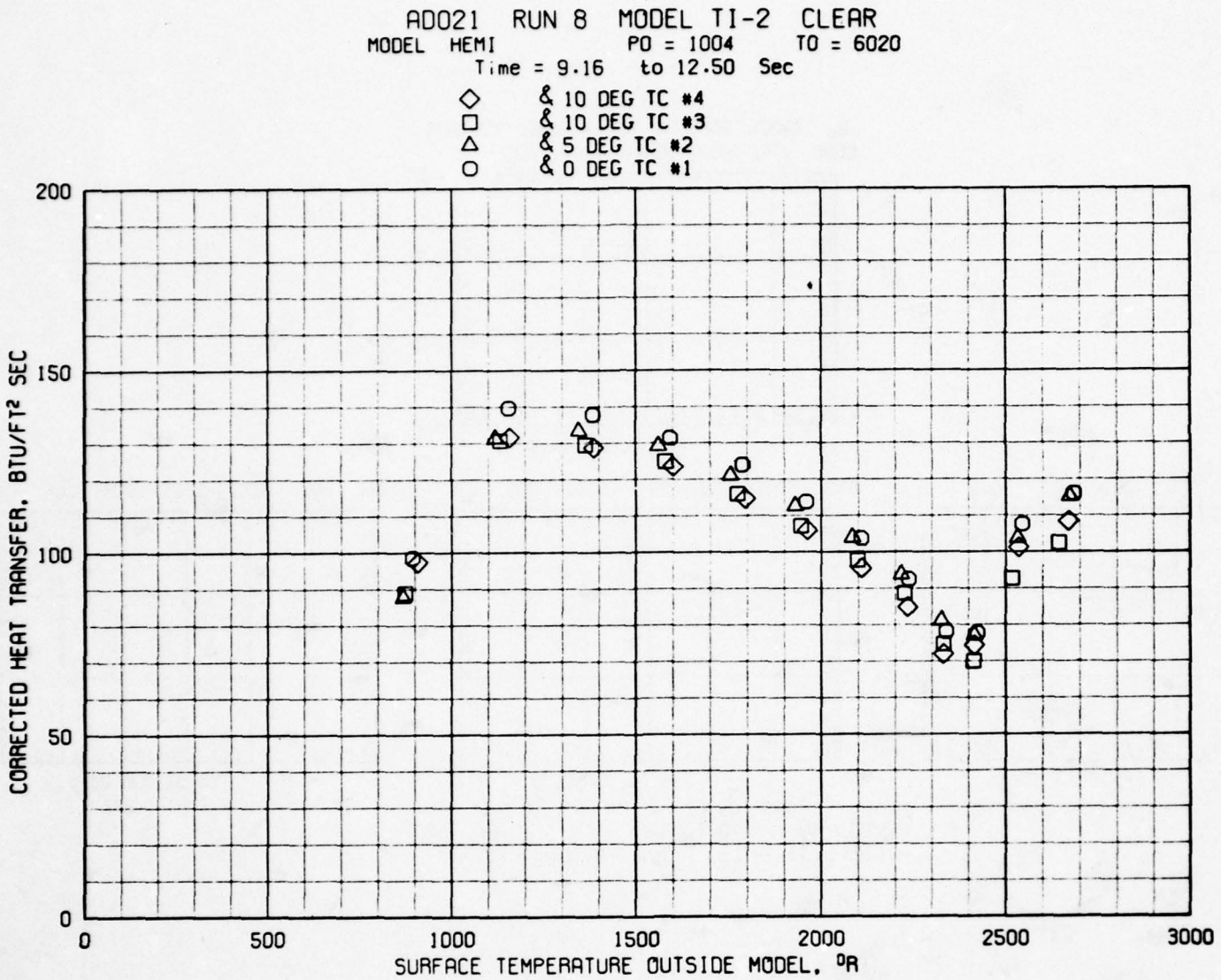


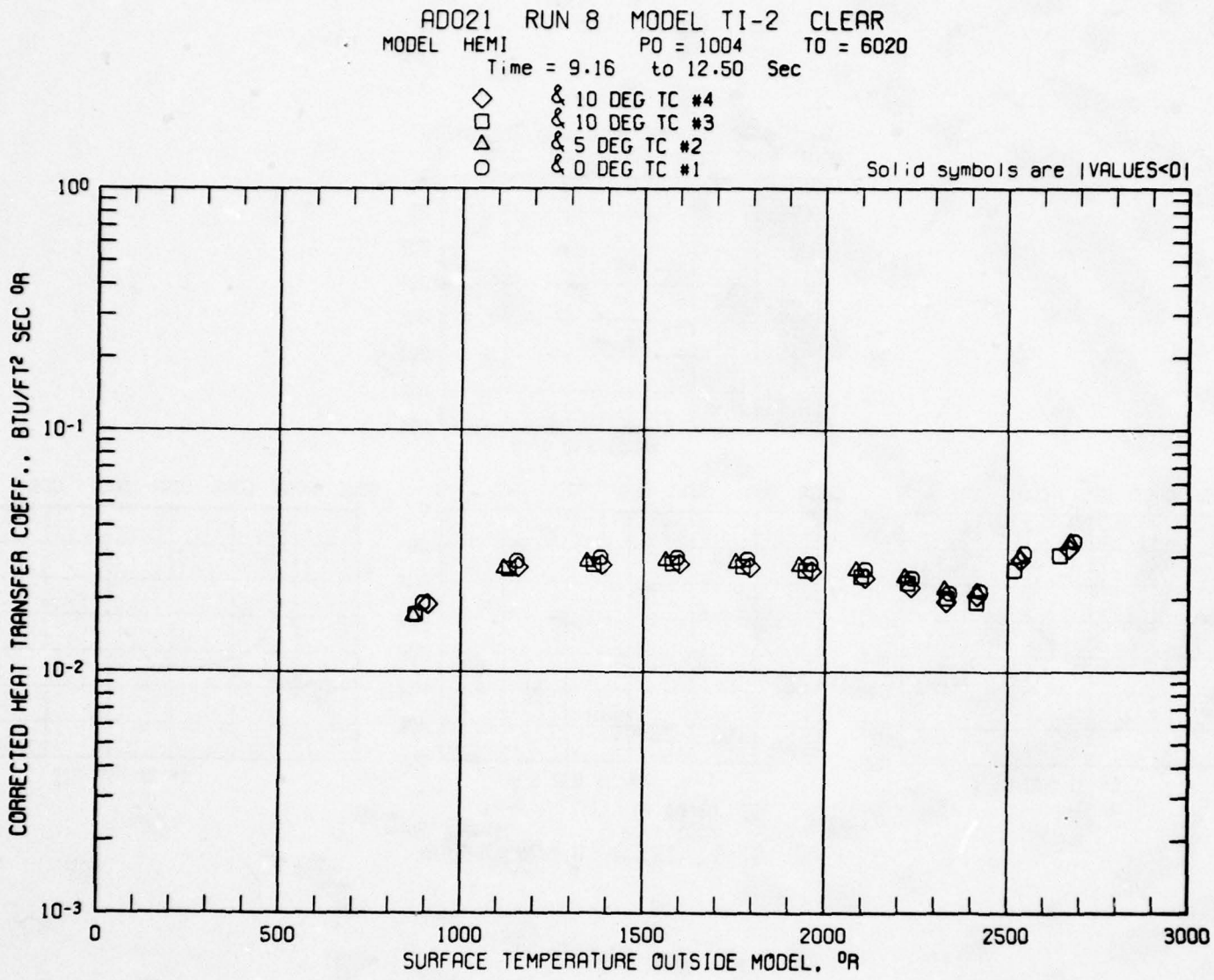

AD021 RUN 8 MODEL TI-2 CLEAR
MODEL HEMI PO = 1004 TO = 6020
Time = 9.16 to 12.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
500
1000
1500
2000
2500
3000

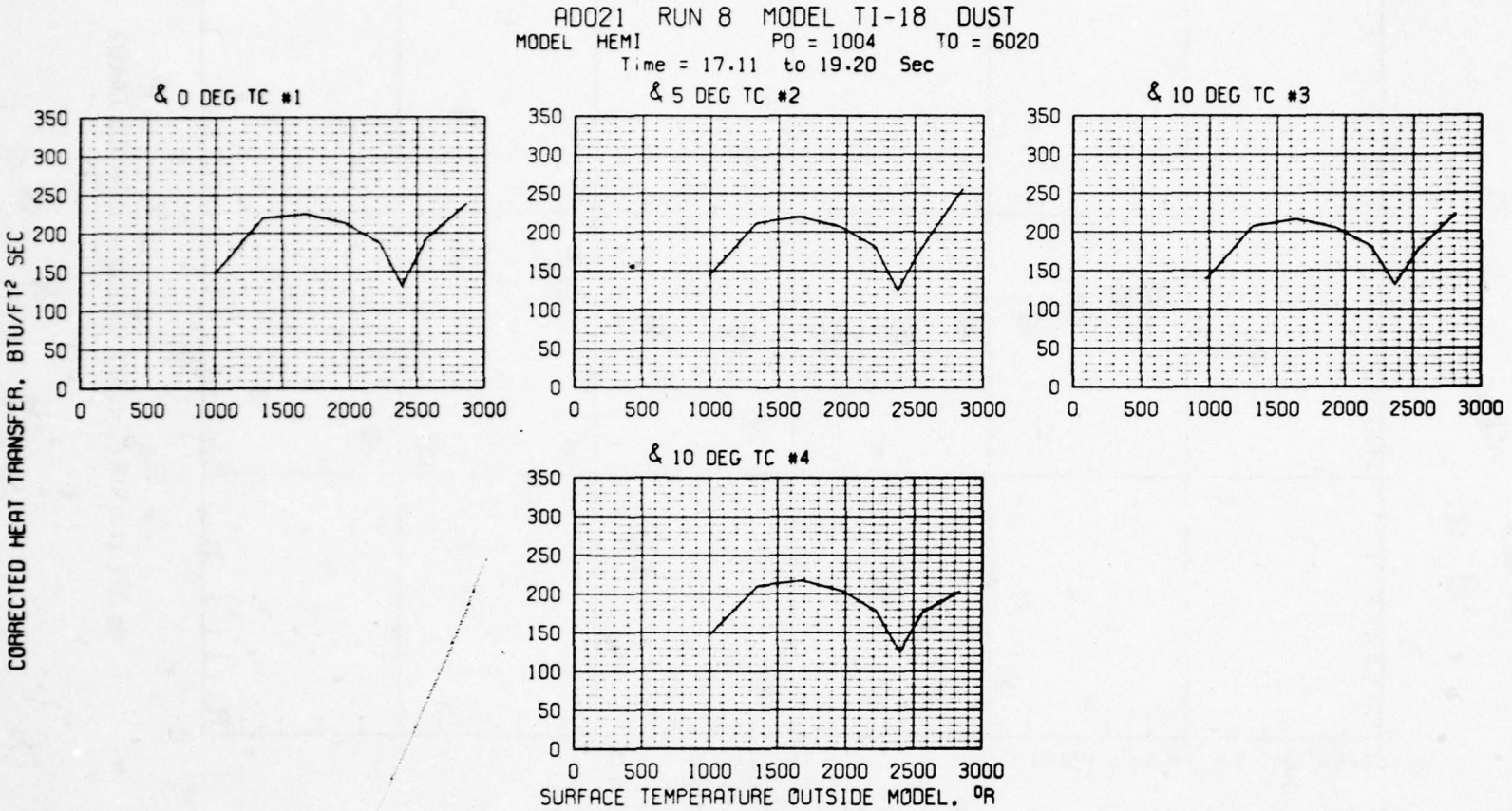

AD021 RUN 8 MODEL TI-2 CLEAR
MODEL HEMI PO = 1004 TO = 6020
Time = 9.16 to 12.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
500
1000
1500
2000
2500
3000

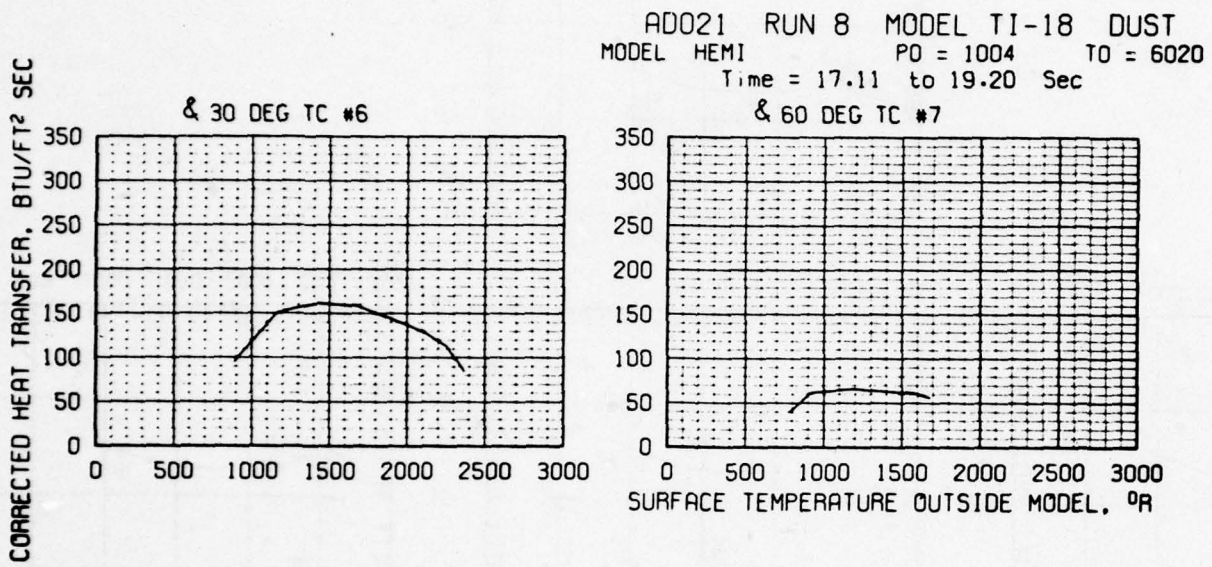

AD021 RUN 8 MODEL TI-2 CLEAR
MODEL HEMI PO = 1004 TO = 6020
Time = 9.16 to 12.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 8 MODEL TI-2 CLEAR
MODEL HEMI PO = 1004 TO = 6020
Time = 9.16 to 12.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000


AD021 RUN 8 MODEL TI-2 CLEAR
MODEL HEMI
PO = 1004
TO = 6020
Time = 9.16 to 12.50 Sec
& 10 DEG TC #4
& 10 DEG TC #3
& 5 DEG TC #2
& 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
0
500
1000
1500
2000
2500
3000


AD021 RUN 8 MODEL TI-2 CLEAR
MODEL HEMI
PO = 1004
TO = 6020
Time = 9.16 to 12.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

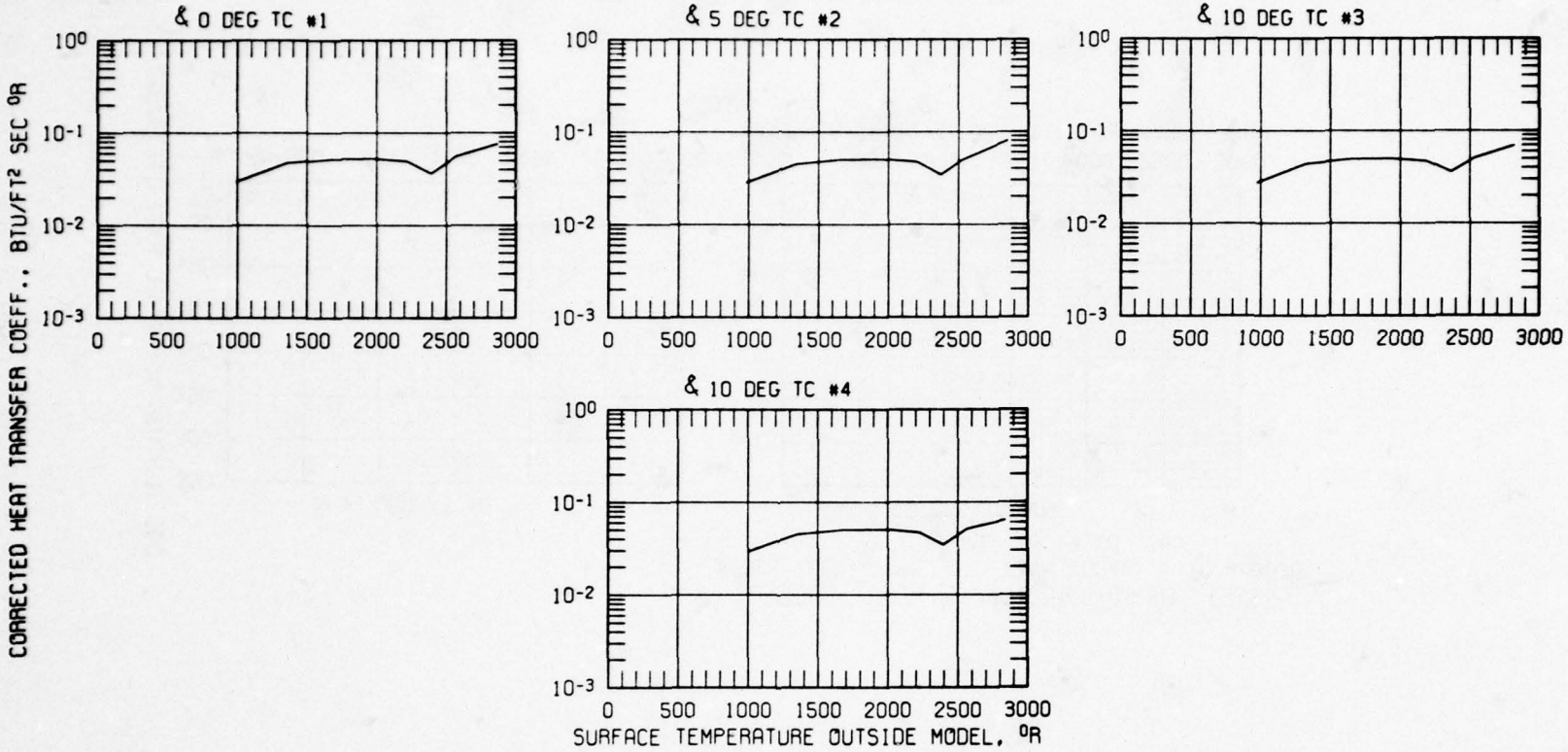

AD021 RUN 8 MODEL TI-18 DUST
MODEL HEMI PO = 1004 TO = 6020
Time = 17.11 to 19.20 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
350
500
1000
1500
2000
2500
3000

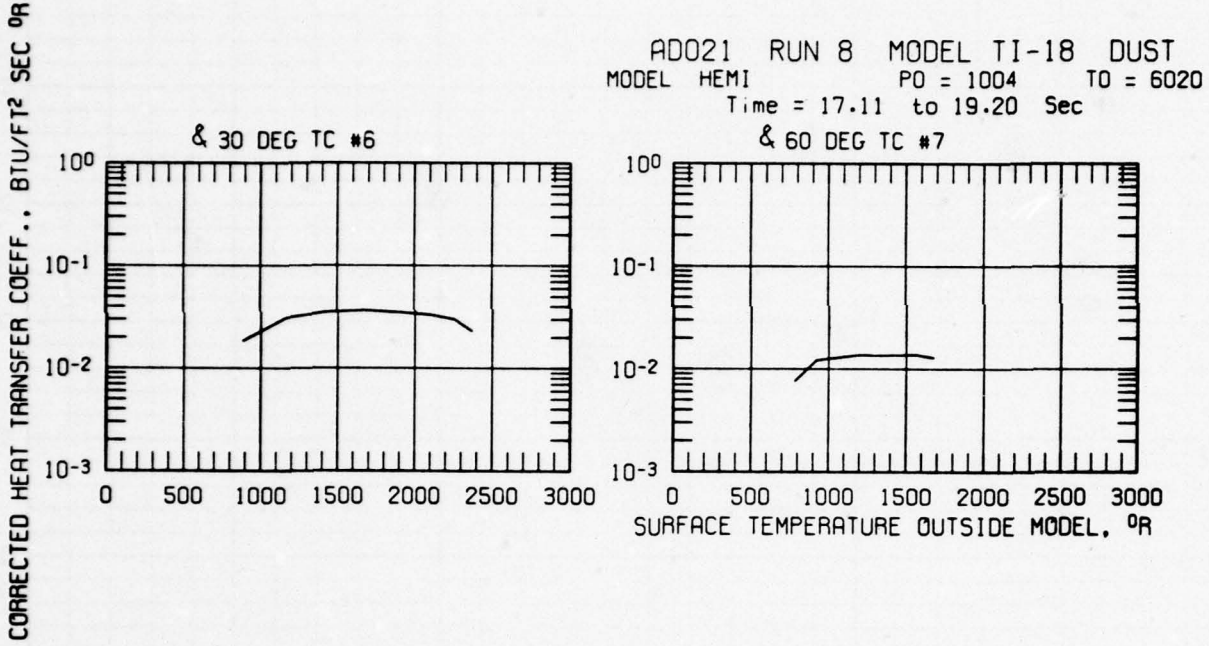

AD021 RUN 8 MODEL TI-18 DUST
MODEL HEMI
PO = 1004
TO = 6020
Time = 17.11 to 19.20 Sec
& 30 DEG TC #6
& 60 DEG TC #7
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
350
0
500
1000
1500
2000
2500
3000

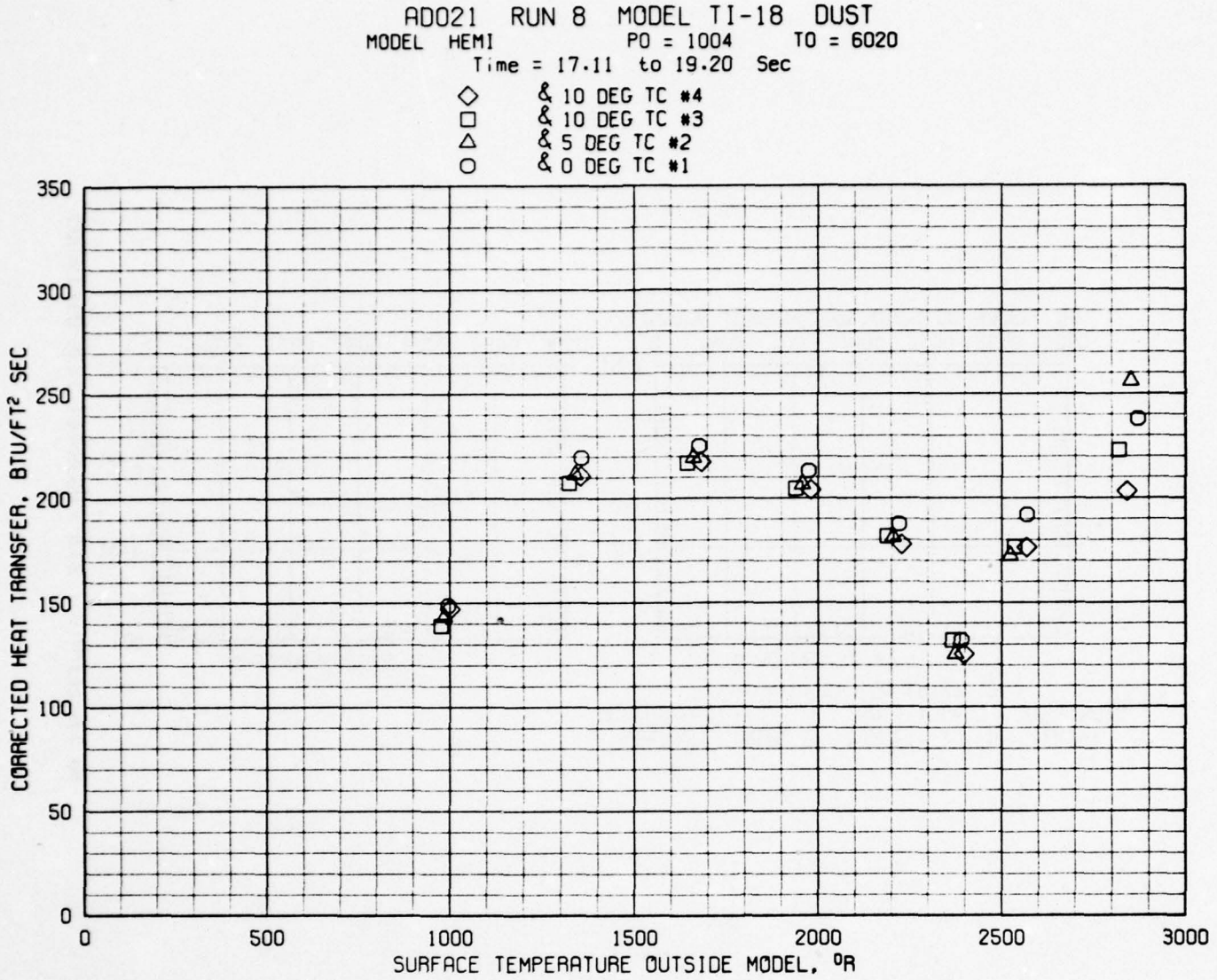
AD021 RUN 8 MODEL TI-18 DUST

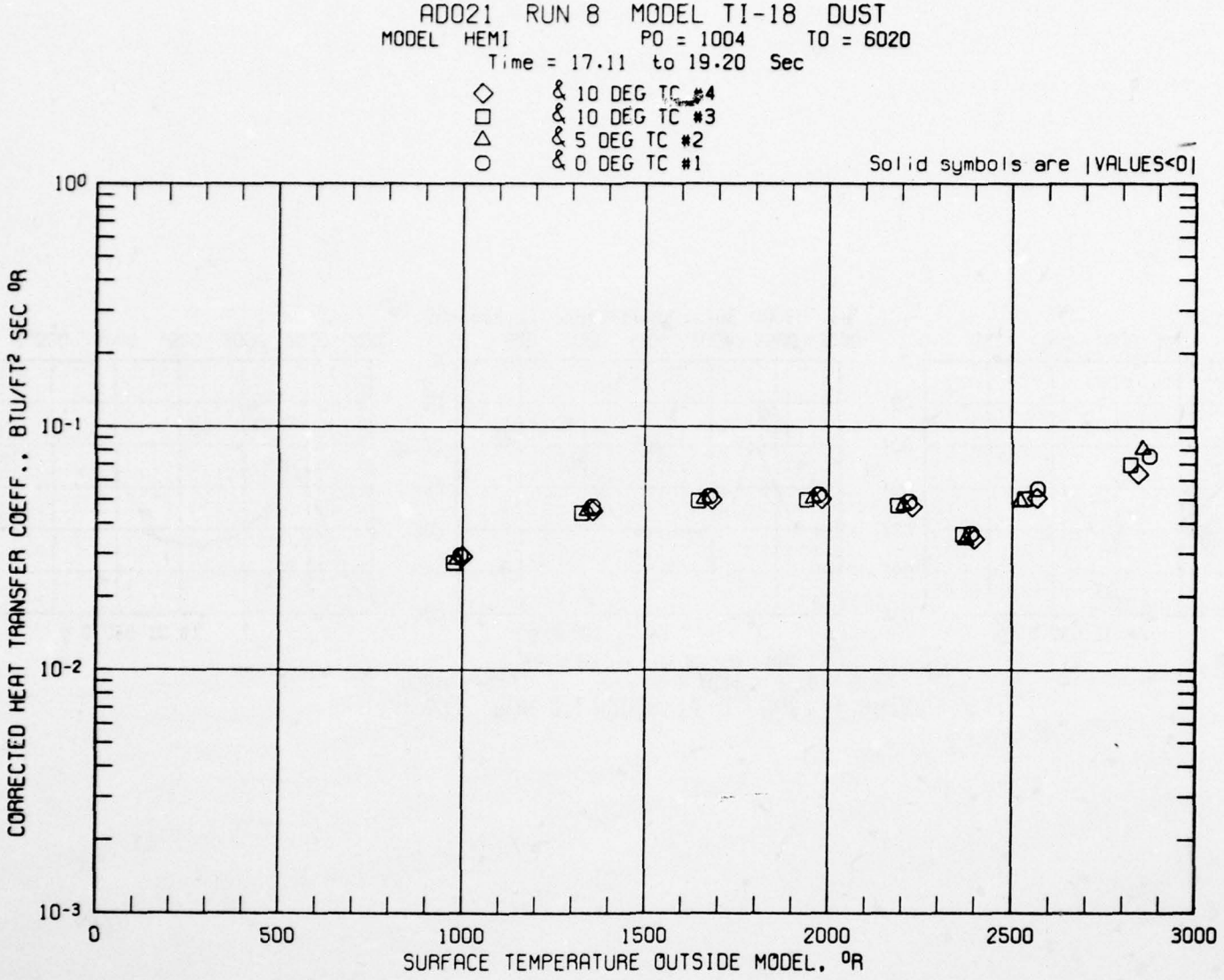
MODEL HEMI PO = 1004 TO = 6020

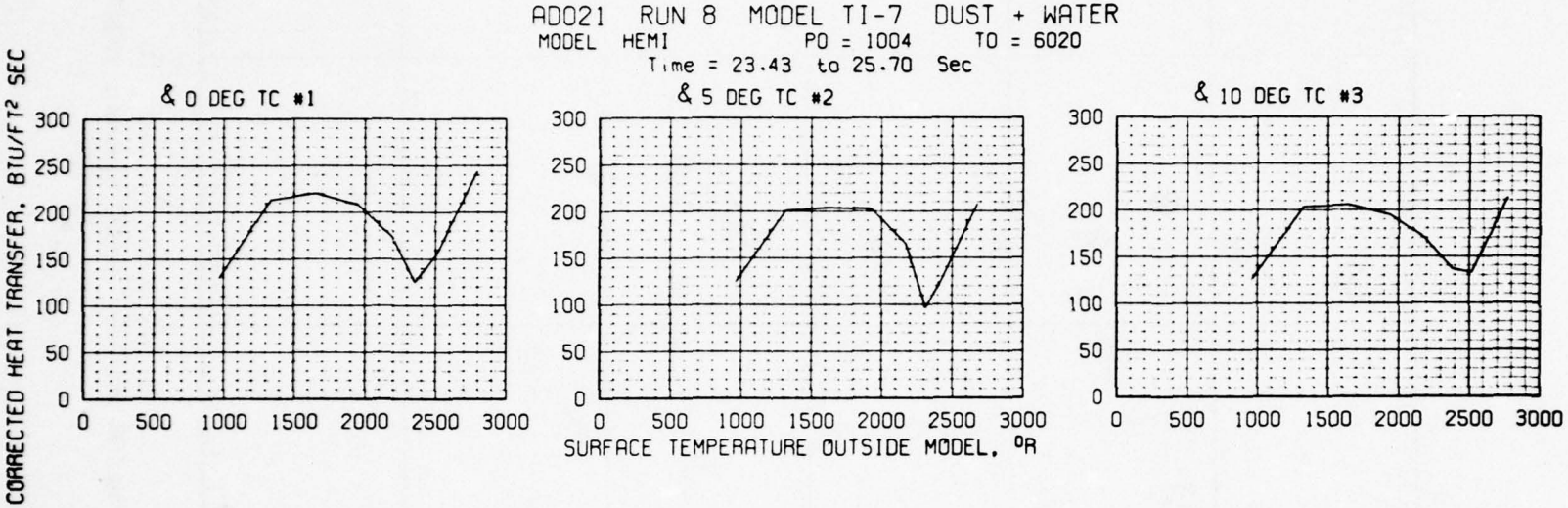
Time = 17.11 to 19.20 Sec

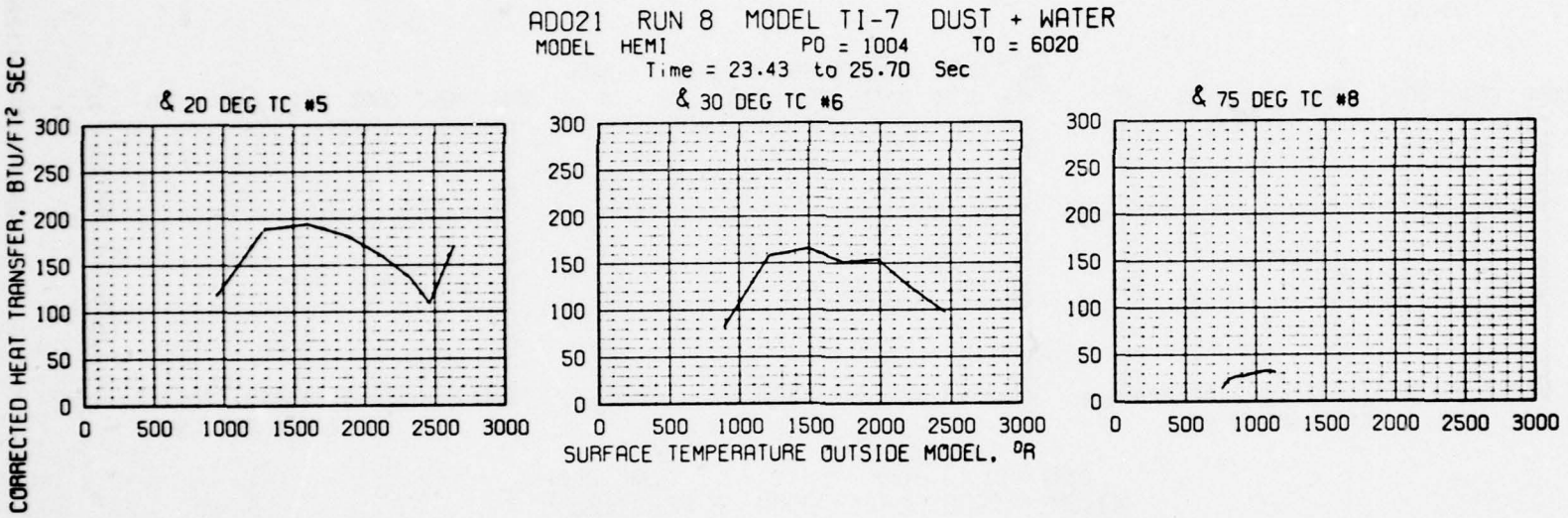


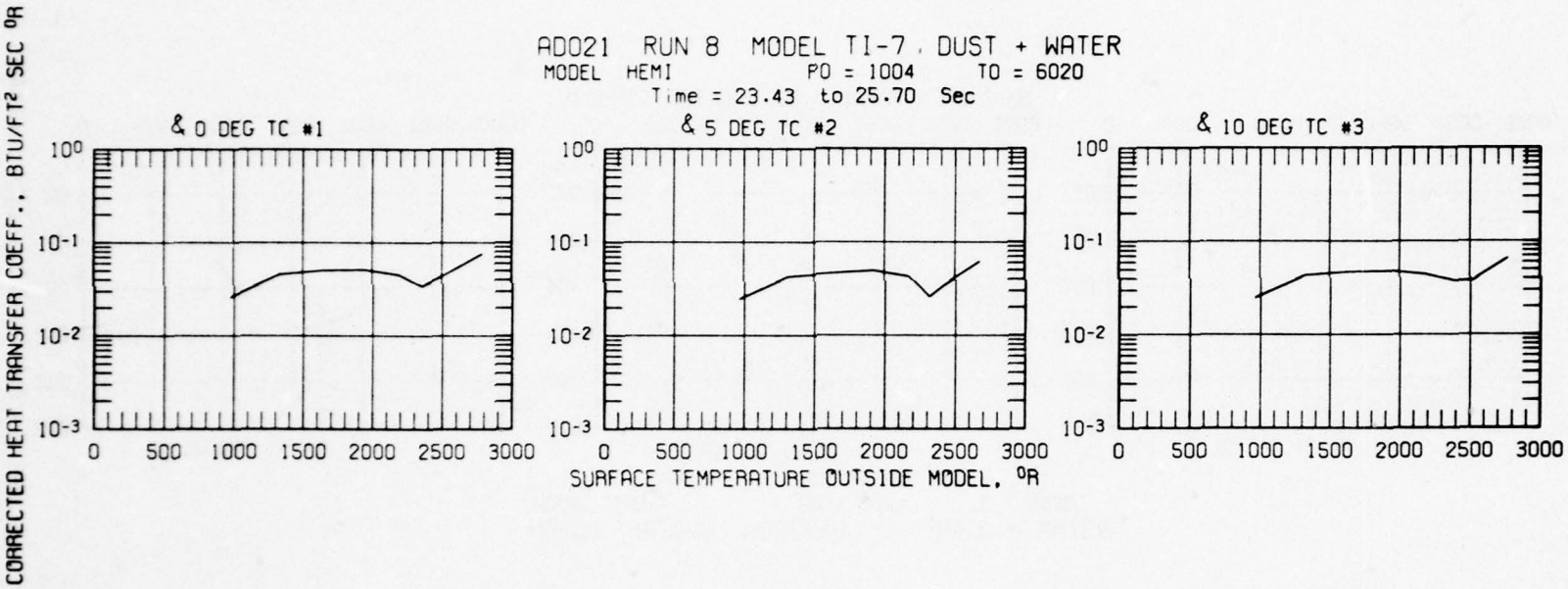

AD021 RUN 8 MODEL TI-18 DUST
MODEL HEMI
PO = 1004
TO = 6020
Time = 17.11 to 19.20 Sec
& 30 DEG TC #6
& 60 DEG TC #7
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10-1
10-2
10-3
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

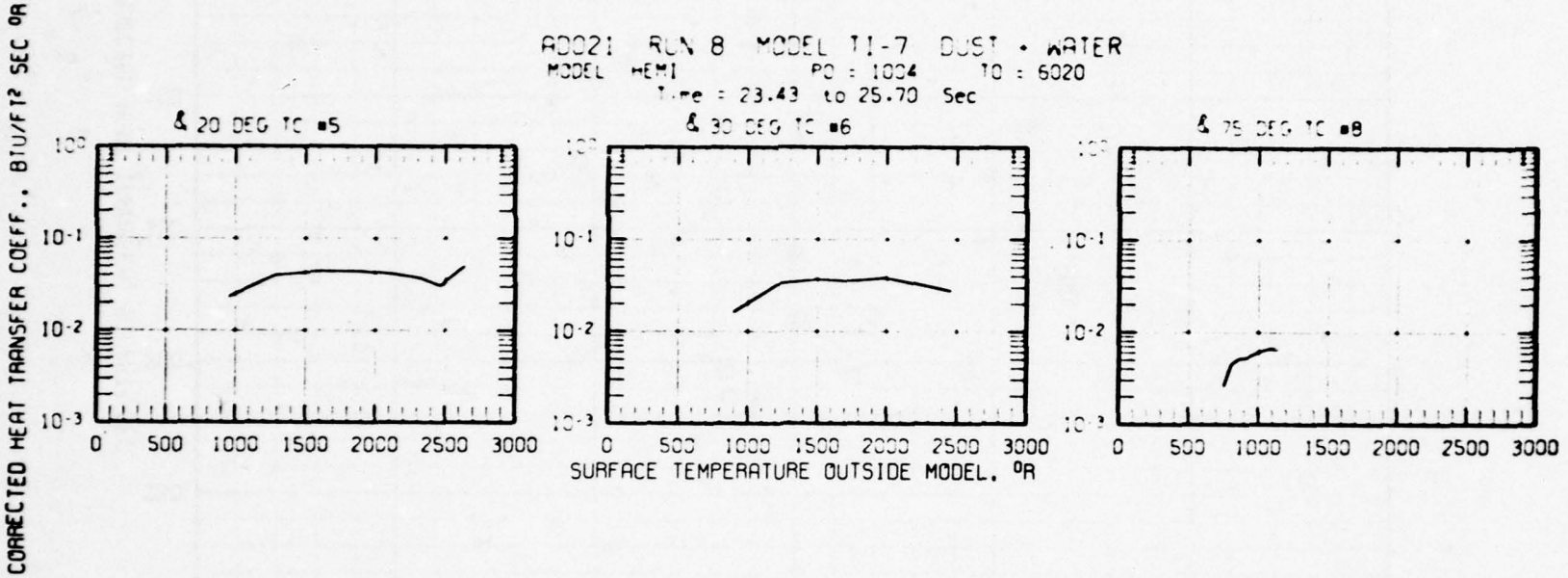

AD021 RUN 8 MODEL TI-18 DUST
MODEL HEMI
PO = 1004
TO = 6020
Time = 17.11 to 19.20 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
0
50
100
150
200
250
300
350
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

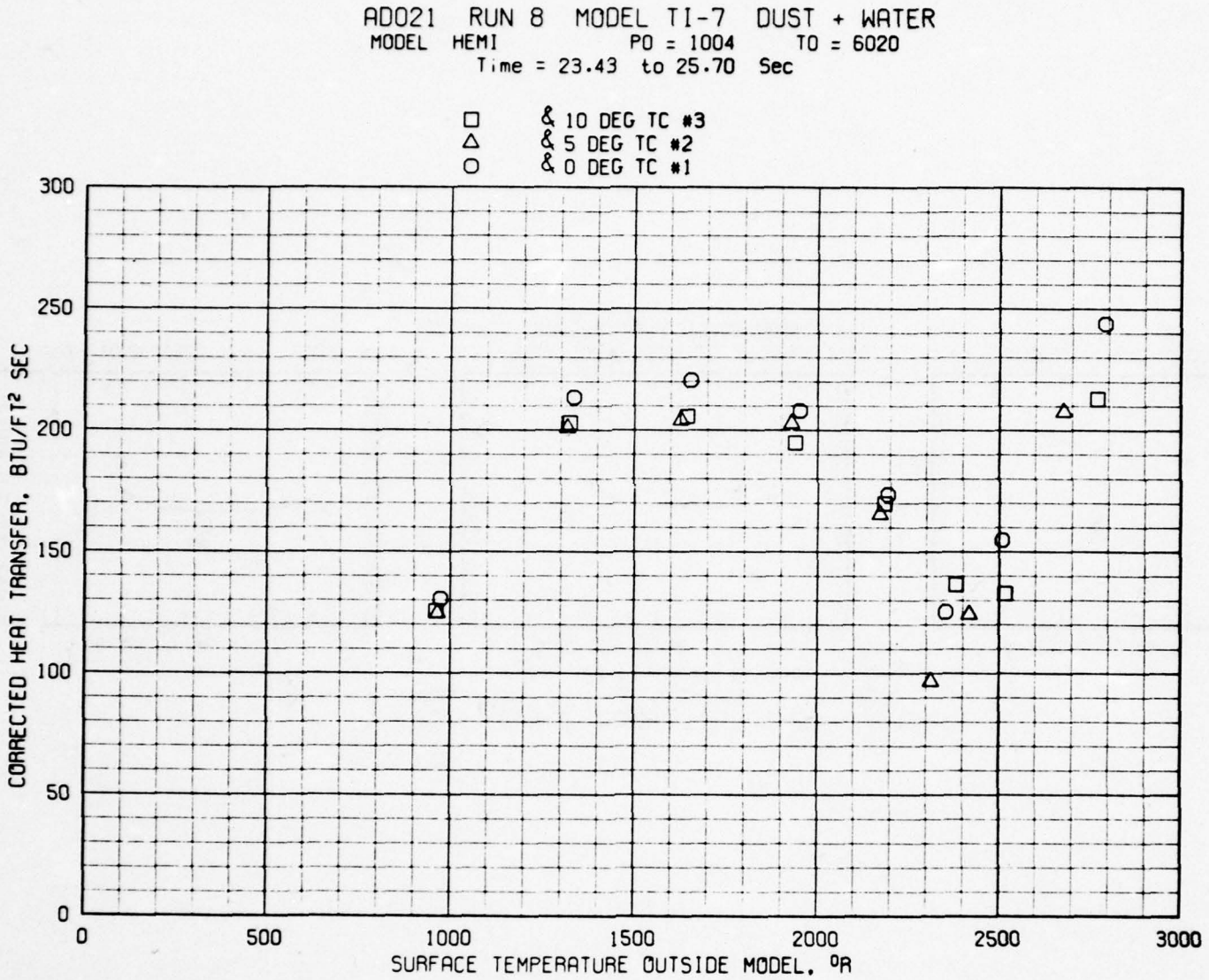

AD021 RUN 8 MODEL TI-18 DUST
MODEL HEMI PO = 1004 TO = 6020
Time = 17.11 to 19.20 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10-1
10-2
10-3
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

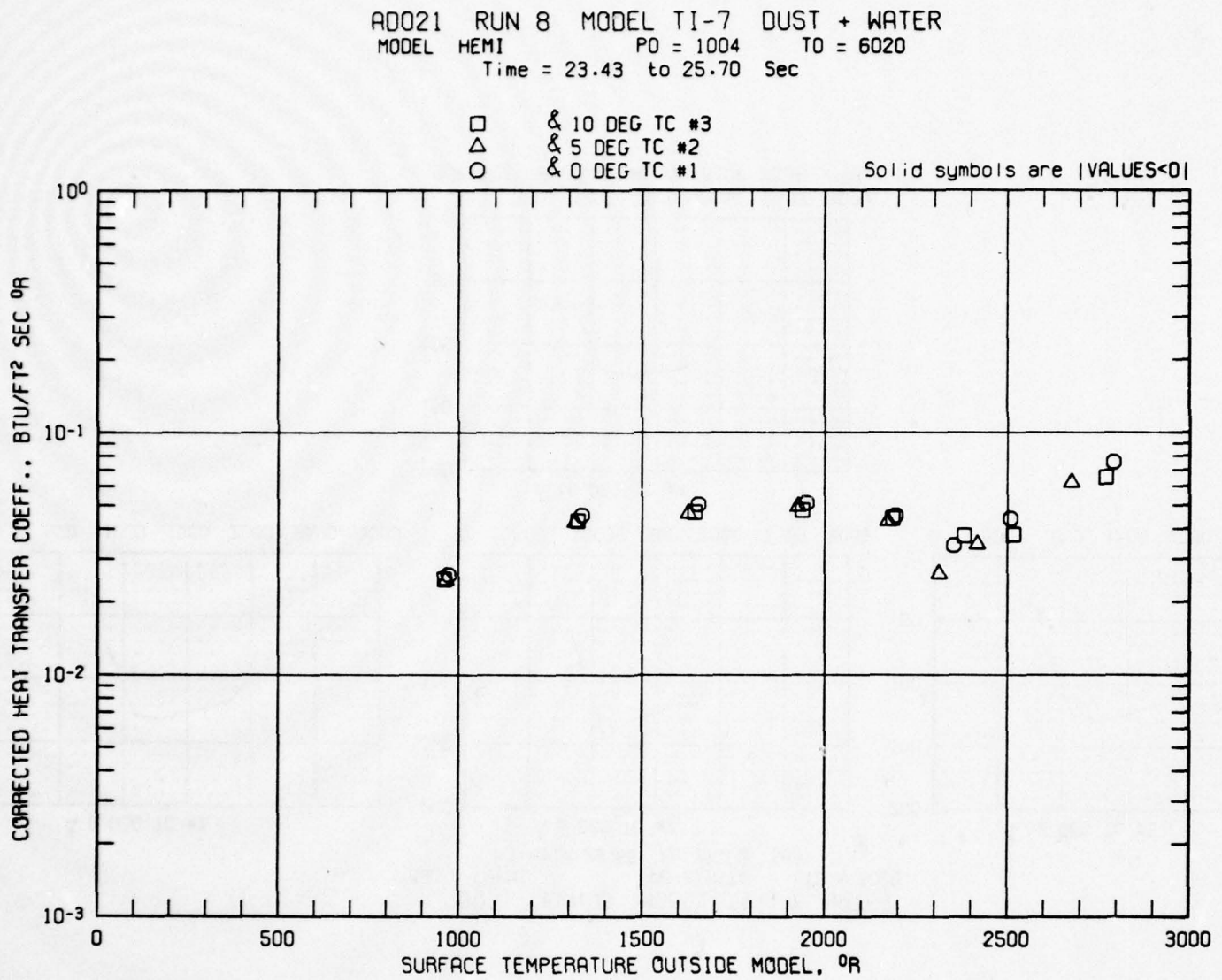

AD021 RUN 8 MODEL TI-7 DUST + WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 23.43 to 25.70 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
500
1000
1500
2000
2500
3000

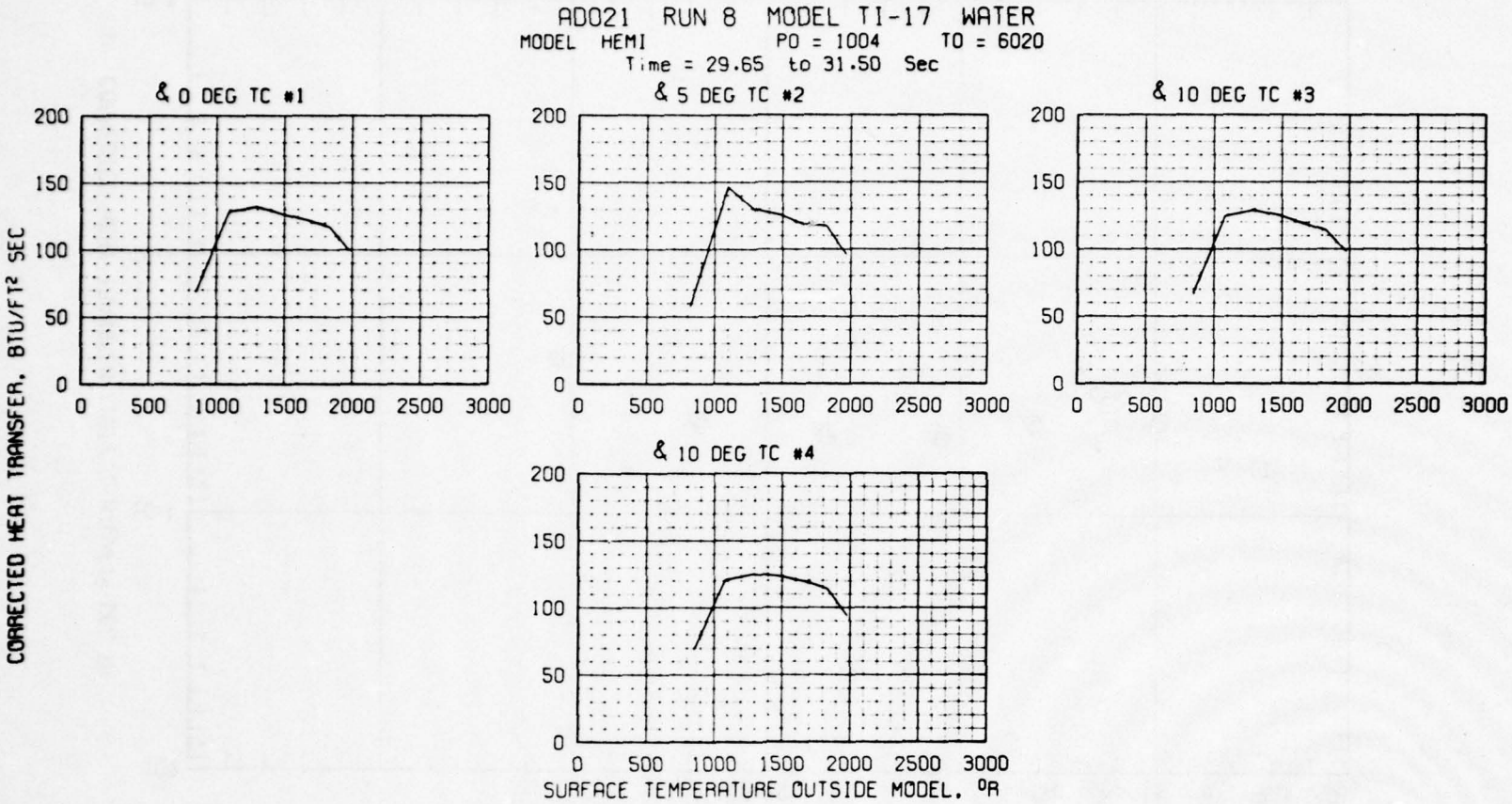

AD021 RUN 8 MODEL TI-7 DUST + WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 23.43 to 25.70 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
500
1000
1500
2000
2500
3000

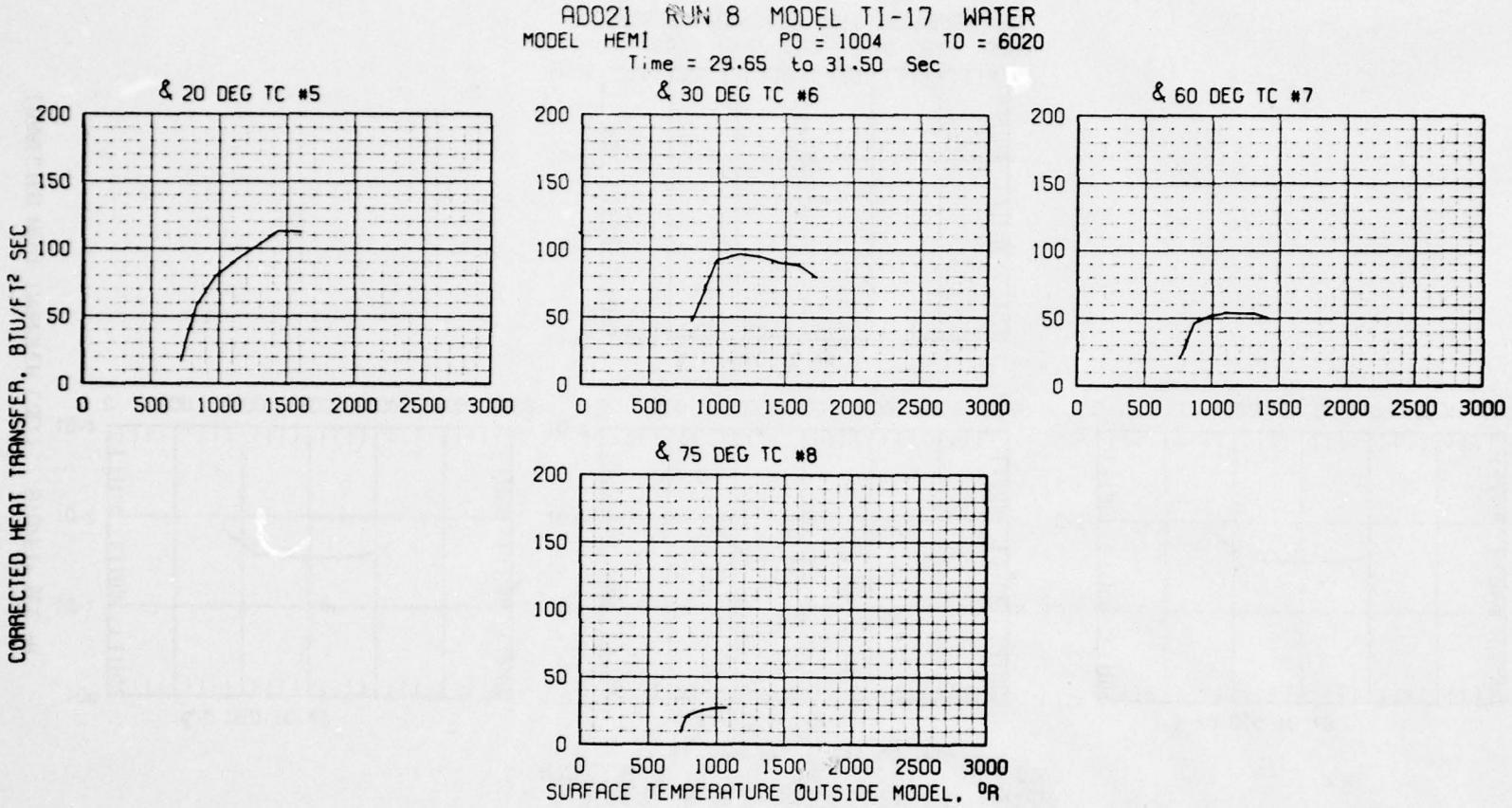

AD021 RUN 8 MODEL TI-7 , DUST + WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 23.43 to 25.70 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10-1
10-2
10-3
0
500
1000
1500
2000
2500
3000

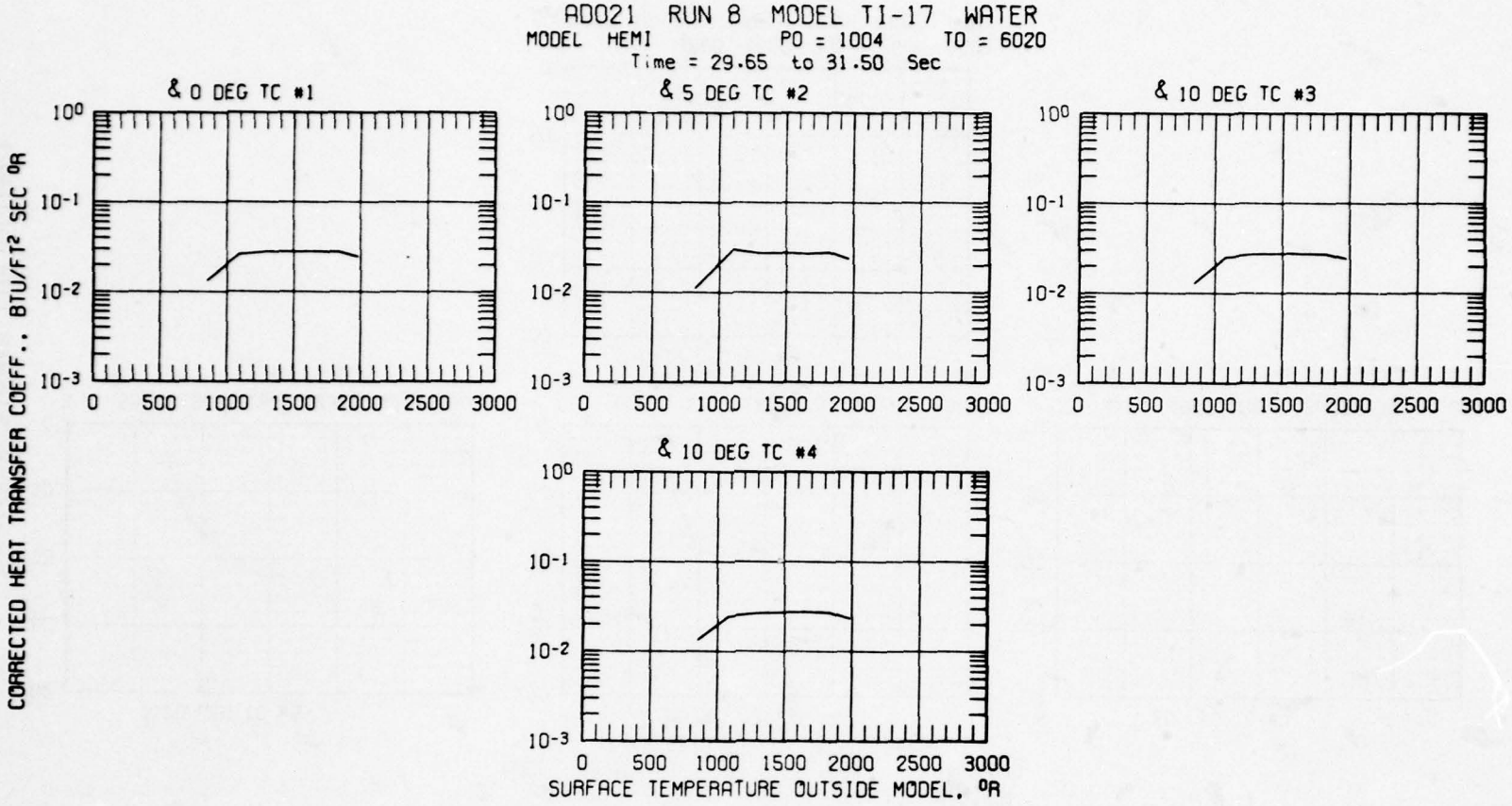

A0021 RUN 8 MODEL TI-7 DUST + WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 23.43 to 25.70 Sec
α 20 DEG TC #5
α 30 DEG TC #6
α 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

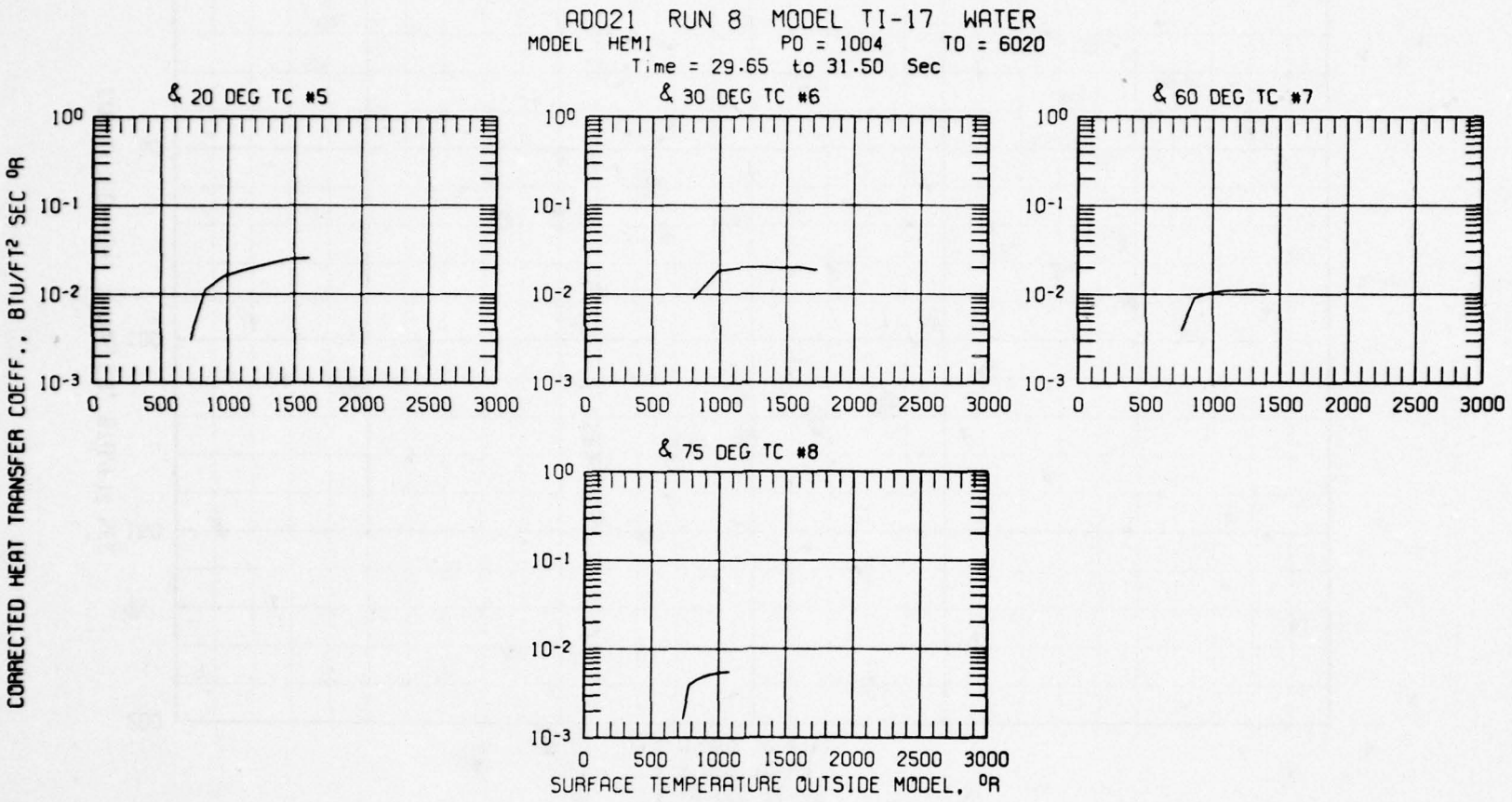

AD021 RUN 8 MODEL TI-7 DUST + WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 23.43 to 25.70 Sec
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
250
300
0
500
1000
1500
2000
2500
3000

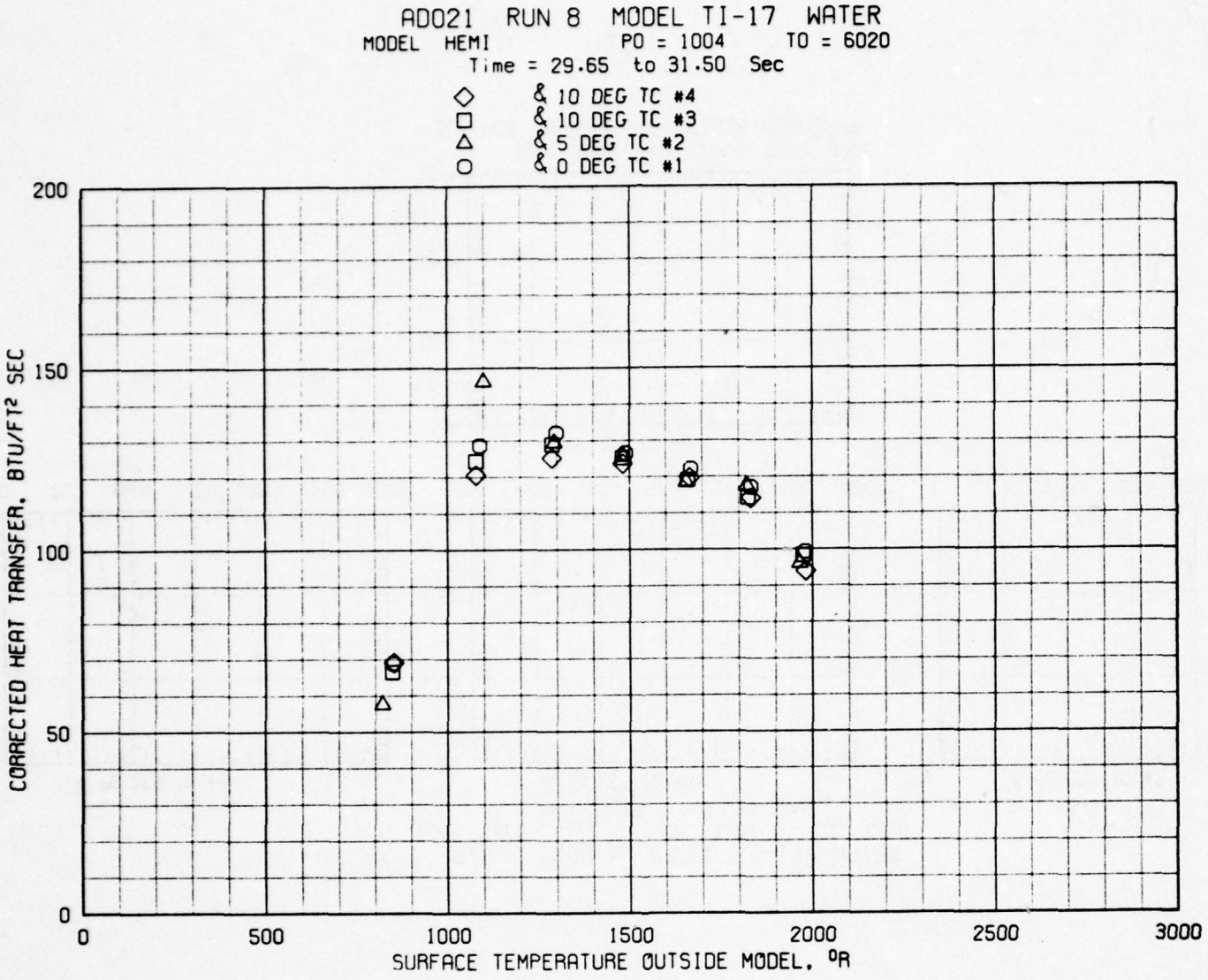

A0021 RUN 8 MODEL TI-7 DUST + WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 23.43 to 25.70 Sec
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

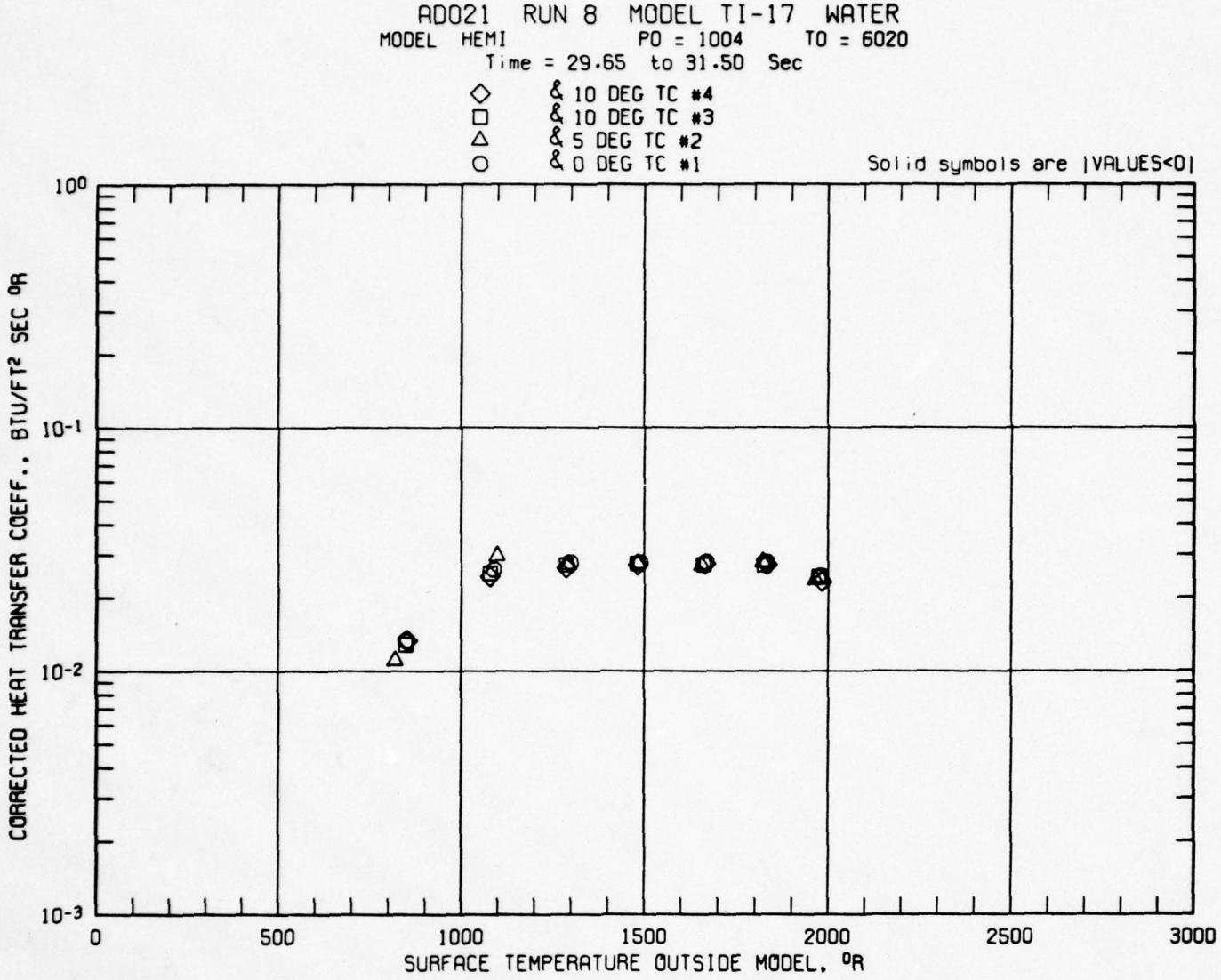

AD021 RUN 8 MODEL TI-17 WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 29.65 to 31.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
500
1000
1500
2000
2500
3000


AD021 RUN 8 MODEL TI-17 WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 29.65 to 31.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
500
1000
1500
2000
2500
3000


AD021 RUN 8 MODEL TI-17 WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 29.65 to 31.50 Sec
& 0 DEG TC #1
& 5 DEG TC #2
& 10 DEG TC #3
& 10 DEG TC #4
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 8 MODEL TI-17 WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 29.65 to 31.50 Sec
& 20 DEG TC #5
& 30 DEG TC #6
& 60 DEG TC #7
& 75 DEG TC #8
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
SURFACE TEMPERATURE OUTSIDE MODEL, °R
10⁰
10⁻¹
10⁻²
10⁻³
0 500 1000 1500 2000 2500 3000


AD021 RUN 8 MODEL TI-17 WATER
MODEL HEMI
PO = 1004
TO = 6020
Time = 29.65 to 31.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
CORRECTED HEAT TRANSFER, BTU/FT² SEC
SURFACE TEMPERATURE OUTSIDE MODEL, °R
0
50
100
150
200
0
500
1000
1500
2000
2500
3000


AD021 RUN 8 MODEL TI-17 WATER
MODEL HEMI PO = 1004 TO = 6020
Time = 29.65 to 31.50 Sec
◇ & 10 DEG TC #4
□ & 10 DEG TC #3
△ & 5 DEG TC #2
○ & 0 DEG TC #1
Solid symbols are |VALUES<0|
CORRECTED HEAT TRANSFER COEFF., BTU/FT² SEC °R
10⁰
10⁻¹
10⁻²
10⁻³
0
500
1000
1500
2000
2500
3000
SURFACE TEMPERATURE OUTSIDE MODEL, °R

APPENDIX B

SAI OXIDATION TEST DATA

SERIES 1

OXIDATION TESTS

JANUARY 1977

TITANIUM OXIDATION RUN SUMMARY: SERIES 1, JANUARY 1977

RUN NO.	SAMPLE GEOMETRY	THERMOCOUPLE TYPE	NOMINAL TEMP (^{0}K)	NOMINAL TIME (MIN)	PRESSURE (atm)	GAS COMPOSITION	WEIGHT GAIN (mg)	CHART SPEED	COMMENTS
4	Disc	E	1200	3	0.5	H_e	2.0	2"/m	
5	Disc	E	1200	3	0.5	He	1.4	2"/m	Good vacuum
6	Disc	E	1200	3	0.5	Arg.	2.0	2"/m	
7	Disc	E	1200	5	0.5	O_2	7.2	2"/m	Start heat in O_2
8	Disc	E	1200	1.5	0.5	O_2	1.6	2"/m	Noisy trace
9	Rect	S	1000	10	0.5	O_2	1.1	2"/m	Did not reach 1200 only 1000. Must re-set machine for high.
10	Rect	S	1200	5	0.5	O_2	5.4	2"/m	Had arc-over
11	Rect	S	1500	1.5	0.5	O_2	22.7	6"/m	Temp overshoot to ∿1600
12	Rect	S	1500	1.5	0.5	H_2O	35 +	6"/m	Lost some flakes
15	Rect	S	1200	∿7	0.5	H_2O	5.4	6"/m	
16	Rect	S	1200	5	0.5	Air	4.2	6"/m	Strip chart not available
17	Rect	S	1200	5	0.1	Air	6.2	6"/m	Strip chart not available
18	Rect	S	1500	1.5	0.5	50/50H_2O-Air	15	6"/m	Some flakes lost

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NICKEL-CHROMIUM vs. COPPER-NICKEL

(Chromel-Constantan)

TYPE E

Temperature in Degrees C

Reference Junction at 0°C

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
-270	-9.835											-270
-260	-9.797	-9.802	-9.808	-9.813	-9.817	-9.821	-9.825	-9.828	-9.831	-9.833	-9.835	-260
-250	-9.719	-9.728	-9.737	-9.746	-9.754	-9.762	-9.770	-9.777	-9.784	-9.791	-9.79	-250
-240	-9.604	-9.617	-9.630	-9.642	-9.654	-9.666	-9.677	-9.688	-9.699	-9.709	-9.719	-240
-230	-9.455	-9.472	-9.488	-9.503	-9.519	-9.534	-9.549	-9.563	-9.577	-9.591	-9.604	-230
-220	-9.274	-9.293	-9.313	-9.332	-9.350	-9.368	-9.386	-9.404	-9.421	-9.438	-9.455	-220
-210	-9.063	-9.085	-9.107	-9.129	-9.151	-9.172	-9.193	-9.214	-9.234	-9.254	-9.274	-210
-200	-8.824	-8.850	-8.874	-8.899	-8.923	-8.947	-8.971	-8.994	-9.017	-9.040	-9.063	-200
-190	-8.561	-8.588	-8.615	-8.642	-8.669	-8.696	-8.722	-8.748	-8.774	-8.799	-8.824	-190
-180	-8.273	-8.303	-8.333	-8.362	-8.391	-8.420	-8.449	-8.477	-8.505	-8.533	-8.561	-180
-170	-7.963	-7.995	-8.027	-8.058	-8.090	-8.121	-8.152	-8.183	-8.213	-8.243	-8.273	-170
-160	-7.631	-7.665	-7.699	-7.733	-7.767	-7.800	-7.833	-7.866	-7.898	-7.931	-7.963	-160
-150	-7.279	-7.315	-7.351	-7.387	-7.422	-7.458	-7.493	-7.528	-7.562	-7.597	-7.631	-150
-140	-6.907	-6.944	-6.980	-7.020	-7.058	-7.095	-7.132	-7.169	-7.206	-7.243	-7.279	-140
-130	-6.516	-6.556	-6.596	-6.635	-6.675	-6.714	-6.753	-6.792	-6.830	-6.869	-6.907	-130
-120	-6.107	-6.149	-6.190	-6.231	-6.273	-6.314	-6.354	-6.395	-6.436	-6.476	-6.516	-120
-110	-5.680	-5.724	-5.767	-5.810	-5.853	-5.896	-5.938	-5.981	-6.023	-6.065	-6.107	-110
-100	-5.237	-5.282	-5.327	-5.371	-5.416	-5.460	-5.505	-5.549	-5.593	-5.637	-5.680	-100
-90	-4.777	-4.824	-4.870	-4.916	-4.963	-5.009	-5.055	-5.100	-5.146	-5.191	-5.237	-90
-80	-4.301	-4.350	-4.398	-4.446	-4.495	-4.541	-4.588	-4.636	-4.683	-4.730	-4.777	-80
-70	-3.811	-3.860	-3.910	-3.959	-4.009	-4.058	-4.107	-4.156	-4.204	-4.253	-4.301	-70
-60	-3.306	-3.357	-3.408	-3.459	-3.509	-3.560	-3.610	-3.661	-3.711	-3.761	-3.811	-60
-50	-2.787	-2.839	-2.892	-2.944	-2.996	-3.049	-3.100	-3.152	-3.203	-3.254	-3.306	-50
-40	-2.254	-2.308	-2.362	-2.416	-2.469	-2.522	-2.575	-2.628	-2.681	-2.734	-2.787	-40
-30	-1.709	-1.764	-1.819	-1.874	-1.929	-1.983	-2.038	-2.092	-2.146	-2.200	-2.254	-30
-20	-1.151	-1.208	-1.264	-1.320	-1.376	-1.432	-1.487	-1.543	-1.599	-1.654	-1.709	-20
-10	-0.581	-0.639	-0.696	-0.754	-0.811	-0.868	-0.925	-0.982	-1.038	-1.095	-1.151	-10
0	0.000	-0.059	-0.117	-0.176	-0.234	-0.292	-0.350	-0.408	-0.466	-0.524	-0.581	0
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
0	0.000	0.059	0.118	0.176	0.235	0.295	0.354	0.413	0.472	0.532	0.591	0
10	0.591	0.651	0.711	0.770	0.830	0.890	0.950	1.011	1.071	1.131	1.192	10
20	1.192	1.252	1.313	1.373	1.434	1.495	1.556	1.617	1.678	1.739	1.801	20
30	1.801	1.862	1.924	1.985	2.047	2.109	2.171	2.233	2.295	2.357	2.419	30
40	2.419	2.482	2.544	2.607	2.669	2.732	2.795	2.858	2.921	2.984	3.047	40
50	3.047	3.110	3.173	3.237	3.300	3.364	3.428	3.491	3.555	3.619	3.683	50
60	3.683	3.748	3.812	3.876	3.941	4.005	4.070	4.134	4.199	4.264	4.329	60
70	4.329	4.394	4.459	4.524	4.590	4.655	4.720	4.786	4.852	4.917	4.983	70
80	4.983	5.049	5.115	5.181	5.247	5.314	5.380	5.446	5.513	5.579	5.646	80
90	5.646	5.713	5.780	5.846	5.913	5.981	6.048	6.115	6.182	6.250	6.317	90
100	6.317	6.385	6.452	6.520	6.588	6.656	6.724	6.792	6.860	6.928	6.996	100
110	6.996	7.064	7.133	7.201	7.270	7.339	7.407	7.476	7.545	7.614	7.683	110
120	7.683	7.752	7.821	7.890	7.960	8.029	8.099	8.168	8.238	8.307	8.377	120
130	8.377	8.447	8.517	8.587	8.657	8.727	8.797	8.867	8.938	9.008	9.078	130
140	9.078	9.149	9.220	9.290	9.361	9.432	9.503	9.573	9.644	9.715	9.787	140
150	9.787	9.858	9.929	10.000	10.072	10.143	10.215	10.286	10.358	10.429	10.501	150
160	10.501	10.573	10.645	10.717	10.789	10.861	10.933	11.005	11.077	11.150	11.222	160
170	11.222	11.294	11.367	11.439	11.512	11.585	11.657	11.730	11.803	11.876	11.949	170
180	11.949	12.022	12.095	12.168	12.241	12.314	12.387	12.461	12.534	12.608	12.681	180
190	12.681	12.755	12.828	12.902	12.975	13.049	13.123	13.197	13.271	13.345	13.419	190
200	13.419	13.493	13.567	13.641	13.715	13.789	13.864	13.938	14.012	14.087	14.161	200
210	14.161	14.236	14.310	14.385	14.460	14.534	14.609	14.684	14.759	14.834	14.909	210
220	14.909	14.984	15.059	15.134	15.209	15.284	15.359	15.435	15.510	15.585	15.661	220
230	15.661	15.736	15.812	15.887	15.963	16.038	16.114	16.190	16.266	16.341	16.417	230
240	16.417	16.493	16.569	16.645	16.721	16.797	16.873	16.949	17.025	17.101	17.178	240
250	17.178	17.254	17.330	17.406	17.483	17.559	17.636	17.712	17.789	17.865	17.942	250
260	17.942	18.018	18.095	18.172	18.248	18.325	18.402	18.479	18.556	18.633	18.710	260
270	18.710	18.787	18.864	18.941	19.018	19.095	19.172	19.249	19.326	19.404	19.481	270
280	19.481	19.558	19.636	19.713	19.790	19.868	19.945	20.023	20.100	20.178	20.256	280
290	20.256	20.333	20.411	20.488	20.566	20.644	20.722	20.800	20.877	20.955	21.033	290
300	21.033	21.111	21.189	21.267	21.345	21.423	21.501	21.579	21.657	21.735	21.814	300
310	21.814	21.892	21.970	22.048	22.127	22.205	22.283	22.362	22.440	22.518	22.597	310
320	22.597	22.675	22.754	22.832	22.911	22.989	23.068	23.147	23.225	23.304	23.383	320
330	23.383	23.461	23.540	23.619	23.698	23.777	23.855	23.934	24.013	24.092	24.171	330
340	24.171	24.250	24.329	24.408	24.487	24.566	24.645	24.724	24.803	24.882	24.961	340
350	24.961	25.041	25.120	25.199	25.278	25.357	25.437	25.516	25.595	25.675	25.754	350
360	25.754	25.833	25.913	25.992	26.072	26.151	26.230	26.310	26.389	26.469	26.549	360
370	26.549	26.628	26.708	26.787	26.867	26.947	27.026	27.106	27.186	27.265	27.345	370
380	27.345	27.425	27.504	27.584	27.664	27.744	27.824	27.903	27.983	28.063	28.143	380
390	28.143	28.223	28.303	28.383	28.463	28.543	28.623	28.703	28.783	28.863	28.943	390
400	28.943	29.023	29.103	29.183	29.263	29.343	29.423	29.503	29.584	29.664	29.764	400
410	29.764	29.824	29.904	29.984	30.065	30.145	30.225	30.305	30.386	30.466	30.546	410
420	30.546	30.627	30.707	30.787	30.868	30.948	31.028	31.109	31.189	31.270	31.350	420
430	31.350	31.430	31.511	31.591	31.672	31.752	31.833	31.913	31.994	32.074	32.155	430
440	32.155	32.235	32.316	32.396	32.477	32.557	32.638	32.719	32.799	32.880	32.960	440
450	32.960	33.041	33.122	33.202	33.283	33.364	33.444	33.525	33.605	33.686	33.767	450
460	33.767	33.848	33.928	34.009	34.090	34.170	34.251	34.332	34.413	34.493	34.574	460
470	34.574	34.655	34.736	34.816	34.897	34.978	35.059	35.140	35.220	35.301	35.382	470
480	35.382	35.463	35.544	35.624	35.705	35.786	35.867	35.948	36.029	36.109	36.190	480
490	36.190	36.271	36.352	36.433	36.514	36.595	36.675	36.756	36.837	36.918	36.999	490
500	36.999	37.080	37.161	37.242	37.323	37.403	37.484	37.565	37.646	37.727	37.808	500
510	37.808	37.889	37.970	38.051	38.132	38.213	38.293	38.374	38.455	38.536	38.617	510
520	38.617	38.698	38.779	38.860	38.941	39.022	39.103	39.184	39.264	39.345	39.426	520
530	39.426	39.507	39.588	39.669	39.750	39.831	39.912	39.993	40.074	40.155	40.236	530
540	40.236	40.316	40.397	40.478	40.559	40.640	40.721	40.802	40.883	40.964	41.045	540
550	41.045	41.125	41.206	41.287	41.368	41.449	41.530	41.611	41.692	41.773	41.853	550
560	41.853	41.934	42.015	42.096	42.177	42.258	42.339	42.419	42.500	42.581	42.662	560
570	42.662	42.743	42.824	42.904	42.985	43.066	43.147	43.228	43.308	43.389	43.470	570
580	43.470	43.551	43.632	43.712	43.793	43.874	43.955	44.035	44.116	44.197	44.278	580
590	44.278	44.358	44.439	44.520	44.601	44.681	44.762	44.843	44.923	45.004	45.085	590
600	45.085	45.165	45.246	45.327	45.407	45.488	45.569	45.649	45.730	45.811	45.891	600
610	45.891	45.972	46.052	46.133	46.213	46.294	46.375	46.455	46.536	46.616	46.697	610
620	46.697	46.777	46.858	46.938	47.019	47.099	47.180	47.260	47.341	47.421	47.502	620
630	47.502	47.582	47.663	47.743	47.824	47.904	47.984	48.065	48.145	48.226	48.306	630
640	48.306	48.386	48.467	48.547	48.627	48.708	48.788	48.868	48.949	49.029	49.109	640
650	49.109	49.189	49.270	49.350	49.430	49.510	49.591	49.671	49.751	49.831	49.911	650
660	49.911	49.992	50.072	50.152	50.232	50.312	50.392	50.472	50.553	50.633	50.713	660
670	50.713	50.793	50.873	50.953	51.033	51.113	51.193	51.273	51.353	51.433	51.513	670
680	51.513	51.593	51.673	51.753	51.833	51.913	51.993	52.073	52.152	52.232	52.312	680
690	52.312	52.392	52.472	52.552	52.632	52.711	52.791	52.871	52.951	53.031	53.110	690
700	53.110	53.190	53.270	53.350	53.429	53.509	53.589	53.668	53.748	53.828	53.907	700
710	53.907	53.987	54.066	54.146	54.226	54.305	54.385	54.464	54.544	54.623	54.703	710
720	54.703	54.782	54.862	54.941	55.021	55.100	55.180	55.259	55.339	55.418	55.498	720
730	55.498	55.577	55.656	55.736	55.815	55.894	55.974	56.053	56.132	56.212	56.291	730
740	56.291	56.370	56.449	56.529	56.608	56.687	56.767	56.846	56.924	57.004	57.083	740
750	57.083	57.162	57.241	57.320	57.399	57.478	57.557	57.636	57.715	57.794	57.873	750
760	57.873	57.952	58.031	58.110	58.189	58.268	58.347	58.426	58.505	58.584	58.663	760
770	58.663	58.742	58.820	58.899	58.978	59.057	59.136	59.216	59.295	59.372	59.451	770
780	59.451	59.529	59.608	59.687	59.765	59.844	59.923	60.001	60.080	60.159	60.237	780
790	60.237	60.316	60.394	60.473	60.551	60.630	60.708	60.787	60.865	60.944	61.022	790
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C

TYPE E

NEW REFERENCE TABLES
SUPERSEDES N.B.S. CIRCULAR #561

OMEGA ENGINEERING INC.

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NICKEL-CHROMIUM vs. COPPER-NICKEL

TYPE E

(Chromel-Constantan)

Temperature in Degrees C

Reference Junction at 0°C

TYPE E

NEW REFERENCE TABLES
SUPERSEDES N.B.S. CIRCULAR #561

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
800	61.022	61.101	61.179	61.258	61.336	61.414	61.493	61.571	61.649	61.728	61.806	800
810	61.806	61.884	61.962	62.041	62.119	62.197	62.275	62.353	62.432	62.510	62.588	810
820	62.588	62.666	62.744	62.822	62.900	62.978	63.056	63.134	63.212	63.290	63.368	820
830	63.368	63.446	63.524	63.602	-3.680	63.758	63.836	63.914	63.992	64.069	64.147	830
840	64.147	64.225	64.303	64.380	64.458	64.536	64.614	64.691	64.769	64.847	64.924	840
850	64.924	65.002	65.080	65.157	65.235	65.312	65.390	65.467	65.545	65.622	65.700	850
860	65.700	65.777	65.855	65.932	66.009	66.087	66.164	66.241	66.319	66.396	66.473	860
870	66.473	66.551	66.628	66.705	66.782	66.859	66.937	67.014	67.091	67.168	67.245	870
880	67.245	67.322	67.399	67.476	67.553	67.630	67.707	67.784	67.861	67.938	68.015	880
890	68.015	68.092	68.169	68.246	68.323	68.399	68.476	68.553	68.630	68.706	68.783	890
900	68.783	68.860	68.936	69.013	69.090	69.166	69.243	69.320	69.396	69.473	69.549	900
910	69.549	69.626	69.702	69.779	69.855	69.931	70.008	70.084	70.161	70.237	70.313	910
920	70.313	70.390	70.466	70.542	70.618	70.694	70.771	70.847	70.923	70.999	71.075	920
930	71.075	71.151	71.227	71.304	71.380	71.456	71.532	71.608	71.683	71.759	71.835	930
940	71.835	71.911	71.987	72.063	72.139	72.215	72.290	72.366	72.442	72.518	72.593	940
950	72.593	72.669	72.745	72.820	72.896	72.972	73.047	73.123	73.199	73.274	73.350	950
960	73.350	73.425	73.501	73.576	73.652	73.727	73.802	73.878	73.953	74.029	74.104	960
970	74.104	74.179	74.255	74.330	74.405	74.480	74.556	74.631	74.706	74.781	74.857	970
980	74.857	74.932	75.007	75.082	75.157	75.232	75.307	75.382	75.458	75.533	75.608	980
990	75.608	75.683	75.758	75.833	75.908	75.983	76.058	76.133	76.208	76.283	76.358	990
1.000	76.358											1.000
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C

COPPER vs. COPPER-NICKEL

TYPE T

(Copper-Constantan)

Temperature in Degrees C

Reference Junction at 0°C

TYPE T

NEW REFERENCE TABLES
SUPERSEDES N.B.S. CIRCULAR #561

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
-270	-6.258											-270
-260	-6.232	-6.236	-6.239	-6.242	-6.245	-6.248	-6.251	-6.253	-6.255	-6.256	-6.258	-260
-250	-6.181	-6.187	-6.193	-6.198	-6.204	-6.209	-6.214	-6.219	-6.224	-6.228	-6.232	-250
-240	-6.105	-6.114	-6.122	-6.130	-6.138	-6.146	-6.153	-6.160	-6.167	-6.174	-6.181	-240
-230	-6.007	-6.018	-6.028	-6.039	-6.049	-6.059	-6.068	-6.078	-6.087	-6.096	-6.105	-230
-220	-5.889	-5.901	-5.914	-5.926	-5.938	-5.950	-5.962	-5.973	-5.985	-5.996	-6.007	-220
-210	-5.753	-5.767	-5.782	-5.795	-5.809	-5.823	-5.836	-5.850	-5.863	-5.876	-5.889	-210
-200	-5.603	-5.619	-5.634	-5.650	-5.665	-5.680	-5.695	-5.710	-5.724	-5.739	-5.753	-200
-190	-5.439	-5.456	-5.473	-5.489	-5.506	-5.522	-5.539	-5.555	-5.571	-5.587	-5.603	-190
-180	-5.261	-5.279	-5.297	-5.315	-5.333	-5.351	-5.369	-5.387	-5.404	-5.421	-5.439	-180
-170	-5.069	-5.089	-5.109	-5.128	-5.147	-5.167	-5.186	-5.205	-5.223	-5.242	-5.261	-170
-160	-4.865	-4.886	-4.907	-4.928	-4.948	-4.969	-4.989	-5.010	-5.030	-5.050	-5.069	-160
-150	-4.648	-4.670	-4.693	-4.715	-4.737	-4.758	-4.780	-4.801	-4.823	-4.844	-4.865	-150
-140	-4.419	-4.442	-4.466	-4.489	-4.512	-4.535	-4.558	-4.581	-4.603	-4.626	-4.648	-140
-130	-4.177	-4.202	-4.226	-4.251	-4.275	-4.299	-4.323	-4.347	-4.371	-4.395	-4.419	-130
-120	-3.923	-3.949	-3.976	-4.000	-4.026	-4.051	-4.077	-4.102	-4.127	-4.152	-4.177	-120
-110	-3.656	-3.684	-3.711	-3.737	-3.764	-3.791	-3.818	-3.844	-3.870	-3.897	-3.923	-110
-100	-3.378	-3.407	-3.435	-3.463	-3.491	-3.519	-3.547	-3.574	-3.602	-3.629	-3.656	-100
-90	-3.089	-3.118	-3.147	-3.177	-3.206	-3.235	-3.264	-3.293	-3.321	-3.350	-3.378	-90
-80	-2.788	-2.818	-2.849	-2.879	-2.909	-2.939	-2.970	-2.999	-3.029	-3.059	-3.089	-80
-70	-2.475	-2.507	-2.539	-2.570	-2.602	-2.633	-2.664	-2.695	-2.726	-2.757	-2.788	-70
-60	-2.152	-2.185	-2.218	-2.250	-2.283	-2.315	-2.348	-2.380	-2.412	-2.444	-2.475	-60
-50	-1.819	-1.853	-1.886	-1.920	-1.953	-1.987	-2.020	-2.053	-2.087	-2.120	-2.152	-50
-40	-1.475	-1.510	-1.544	-1.579	-1.614	-1.648	-1.682	-1.717	-1.751	-1.785	-1.819	-40
-30	-1.121	-1.157	-1.192	-1.228	-1.263	-1.299	-1.334	-1.370	-1.405	-1.440	-1.475	-30
-20	-0.757	-0.794	-0.830	-0.867	-0.903	-0.940	-0.976	-1.013	-1.049	-1.085	-1.121	-20
-10	-0.383	-0.421	-0.458	-0.496	-0.534	-0.571	-0.608	-0.646	-0.683	-0.720	-0.757	-10
0	0.000	-0.039	-0.077	-0.116	-0.154	-0.193	-0.231	-0.269	-0.307	-0.345	-0.383	0

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
0	0.000	0.039	0.078	0.117	0.156	0.195	0.234	0.273	0.312	0.351	0.391	0
10	0.391	0.430	0.470	0.510	0.549	0.589	0.629	0.669	0.709	0.749	0.789	10
20	0.789	0.830	0.870	0.911	0.951	0.992	1.032	1.073	1.114	1.155	1.196	20
30	1.196	1.237	1.279	1.320	1.361	1.403	1.444	1.486	1.528	1.569	1.611	30
40	1.611	1.653	1.695	1.738	1.780	1.822	1.865	1.907	1.950	1.992	2.035	40
50	2.035	2.078	2.121	2.164	2.207	2.250	2.294	2.337	2.380	2.424	2.467	50
60	2.467	2.511	2.555	2.599	2.643	2.687	2.731	2.775	2.819	2.864	2.908	60
70	2.908	2.953	2.997	3.042	3.087	3.131	3.176	3.221	3.266	3.312	3.357	70
80	3.357	3.402	3.447	3.493	3.538	3.584	3.630	3.676	3.722	3.767	3.813	80
90	3.813	3.859	3.906	3.952	3.998	4.044	4.091	4.137	4.184	4.231	4.277	90
100	4.277	4.324	4.371	4.418	4.465	4.512	4.559	4.607	4.654	4.701	4.749	100
110	4.749	4.796	4.844	4.891	4.939	4.987	5.035	5.083	5.131	5.179	5.227	110
120	5.227	5.275	5.324	5.372	5.420	5.469	5.517	5.566	5.615	5.663	5.712	120
130	5.712	5.761	5.810	5.859	5.908	5.957	6.007	6.056	6.105	6.155	6.204	130
140	6.204	6.254	6.303	6.353	6.403	6.452	6.502	6.552	6.602	6.652	6.702	140
150	6.702	6.753	6.803	6.853	6.903	6.954	7.004	7.055	7.106	7.156	7.207	150
160	7.207	7.258	7.309	7.360	7.411	7.462	7.513	7.564	7.615	7.666	7.718	160
170	7.718	7.769	7.821	7.872	7.924	7.975	8.027	8.079	8.131	8.183	8.235	170
180	8.235	8.287	8.339	8.391	8.443	8.495	8.548	8.600	8.652	8.705	8.757	180
190	8.757	8.810	8.863	8.915	8.968	9.021	9.074	9.127	9.180	9.233	9.286	190
200	9.286	9.339	9.392	9.446	9.499	9.553	9.606	9.659	9.713	9.767	9.820	200
210	9.820	9.874	9.928	9.982	10.036	10.090	10.144	10.198	10.252	10.306	10.360	210
220	10.360	10.414	10.469	10.523	10.578	10.632	10.687	10.741	10.796	10.851	10.905	220
230	10.905	10.960	11.015	11.070	11.125	11.180	11.235	11.290	11.345	11.401	11.456	230
240	11.456	11.511	11.566	11.622	11.677	11.733	11.788	11.844	11.900	11.956	12.011	240
250	12.011	12.067	12.123	12.179	12.235	12.291	12.347	12.403	12.459	12.515	12.572	250
260	12.572	12.628	12.684	12.741	12.797	12.854	12.910	12.967	13.024	13.080	13.137	260
270	13.137	13.194	13.251	13.307	13.364	13.421	13.478	13.535	13.592	13.650	13.707	270
280	13.707	13.764	13.821	13.879	13.936	13.993	14.051	14.108	14.166	14.223	14.281	280
290	14.281	14.339	14.396	14.454	14.512	14.570	14.628	14.686	14.744	14.802	14.860	290
300	14.860	14.918	14.976	15.034	15.092	15.151	15.209	15.267	15.326	15.384	15.443	300
310	15.443	15.501	15.560	15.619	15.677	15.736	15.795	15.853	15.912	15.971	16.030	310
320	16.030	16.089	16.148	16.207	16.266	16.325	16.384	16.444	16.503	16.562	16.621	320
330	16.621	16.681	16.740	16.800	16.859	16.919	16.978	17.038	17.097	17.157	17.217	330
340	17.217	17.277	17.336	17.396	17.456	17.516	17.576	17.636	17.696	17.756	17.816	340
350	17.816	17.877	17.937	17.997	18.057	18.118	18.178	18.238	18.299	18.359	18.420	350
360	18.420	18.480	18.541	18.602	18.662	18.723	18.784	18.845	18.905	18.966	19.027	360
370	19.027	19.088	19.149	19.210	19.271	19.332	19.393	19.455	19.516	19.577	19.638	370
380	19.638	19.699	19.761	19.822	19.883	19.945	20.006	20.068	20.129	20.191	20.252	380
390	20.252	20.314	20.376	20.437	20.499	20.560	20.622	20.684	20.746	20.807	20.869	390
400	20.869											400
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C

OMEGA ENGINEERING INC.

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PLATINUM vs. PLATINUM-10% RHODIUM — TYPE S

Temperature in Degrees C — Reference Junction at 0°C

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
0	0.000	0.005	0.011	0.016	0.022	0.027	0.033	0.038	0.044	0.050	0.055	0
10	0.055	0.061	0.067	0.072	0.078	0.084	0.090	0.095	0.101	0.107	0.113	10
20	0.113	0.119	0.125	0.131	0.137	0.142	0.148	0.154	0.161	0.167	0.173	20
30	0.173	0.179	0.185	0.191	0.197	0.203	0.210	0.216	0.222	0.228	0.235	30
40	0.235	0.241	0.247	0.254	0.260	0.266	0.273	0.279	0.286	0.292	0.299	40
50	0.299	0.305	0.312	0.318	0.325	0.331	0.338	0.345	0.351	0.358	0.365	50
60	0.365	0.371	0.378	0.385	0.391	0.398	0.405	0.412	0.419	0.425	0.432	60
70	0.432	0.439	0.446	0.453	0.460	0.467	0.474	0.481	0.488	0.495	0.502	70
80	0.502	0.509	0.516	0.523	0.530	0.537	0.544	0.551	0.558	0.566	0.573	80
90	0.573	0.580	0.587	0.594	0.602	0.609	0.616	0.623	0.631	0.638	0.645	90
100	0.645	0.653	0.660	0.667	0.675	0.682	0.690	0.697	0.704	0.712	0.719	100
110	0.719	0.727	0.734	0.742	0.749	0.757	0.764	0.772	0.780	0.787	0.795	110
120	0.795	0.802	0.810	0.818	0.825	0.833	0.841	0.848	0.856	0.864	0.872	120
130	0.872	0.879	0.887	0.895	0.903	0.910	0.918	0.926	0.934	0.942	0.950	130
140	0.950	0.957	0.965	0.973	0.981	0.989	0.997	1.005	1.013	1.021	1.029	140
150	1.029	1.037	1.045	1.053	1.061	1.069	1.077	1.085	1.093	1.101	1.109	150
160	1.109	1.117	1.125	1.133	1.141	1.149	1.158	1.166	1.174	1.182	1.190	160
170	1.190	1.198	1.207	1.215	1.223	1.231	1.240	1.248	1.256	1.264	1.273	170
180	1.273	1.281	1.289	1.297	1.306	1.314	1.322	1.331	1.339	1.347	1.356	180
190	1.356	1.364	1.373	1.381	1.389	1.398	1.406	1.415	1.423	1.432	1.440	190
200	1.440	1.448	1.457	1.465	1.474	1.482	1.491	1.499	1.508	1.516	1.525	200
210	1.525	4.534	1.542	1.551	1.559	1.568	1.576	1.585	1.594	1.602	1.611	210
220	1.611	1.620	1.628	1.637	1.645	1.654	1.663	1.671	1.680	1.689	1.698	220
230	1.698	1.706	1.715	1.724	1.732	1.741	1.750	1.759	1.767	1.776	1.785	230
240	1.785	1.794	1.802	1.811	1.820	1.829	1.838	1.846	1.855	1.864	1.873	240
250	1.873	1.882	1.891	1.899	1.908	1.917	1.926	1.935	1.944	1.953	1.962	250
260	1.962	1.971	1.979	1.988	1.997	2.006	2.015	2.024	2.033	2.042	2.051	260
270	2.051	2.060	2.069	2.078	2.087	2.096	2.105	2.114	2.123	2.132	2.141	270
280	2.141	2.150	2.159	2.168	2.177	2.186	2.195	2.204	2.213	2.222	2.232	280
290	2.232	2.241	2.250	2.259	2.268	2.277	2.286	2.295	2.304	2.314	2.323	290
300	2.323	2.332	2.341	2.350	2.359	2.368	2.378	2.387	2.396	2.405	2.414	300
310	2.414	2.424	2.433	2.442	2.451	2.460	2.470	2.479	2.488	2.497	2.506	310
320	2.506	2.516	2.525	2.534	2.543	2.553	2.562	2.571	2.581	2.590	2.599	320
330	2.599	2.608	2.618	2.627	2.636	2.646	2.655	2.664	2.674	2.683	2.692	330
340	2.692	2.702	2.711	2.720	2.730	2.739	2.748	2.758	2.767	2.776	2.786	340
350	2.786	2.795	2.805	2.814	2.823	2.833	2.842	2.852	2.861	2.870	2.880	350
360	2.880	2.889	2.899	2.908	2.917	2.927	2.936	2.946	2.955	2.965	2.974	360
370	2.974	2.984	2.993	3.003	3.012	3.022	3.031	3.041	3.050	3.059	3.069	370
380	3.069	3.078	3.088	3.097	3.107	3.117	3.126	3.136	3.145	3.155	3.164	380
390	3.164	3.174	3.183	3.193	3.202	3.212	3.221	3.231	3.241	3.250	3.260	390
400	3.260	3.269	3.279	3.288	3.298	3.308	3.317	3.327	3.336	3.346	3.356	400
410	3.356	3.365	3.375	3.384	3.394	3.404	3.413	3.423	3.433	3.442	3.452	410
420	3.452	3.462	3.471	3.481	3.491	3.500	3.510	3.520	3.529	3.539	3.549	420
430	3.549	3.558	3.568	3.578	3.587	3.597	3.607	3.616	3.626	3.636	3.645	430
440	3.645	3.655	3.665	3.675	3.684	3.694	3.704	3.714	3.723	3.733	3.743	440
450	3.743	3.752	3.762	3.772	3.782	3.791	3.801	3.811	3.821	3.831	3.840	450
460	3.840	3.850	3.860	3.870	3.879	3.889	3.899	3.909	3.919	3.928	3.938	460
470	3.938	3.948	3.958	3.968	3.977	3.987	3.997	4.007	4.017	4.027	4.036	470
480	4.036	4.046	4.056	4.066	4.076	4.086	4.095	4.105	4.115	4.125	4.135	480
490	4.135	4.145	4.155	4.164	4.174	4.184	4.194	4.204	4.214	4.224	4.234	490
500	4.234	4.243	4.253	4.263	4.273	4.283	4.293	4.303	4.313	4.323	4.333	500
510	4.333	4.343	4.352	4.362	4.372	4.382	4.392	4.402	4.412	4.422	4.432	510
520	4.432	4.442	4.452	4.462	4.472	4.482	4.492	4.502	4.512	4.522	4.532	520
530	4.532	4.542	4.552	4.562	4.572	4.582	4.592	4.602	4.612	4.622	4.632	530
540	4.632	4.642	4.652	4.662	4.672	4.682	4.692	4.702	4.712	4.722	4.732	540
550	4.732	4.742	4.752	4.762	4.772	4.782	4.792	4.802	4.812	4.822	4.832	550
560	4.832	4.842	4.852	4.862	4.873	4.883	4.893	4.903	4.913	4.923	4.933	560
570	4.933	4.943	4.953	4.963	4.973	4.984	4.994	5.004	5.014	5.024	5.034	570
580	5.034	5.044	5.054	5.065	5.075	5.085	5.095	5.105	5.115	5.125	5.136	580
590	5.136	5.146	5.156	5.166	5.176	5.186	5.197	5.207	5.217	5.227	5.237	590
600	5.237	5.247	5.258	5.268	5.278	5.288	5.298	5.309	5.319	5.329	5.339	600
610	5.339	5.350	5.360	5.370	5.380	5.391	5.401	5.411	5.421	5.431	5.442	610
620	5.442	5.452	5.462	5.473	5.483	5.493	5.503	5.514	5.524	5.534	5.544	620
630	5.544	5.555	5.565	5.575	5.586	5.596	5.606	5.617	5.627	5.637	5.648	630
640	5.648	5.658	5.668	5.679	5.689	5.700	5.710	5.720	5.731	5.741	5.751	640
650	5.751	5.762	5.772	5.782	5.793	5.803	5.814	5.824	5.834	5.845	5.855	650
660	5.855	5.866	5.876	5.887	5.897	5.907	5.918	5.928	5.939	5.949	5.960	660
670	5.960	5.970	5.980	5.991	6.001	6.012	6.022	6.033	6.043	6.054	6.064	670
680	6.064	6.075	6.085	6.096	6.106	6.117	6.127	6.138	6.148	6.159	6.169	680
690	6.169	6.180	6.190	6.201	6.211	6.222	6.232	6.243	6.253	6.264	6.274	690
700	6.274	6.285	6.295	6.306	6.316	6.327	6.338	6.348	6.359	6.369	6.380	700
710	6.380	6.390	6.401	6.412	6.422	6.433	6.443	6.454	6.465	6.475	6.486	710
720	6.486	6.496	6.507	6.518	6.528	6.539	6.549	6.560	6.571	6.581	6.592	720
730	6.592	6.603	6.613	6.624	6.635	6.645	6.656	6.667	6.677	6.688	6.699	730
740	6.699	6.709	6.720	6.731	6.741	6.752	6.763	6.773	6.784	6.795	6.805	740
750	6.805	6.816	6.827	6.838	6.848	6.859	6.870	6.880	6.891	6.902	6.913	750
760	6.913	6.923	6.934	6.945	6.956	6.966	6.977	6.988	6.999	7.009	7.020	760
770	7.020	7.031	7.042	7.053	7.063	7.074	7.085	7.096	7.107	7.117	7.128	770
780	7.128	7.139	7.150	7.161	7.171	7.182	7.193	7.204	7.215	7.225	7.236	780
790	7.236	7.247	7.258	7.269	7.280	7.291	7.301	7.312	7.323	7.334	7.345	790
800	7.345	7.356	7.367	7.377	7.388	7.399	7.410	7.421	7.432	7.443	7.454	800
810	7.454	7.465	7.476	7.486	7.497	7.508	7.519	7.530	7.541	7.552	7.563	810
820	7.563	7.574	7.585	7.596	7.607	7.618	7.629	7.640	7.651	7.661	7.672	820
830	7.672	7.683	7.694	7.705	7.716	7.727	7.738	7.749	7.760	7.771	7.782	830
840	7.782	7.793	7.804	7.815	7.826	7.837	7.848	7.859	7.870	7.881	7.892	840
850	7.892	7.904	7.915	7.926	7.937	7.948	7.959	7.970	7.981	7.992	8.003	850
860	8.003	8.014	8.025	8.036	8.047	8.058	8.069	8.081	8.092	8.103	8.114	860
870	8.114	8.125	8.136	8.147	8.158	8.169	8.180	8.192	8.203	8.214	8.225	870
880	8.225	8.236	8.247	8.258	8.270	8.281	8.292	8.303	8.314	8.325	8.336	880
890	8.336	8.348	8.359	8.370	8.381	8.392	8.404	8.415	8.426	8.437	8.448	890
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C

TYPE S

NEW REFERENCE TABLES
SUPERSEDES N.B.S. CIRCULAR #561

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PLATINUM vs. PLATINUM-10% RHODIUM — TYPE S

Temperature in Degrees C — Reference Junction at 0°C

TYPE S

NEW REFERENCE TABLES
SUPERSEDES N.B.S. CIRCULAR #561

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
					THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS							
900	8.448	8.460	8.471	8.482	8.493	8.504	8.516	8.527	8.538	8.549	8.560	900
910	8.560	8.572	8.583	8.594	8.605	8.617	8.628	8.639	8.650	8.662	8.673	910
920	8.673	8.684	8.695	8.707	8.718	8.729	8.741	8.752	8.763	8.774	8.786	920
930	8.786	8.797	8.808	8.820	8.831	8.842	8.854	8.865	8.876	8.888	8.899	930
940	8.899	8.910	8.922	8.933	8.944	8.956	8.967	8.978	8.990	9.001	9.012	940
950	9.012	9.024	9.035	9.047	9.058	9.069	9.081	9.092	9.103	9.115	9.126	950
960	9.126	9.138	9.149	9.160	9.172	9.183	9.195	9.206	9.217	9.229	9.240	960
970	9.240	9.252	9.263	9.275	9.286	9.298	9.309	9.320	9.332	9.343	9.355	970
980	9.355	9.366	9.378	9.389	9.401	9.412	9.424	9.435	9.447	9.458	9.470	980
990	9.470	9.481	9.493	9.504	9.516	9.527	9.539	9.550	9.562	9.573	9.585	990
1,000	9.585	9.596	9.608	9.619	9.631	9.642	9.654	9.665	9.677	9.689	9.700	1,000
1,010	9.700	9.712	9.723	9.735	9.746	9.758	9.770	9.781	9.793	9.804	9.816	1,010
1,020	9.816	9.828	9.839	9.851	9.862	9.874	9.886	9.897	9.909	9.920	9.932	1,020
1,030	9.932	9.944	9.955	9.967	9.979	9.990	10.002	10.013	10.025	10.037	10.048	1,030
1,040	10.048	10.060	10.072	10.083	10.095	10.107	10.118	10.130	10.142	10.154	10.165	1,040
1,050	10.165	10.177	10.189	10.200	10.212	10.224	10.235	10.247	10.259	10.271	10.282	1,050
1,060	10.282	10.294	10.306	10.318	10.329	10.341	10.353	10.364	10.376	10.388	10.400	1,060
1,070	10.400	10.411	10.423	10.435	10.447	10.459	10.470	10.482	10.494	10.506	10.517	1,070
1,080	10.517	10.529	10.541	10.553	10.565	10.576	10.588	10.600	10.612	10.624	10.635	1,080
1,090	10.635	10.647	10.659	10.671	10.683	10.694	10.706	10.718	10.730	10.742	10.754	1,090
1,100	10.754	10.765	10.777	10.789	10.801	10.813	10.825	10.836	10.848	10.860	10.872	1,100
1,110	10.872	10.884	10.896	10.908	10.919	10.931	10.943	10.955	10.967	10.979	10.991	1,110
1,120	10.991	11.003	11.014	11.026	11.038	11.050	11.062	11.074	11.086	11.098	11.110	1,120
1,130	11.110	11.121	11.133	11.145	11.157	11.169	11.181	11.193	11.205	11.217	11.229	1,130
1,140	11.229	11.241	11.252	11.264	11.276	11.288	11.300	11.312	11.324	11.336	11.348	1,140
1,150	11.348	11.360	11.372	11.384	11.396	11.408	11.420	11.432	11.443	11.455	11.467	1,150
1,160	11.467	11.479	11.491	11.503	11.515	11.527	11.539	11.551	11.563	11.575	11.587	1,160
1,170	11.587	11.599	11.611	11.623	11.635	11.647	11.659	11.671	11.683	11.695	11.707	1,170
1,180	11.707	11.719	11.731	11.743	11.755	11.767	11.779	11.791	11.803	11.815	11.827	1,180
1,190	11.827	11.839	11.851	11.863	11.875	11.887	11.899	11.911	11.923	11.935	11.947	1,190
1,200	11.947	11.959	11.971	11.983	11.995	12.007	12.019	12.031	12.043	12.055	12.067	1,200
1,210	12.067	12.079	12.091	12.103	12.116	12.128	12.140	12.152	12.164	12.176	12.188	1,210
1,220	12.188	12.200	12.212	12.224	12.236	12.248	12.260	12.272	12.284	12.296	12.308	1,220
1,230	12.308	12.320	12.332	12.345	12.357	12.369	12.381	12.393	12.405	12.417	12.429	1,230
1,240	12.429	12.441	12.453	12.465	12.477	12.489	12.501	12.514	12.526	12.538	12.550	1,240
1,250	12.550	12.562	12.574	12.586	12.598	12.610	12.622	12.634	12.647	12.659	12.671	1,250
1,260	12.671	12.683	12.695	12.707	12.719	12.731	12.743	12.755	12.767	12.780	12.792	1,260
1,270	12.792	12.804	12.816	12.828	12.840	12.852	12.864	12.876	12.888	12.901	12.913	1,270
1,280	12.913	12.925	12.937	12.949	12.961	12.973	12.985	12.997	13.010	13.022	13.034	1,280
1,290	13.034	13.046	13.058	13.070	13.082	13.094	13.107	13.119	13.131	13.143	13.155	1,290
1,300	13.155	13.167	13.179	13.191	13.203	13.216	13.228	13.240	13.252	13.264	13.276	1,300
1,310	13.276	13.288	13.300	13.313	13.325	13.337	13.349	13.361	13.373	13.385	13.397	1,310
1,320	13.397	13.410	13.422	13.434	13.446	13.458	13.470	13.482	13.495	13.507	13.519	1,320
1,330	13.519	13.531	13.543	13.555	13.567	13.579	13.592	13.604	13.616	13.628	13.640	1,330
1,340	13.640	13.652	13.664	13.677	13.689	13.701	13.713	13.725	13.737	13.749	13.761	1,340
1,350	13.761	13.774	13.786	13.798	13.810	13.822	13.834	13.846	13.859	13.871	13.883	1,350
1,360	13.883	13.895	13.907	13.919	13.931	13.943	13.956	13.968	13.980	13.992	14.004	1,360
1,370	14.004	14.016	14.028	14.040	14.053	14.065	14.077	14.089	14.101	14.113	14.125	1,370
1,380	14.125	14.138	14.150	14.162	14.174	14.186	14.198	14.210	14.222	14.235	14.247	1,380
1,390	14.247	14.259	14.271	14.283	14.295	14.307	14.319	14.332	14.344	14.356	14.368	1,390
1,400	14.368	14.380	14.392	14.404	14.416	14.429	14.441	14.453	14.465	14.477	14.489	1,400
1,410	14.489	14.501	14.513	14.526	14.538	14.550	14.562	14.574	14.586	14.598	14.610	1,410
1,420	14.610	14.622	14.635	14.647	14.659	14.671	14.683	14.695	14.707	14.719	14.731	1,420
1,430	14.731	14.744	14.756	14.768	14.780	14.792	14.804	14.816	14.828	14.840	14.852	1,430
1,440	14.852	14.865	14.877	14.889	14.901	14.913	14.925	14.937	14.949	14.961	14.973	1,440
1,450	14.973	14.985	14.998	15.010	15.022	15.034	15.046	15.058	15.070	15.082	15.094	1,450
1,460	15.094	15.106	15.118	15.130	15.143	15.155	15.167	15.179	15.191	15.203	15.215	1,460
1,470	15.215	15.227	15.239	15.251	15.263	15.275	15.287	15.299	15.311	15.324	15.336	1,470
1,480	15.336	15.348	15.360	15.372	15.384	15.396	15.408	15.420	15.432	15.444	15.456	1,480
1,490	15.456	15.468	15.480	15.492	15.504	15.516	15.528	15.540	15.552	15.564	15.576	1,490
1,500	15.576	15.589	15.601	15.613	15.625	15.637	15.649	15.661	15.673	15.685	15.697	1,500
1,510	15.697	15.709	15.721	15.733	15.745	15.757	15.769	15.781	15.793	15.805	15.817	1,510
1,520	15.817	15.829	15.841	15.853	15.865	15.877	15.889	15.901	15.913	15.925	15.937	1,520
1,530	15.937	15.949	15.961	15.973	15.985	15.997	16.009	16.021	16.033	16.045	16.057	1,530
1,540	16.057	16.069	16.080	16.092	16.104	16.116	16.128	16.140	16.152	16.164	16.176	1,540
1,550	16.176	16.188	16.200	16.212	16.224	16.236	16.248	16.260	16.272	16.284	16.296	1,550
1,560	16.296	16.308	16.319	16.331	16.343	16.355	16.367	16.379	16.391	16.403	16.415	1,560
1,570	16.415	16.427	16.439	16.451	16.462	16.474	16.486	16.498	16.510	16.522	16.534	1,570
1,580	16.534	16.546	16.558	16.569	16.581	16.593	16.605	16.617	16.629	16.641	16.653	1,580
1,590	16.653	16.664	16.676	16.688	16.700	16.712	16.724	16.736	16.747	16.759	16.771	1,590
1,600	16.771	16.783	16.795	16.807	16.819	16.830	16.842	16.854	16.866	16.878	16.890	1,600
1,610	16.890	16.901	16.913	16.925	16.937	16.949	16.960	16.972	16.984	16.996	17.008	1,610
1,620	17.008	17.019	17.031	17.043	17.055	17.067	17.078	17.090	17.102	17.114	17.125	1,620
1,630	17.125	17.137	17.149	17.161	17.173	17.184	17.196	17.208	17.220	17.231	17.243	1,630
1,640	17.243	17.255	17.267	17.278	17.290	17.302	17.313	17.325	17.337	17.349	17.360	1,640
1,650	17.360	17.372	17.384	17.396	17.407	17.419	17.431	17.442	17.454	17.466	17.477	1,650
1,660	17.477	17.489	17.501	17.512	17.524	17.536	17.548	17.559	17.571	17.583	17.594	1,660
1,670	17.594	17.606	17.617	17.629	17.641	17.652	17.664	17.676	17.687	17.699	17.711	1,670
1,680	17.711	17.722	17.734	17.745	17.757	17.769	17.780	17.792	17.803	17.815	17.826	1,680
1,690	17.826	17.838	17.850	17.861	17.873	17.884	17.896	17.907	17.919	17.930	17.942	1,690
1,700	17.942	17.953	17.965	17.976	17.988	17.999	18.010	18.022	18.033	18.045	18.056	1,700
1,710	18.056	18.068	18.079	18.090	18.102	18.113	18.124	18.136	18.147	18.158	18.170	1,710
1,720	18.170	18.181	18.192	18.204	18.215	18.226	18.237	18.249	18.260	18.271	18.282	1,720
1,730	18.282	18.293	18.305	18.316	18.327	18.338	18.349	18.360	18.372	18.383	18.394	1,730
1,740	18.394	18.405	18.416	18.427	18.438	18.449	18.460	18.471	18.482	18.493	18.504	1,740
1,750	18.504	18.515	18.526	18.536	18.547	18.558	18.569	18.580	18.591	18.602	18.612	1,750
1,760	18.612	18.623	18.634	18.645	18.655	18.666	18.677	18.687	18.698			1,760
DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C

RUN NO. 4 DATE: 1/25/77

Type "E" 1200°K, Helium Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 2.00 mg

Disk Sample

Comment: Good data but note weight gain in Helium!

Time (sec)	Output (mv)
0	0
15	27.5
30	46.5
45	57.5
60	62.0
75	64.5
90	65.5
105	67.0
120	68.5
150	70.0
180	70.0
192	70.0
195	66.5

RUN NO. 5 DATE: 1/26/77

Type "E" 1200^{0}K, Helium Thermocouple, 23^{0}C Reference

Pressure = .5 atm

ΔW = 1.44 mg

Disk Sample

Comment: Good data with repeat of weight gain in Helium!

Time (sec)	Output (mv)
0	0
6	31
15	44
30	56.5
45	63
60	65
75	66
90	67
105	68
120	69
135	69.5
150	70.5
165	71
180	71.5
192	71.5
195	69
210	54

RUN NO. 6 DATE: 1/26/77

Type "E" 1200^{0}K, Argon Thermocouple, 23^{0}C Reference

Pressure = .5 atm

ΔW = 2.0 mg

Disk Sample

Comment: Weight gain in Argon!

Time (sec)	Output (mv)
0	0
15	40
30	61
45	69.5
60	71
62	0

RUN NO. 7 DATE: 1/26/77

Type "E" 1200°K Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 7.15 mg

Disk Sample

Comment: Good data, no He/Ar purge

Time (sec)	Output (mv)
0	0
6	32
15	52
30	67.5
45	70
60	70
90	70
120	70
150	70
180	70
210	70
240	70
270	70
300	69.5
315	58

RUN NO. 8 DATE: 1/26/77

Type "E" 1200°K, O_2 Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 1.62

Disk Sample

Comment: Looks okay - short run time however

Time (sec)	Output (mv)
0	0
6	29
15	49
30	67
33	68
39	68.5
45	70
60	70
90	70
93	70
105	57

RUN NO. 9 DATE: 1/26/77

Type "S" 1000°K, O_2 Thermocouple, 23°C Reference

Pressure = .5 atm

$\Delta W = 1.05$

Rectangular sample

Comment: Looks good - longer running time

Time (sec)	Output (mv)
0	0
6	1.4
15	2.9
30	5.0
45	6.1
60	6.55
75	6.65
90	6.65
105	6.6
120	6.55
135	6.55
150	6.5
180	6.5
210	6.45
240	6.45
270	6.4
300	6.4
330	6.4
360	6.4
390	6.4
420	6.4
450	6.4
480	6.4
510	6.4
540	6.4
570	6.4
585	6.4
594	6.4
600	5.4

RUN NO. 10 DATE: 1/26/77

Type "S" 1200° K, O_2 Thermocouple, 23° C Reference

Pressure = .5 atm

ΔW = 5.35 mg

Rectangular Sample

Comment: Arco-over at 75 seconds with cool-down and subsequent re-heat

Time (sec)	Output (mv)
0	0
15	2.8
30	5.1
45	6.3
48	6.5
60	7.5
75	8.0
90	5.2
105	3.9
120	3.05
150	2.1
165	1.8
180	4.7
195	7.2
210	8.1
216	8.3
225	8.7
240	8.75
270	8.75
285	8.75
300	8.7
330	8.7
360	8.6
390	8.5
420	8.4
450	8.3
465	8.25
480	5.4

RUN NO. 11 DATE: 1/27/77

Type "S" 1500°K, O_2 Thermocouple, 23°C Reference

Pressure = .5 atm

$\Delta W = 22.7$

Rectangular Sample

Comment: Long transient period to reach 1500°K - data somewhat questionable!

Time (sec)	Output (mv)
0	0
10	2.8
15	4.5
20	6.1
30	8.1
35	8.6
40	9.1
41	9.2
45	8.4
50	9.4
60	10.6
70	10.8
75	10.5
80	10.8
90	12.2
95	12.0
100	12.3
105	12.4
110	12.4
115	12.3
120	12.2
130	12.2
140	12.2
150	12.2
151	12.2
155	9.3

RUN NO. 12 DATE: 1/27/77

Type "S" 1500°K, H_2O, 23°C Reference

Pressure = .5 atm

ΔW = 35 mg

Rectangular Sample

Comment: Some oxide coating lost, weight gain should be larger

Time, (sec)	Output (mv)
0	0
.5	.2
5	.2
10	.6
15	2.0
20	4.3
25	6.8
30	8.4
32	8.8
35	10.1
40	11.3
45	11.4
50	11.5
55	11.6
60	11.5
70	11.5
80	11.4
83	11.4
85	9.4

RUN NO. 15 DATE: 1/28/77

Type "S" 1200°K, H_2O Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 5.37 mg

Rectangular Sample

Comment: Good data

Time, (sec)	Output (mv)
0	0
5	1.25
10	3.7
20	7.8
25	8.65
30	8.95
35	9.0
40	9.05
45	9.0
50	8.8
55	8.7
60	8.65
70	8.6
80	8.5
90	8.45
100	8.4
110	8.35
120	8.3
130	8.15
135	7.9
140	7.7
143	7.55
150	7.7
160	7.5
165	7.3
170	7.4
180	7.35

RUN NO. 15 Continued

Time (sec)	Output (mv)
185	7.4
190	7.5
200	7.8
210	8.1
220	8.5
230	8.8
235	8.7
240	8.65
250	8.7
260	8.7
270	8.7
280	8.7
290	8.7
300	8.7
310	8.7
320	8.6
330	8.6
340	8.55
350	8.5
360	8.5
370	8.45
380	8.4
390	8.4
400	8.35
410	8.3
415	8.3
420	6.6

RUN NO. 16 DATE: 2/1/77

Type "E" 1200°K, Air Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 4.2 mg

Rectangular Sample

Comment: Strip chart not available

Time (sec)	Output (mv)
0	0
5	1.05
10	2.0
20	3.9
30	5.4
40	6.4
50	7.1
55	7.55
60	8.05
70	8.6
80	8.85
90	8.95
95	8.95
100	8.9
105	8.85
110	8.8
120	8.8
130	8.8
140	8.75
150	8.7
160	8.7
170	8.65
180	8.6
190	8.6
200	8.6
210	8.55

RUN NO. 16 Continued

Time (sec)	Output (mv)
220	8.5
230	8.45
240	8.4
250	8.4
260	8.4
265	8.3
270	8.25
280	8.2
290	8.15
295	8.45
300	8.75
304	8.9
310	7.05

RUN NO. 17 DATE: 2/1/77

Type "E" 1200°K, Air Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 6.2 atm

Rectangular Sample

Comment: Strip chart not available

Time (sec)	Output (mv)
0	0
10	2.54
20	5.25
30	7.00
40	7.85
50	8.15
59	8.35
60	8.10
65	7.00
70	6.25
71.5	6.10
80	6.80
85	7.20
90	7.90
95	8.55
100	8.75
105	8.80
110	8.90
120	9.0
130	9.05
140	9.05
150	9.00
160	8.90
165	8.85
170	8.75
180	8.70
185	8.65

RUN NO. 17 Continued

Time (sec)	Output (mv)
189	8.65
190	8.55
195	8.4
200	8.2
205	8.4
210	8.6
215	8.7
220	8.85
221	8.95
225	9.25
228	9.5
230	9.25
235	8.6
240	8.45
245	8.6
250	8.7
260	8.8
270	8.8
280	8.8
290	8.75
300	8.75
310	8.7
320	8.65
327	8.65
330	7.5

RUN NO. 18 DATE: 2/1/77

Type "S" 1500°K, O_2 + H_2O Thermocouple, 23°C Reference

Pressure = .5 atm

ΔW = 15 mg

Rectangular Sample

Comment: Some oxide flakes lost

Time (sec)	Output (mv)
0	0
2	.4
4	.8
10	3.0
15	4.9
20	6.6
25	8.1
30	9.0
35	10.0
40	10.6
44	10.8
50	11.5
60	11.9
70	12.0
80	12.0
90	12.0
95	11.9
102	11.9
105	8.8

SERIES 2

OXIDATION TESTS

MAY 1977

Titanium Oxidation Run Summary: Series 2, May 1977

RUN NO.	NOMINAL TEMP (^{0}K)	NOMINAL TIME (SEC)	PRESSURE (atm)	GAS COMPOSITION	WEIGHT GAIN (mg)	COMMENTS
2	1500	100	0.5	O_2	16.15	No scale catcher in setup
3	1500	100	0.5	O_2	19.74	No scale catcher in setup
4	1600	100	0.5	O_2	73.75	
7	1650	50	0.5	O_2	101.76	
8	1500	100	0.5	H_2O(v)	46.57	Baked out weight less 1.7 mg
9	1500	100	0.5	O_2	22.34	
10	1450	100	0.5	H_2O(v)	35.22	Temp lower than 1500^{0}K
11	1500	120	0.5	O_2H_2O(v)	18.82	Mix of gases uncertain, significant pressure change
12	1500	100	0.5	O_2H_2O(v)	19.66	Mix of gases uncertain, significant pressure change
15	1500	50	0.5	O_2	11.97	
17	1650	60	0.5	O_2	70.39	Temperature slightly low
18	1650	60	0.5	H_2O(v)	50.90	Temperature too low
19	1650	60	0.5	H_2O	63.20	Temperature too low
20	1200	300	0.5	H_2O(v)	8.56	
21	1200	300	0.5	H_2O(v)	8.10	
22	1500	35	1.0	O_2	-	Specimen ignited
24	1400	50	1.0	O_2	15.80	
25	1400	50	1.0	H_2O(v)	50.63	

NOTE: All specimens 1 cm x 2 cm x 0.2 cm, Mass = 1.8 gms. Thermocouples Type S. Reference Temperature, 18^{0}C. Chart speed 0.1 in/sec.

RUN NO. 1 DATE: 5/10/77

Type "S"

Comment: Shakedown and calibration run

Time (sec)	Output (mv)
0	0
10	4.0
20	6.9
30	10.2
40	11.1
50	12.1
60	12.4
65	12.5
70	12.5
80	12.5
90	12.5
100	12.6
110	12.6
120	12.6
130	12.7
140	12.7
147	12.7
150	10.8

RUN No. 2 DATE: 5/10/77

Type "S" 1500^{0}K, O_2 Thermocouple, 18^{0}C Reference

Pressure = .5 atm

ΔW = 16.15 mg

Comment: Good test data

Time (sec)	Output (mv)
0	0
10	5.6
15	8.1
20	10.0
25	12.1
28	12.4
30	12.3
35	12.1
40	12.05
50	12.0
60	11.9
70	11.9
75	12.0
80	12.0
90	12.0
95	12.1
100	12.1
110	12.1
120	12.0
127	12.0
130	9.8

RUN NO. 3 DATE: 5/10/77

Type "S" 1500^{0}K, O_2 Thermocouple, 18^{0}C Reference

Pressure = .5 atm

ΔW = 19.74 mg

Comment: Good test data

Time (sec)	Output (mv)
0	0
10	6.0
15	8.2
20	10.0
25	11.6
30	12.0
35	11.9
40	11.8
50	11.7
55	11.6
60	11.7
70	11.8
75	11.8
80	11.9
90	11.9
100	11.85
110	11.8
120	11.8
129	11.8
130	11.0

RUN NO. 4 DATE: 5/11/77

Type "S" 1700°K, O_2 Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 73.75 mg

Comment: Temperature varies significantly between 1500 - 1700°K, questionable data

Time (sec)	Output (mv)
0	0
10	6.3
15	8.6
20	11.6
25	13.1
28	13.0
30	12.9
35	12.8
40	12.8
50	13.1
60	14.0
65	14.1
70	14.0
75	13.9
80	13.8
90	13.5
100	13.3
110	13.0
120	13.0
122	13.0
125	9.8

RUN NO. 5 DATE: 5/11/77

Type "S" 1500^{0}K, H_2O(v) Thermocouple, 18^{0}C Reference
Pressure = .15 atm at start, .5 atm at end of run
ΔW = 7.69 mg

Comment: Widely varying pressure, questionable result

Time (sec)	Output (mv)
0	0
1	1.0
2	.8
6.5	.8
7	.2
18	.2
20	1.0
30	5.9
35	7.2
40	7.9
45	8.6
50	9.3
55	9.6
58	9.55
60	9.6
65	10.3
70	11.0
80	11.4
85	11.55
90	11.8
100	12.0
110	11.95
115	11.8
120	11.8
130	11.7
138	11.6

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TITANIUM RESPONSE TO SIMULATED NUCLEAR CLOUD PARTICLE ENVIRONME--ETC(U).
AUG 77 L E DUNBAR, R M CLEVER, G H BURGHART DNA001-76-C-0366
UNCLASSIFIED SAI-78-561-LA-VOL-2 DNA-4404F-2 NL

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RUN NO. 5 Continued

Time (sec)	Output (mv)
140	11.7
145	11.85
150	12.0
157	12.15
160	12.15
165	12.0
170	12.0
180	11.9
190	11.8
195	11.7
200	8.2

RUN NO. 6 DATE: 5/13/77

Type "S", 1500 K, O_2 Thermocouple, 18 C Reference

Comment: Test invalid as oxide scale was lost

Time (sec)	Output (mv)
0	0
10	6.2
15	8.1
20	9.6
25	11.2
30	11.8
35	11.9
40	11.8
45	11.9
50	12.15
55	11.4
60	11.4
65	11.6
70	11.9
75	12.0
80	12.0
90	12.0
100	12.0
110	11.95
120	11.9
130	11.9
131	11.9
135	9.3

RUN NO. 7 DATE: 5/13/77

Type "S" 1700°K, O_2 Thermocouple, 18°C Reference

ΔW = 101.76 mg

Comment: 1) Arc-over and shut down after 50 seconds
2) Temperature varies significantly between 1600-1700°K
3) Data difficult to use

Time (sec)	Output (mv)
0	0
10	6.0
13.5	8.1
18	7.0
18.5	7.05
20	6.8
22.5	6.3
30	11.2
35	14.7
37	14.9
40	14.8
45	13.9
50	13.3
55	13.3
60	13.3
65	13.5
70	13.5
75	13.5
80	13.7
81	13.75

RUN No. 8 DATE: 5/13/77

Type "S" 1500°K, H_2O(v) Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 46.57 mg

Comment: Good test data

Time (sec)	Output (mv)
0	0
5	4.4
10	6.0
15	8.4
20	11.4
25	12.5
30	12.3
35	12.1
40	12.0
50	11.9
60	11.8
70	11.8
75	11.8
80	12.1
85	12.1
90	12.05
100	12.0
110	11.9
120	11.9
122	11.9
125	9.6

RUN NO. 9 DATE: 5/13/77

Type "S" 1500°K, O_2 Thermocouple, 18°C Reference
Pressure = .5 atm
ΔW = 22.34 mg

Comment: Good test data

Time (sec)	Output (mv)
0	0
10	5.8
15	7.9
20	9.3
25	11.5
30	12.2
32	12.5
35	12.3
40	12.0
50	11.8
60	11.75
70	11.7
75	11.9
80	12.0
90	12.0
100	12.0
110	11.9
120	11.85
130	11.8
135	8.5

RUN NO. 10 DATE: 5/13/77

Type "S" 1500°K, $H_2O(v)$ Thermocouple, 18°C Reference
Pressure = .5 atm
ΔW = 35.22 mg

Comment: Temperature slightly low during run

Time (sec)	Output (mv)
0	0
10	8.0
15	10.4
16	11.0
17	11.0
20	11.5
25	11.4
30	11.3
40	11.4
45	11.6
50	11.8
60	11.8
70	11.8
80	11.8
90	11.7
100	11.65
110	11.6
113	11.6
118	11.8
120	10.4

RUN NO. 11 DATE: 5/16/77

Type "S" 1500°K, $H_2O(v) + O_2$ Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 18.81 mg

Comment: Significant pressure change may make data questionable

Time (sec)	Output (mv)
0	0
10	6.5
15	8.9
20	11.0
25	12.4
28	12.5
30	12.4
35	12.3
40	12.2
45	12.2
50	12.1
55	12.1
60	12.05
70	12.0
80	12.0
90	11.95
100	11.9
110	11.9
120	11.85
125.5	11.85
130	8.8

RUN NO. 12 DATE: 5/16/77

Type "S" 1500°K, $H_2O(v)$ + O_2 Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 19.66 mg

Comment: Good data but temperature slightly low

Time (sec)	Output (mv)
0	0
10	6.2
15	8.4
18	9.2
20	10.0
25	11.5
30	11.9
35	11.8
40	11.8
50	11.9
60	11.8
70	11.8
80	11.8
90	11.8
95	11.7
100	11.75
105	11.8
110	11.9
115	12.0
120	12.0
130	12.0
132	12.0
135	9.8

RUN NO. 13 DATE: 5/16/77

Comment: Calibration for 1700°K case overshoot caused specimen to melt off thermocouple

Time (sec)	Output (mv)
0	0
10	8.3
20	12.0
25	12.5
30	13.1
38	14.2
40	14.25
42.5	14.3
43.5	12.5
45	12.4
50	12.7
60	14.2
61	14.2
63	14.9
63.5	14.8
63.7	17.0
65	7.0

RUN NO. 14 DATE: 5/16/77

Type "S" 1700°K, O_2 Thermocouple, 18°C Reference

Comment: Induction heater cut-out before temperature reached

Time (sec)	Output (mv)
0	0
10	8.3
12	9.1
15	11.0
20	12.8
25	13.2
29	13.2
30	12.4
32.5	10.1
35	11.4
40	12.7
45	13.15
48	13.2
50	13.4
55	13.6
60	13.6
65	13.7
70	13.8
80	13.8
90	13.7
100	13.6
105	13.5
107	13.5
110	10.5

RUN NO. 15 DATE: 5/16/77

Type "S" 1500°K, O_2 Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 11.97 mg

Comment: Good data

Time (sec)	Output (mv)
0	0
10	11.8
11.5	13.4
13	13.4
18	12.5
20	12.5
25	12.45
30	12.2
40	12.1
50	12.0
60	12.0
66	12.0
70	8.9

RUN NO. 16 DATE: 5/16/77

Type "S" 1700°K, O_2 Thermocouple, 18°C Reference

Comment: Pressure increased to 10 inch vacuum by end of run, excess time required to reach temperature

Time (sec)	Output (mv)
0	0
10	7.3
15	10.2
20	12.6
25	13.5
30	13.6
35	13.5
40	13.6
45	13.7
50	13.9
55	13.8
60	13.8
65	14.0
70	14.0
76	14.0
80	14.1
85	14.2
90	14.2
99	14.2
100	13.4

RUN No. 17 DATE: 5/17/77

Type "S" 1700°K, O_2 Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 70.39 mg

Comment: Good data but temperature slightly lower than 1700°K

Time (sec)	Output (mv)
0	0
5	7.0
10	12.0
12	13.6
15	15.6
20	14.8
25	14.0
30	13.8
40	13.8
45	14.0
50	14.1
60	14.1
65	14.0
70	9.8

RUN NO. 18 DATE: 5/17/77

Type "S" 1700°K, $H_2O(v)$ Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 50.90 mg

Comment: Temperature too low

Time (sec)	Output (mv)
0	0
10	11.4
15	13.3
20	13.8
22	13.8
25	14.0
30	14.0
40	13.9
50	13.8
55	13.7
60	13.6
65	13.6
70	13.6
75	13.6
80	9.4

RUN NO. 19 DATE: 5/17/77

Type "S" 1700°K, H_2O(v) Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 63.2 mg

Comment: Condensation occured on sample during run, pressure not maintained at 15 inch during run, data may be questionable

Time (sec)	Output (mv)
0	0
10	11.8
15	13.6
20	14.4
25	14.6
30	14.45
35	14.2
40	13.8
45	13.7
50	13.5
51	13.4
54	13.6
55	13.5
60	13.5
65	13.6
70	13.6
73	13.7
75	11.6

RUN No. 20 DATE: 5/17/77

Type "S" 1200°K, $H_2O(v)$ Thermocouple, 18°C Reference

ΔW = 8.56 mg

Comment: Good data

Time (sec)	Output (mv)
0	0
10	3.8
20	7.0
30	8.0
40	8.6
50	9.2
55	9.3
60	9.3
70	9.2
80	9.0
90	9.0
100	8.0
110	8.8
120	8.8
130	8.8
140	8.8
150	8.8
160	8.8
170	8.7
180	8.7
190	8.7
200	8.7
210	8.65
220	8.6
220	8.6
240	8.6

RUN NO. 20 Continued

Time (sec)	Output (mv)
250	8.6
260	8.6
270	8.6
280	8.6
290	8.6
300	8.6
310	8.6
320	8.6
330	8.6
340	8.6
345	8.6
350	7.2

RUN NO. 21 DATE: 5/17/77

Type "S" 1200°K, H_2O(v) Thermocouple, 18°C Reference

Pressure = .5 atm

ΔW = 8.1 mg

Comment: Good data

Time (sec)	Output (mv)
0	0
10	3.5
20	6.2
30	7.5
35	7.8
40	8.1
50	9.2
52	9.5
55	9.5
60	9.3
70	9.0
80	8.8
90	8.75
100	8.7
110	8.6
120	8.6
130	8.6
140	8.6
150	8.6
160	8.6
170	8.6
180	8.5
190	8.5
200	8.5
210	8.5
230	8.4

RUN NO. 21 Continued

Time (sec)	Output (mv)
250	8.4
270	8.4
290	8.4
300	8.4
310	8.4
320	8.4
330	8.4
340	8.4
345	8.4
346	8.4
350	7.0

RUN NO. 22 DATE: 5/18/77

Type "S" 1500°K, O_2 Thermocouple, 18°C Reference
Pressure = 1.0 atm

Comment: Specimen ignited after 35 seconds

Time (sec)	Output (mv)
0	0
1	.6
7	.6
10	2.4
20	7.9
25	9.0
27	9.9
30	11.0
35	11.8
38	11.8
40	11.7
43	11.6
45	11.65
50	11.9
55	12.0
60	12.0
70	11.9
73	12.4
75	14.2
76	20.0
77	20.0
80	11.6

RUN NO. 23 DATE: 5/18/77

Type "S" 1400 K, O_2 Thermocouple, 18 C Reference
Pressure = 1.0 atm

Comment: Temperature too high

Time (sec)	Output (mv)
0	0
5	3.6
10	7.0
15	8.9
20	10.5
25	11.2
27	11.4
30	9.5

RUN NO. 24 DATE: 5/18/77

Type "S" 1400°K, O_2 Thermocouple, 18°C Reference

Pressure = 1.0 atm

ΔW = 15.8 mg

Comment: Good data

Time (sec)	Output (mv)
0	0
10	5.8
15	7.6
18	8.3
20	9.0
25	10.7
28	11.0
30	11.0
35	10.8
40	10.6
45	10.6
50	10.7
55	10.8
60	10.8
70	10.8
77	10.8
80	8.9

RUN NO. 25 DATE: 5/18/77

Type "S" 1400°K, H_2O(v) Thermocouple, 18°C Reference

Pressure = 1.0 atm

ΔW = 50.63 mg

Comment: Good data

Time (sec)	Output (mv)
0	0
0	.2
6.5	.2
10	2.4
15	6.7
20	7.8
25	8.9
30	9.9
40	10.9
45	11.0
50	11.1
55	11.1
60	10.9
65	10.8
70	10.8
80	10.7
90	10.6
91	10.6
95	8.2

SERIES 3

OXIDATION TESTS

JULY 1977

TITANIUM OXIDATION RUN SUMMARY: SERIES 3, JULY 1977

RUN NO.	NOMINAL TEMP (^{o}K)	NOMINAL TIME (SEC)	PRESSURE (ATMOSPHERE)	GAS COMP.	WT. GAIN (mg)	COMMENTS
26	1500	60	0.5	H_2O	20.4	time more like 58-63 sec but steady temp. - good run
27	1450	85	1.0	H_2O	31.2	~ 53 sec at 1500^{o}K but additional 35 sec init at ~ 1400^{o}K! No good
28	1500	55	1.0	H_2O	40.0	~ 53-60 sec and steady good run.
29	1200	150	0.5	H_2O	6.8	Temp overshot init ~ 40 sec
31	1600	70	0.5	H_2O	65.8	Temp low most of run, more like ~ 70 sec @ 1600^{o}K
32	1600	80	0.5	H_2O	89.1	Temp low-more like 80 sec @ 1600^{o}K slightly higher levels to run 31 however higher pressure may cause high AW
33	1600	60	0.5	O_2	90.8	Temp erratic (low) time about 60 sec @ ~ 1600^{o}K
34	1600	70	0.5	O_2	102.4	Stable Temp not achieved, low temp ~ 70 sec @ 1600^{o}K
35	1650	60	0.5	O_2	120.7	1700^{o}K maintained for only 10 sec -- ~60 sec total, most @ 1500^{o}K+, no good
36	1600	50	0.5	O_2	35.6	Overshoot to nearly 1700^{o} ~ 30 sec @ ~ 1400^{o}K, ~ 22 sec above 1500^{o}K No good
37	1500	50	1.0	O_2	15.9	Good run 50 sec @ ~1500^{o}K
38	1500	50	1.0	O_2	16.7	Slight overshoot for 1st 10 sec to ~1550^{o}K and undershoot for last 40 sec to ~1450^{o}K, good
39	1300	300	0.5	O_2	10.8	Temp overshoot an ave. of ~1300^{o}K for entire 300 sec
40	1300	300	0.5	O_2	10.1	Temp overshoot an ave. of ~1300^{o}K for entire 300 sec
41	1700	-	0.5	O_2	-	Ignited at 5 sec, strange tc response above 1500^{o}K
42	1250	300	0.5	H_2O	17.0	Temp 1200-1300^{o}K, good

RUN NO. 26 DATE: 7/8/77

Type "S" Thermocouple, 1500°K, H_2O

Pressure = .5 atm

ΔW = 31.2 mg

Comment: Time more like 58-63 sec but steady temperature, good run.

Time (sec)	Output (mv)
0	0
5.0	3.4
10.0	6.4
15.0	8.4
17.5	9.0
20.0	9.8
22.5	10.8
25.0	11.2
27.5	11.3
30.0	11.4
35.0	11.6
40.0	11.8
45.0	11.9
50.0	11.9
55.0	11.9
60.0	12.0
65.0	12.0
70.0	12.0
75.0	12.0
80.0	12.0
85.0	12.0
90.0	11.9
92.5	10.1

RUN NO. 27 DATE: 7/8/77

Type "S" Thermocouple, 1450°K, H_2O

Pressure = 1.0 atm

ΔW = 31.2 mg

Comment: ∿53 seconds at 1500°K but additional 35 seconds initial at ∿1400°K. No good.

Time (sec)	Output (mv)
0	0
2.5	1.4
5.0	3.0
10.0	6.1
12.5	7.3
15.0	8.2
17.5	8.9
20.0	10.1
22.5	10.9
25.0	11.1
26.0	11.2
27.5	10.9
30.0	10.9
35.0	11.0
40.0	10.9
44.0	10.6
46.0	10.8
50.0	11.1
55.0	11.3
60.0	11.5
65.0	11.6
70.0	11.8
75.0	11.9
77.5	12.0

RUN NO. 27 continued

Time (sec)	Output (mv)
80.0	11.9
85.0	11.9
90.0	11.9
92.5	12.0
95.0	11.9
100.0	11.9
105.0	11.9
110.0	11.8
111.0	11.8
112.5	10.4

RUN No. 28

Type "S" Thermocouple, 1500°K, H_2O

Pressure = 1.0 atm

ΔW = 40.0

Comment: ∿53-60 sec at 1500°K but additional 35 sec initial at ∿1400°K. No good

Time (sec)	Output (mv)
0	0
2.5	.3
5.0	2.8
7.5	5.1
8.5	5.7
10.0	7.8
12.5	9.2
15.0	10.4
17.0	11.2
18.0	11.2
20.0	11.4
22.5	11.7
25.0	12.0
30.0	12.1
35.0	12.0
40.0	12.0
45.0	12.0
50.0	11.9
55.0	11.9
60.0	11.9
65.0	11.9
70.0	11.8
75.0	11.8
77.0	11.8
80.0	9.2

RUN NO. 29

Type "S" Thermocouple, 1200^{0}K, H_2O

Pressure = .5

ΔW = 6.8 mg

Comment: Temperature overshot initial ∿40 sec

Time (sec)	Output (mv)
0	0
2.5	2.0
5.0	4.0
10.0	6.7
11.0	7.1
15.0	7.6
17.5	7.8
20.0	8.2
25.0	9.0
27.5	9.2
30.0	9.3
32.5	9.3
35.0	9.1
40.0	8.8
45.0	8.7
50.0	8.6
55.0	8.6
60.0	8.7
65.0	8.6
67.5	8.5
70.0	8.4
75.0	8.4
80.0	8.2
82.5	8.1
85.0	8.2

RUN NO. 29 continued

Time (sec)	Output (mv)
90.0	8.2
95.0	8.2
100.0	8.2
105.0	8.3
110.0	8.4
115.0	8.4
120.0	8.4
125.0	8.4
130.0	8.5
135.0	8.5
140.0	8.5
145.0	8.5
150.0	8.5
155.0	8.5
160.0	8.4
165.0	8.4
170.0	8.4
175.0	8.4
180.0	8.3
182.5	6.7

RUN NO. 31 DATE: 7/11/77

Type "S" Thermocouple, 1700°K, H_2O

Pressure = .5

ΔW = 65.8 mg

Comment: Temperature low most of run, more like ∿70 sec at 1600°K.

Time (sec)	Output (mv)
0	0
5	6.6
10	10.3
15	12.5
20	12.9
25	13.3
30	13.5
35	13.8
40	13.8
50	13.8
60	13.6
65	13.4
70	13.5
80	14.0
85	14.2
87	14.0
90	9.3

RUN NO. 32 DATE: 7/11/77

Type "S" Thermocouple, 1700°K, H_2O

Pressure = .5 atm

ΔW = 89.1 mg

Comment: Temperature low ~ more like 80 sec at 1600°K, slightly higher levels to RUN 31 however higher pressure may cause high ΔW

Time (sec)	Output (mv)
0	0
10	7.4
15	11.4
20	13.0
25	13.2
30	13.3
35	13.7
40	14.0
50	13.7
55	13.8
60	13.9
70	14.0
73	14.1
75	13.5

RUN NO. 33 DATE: 7/11/77

Type "S" Thermocouple, 1700^{0}K, O_2

Pressure = .5 atm

ΔW = 9.08 mg

Comment: Temperature erratic, low; time $\sim$60 sec at $\sim$1600^{0}K

Time (sec)	Output (mv)
0	0
10	9.7
15	13.3
20	13.0
25	13.4
30	14.1
40	13.8
50	13.2
55	13.5
60	13.0
63	12.6
64	13.6
70	13.3
72	13.2
74	9.8

RUN NO. 34 DATE: 7/11/77

Type "S" Thermocouple, 1700°K, O_2

Pressure = .5 atm

ΔW = 102.4

Comment: Stable temperature not achieved, low temperature, time ∿70 sec at ∿1600°K.

Time (sec)	Output (mv)
0	0
10	7.8
15	10.8
20	13.0
25	13.2
30	13.4
40	14.0
45	13.9
47	13.8
50	13.9
53	14.1
60	13.9
65	13.8
70	13.7
75	13.5
78	13.4
80	12.7
90	12.4
98	12.0
100	10.0

RUN NO. 35 DATE: 7/12/77

Type "S" Thermocouple, 1600^{0}K, O_2

Pressure = .5

ΔW = 120.7 mg

Comment: 1700^{0}maintained only 10 sec, ∿60 sec total, most at 1500^{0}K+, no good

Time (sec)	Output (mv)
0	0
10	5.3
15	6.9
20	9.7
25	11.4
27	11.4
30	12.0
35	13.8
40	13.8
42	13.8
45	12.2
50	12.0
60	12.1
70	12.3
75	12.3
80	12.3
85	12.2
89	12.2
90	11.6

RUN NO. 36 DATE: 7/12/77

Type "S" Thermocouple, 1500°K, O_2

Pressure = .5 atm

ΔW = 35.6 mg

Comment: Overshoot to nearly 1700°; ∿30 sec at ∿1400°K; 27 sec above 1500°K, no good

Time (sec)	Output (mv)
0	0
5	5.2
10	9.0
15	13.4
20	12.4
25	11.6
30	11.0
40	10.8
50	10.8
55	10.9
60	11.0
63	11.0
65	9.6

RUN NO. 37 DATE: 7/12/77

Type "S" Thermocouple, 1500°K, O_2

Pressure = 1.0 atm

ΔW = 15.9 mg

Comment: Good run, 50 sec at ∿1500°K

Time (sec)	Output (mv)
0	0
10	7.0
15	9.6
20	11.6
22	11.9
25	11.8
30	11.5
35	11.4
40	11.3
50	11.2
60	11.2
68	11.2
70	9.4

RUN NO. 38 DATE: 7/12/77

Type "S" Thermocouple, 1500°K, O_2

Pressure = 1.0 atm

ΔW = 16.7 mg

Comment: Slight overshoot for first 10 sec to ∿1550°K and undershoot for last 40 sec to ∿1450°K, good

Time (sec)	Output (mv)
0	0
5	5.2
10	8.0
15	11.0
20	12.0
25	11.2
30	10.9
35	10.7
40	10.7
45	10.8
50	10.9
55	11.0
60	11.0
68	11.0
70	9.4

RUN NO. 39

Type "S" Thermocouple, 1300°K, O_2

Pressure = .5 atm

ΔW = 10.8 mg

Comment: Temperature overshoot and average of ∿1300°K for entire 300 sec

Time (sec)	Output (mv)
0	0
10	5.9
20	9.0
25	9.8
30	10.3
35	10.5
40	10.4
45	10.4
50	10.3
55	10.2
60	10.1
70	10.0
80	10.0
90	9.9
100	9.8
110	9.8
120	9.7
130	9.7
140	9.6
150	9.6
160	9.6
170	9.5
180	9.5
190	9.5
200	9.4

RUN NO. 39 continued

Time (sec)	Output (mv)
210	9.4
220	9.3
230	0.2
240	9.2
250	9.2
260	9.1
270	9.15
280	9.1
290	9.1
300	9.2
310	9.2
318	9.2
320	7.8

RUN NO. 40 DATE: 7/13/77

Type "S" Thermocouple, 1300^{0}K, O_2

Pressure = .5 atm

ΔW = 10.1

Comment: Temperature overshoot and average of $\sim$1300^{0}K for entire 300 sec

Time (sec)	Output (mv)
0	0
10	4.4
15	6.0
20	7.3
25	8.0
30	8.4
35	8.9
40	9.4
45	9.6
50	9.7
60	9.6
70	9.5
80	9.4
90	9.4
100	9.3
110	9.2
120	9.2
130	9.2
140	9.2
150	9.2
160	9.2
170	9.1
180	9.1
190	9.1

RUN NO. 40 continued

Time (sec)	Output (mv)
200	9.1
210	9.05
220	9.0
230	9.0
240	9.0
250	9.0
260	9.0
270	9.0
280	9.0
290	9.0
300	9.0
310	9.0
320	9.0
327	9.0
330	8.0

RUN NO. 41

Type "S" Thermocouple, 1700^{0}K, O_2

Pressure = 1700 K

Comment: Ignited at 5 sec, strange response above 1500^{0}K

Time (sec)	Output (mv)
0	0
5	2.7
10	5.8
15	8.3
20	11.0
22	11.7
25	12.4
30	12.2
35	12.2
40	12.9
45	14.8
47	15.3
48	19.8
49	19.8
50	14.2

RUN NO. 42

Type "S" Thermocouple, 1250^{0}K, H_2O

Pressure = .5 atm

ΔW = 17.0 mg

Comment: Temperature 1200^0-1300^{0}K, good

Time (sec)	Output (mv)
0	0
10	4.4
15	6.4
20	7.4
25	7.9
30	8.3
35	8.6
40	8.8
42	8.9
43	8.4
45	8.3
47	8.2
50	8.2
60	8.4
70	8.6
80	8.7
85	8.7
90	8.6
100	8.8
105	8.2
108	8.2
110	8.5
115	8.6
120	8.2
125	8.6

RUN NO. 42 continued

Time (sec)	Output (mv)
130	8.7
135	8.6
140	8.5
145	8.6
150	8.7
155	8.5
160	8.6
165	8.7
170	8.7
175	8.8
180	8.8
190	8.9
200	9.0
210	9.0
220	9.0
230	9.0
240	9.0
245	9.1
250	9.1
260	9.1
270	9.1
280	9.1
285	9.2
290	9.2
300	9.2
310	9.2
320	9.2
330	9.2
332	9.2
335	7.9

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