NASA Technical Memorandum 104778

Compilation of Reinforced Carbon-Carbon Transatlantic Abort Landing Arc Jet Test Results

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by

James D. Milhoan, Vuong T. Pham, and Eric H. Yuen

Substitute the attached pages for those of the original document to correct the errors described below:

Cover and Title Page: Eric H. Yuen, inadvertently omitted from the original issue, has been added to the author line on both pages.

Preface: On the fifth line from the bottom, the first surface temperature figure, originally misprinted as 25690° F, has been changed to 2690° F.

Report Documentation Page (SF 298), in rear of document: Eric H. Yuen has been added to the author line (block 6).

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Compilation of Reinforced Carbon-Carbon Transatlantic Abort Landing Arc Jet Test Results

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National Aeronautics
and Space Administration

Scientific and Technical Information Branch

1993

Preface

The purpose of this document is to compile the entire test database that was generated to support the Reinforced Carbon-Carbon (RCC) Transatlantic Abort Landing (TAL) Study. The RCC components used as the Shuttle Orbiter nose cap and wing leading edge thermal protection system were originally designed and tested to establish a multi-mission entry capability of 2800°F. The requirement to increase the Orbiter range capability during certain abort missions resulted in predicted RCC surface temperature in excess of 3300°F. Three test series were conducted in the Johnson Space Center (JSC) 10 megawatt arc-heated and pressures of the TAL conditions. Test series #1 (first reported in internal document JSC-22934) was conducted during the period from December 16, 1987 to February 2, 1988. The test specimens were ENKA-based RCC, coated with silicon carbide, treated with tetraethyl orthosilicate (TEOS), and sealed with Type A surface enhancement. The surface temperature ranged from 3000°F to 3400°F, and the surface pressure ranged from 60 psf to 101 psf. Test series #2 (first reported in internal document JSC-24829) was conducted during the period from October 4, 1989 to October 19, 1990. Test specimens were either ENKA- or AVTEX-based RCC. Some were coated with silicon carbide, and some were not. Some had Type A, and some had double Type A surface enhancement. All test specimens were impregnated with TEOS. The surface temperatures ranged from 1440°F to 3350°F, and the surface pressure ranged from 100 psf to 350 psf. Test series #3 (first reported in internal document JSC-25792) was conducted during the period from January 30, 1992 to March 05, 1992. In this last test series, the test specimens were ENKA-based RCC. Some specimens were coated with silicon carbide, and some were not. None of the specimens was treated with TEOS or sealed with Type A. The surface temperature ranged from 2690°F to 3440°F, and the pressure ranged from 313 psf to 400 psf. The results from these test programs provided the database for establishing RCC material single-mission-limit temperature and developing surface recession correlations used to predict mass loss for abort conditions.

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Test Series 1

Conducted from

December 1987 to February 1988

SUMMARY

Single mission entry heating simulation tests were performed on Reinforced Carbon-Carbon (RCC) specimens over the temperature range from 3000°F to 3400°F to support evaluation of RCC performance for transatlantic abort landings. Coating integrity of these specimens was maintained up to 3300°F but mass losses corresponding to a 60% reduction in specimen thicknesses were observed at 3400°F.

RCC multi-mission entry heating simulation tests are scheduled to be performed in the ARMSEF during the Summer of 1988 to evaluate reuse capability at temperatures above 3000°F.

INTRODUCTION

Reinforced Carbon-Carbon (RCC) serves as the primary structural component of the Shuttle Leading Edge Structural Subsystem (LESS). The LESS design temperature limit of 2700°F was established using an RCC ground test data base that extends up to 3000°F. Aerothermal analyses performed recently to assess maximum RCC reentry temperatures during Transatlantic Abort Landings (TAL) predict surface temperatures in the range of 3000°F to 3400°F.

A meeting was held at JSC on August 18, 1987, to develop a plan for extending the ground test data base for RCC up to 3400°F. At this meeting it was agreed that Rockwell would provide funding for Vought to write a test request, fabricate test hardware, and analyze the test results. JSC personnel agreed to conduct the test program in the Structures and Mechanics Division's reentry simulation facilities. This meeting was documented in Rockwell Internal Letter SAS-TA-TPS-87-246. The test request was generated by Vought on September 25, 1987, and was identified as TQ No. 221TQ10130.

OBJECTIVE

The objective of this test program was to evaluate the single mission survivability of silicon carbide coated RCC over the temperature range of 3000°F to 3400°F.

TEST SPECIMENS

Test specimens are 2.8-inch diameter 19-ply discs of reinforced carbon-carbon that have been silicon carbide coated by a pack cementation process, treated with tetraethyl orthosilicate (TEOS), and sealed with type A surface enhancement. Although some specimens were purchased by Rockwell and some by JSC, all of the test specimens were fabricated by LTV Missiles and Electronics Group (LTVMEG). Three of the fourteen test specimens were mass loss conditioned in LTVMEG's Mission Cycle Facility to simulate ten Shuttle entries. Pre-test views of the front and back surfaces of the test specimens are shown in figure 1.

Specimen holders were machined from high density graphite and were coated with LTVMEG's type IV coating. These holders were fitted with discs of zirconia insulation to reduce heat losses from the back surfaces of the specimens (see figs. 2 and 3).Poco graphite pins with Vought type IV coating were used to retain the specimens.

Four calibration specimens with type C tungsten thermocouples (5% - 26% rhenium) were used to establish test conditions. These calibration specimens had two front surface thermocouple and one back surface thermocouple located as shown in figure 4.

TEST FACILITY

This test program was performed in test position #1 of the JSC Atmospheric Reentry and Structures Evaluation Facility (ARMSEF).

Inside this facility, test gases (77% nitrogen and 23% oxygen) are heated by a segmented constricted arc heater and injected into a vacuum chamber through a water cooled nozzle that has a 15-degree half angle. While tests are in progress the facility vacuum chamber is maintained below 200 microns of mercury. Test models are mounted on two water-cooled, remotely actuated sting arms that allow them to be inserted after test conditions are stabilized. The stagnation pressures experienced by test specimens were determined with a 0.5-inch diameter water-cooled pitot probe prior to specimen insertion.

TEST CONDITIONS

Tests were performed at 3000°F, 3150°F, 3300°F, and 3400°F at stagnation pressures ranging from 60 PSF to 101 PSF. Test gas enthalpies ranged from 9,400 BTU/lb. to 10,300 BTU/lb. and were determined by the energy balance method. A summary of the test conditions which includes surface temperatures, pressures, and enthalpies is shown in table I. Two types of pyrometers were used during this test program but their indicated readings were of very limited use due to the high level of chemical activity present on the specimens' surfaces at temperatures above 3000°F. All test conditions specified in this report were based on thermocouple readings.

A minimum exposure time of 300 seconds after surface TC#1 reached 2600°F was required by the test request. Calibration tests showed that a 30-second time period was sufficient for the specimen to reach 2600°F as shown in figure 5.

TEST PROCEDURES

Test specimens were photographed, weighed, and measured prior to testing and after testing. Specimens were handled with clean white gloves and weighed to within .0001 gram. Test specimens were stored in evacuated desicators that were maintained under supervised control by Boeing quality personnel. All weights and measures were witnessed by Boeing quality assurance inspectors.

Aluminum bags were used to prevent absorption of atmospheric moisture while the specimens were being weighed. Prior to weighing, the specimens were placed inside aluminum bags that were then placed inside a 300°F oven for four hours to remove water of hydration. The aluminum bags were then sealed and the specimens allowed to cool prior to weighing.

RESULTS

Tests were performed at the conditions shown in table I. No test conditions are specified in this table for specimens 13 and 16 because they experienced various combinations of temperatures and pressures during the performance of pretest calibrations.

The mass losses specified in table I are subject to errors due to erosion of the back surfaces of the specimens, possibly through a reaction with the zirconia insulators. Complete loss of coating was observed at 3400°F on test specimens OT-5 and OT-6 within about 60 seconds. Although the facility two-color pyrometer was not useful for determining RCC coating temperatures, it did accurately indicate the temperatures of the exposed carbon substrates after coating loss occurred. During both 3400°F tests the pyrometer readings quickly rose to 3900°F when the carbon substrate was exposed as shown in figure 6. Specimens OT-5 and OT-6 completed the 330-second exposure time without breeching through to their back surfaces, but did undergo approximately a 60% reduction in thickness.

Up to 3300°F the test specimens continued to provide oxidation protection for the carbon substrate and did not undergo the dramatic mass loss reduction observed at 3400°F. A hot spot that grew rapidly was observed at 3300°F on specimen OT-2. This test was aborted at 180 seconds to preserve this specimen for inspection. Another OT series specimen (OT-7) was run without any anomalies at this condition to verify that this phenomenon was not "batch" related.

The test articles and preliminary data were shipped to LTVMEG for evaluation following these tests. Data sheets containing the weights and thickness measurements are included in appendix A. Post-test photographs of the test specimens are shown in figure 7.

CONCLUSIONS

The objectives of this test program were fully satisfied. The test facility was able to simulate peak reentry conditions that are predicted for a Trans-atlantic Abort Landings. Test were performed over the required temperature span from 3000°F to 3400°F while maintaining the test gas enthalpy near 10,000 BTU/lb. and the stagnation pressure at or below 100 psf. Eleven RCC specimens were exposed to the full test time that was requested (300 sec. exposure after initial transient reaches 2600°F).

Maintenance of RCC coating integrity was demonstrated under these test conditions up to and including 3300°F. Rapid coating degradation and subsequent substrate erosion was observed at 3400°F.

TABLE I

RCC OVERTEMPERATURE
TEST MATRIX

TEMPERATURE, $^{\circ}F$	PRESSURE, PSF	ENTHALPY, BTU/LB	EXPOSURE TIME, SEC.	SPECIMEN #	MASS LOSS, GR.	RUN #
3000	60	10,000	330	OT-1	0.49	628
3000	65	9,500	330	21	0.22	650
3000	65	9,400	330	15*	0.08	651
3150	80	10,000	330	OT-3	0.68	634
3150	73	10,200	330	23	0.55	652
3150	80	10,100	330	17*	0.38	653
3300	90	10,000	180	OT-2	0.82	631
3300	85	10,600	330	18	0.75	654
3300	86	10,600	330	19*	0.74	655
3300	85	10,600	330	OT-7	1.17	657
3400	101	10,300	330	OT-5	21.1	656
3400	101	10,300	330	OT-6	19.6	658

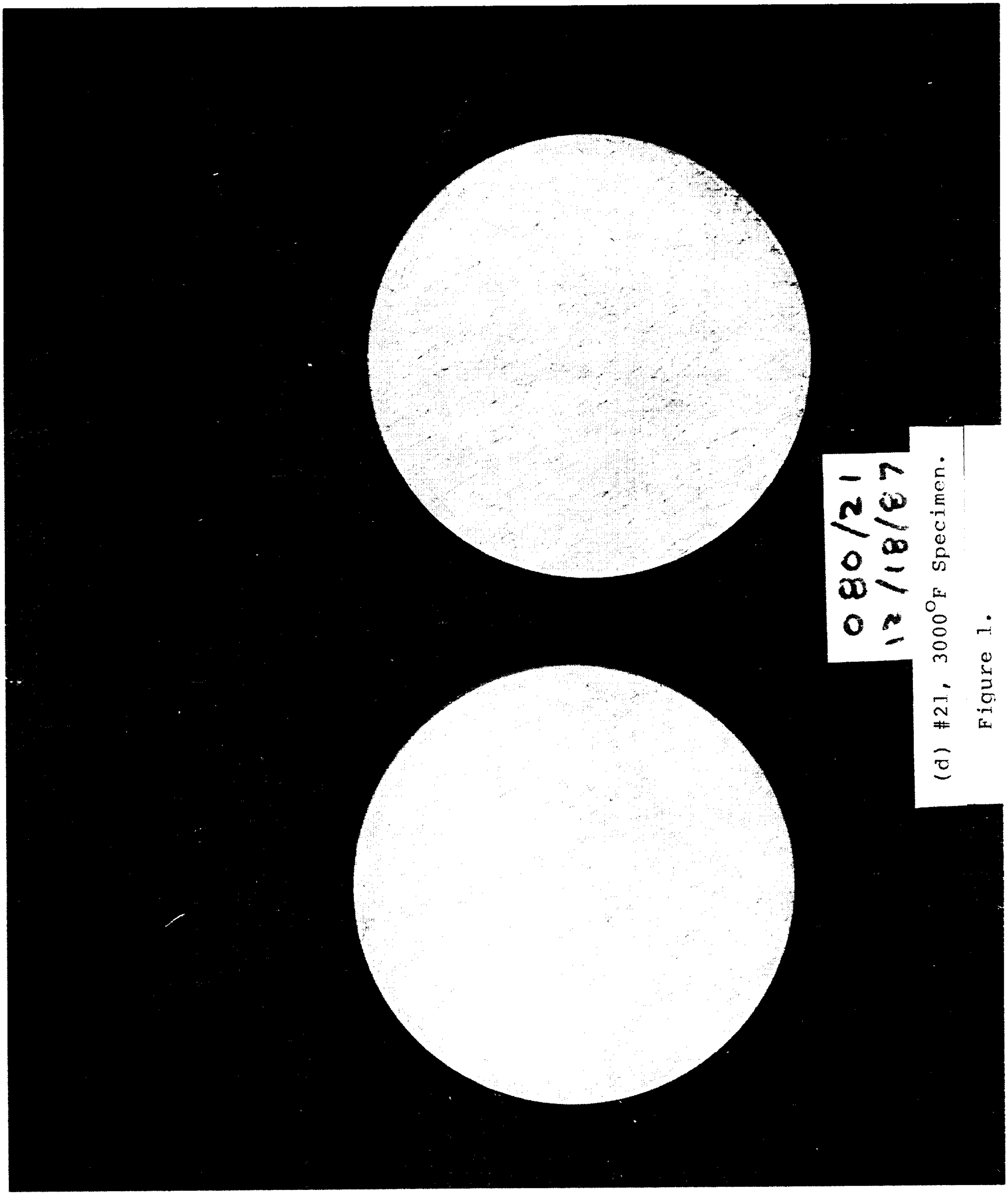
* PRE-CONDITIONED

Note on Figure 1 contents:

Pretest photographs were not available of the following:

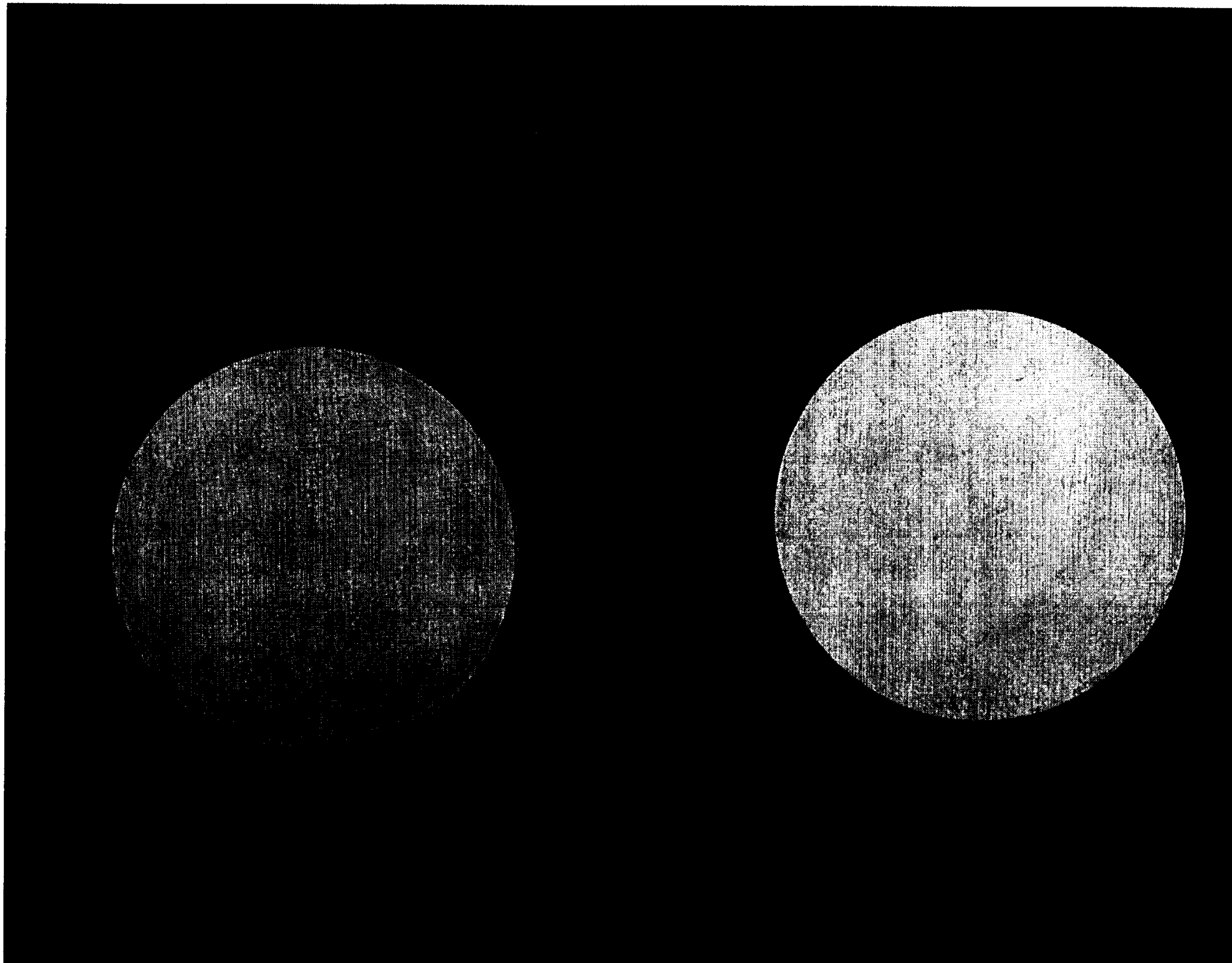
(a) #13, calibration specimen
(b) #16, calibration specimen
(c) #OT-1, 3000 F specimen
(f) #OT-3, 3150 F specimen
(i) #OT-2, 3300 F specimen

Thus figure 1 begins with item (d). (See opposite page.)



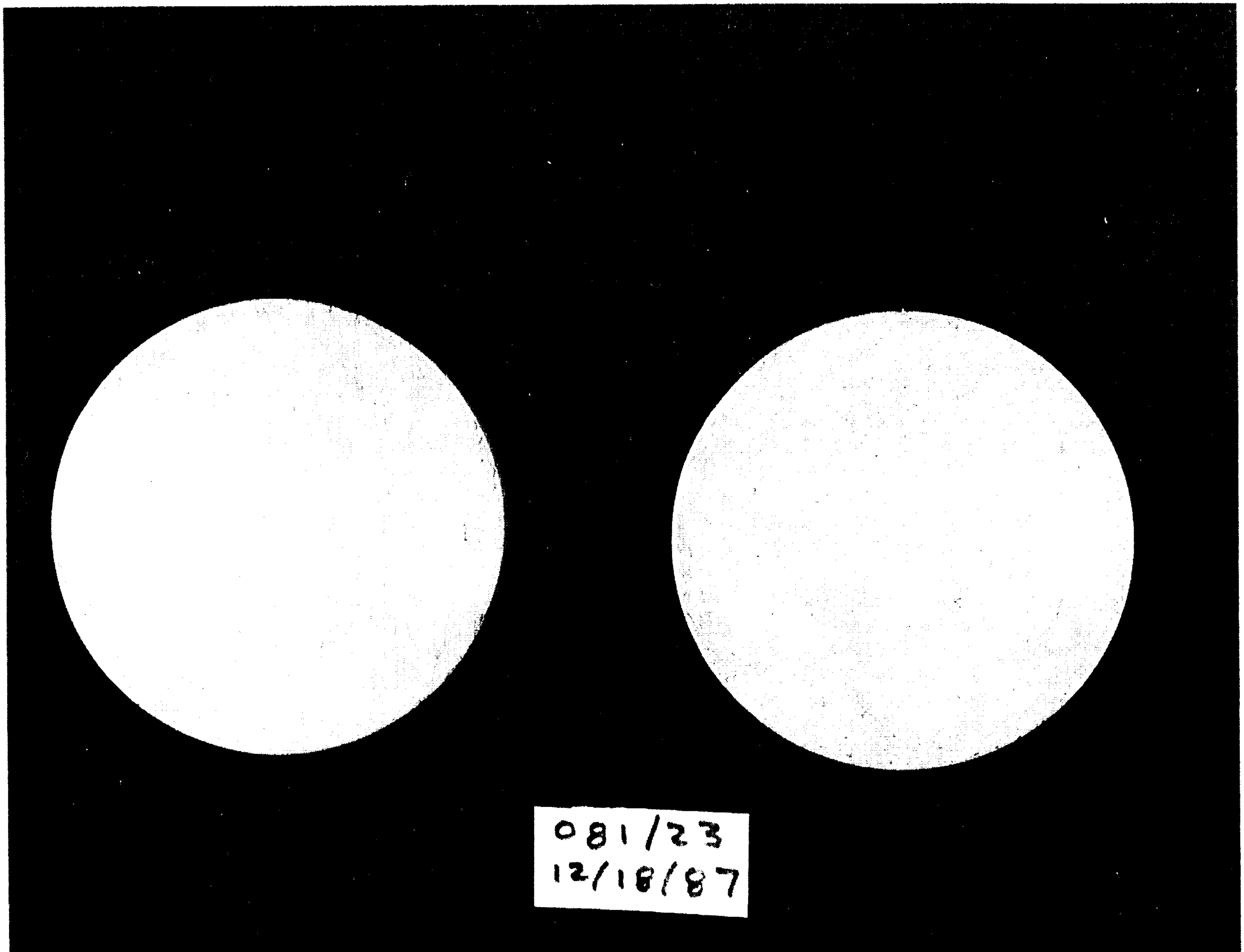
(d) #21, 3000°F Specimen.

Figure 1.



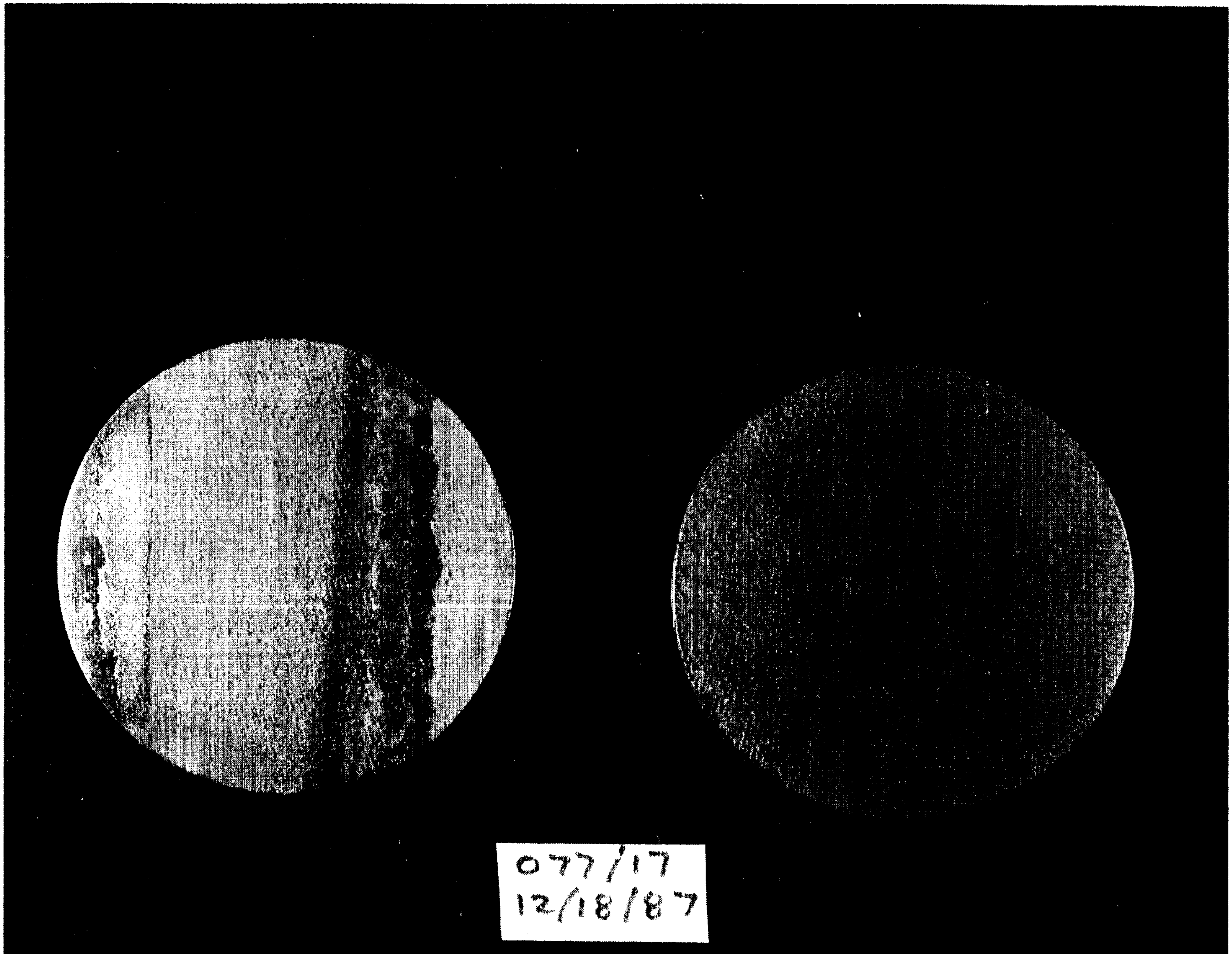
(e) #15, 3000°F Specimen (Preconditioned).

Figure 1.- Continued.



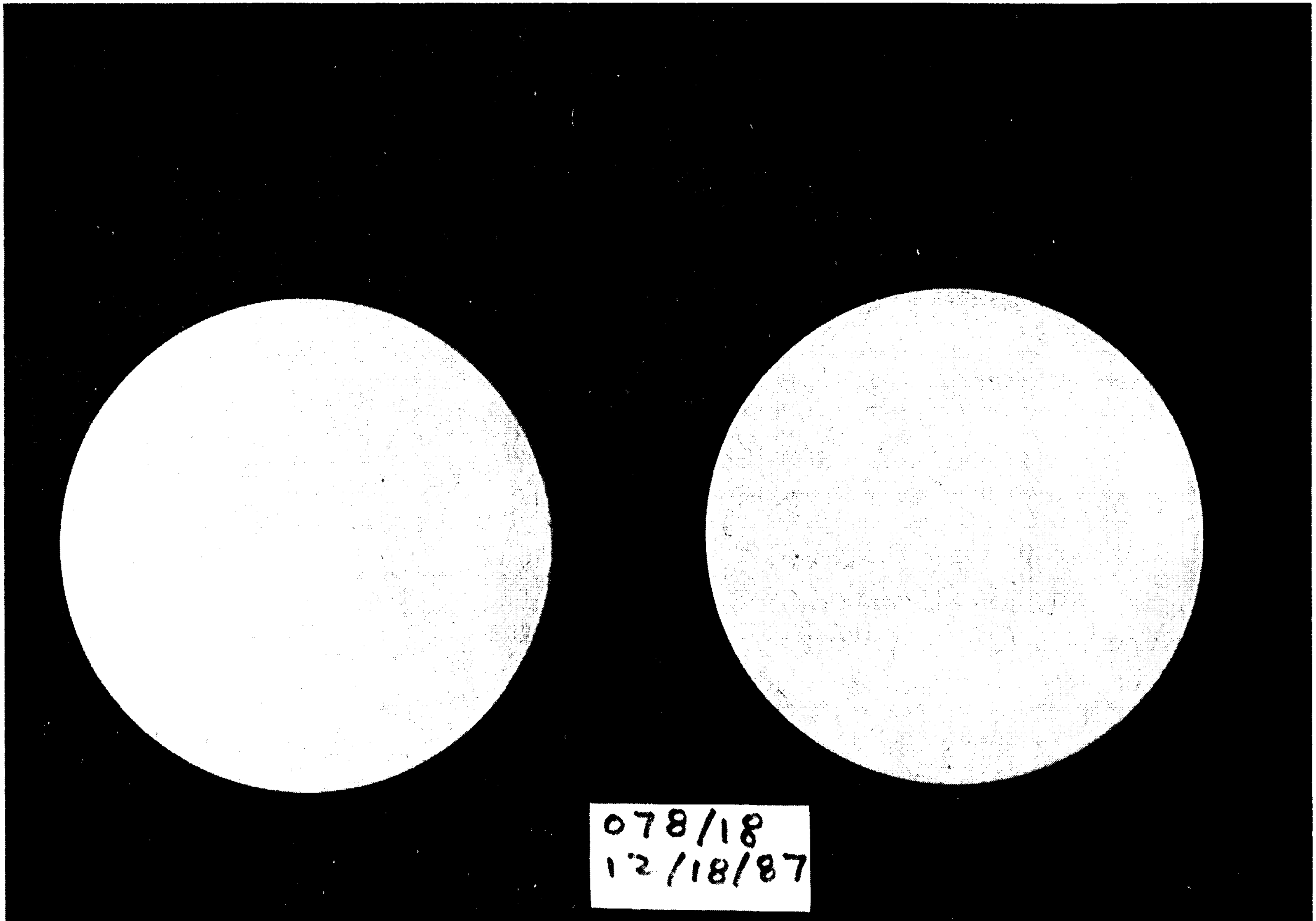
(g) #23, 3150°F Specimen.

Figure 1.- Continued.



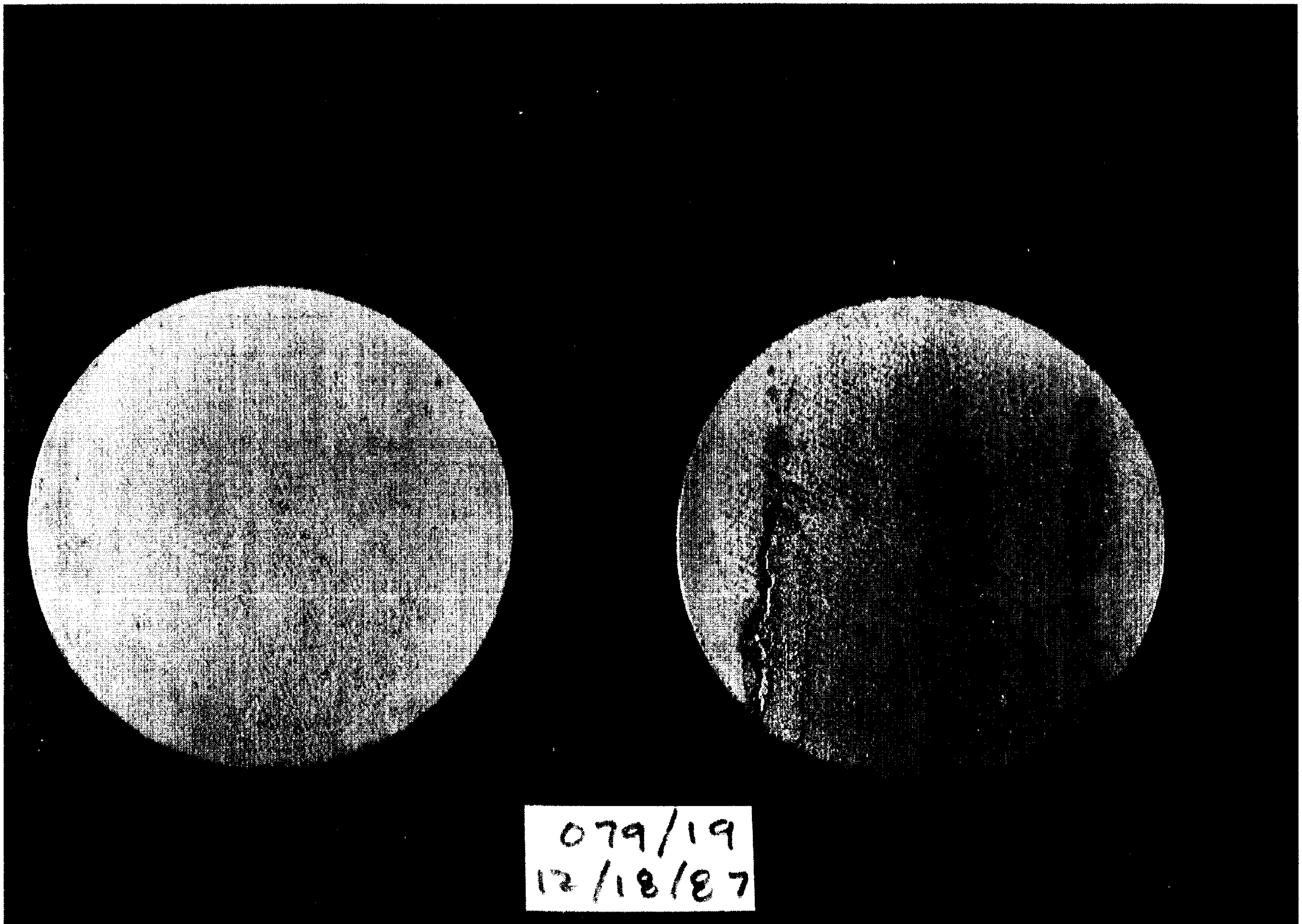
(h) #17, 3150°F Specimen (Preconditioned).

Figure 1.- Continued.



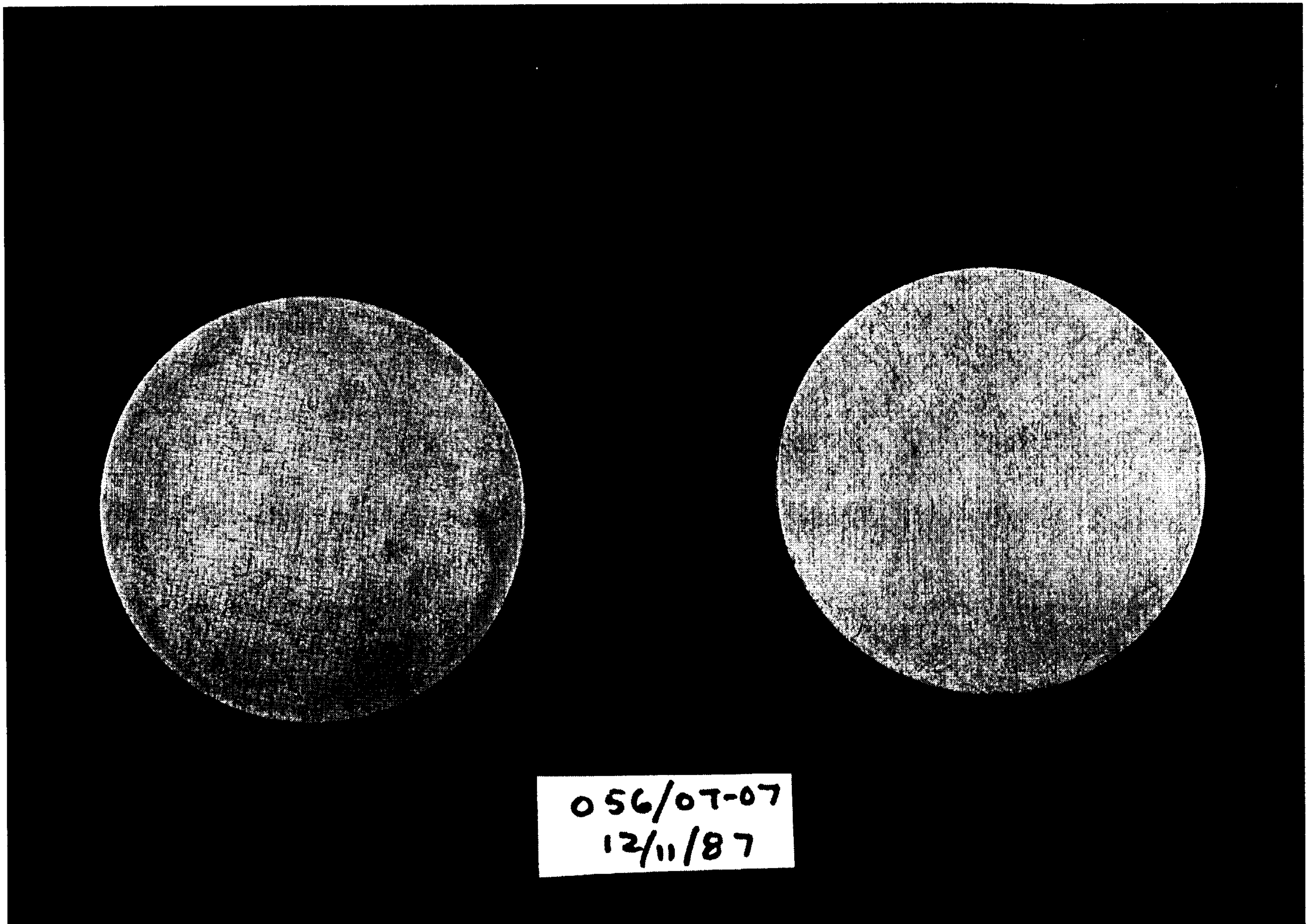
(j) #18, 3300°F Specimen.

Figure 1.- Continued.



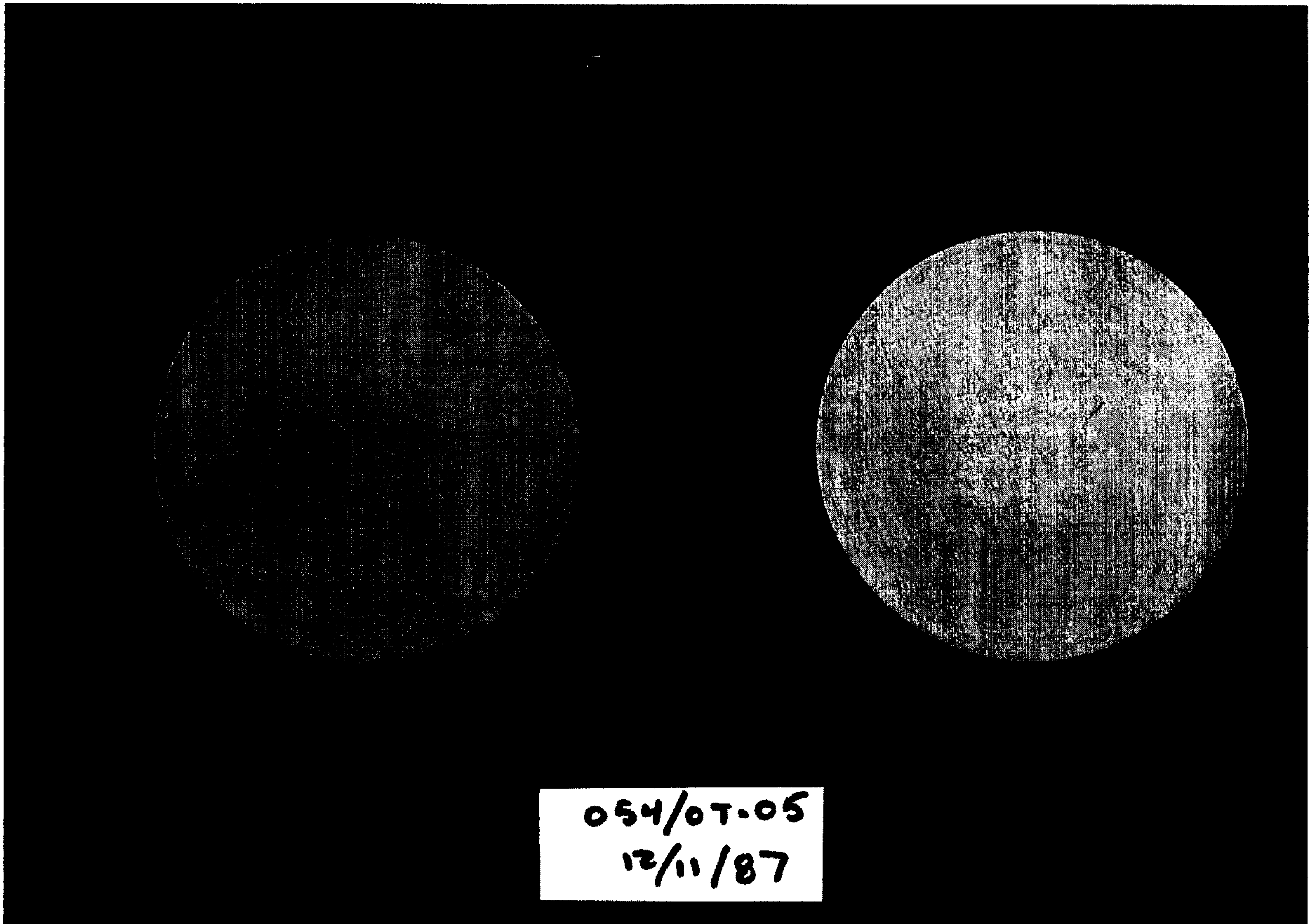
(k) #19, 3300° Specimen (Preconditioned).

Figure 1.-Continued.



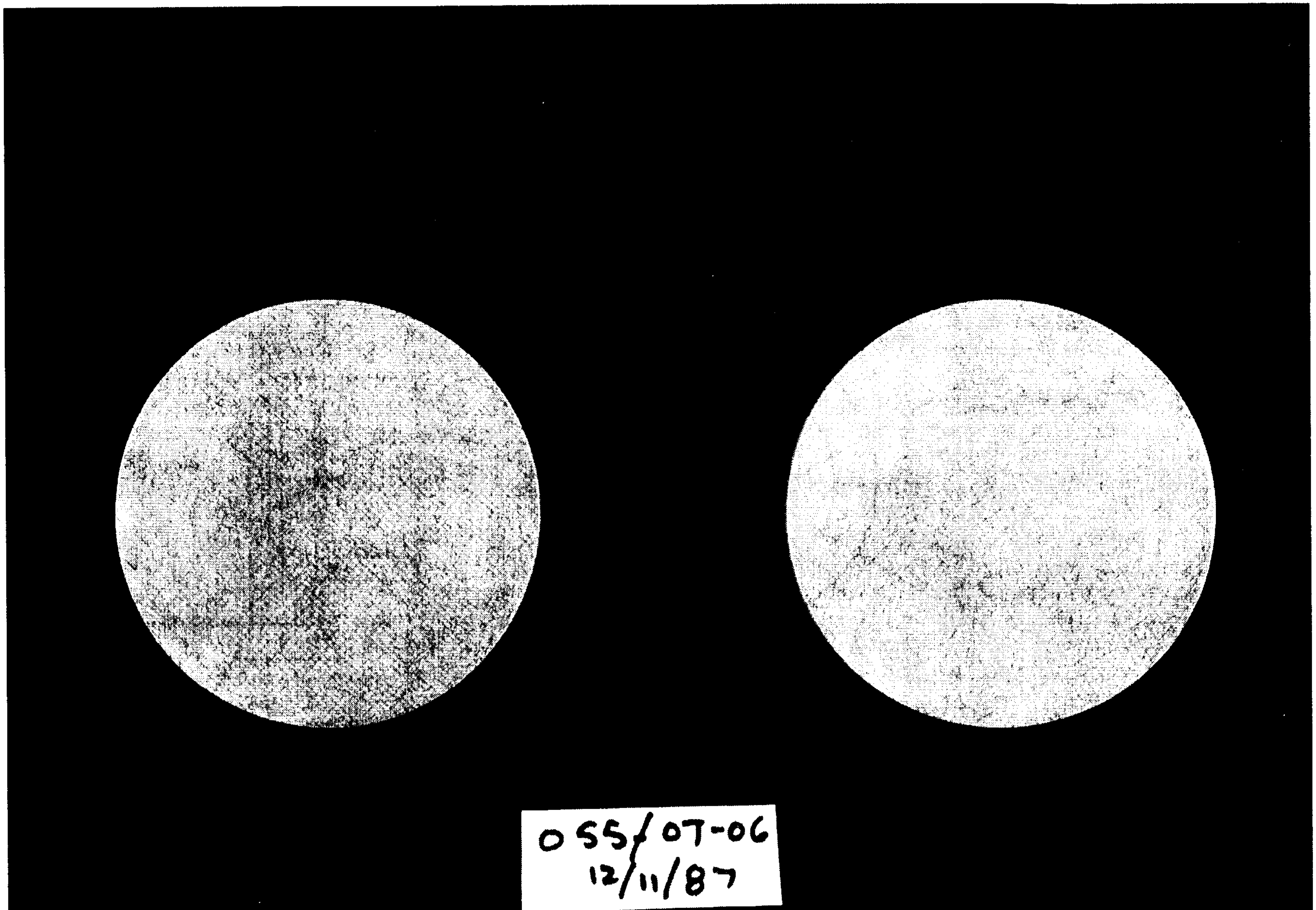
(1) #0T7, 3300°F Specimen.

Figure 1.-Continued.



(m) #0T5, 3400^{O}F Specimen.

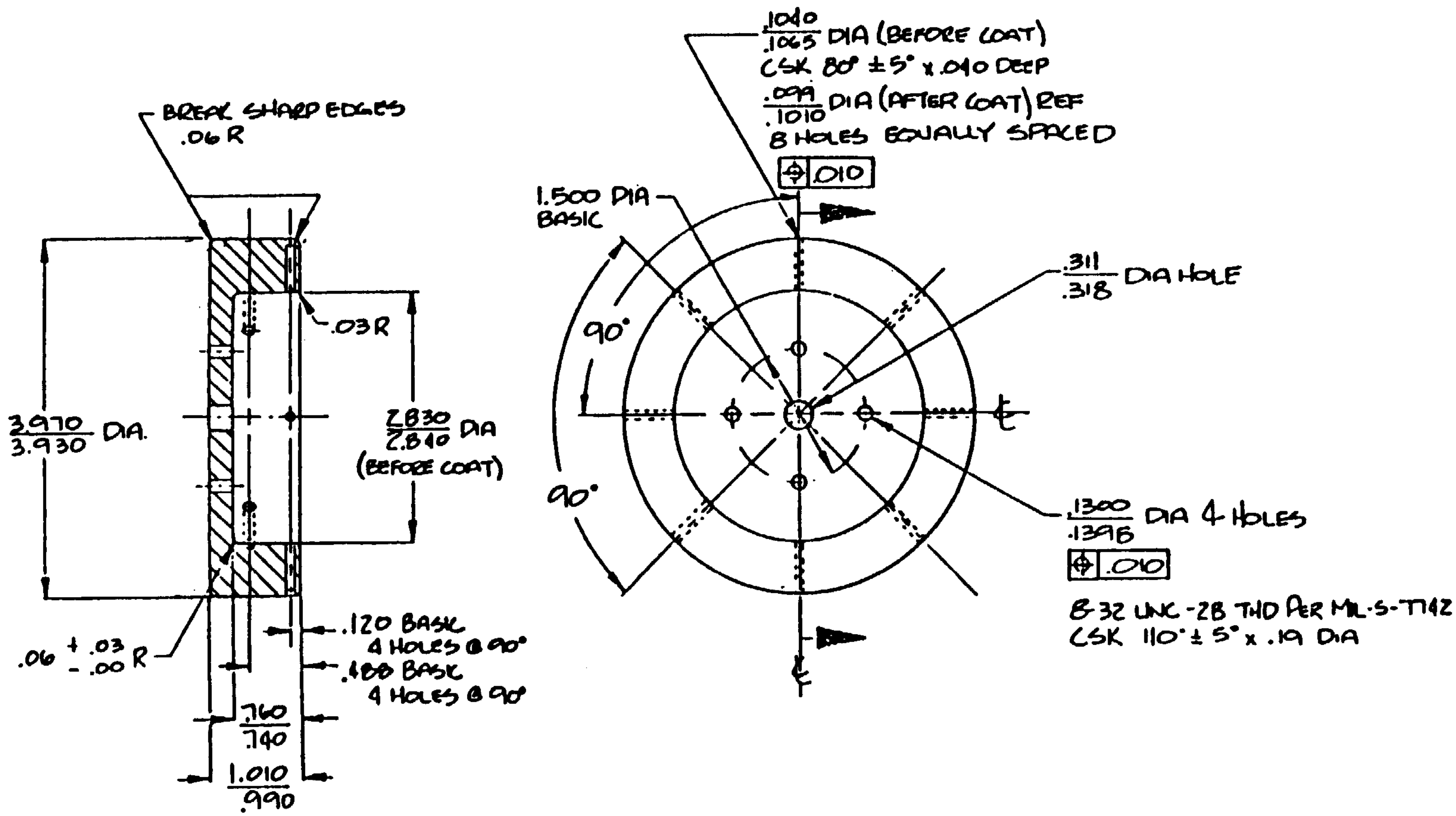
Figure 1.-Continued.



(n) #0T6, 3400°F Specimen.

Figure 1- Concluded.

HOLDER

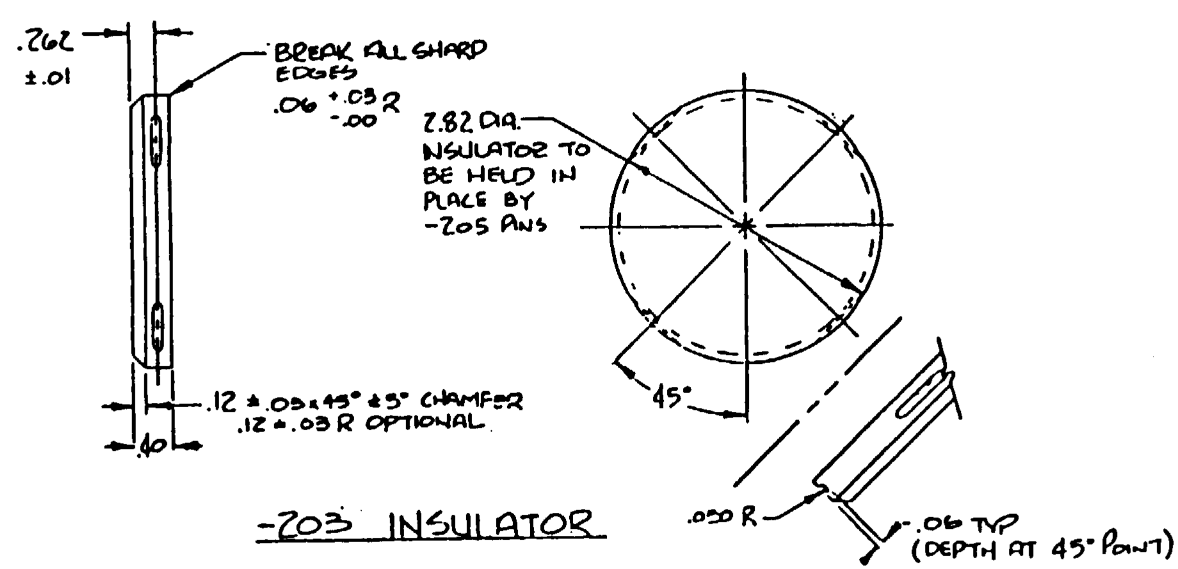


-201 HOLDER

(a) Holder

Figure 2.- Specimen Holder Configuration

ZIRCONIA INSULATOR DISK



(b) Insulator

Figure 3.- Zirconia Insulator

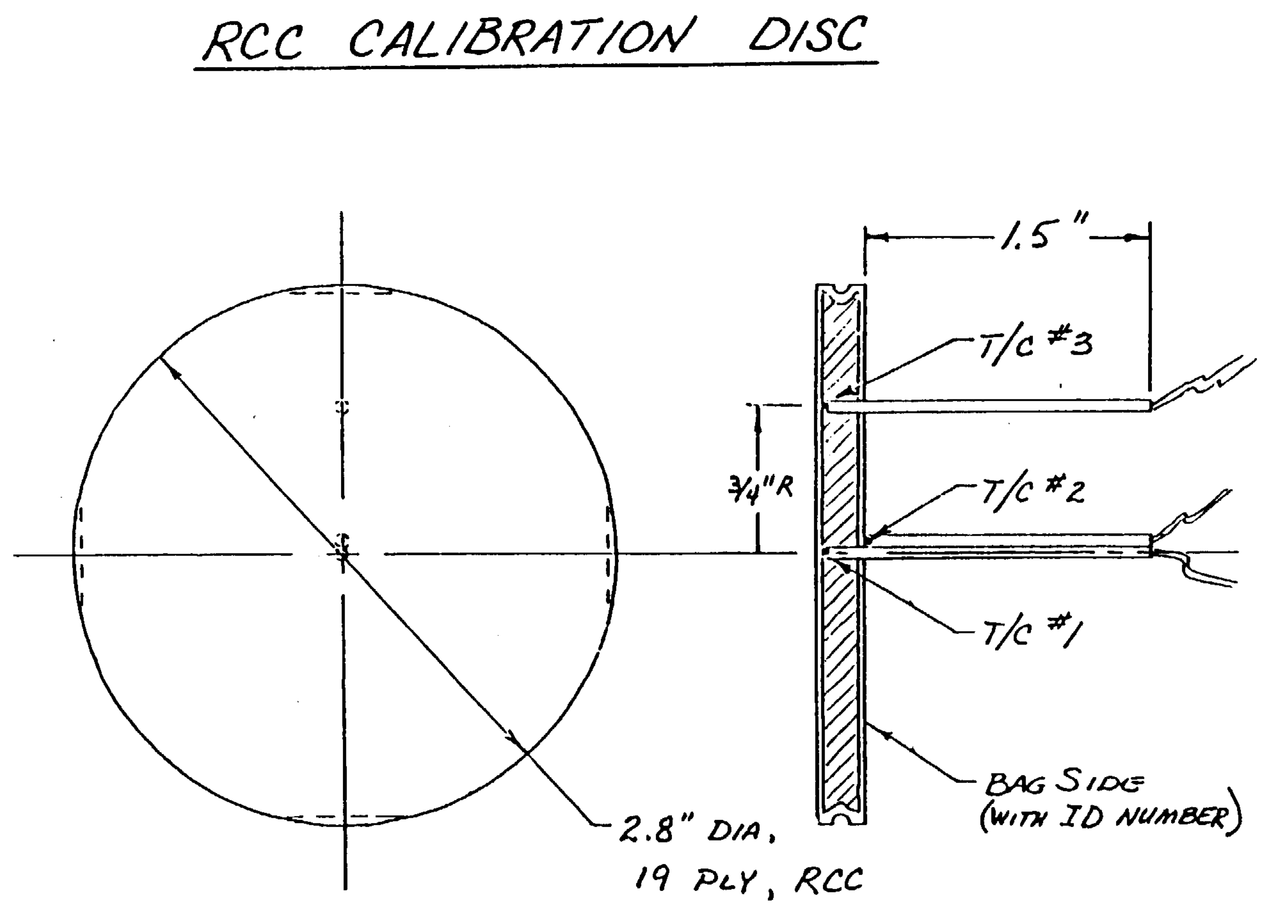


Figure 4. Calibration Specimen Configuration, showing thermocouple installation

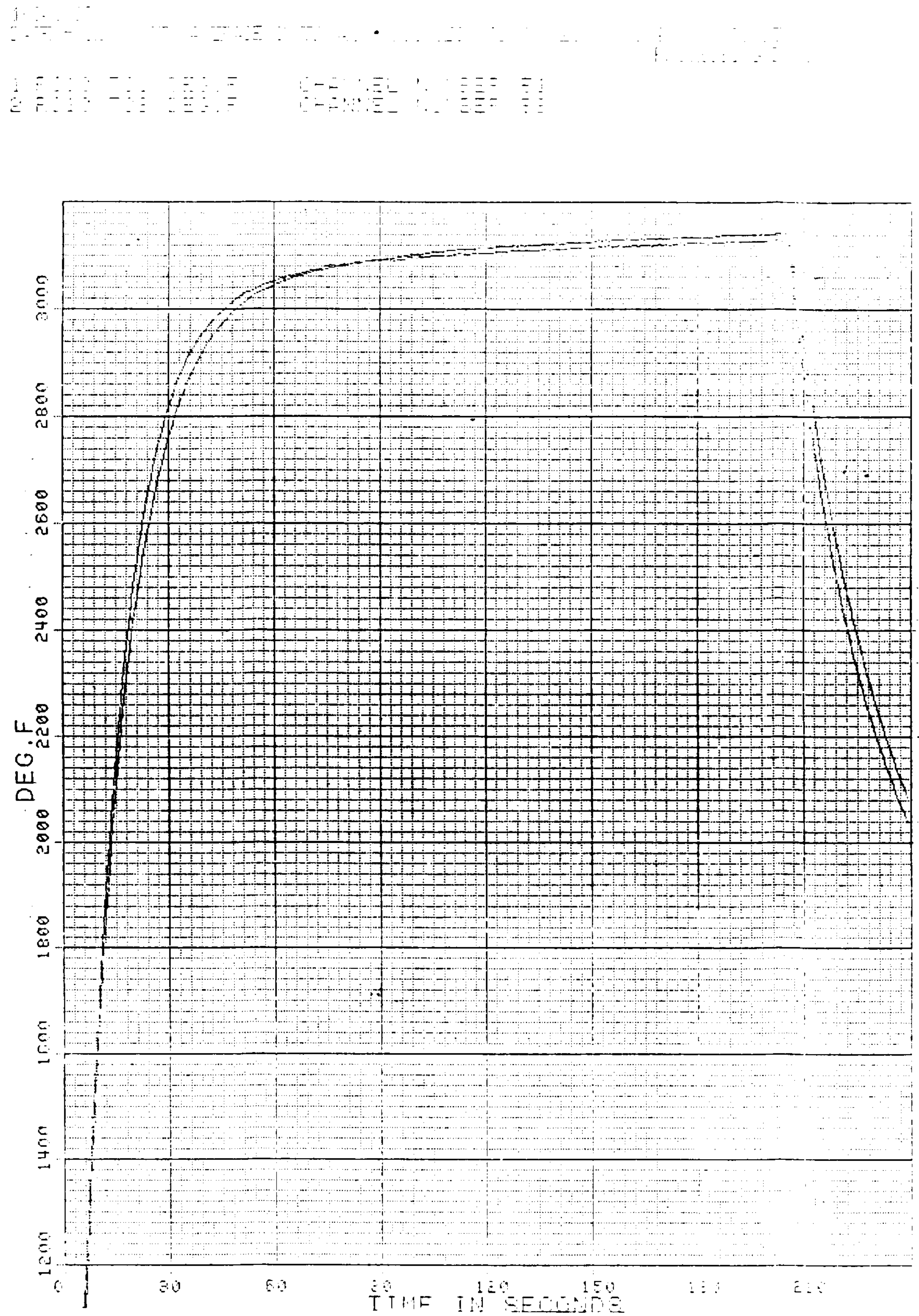


Figure 5.- Typical Thermocouple Response, showing that 2600°F level is reached within 30 seconds.

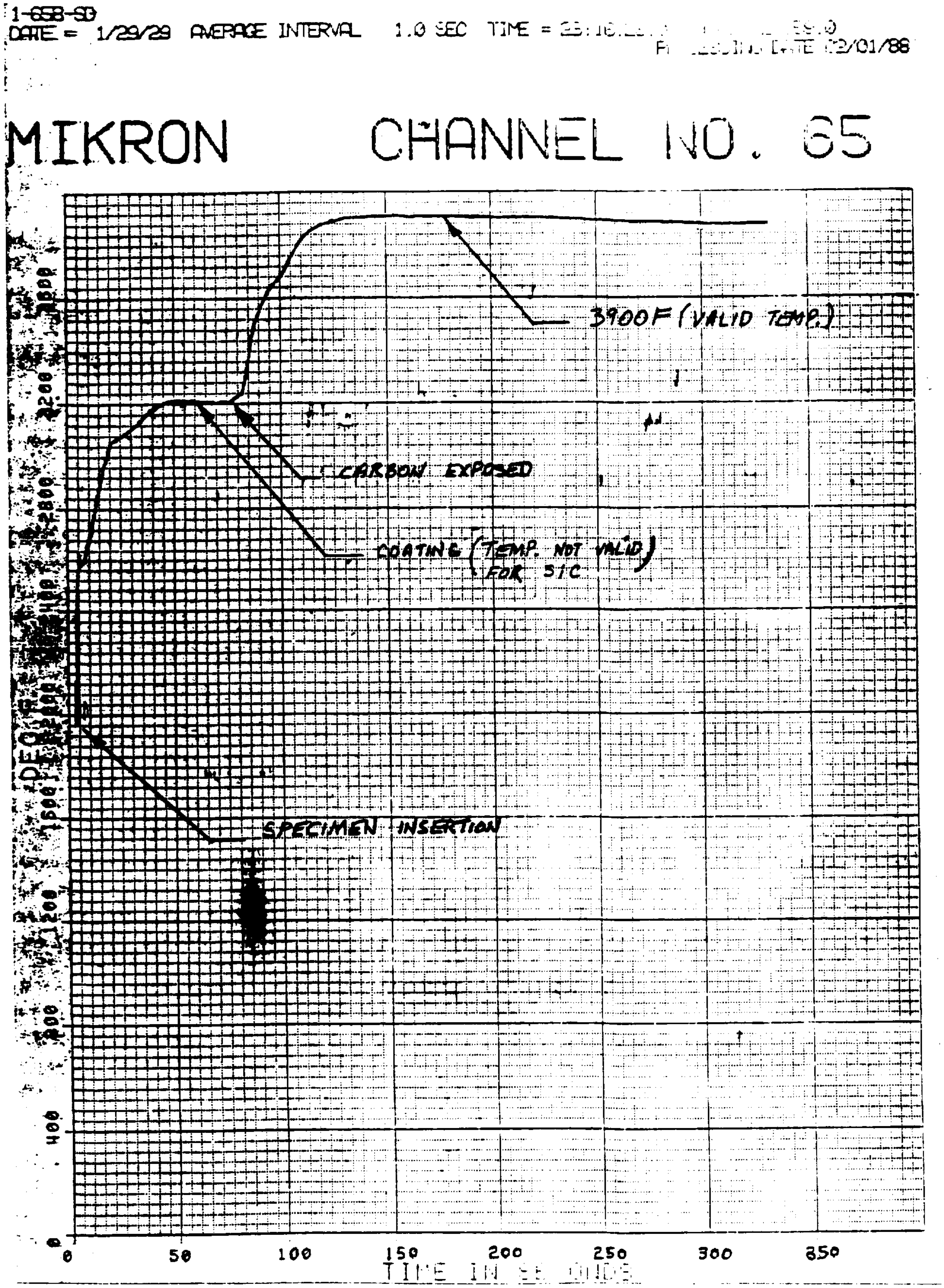
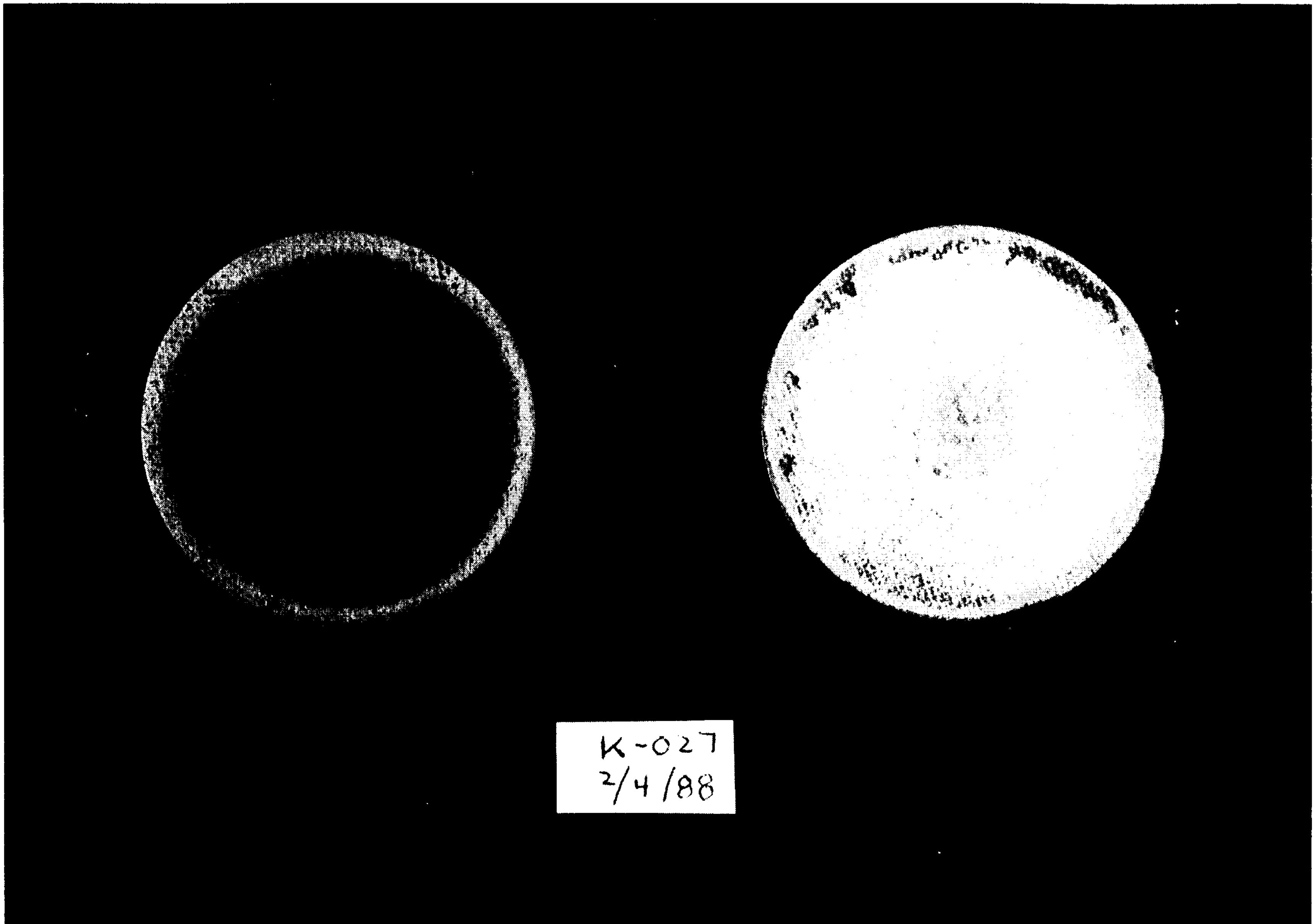
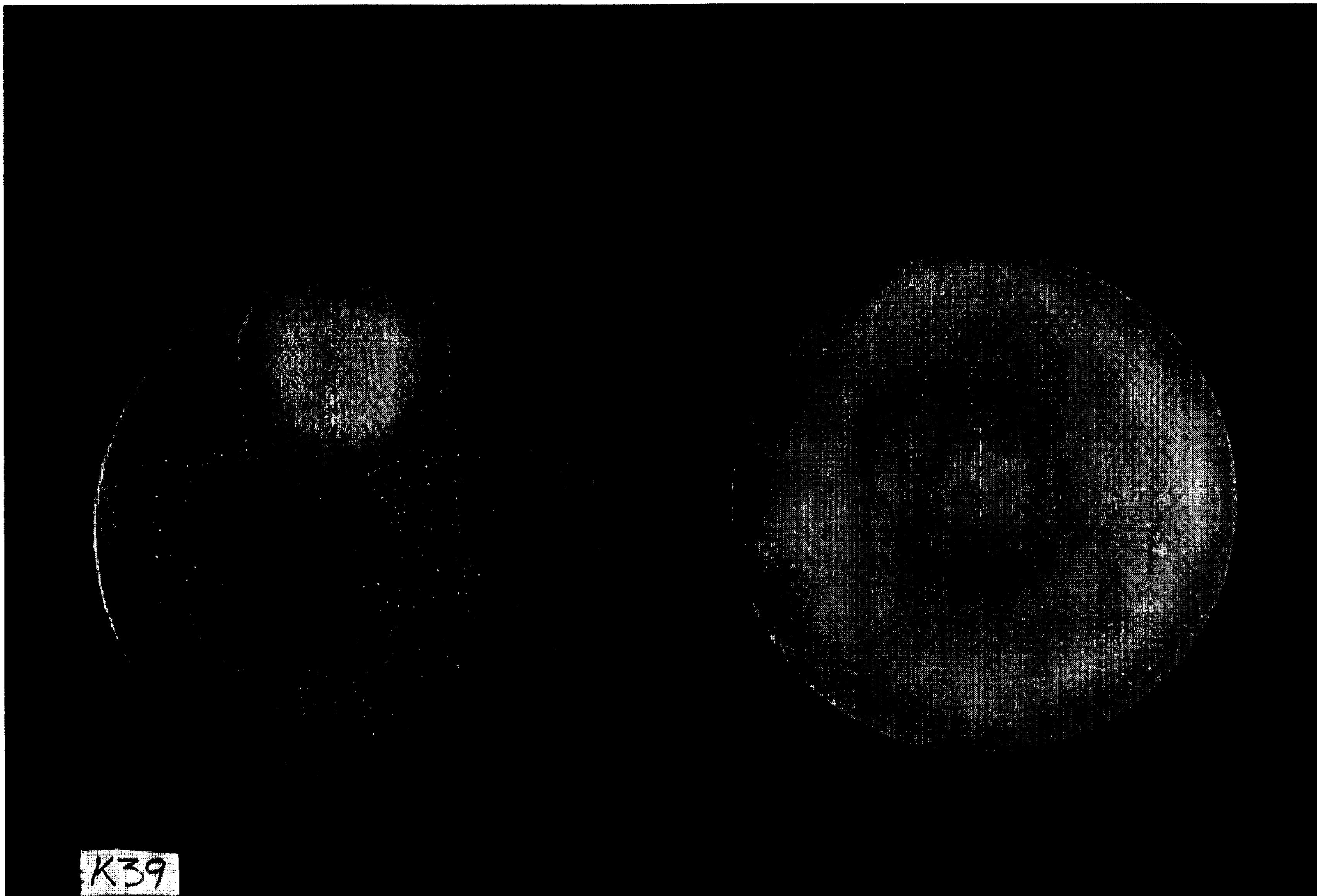


Figure 6.- Ratio Pyrometer Reading, showing rise to 3900°F when carbon substrate is exposed.



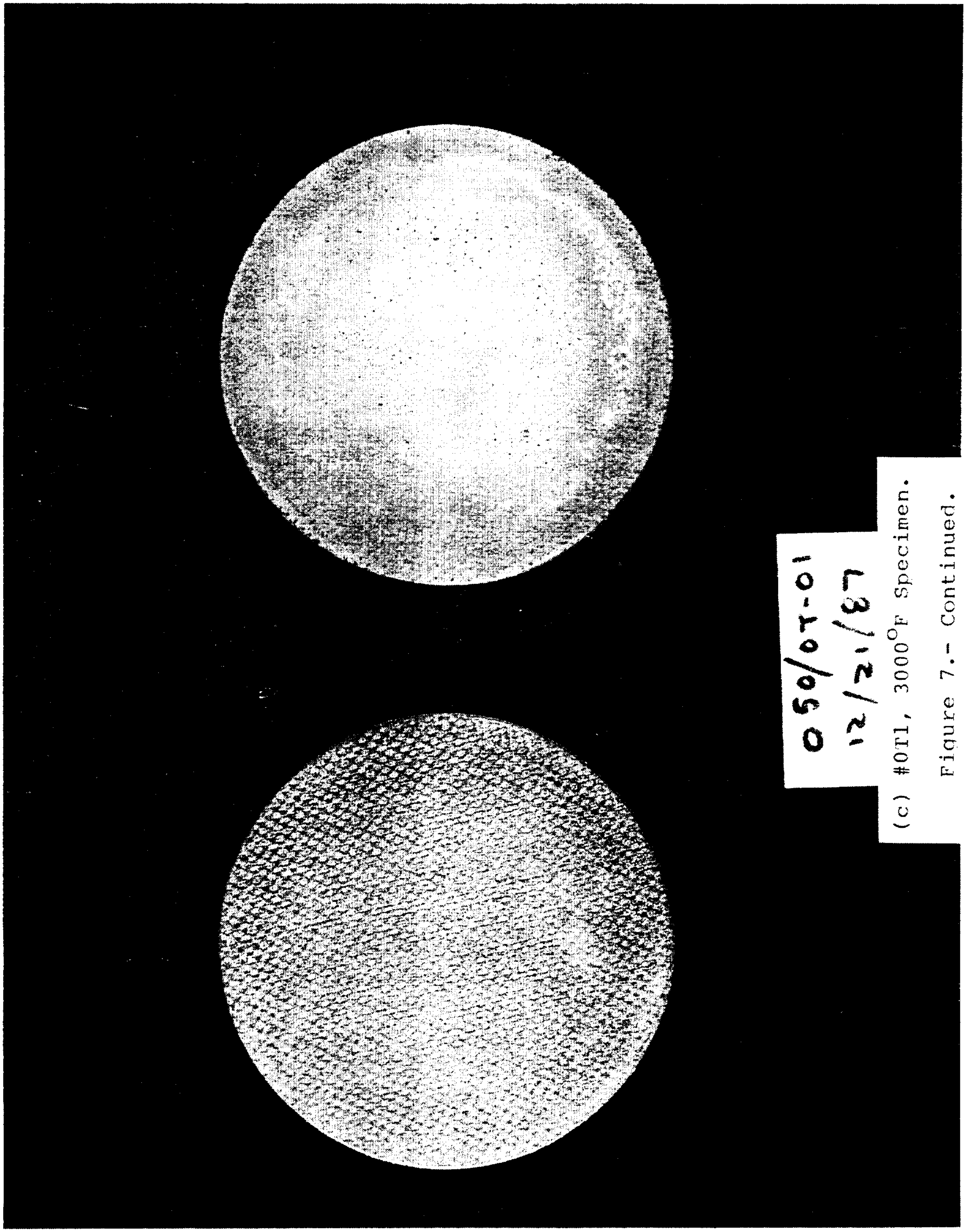
(a) #13, Calibration Specimen

Figure 7.- Post Test Views of Test Specimen - Front and Back Surfaces.



(b) #16, Calibration Specimen.

Figure 7.- Continued.

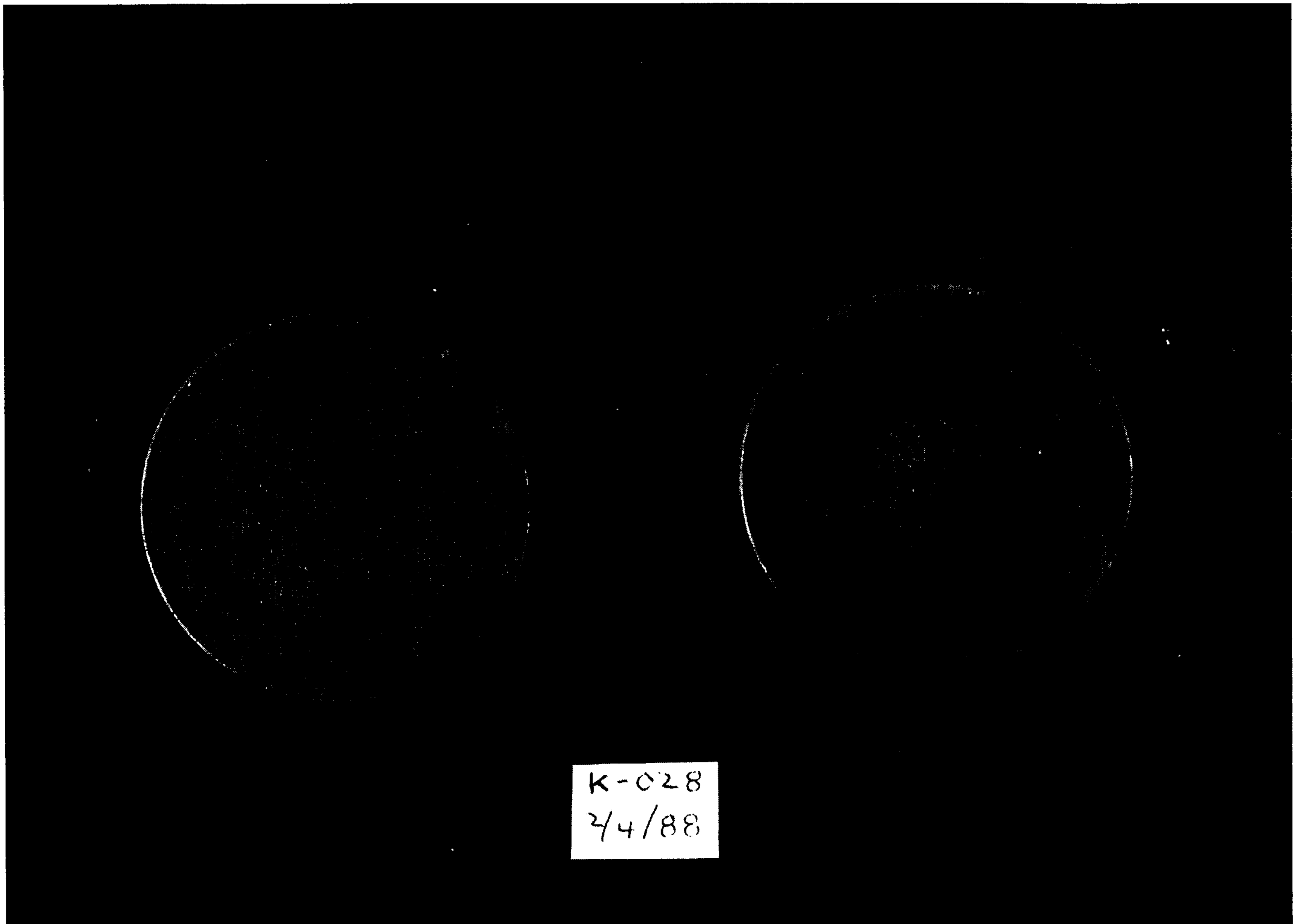


(c) #0T1, 3000^{o}F Specimen.

Figure 7.- Continued.

(d) #21, 3000°F Specimen.

Figure 7.- Continued.

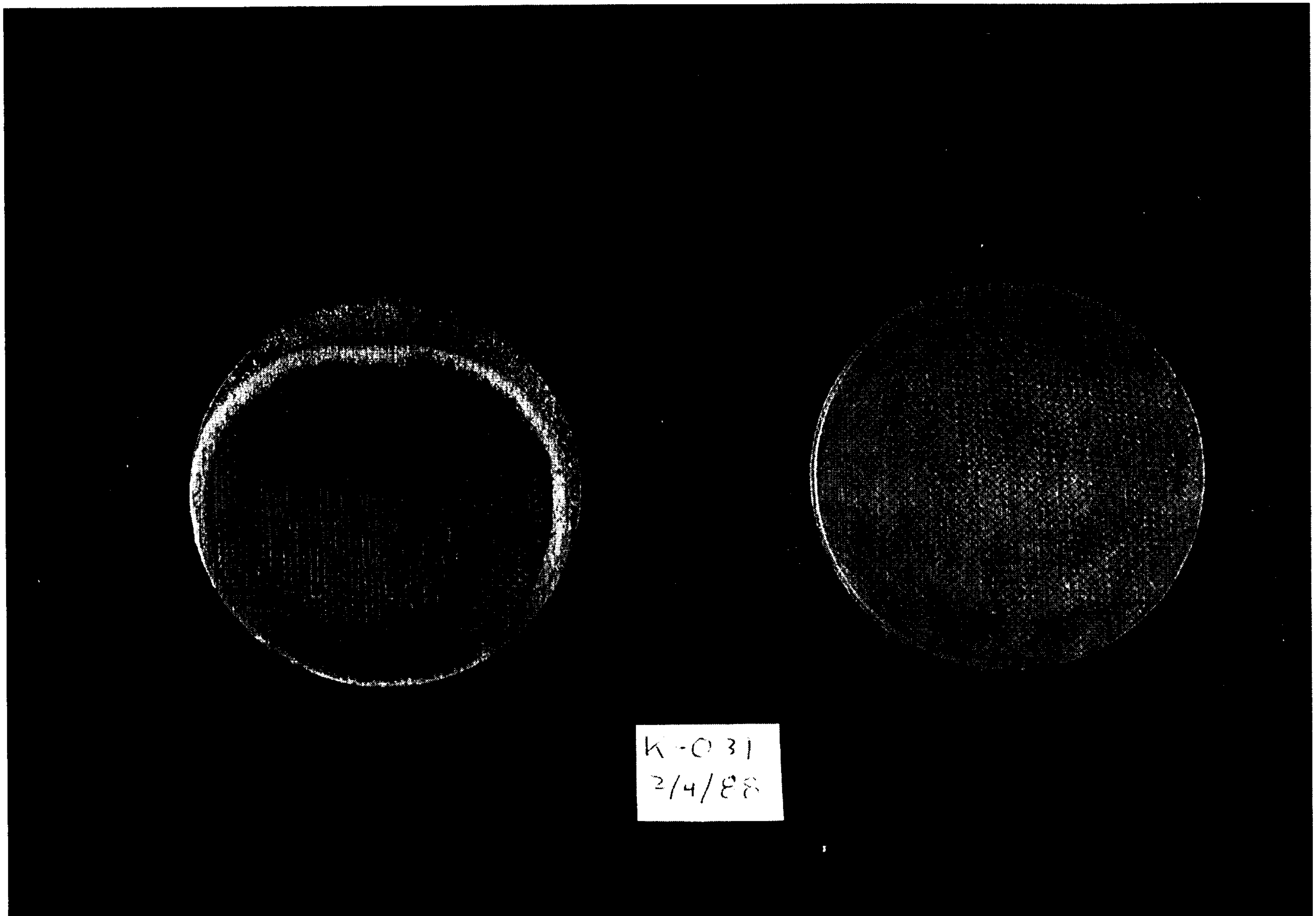


(e) #15, 3000°F Specimen (Preconditioned).

Figure 7.- Continued.

(f) #0T3, 3150°F Specimen.

Figure 7.- Continued.

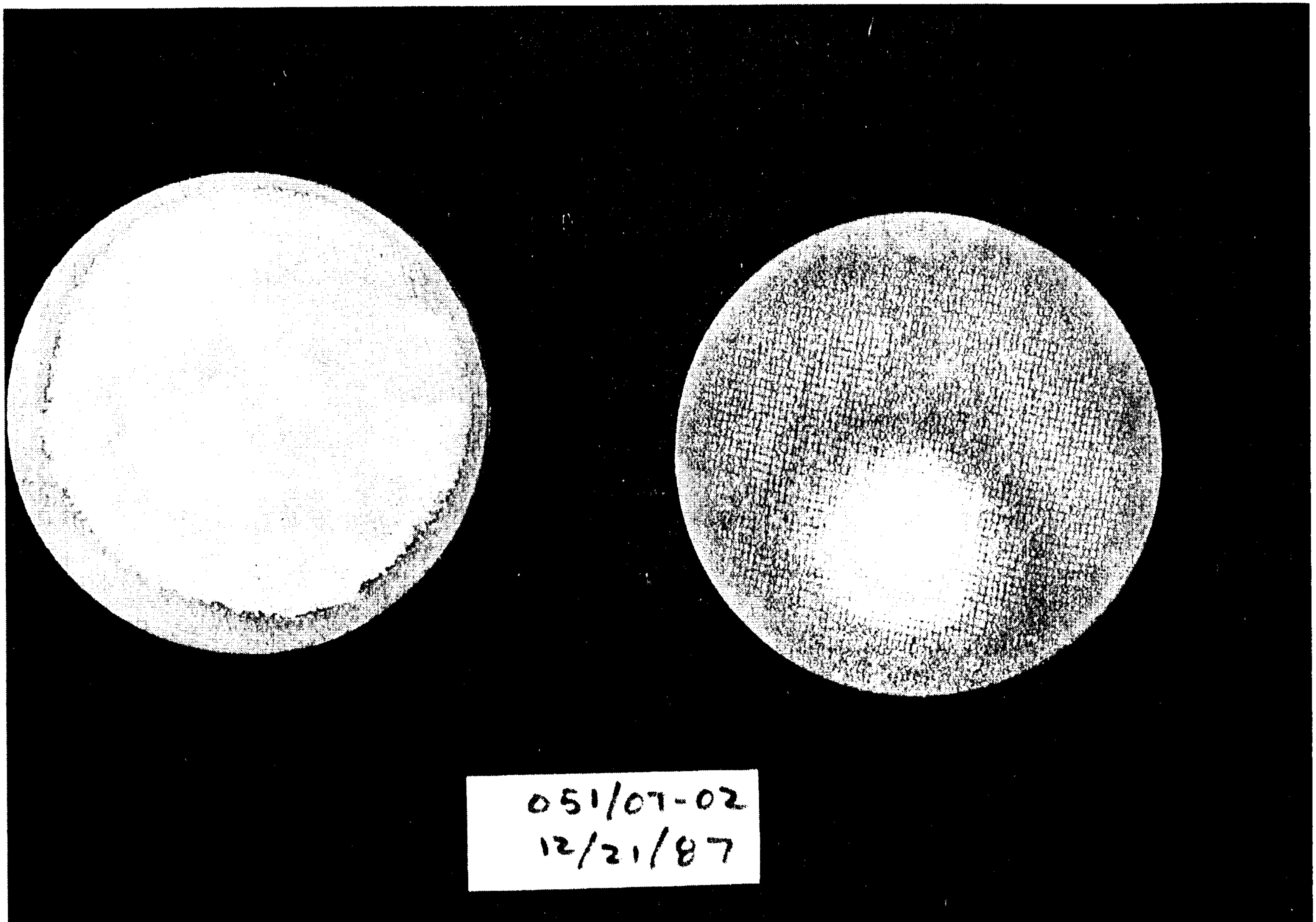


(g) #23, 3150°F Specimen.

Figure 7.- Continued.

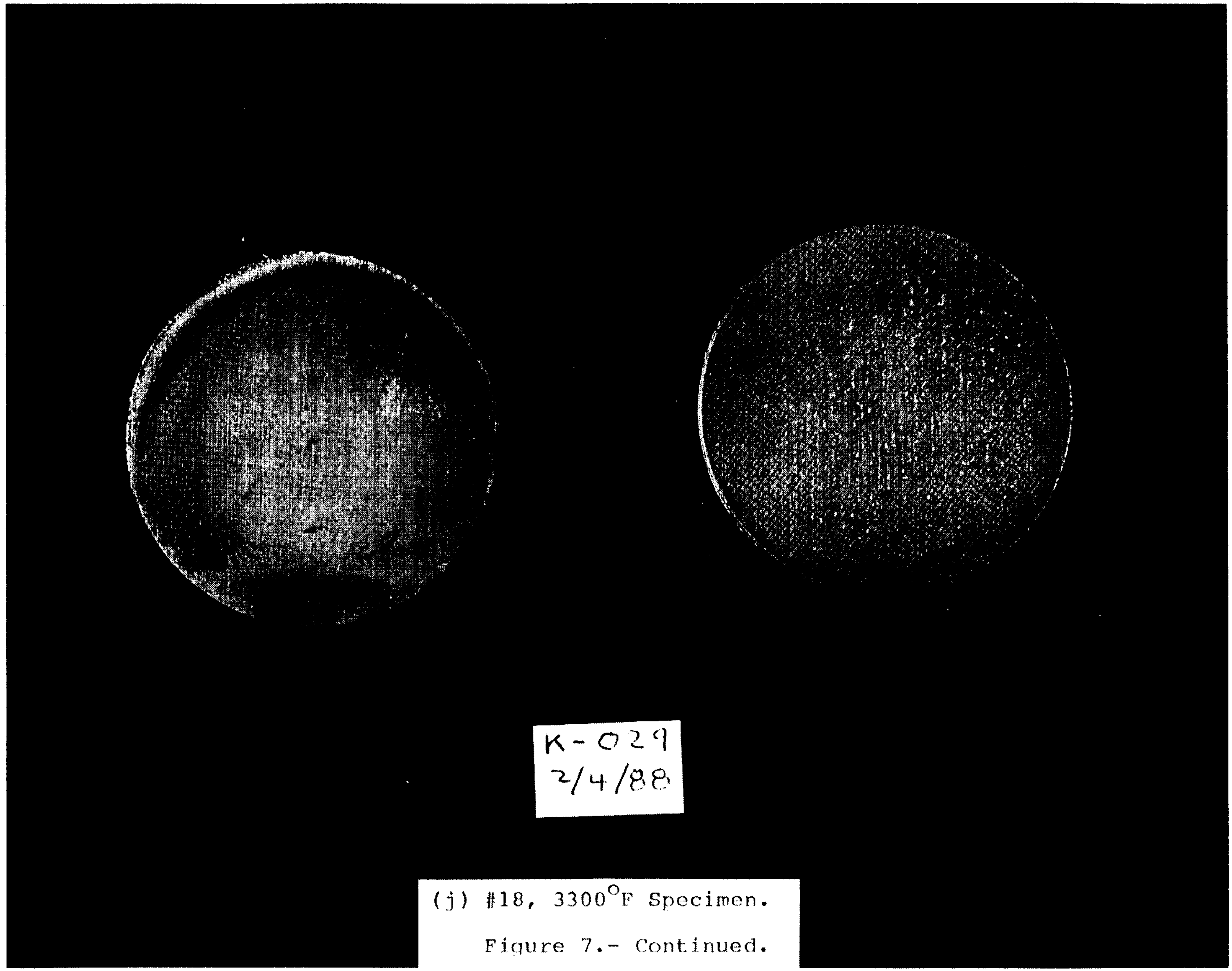
(h) #17, 3150°F Specimen (Preconditioned).

Figure 7.- Continued.



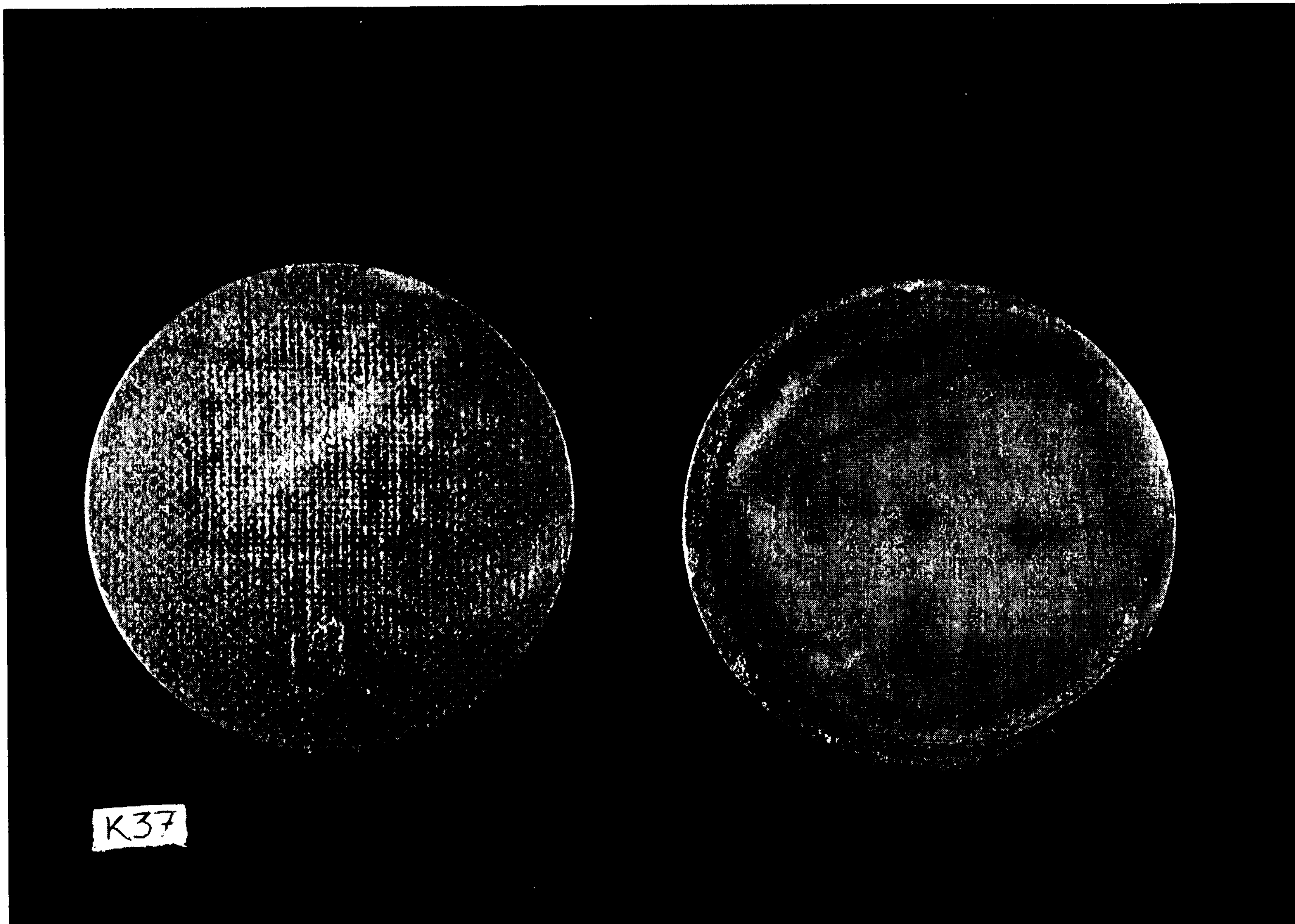
(i) #0T2, 3300°F Specimen.

Figure 7.-Continued.



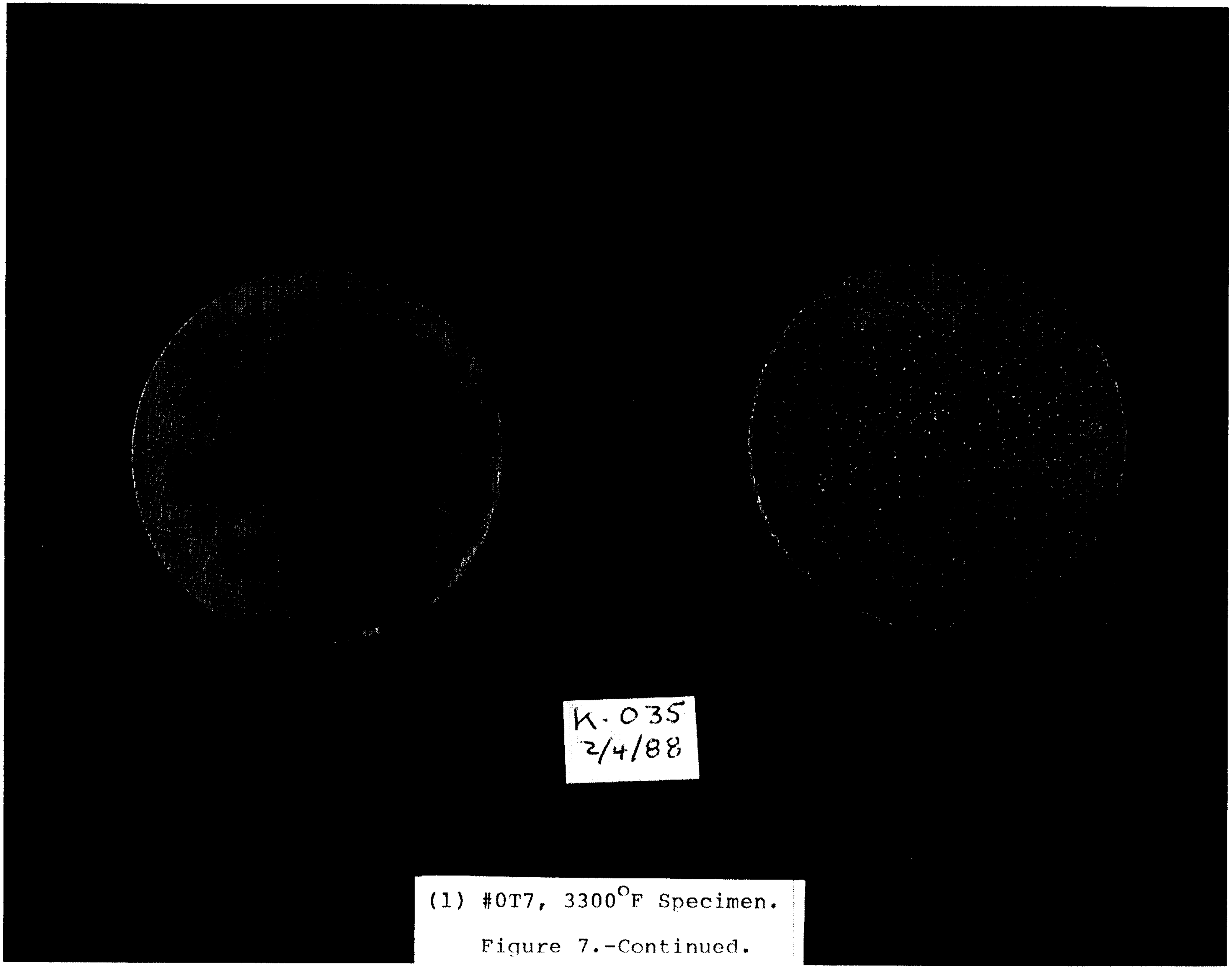
(j) #18, 3300°F Specimen.

Figure 7.- Continued.



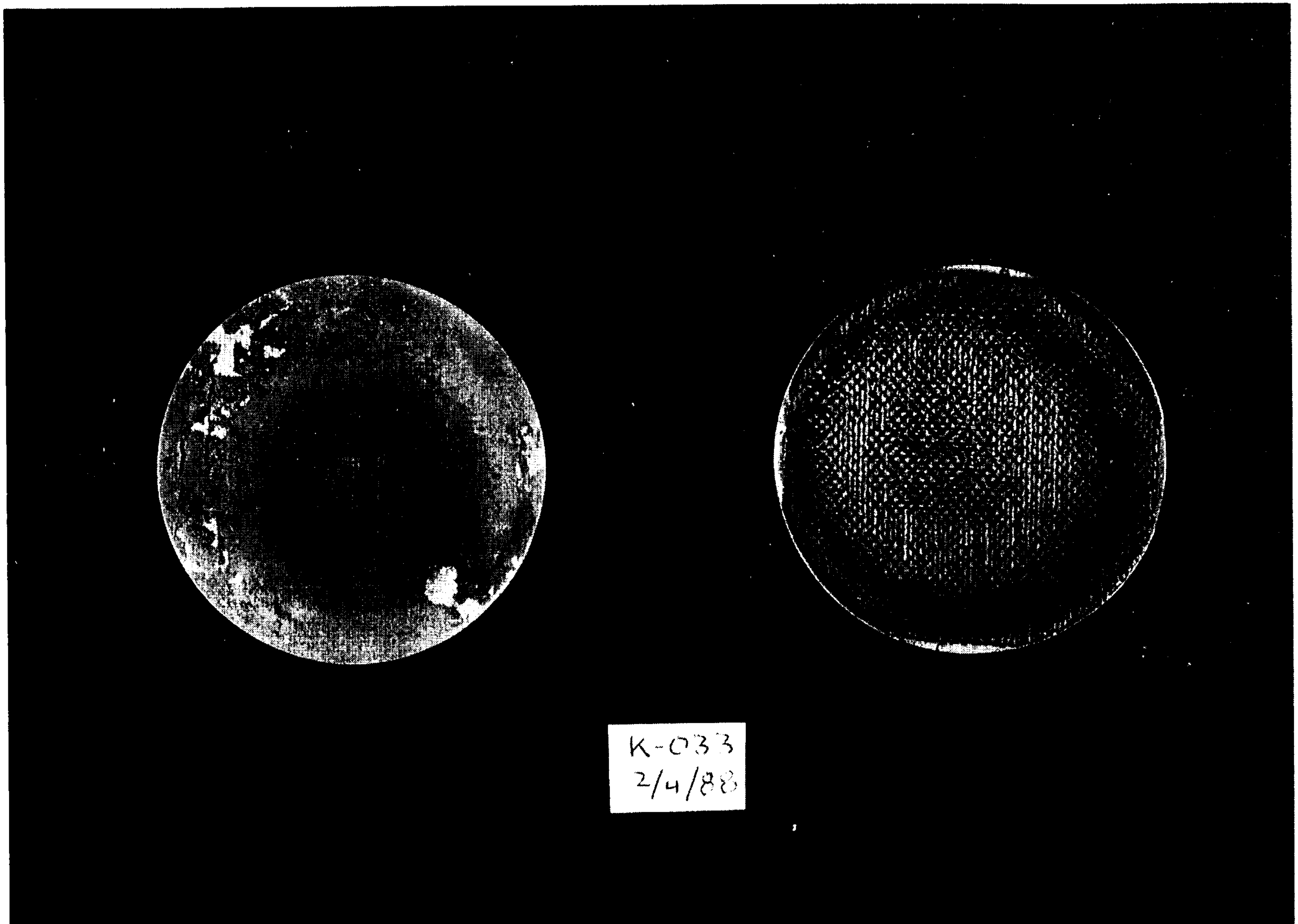
(k) #19, 3300° Specimen (Preconditioned).

Figure 7.-Continued.



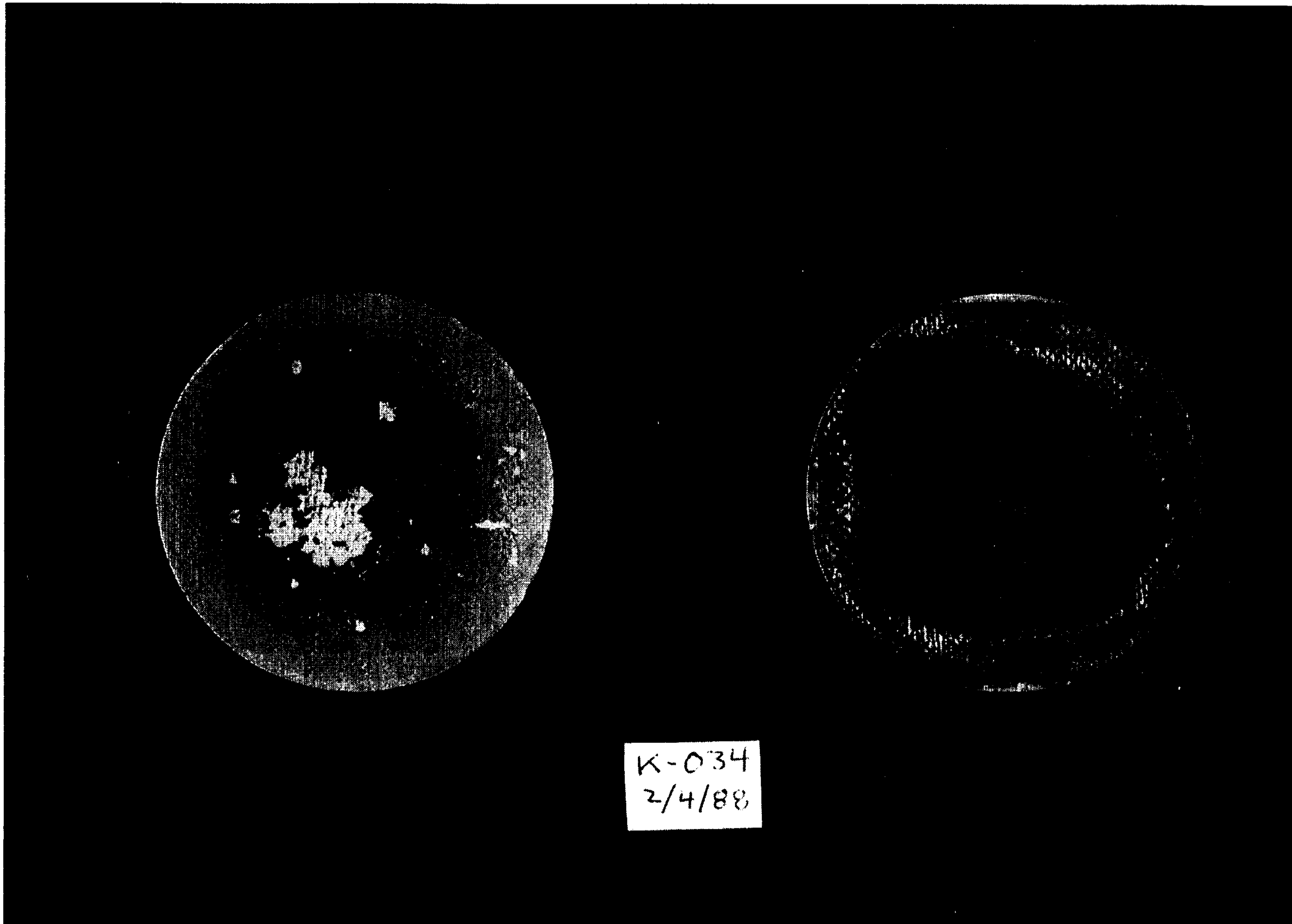
(1) #0T7, 3300°F Specimen.

Figure 7.-Continued.



(m) #0T5, 3400°F Specimen.

Figure 7.-Continued.



(n) #0T6, 3400°F Specimen.

Figure 7.- Concluded.

Test Series 1

APPENDIX A

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: OT-01 RUN NO.: 1-L28-SD TEST CONDITION: 3000°F CYCLE NO.: 1

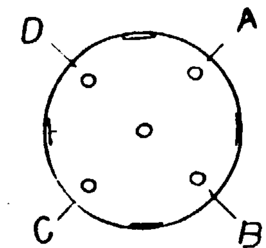
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 53.0730 CENTERLINE: .233

BAG WEIGHT ONLY : 17.6000 POINT A : .235 POINT C: .232

SPECIMEN WEIGHT : 35.4730 POINT B : .237 POINT D : .236

TECH : [illegible] 12/15/87 TECH : [illegible] 12/15/87



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : 52.5826 CENTERLINE: .233

BAG WEIGHT ONLY : 17.6000 POINT-A : .233 POINT-C : .232

SPECIMEN WEIGHT : 34.9826 POINT-B : .232 POINT-D : .232

TECH : [illegible] TECH : [illegible] 12/18/87

POST TEST RESULTS/COMMENTS: PSF 125,

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

PRECEDING PAGE BLANK NOT FILMED

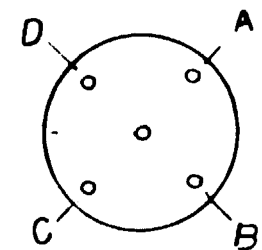
RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: OT-02 RUN NO.: 1.63150 TEST CONDITION: 3100 CYCLE NO.: 1

PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 52.7380	CENTERLINE:	.233		
BAG WEIGHT ONLY	: 17.3180	POINT A	: .231	POINT C	: .232
SPECIMEN WEIGHT	: 35.4190	POINT B	: .231	POINT D	: .234
TECH	: WGm 12/16/87	TECH	: WGm 12/16/87		



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 52.0637	CENTERLINE:	.232		
BAG WEIGHT ONLY	: 17.3190	POINT-A	: .231	POINT-C	: .232
SPECIMEN WEIGHT	:	POINT-B	: .231	POINT-D	: .232
TECH	: [illegible] 12/17/87	TECH	: WGm 12/17/87		

POST TEST RESULTS/COMMENTS:

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: OT-03 RUN NO.: H84-50 TEST CONDITION: 2980 CYCLE NO.: 1

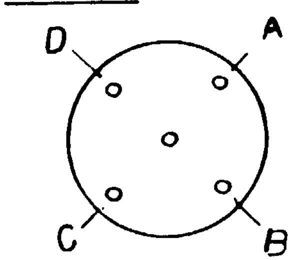
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 52.6634 CENTERLINE: .233

BAG WEIGHT ONLY : 16.9341 ~~17.6195~~ POINT A : .233 POINT C: .232

SPECIMEN WEIGHT : 35.7293 POINT B : .231 POINT D: .234

TECH : JAC 12/31/87 TECH : JAC 12/31/87



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : 51.8351 CENTERLINE: .230

BAG WEIGHT ONLY : 16.9341 POINT-A : .230 POINT-C : .232

SPECIMEN WEIGHT : ______ POINT-B : .231 POINT-D : .232

TECH : ______ ______ TECH : JAC 12/30/87

POST TEST RESULTS/COMMENTS: REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: OT-05 RUN NO.: ______ TEST CONDITION: ______ CYCLE NO.: ______

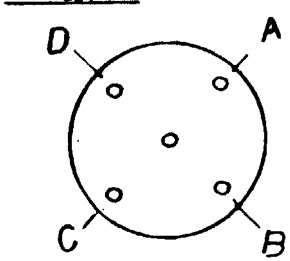
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 53.2043 CENTERLINE: ~~.22~~ .232

BAG WEIGHT ONLY : 17.7661 POINT A : .233 POINT C : .232

SPECIMEN WEIGHT : 35.4382 POINT B : .233 POINT D : .234

TECH : JAC 1/21 TECH : WBM



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : (PRELIM) 32.0951 (FINAL) 32.0048 CENTERLINE: .088

BAG WEIGHT ONLY : 17.7661 17.7641 POINT-A : .105 POINT-C : .092

SPECIMEN WEIGHT : 14.3290 14.2407 POINT-B : .098 POINT-D : .107

TECH : ______ 1/28 TECH : ______ 1/28

POST TEST RESULTS/COMMENTS: POST TEST WEIGHT IS A PRELIMINARY WEIGHT.
(PRIOR TO 4 HOUR BAKE CYCLE)
REMOVED FROM STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

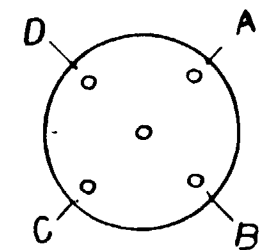
RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: OT-06 RUN NO.: 1-658-SD TEST CONDITION: 3400 CYCLE NO.: 1

PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT:	53.5469	CENTERLINE:	.235		
BAG WEIGHT ONLY	: 17.6757	POINT A	: .236	POINT C:	.236
SPECIMEN WEIGHT	: 35.8712	POINT B	: .236	POINT D:	.237
TECH	: JAC 10/21	TECH	: WBM	1/28/88	



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT:	33.9669	CENTERLINE:	.096		
BAG WEIGHT ONLY	: 17.6757	POINT-A	: .097	POINT-C	: .119
SPECIMEN WEIGHT	: 16.2912	POINT-B	: .098	POINT-D	: .121
TECH	: WBM 8/2/87	TECH	: WBM	[illegible]	

POST TEST RESULTS/COMMENTS: Holder fel off arm at 330 seconds, landed flat on face, specimen held in holder with pins, mole' landed on silfrax flooring, no contact between specimen and floor due to recessed specimen thickness. REMOVED FROM STORAGE/INVENTORY PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: OT-07 RUN NO.: ________ TEST CONDITION: ________ CYCLE NO.: ________

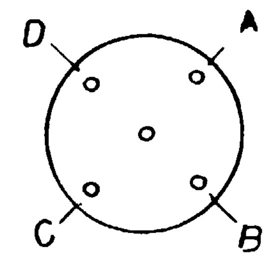
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 52.9187 CENTERLINE: .234

BAG WEIGHT ONLY : 17.2238 POINT A : .234 POINT C: .232

SPECIMEN WEIGHT : 35.6949 POINT B : .234 POINT D: .232

TECH : JAC 10/31 TECH : [illegible] 2/1/88



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : 51.7469 CENTERLINE: .233

BAG WEIGHT ONLY : 17.2238 POINT-A : .233 POINT-C : .232

SPECIMEN WEIGHT : 34.5231 POINT-B : .231 POINT-D : .232

TECH : [illegible] 2/2/88 TECH : [illegible] 2/2/88

POST TEST RESULTS/COMMENTS: REMOVED FROM STORAGE/INVENTORY PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 13 RUN NO.: ______ TEST CONDITION: ______ CYCLE NO.: ______

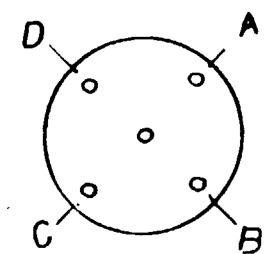
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: ______ CENTERLINE: ______

BAG WEIGHT ONLY : 16.9534 POINT A : ______ POINT C: ______

SPECIMEN WEIGHT : ______ POINT B : ______ POINT D: ______

TECH : JAC 12/2 TECH : ______ ______



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : ______ CENTERLINE: ______

BAG WEIGHT ONLY : ______ POINT-A : ______ POINT-C : ______

SPECIMEN WEIGHT : ______ POINT-B : ______ POINT-D : ______

TECH : ______ ______ TECH : ______ ______

POST TEST RESULTS/COMMENTS: ORIGINALLY USED AS CAL-MODEL AND DELETED FROM REVISED TEST MATRIX. REMOVED FROM INVENTORY/STORAGE PER TPS ______

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 15 RUN NO.: 1-651-5D TEST CONDITION: 3000°F CYCLE NO.: 1

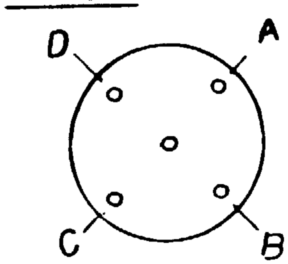
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 52.3353 CENTERLINE: .233

BAG WEIGHT ONLY : 16.8330 POINT A : .232 POINT C: .233

SPECIMEN WEIGHT : 35.5023 POINT B : .233 POINT D: .233

TECH : JAC 1/19/88 TECH : JAC 1-19-88



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 52.2629 CENTERLINE: .226

BAG WEIGHT ONLY : 16.8334 POINT-A : .226 POINT-C : .227

SPECIMEN WEIGHT : 35.4295 POINT-B : .226 POINT-D : .227

TECH : WBm 1/19/88 TECH : JAC 1-19-88

POST TEST RESULTS/COMMENTS: REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 16 RUN NO.: ________ TEST CONDITION: ________ CYCLE NO.: ________

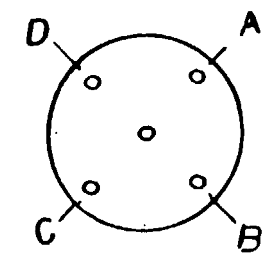
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: ________ CENTERLINE: ________

BAG WEIGHT ONLY : 16.9303 POINT A : ________ POINT C: ________

SPECIMEN WEIGHT : ________ POINT B : ________ POINT D: ________

TECH : JAC 10/21 TECH : ________ ________



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : ________ CENTERLINE: ________

BAG WEIGHT ONLY : ________ POINT-A : ________ POINT-C : ________

SPECIMEN WEIGHT : ________ POINT-B : ________ POINT-D : ________

TECH : ________ ________ TECH : ________ ________

POST TEST RESULTS/COMMENTS: ORIGINALLY USED AS CAL-MODEL AND DELETED FROM REVISED TEST MATRIX FOR ACTUAL TESTS. REMOVED FROM INVENTORY / STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

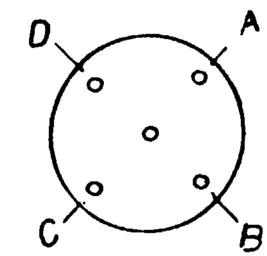
RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 17 RUN NO.: ______ TEST CONDITION: ______ CYCLE NO.: ______

PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 51.9537	CENTERLINE	: .225		
BAG WEIGHT ONLY	: 16.9824	POINT A	: .223	POINT C	: .223
SPECIMEN WEIGHT	: 34.9715	POINT B	: .224	POINT D	: .225
TECH	: [illegible] 12/21	TECH	: [illegible]		



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 51.5713	CENTERLINE	: .224		
BAG WEIGHT ONLY	: 16.9824	POINT-A	: .225	POINT-C	: .225
SPECIMEN WEIGHT	:	POINT-B	: .224	POINT-D	: .227
TECH	:	TECH	: [illegible] 21 88		

POST TEST RESULTS/COMMENTS: REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

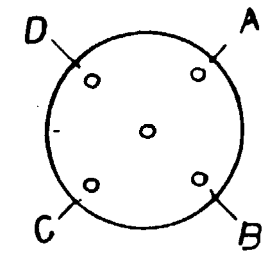
RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 18 RUN NO.: 1-6B TEST CONDITION: 3270 CYCLE NO.: 1

PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 52.0577	CENTERLINE	: .226		
BAG WEIGHT ONLY	: 16.9697	POINT A	: .226	POINT C	: .226
SPECIMEN WEIGHT	: 35.0880	POINT B	: .227	POINT D	: .226
TECH	: JAC 12/3	TECH	: BB 1-21-88		



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 51.3080	CENTERLINE	: .227		
BAG WEIGHT ONLY	: 16.9730	POINT-A	: .223	POINT-C	: .225
SPECIMEN WEIGHT	: 34.3337	POINT-B	: .228	POINT-D	: .226
TECH	: WBM 1/2	TECH	: WBM 1/22/88		

POST TEST RESULTS/COMMENTS: MODEL PLACED IN OVEN AT 23:20 - REMOVE AFTER 4HRS
REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 19 RUN NO.: ______ TEST CONDITION: ______ CYCLE NO.: ______

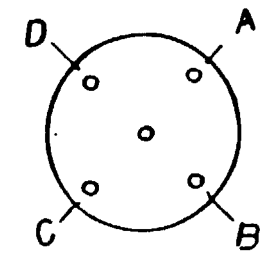
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 51.7414 CENTERLINE: .225

BAG WEIGHT ONLY : 17.0080 POINT A : .226 POINT C: .224

SPECIMEN WEIGHT : 34.7334 POINT B : .227 POINT D: .225

TECH : JAC [illegible] TECH : [illegible] 1 21 88



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : 51.0016 CENTERLINE: .228

BAG WEIGHT ONLY : 17.0080 POINT-A : .225 POINT-C : .225

SPECIMEN WEIGHT : ______ POINT-B : .225 POINT-D : .227

TECH : ______ TECH : [illegible] 1/27/88

POST TEST RESULTS/COMMENTS: REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 21 RUN NO.: 1-650-SD TEST CONDITION: 3000°F CYCLE NO.: 1

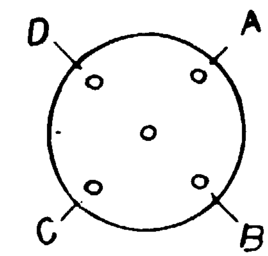
PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT: 51.0496 CENTERLINE: .225

BAG WEIGHT ONLY : 16.8381 POINT A : .225 POINT C: .223

SPECIMEN WEIGHT : 34.2115 POINT B : .227 POINT D: .225

TECH : JAC 1/8/[illegible] TECH : WBm 1/15/88



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT : 50.8294 CENTERLINE: .224

BAG WEIGHT ONLY : 16.8381 POINT-A : .229 POINT-C : .228

SPECIMEN WEIGHT : ______ POINT-B : .227 POINT-D : .227

TECH : ______ ______ TECH : JAC 1.19.88

POST TEST RESULTS/COMMENTS: INSPECTION OF POST TEST T/A INDICATES NO BREACH OF UNIFORM[illegible] OR SURFACE ABNORMALITIES. REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

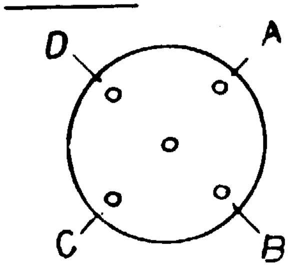
RCC OVERTEMP CAPABILITY TESTS

TEST ARTICLE DATA SHEET

TEST ARTICLE NO.: 23 RUN NO.: 1-652-SD TEST CONDITION: 3150 CYCLE NO.: 1

PRE-TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 51.0437	CENTERLINE	: .225		
BAG WEIGHT ONLY	: 16.9902	POINT A	: .225	POINT C	: .225
SPECIMEN WEIGHT	: 34.0535	POINT B	: .227	POINT D	: .225
TECH	: JAC 1/21	TECH	: JAC 1-19.88		



POST TEST WEIGHTS AND MEASUREMENTS

BAG AND SPECIMEN WEIGHT	: 50.4866	CENTERLINE	: .223		
BAG WEIGHT ONLY	: 16.9978	POINT-A	: .222	POINT-C	: .224
SPECIMEN WEIGHT	: 33.4889	POINT-B	: .222	POINT-D	: .224
TECH	: [illegible] 1/20/88	TECH	: JAC 1-20-88		

POST TEST RESULTS/COMMENTS: REMOVED FROM INVENTORY/STORAGE PER TPS

NOTE: ALL TEST ARTICLES SHALL BE HANDLED WITH CLEAN WHITE GLOVES.

NOTE: QAS SHALL VERIFY ALL WEIGHTS AND MEASUREMENTS.

50.4867

Test Series 2

Conducted from

October 4, 1989 to October 19, 1990

1.0 SUMMARY

Reentry simulation testing of reinforced carbon-carbon (RCC) specimens was performed between October 4,1989 and October 19, 1990 in the Structures and Mechanics Division (SMD) arc jet facilities to support development of transatlantic abort landings (TAL) RCC recession rate correlations.

Forty-one single mission simulation tests were performed on ENKA and AVTEX based coated RCC for temperatures ranging from 3000 °F to 3350 °F and pressures ranging from 100 to 350 psf. Initiation of rapid coating degradation was observed for both materials at 3250 °F to 3300 °F as documented previously for ENKA based RCC (JSC 22934). Results from these tests show that no loss of performance has been induced by changing the RCC cloth precursor from ENKA to AVTEX.

Verification that these single mission simulation tests are acceptable for evaluation of RCC with multi-mission exposure was achieved by testing a specimen up to 3250 °F after it was conditioned to have the equivalent of 10 nominal mission reentries and 5 heavy load mission reentries.

Thirteen tests were performed on uncoated RCC specimens over the same pressure range from 1440 °F to 3330 °F to evaluate the performance of RCC substrates after coating loss occurs.

At the conclusion of this test program, two coated ENKA RCC specimens were evaluated under conditions that were estimated to be equivalent to a CAMA-6 TAL reentry (3340 °F peak temperature). These specimens survived without breaching of the coating, since the CAMA-6 temperature prediction is within the rapid degradation range for only a short period.

2.0 INTRODUCTION

A desire for increasing orbiter contingency abort ranging capability was identified in early 1989. The rationale for this stretch capability is to maximize crew and vehicle survivability. Extending the orbiter ranging capabilities can be accomplished by reducing the post main engine cut off (MECO) entry angle-of-attack. The aerodynamics involved with these reduced angle-of-attack trajectories cause a large initial decent of the orbiter. This rapid descent into the denser lower atmosphere causes high aeroheating on the orbiter. Thermal math model analysis of these trajectories have predicted surface temperatures to 3350 °F range on the wing leading edge which is constructed from reinforced carbon-carbon (RCC). A contingency abort trajectory was established for STS-36 which results in a maximum surface temperature of 3343 °F. These temperature levels exceed the RCC single mission design limits and the current RCC data base.

The present orbiter Leading Edge Structure Subsystem (LESS) uses ENKA rayon as the precursor in the fabrication of RCC (Vehicles OV102 - OV105 LESS). The ENKA rayon is no longer available for the fabrication of future replacement parts of the RCC LESS. A replacement material is AVTEX rayon. Test specimens were fabricated from the available ENKA rayon and AVTEX rayon to obtain test data and establish a data base to be used in the assessment of orbiter surface environments which would result in surface temperatures that exceed the RCC design limits.

LTV was provided funding through Rockwell for fabrication of the test hardware. Rockwell wrote a test request and analyzed the test results. The test request was generated by Rockwell-Houston on June 14, 1989, and was identified as TR # SE-TSAT-89-041. The test program was conducted in the JSC Structures and Mechanics Division's 10 MW reentry simulation facility. Only AVTEX RCC specimens were available during the early phase (from October 4, 1989 to March 21, 1990) of this test program. When the ENKA RCC specimens became available, the test was resumed on August 6, 1990 and was completed on October 19, 1990. The purpose of this report is to document the results of this test program.

3.0 OBJECTIVES

The objective of this test program was to generate a data base for quantifying coated and uncoated RCC surface recession as a function of temperature and pressure in environment regimes representative of a stretched TAL abort.

4.0 TEST SPECIMENS

A total of 62 test specimens and 17 calibration models were available in this test program. All 79 test specimens are 2.8 - inch diameter 19 - ply discs of reinforced carbon-carbon. A schematic of a typical test specimen is shown in figure 1-(a). There were four classes of specimens which were fabricated from either AVTEX or ENKA RCC substrate:

Coated/TEOS/Type A specimens have been silicon carbide coated, impregnated with Tetra-Ethyl Ortho-Silicate (TEOS) and sealed with Type A surface enhancement.

Coated/TEOS/No Type A specimens have been silicon carbide coated, impregnated with TEOS but have not been sealed with Type A surface enhancement.

Coated/TEOS/Double Type A specimens have been silicon carbide coated, impregnated with TEOS and sealed with double coated Type A surface enhancement.

Uncoated/TEOS specimens only have RCC rayon, impregnated with TEOS.

Each specimen has an identification number inscribed on the "bag side" surface. Thirteen test specimens out of the 62 specimens were transferred from the "Convective Mass Loss Characterization Test for AVTEX Based RCC" test program. Thirty-one specimens and 7 calibration models were AVTEX/coated/TEOS/Type A; two specimens were AVTEX/coated/TEOS/Double Type A; 7 specimens and three calibration models were ENKA/coated/TEOS/No Type A; 10 specimens and two calibration models were ENKA/coated/TEOS/Type A; 8 specimens and two calibration models were AVTEX/uncoated/TEOS; four specimens and three calibration models were ENKA/uncoated/TEOS. A summary of the model identification can be found in table I.

Seventeen calibration models with type C tungsten thermocouples (5% - 26% rhenium) were used to establish the test conditions. These calibration models had two front surface thermocouples located as shown in figure 1-(b) to 1-(d). Although some errors are induced by conduction down the thermocouple lead wires, a thermal math model of this configuration indicates that the RCC surface temperature should not be more than 15 °F higher than the measured values.

All test specimens and calibration models were fabricated by LTV Missiles and Electronics Group (LTVMEG). Each specimen has four edge slots to accept the pins that retain the specimen within the holder. Specimen holders were machined from high density graphite and were coated with LTVMEG's type IV coating. These holders were fitted with discs of zirconia insulation to reduce heat losses from the back surfaces of the specimens as shown in figure 2. Poco graphite pins with Vought type IV coating were used to retain the specimens as shown in this figure.

5.0 TEST FACILITY

This test program was performed in test position #1 of the JSC Atmospheric Reentry and Structures Evaluation Facility (ARMSEF). This test position is the larger of the two shown in the artist's concept of the ARMSEF that is presented in figure 3. Test gases (77% nitrogen and 23% oxygen) are heated by a segmented constricted arc heater and injected into a vacuum chamber through a water cooled 5-inch diameter nozzle that has a 15-degree half angle. To maintain high stagnation pressures while achieving the lower temperatures required to test the uncoated RCC, 25 % of the nitrogen gas was injected at the plenum. When tests are in progress the facility vacuum is maintained below 200 microns of mercury. Test specimens are mounted on two water-cooled, remotely actuated sting arms that allow them to be inserted after test conditions are stabilized.

6.0 TEST PROCEDURES

Test specimens were photographed, weighed, and measured prior to testing and after testing. Specimens were handled with clean white gloves and weighed to within 0.001 gram. Test specimens were stored in an evacuated desiccator that was maintained under supervised control by EBASCO quality personnel. All weights and measures were witnessed by EBASCO quality assurance inspectors. Rigorous test management and control were implemented by formal documentations (e.g. Discrepancy Reports, Anomaly Logs, Standard Operating Procedures, and Test Plan Sheets).

Aluminum bags were used to prevent absorption of atmospheric moisture while the specimens were being weighed. Prior to weighing, the specimens were placed inside aluminum bags that were then placed inside a 300 °F oven for four hours to remove water of hydration. The aluminum bags were then sealed and the specimens allowed to cool prior to weighing.

After the specimens had been tested, the specimens were left in vacuum for 25 minutes so that the temperature of the specimens would fall below 500 °F to minimize oxidation of the carbon substrate.

7.0 TEST CONDITIONS AND CALIBRATIONS

The test conditions in this test program were chosen to simulate the maximum temperature and pressure of the TAL trajectories predictions. Several test conditions at lower temperatures and pressure were also needed to provide data for the thermal math model. Due to the complexities of the test matrix, the surface temperature of the specimens was chosen to be the primary requirement while the surface pressure was the secondary requirement. The surface pressure of the test specimens range from 100 psf to 350 psf; the surface temperature of the coated test specimens range from 3000 °F to 3350 °F and the surface temperature of the uncoated test specimens range from 1440 °F to 3330 °F. The exact test conditions in terms of RCC surface temperature and surface pressure are summarized in Table I.

The surface pressure of the test specimen was established using a pressure model, as shown in figure 4, which had the same physical dimensions as the test specimen installed in its holder. Three pressure ports on the front surface of the pressure model recorded the surface pressure at different locations to give a pressure distribution across the pressure model. The centerline pressure measurement was then correlated to the 0.5-inch diameter water-cooled facility pitot probe. The resultant correlation is shown in figure 5-(a). Figure 5-(b) shows typical plots of the pressure profile at three different test conditions. Prior to model insertion during test, a pitot probe measurement was taken to confirm the surface pressure of the model.

A laser pyrometer was used to measure the surface temperature response of the calibration models. A brief description on the theory and operation of the laser pyrometer can be found in appendix A. The output of the laser pyrometer was then correlated with the type C tungsten thermocouples of the calibration models. An emissivity of 0.68 and a viewing angle of 35 ° were used to compensate for the emittance loss, and losses due to the optics. After the emissivity correction was made, the corrected temperature was recorded and designated as "L PYR X". The emissivity corrected temperature of the laser pyrometer agreed with the reading of the center thermocouple (TC1) of the calibration models to within 10 °F. The agreement of the L PYR X and the thermocouple was checked and confirmed repeatedly throughout the test program over a temperature range from 2700 °F to 3400 °F. Figure 6 shows a schematic of the test setup with the laser pyrometer and figure 7 shows a typical response of the surface thermocouples and the L PYR X. During test, the laser pyrometer was the sole instrument used to monitor the surface temperature of the test specimens.

Heating rate measurements were also taken to monitor the arc jet conditions before inserting the test specimens. The heating rate sensor was a Gardon-gage type calorimeter with a polished one inch diameter copper heat sink surrounding a polished 0.1 inch diameter constantan disk. It was installed in a four-inch diameter water cooled copper holder, as shown in figure 8, to match the size of the specimen holder. Since the mechanism of the gas dissociation in the arc jet is different from the flight environment, the heating rate measurements should not be used to compare with the flight prediction.

Since only a limited number of calibration models were available in this test program, the calibration procedures employed in this test program deviated slightly from common practice of the ARMSEF. Instead of homing in on each of the surface temperatures listed in the test matrix by using a calibration model for each test specimen, the calibration models were used to build up a family of curves from 2800 °F up to 3350 °F. The arc jet operating conditions required to achieve the test conditions in the test matrix were then extracted from these curves. There was one curve for each type of test specimens at each pressure range. Figure 9-(a) to (e) are the temperature versus heating rate curves, and figure 10 is a composite plot of the curves at 100 psf and 300psf with some of the coated specimens identified on the plot.

8.0 RESULTS

Tests were performed at the conditions shown in table I. Before any discussion of the test results, a few terminologies will be defined here to facilitate understanding the phenomena observed during tests.

Hot spot is referred to a rapid increase in temperature on the surface of the model. This is a well defined transition at pressure below 200 psf but the transition becomes less distinct at higher pressure. The onset of the hot spot can be identified visually viewing through the television monitor or graphically plotting the surface temperature response of the specimen as shown in figure 7.

Coating breach occurs when the silicon carbide (SiC) coating is eroded away and carbon substrate is exposed. Coating breach occurred about 30 seconds to a minute after the hot spot is developed.

The test results documented in the following sections are grouped into five categories: (1) test conditions under which no hot spot is developed; (2) test conditions under which hot spot may be developed; (3) test conditions under which hot spot is definitely developed; (4) miscellaneous tests on coated RCC; (5) tests on the uncoated RCC. A test summary can be found in appendix B and the temperature response curves of the test specimens can be found in appendix C.

8.1 Surface temperature below 3250 °F

All test specimens except IN09 tested below 3250 °F did not develop a hot spot. Table II shows the test conditions and figure 11-(a) to (q) are the post test photographs of the test specimens. Post test inspection indicated that the coating at the back of specimens # IN09, IN21, IN25 had some reactions with oxygen exposing the carbon substrate as shown in figure 11-(g), (j), (m). The exact mechanism for this reaction is not well understood but the reaction seems to be temperature and pressure sensitive since only a narrow strip of the coating is being affected. The following paragraphs document the abnormalities during testing.

Specimen # 2 was installed backward with the "bag side" being tested. However, no abnormal degradation was observed due to this oversight.

The test on specimen # 16 was aborted after 800 seconds due to vacuum fluctuation. No vacuum cooldown was performed on this specimen.

After testing specimen # 18 at 3200 °F for 330 seconds, there was a vacuum abort at about five minutes into the vacuum cooldown cycle. The surface temperature of the specimen at that time was estimated to be about 1000 °F.

The target test conditions of specimen # IN05 was 3200 °F, 100 psf but the temperature stabilized at 3120°F. The test was terminated after 737 seconds of testing. This test condition was repeated using specimen # IN09.

Specimen # IN09 was tested at 3200 °F, 100 psf test conditions. A hot spot was observed at 58 minutes into the test and the hot spot did not propagate until 70 seconds later. Post test inspection revealed an indentation at the location of the hot spot as shown in figure 11-(g). It is believed that the hot spot was due to a coating flaw rather than coating failure.

The test on specimen # IN14 was aborted after 223 seconds due to vacuum fluctuation. No vacuum cooldown was performed on this specimen.

8.2 Surface temperature between 3250 °F and 3300 °F

Except specimens # 17 and IN23, all other specimens had developed a hot spot in this temperature range. Since specimen # 17 was tested at 3300 °F and 187 psf for 170 seconds while specimen # IN23 was tested at 3250 °F and 313 psf for 900 seconds without developing a hot spot, it is believed that the temperature for the hot spot to develop lies within this temperature zone. Table III shows the test conditions of these specimens, and figure 12-(a) to (o) are the post test photographs of the specimens.

The test on specimen # 17 / 287 was aborted after 170 seconds due to vacuum fluctuation. No vacuum cooldown was performed on this specimen.

Specimen IN18 was tested at 3300 °F and 325 psf for 330 seconds. Post test inspections showed that the front surface silicon carbide (SiC) coating and all the carbon substrate had been eroded, and only the coating on the back of the specimen remained, as shown in figure 12-(n).

8.3 Surface temperature above 3300 °F

All test specimens tested above 3300 °F developed a hot spot. Table IV is a summary of the test conditions and figure 13-(a) to (f) are post test photographs of the models.

8.4 Miscellaneous tests on coated RCC

Specimen AC13/191 was exposed to 2770 °F, 150 psf for 3550 seconds to simulate ten normal load orbiter reentry missions. It was then exposed to 2900 °F, 150 psf for 1850 seconds to simulate five heavy load orbiter reentry missions. This specimen was tested again to search for the conditions that the hot spot developed. The surface temperature of the specimen was allowed to stabilized at 3000 °F and 200 psf, then increased slowly at 50 °F increment. Hot spot was observed at 3250 °F and the test was terminated 30 seconds after the hot spot had developed.

Two specimens, AU05/180 and AU08/184, were tested to simulate the CAMA-6 trajectory. The peak temperature and pressure of the CAMA-6 trajectory were 3340 °F and 300 psf respectively. Both specimens were tested at constant pressure of 300 psf and time-varying heating conditions.

Specimen AU05/180 was held at 3340 °F for ten seconds and a hot spot developed at the same time the heat load on the specimen was reduced. The hot spot disappeared 35 seconds after it had developed and the temperature stabilized at 3200 °F for another 30 seconds. Figure 14-(a) shows the surface temperature of the specimen with the CAMA-6 temperature prediction superimposed for comparison. The total exposure time for AU05/180 was 154 seconds. Figure 14-(b) is the post test photograph of AU05/180 which showed coating failure but did not show coating breach.

The surface temperature of specimen AU08/184 was held above 3300 °F for 25 seconds and the peak surface temperature was 3350 °F for six seconds. The heat load on the specimen was then reduced at 45 seconds into test to lower the surface temperature to 3200 °F for 30 seconds. Total exposure time for this specimen was 80 seconds. Figure 15-(a) shows the surface temperature of the specimen with the CAMA-6 temperature prediction superimposed for comparison. Figure 15-(b) is the post test photograph of AU08/184 which did not experience any coating failure.

8.5 Uncoated RCC

Twelve uncoated RCC specimens, eight AVTEX and four ENKA, were tested at different combinations of surface temperature, pressure, and test duration so that approximately 40 percent erosion of the RCC could occur. Table V shows the conditions under which the specimens were tested, and figure 16-(a) to (m) are the post test photographs of the uncoated specimens. Since the uncoated RCC does not erode significantly in nitrogen rich environment, the uncoated test specimens were pre-heated in a pure nitrogen environment before switching to air. This pre-heat cycle reduced the transient time that the specimens were exposed to air and thus improved the data accuracy.

Specimen # 27 was tested twice, once on the front surface and once on the back surface. Specimens tested below 2600 °F had a layer of white silica formed on the surface as shown on figure 16. At higher temperature, the silica was probably eroded away leaving the carbon substrate as shown in figure 16-(l), and 16-(m).

8.6 Surface temperature responses of coated RCC specimens

During the early phase of the test program, only AVTEX based RCC specimens were available for testing. Calibration curves from figure 9-(a), and 9-(c) were able to predict the surface temperature of the TAL abort AVTEX RCC specimens which had thicker SiC coating, and those specimens being transferred from the AVTEX Mass Loss Characterization Test. These two curves were confirmed again using an AVTEX calibration model and two ENKA coated/TEOS/Type A RCC calibration models when the ENKA RCC test specimens became available. Calibration curves from figure 9-(b), and 9-(d) were also established using the appropriate ENKA RCC calibration models.

When all the tests at the 100 psf conditions had been completed, test data had shown that the surface temperature responses of some test specimens deviated from the calibration curves. An AVTEX RCC specimen # AU04 from the mass loss program was used as a calibration model to check or to establish the calibration curve at 300 psf conditions. The new calibration curve using specimen # AU04 behaved significantly different from the calibration curve using the ENKA calibration models as shown in figure 10. In order to deal with the uncertainties in temperature responses, these tests at 3250 °F and 3300 °F surface temperature conditions were performed first so that any higher or lower surface temperature responses would fall back onto the test matrix. Figure 10 shows the composite plot of the calibration curves for 100 psf and 300 psf test conditions with all the ENKA RCC and some AVTEX RCC test specimens identified on the plot. Although no recognizable pattern can be established among each type of test specimens, all the specimens tested at 300 psf in general can be grouped into three curves as shown in figure 10. By extrapolating these three curves, they seem to converge into a single curve at temperature below 2900 °F. The uncertainties in surface temperature responses at elevated temperatures may be due to slight variation in emissivity which was being amplified when the specimens were tested to their maximum capabilities.

9.0 CONCLUSIONS

9.1 Mass Loss Correlation Tests

After testing 17 calibration models and 59 test specimens, the primary test findings can be summarized as follows: (1) hot spot (i.e. rapid coating degradation) develops at temperatures between 3250 °F to 3300 °F; (2) for up to 15 missions the temperature for onset of this phenomena is independent of the number of missions flown; (3) there are no differences in thermal performance between ENKA and AVTEX RCC at high temperatures; (4) the onset of hot spots is independent of pressure within the pressure range from 100 psf to 350 psf; (5) coating thickness has no bearing on the onset of hot spots; (6) test specimens tested under identical test conditions have markedly different temperature responses at temperature above 3100 °F.

9.2 Survivability Tests

No coating breach was observed during the CAMA-6 simulation tests, thereby demonstrating the survivability of coated RCC under predicted TAL Abort reentry conditions.

TABLE I

MODEL IDENTIFICATION

AVTEX / COATED / TEOS / TYPE A				
	LTV ID	JSC ID	TEST CONDITIONS	REMARKS
1	2	274	3200 °F, 103 psf	
2	3	275	3000 °F, 160 psf	
3	4	276	3060 °F, 320 psf	
4	5	277	3200 °F, 320 psf	
5	6	278	3250 °F, 320 psf	
6	7	279	3250 °F, 320 psf	
7	8	280	3300 °F, 104 psf	
8	9	281	3300 °F, 105 psf	
9	10	282	3300 °F, 353 psf	
10	13	283	3300 °F, 188 psf	
11	14	284	3200 °F, 178 psf	
12	15	285	3280 °F, 186 psf	
13	16	286	3000 °F, 160 psf	
14	17	287	3300 °F, 187 psf	
15	18	288	3200 °F, 176 psf	
16	1	301		calibration model
17	19	294		calibration model
18	20	295		calibration model
19	21	296		calibration model
20	31	297		calibration model
21	35	298		calibration model
22	36	299		calibration model
23	AB-12	171	3300 °F, 107 psf	mass loss transfer
24	AB-13	173	2975 °F, 95 psf	mass loss transfer
25	AB-14	175	3300 °F, 104 psf	mass loss transfer
26	AB-15	177	3100 °F, 90 psf	mass loss transfer
27	AB-16	179	3200 °F, 103 psf	mass loss transfer
28	AU-01	172	3300 °F, 183 psf	mass loss transfer

29	AU-02	174	calibrations	mass loss transfer
30	AU-04	178	calibrations	mass loss transfer
31	AU-05	180	CAMA-6	mass loss transfer
32	AU-08	184	CAMA-6	mass loss transfer
33	AC-13	191	simulate 15 missions	mass loss transfer
34	AC-22	207	3100 °F, 100 psf	mass loss transfer
35	AT-15	183	3350 °F, 338 psf	mass loss transfer
36	IN-25	394	3200 °F, 105 psf	
37	IN-26	395	3350 °F, 338 psf	
38	IN-28	396	3225 °F, 312 psf	
ENKA / COATED / TEOS / TYPE A				
39	IN-04	384	3340 °F, 337 psf	
40	IN-06	385	3350 °F, 101 psf	
41	IN-08	386	3300 °F, 325 psf	
42	IN-12	387	3250 °F, 317 psf	
43	IN-14	388	3230 °F, 309 psf	
44	IN-18	389	3300 °F, 325 psf	
45	IN-20	390	3320 °F, 338 psf	
46	IN-21	391	3200 °F, 293 psf	
47	IN-22	392	3180 °F, 303 psf	
48	IN-33	393	did not test	
49	IN-10	369		calibration model
50	IN-16	372		calibration model
ENKA / COATED / TEOS / NO TYPE A				
51	IN-05	373	3120 °F, 97 psf	
52	IN-09	374	3200 °F, 97 psf	
53	IN-11	375	various	
54	IN-17	376	3200 °F, 293 psf	test not valid
55	IN-19	377	3230 °F, 301 psf	
56	IN-23	378	3250 °F, 313 psf	
57	IN-29	379	3350 °F, 325 psf	
58	IN-07	368		calibration model
59	IN-13	370		calibration model
60	IN-15	371		calibration model

AVTEX / UNCOATED / TEOS				
61	23	266	2850 °F, 59 psf	
62	24	267	2400 °F, 215 psf	
63	25	268	1800 °F, 193 psf	
64	26	269	2140 °F, 207 psf	
65	27	270	1800 °F, 100 psf	3100 °F, 60 psf
66	28	271	1440 °F, 75 psf	
67	29	272	2900 °F, 100 psf	
68	32	273	2500 °F, 100 psf	
69	33	291		calibration model
70	34	292		calibration model
ENKA / UNCOATED / TEOS				
71	IN-24	380	3330 °F, 312 psf	
72	IN-30	381	3160 °F, 300 psf	
73	IN-31	382	2620 °F, 180 psf	
74	IN-34	383	2200 °F, 105 psf	
75	IN-01	365		calibration model
76	IN-02	366		calibration model
77	IN-03	367		calibration model
AVTEX / COATED / TEOS / DOUBLE A				
78	11	289	did not test	
79	12	290	did not test	

TABLE II

SPECIMENS TESTED BELOW 3250 °F

LTV ID / JSC ID	TEMPERATURE	PRESSURE	TEST TIME	HOT SPOT
AB13 / 173	2975 °F	95 psf	353 s	no
3 / 275	3000 °F	160 psf	330 s	no
16 / 286	3000 °F	160 psf	800 s	no
4 / 276	3060 °F	320 psf	330 s	no
AB15 / 177	3100 °F	90 psf	330 s	no
AC22 / 207	3100 °F	100 psf	3300 s	no
IN05 / 373	3120 °F	97 psf	770 s	no
IN22 / 392	3180 °F	303 psf	330 s	no
IN09 / 374	3200 °F	97 psf	3600 s	coating flaw
2 / 274	3200 °F	103 psf	330 s	no
AB16 / 179	3200 °F	103 psf	330 s	no
IN25 / 394	3200 °F	105 psf	3600 s	no
18 / 288	3200 °F	176 psf	330 s	no
14 / 284	3200 °F	178 psf	600 s	no
IN21 / 391	3200 °F	293 psf	1200 s	no
5 / 277	3200 °F	320 psf	330 s	no
IN28 / 396	3225 °F	312 psf	900 s	no
IN19 / 377	3230 °F	301 psf	3600 s	no
IN14 / 388	3230 °F	309 psf	223 s	no

TABLE III

SPECIMENS TESTED BETWEEN 3250 °F AND 3300 °F

LTV ID / JSC ID	TEMPERATURE	PRESSURE	TEST TIME	HOT SPOT
IN23 / 378	3250 °F	313 psf	900 s	no
IN12 / 387	3250 °F	317 psf	330 s	yes @150 s
6 / 278	3250 °F	320 psf	127 s	yes @ 95 s
7 / 279	3250 °F	320 psf	187 s	yes @ 55 s
15 / 285	3280 °F	186 psf	67 s	yes @ 63 s
AB14 / 175	3300 °F	104 psf	105 s	yes @ 45 s
8 / 280	3300 °F	104 psf	78 s	yes @ 48 s
9 / 281	3300 °F	105 psf	63 s	yes @ 60 s
AB12 / 171	3300 °F	107 psf	58 s	yes @ 53 s
AU01 / 172	3300 °F	183 psf	158 s	yes @ 103 s
17 / 287	3300 °F	187 psf	170 s	no
13 / 283	3300 °F	188 psf	45 s	yes @ 43 s
IN08 / 386	3300 °F	325 psf	110 s	yes @ 80 s
IN18 / 389	3300 °F	325 psf	330 s	yes @ 73 s
10 / 282	3300 °F	353 psf	103 s	yes @ 58 s

TABLE IV

SPECIMENS TESTED ABOVE 3300 °F

LTV ID / JSC ID	TEMPERATURE	PRESSURE	TEST TIME	HOT SPOT
IN20 / 390	3320 °F	338 psf	94 s	yes @ 44s
IN04 / 384	3340 °F	337 psf	70 s	yes @ 45 s
IN06 / 385	3350 °F	101 psf	73 s	yes @ 43 s
AT15 / 183	3350 °F	338 psf	87 s	yes @ 52 s
IN29 / 379	3350 °F	325 psf	133 s	yes @ 103 s
IN26 / 395	3350 °F	338 psf	64 s	yes @ 20 s

TABLE V

TEST CONDITIONS FOR UNCOATED RCC

LTV ID / JSC ID	TEMPERATURE	PRESSURE	TEST TIME
28 / 271	1440 °F	75 psf	120 s pre-heat + 4500 s air
27 / 270	1800 °F	100 psf	120 s pre-heat + 525 s air
25 / 268	1800 °F	193 psf	600 s air
26 / 269	2140 °F	207 psf	500 s air
IN34 / 383	2200 °F	105 psf	70 s pre-heat + 600 s air
24 / 267	2400 °F	215 psf	300 s air
32 / 273	2500 °F	100 psf	120 s pre-heat + 400 s air
IN31 / 382	2620 °F	180 psf	120 s pre-heat + 330 s air
23 / 266	2850 °F	59 psf	225 s pre-heat + 180 s air
29 / 272	2900 °F	100 psf	120 s pre-heat + 200 s air
27 / 270	3100 °F	60 psf	320 s air / retest on the back
IN30 / 381	3160 °F	300 psf	120 s pre-heat + 153 s air
IN24 / 380	3330 °F	312 psf	120 s pre-heat + 150 s air

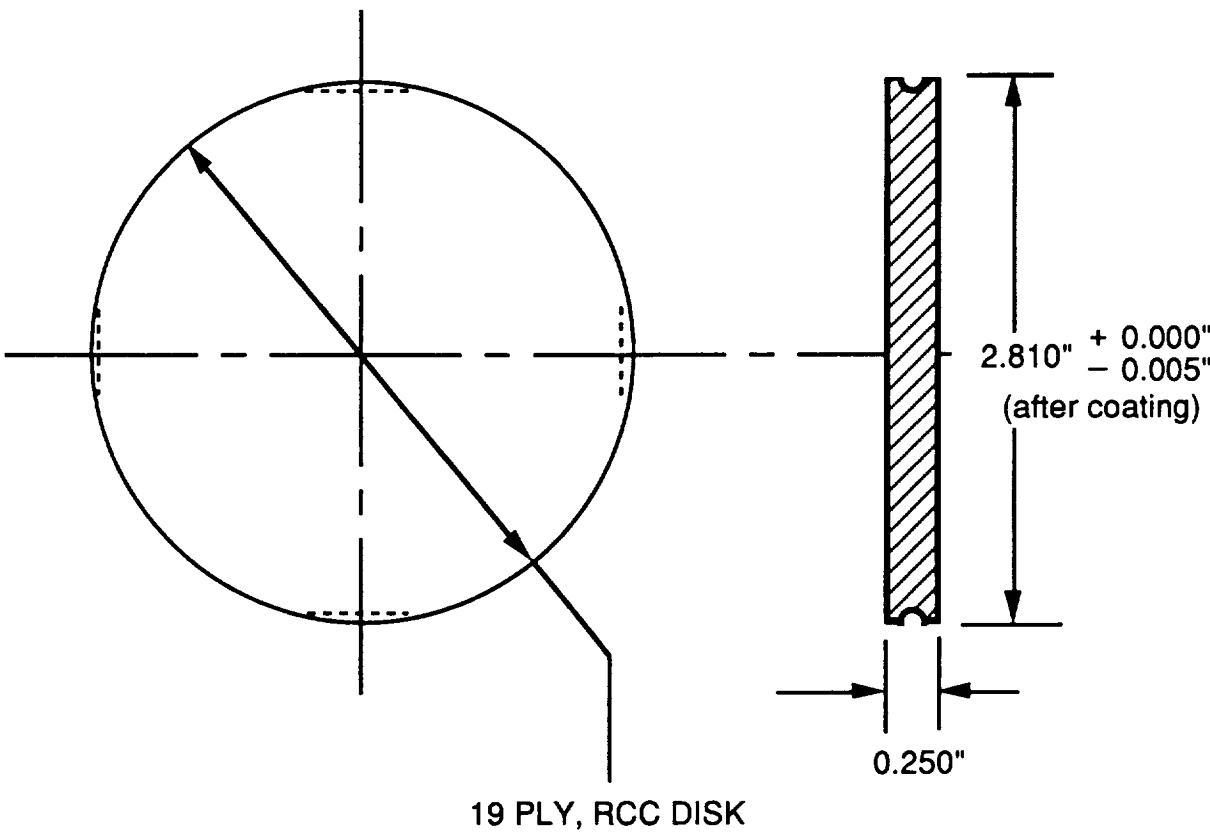
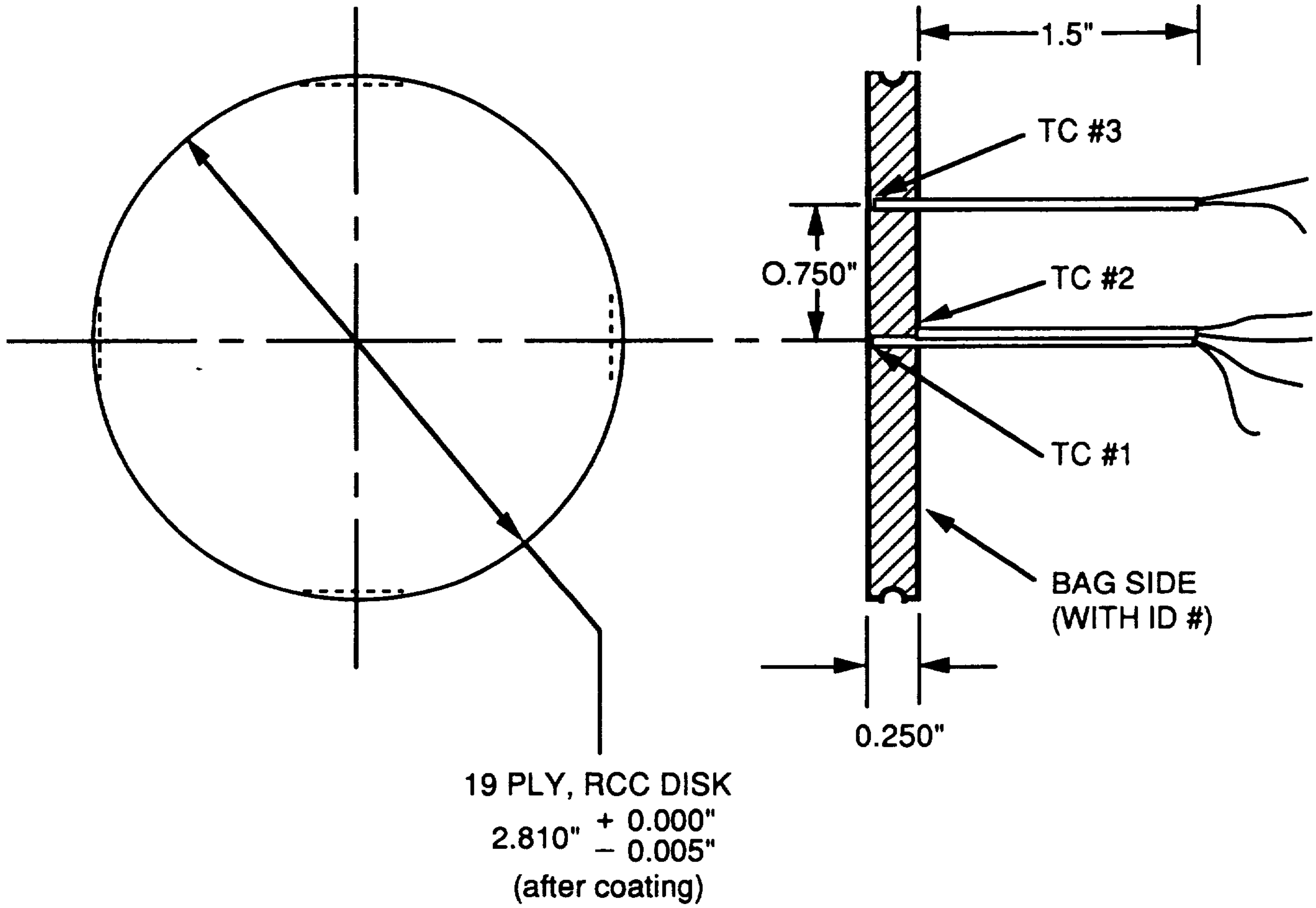


Figure 1-(a). Schematic of the RCC test specimen.



NOTE:
1. INSTRUMENT THE RCC DISK WITH THREE (3) TUNGSTEN 5% RHENIUM / TUNGSTEN 26% RHENIUM (TYPE C) THERMOCOUPLES.
2. FOR THERMOCOUPLES #1 AND #3, DRILL HOLES THROUGH BACK FACE (BAG SIDE) COATING FOR 1/16" DIA. ALUMINA INSULATORS. THERMOCOUPLES ARE TO BE INSTALLED AGAINST THE BACK OF THE FRONT FACE COATING.
3. THERMOCOUPLE #2 IS TO BE BONDED TO THE BACK FACE OF THE DISK.
4. BOND THE INSULATOR FOR TC #2 TO THE INSULATOR FOR TC#1.
5. ALUMINA INSULATORS ARE TO EXTEND 1.5"FROM THE BACK FACE.
6. THE TOTAL LENGTH OF THERMOCOUPLE WIRE PLUS THE COMPENSATING LEAD WIRES IS TO 31/2 FEET.

Figure 1-(b). Schematic of the calibration model.

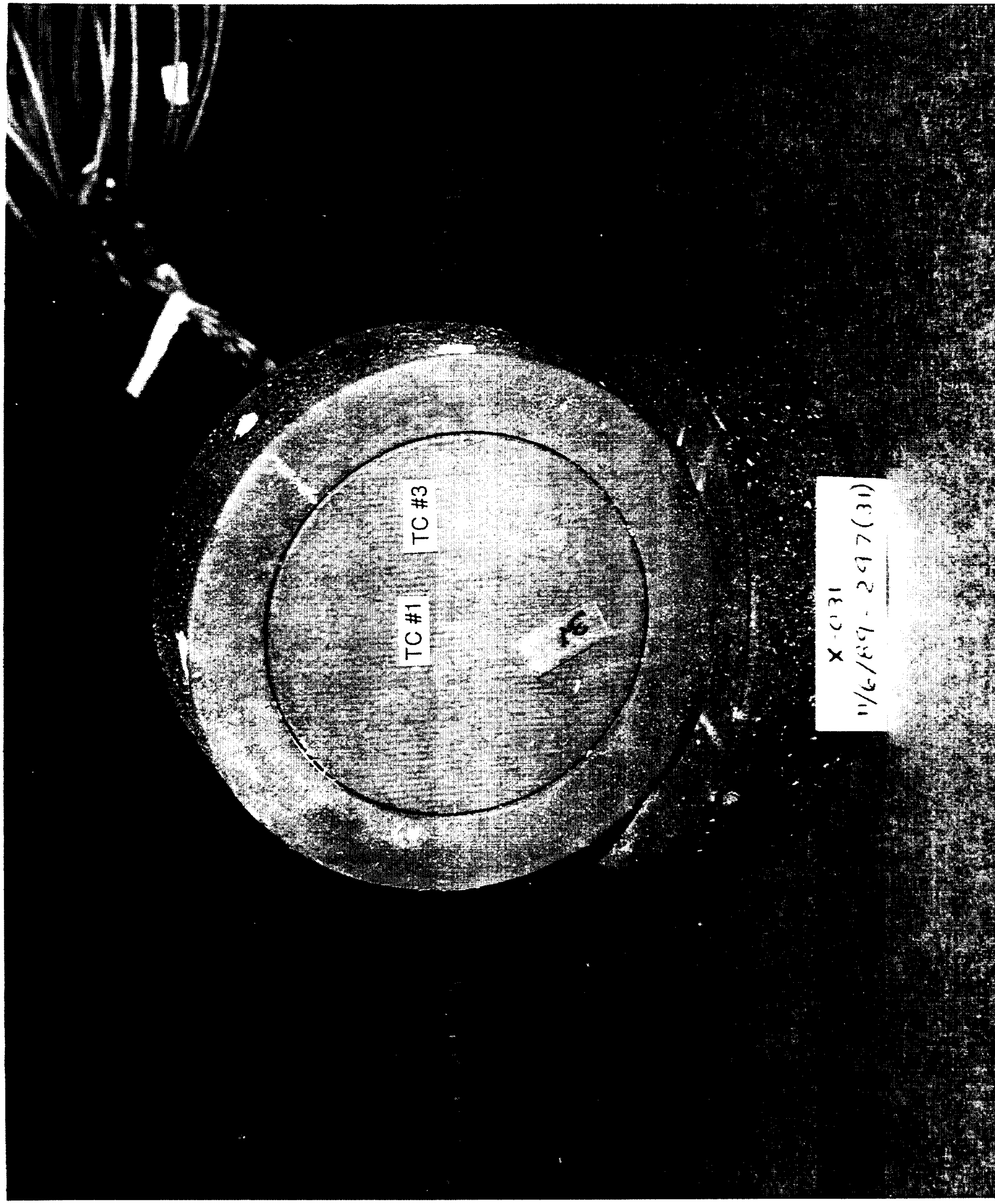


Figure 1-(c). Pre-test photograph of a coated calibration model.

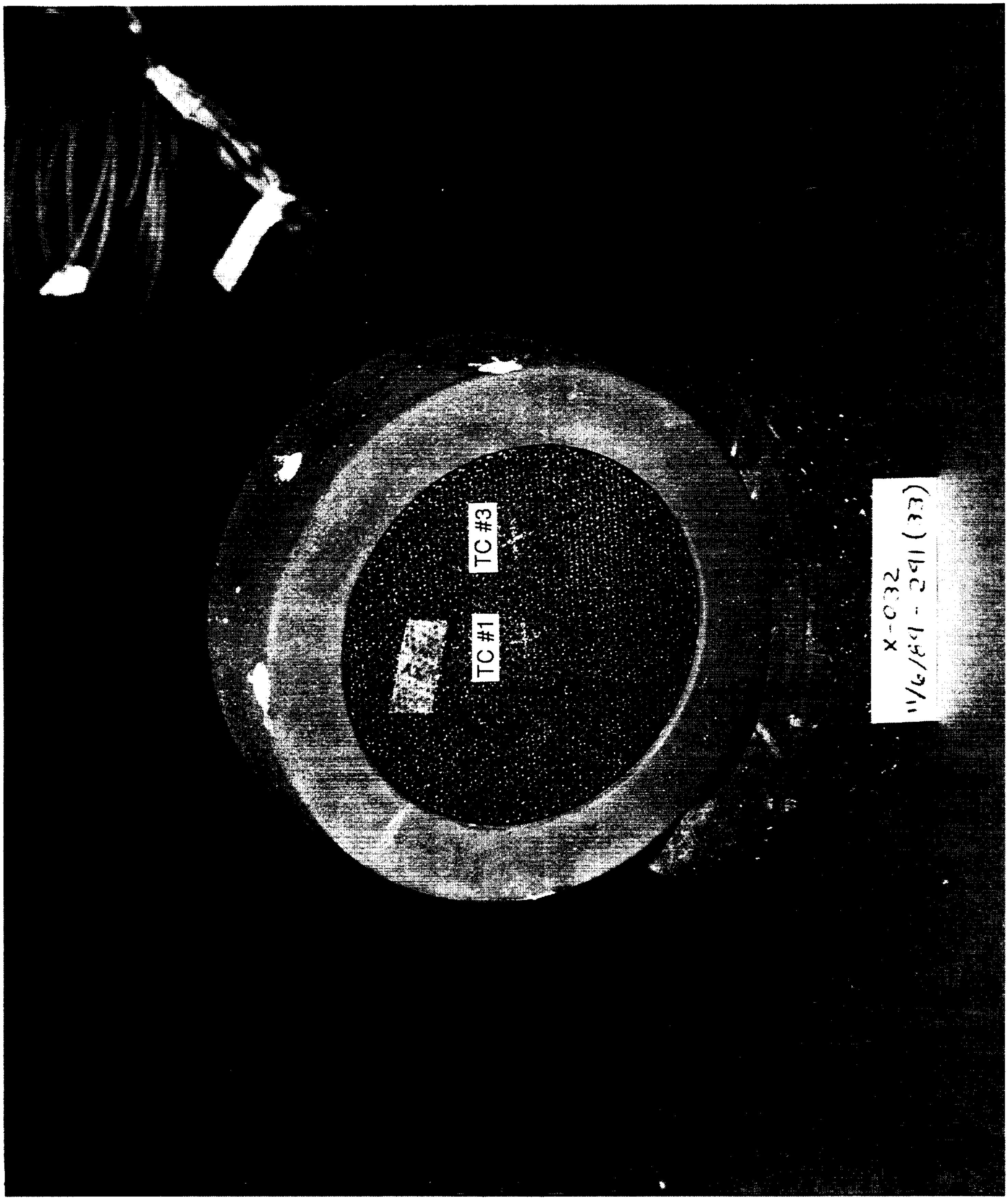


Figure 1-(d). Pre-test photograph of an uncoated calibration model.

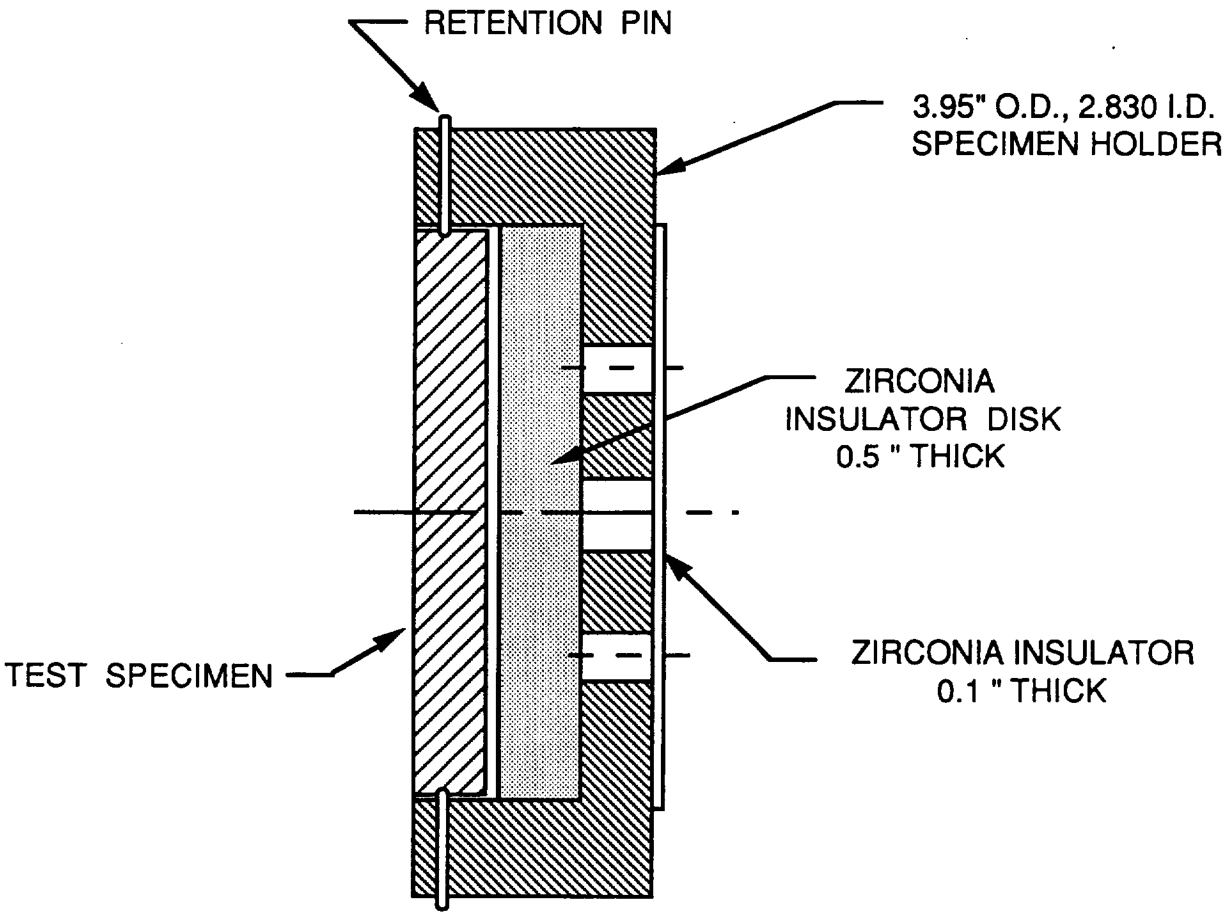


Figure 2. Test configuration with the RCC test specimen installed in the model holder.

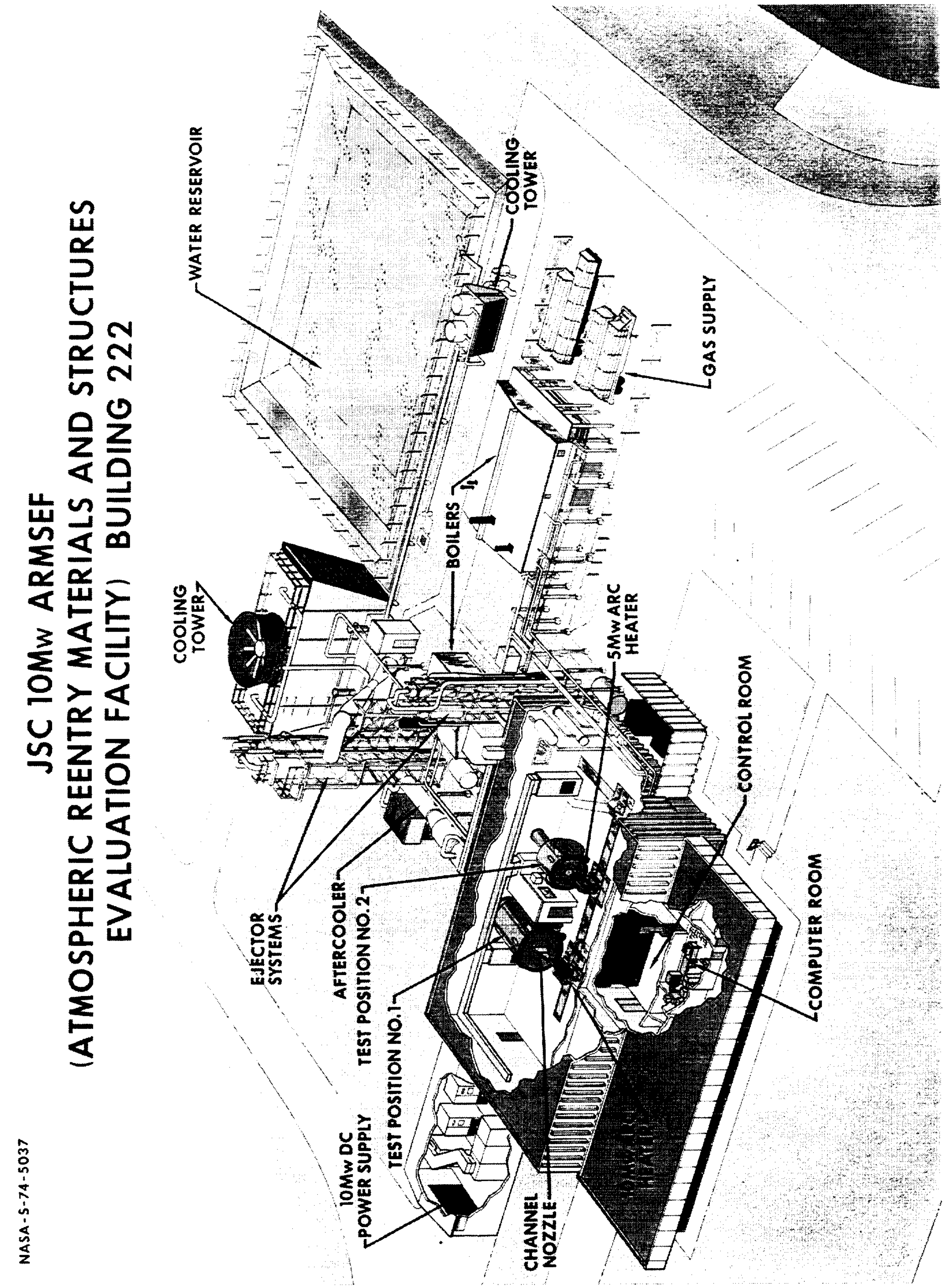


Figure 3. Artist's Concept of ARMSEF, depicting test chambers, vacuum system, and control room.

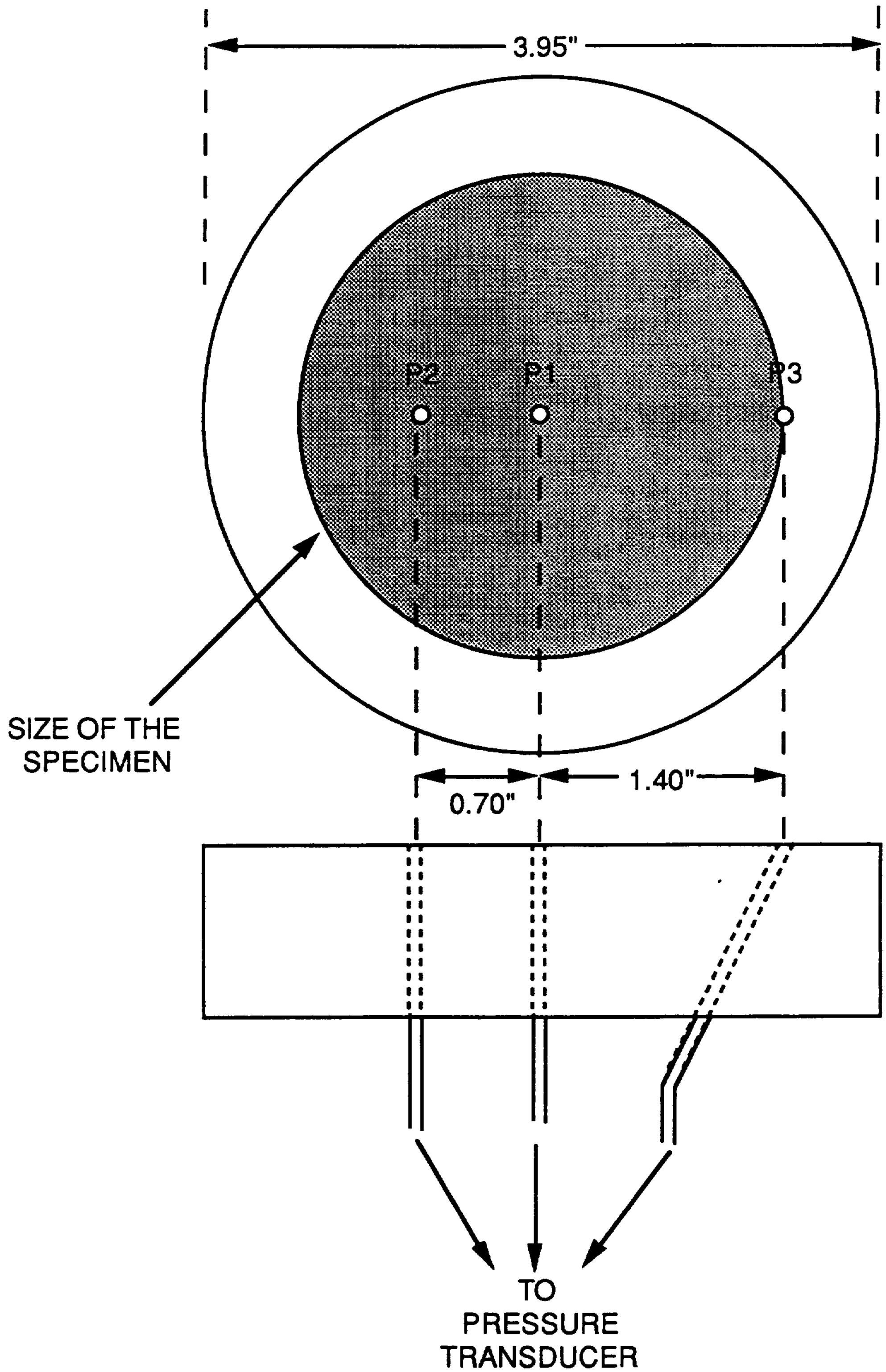


Figure 4-(a). Schematic of the pressure model.

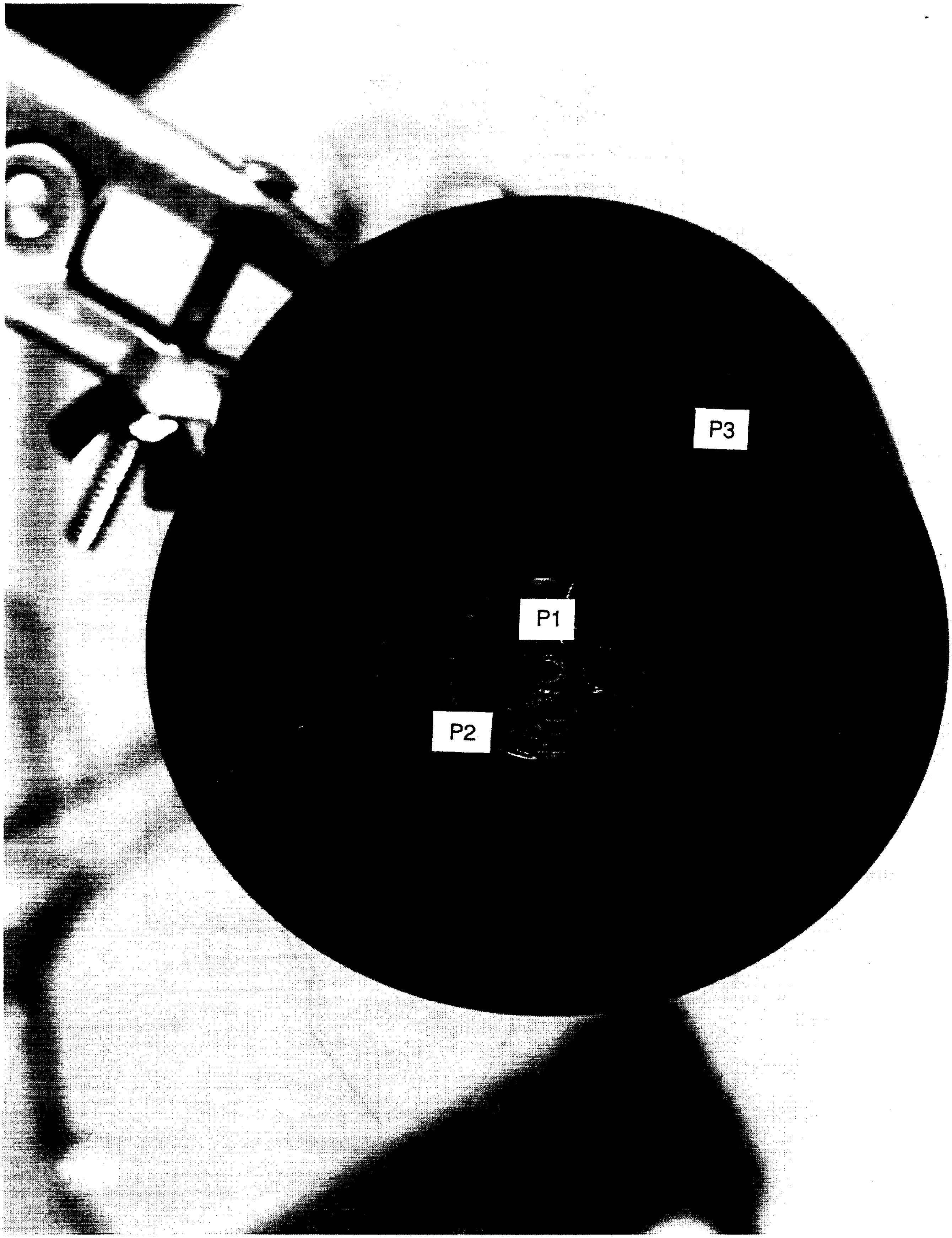


Figure 4-(b). Photograph of the pressure model.

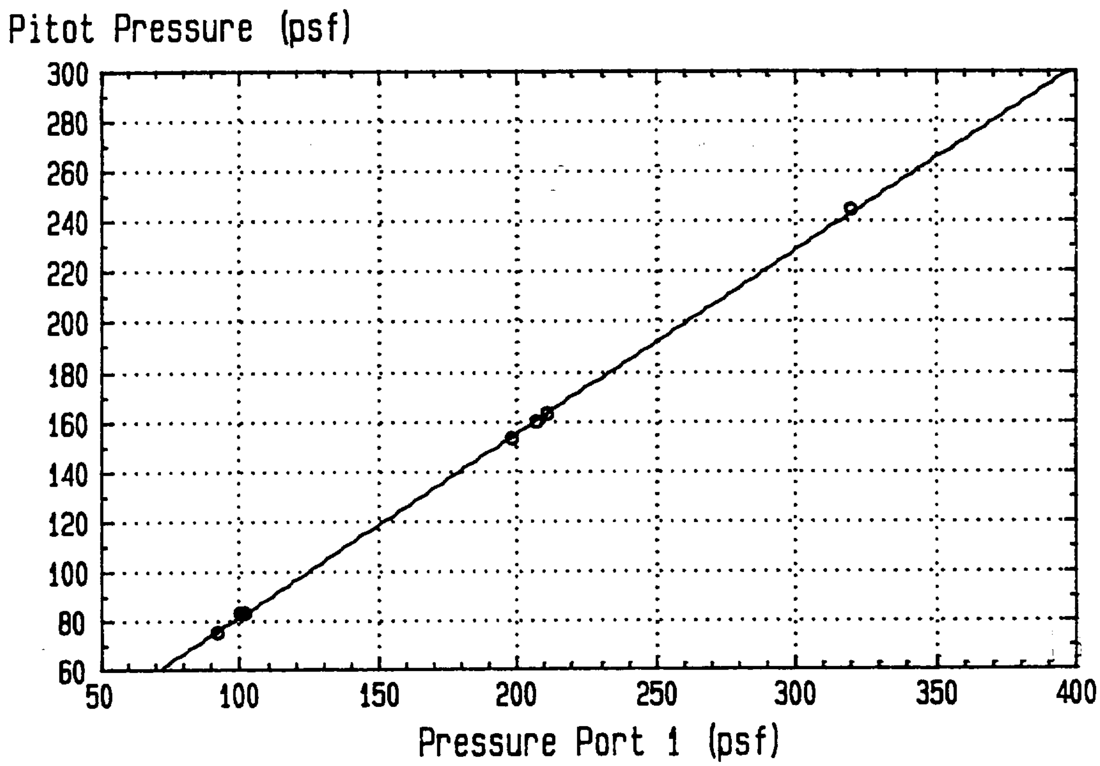


Figure 5-(a). Pressure correlation between the pressure port, P1, and the pitot probe.

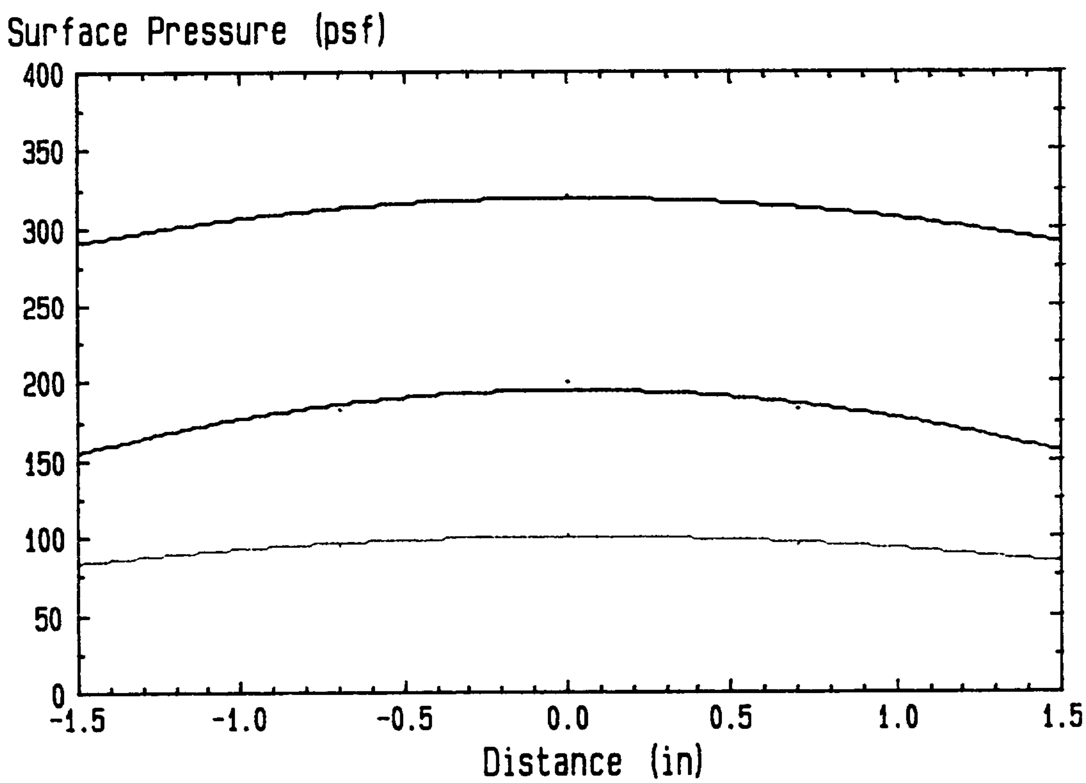


Figure 5-(b). Pressure distribution on the surface of the RCC model at three different pressure ranges.

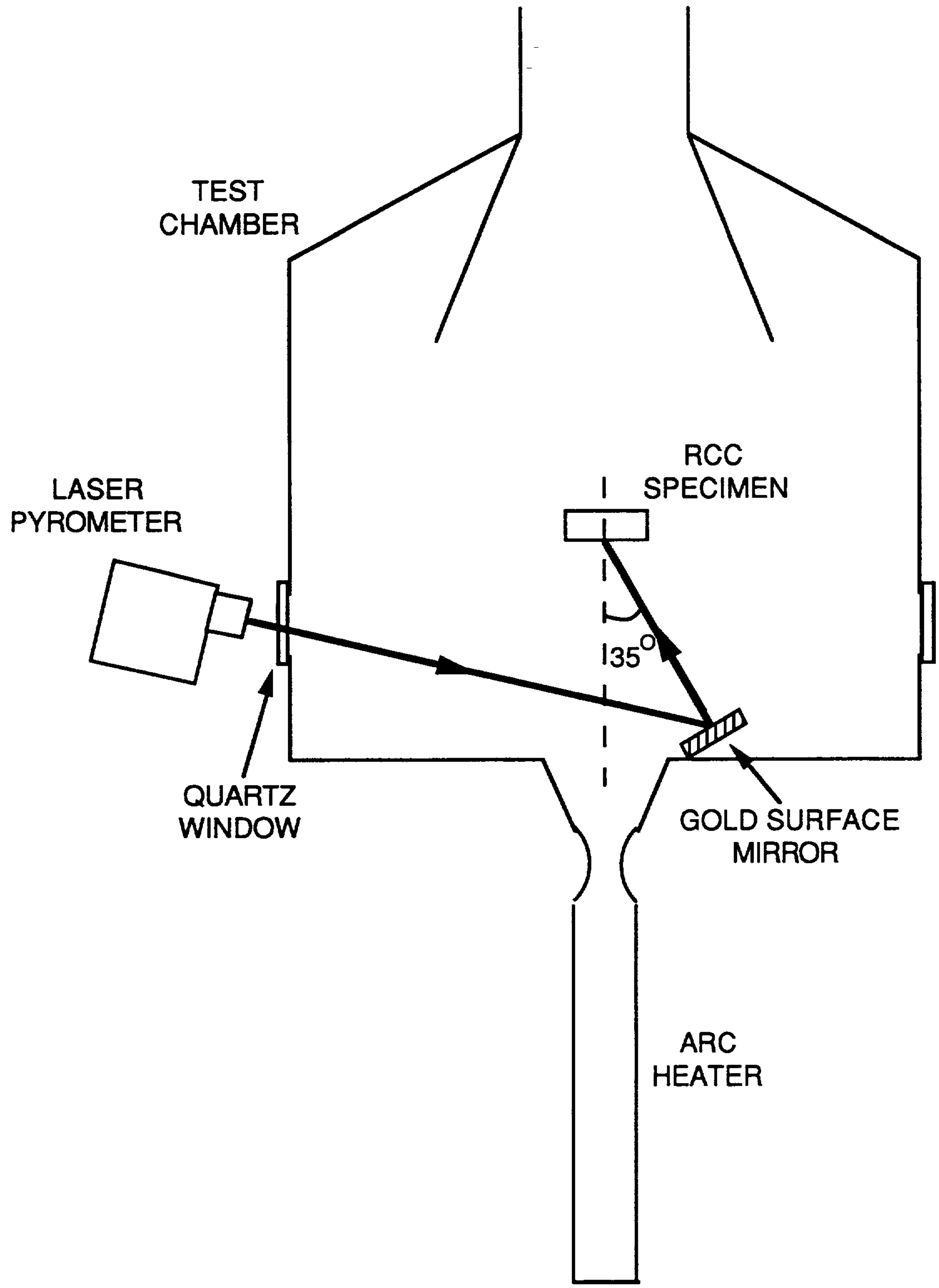


Figure 6. Test setup with the laser pyrometer.

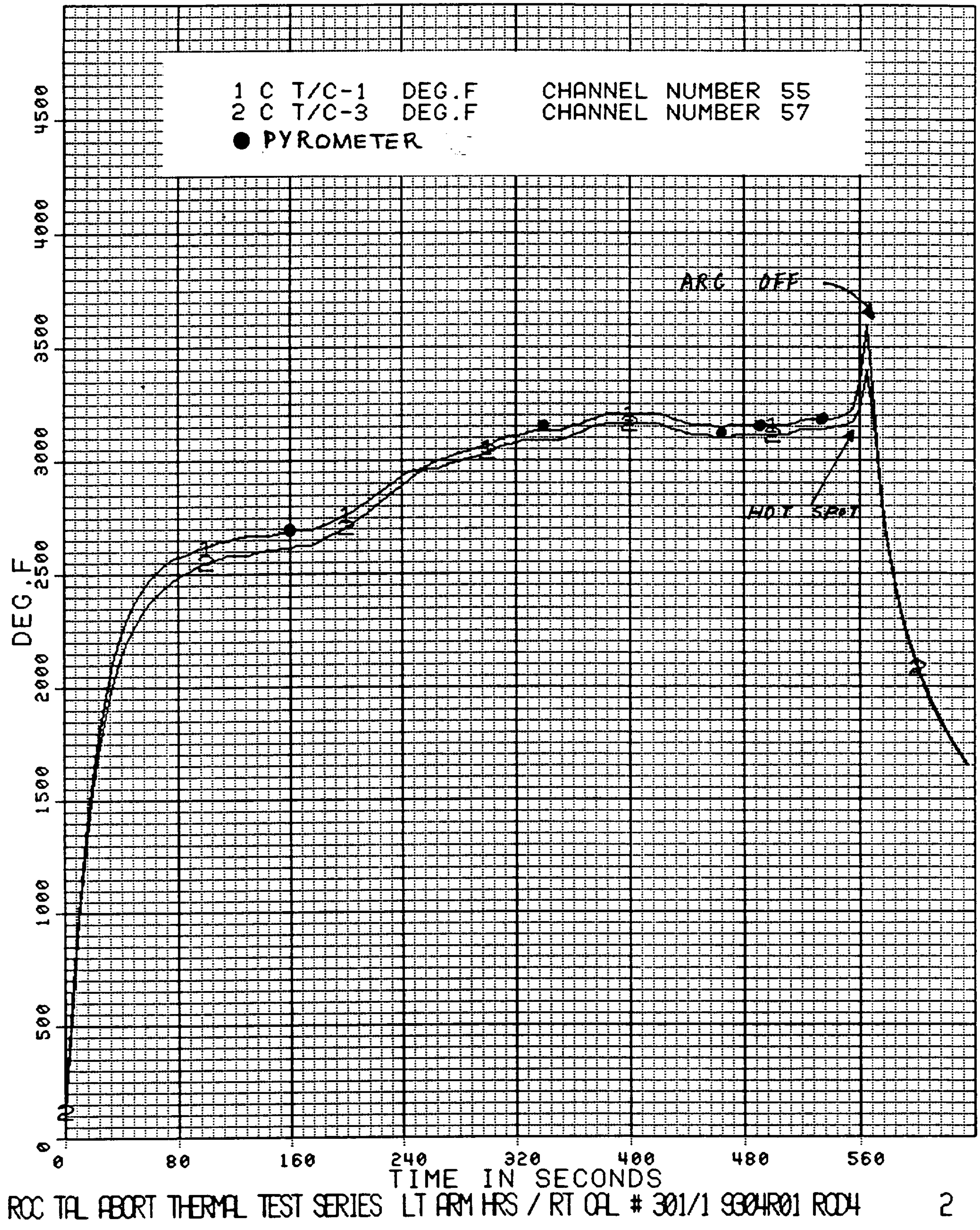


Figure 7-(a). Temperature responses of the surface thermocouples and the laser pyrometer on an AVTEX Coated/TEOS/Type A specimen.

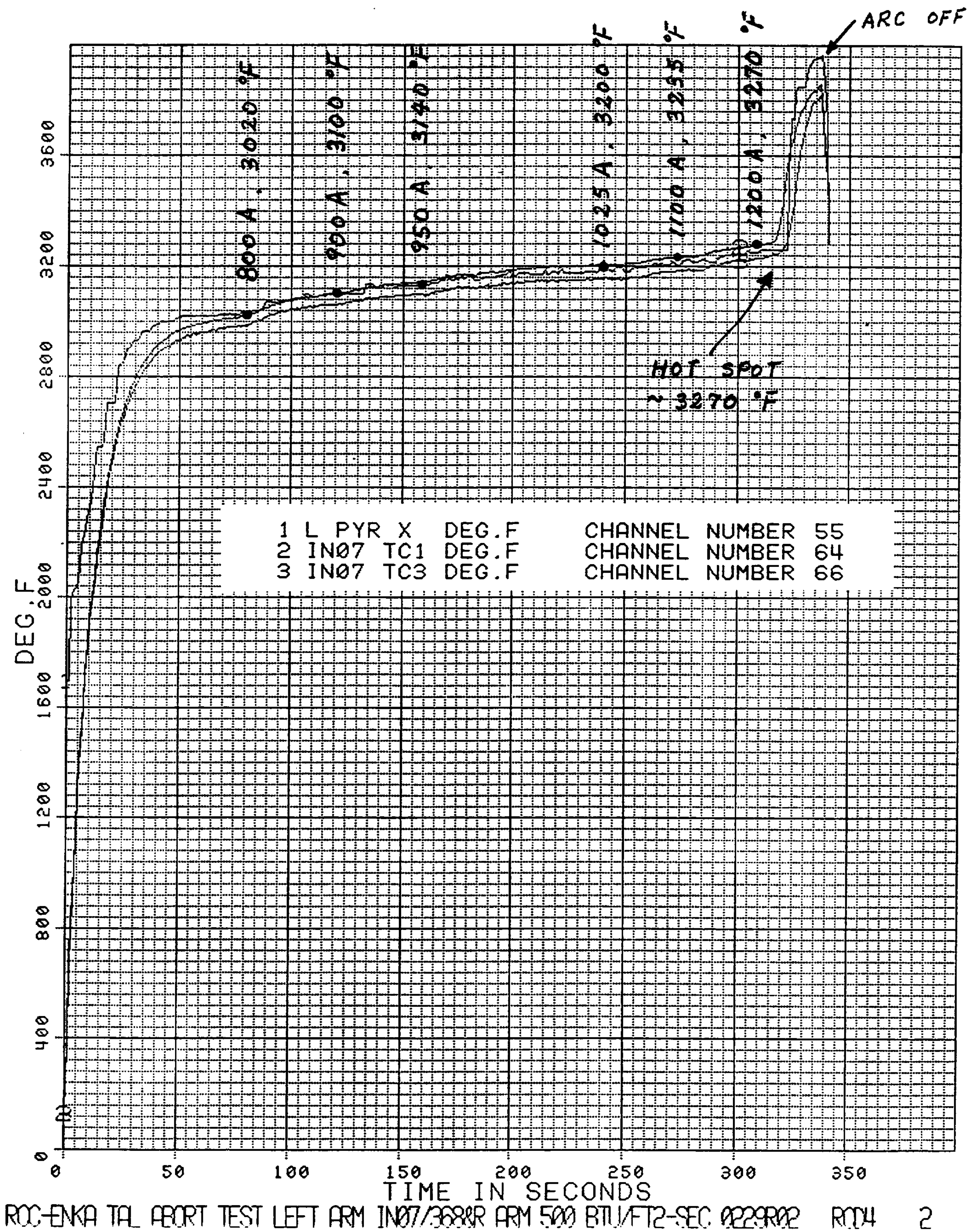


Figure 7-(b). Temperature responses of the surface thermocouples and the laser pyrometer on an ENKA Coated/TEOS/No Type A specimen.

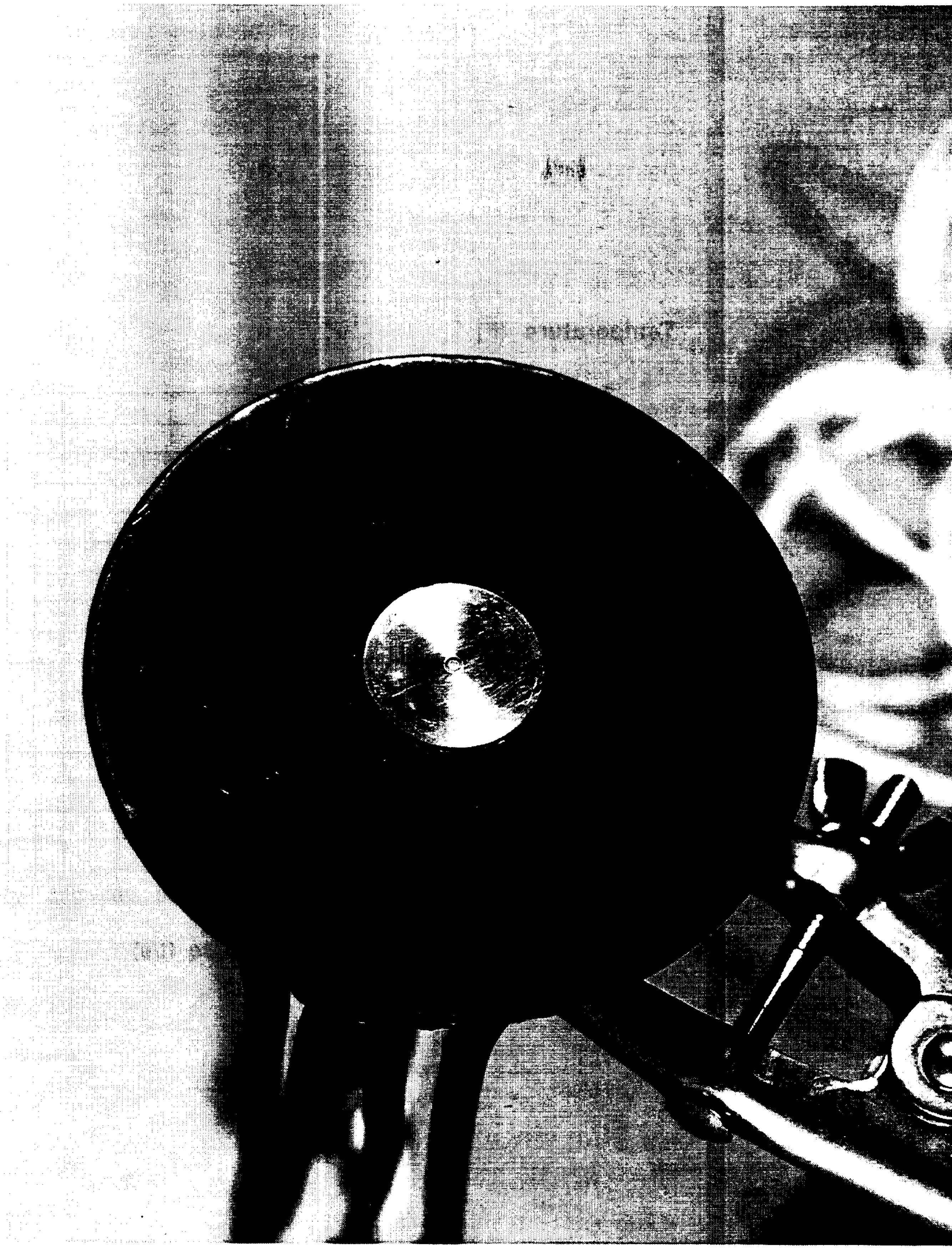


Figure 8. Photograph of the calorimeter installed in a 4.0" diameter water cooled copper holder.

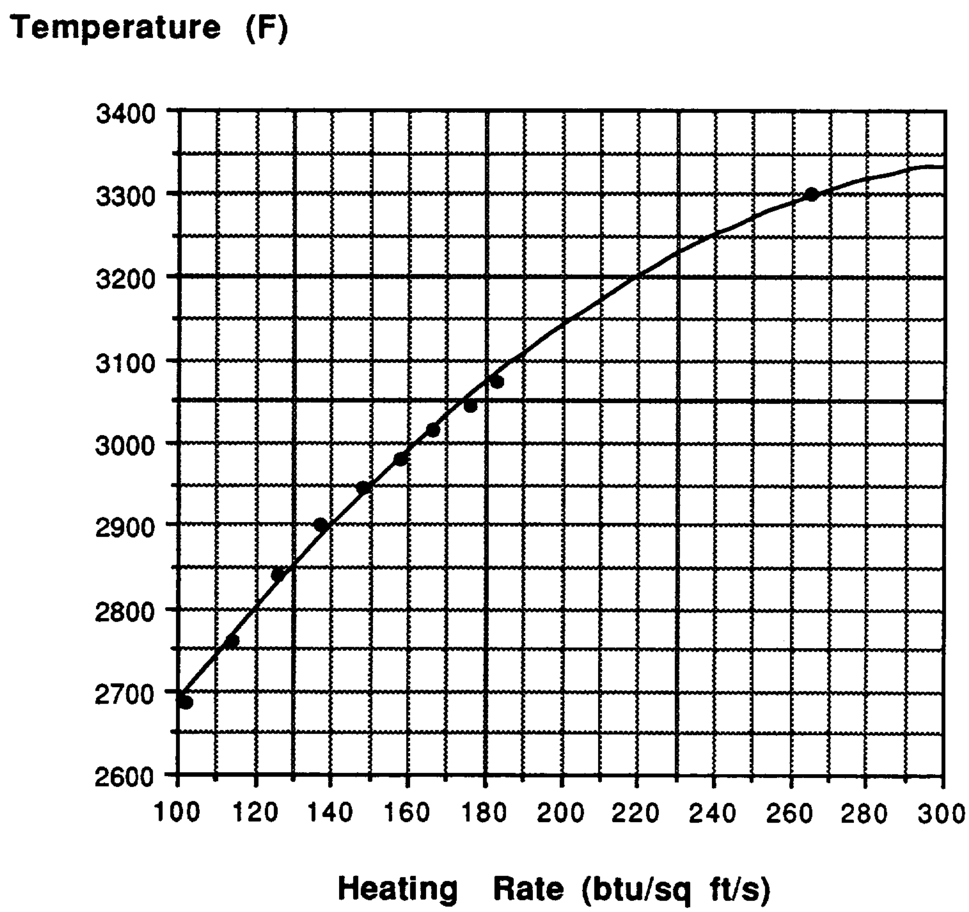


Figure 9-(a). Temperature versus heating rate curve for Coated/TEOS/Type A RCC specimen at 100 psf pressure range.

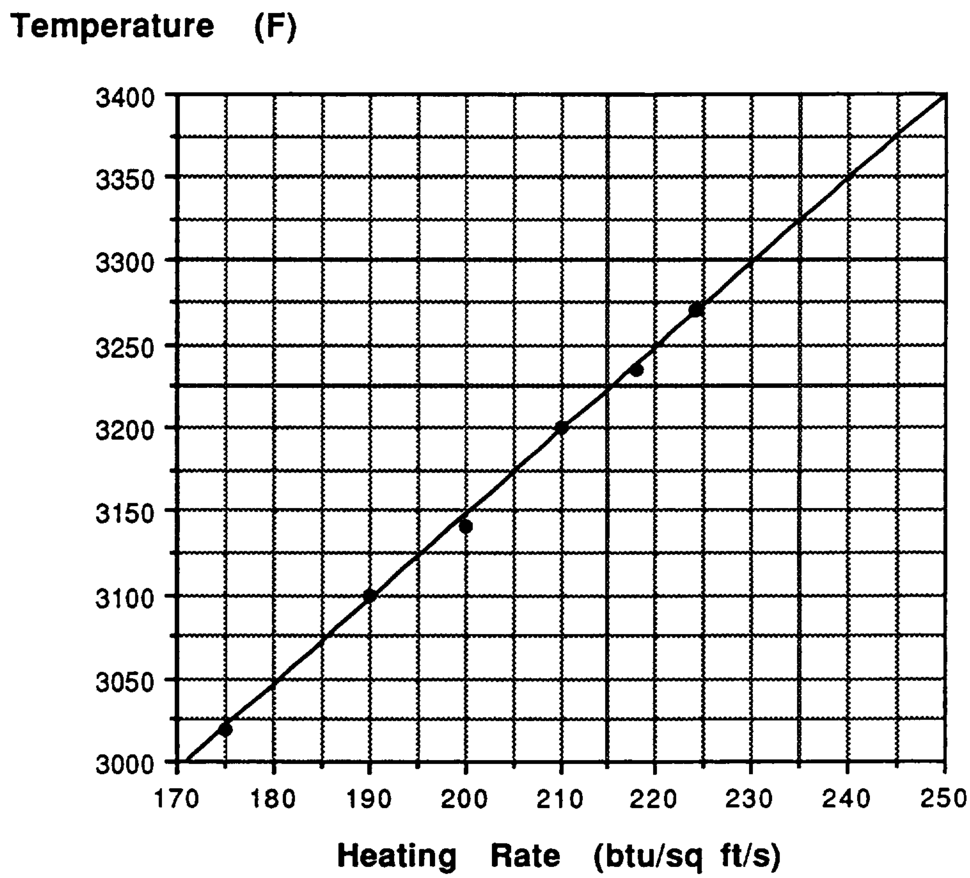


Figure 9-(b). Temperature versus heating rate curve for Coated/TEOS/No Type A RCC specimen at 100 psf range.

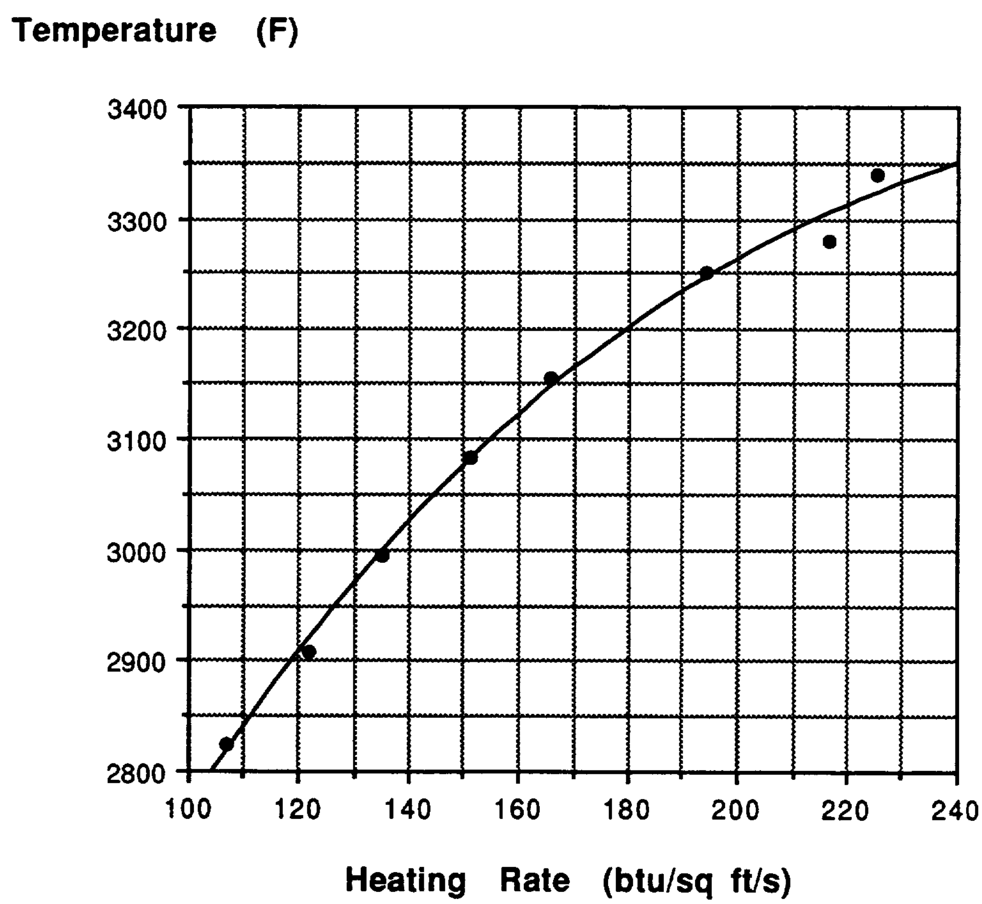


Figure 9-(c). Temperature versus heating rate curve for Coated/TEOS/Type A RCC specimen at 200 psf pressure range.

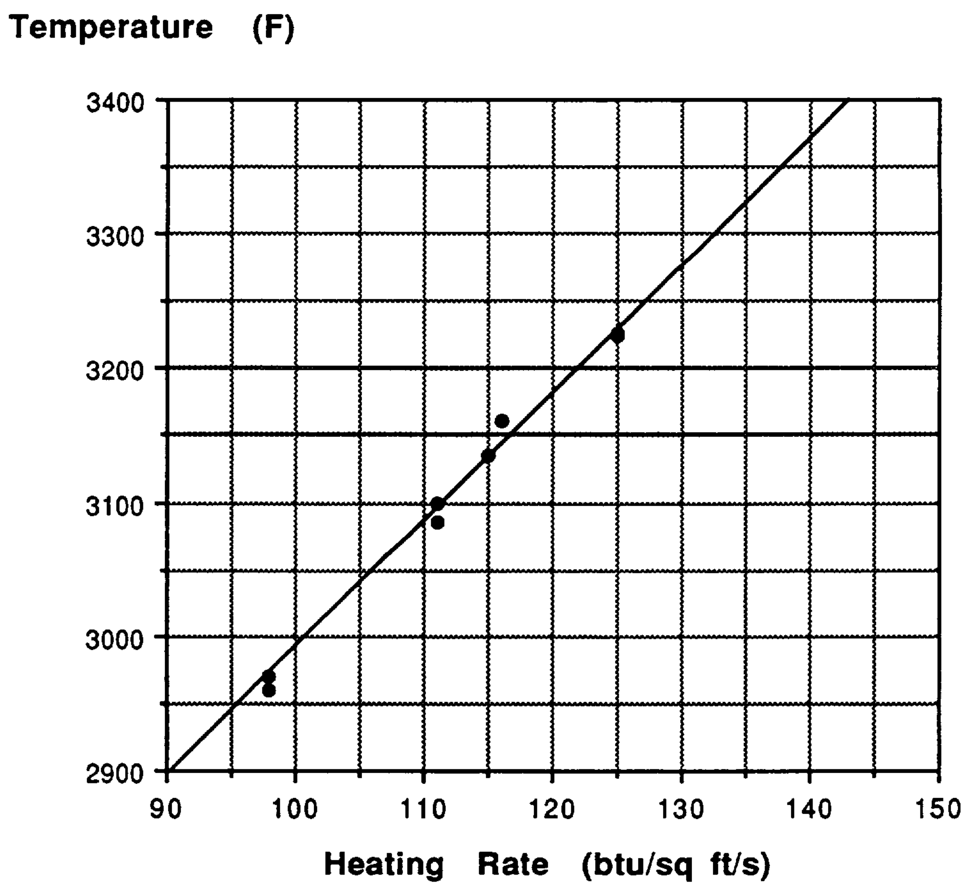


Figure 9-(d). Temperature versus heating rate curve for Coated/TEOS/Type A and No Type A RCC specimen at 300 psf pressure range.

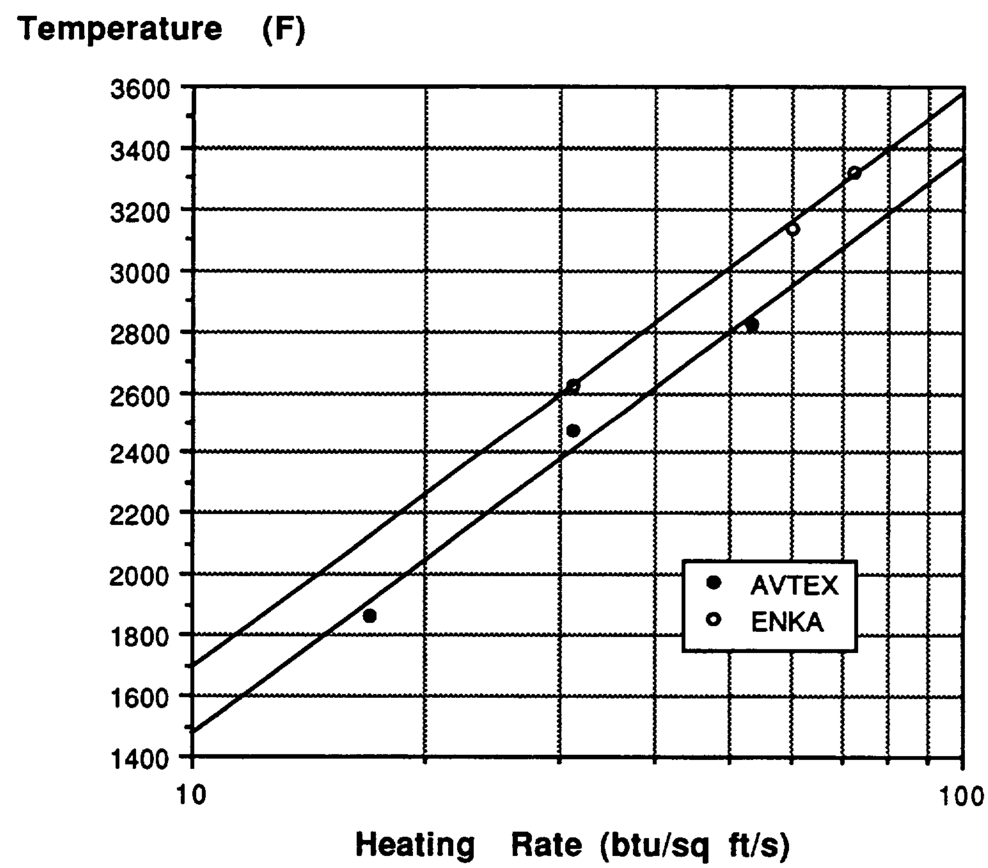


Figure 9-(e). Temperature versus heating rate curves for Uncoated/TEOS RCC specimen.

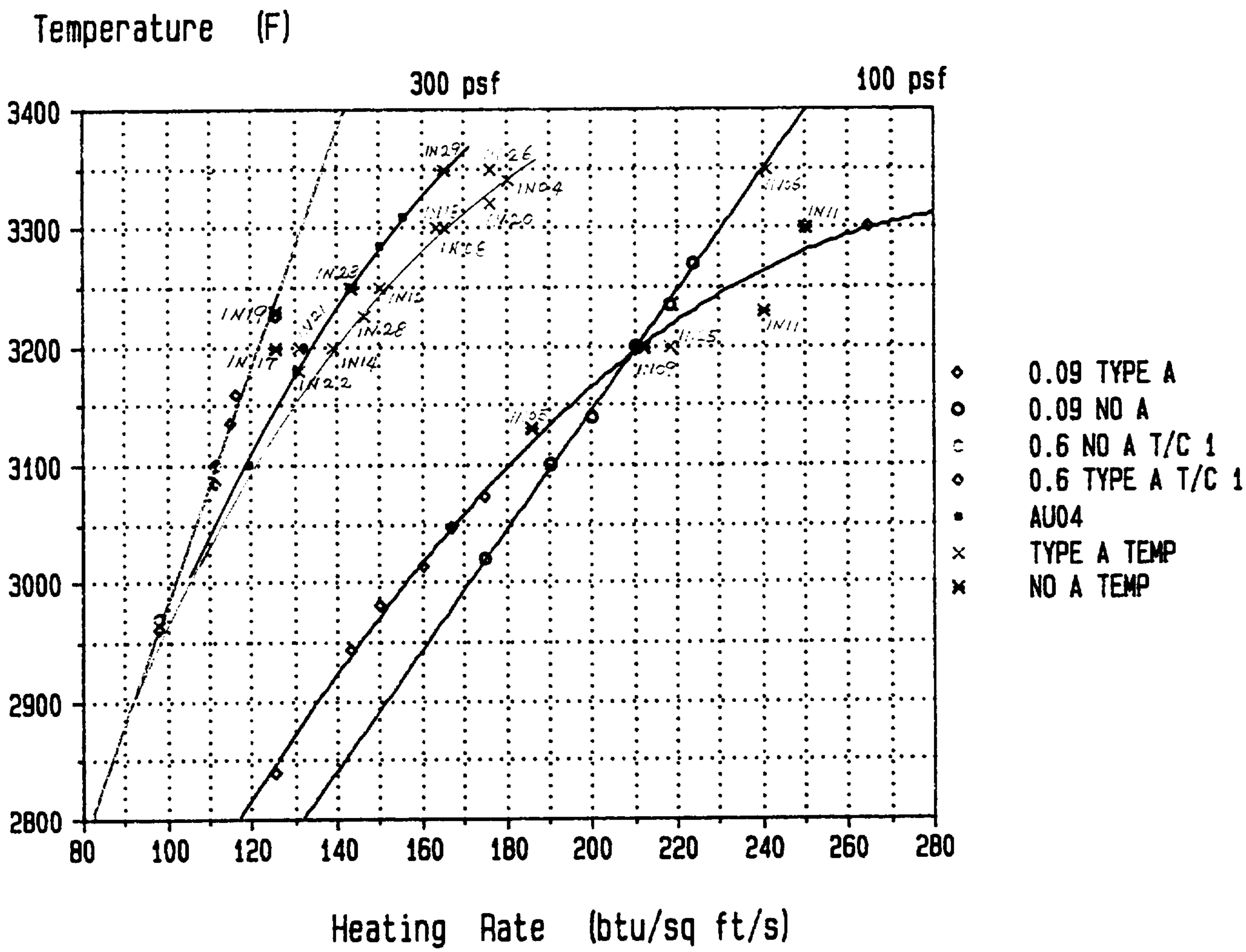
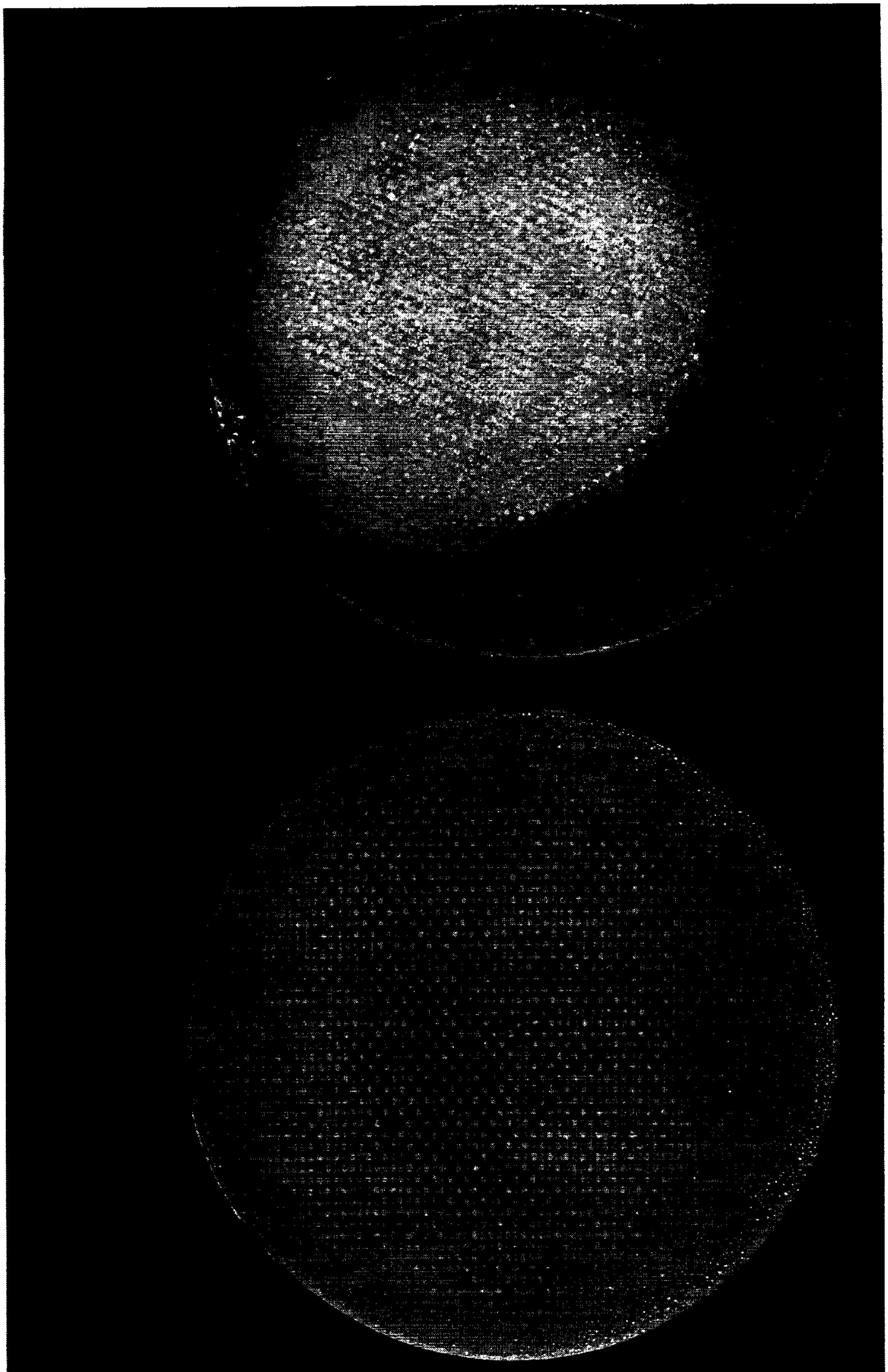


Figure 10. Composite plot of the temperature versus heating rate curves at 100 psf and 300 psf with some coated specimens identified on the plot.



BACK

FRONT

Figure 11-(a). Post test photograph of specimen #AB13 at 2975 °F, 95 psf for 353 s.

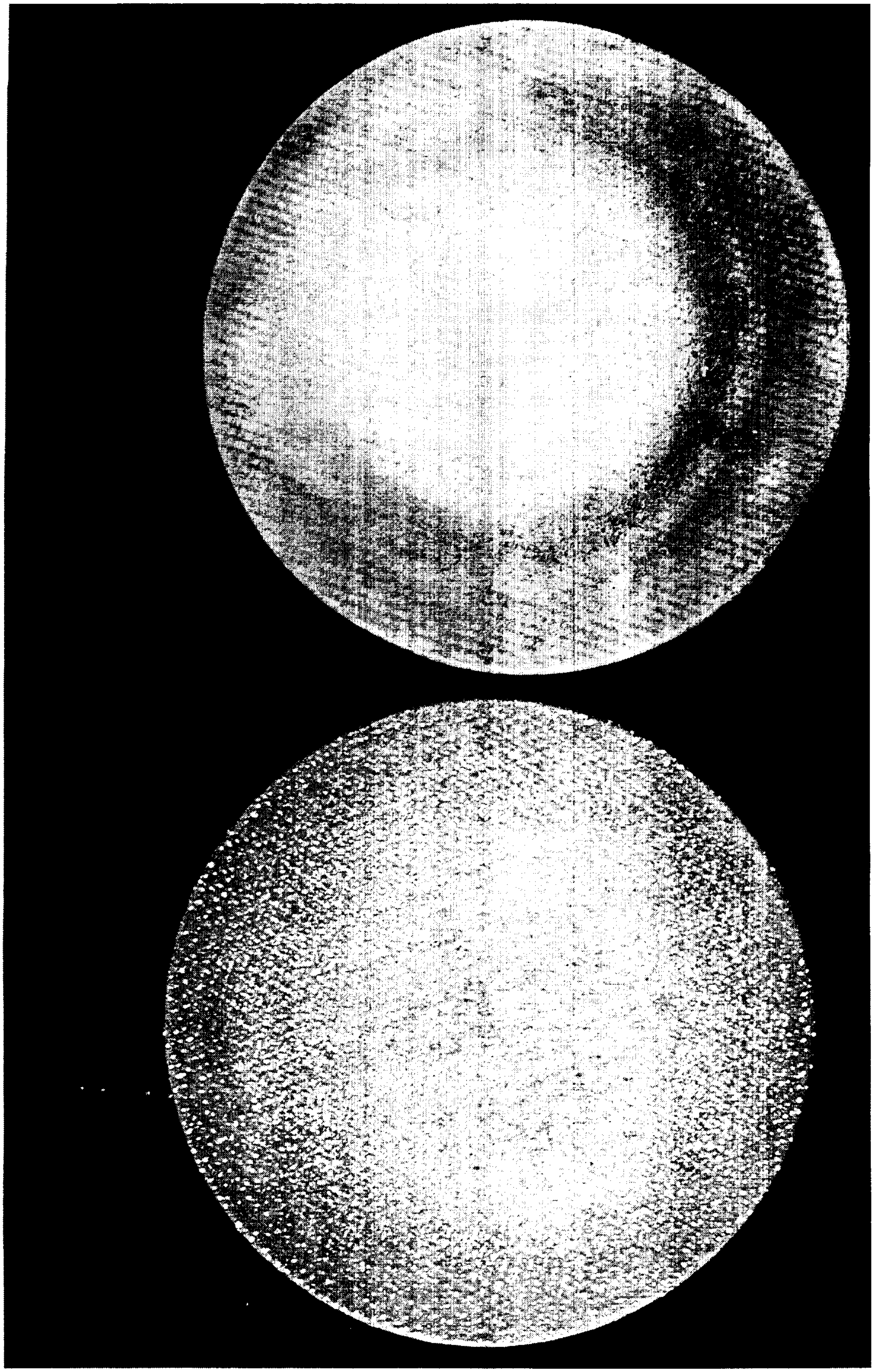


Figure 11-(b). Post test photograph of specimen #3 at 3000 °F, 160 psf for 330s.

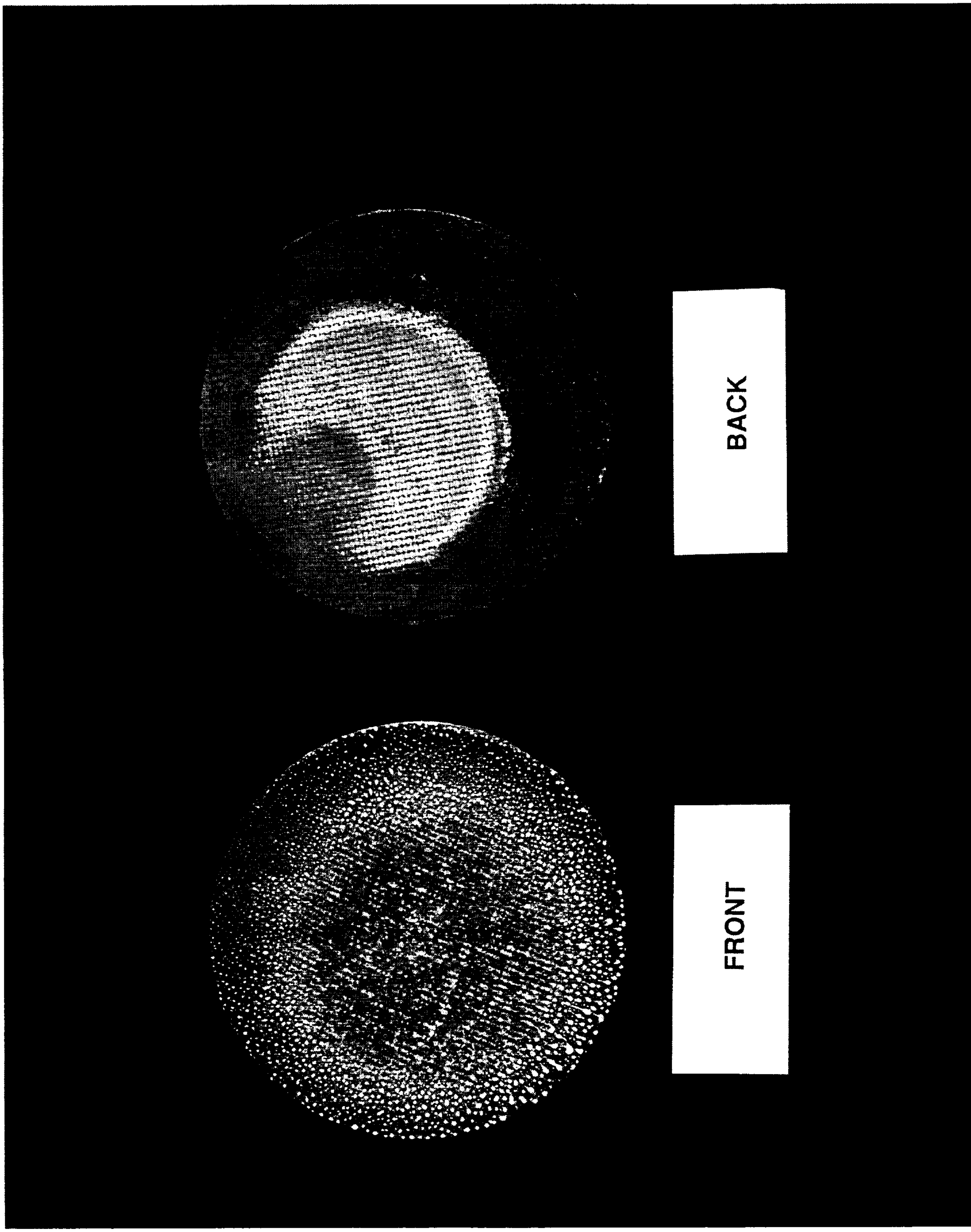
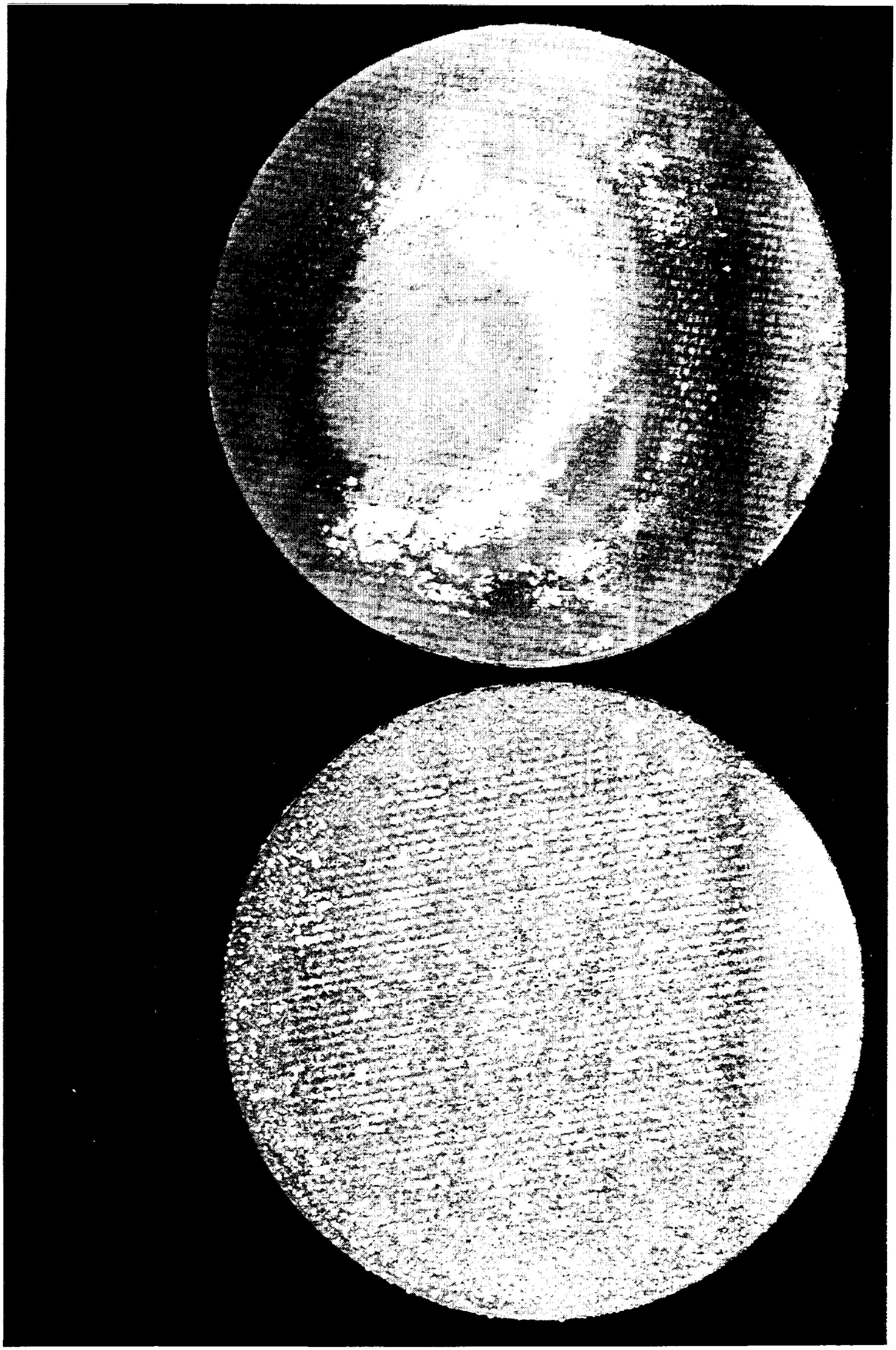


Figure 11-(c). Post test photograph of specimen #16 at 3000 °F, 160 psf for 800s.



BACK

FRONT

Figure 11-(d). Post test photograph of specimen #4 at 3060 °F, 320 psf for 330s.

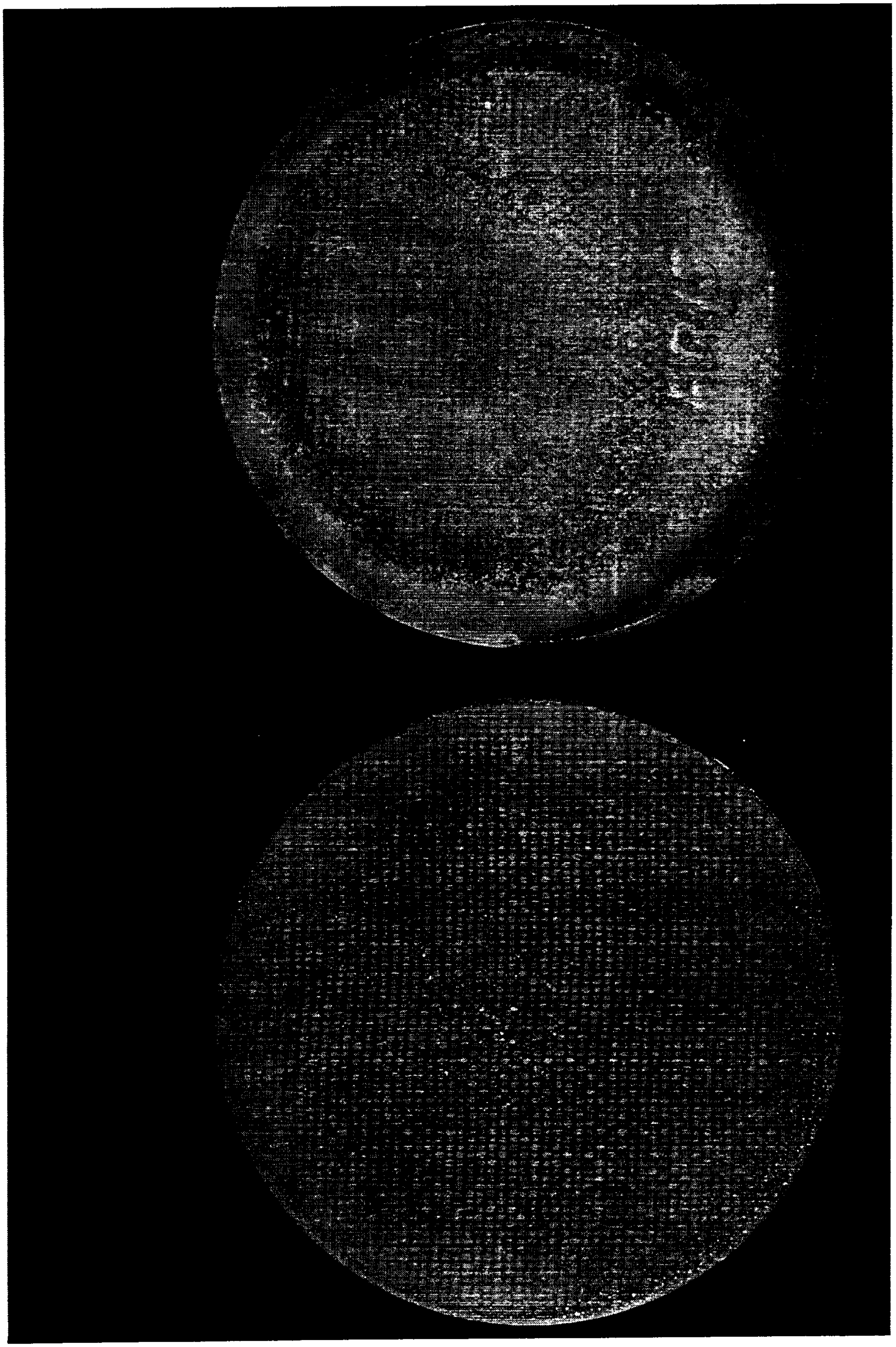
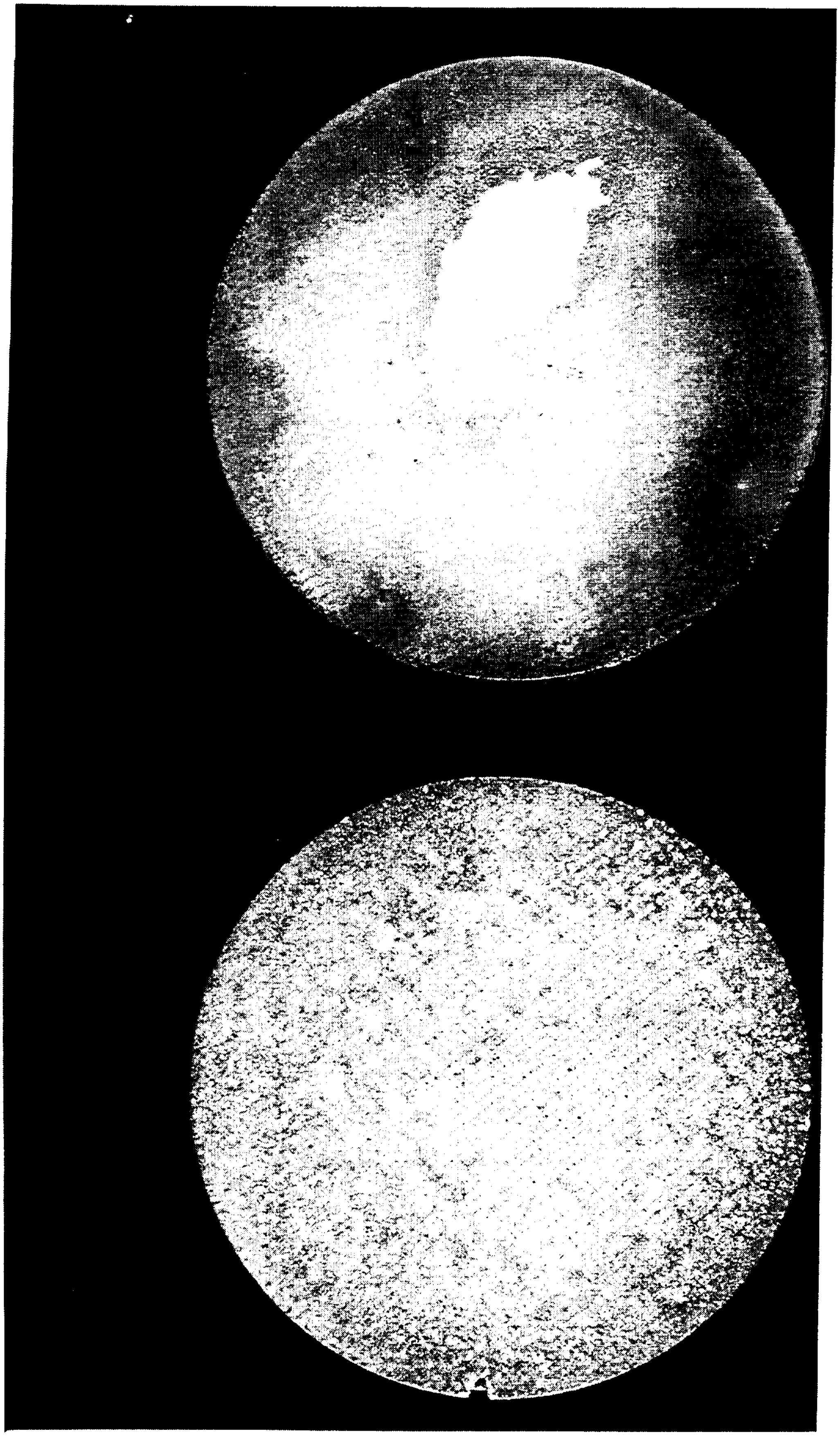


Figure 11-(e). Post test photograph of specimen #AB15 at 3100 °F, 90 psf for 330 s.



BACK

FRONT

Figure 11-(f). Post test photograph of specimen #IN22 at 3180 °F, 303 psf for 330 s.

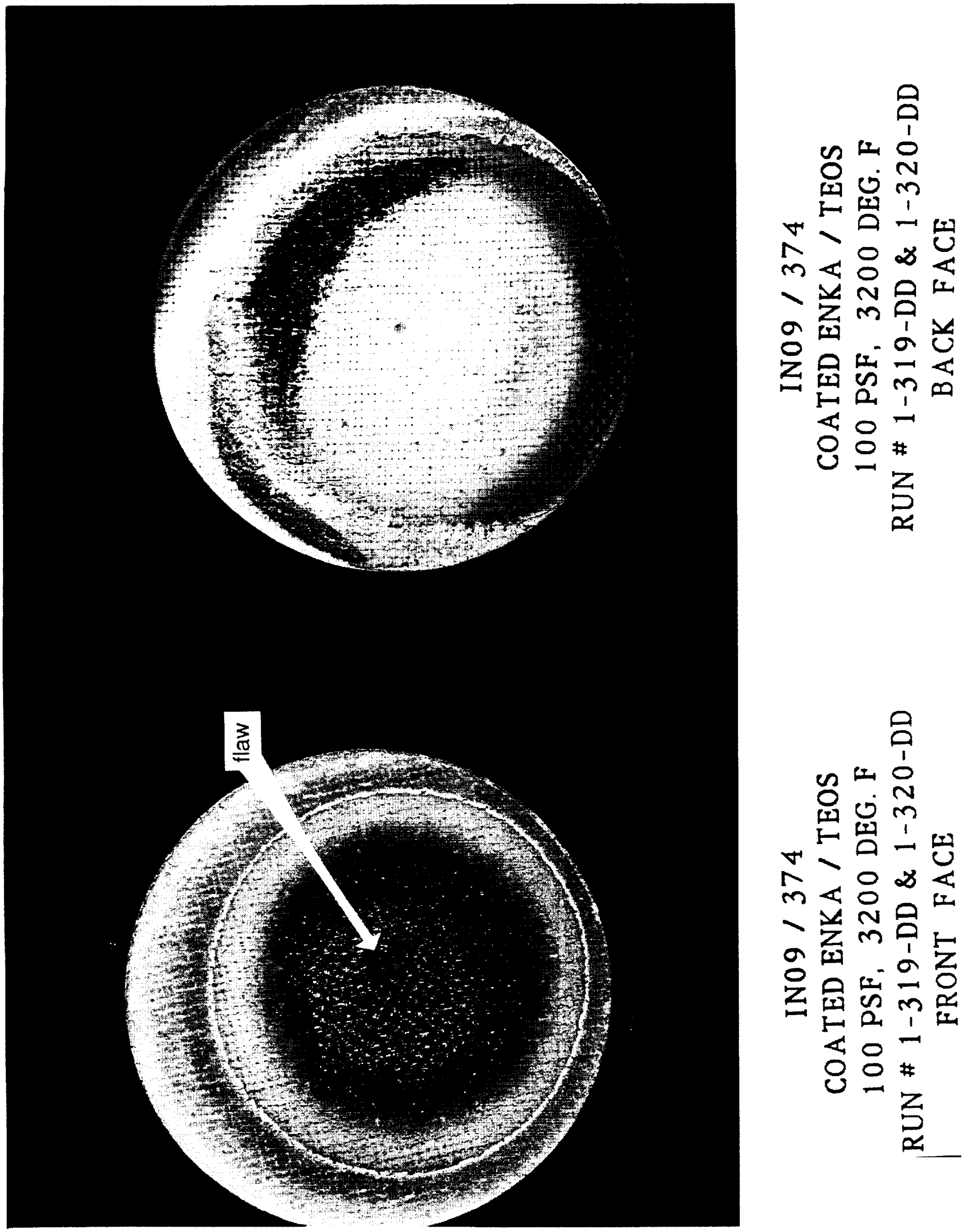


Figure 11-(g). Post test photograph of specimen #IN09 at 3200 °F, 97 psf for 3600 s.

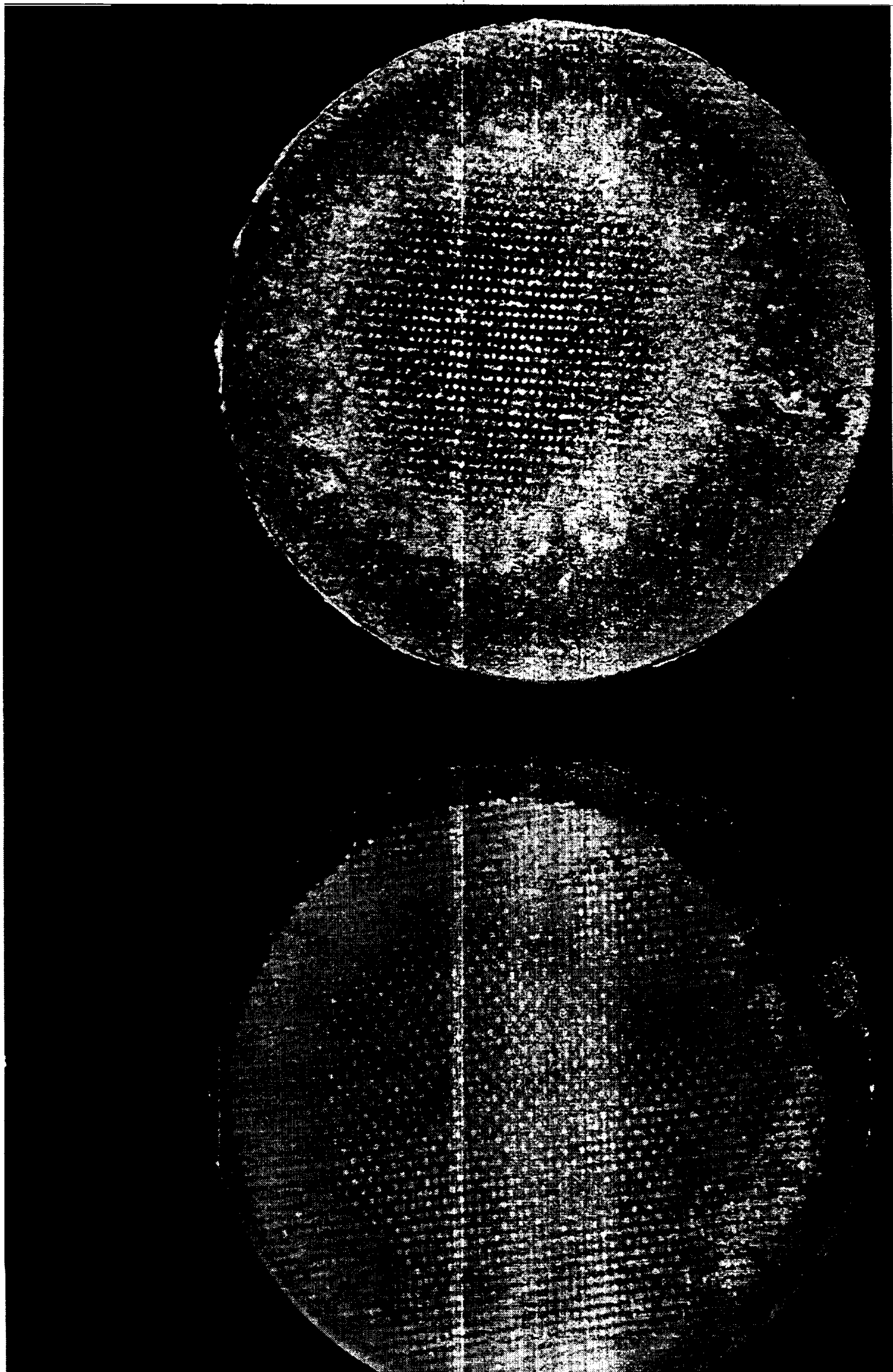


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Figure 11-(h). Post test photograph of specimen #2 at 3200 °F, 103 psf for 330s.

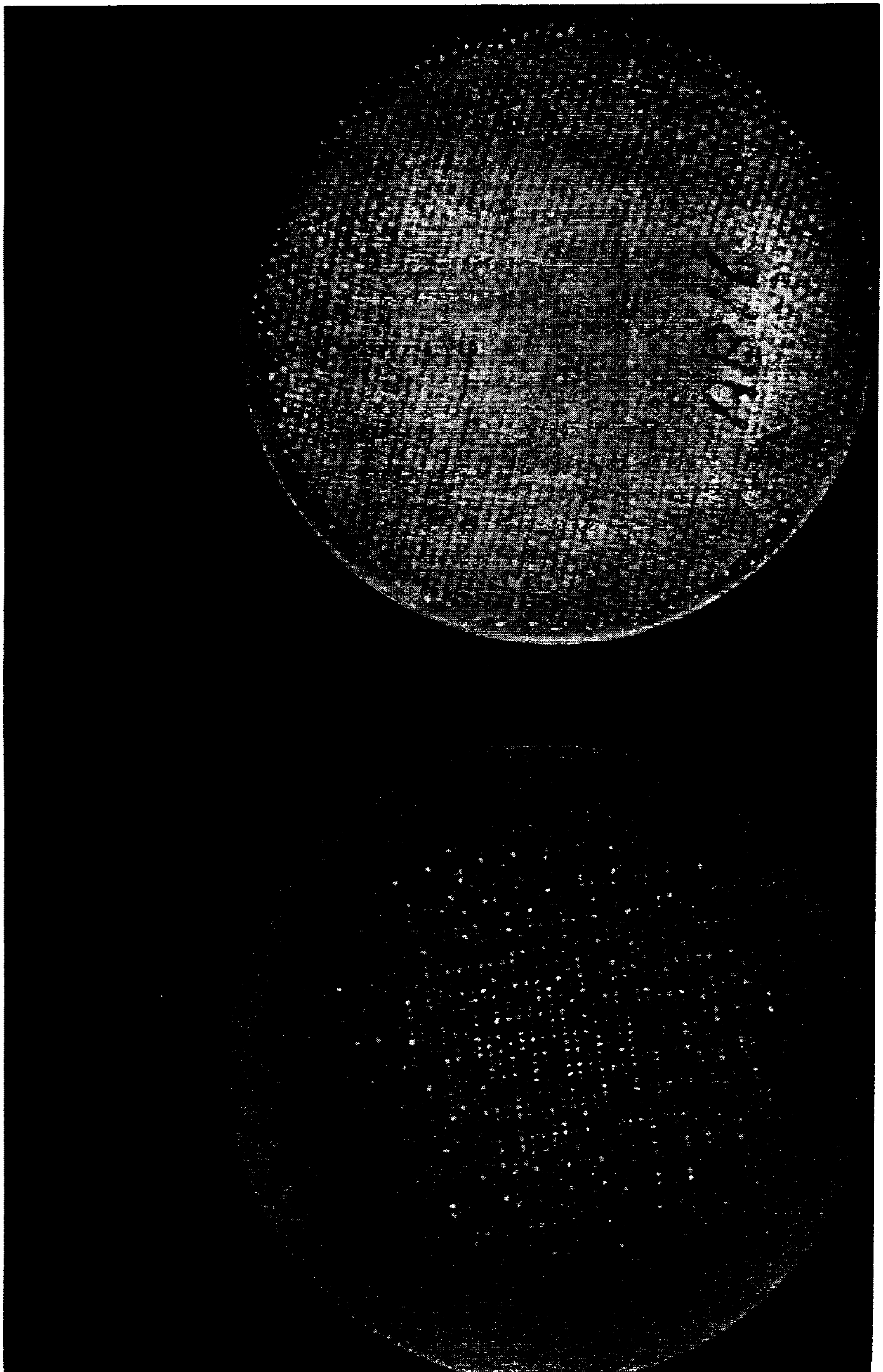

Figure 11-(i). Post test photograph of specimen #AB16 at 3200 °F, 103 psf for 330 s.

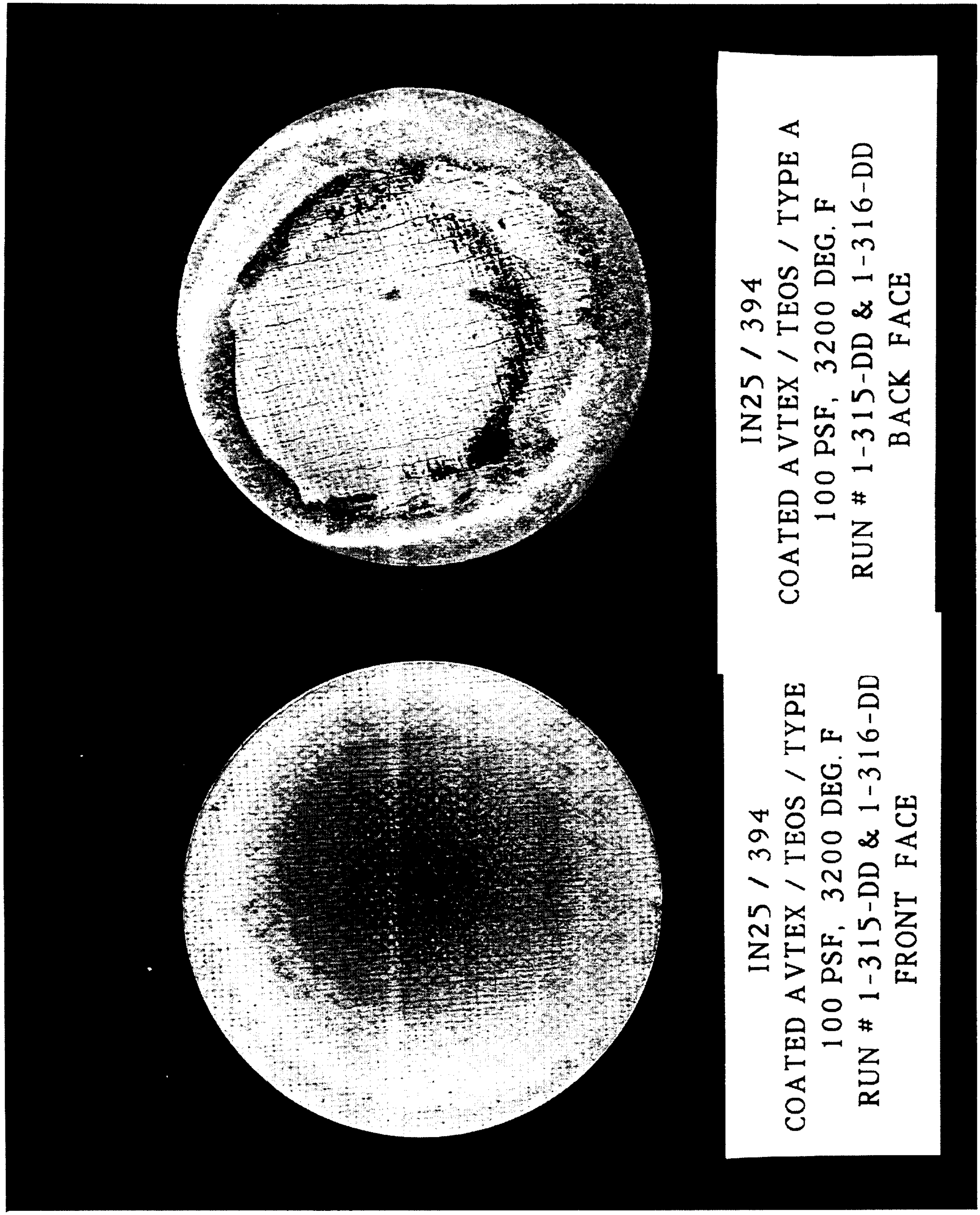

Figure 11-(j). Post test photograph of specimen #IN25 at 3200 °F, 105 psf for 3600 s.

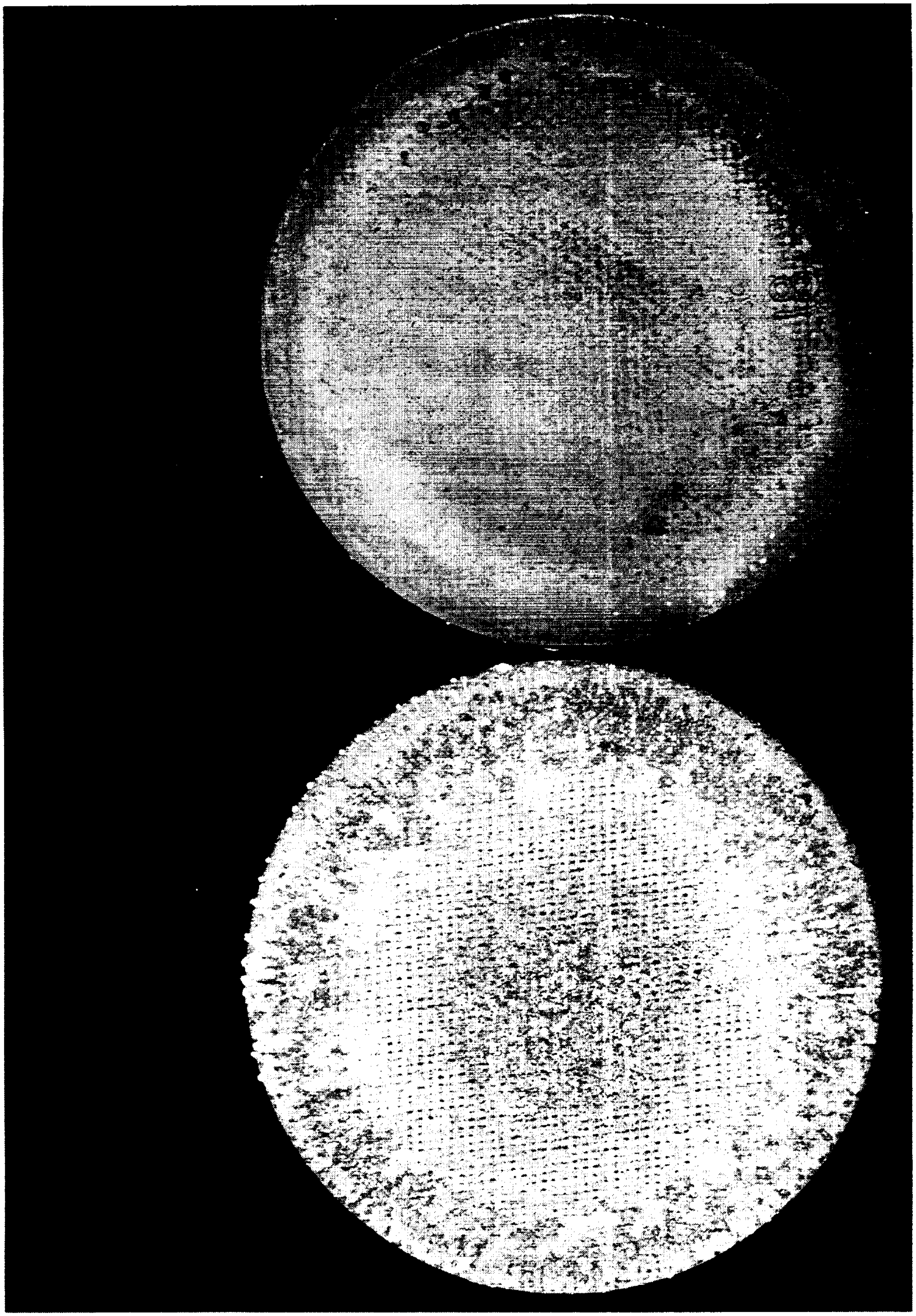

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Figure 11-(k). Post test photograph of specimen #18 at 3200 °F, 176 psf for 330s.

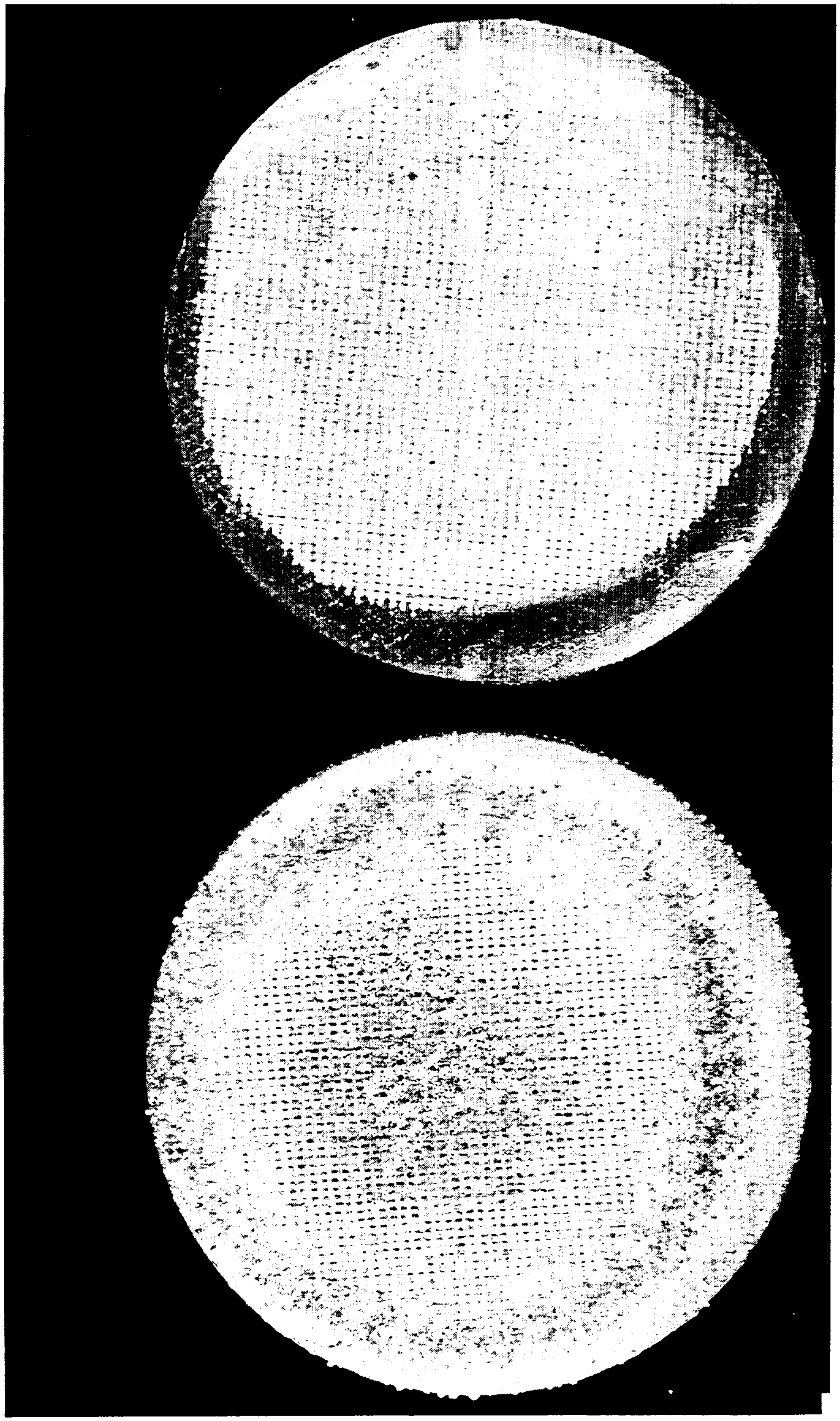

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Figure 11-(l). Post test photograph of specimen #14 at 3200 °F, 178 psf fc
600s.

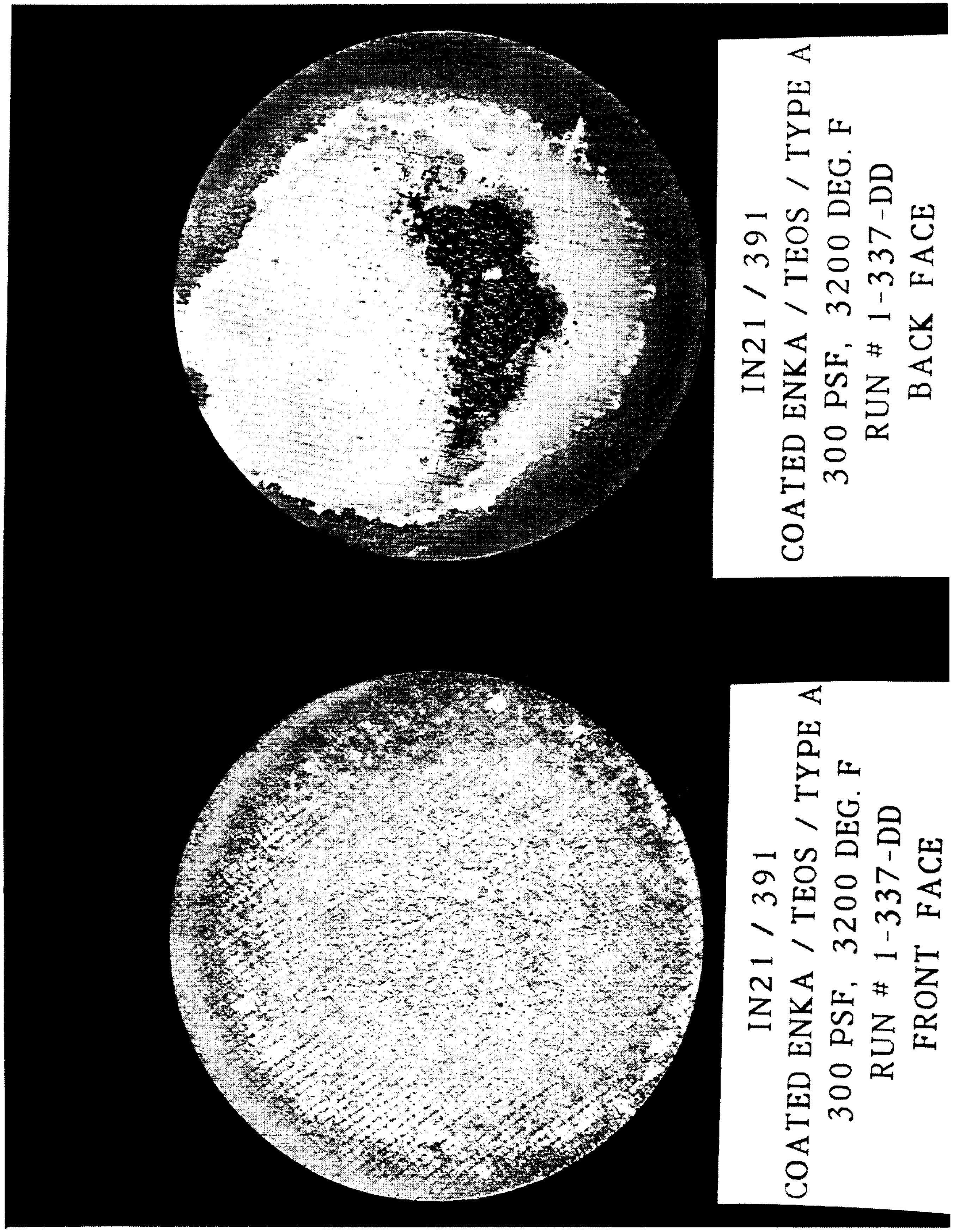

Figure 11-(m). Post test photograph of specimen #IN21 at 3200 °F, 293 psf for 1200 s.

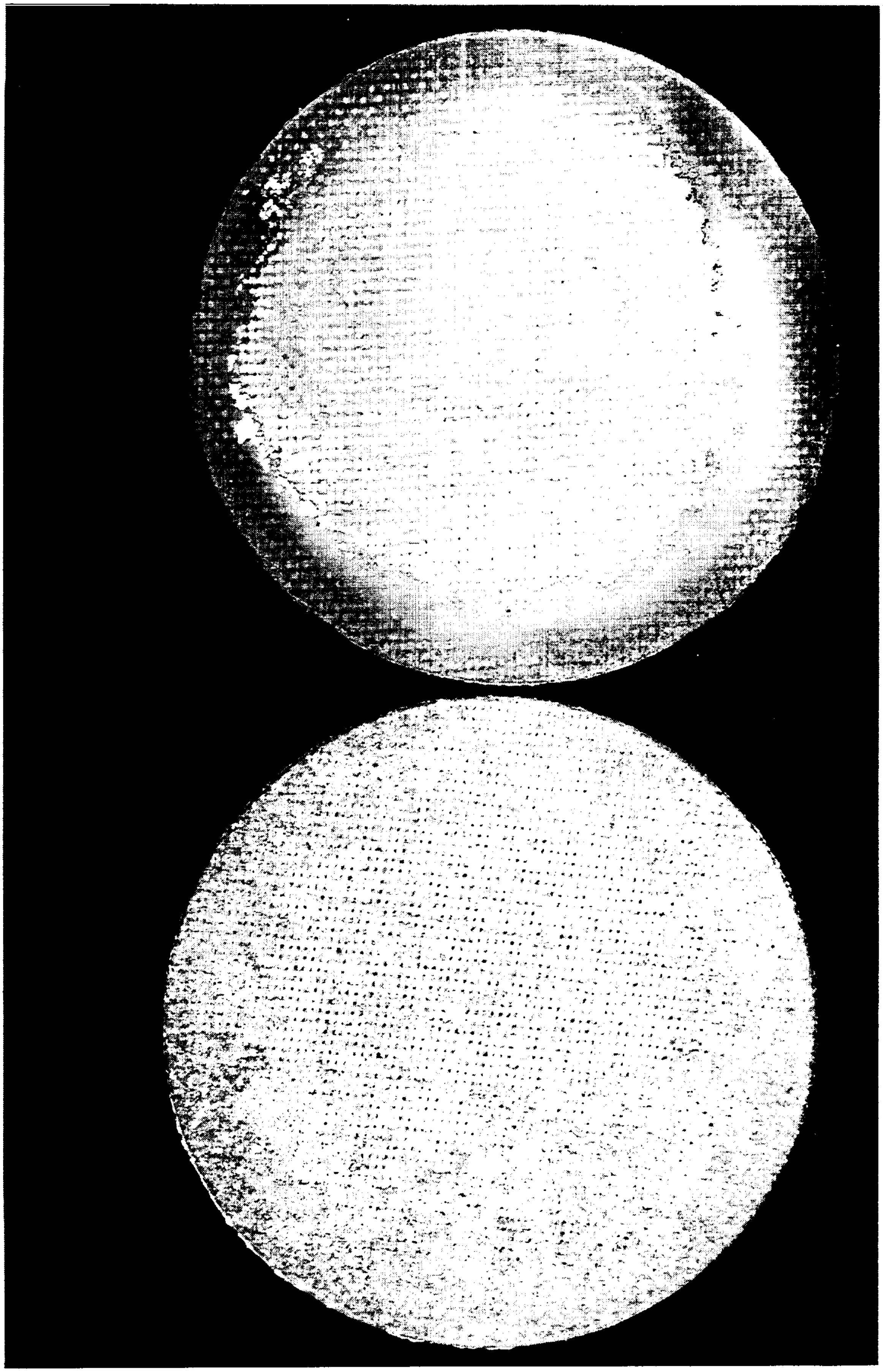

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Figure 11-(n). Post test photograph of specimen #5 at 3200 °F, 320 psf for 330s.

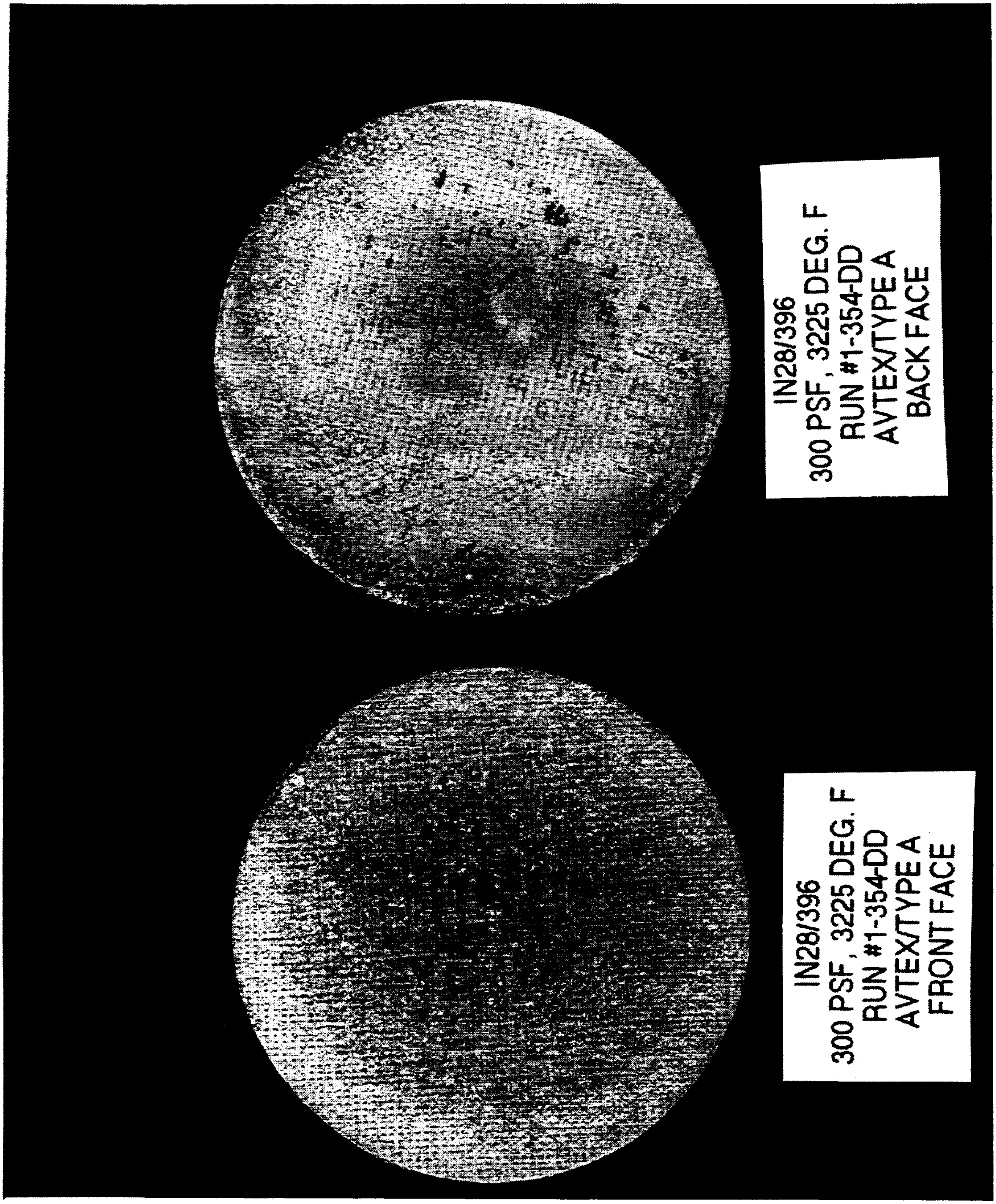

Figure 11-(o). Post test photograph of specimen #IN28 at 3225 °F, 312 psf for 900 s.

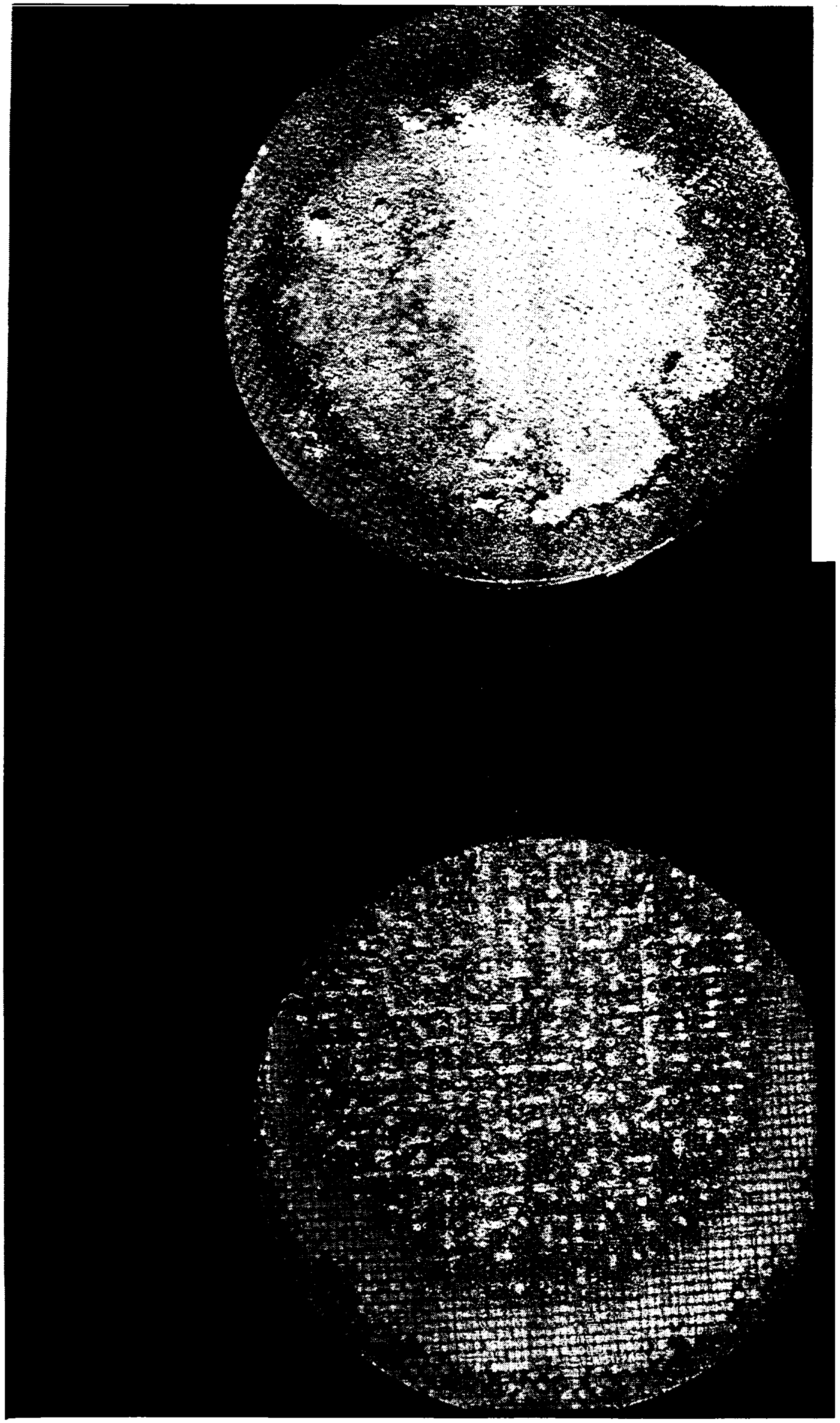

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Figure 11-(p). Post test photograph of specimen #IN19 at 3230 °F, 301 psf for 3600 s.

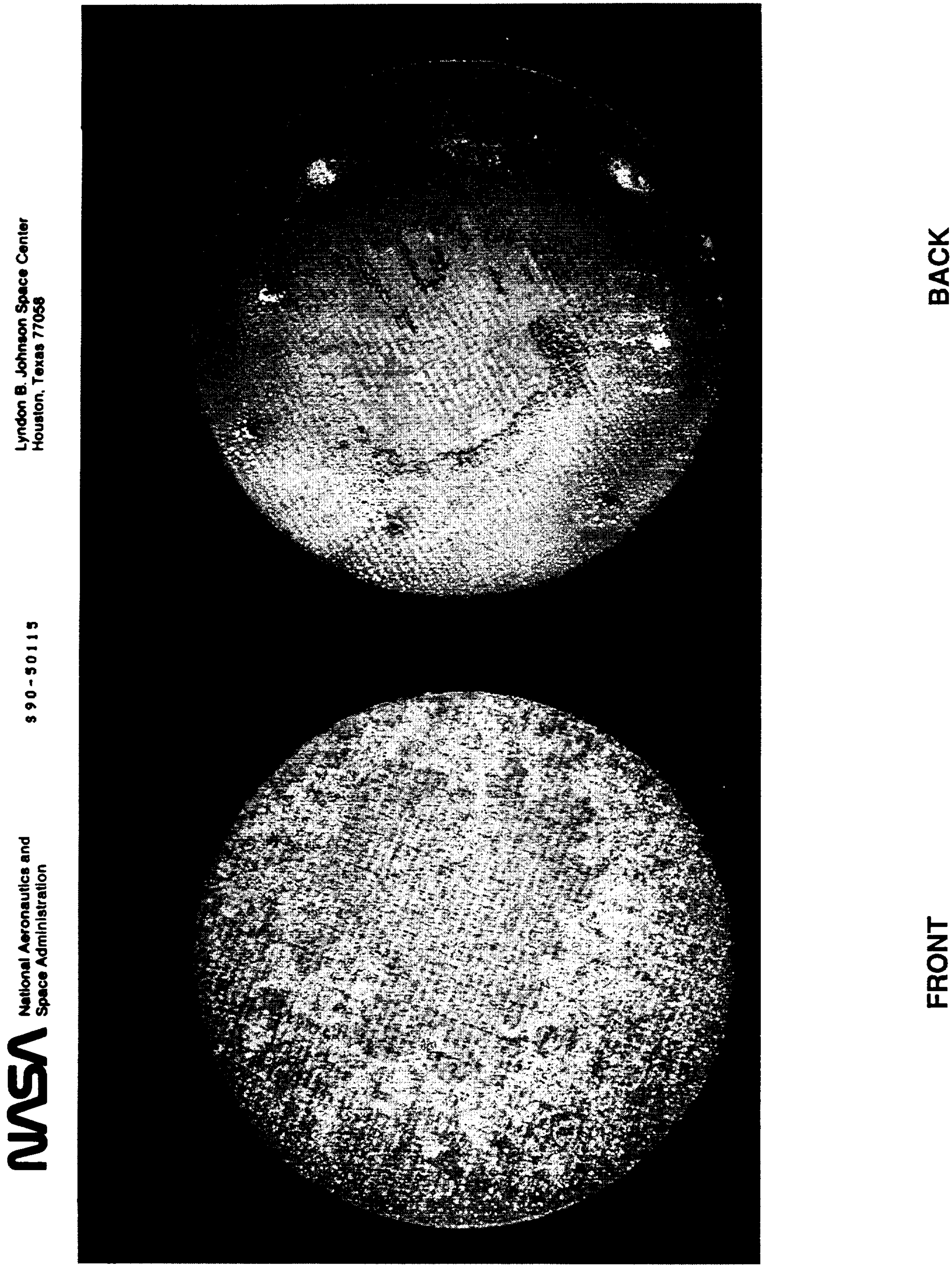

Figure 11-(q). Post test photograph of specimen #IN14 at 3230 °F, 309 psf for 223 s.

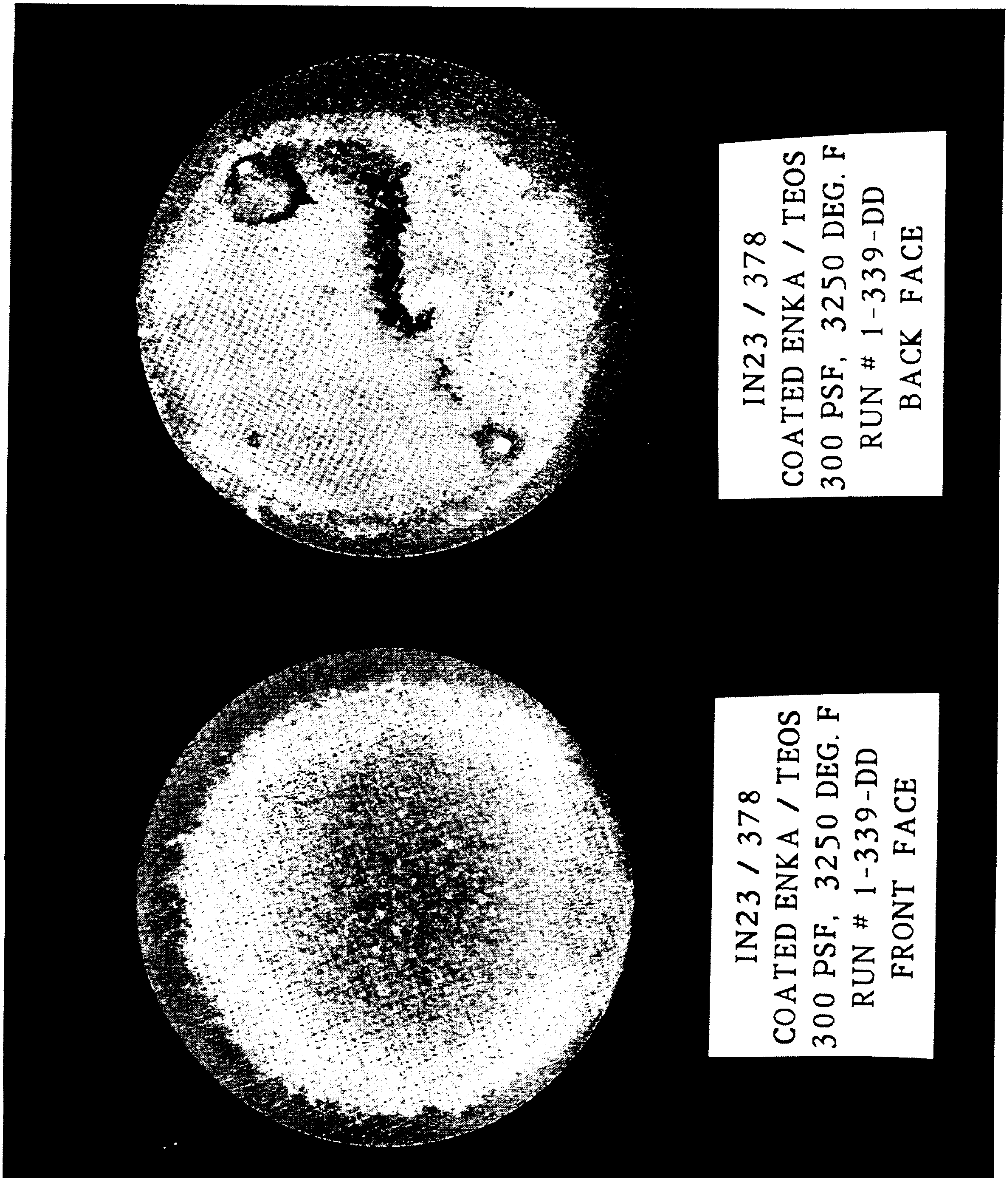

Figure 12-(a). Post test photograph of specimen #IN23 at 3250 °F, 313 psf for 900 s.

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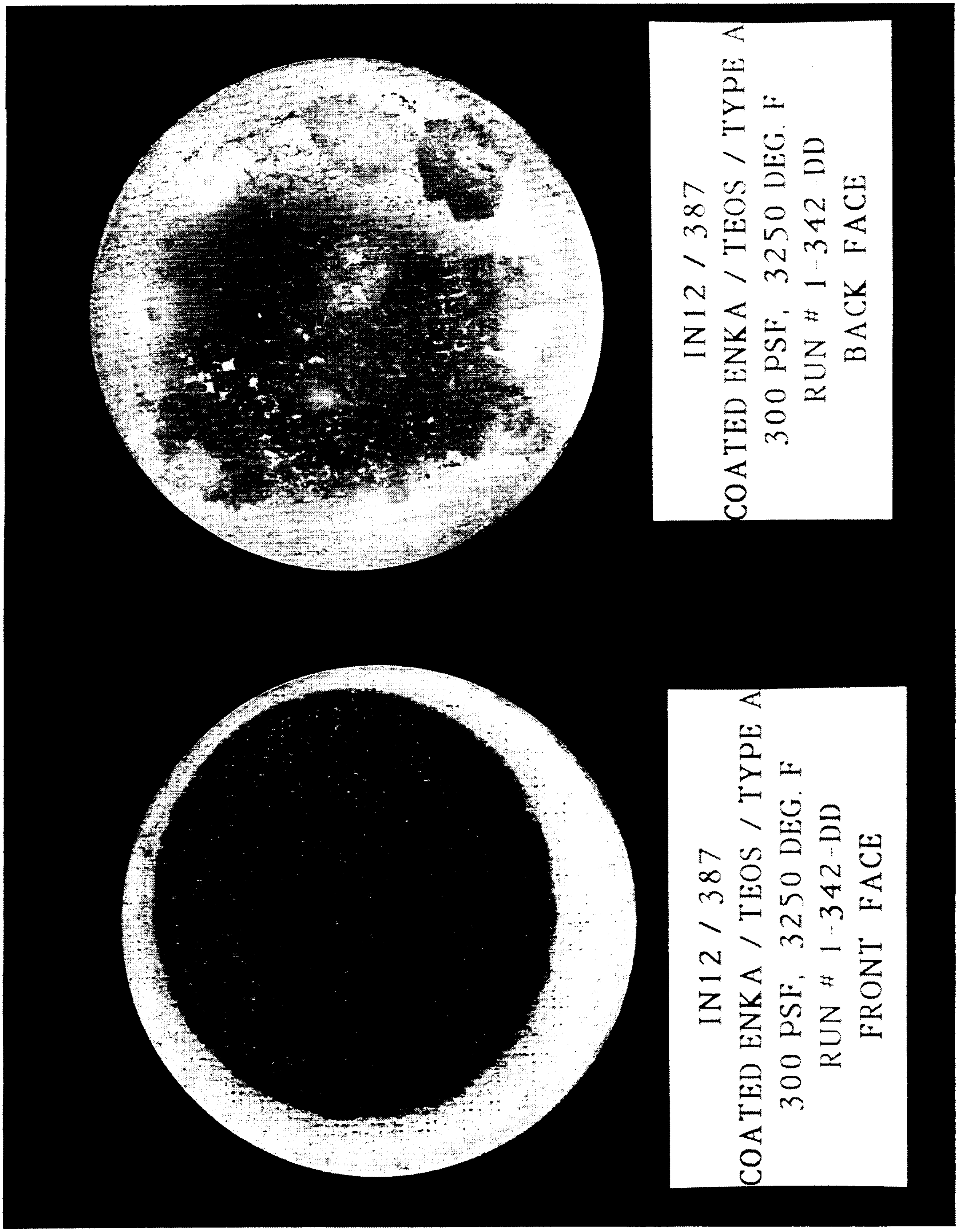

Figure 12-(b). Post test photograph of specimen #IN12 at 3250 °F, 317 psf for 330 s.

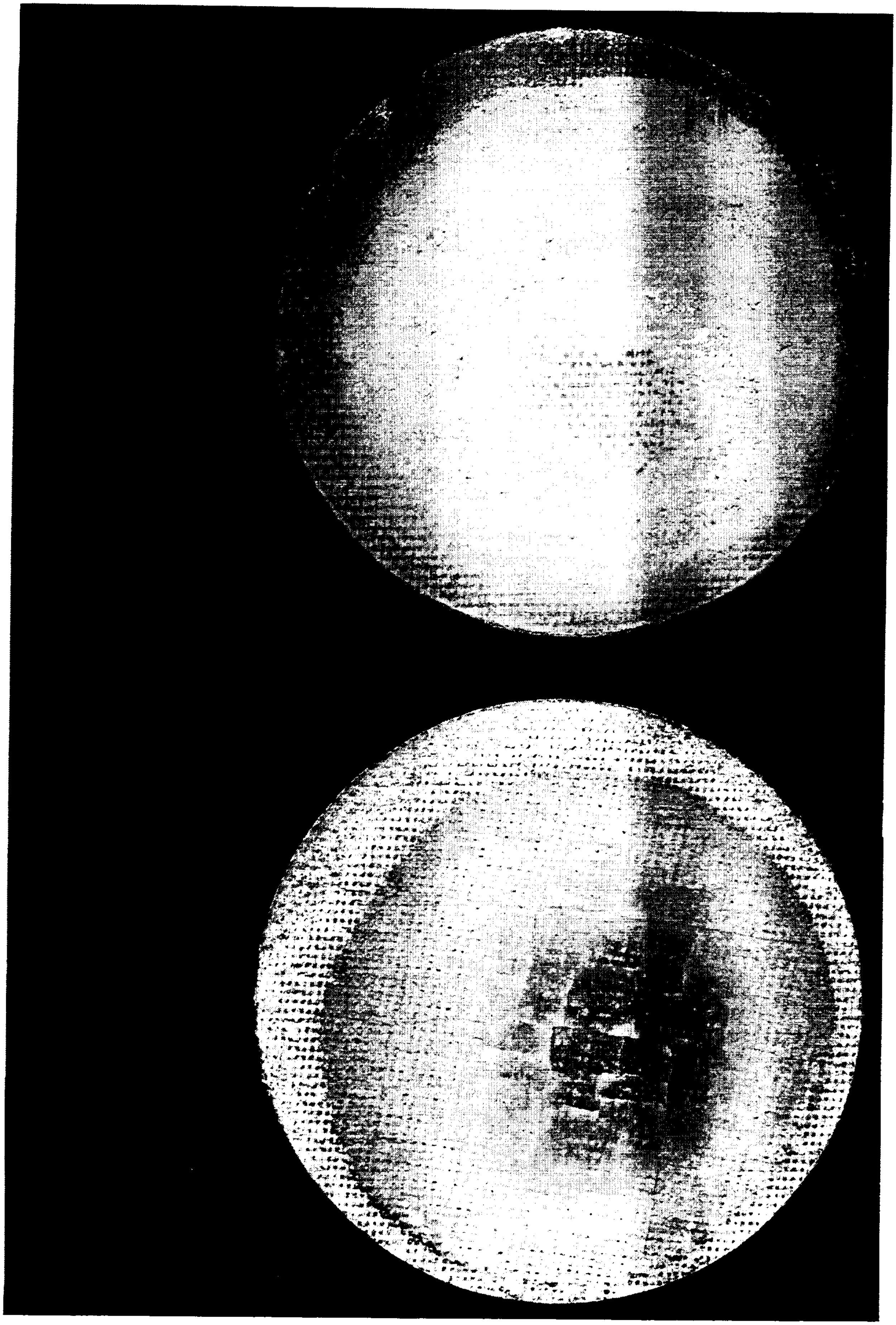

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Figure 12-(c). Post test photograph of specimen #6 at 3250 °F, 320 psf for 127s.

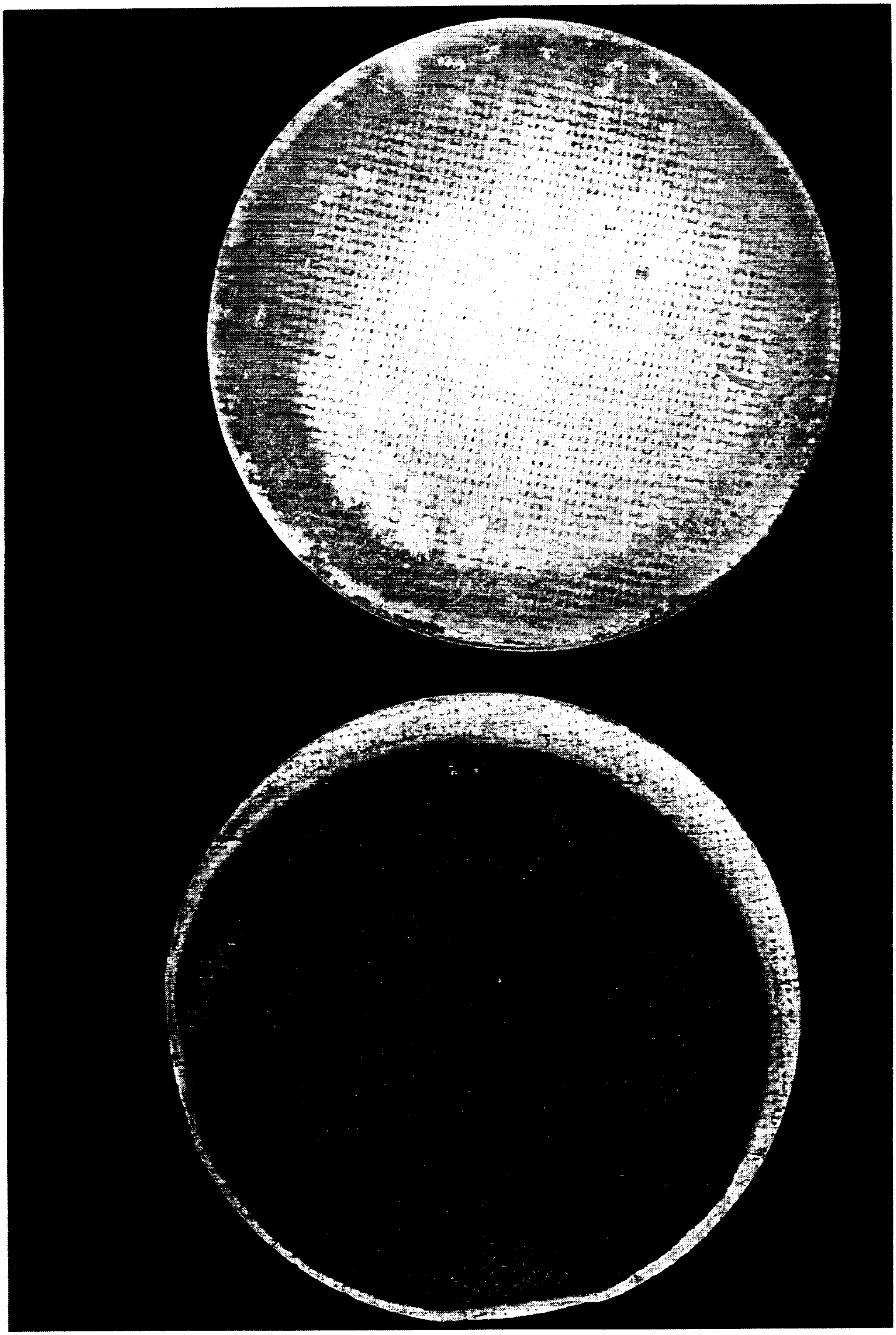

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Figure 12-(d). Post test photograph of specimen #7 at 3250 °F, 320 psf for 187s.

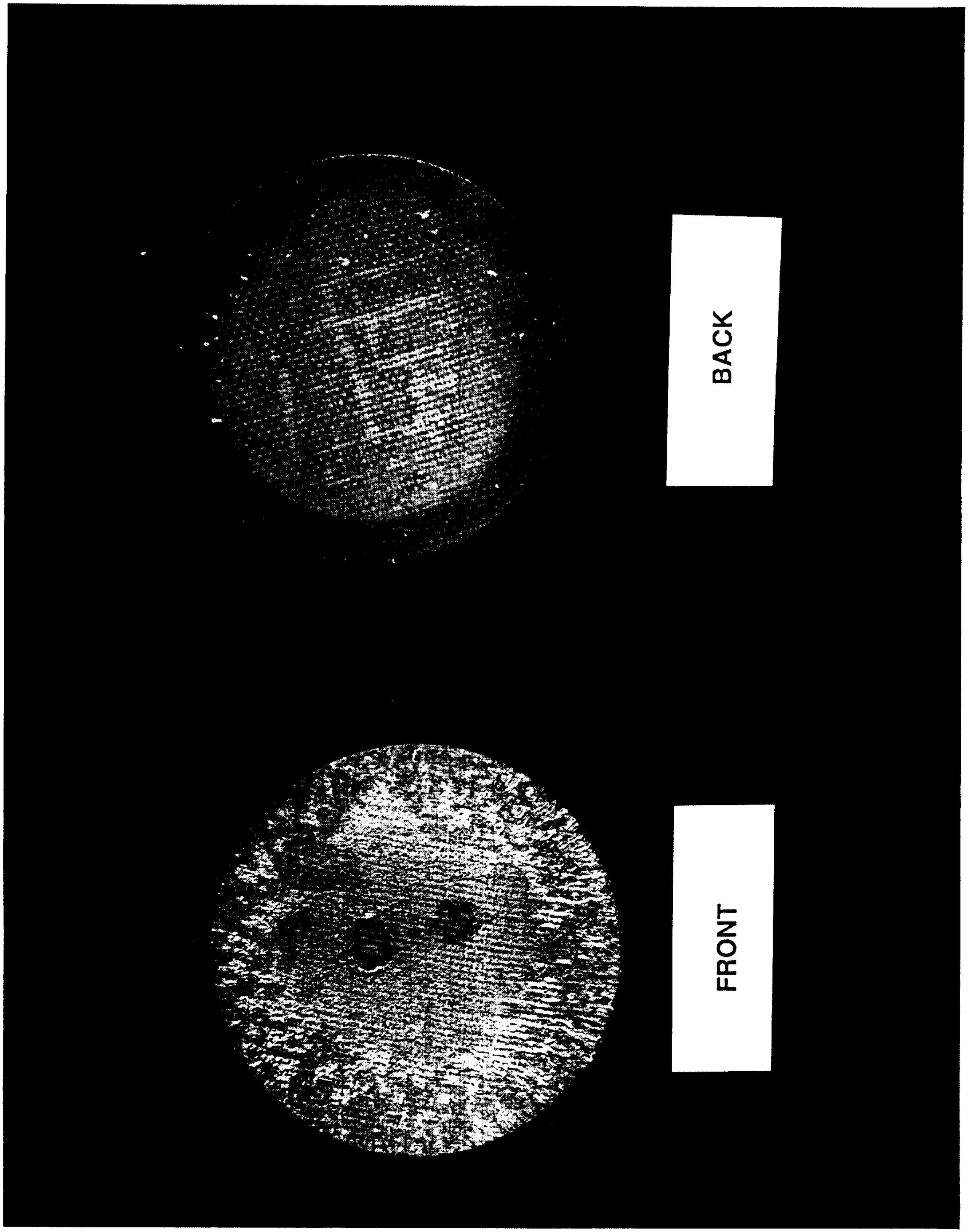

Figure 12-(e). Post test photograph of specimen #15 at 3280 °F, 186 psf for 67s.

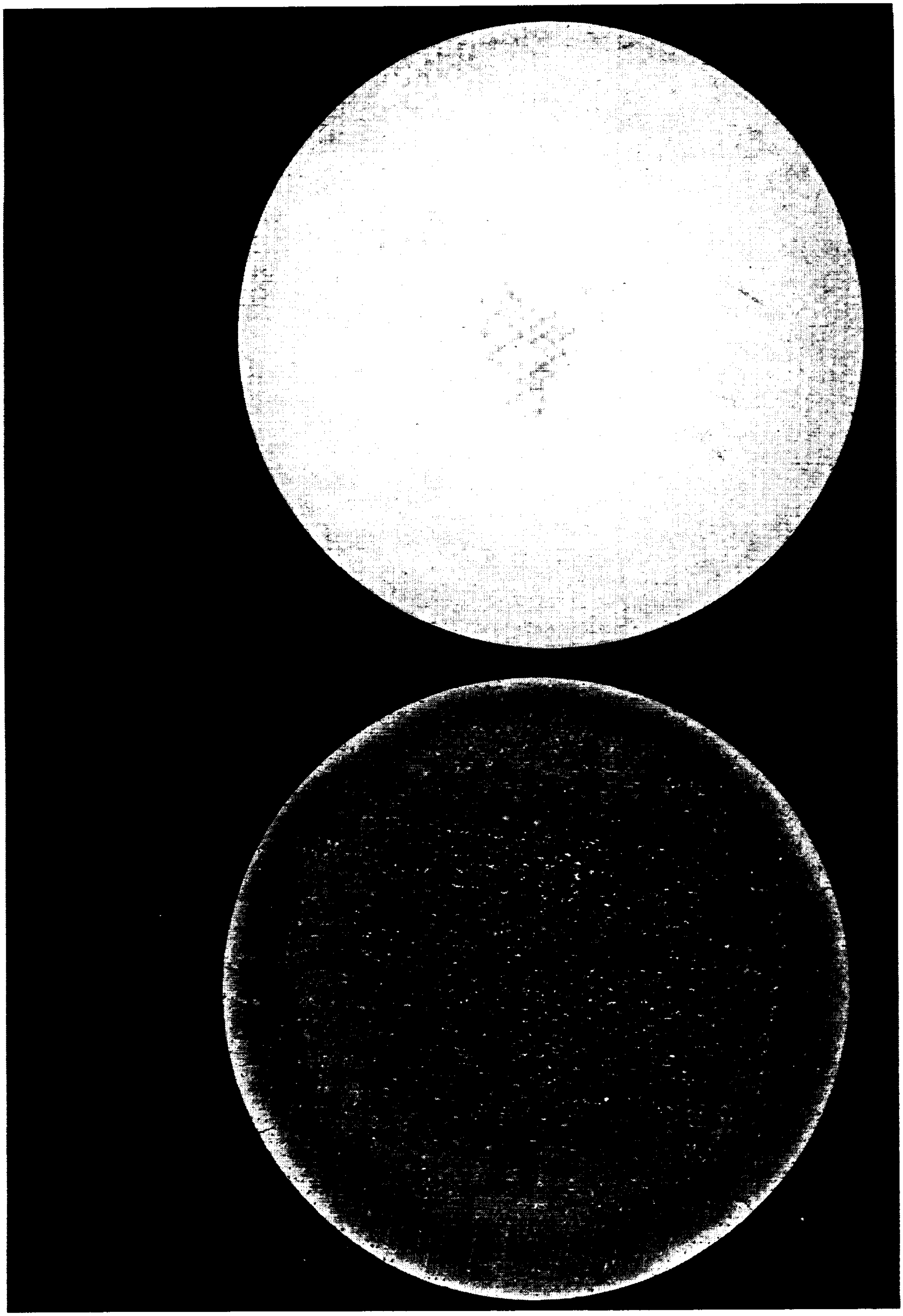

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Figure 12-(f). Post test photograph of specimen #AB14 at 3300 °F, 104 psf for 105 s.

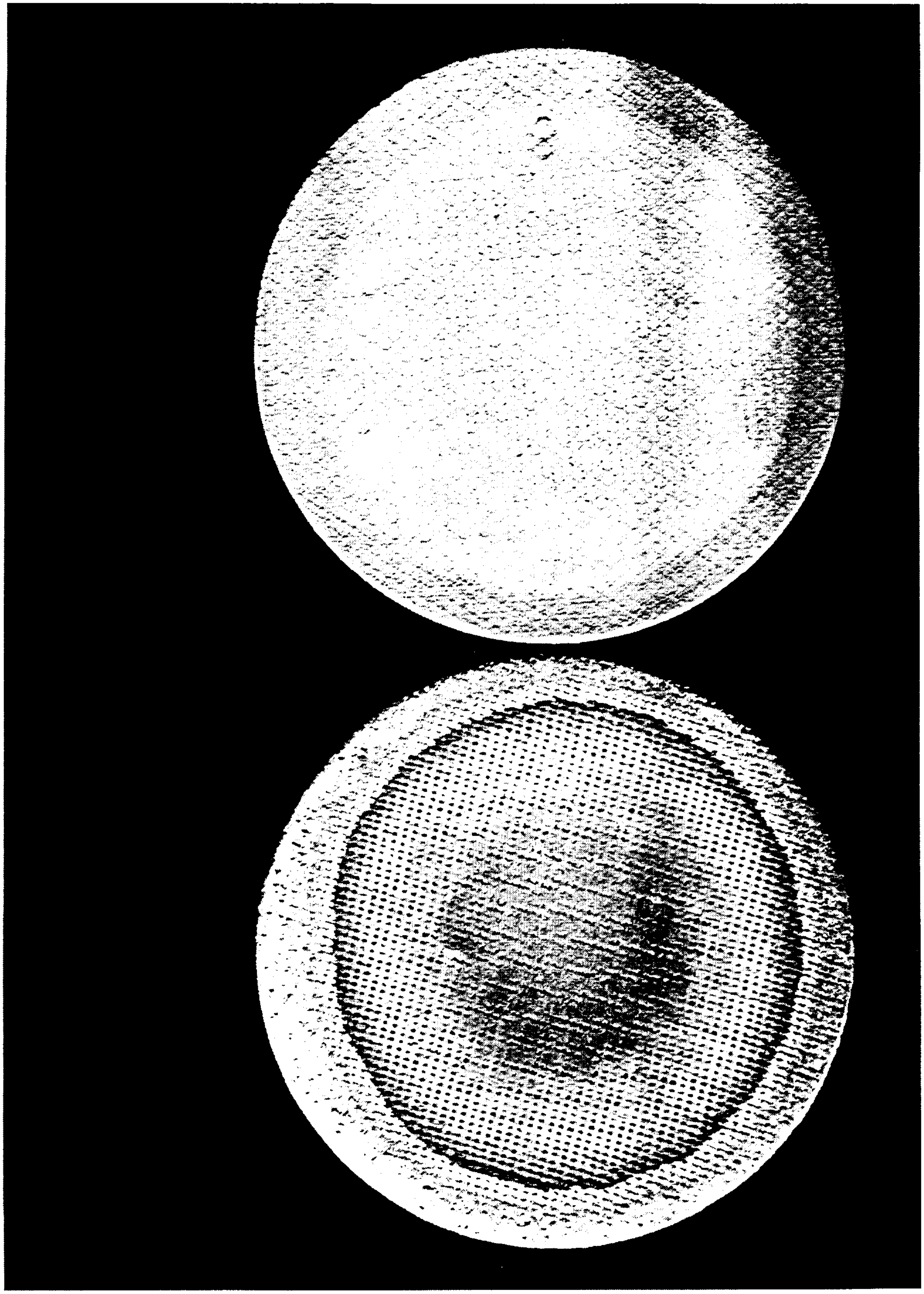

Figure 12-(g). Post test photograph of specimen #8 at 3300 °F, 104 psf for 78 s.

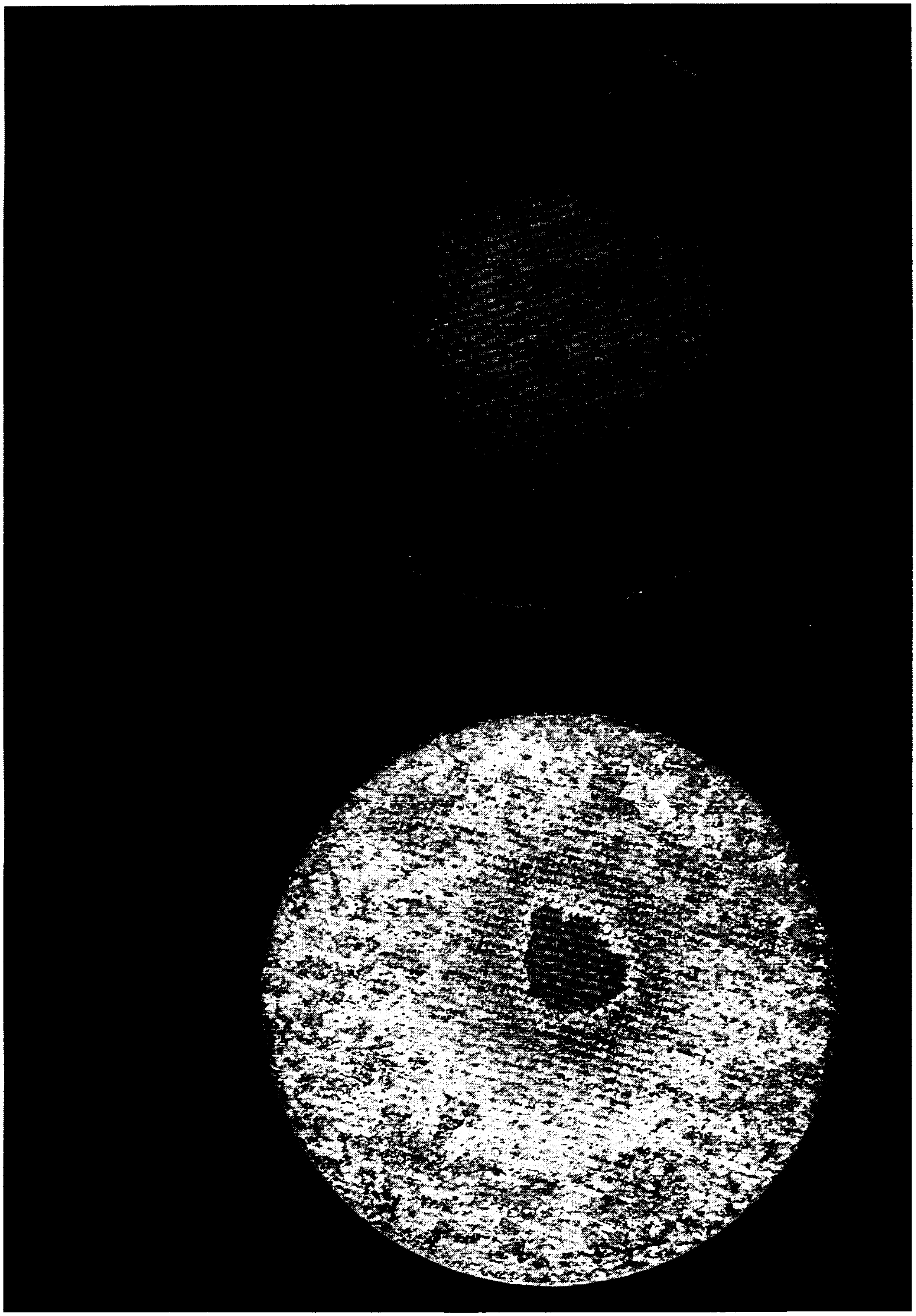

Figure 12-(h). Post test photograph of specimen #9 at 3300 °F, 105 psf for 63 s.

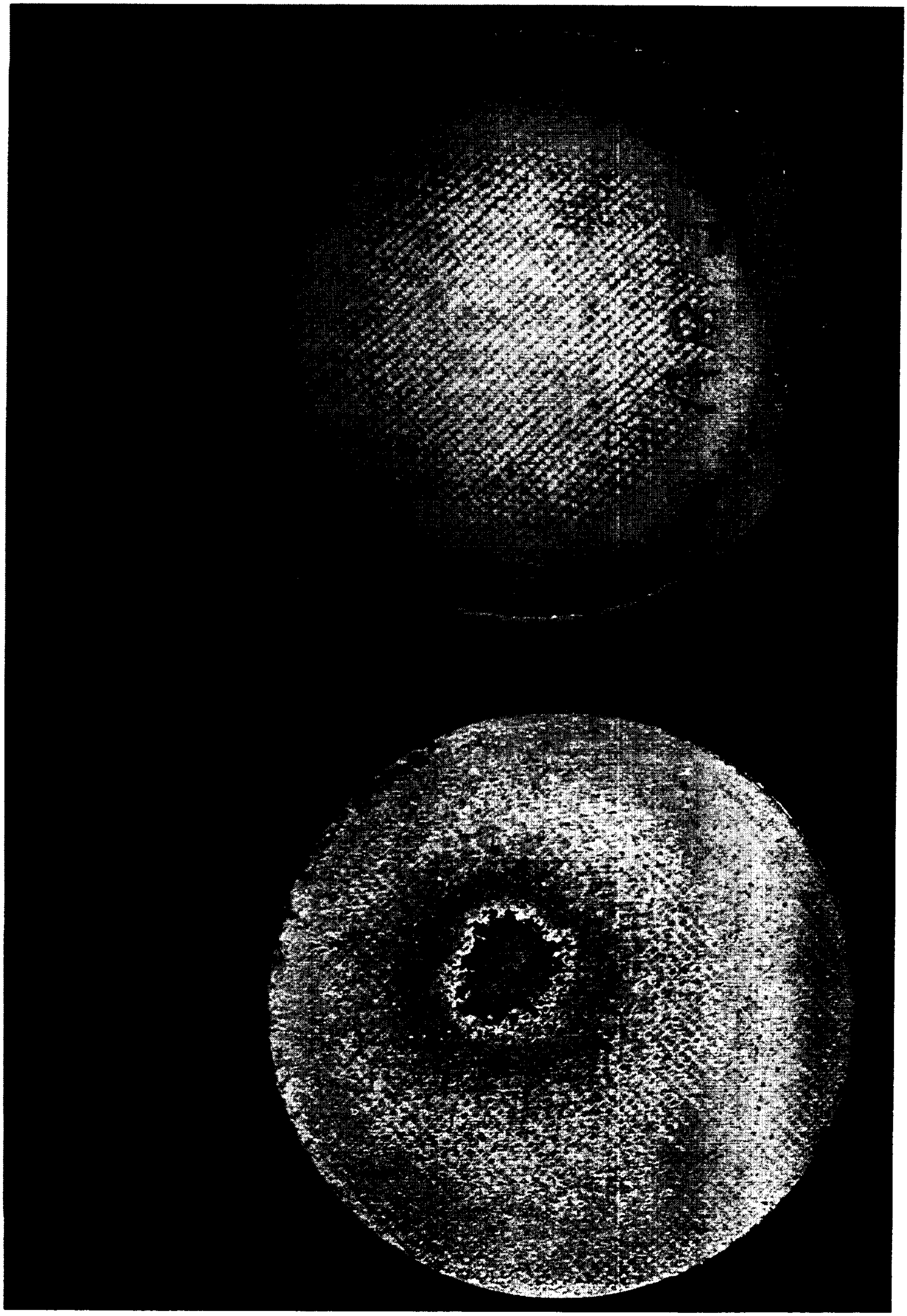

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Figure 12-(i). Post test photograph of specimen #AB12 at 3300 °F, 107 psf for 58 s.

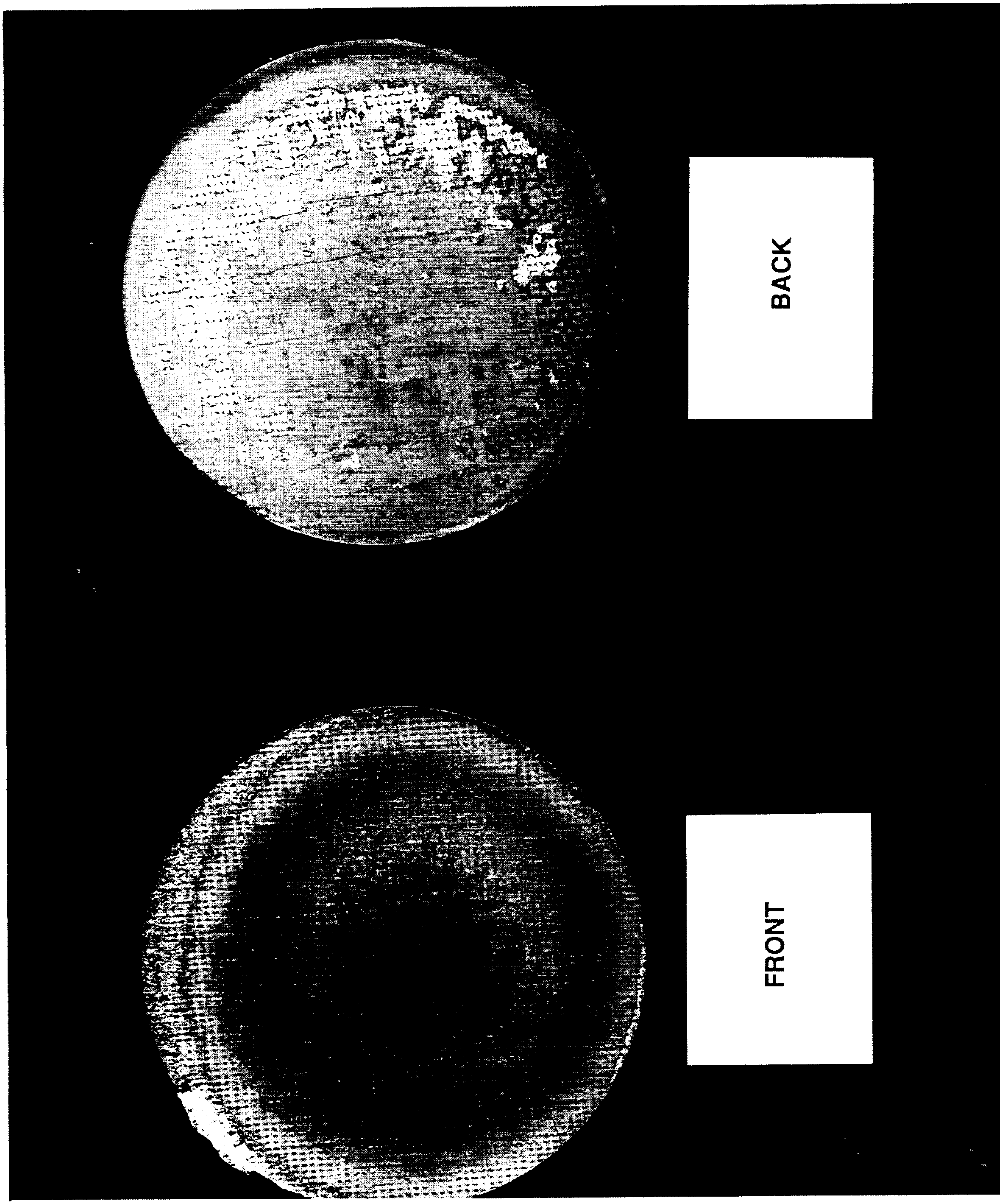

Figure 12-(j). Post test photograph of specimen #AU01 at 3300 °F, 183 psf for 158 s.

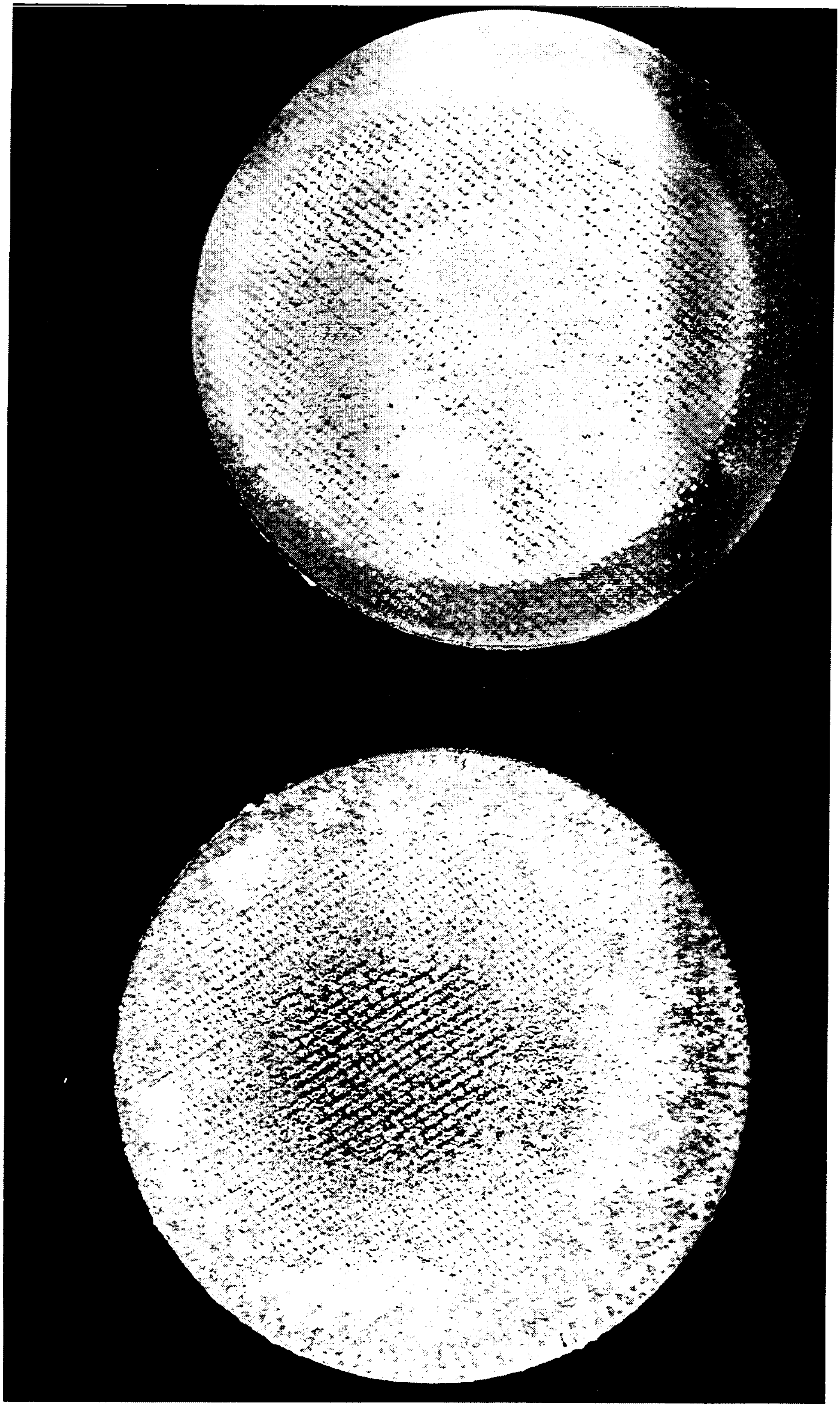

Figure 12-(k). Post test photograph of specimen #17 at 3300 °F, 187 psf for 170s.

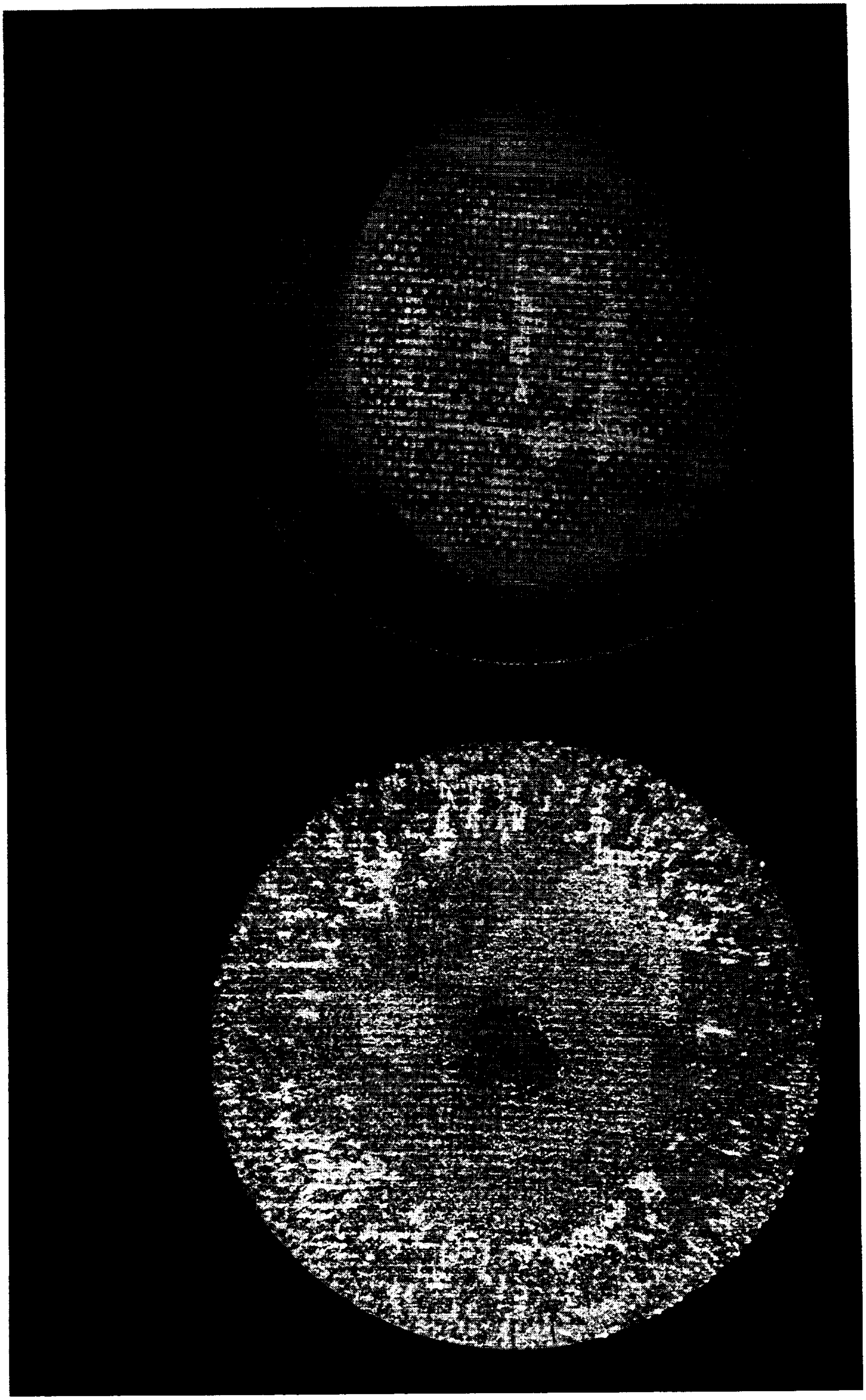

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Figure 12-(l). Post test photograph of specimen #13 at 3300 °F, 188 psf for 45 s.

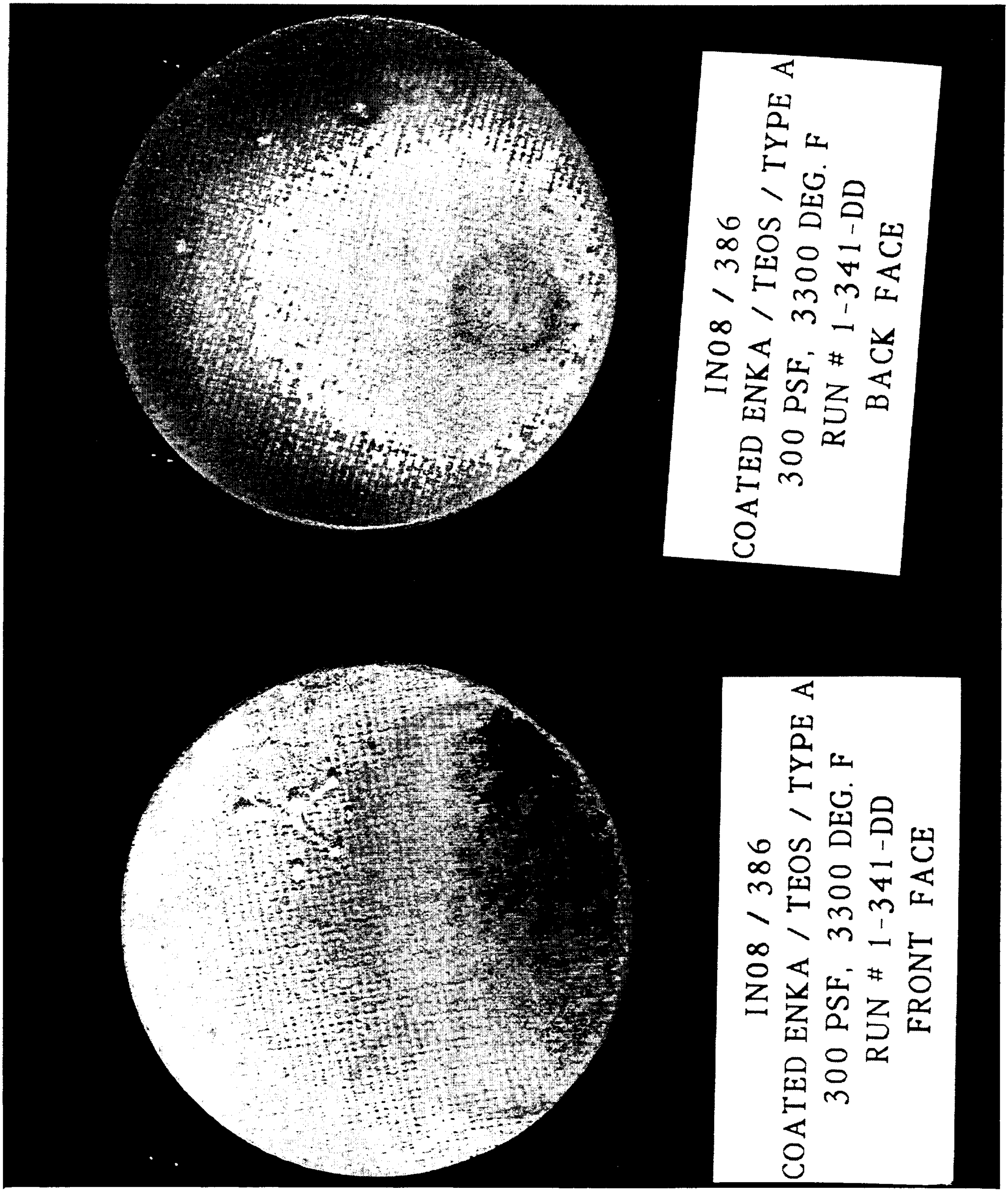

Figure 12-(m). Post test photograph of specimen #IN08 at 3300 °F, 325 psf for 110 s.

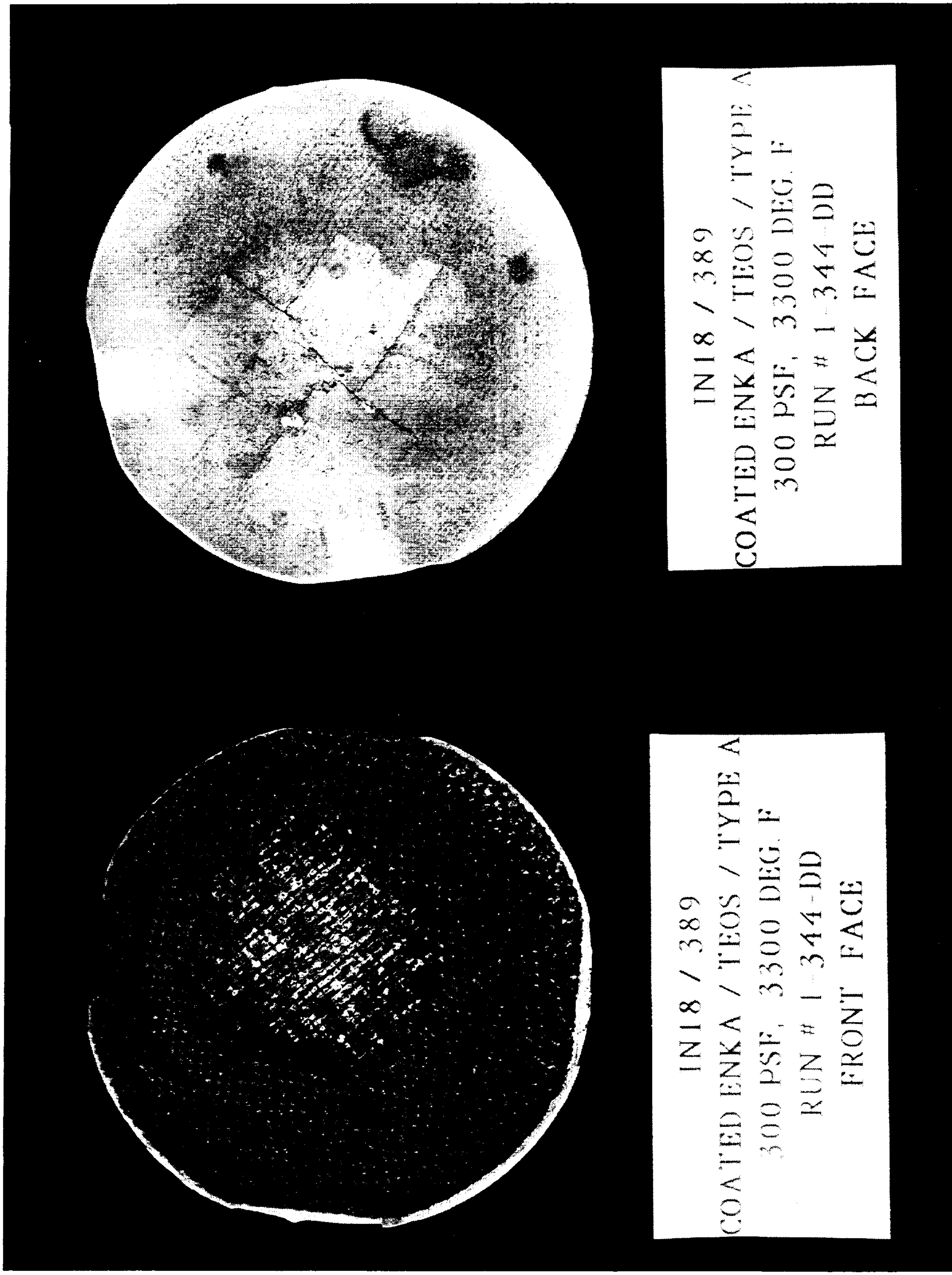

Figure 12-(n). Post test photograph of specimen #IN18 at 3300 °F, 325 psf for 330 s.

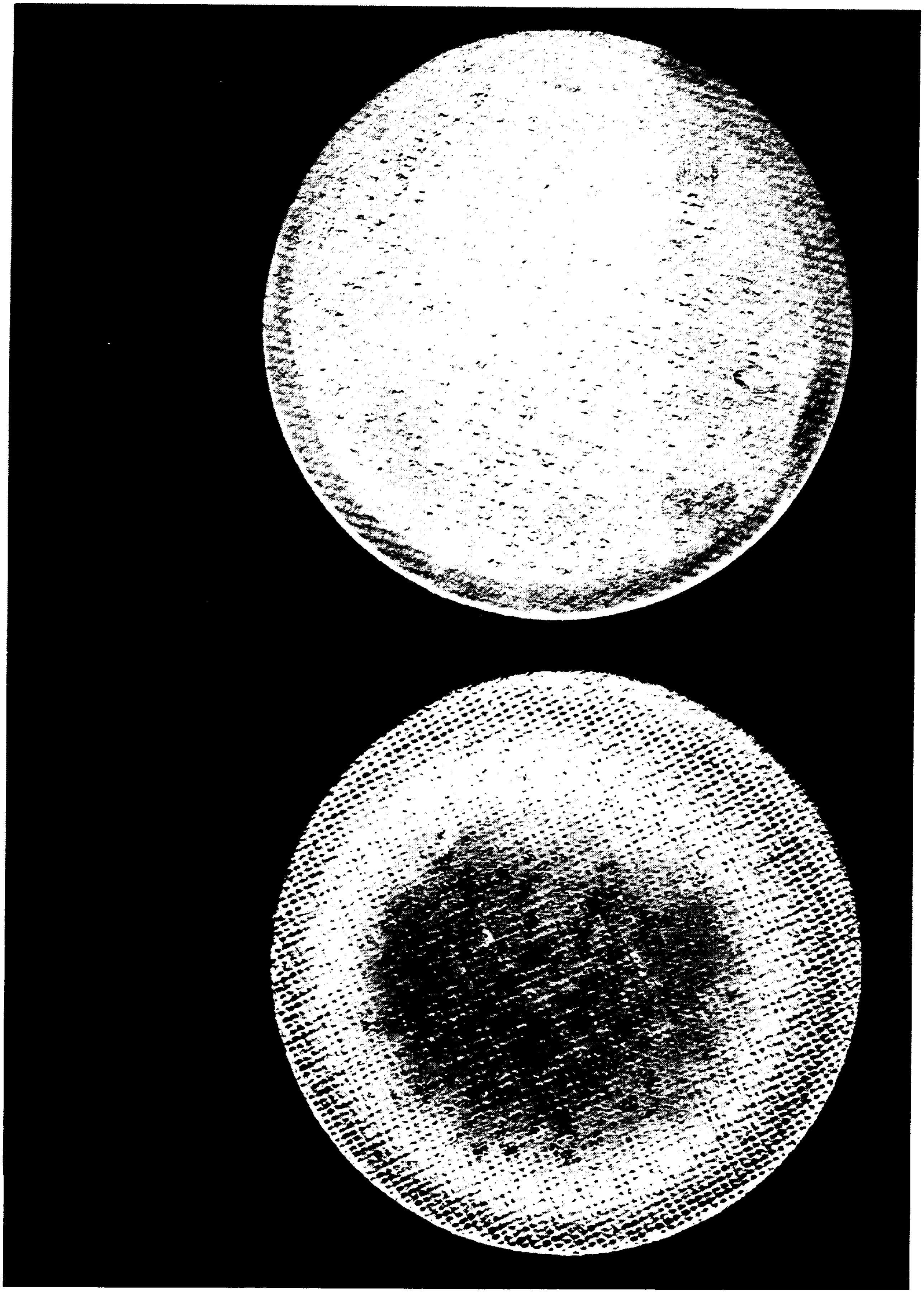

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Figure 12-(o). Post test photograph of specimen #10 at 3300 °F, 353 psf for 103s.

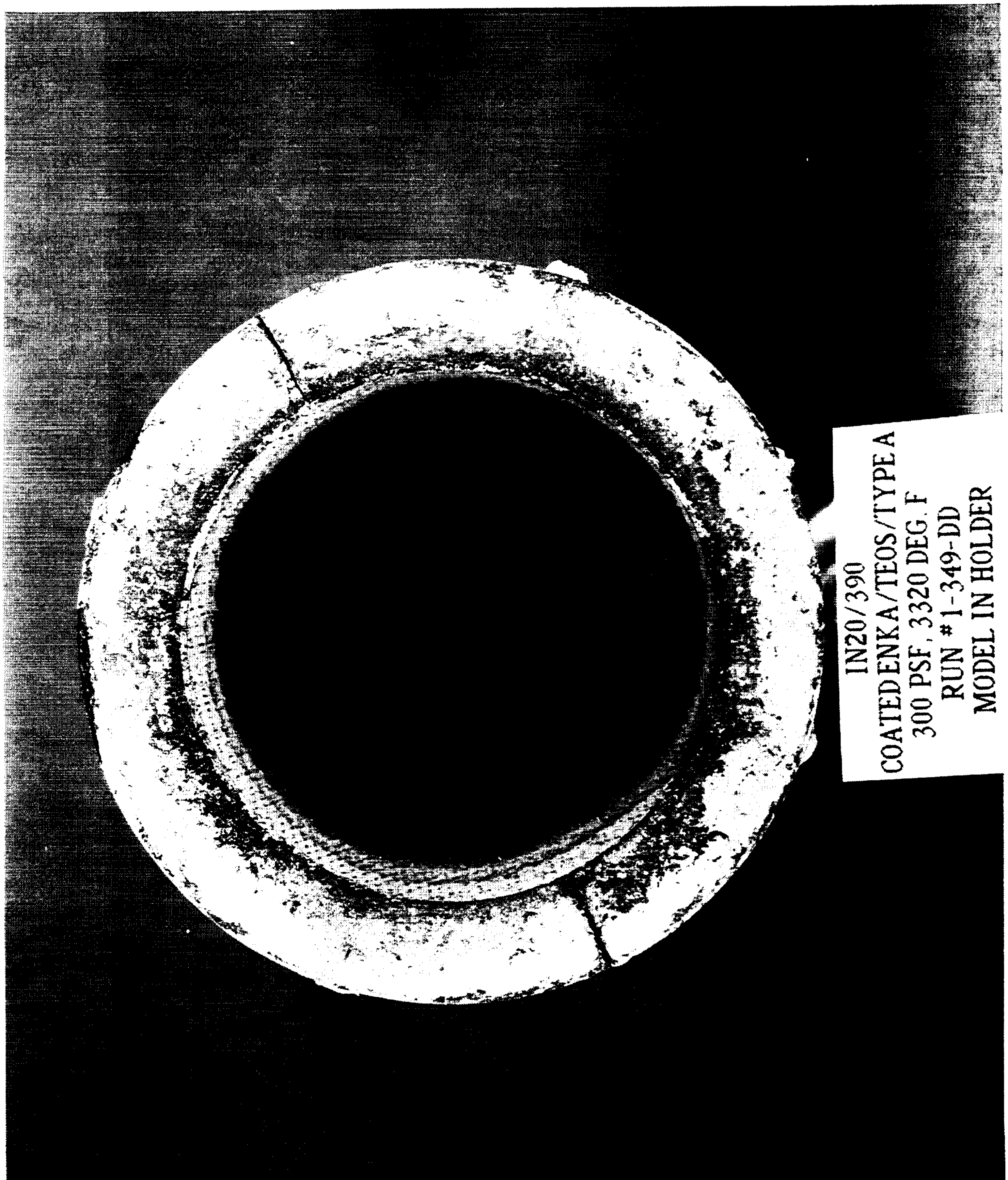

Figure 13-(a). Post test photograph of specimen #IN20 at 3320 °F, 338 psf for 94 s.

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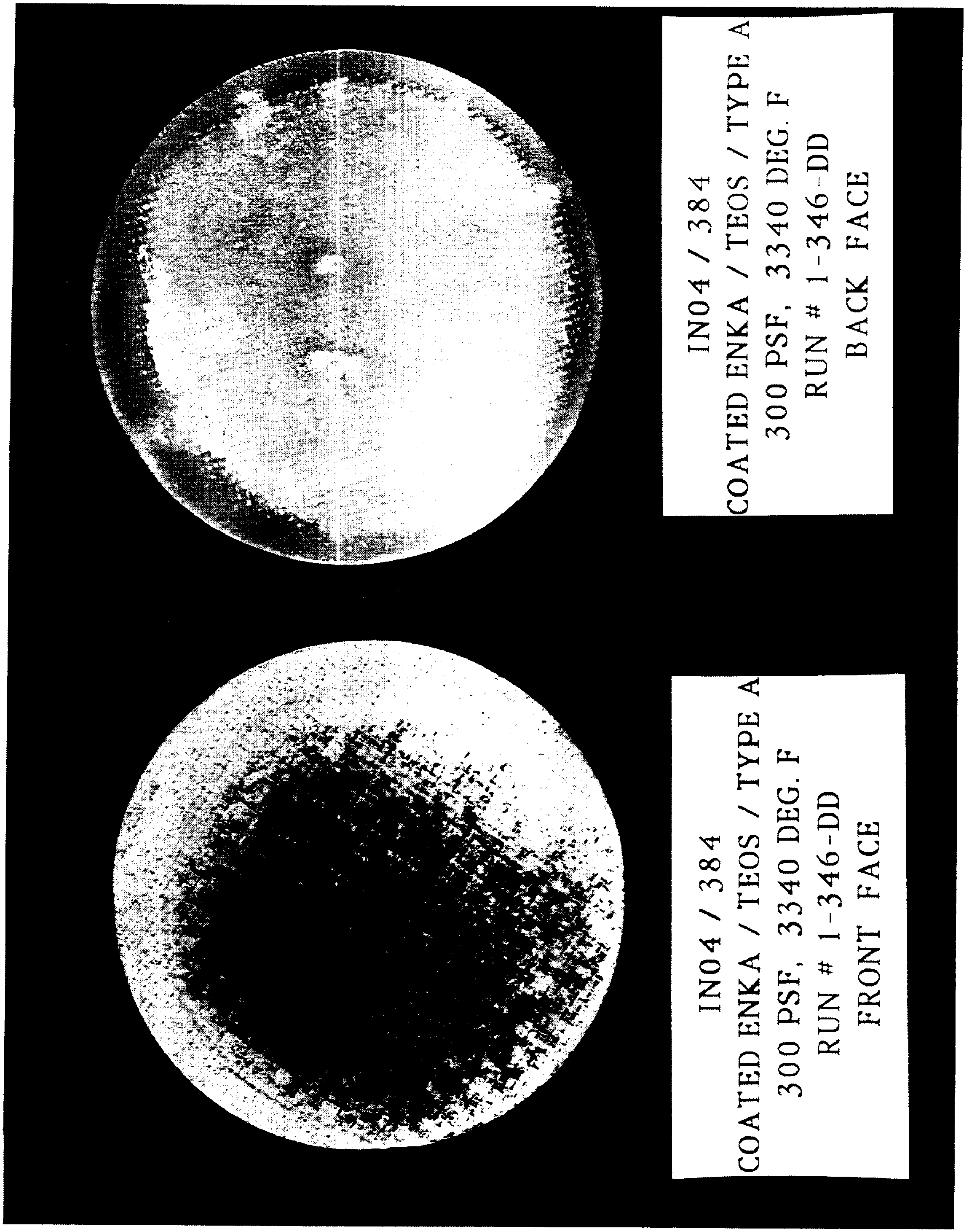


Figure 13-(b). Post test photograph of specimen #IN04 at 3340 °F, 337 psf for 70 s.

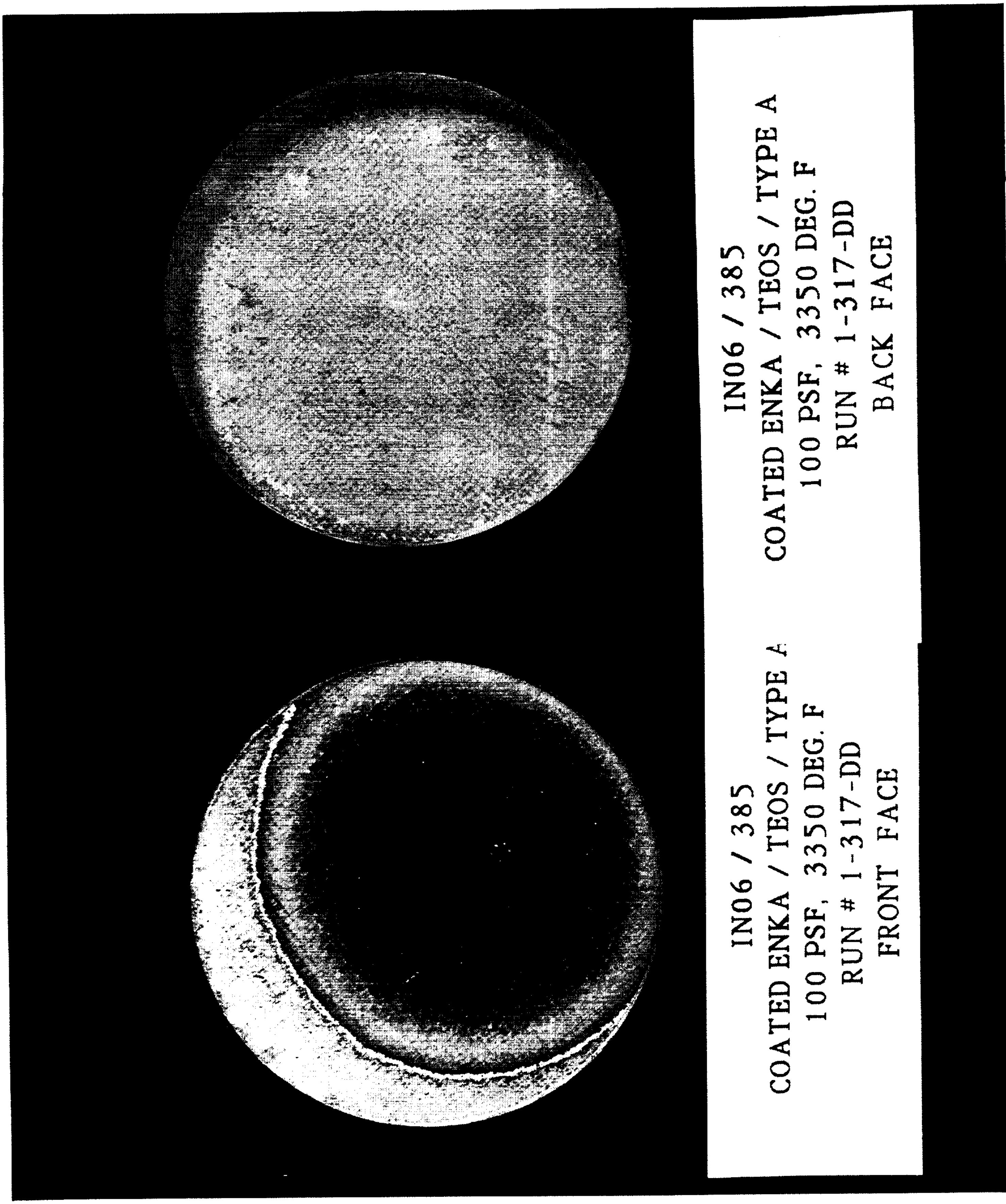


Figure 13-(c). Post test photograph of specimen #IN06 at 3350 °F, 101 psf for 73 s.

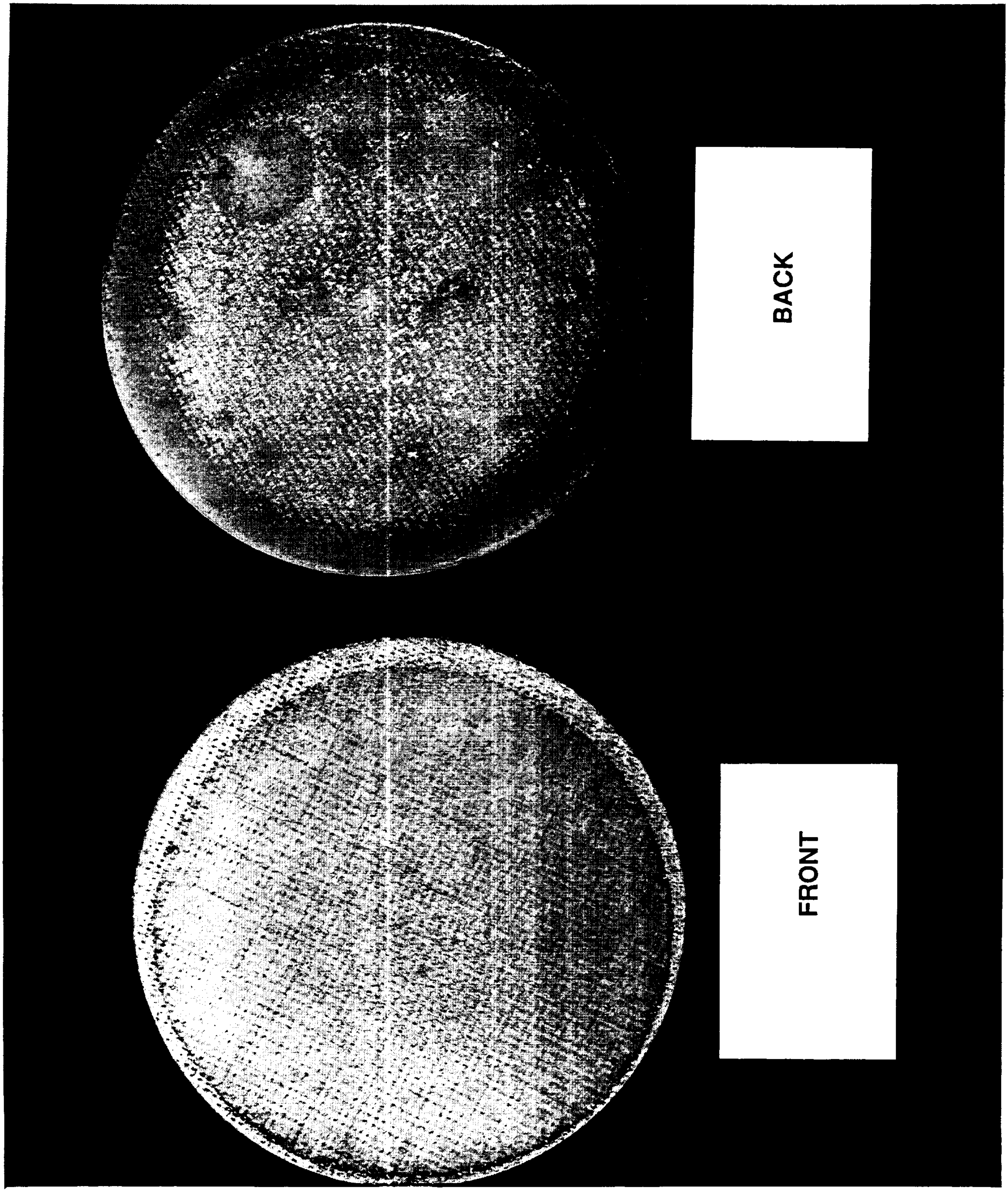


Figure 13-(d). Post test photograph of specimen #AT15 at 3350 °F, 338 psf for 87 s.

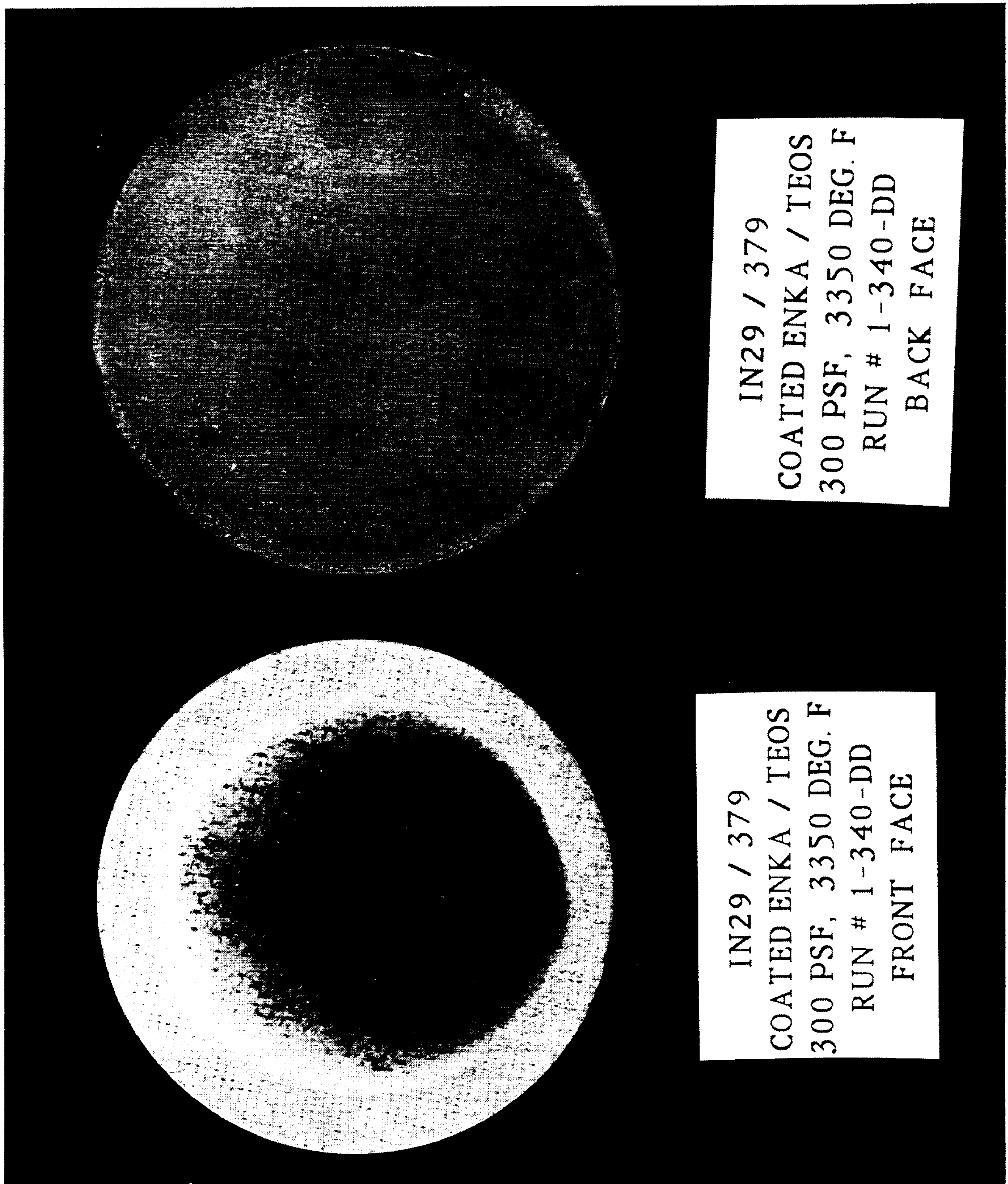


Figure 13-(e). Post test photograph of specimen #IN29 at 3350 °F, 325 psf for 133 s.

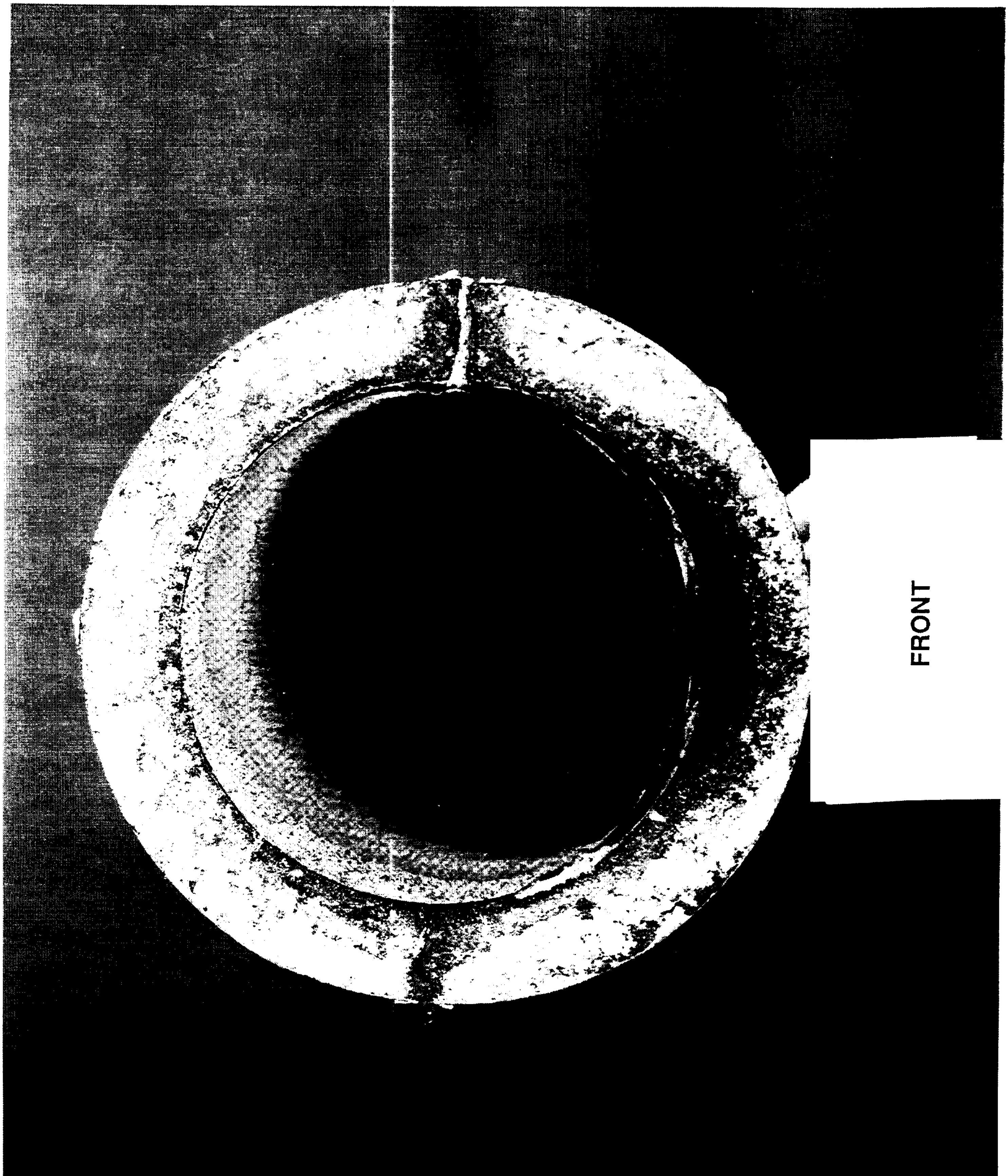


Figure 13-(f). Post test photograph of specimen #IN26 at 3350 °F, 338 psf for 64s.

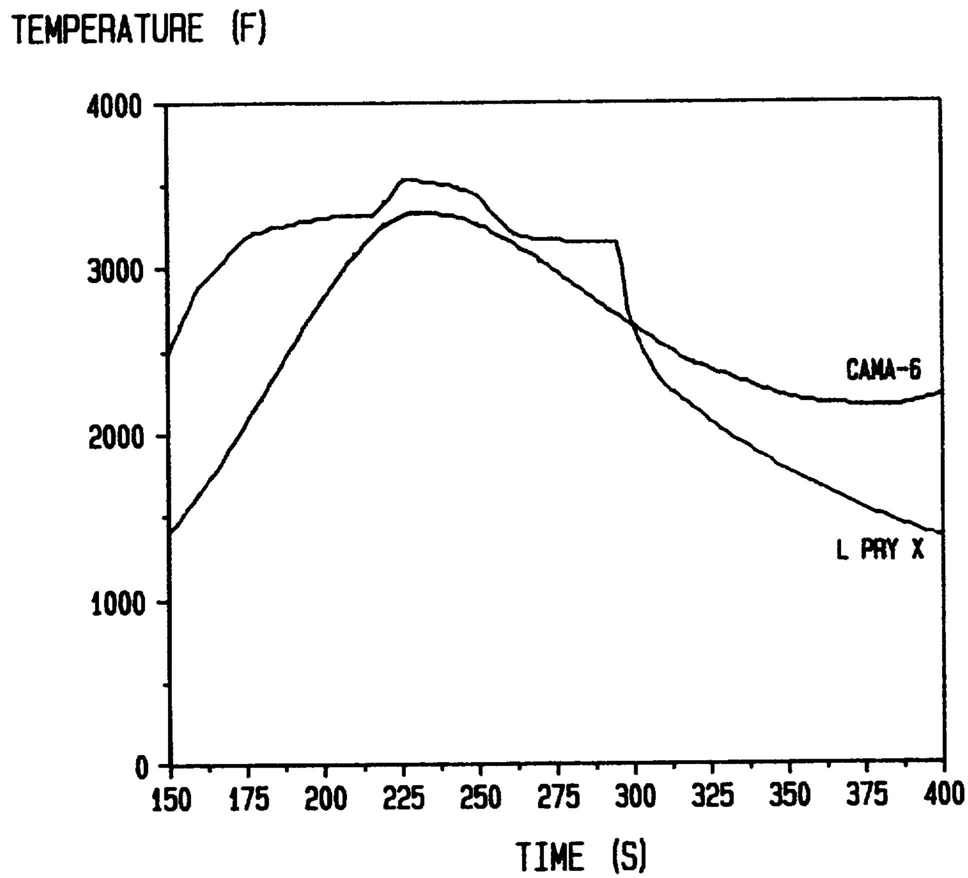
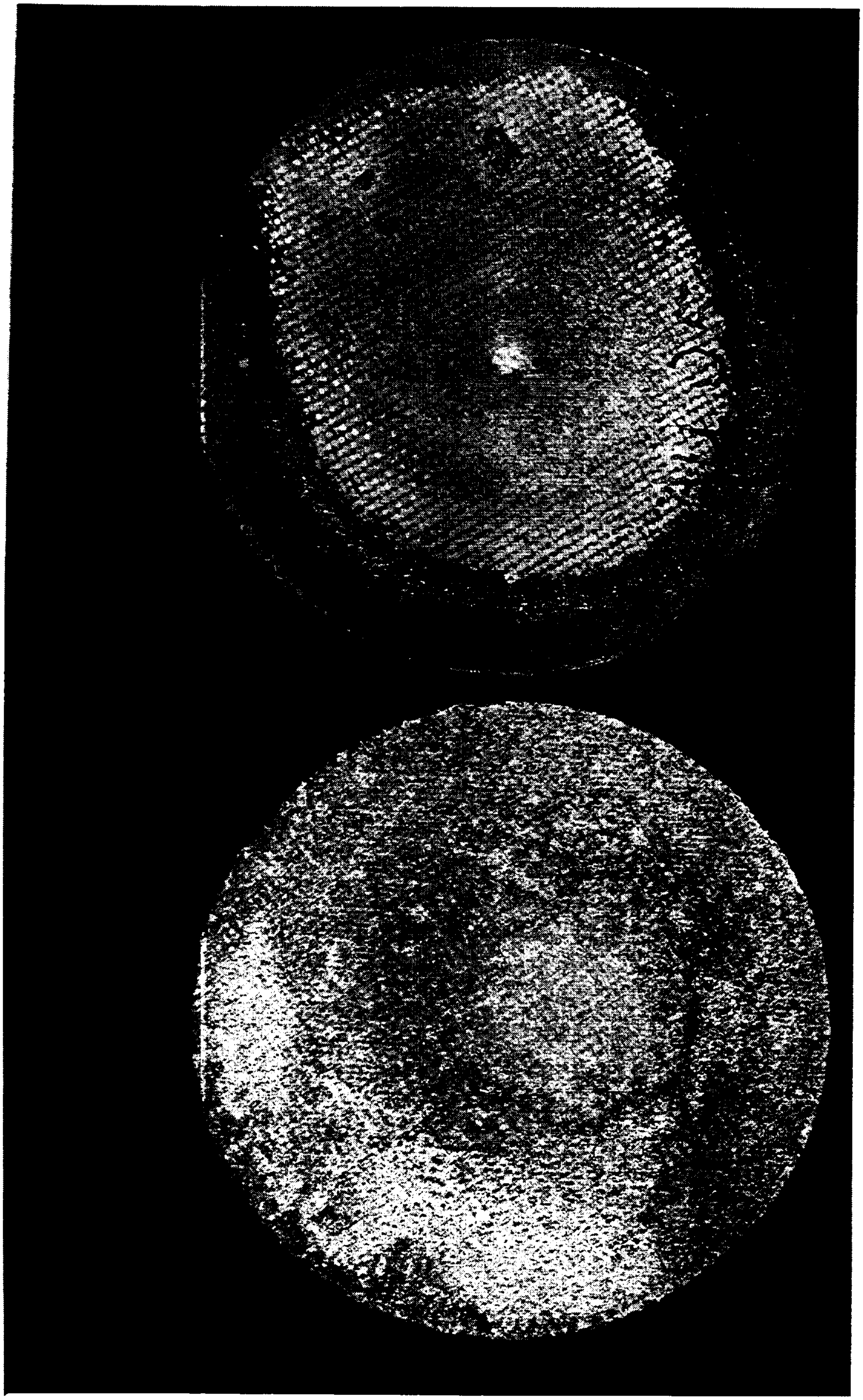


Figure 14-(a). Surface temperature response of specimen #AU05 superimposed with the CAMA-6 flight trajectory.



CAMA-6 BACK

CAMA-6 FRONT

Figure 14-(b). Photograph of specimen #AU05 after the CAMA-6 simulation.

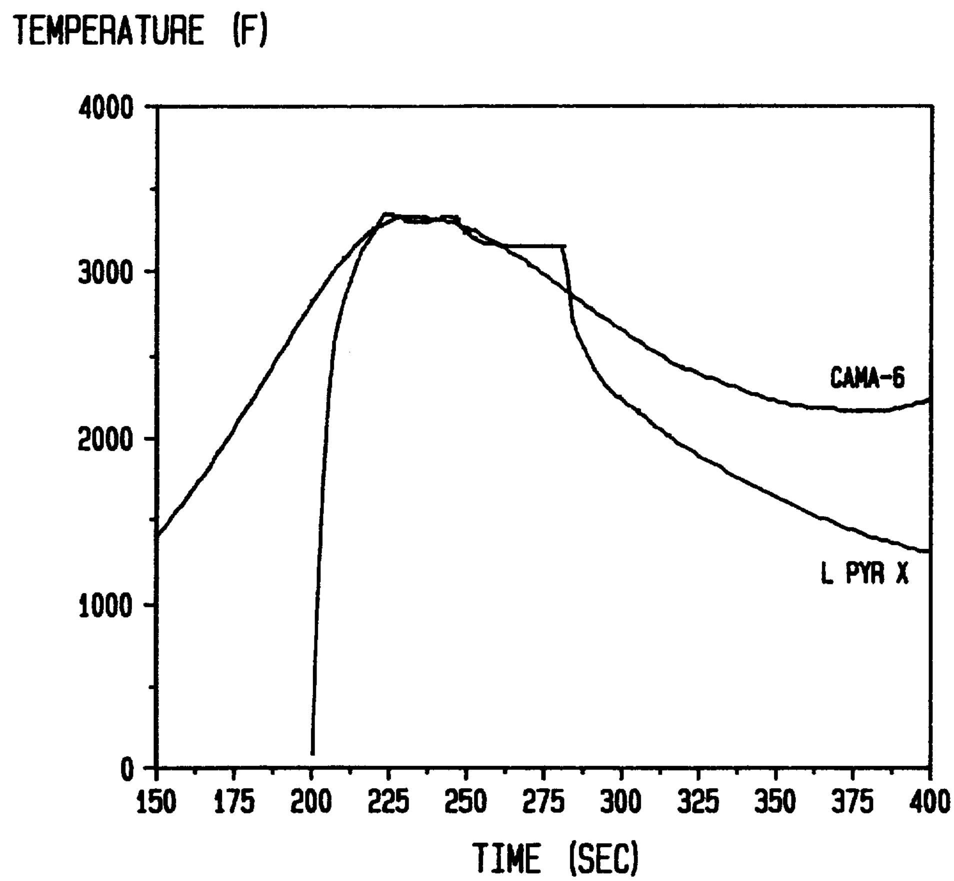
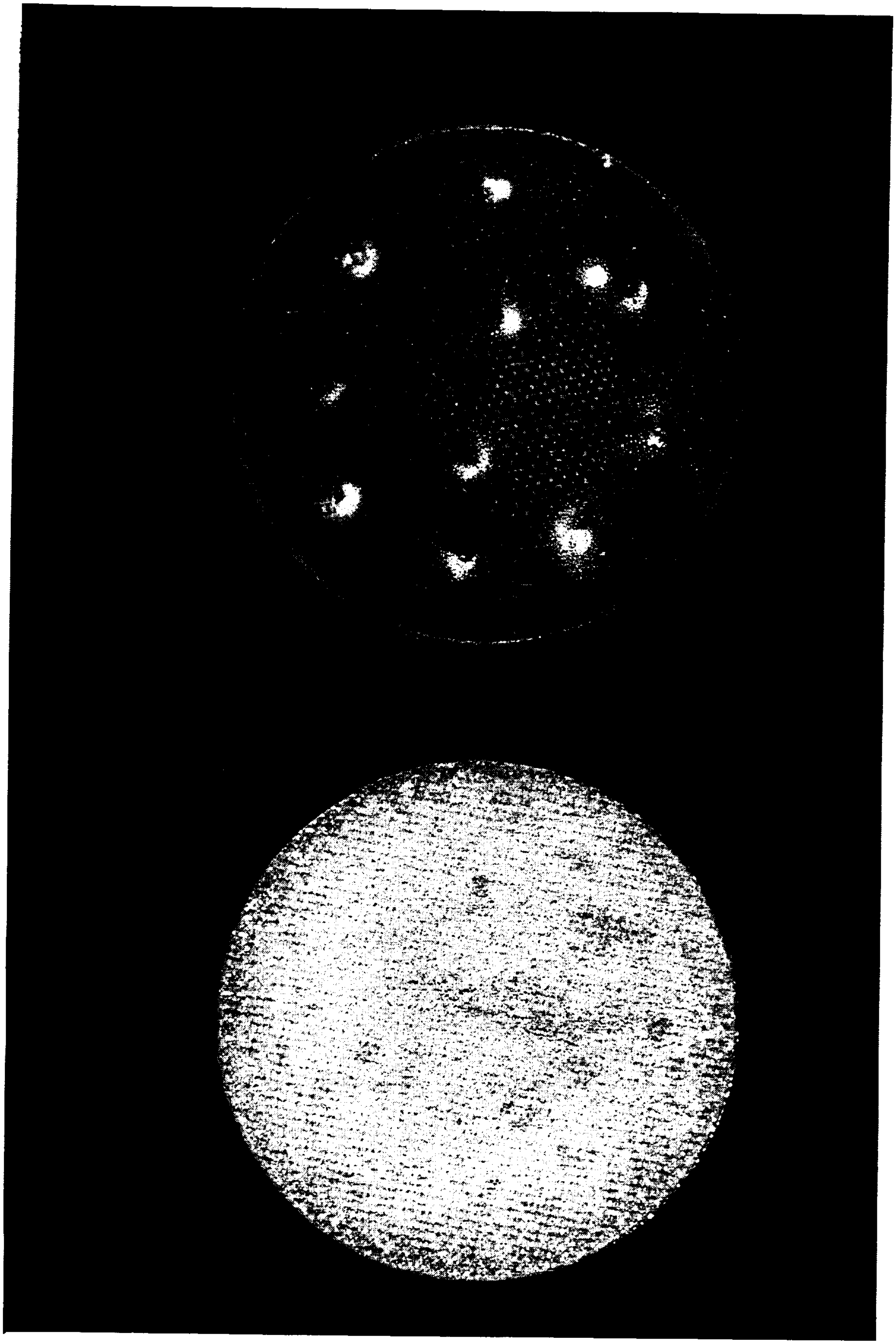


Figure 15-(a). Surface temperature response of specimen #AU08 superimposed with the CAMA-6 flight trajectory.



CAMA-6 BACK

CAMA-6 FRONT

Figure 15-(b). Photograph of specimen #AU08 after the CAMA-6 simulation.

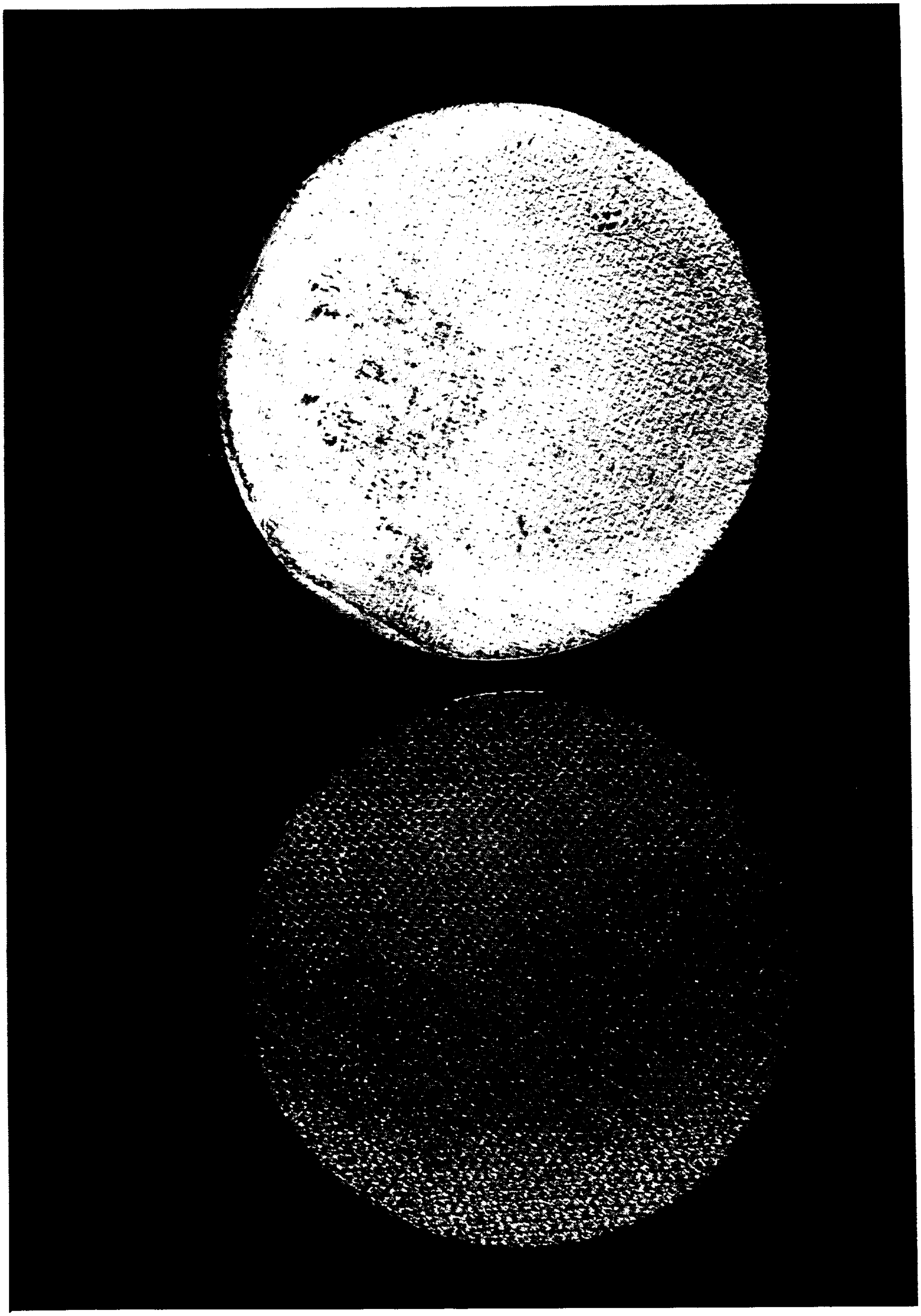


Figure 16-(a). Post test photograph of specimen #28 at 1440 °F, 75 psf for 4500s.

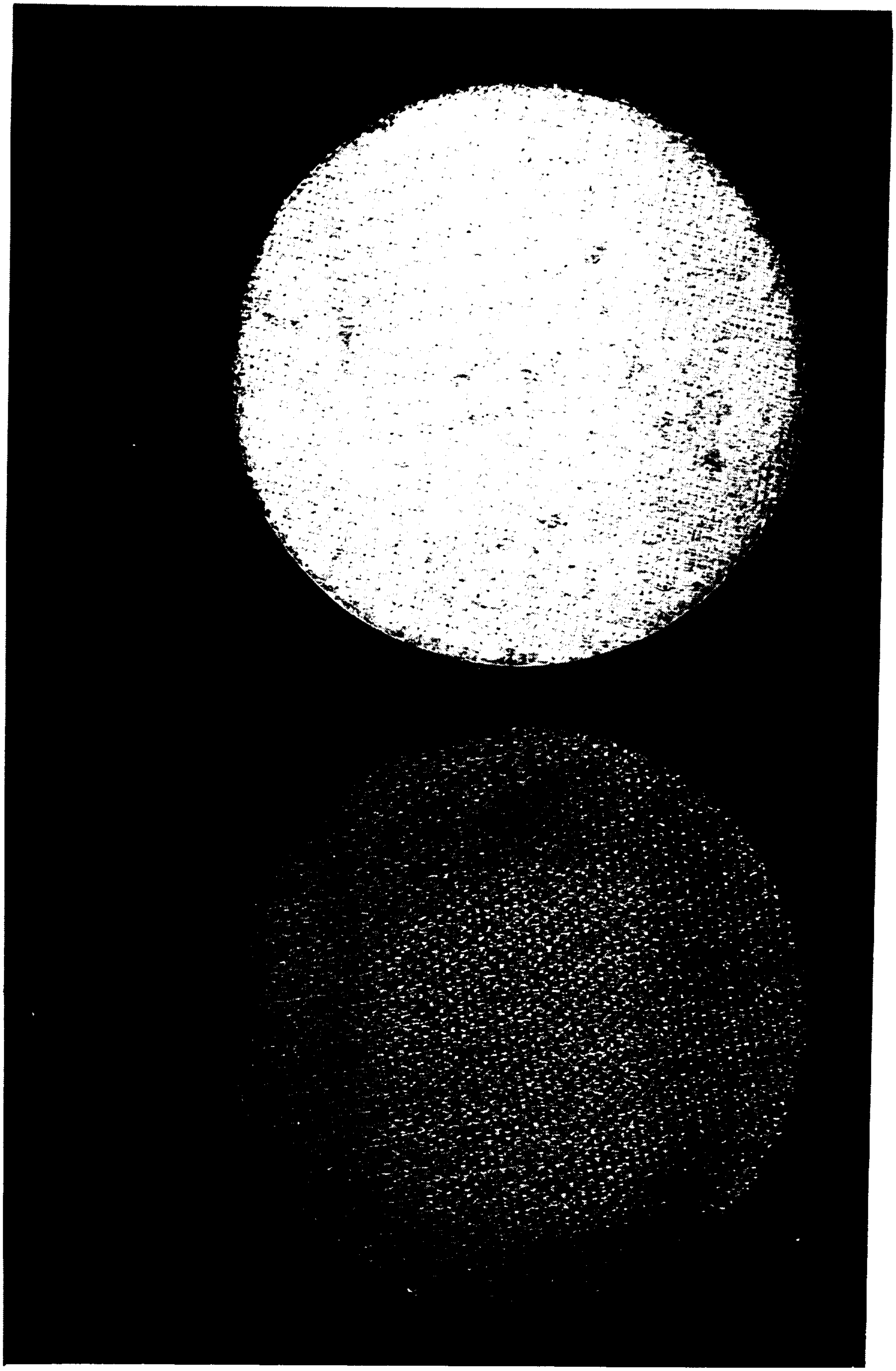


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Figure 16-(b). Post test photograph of specimen #27 at 1800 °F, 100 psf for 525s.

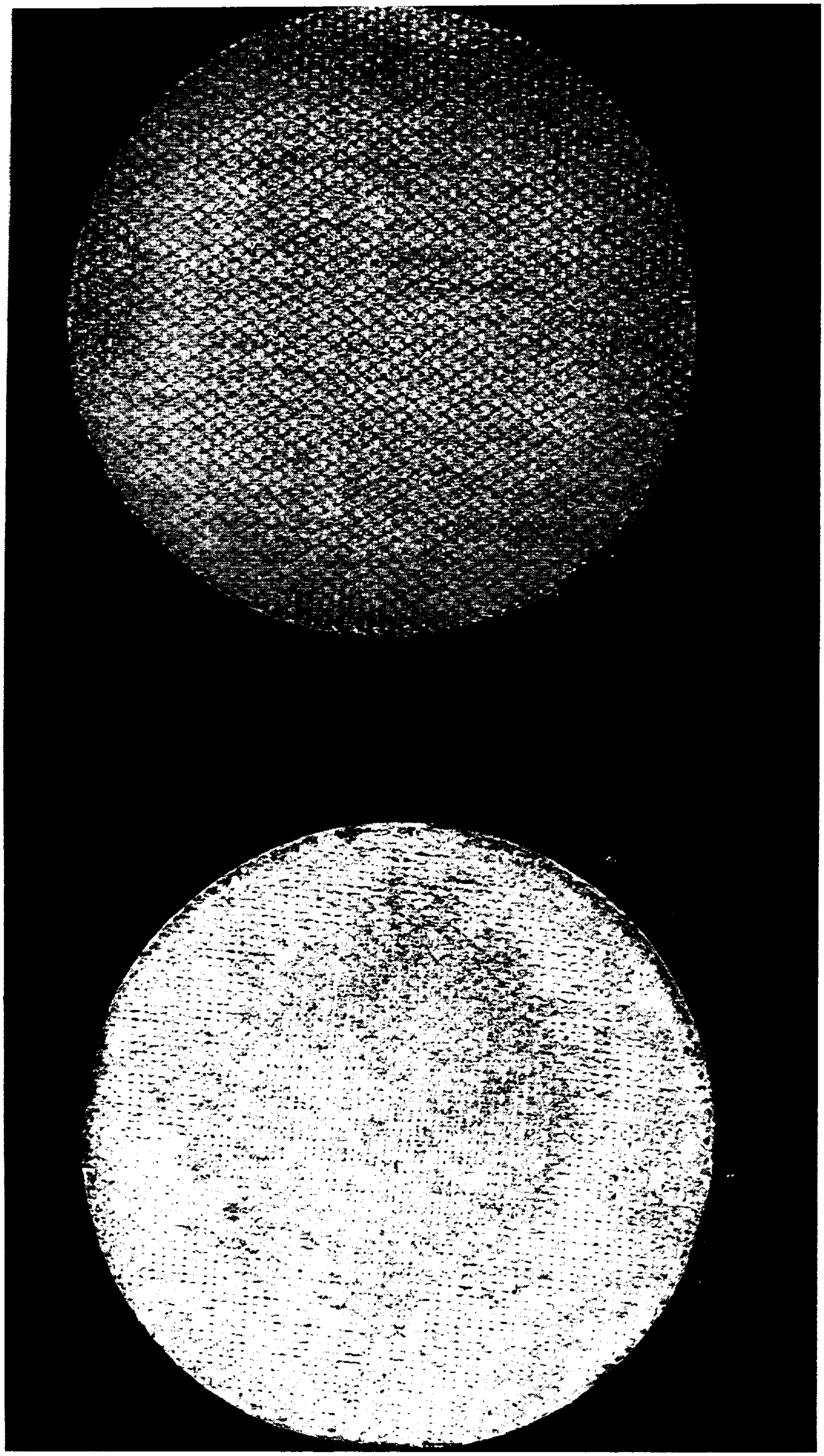

Figure 16-(c). Post test photograph of specimen #25 at 1800 °F, 193 psf for 600s.

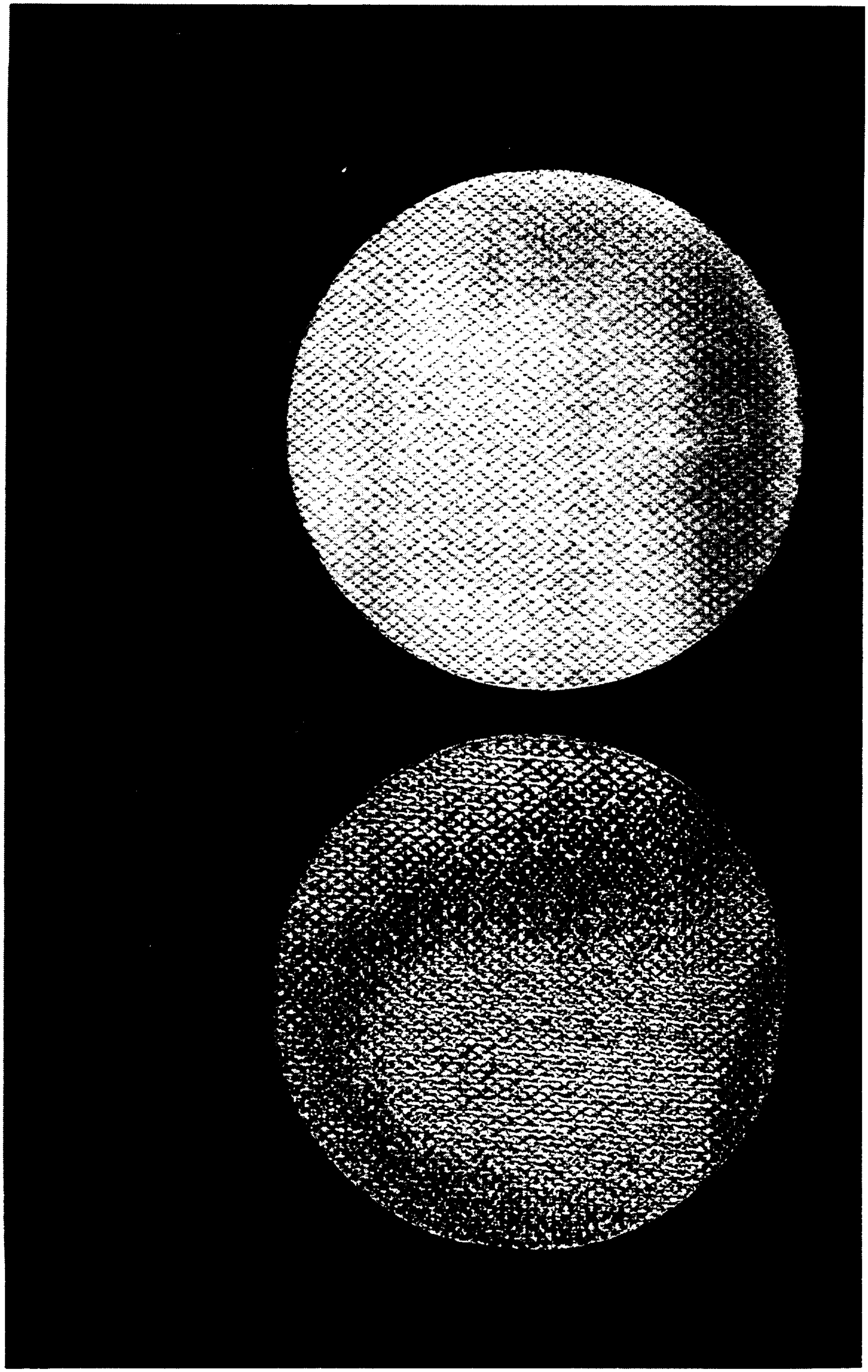

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Figure 16-(d). Post test photograph of specimen #26 at 2140 °F, 207 psf for 500s.

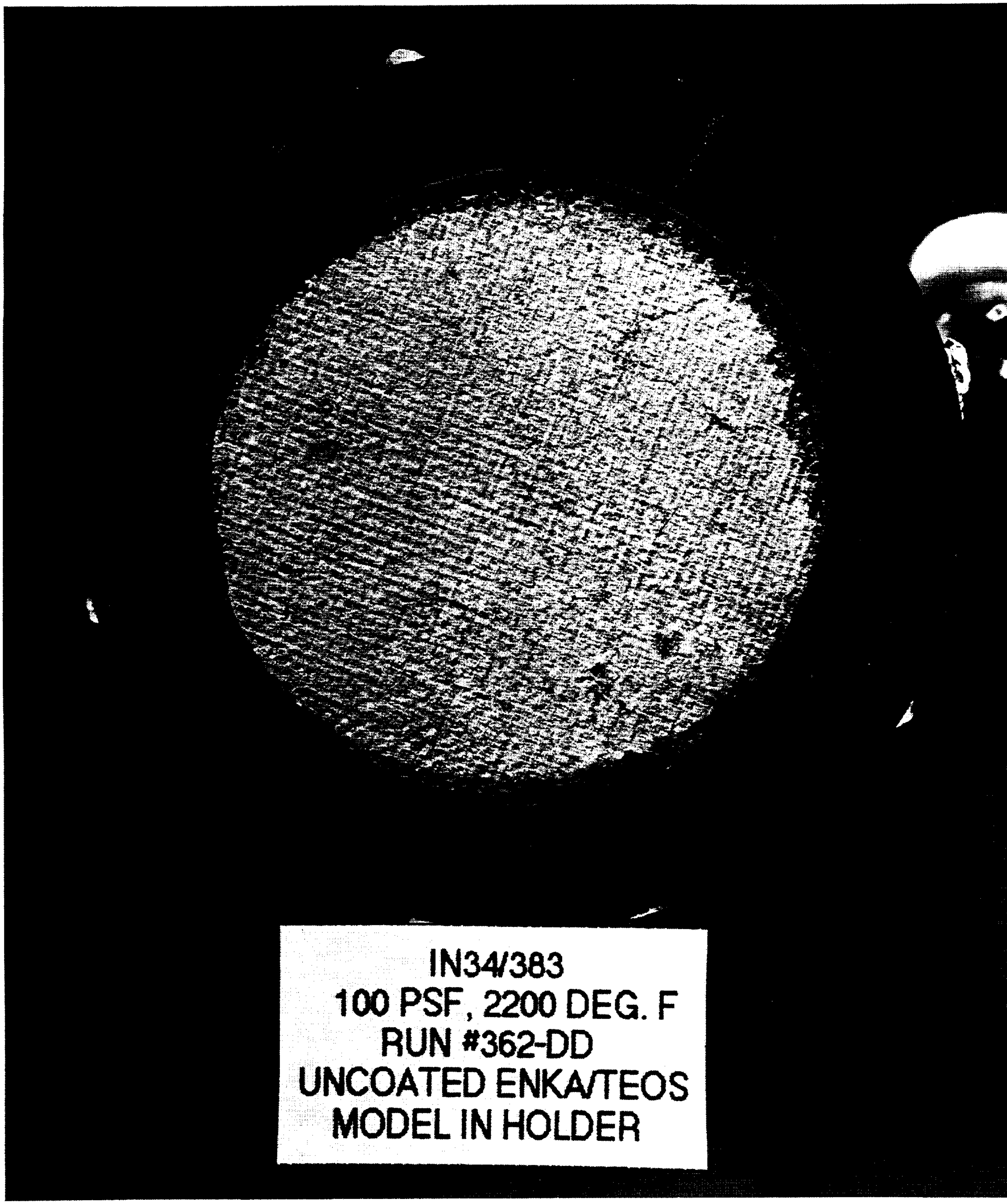

Figure 16-(e). Post test photograph of specimen #IN34 at 2200 °F, 105 psf for 600 s.

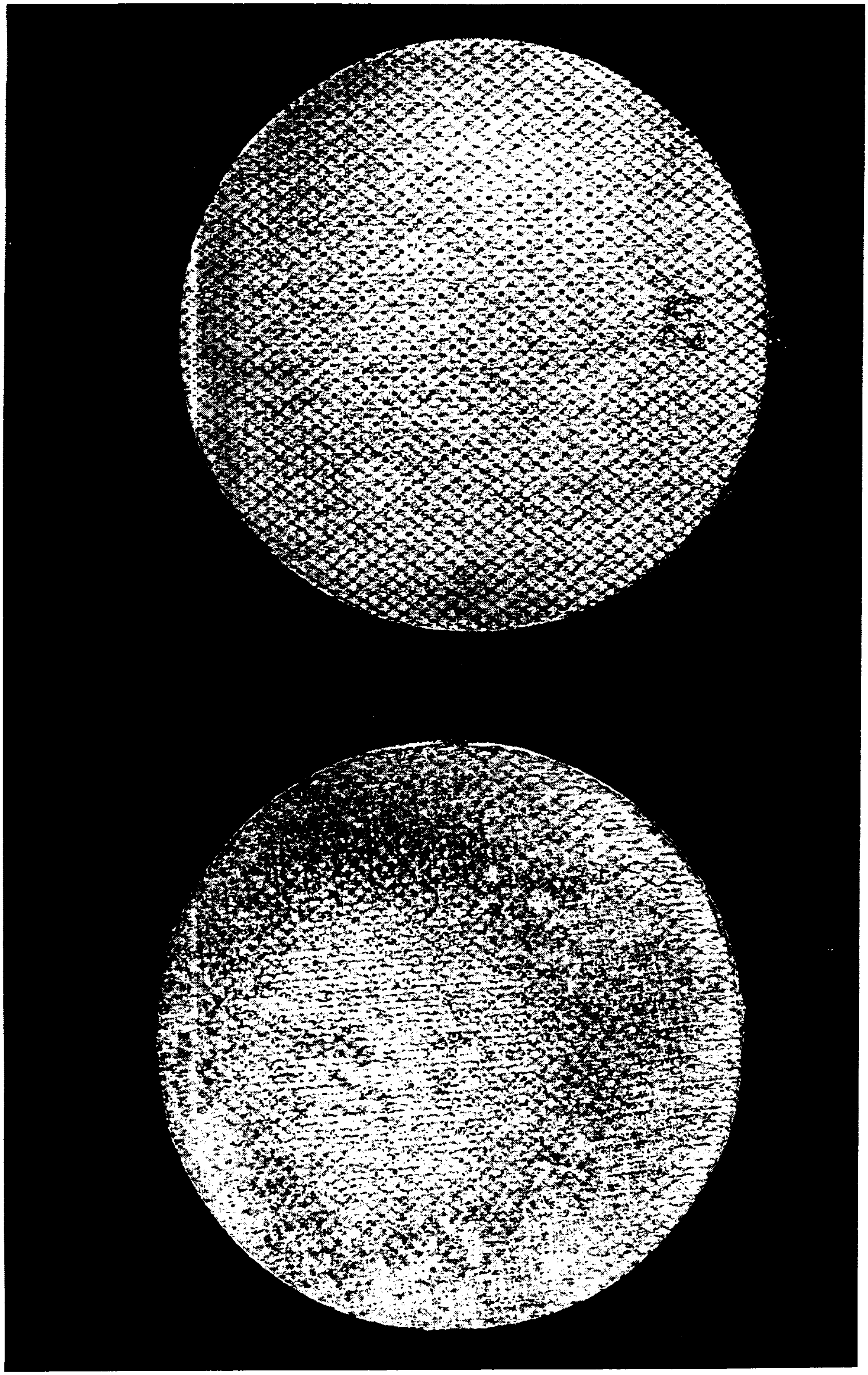

Figure 16-(f). Post test photograph of specimen #24 at 2400 °F, 215 psf for 300s.

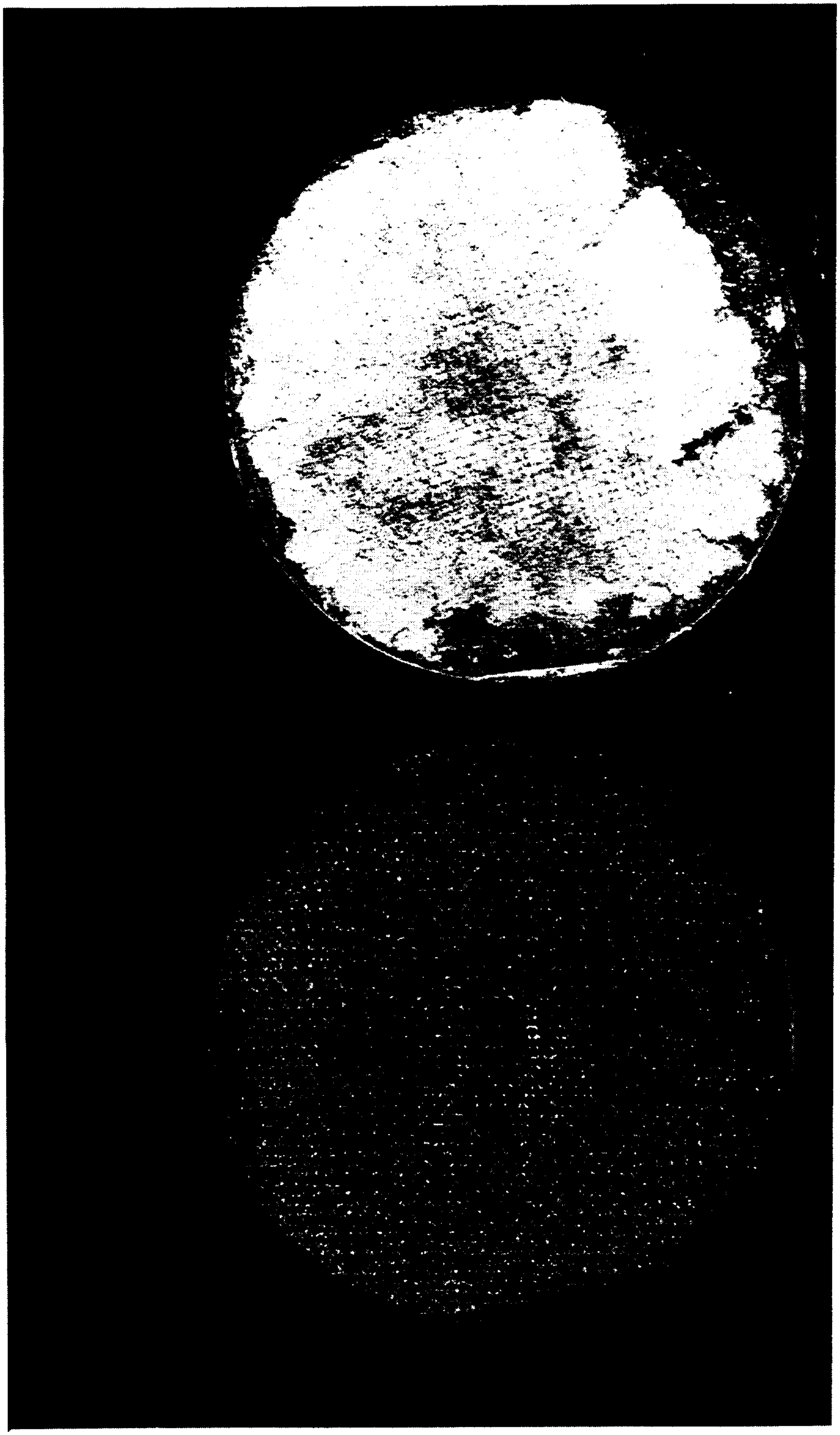

Figure 16-(g). Post test photograph of specimen #32 at 2500 °F, 100 psf for 400s.

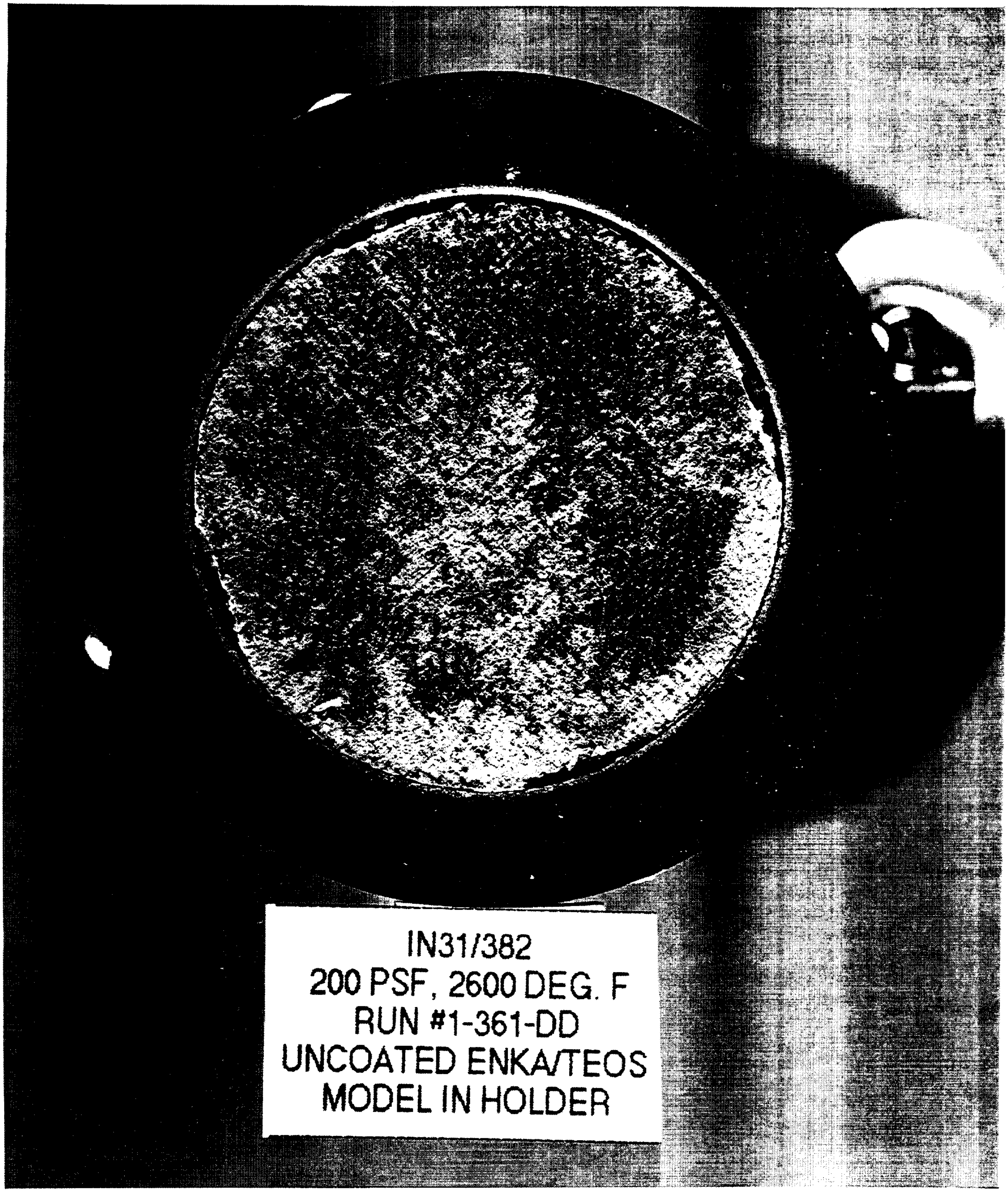

Figure 16-(h). Post test photograph of specimen #IN31 at 2620 °F, 180 psf for 330 s.

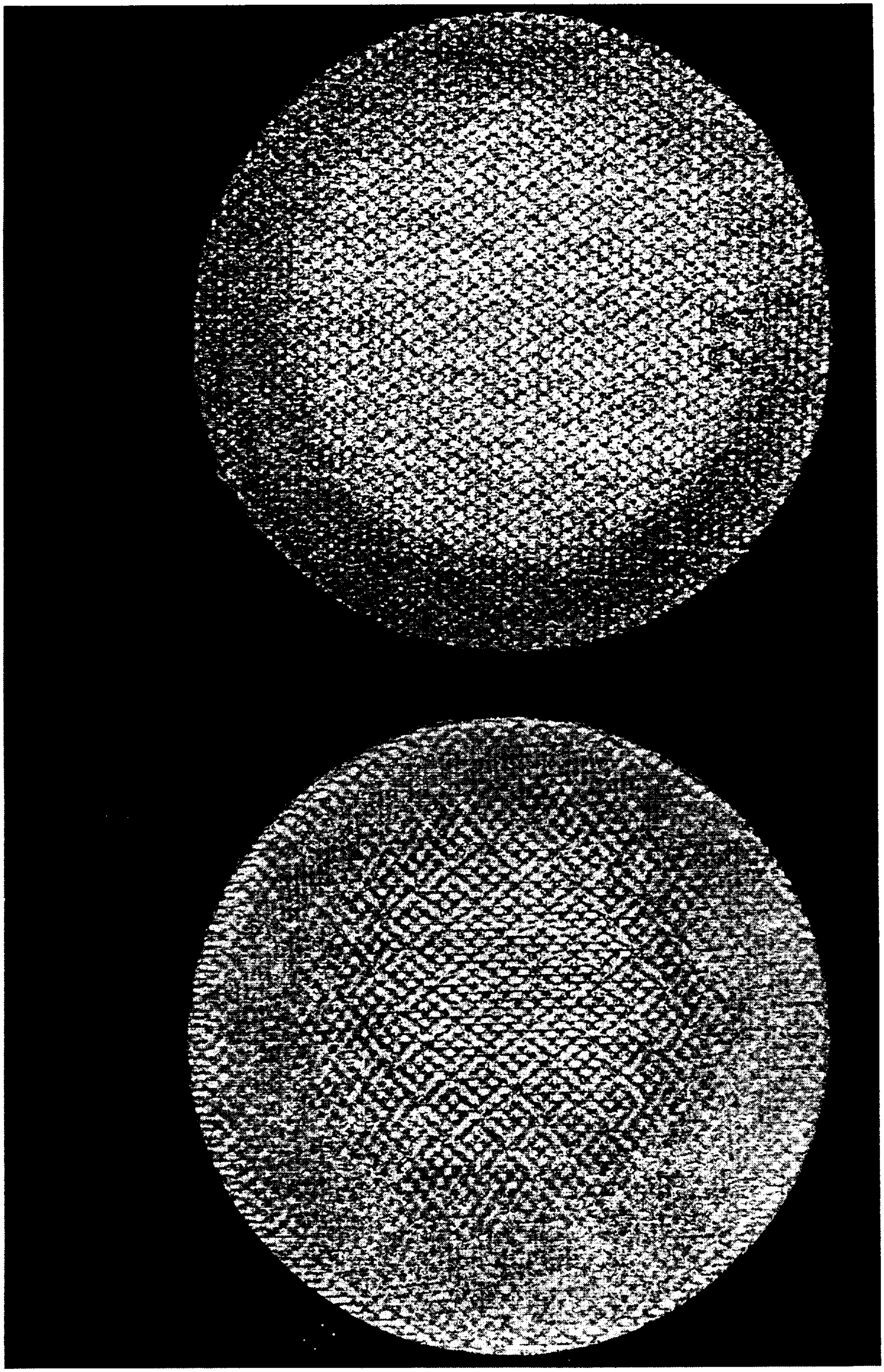

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Figure 16-(i). Post test photograph of specimen #23 at 2850 °F, 59 psf for 180 s.

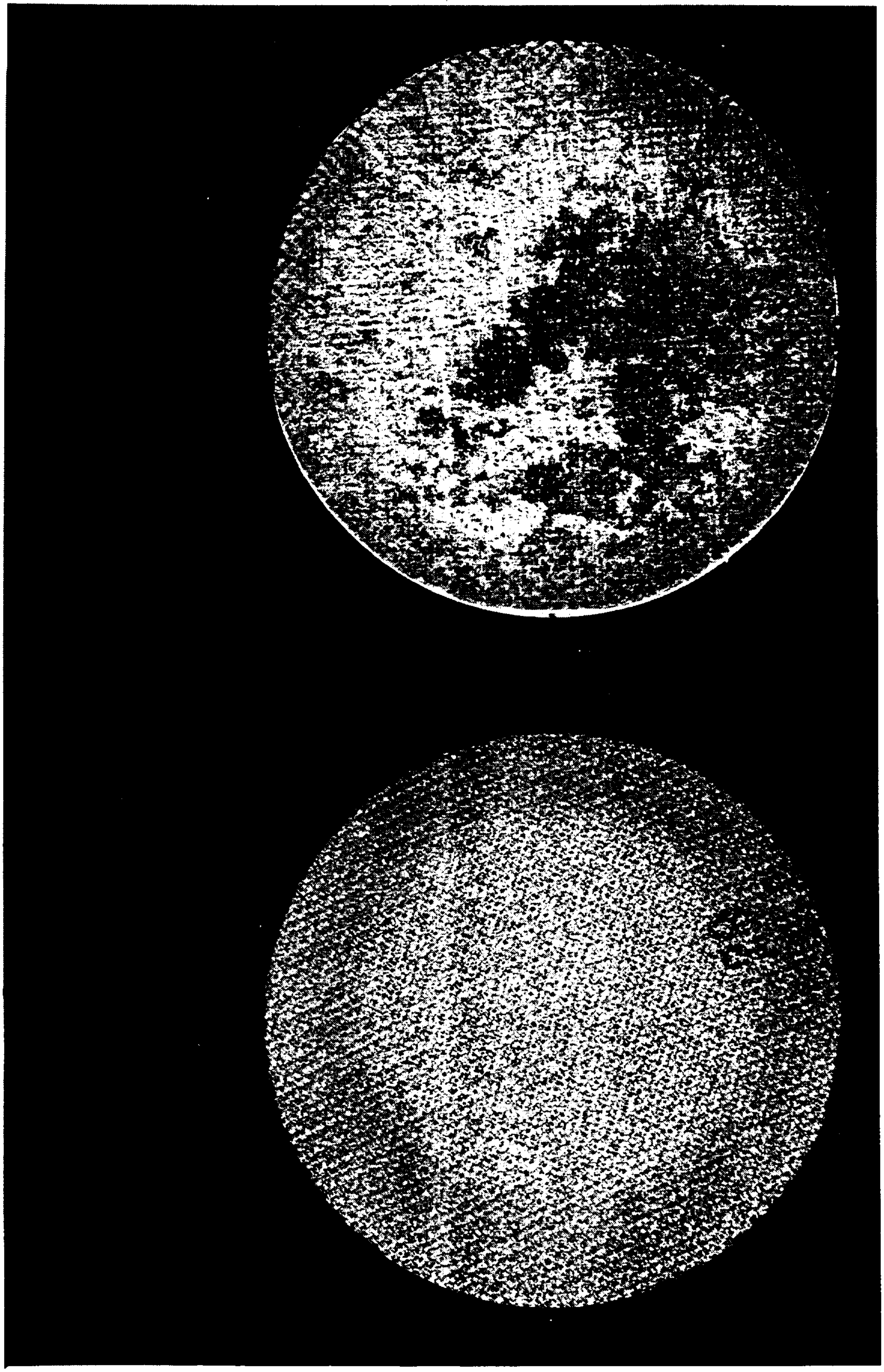

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Figure 16-(j). Post test photograph of specimen #29 at 2900 °F, 100 psf for 200s.

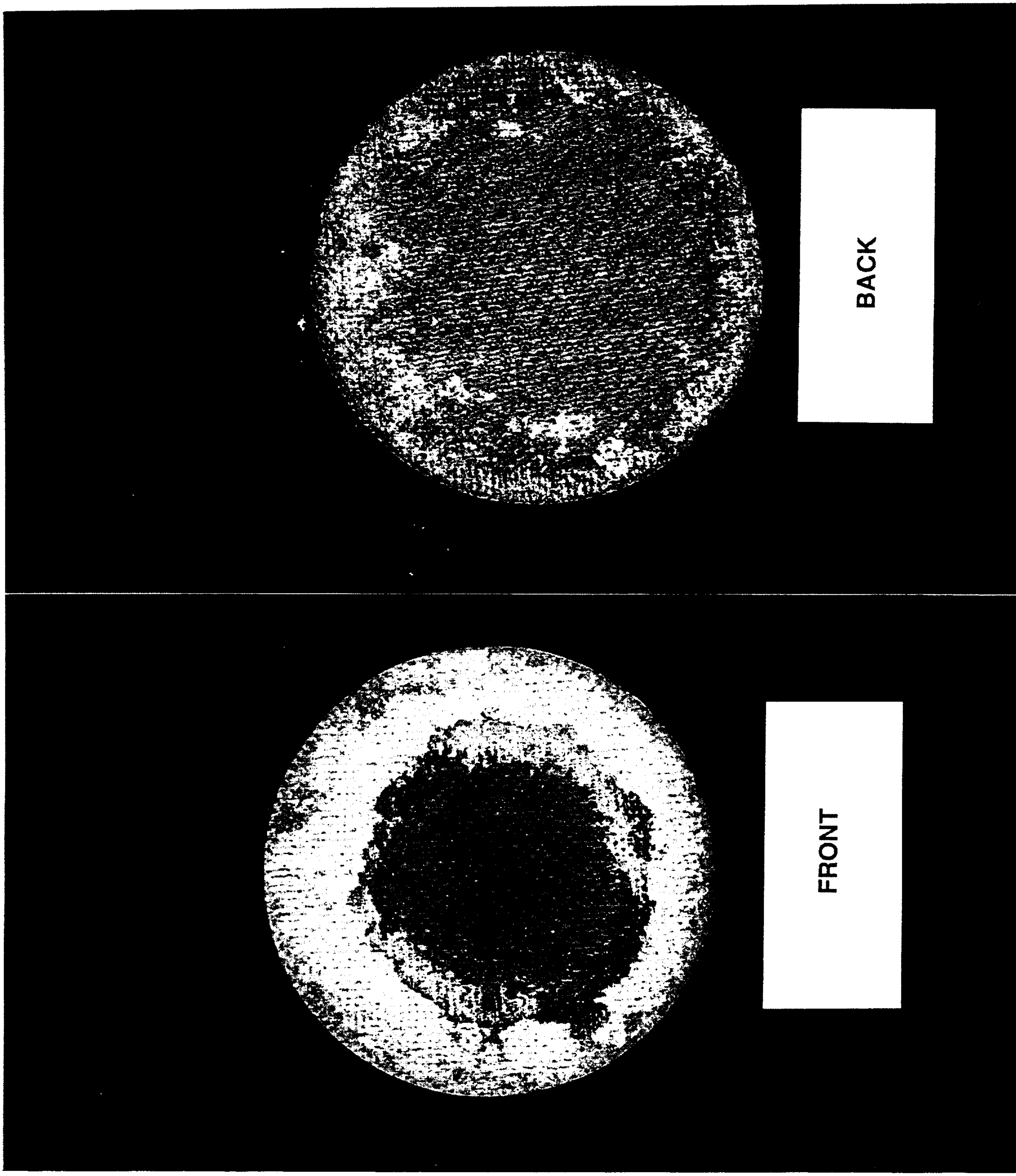


Figure 16-(k). Post test photograph of specimen #27 at 3100 °F, 60 psf for 320s.

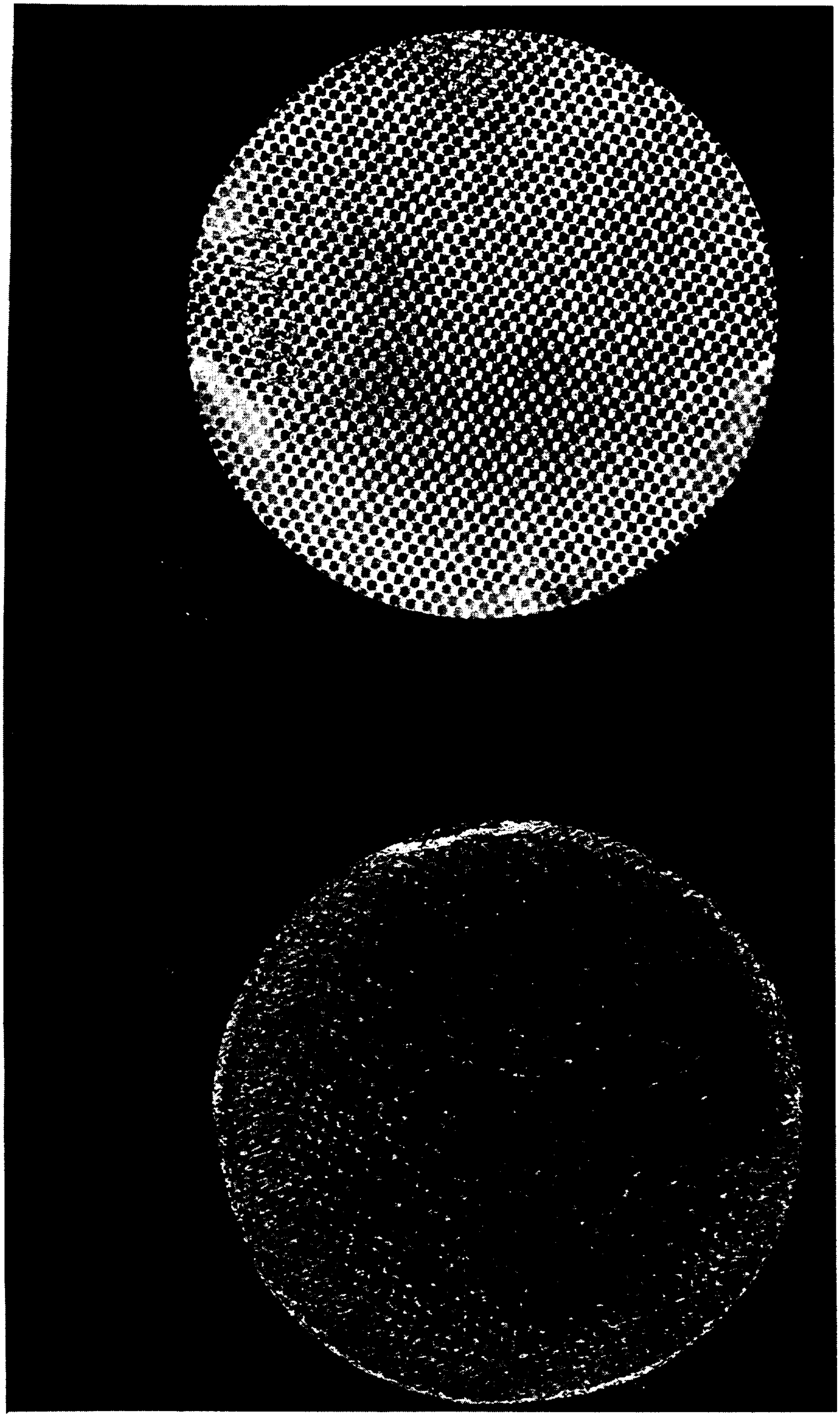


Figure 16-(l). Post test photograph of specimen #IN30 at 3160 °F, 300 psf for 153 s.

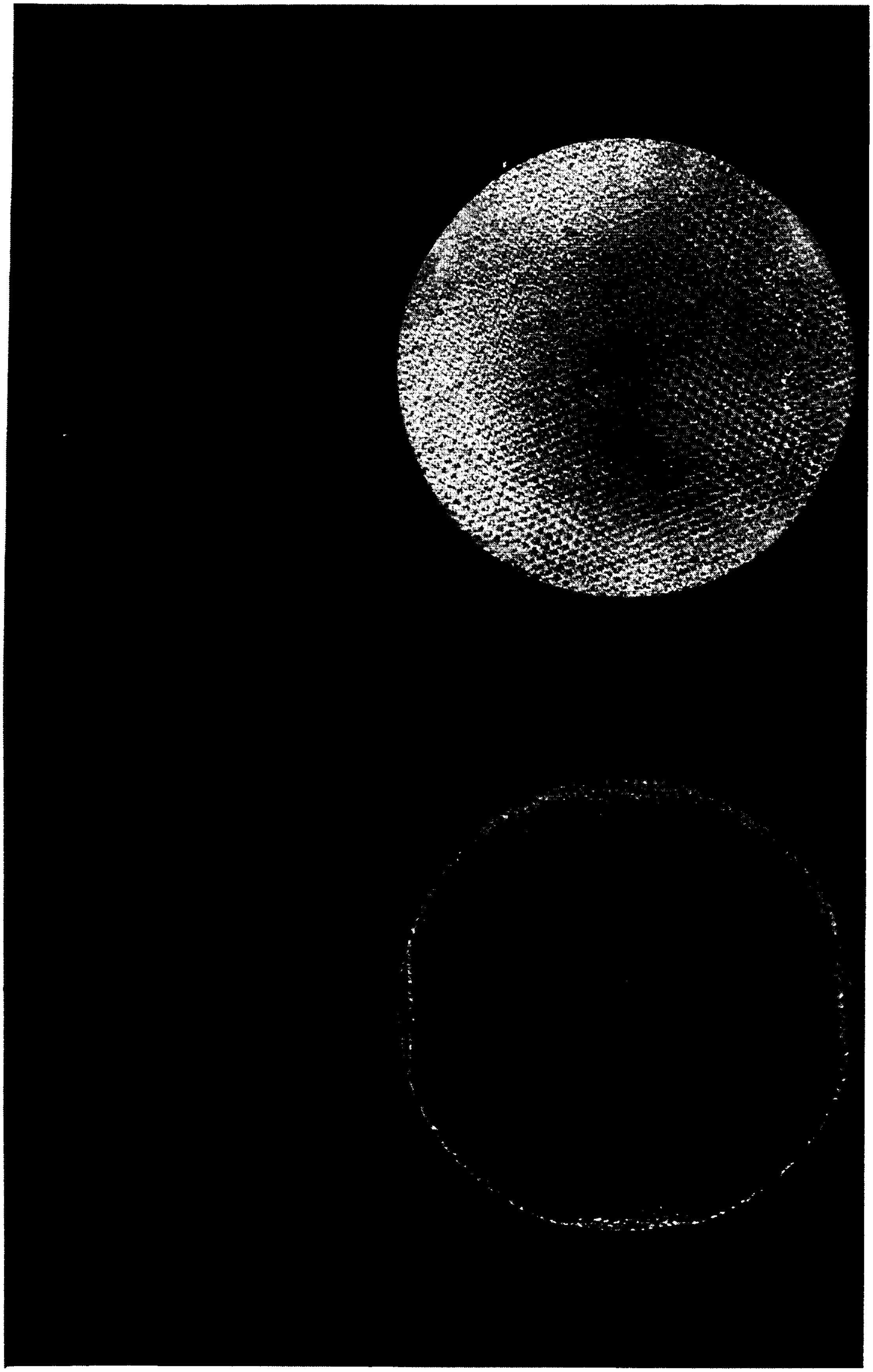


Figure 16-(m). Post test photograph of specimen #IN24 at 3330 °F, 312 psf for 150 s.

Test Series 2

APPENDIX A

THEORY AND OPERATION OF THE
LASER PYROMETER

The laser pyrometer by The Pyrometer Instrument Co., Inc. is a self-contained hand-held device which permits measurement of temperature from a remote position. This section will present the technique of using the laser pyrometer to measure the surface temperature of the coated RCC during the TAL Abort test program.

An object will radiate electromagnetic energy when the temperature of the object rises above absolute zero. The distribution of the electromagnetic energy as a function of wavelength, the spectral distribution, depends on temperature and the surface characteristic of the object. At low temperature, the object radiates more energy at long wavelength in the form of infra-red radiation. As the temperature of the object increases, more energy will be radiated at shorter wavelength and may eventually become visible light. The spectral distribution of the electromagnetic energy at a fixed temperature is given by the Planck's distribution law. The surface characteristic of the object such as texture, or color can also affect the amount of energy radiated by the object. In order to quantify the effectiveness of a surface to radiate energy, the nature of the surface is represented by emissivity, ε. The emissivity for a perfect radiator is unity while the emissivity for a perfect reflector is zero. When the object is in thermal equilibrium with its surroundings, it radiates and absorbs the same amount of energy i.e. the emissivity of an object is the same as its absorptivity. Since an opaque object either absorbs or reflects energy, therefore, the sum of the emissivity, ε, and reflectivity, r, of an object must be equal to unity.

In order to measure the temperature of a specimen, it is necessary to measure the energy radiates by the object and its emissivity. Since the intensity of the radiation decreases as the square of the distance, it is necessary to know the distance between the laser pyrometer and the test specimen. The laser pyrometer has a Linear Variable Distance Transducer attached to the ojective lens to measure the target distance. By measuring the radiation from 835 nm to 895 nm with a 1/3° solid angle and assuming a Lambertian surface, the total hemispherical radiation is calculated. The reflectivity is obtained by sending a laser pulse to the target and monitoring the fraction of laser light being reflected. The emissivity can then be calculated by the expression $\varepsilon = 1.0 - r$.

The laser pyrometer used in this test program operares at a temperature range from 1832 °F to 4532 °F with 1 °F resolution and 5 °F accuracy. The laser is a mutiheterostructure Gallium Aluminum Arsenide injection laser diode lasing at a wavelength of 865 nm. The laser pyrometer is capable of sending high level output of the temperature measurement to external instruments. Throughout this test program, the uncorrected temperature, i.e. assuming $\varepsilon = 1.0$, is recorded by the data acquisition system. Most of the measurements were taken using 10 ms data acquisition time to minimize the temperature transient effect when the hot spot occurs (the laser pyrometer cannot make measurement when there is rapid temperature fluctuation).

The laser pyrometer had to view through a half inch thick quatz window and a gold surface mirror in order to reach the test specimen. A schematic of the optical layout can be found in figure 6. Several calibration runs were performed to establish a correlation of the laser pyrometer reading and the type C tungsten thermocouples of the calibration models. A emissivity of 0.68 and a viewing angle of 35 ° were used to compensate for the emittance loss, and losses due to the optics. After the emissivity correction was made, the corrected temperature was recorded and designated as "L PYR X".

Since the high level analog output is reconstructed from the digital measurements, therefore, the temperature versus time plots have the typical "sample and hold" feature of the digital measurements. In other words, the output will not be updated until a new good measurement is made. However, the complete temperature history of the specimen can be obtained by connecting the outer corners on the rising slope and connecting the inner corners on the falling slope as shown in figure 17.

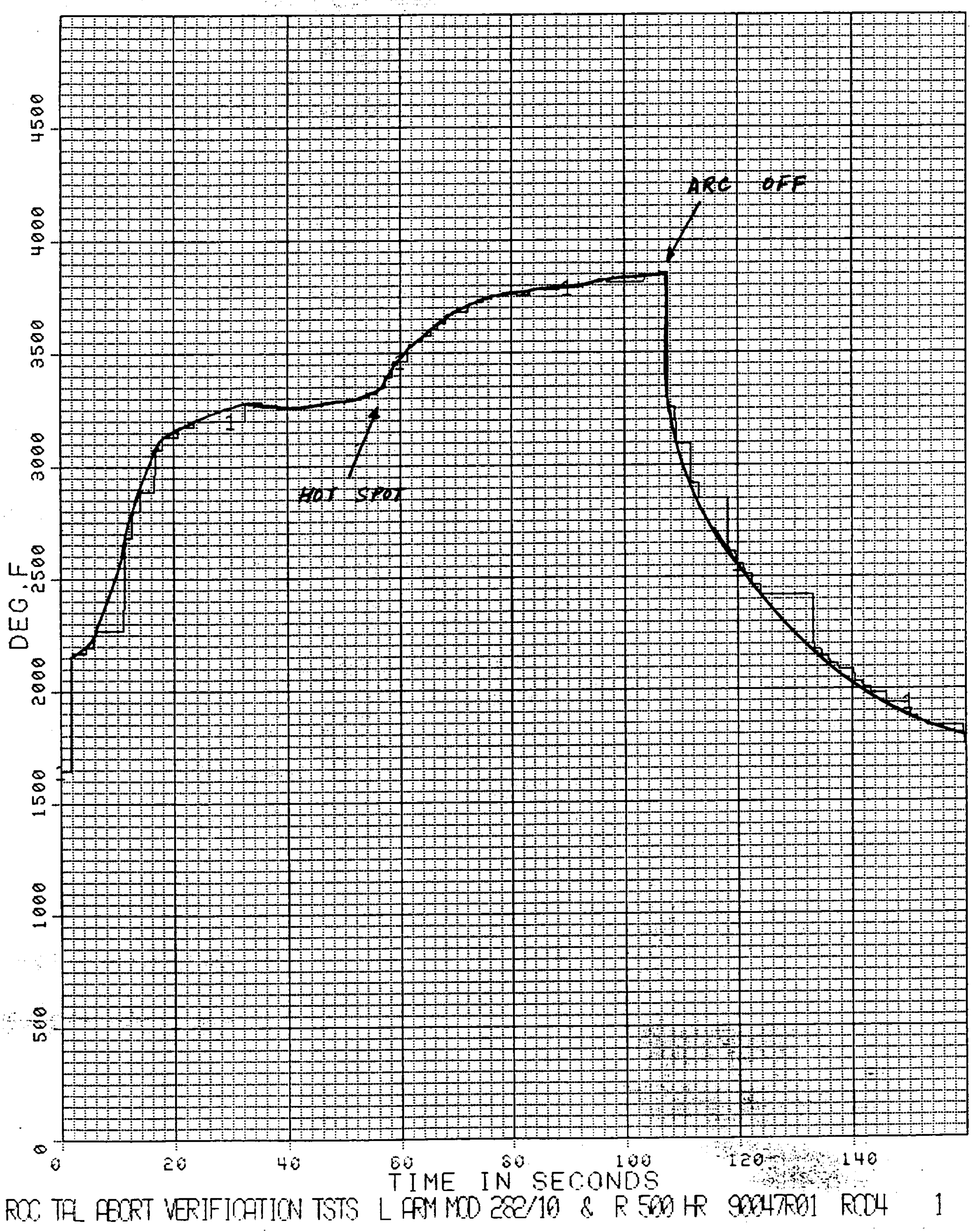


Figure 17. A typical temperature versus time plot from the laser pyrometer.

Test Series 2

APPENDIX B

SUMMARY OF TEST FACILITY OPERATING PARAMETERS

RUN SUMMARY

	model #	run #	mass flow (lb/s)	z distance (in)	current (A)	Q-dot (btu/sqft s)	mean temp (F)	pressure (psf)	run time (s)
1	ENKA	no type A							
2	IN05	1-318-DD	0.09	9.0	1025	186	3120	97	737 S
3	IN09	1-320-DD	0.09	9.0	1160	212	3200	97	1800 S
4	IN09	1-321-DD	0.09	9.0	1160	212	3200	97	1800 S
5	IN11	1-322-DD	0.09	9.0	1425	240	3230	100	66 S + 6 S TRANSIENT
6					1500	250	3300		52 S
7	IN17	1-326-DD	0.60	9.0	590	117		293	100 S
8					630	125	3200		800 S
9	IN19	1-327-DD	0.60	10.5	630	125	3230	301	400 S
10	IN19	1-328-DD	0.60	10.5	630	125	3230	300	900 S
11	IN19	1-329-DD	0.60	10.5	630	125	3230	300	900 S
12	IN19	1-330-DD	0.60	10.5	630	125		300	27 s
13	IN19	1-331-DD	0.60	10.5	630	125	3230	300	1400 S
14	IN23	1-339-DD	0.60	10.5	700	143	3250	313	900 S
15	IN29	1-340-DD	0.60	10.5	785	165	3350	325	HOT SPOT @ 103 S + 30 S
16	with	type A							
17	2	1-151-DD	0.09	9.0	1110	220	3200	103	330 S
18	3	1-169-DD	0.20	9.0	500	135	3000	160	330 S
19	4	1-186-DD	0.70	10.5	550	115	3060	320	330 S
20	5	1-187-DD	0.70	10.5	640	N/A	3200	320	330 S
21	6	1-189-DD	0.70	10.5	685	N/A	3250	320	HOT SPOT @ 95 S + 32 S
22	7	1-190-DD	0.70	10.5	760	161	3250	320	HOT SPOT @ 55 S + 132 S
23	8	1-195-DD	0.09	9.0	1450	265	3300	104	HOT SPOT @ 48 S + 30 S
24	9	1-143-DD	0.09	9.0	1450	265	3300	105	HOT SPOT @ 60 S + 3 S
25	10	1-196-DD	0.70	10.5	760	161	3300	353	HOT SPOT @ 58 S + 45 S
26	13	1-156-DD	0.20	9.0	750	213	3300	188	HOT SPOT @ 43 S + 2 S
27	14	1-153-DD	0.20	9.0	650	180	3200	178	600 S
28	15	1-162-DD	0.20	9.0	750	210	3280	186	HOT SPOT @ 63 S + 4 S
29	16	1-163-DD	0.20	9.0	500	135	3000	160	800 S
30	17	1-155-DD	0.20	9.0	750	213	3300	187	170 S
31	18	1-168-DD	0.20	9.0	650	180	3200	176	330 S
32	AB-12	1-146-DD	0.09	9.0	1450	265	3300	107	HOT SPOT @ 53 S + 4 S
33	AB-13	1-148-DD	0.09	9.0	660	160	2975	95	353 S
34	AB-14	1-193-DD	0.09	9.0	1450	265	3300	104	HOT SPOT @ 45 S + 60 S
35	AB-15	1-149-DD	0.09	9.0	860	186	3100	90	330 S
36	AB-16	1-150-DD	0.09	9.0	1110	220	3200	103	330 S
37	AU-01	1-197-DD	0.20	9.0	750	213	3300	183	HOT SPOT @ 103 S + 55 S
38	AC-22	1-300-DD	0.09	9.0	860	186	3100	100	3300 S
39	IN04	1-346-DD	0.60	10.5	880	180	3340	337	HOT SPOT @45 S + 25 S
40	IN06	1-317-DD	0.09	9.0	1650	241	3350	101	HOT SPOT @ 43 S + 30 S
41	IN08	1-341-DD	0.60	10.5	785	165	3300	325	HOT SPOT @ 80 S + 30 S
42	IN12	1-342-DD	0.60	10.5	725	150	3250	317	HOT SPOT @ 150 S + 180 S

	model #	run #	mass flow (lb/s)	z distance (in)	current (A)	Q-dot (btu/sqft s)	mean temp (F)	pressure (psf)	run time (s)
43	IN14	1-343-DD	0.60	10.5	675	139	3230	309	223 S
44	IN18	1-344-DD	0.60	10.5	785	163	3300	325	HOT SPOT @73 S + 257 S
45	IN20	1-349-DD	0.60	10.5	860	176	3320	338	HOT SPOT @44S +50 S
46	IN21	1-337-DD	0.60	10.5	650	130	3200	293	1200 S
47	IN22	1-338-DD	0.60	10.5	650	131	3180	303	330 S
48	IN25	1-315-DD	0.09	9.0	1100	218	3200	105	1800 S
49	IN25	1-316-DD	0.09	9.0	1100	217	3200	105	1800 S
50	IN26	1-350-DD	0.60	10.5	860	176	3350	338	HOT SPOT @20S + 44 S
51	IN28	1-354-DD	0.60	10.5	700	146	3225	312	900S S
52	AT15	1-351-DD	0.60	10.5	860	176	3350	338	HOT SPOT @52 S + 35 S
53	uncoated	with	gas injection						
54	IN24	1-356-DD	0.70	10.5	560	73	3330	312	120 S pre-heat + 150 S air
55	IN30	1-360-DD	0.70	10.5	450	61	3160	300	120 S pre-heat + 153 S
56	IN31	1-361-DD	0.40	10.5	350	31	2620	180	120 S pre-heat + 330 S
57	IN34	1-362-DD	0.40	15.0	300	17.5	2200	105	70 S pre-heat + 600 S
58	23	1-178-DD	0.09	9.0	200	40	2850	59	225 S pre-heat + 180 air
59	24	1-243-DD	0.60	9.0	530	23	2400	215	300 S air
60	25	1-244-DD	0.60	9.0	310	11.5	1800	193	600 S air
61	26	1-250-DD	0.60	9.0	400	16	2140	207	500 S air
62	27	1-224-DD	0.2	9.0	225	11.5	1800	100	120 S pre-heat + 525 S air
63	27	1-251-DD	0.09	9.0	235	55	3100	60	retest on back for 320 S air
64	28	1-232-DD	0.20	9.0	180	9.5	1440	75	120 S pre-heat + 4500 S air
65	29	1-222-DD	0.17	9.0	455	43	2900	100	120 S pre-heat + 200 S air
66	32	1-221-DD	0.20	9.0	300	26	2500	100	120 S pre-heat + 400 S air
67									
68									
69						Q-dot here have no			
70						relationship to flight			
71						data			

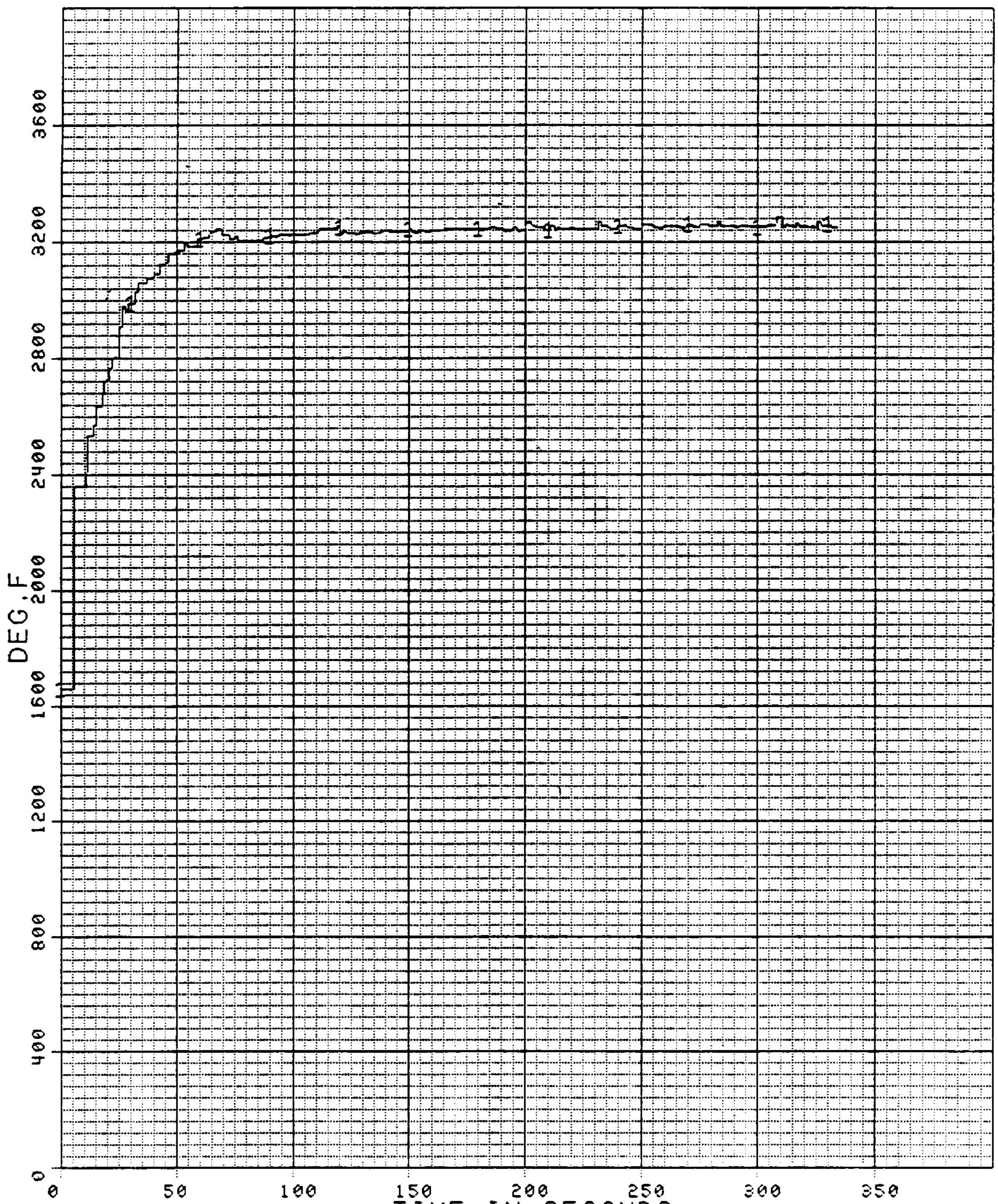
Test Series 2

APPENDIX C

POST TEST MEASUREMENTS AND TEMPERATURE VERSUS TIME PLOTS

1-151-DD PROCESSING DATE 12/15/89
DATE = 12/15/89 AVERAGE INTERVAL 0.1 SEC TIME = 17:42:48.0 TO 17:48:22.0

L PYR X CHANNEL NO. 62



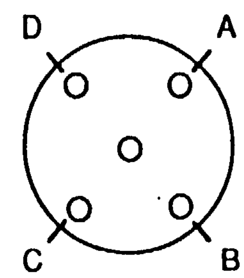
ROC TAL ABORT VERIFICATION TESTS L ARM 274/2 / R 500 BTU HRS 9349R02 ROD4 1

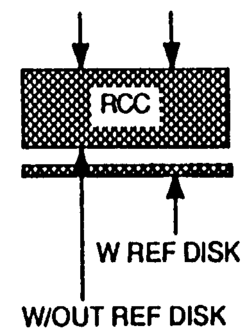
PRECEDING PAGE BLANK NOT FILMED

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 274 (2) RUN NO: ____ TEST CONDITION: 3200 F 100 psf, 330 sec.

$\Delta m = 1.6431$



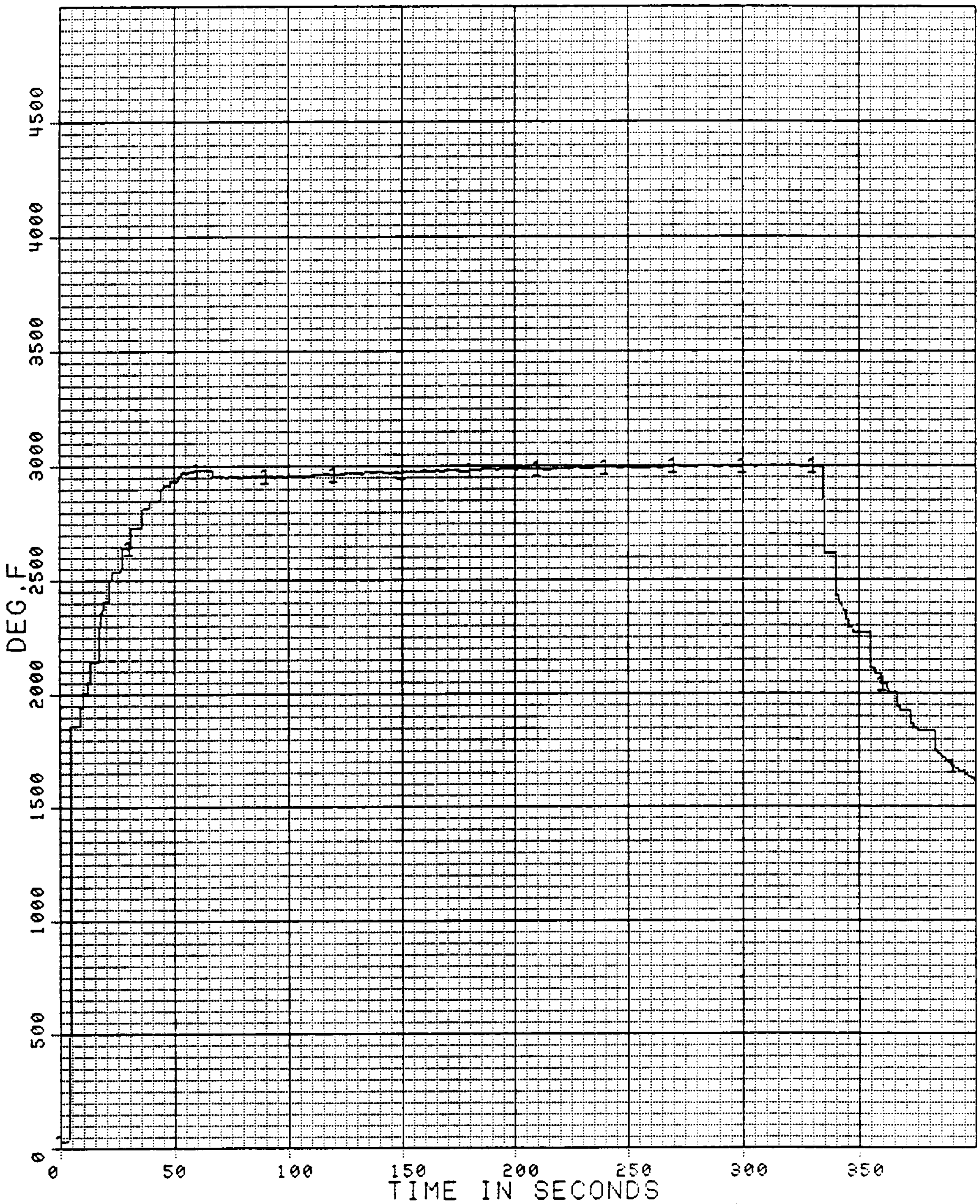


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.0221		55.379	
BAG WEIGHT ONLY	8.2242		8.2242	
SPECIMEN WEIGHT ONLY	48.7979		47.1548	
EMISSIVITY	.160			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.274	.544	.268	.549
THICKNESS AT POINT A	.273	.542	.272	.548
THICKNESS AT POINT B	.275	.543	.275	.547
THICKNESS AT POINT C	.275	.545	.274	.546
THICKNESS AT POINT D	.274	.546	.272	.546
REFERENCE DISK THICKNESS	.268		.267	
TECH / QA / DATE	BZ BOEING QUALITY 9/19/89		BZ 12 15 89	

POST-TEST RESULTS/COMMENTS:

1-169-DD PROCESSING DATE 01/22/90
DATE = 1/22/90 AVERAGE INTERVAL 0.1 SEC TIME = 22:22: 8.0 TO 22:28:48.0

L PYR X CHANNEL NO. 62



ROC TAL ABORT VERIFICATION TESTS LFT MOD 275-3 & RT 500 BTU HRS 90022R01 ROD4 1

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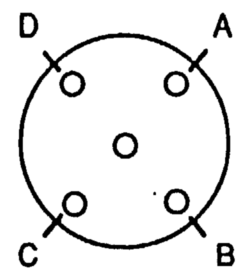
9/8/89

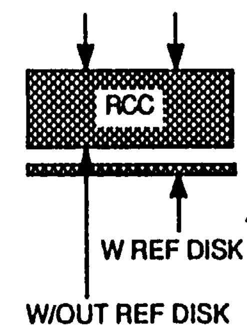
3000F

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 275 (3) RUN NO: ______ TEST CONDITION: 3000F, 200 psf

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.1338		56.776	
BAG WEIGHT ONLY	8.2040		8.2040	
SPECIMEN WEIGHT ONLY	48.9298 ~~48.8298~~		48.572	
EMISSIVITY	.159			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.273	.543	.274	.548
THICKNESS AT POINT A	.273	.542	.277	.548
THICKNESS AT POINT B	.275	.544	.279	.549
THICKNESS AT POINT C	.276	.546	.276	.550
THICKNESS AT POINT D	.275	.545	.277	.549
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ	BOEING 23 QUALITY / BOEING T QUALITY 9/19/89	BZ	BOEING 23 QUALITY 1 23 90



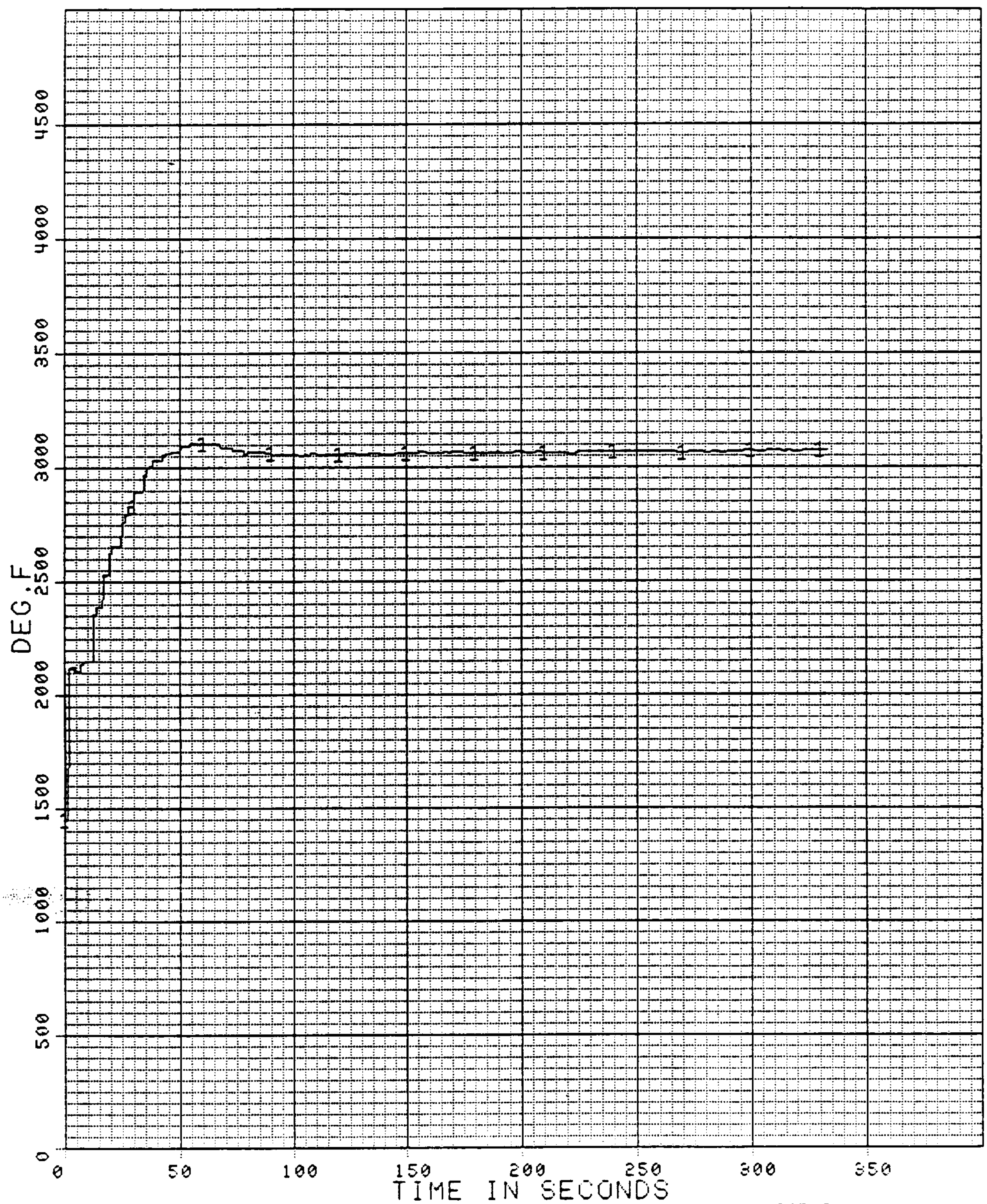


Am = 0.3578 g

POST-TEST RESULTS/COMMENTS:

1-186-DD PROCESSING DATE 02/08/90
DATE = 2/ 8/90 AVERAGE INTERVAL 0.1 SEC TIME = 22: 3:37.0 TO 22: 9:10.0

L PYR X CHANNEL NO. 62



ROC TAL ABORT VERIFICATION TSTS L.ARM CAL # 276/4 & R 500 HR 90039R02 ROO4 2

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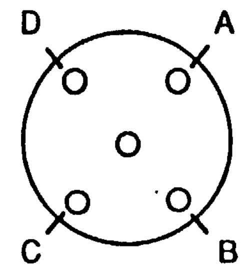
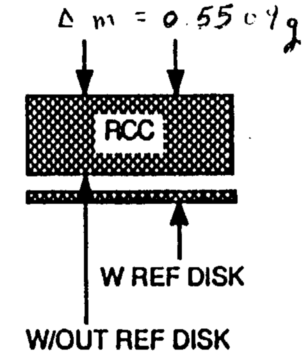
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 276 (4) RUN NO: ______ TEST CONDITION: 3100 F 320 psf





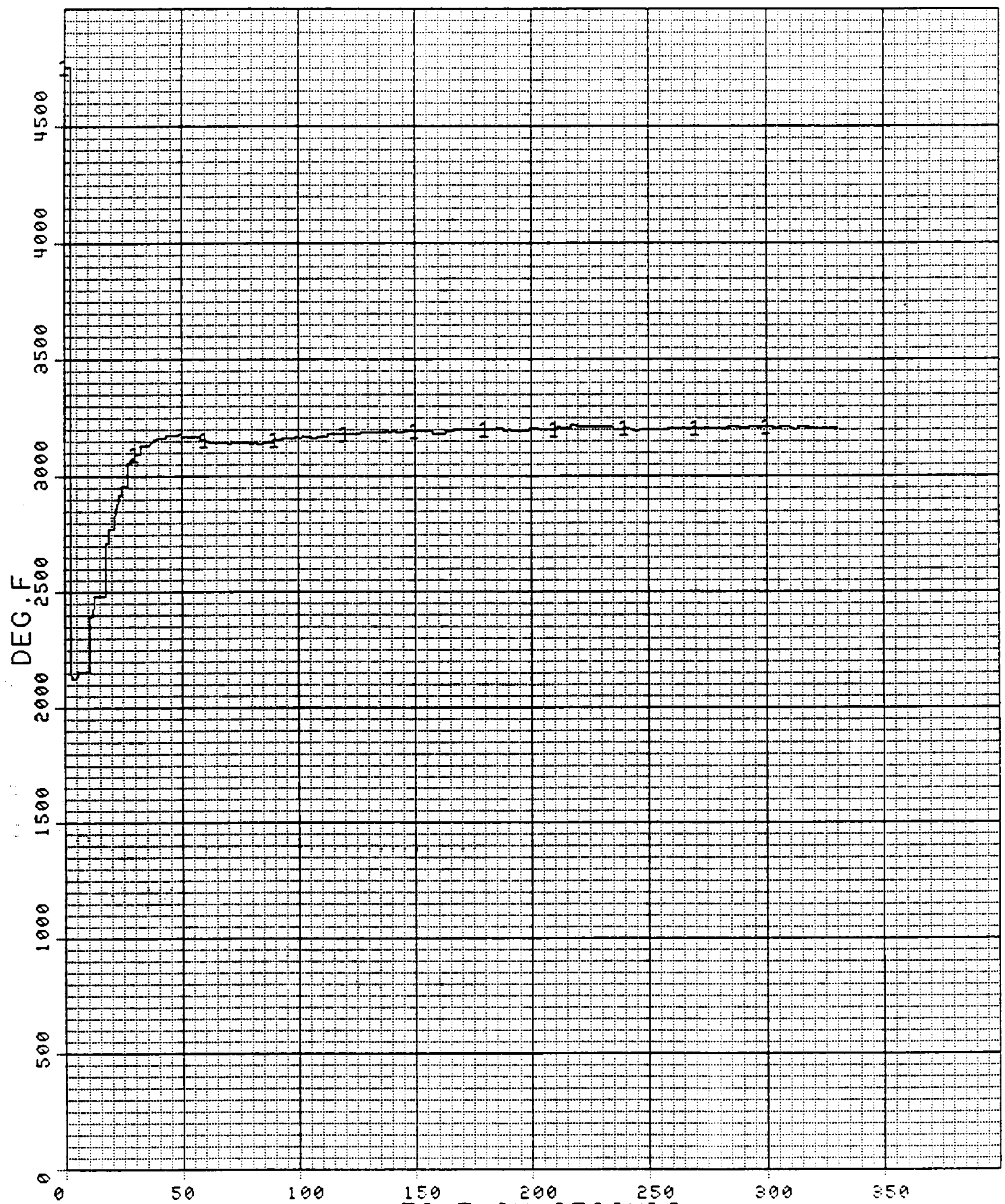
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.5919		57.041	
BAG WEIGHT ONLY	8.2148		8.2148	
SPECIMEN WEIGHT ONLY	49.3771		48.8262	
EMISSIVITY	.155			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.275	.543	.285	.561
THICKNESS AT POINT A	.275	.543	.279	.554
THICKNESS AT POINT B	.275	.546	.281	.554
THICKNESS AT POINT C	.277	.545	.280	.550
THICKNESS AT POINT D	.276	.545	.282	.554
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ BOEING QUALITY 9/19/89		BZ 2 12 90	

POST-TEST RESULTS/COMMENTS:

1-187-DD
DATE = 2/ 9/90 AVERAGE INTERVAL 0.1 SEC TIME = 22:11:38.0 TO 22:17: 8.0

PROCESSING DATE 02/09/90

L PYR X CHANNEL NO. 62



ROC TAL ABORT VERIFICATION TSTS L.ARM CAL # 277/5 & R 500 HR 90040R01 RCD4 2

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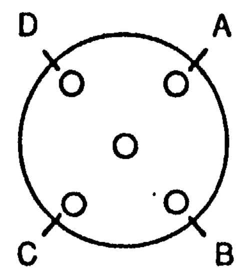
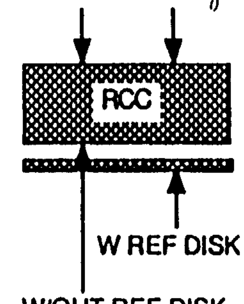
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 277 (5) RUN NO: ______ TEST CONDITION: 3200 F, 320 psf

Δm = 2.108 g





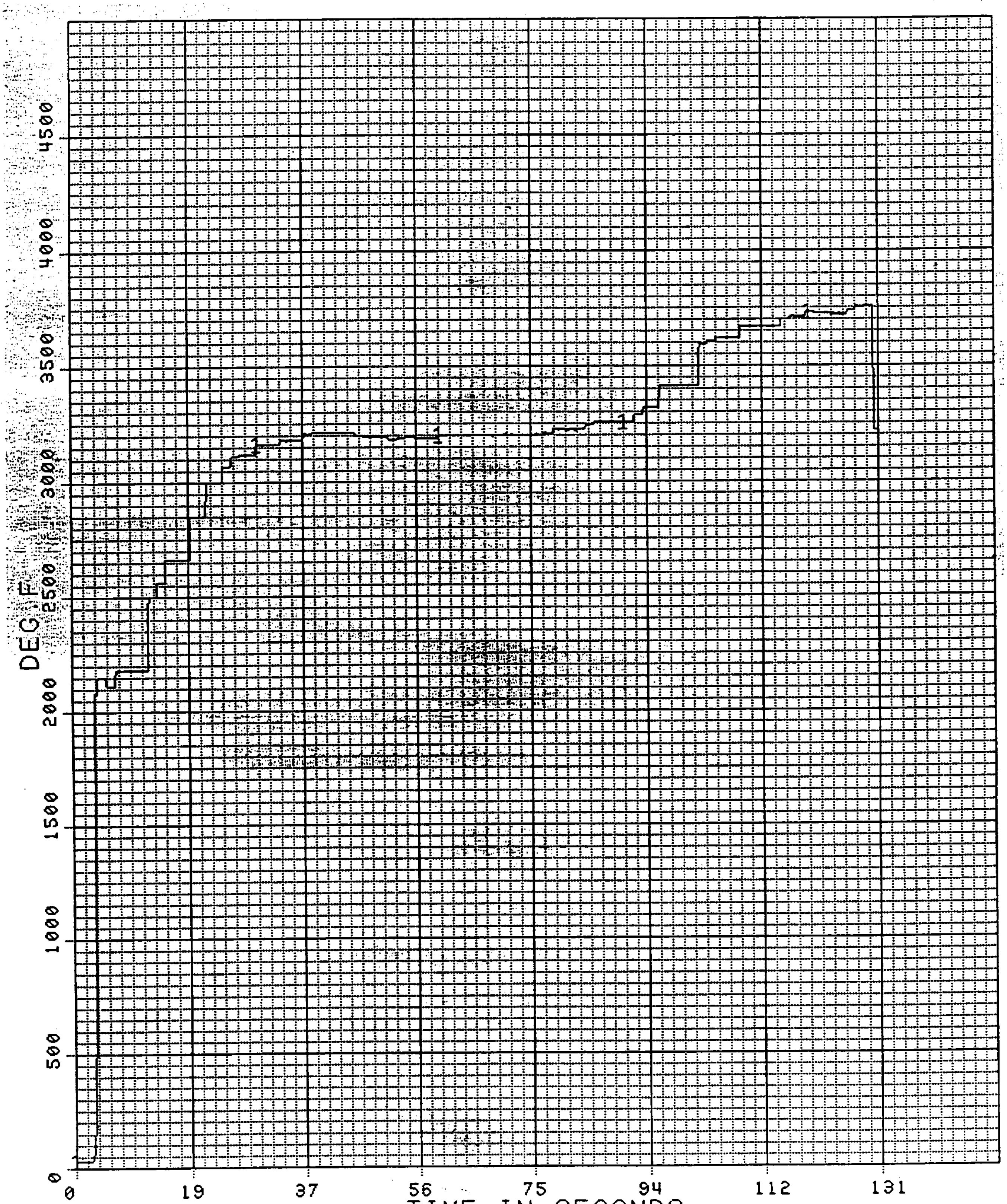
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	56.5940		54.486	
BAG WEIGHT ONLY	7.4021		7.4021	
SPECIMEN WEIGHT ONLY	49.1919		47.0839	
EMISSIVITY	.154			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	JE ~~.276~~ .271	.542	.266	.549
THICKNESS AT POINT A	.272	.541	.282	.659
THICKNESS AT POINT B	.274	.543	.283	.656
THICKNESS AT POINT C	.276	.546	.285	.565
THICKNESS AT POINT D	.274	.544	.270	.549
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ / BOEING QUALITY / 9/19/89		BZ / 2 12 90	

POST-TEST RESULTS/COMMENTS:

1-189-DD
DATE = 2/13/90 AVERAGE INTERVAL 0.1 SEC TIME = 18: 1:50.0 TO 18: 4: 1.0

PROCESSING DATE 02/13/90

L PYR X CHANNEL NO. 62



RCC TAL ABORT VERIFICATION TSTS L.ARM CAL # 278/6 & R 500 HR 9004HR01 RCD4 1

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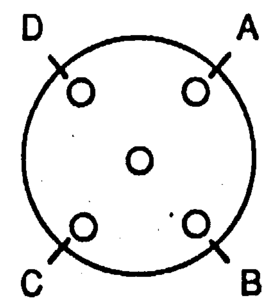
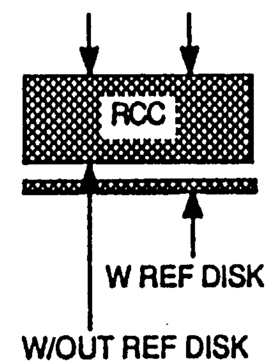
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 278 (6) RUN NO: ______ TEST CONDITION: 3300F, 320 psf

$\Delta m = 5.9352$





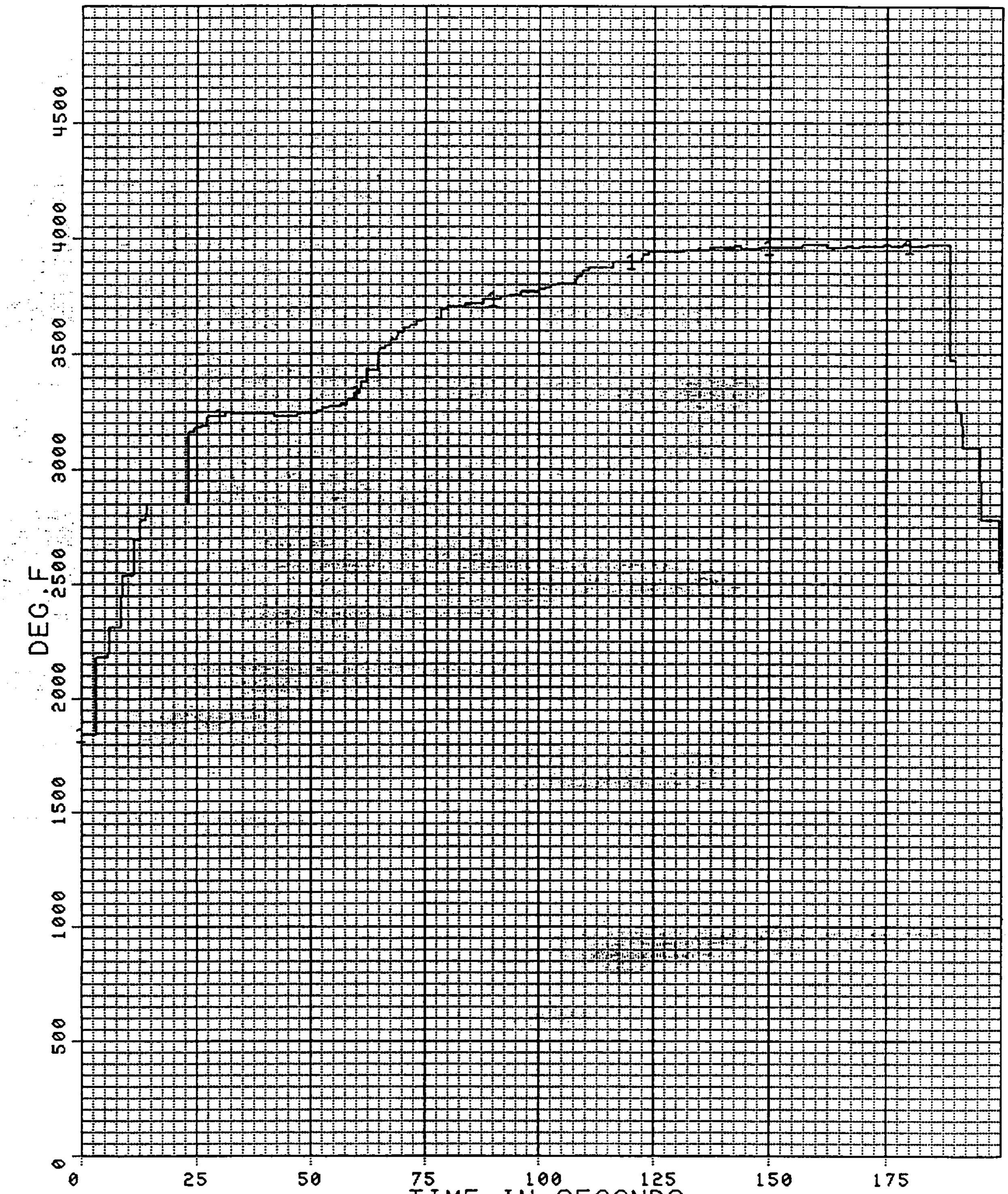
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	56.7042		50.769	
BAG WEIGHT ONLY	8.1264		8.1264	
SPECIMEN WEIGHT ONLY	48.5778		42.6426	
EMISSIVITY	.154			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.271	.541	.235	.507
THICKNESS AT POINT A	.271	.540	.252	.516
THICKNESS AT POINT B	.270	.540	.248	.517
THICKNESS AT POINT C	.270	.543	.268	.540
THICKNESS AT POINT D	.272	.542	.267	.531
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ / QUALITY / 9/19/89		BZ / FORD 23 / 2 14 90	

POST-TEST RESULTS/COMMENTS:

1-190-DD
DATE = 2/13/90 AVERAGE INTERVAL 0.1 SEC TIME = 21:40:40.0 TO 21:44: 0.0

PROCESSING DATE 02/13/90

L PYR X CHANNEL NO. 62

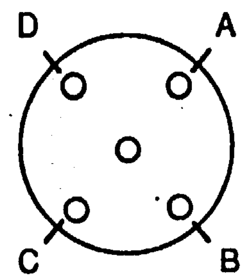


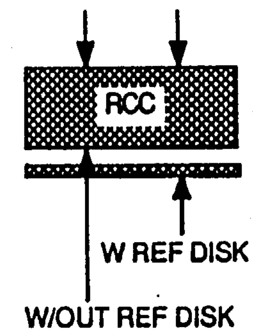
ROC TAL ABORT VERIFICATION TSTS LFT ARM # 279/7 & R 500 HR 90044R01 ROD4 2

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 279(7) RUN NO: C-190-DD TEST CONDITION: 3300F, 320psf

Δm = 19.1213



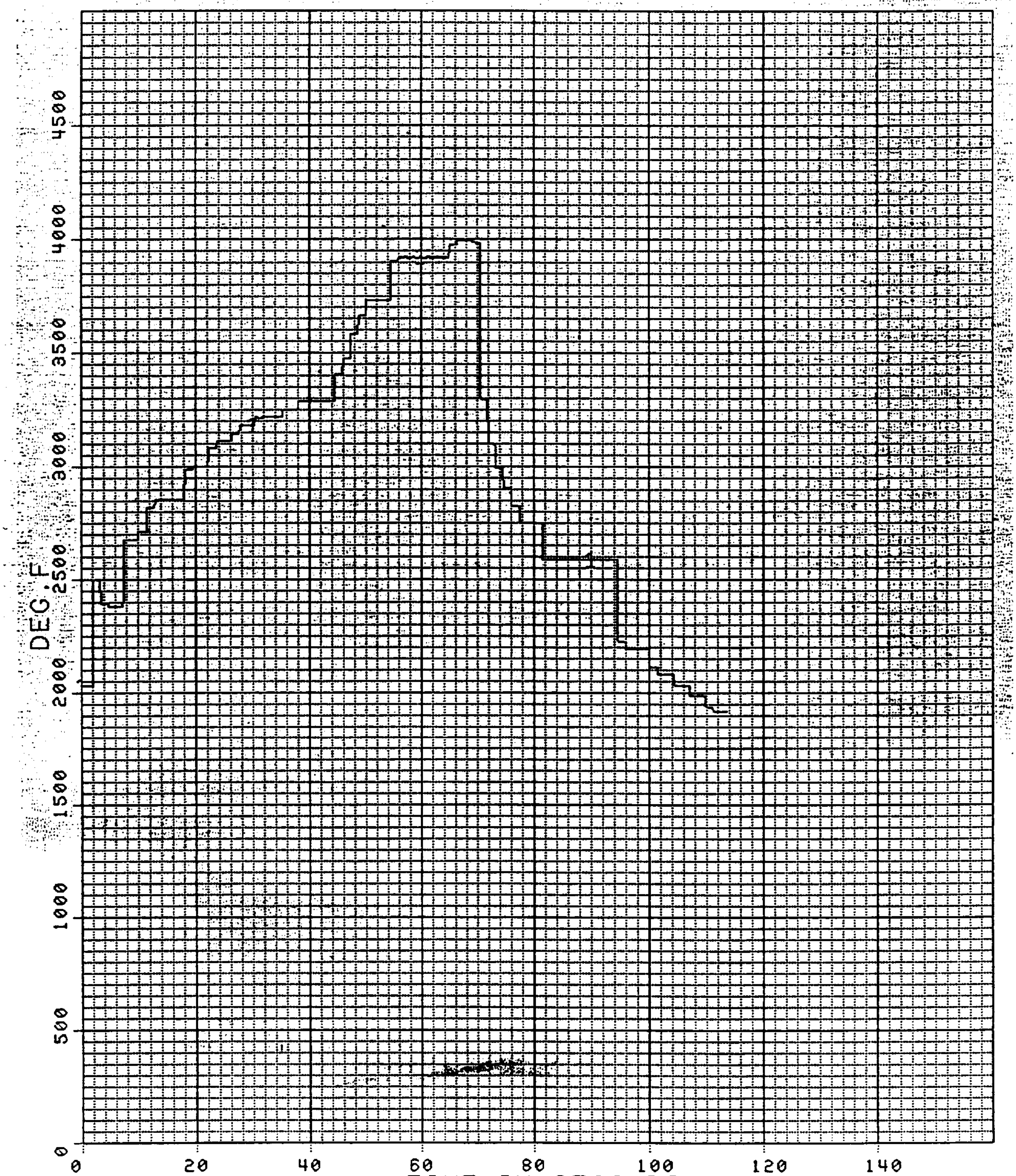


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	56.4933		37.372	
BAG WEIGHT ONLY	8.2190		8.2190	
SPECIMEN WEIGHT ONLY	48.2753		29.163	
EMISSIVITY	.153			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.272	.544	.143	.434
THICKNESS AT POINT A	.271	.542	.158	.446
THICKNESS AT POINT B	see ~~.272~~ .277	.546	.161	.442
THICKNESS AT POINT C	.277	.547	.168	.445
THICKNESS AT POINT D	.274	.544	.167	.451
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ / BOEING QUALITY / 9/19/89		BZ / FORD 23 / 2 14 90	

POST-TEST RESULTS/COMMENTS:

1-195-DD PROCESSING DATE 02/15/90
DATE = 2/15/90 AVERAGE INTERVAL 0.1 SEC TIME = 21:33: 8.0 TO 21:35: 1.5

L PYR X CHANNEL NO. 62



RCC TAL ABORT VERIFICATION TSTS L ARM MOD 280/8 & R 500 HR 90046R01 RCD4 1

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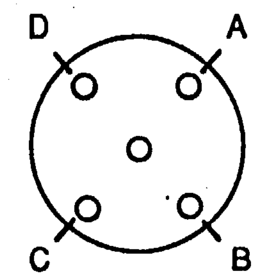
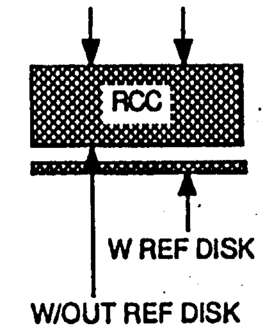
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 280 (8) RUN NO: ______ TEST CONDITION: 3300 F, 100 psf

$\Delta m = 3.0588$



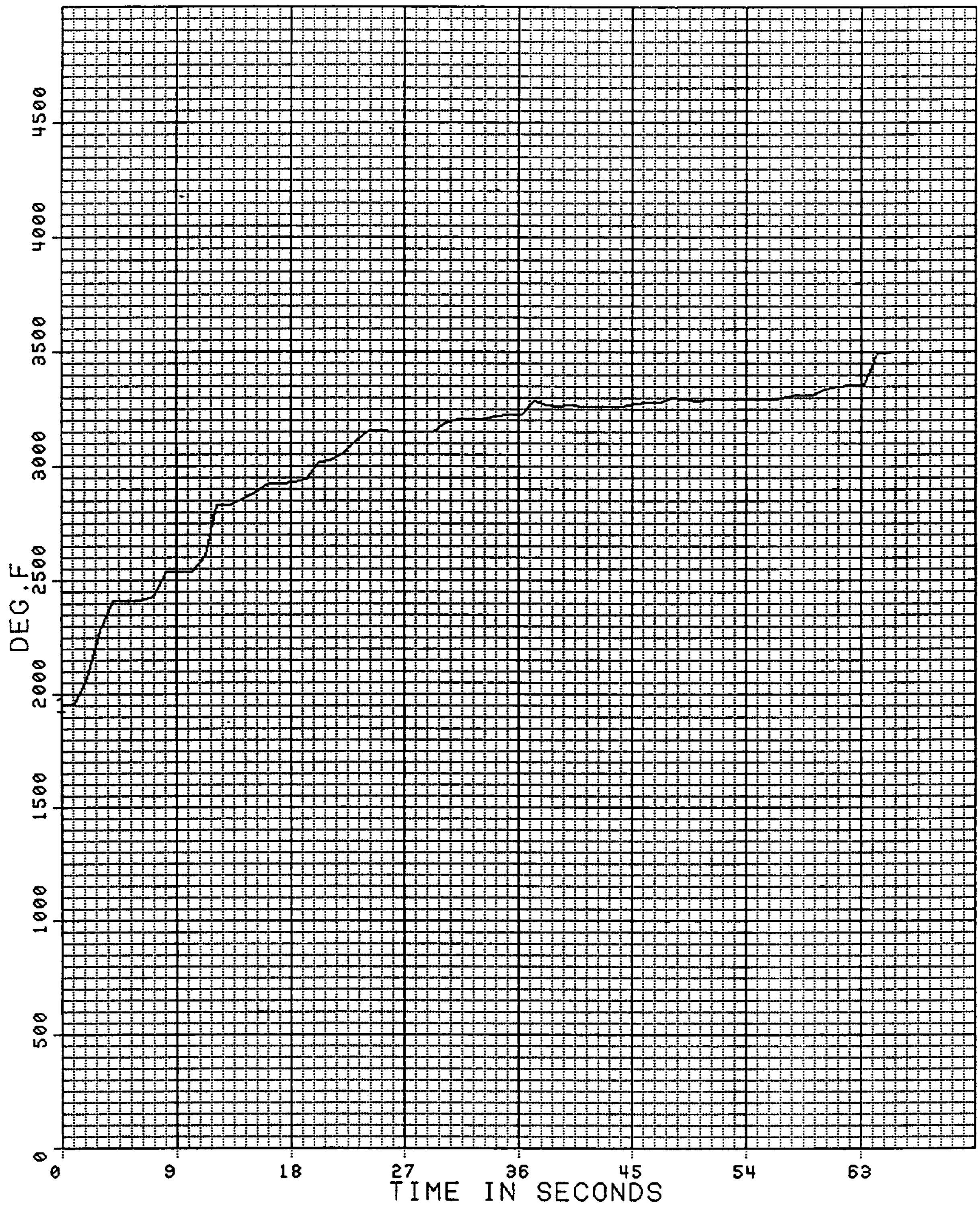


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.3998		54.341	
BAG WEIGHT ONLY	9.1064		8.1064	
SPECIMEN WEIGHT ONLY	49.2934		46.2346	
EMISSIVITY	.159			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	~~.25~~ .275 IE	.547	.273	.527
THICKNESS AT POINT A	.277	.545	.273	.541
THICKNESS AT POINT B	.277	.545	.269	.542
THICKNESS AT POINT C	.277	.546	.269	.539
THICKNESS AT POINT D	.278	.547	.266	.542
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ	9/19/89	BZ	FORD 23 2/15/90

POST-TEST RESULTS/COMMENTS:

1-143-DD
PROCESSING DATE 12/08/89
DATE = 12/ 8/89 AVERAGE INTERVAL 1.0 SEC TIME = 21:10:38.0 TO 21:11:44.2

L PYR X CHANNEL NO. 62



ROC TAL ABORT VERIFICATION TESTS LFT ARM MOD 281/9 R 500 BTU HRS 9342R01 ROD4 1

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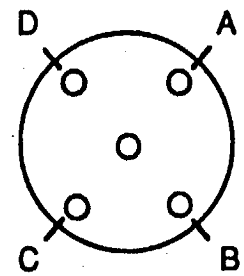
9/8/89

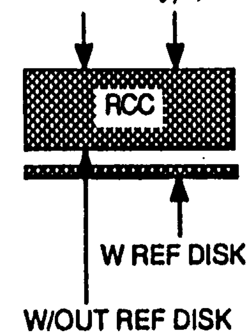
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 281/19 RUN NO: ______ TEST CONDITION: 3300 F, 100psf, 63 sec.

$\Delta m = .7176$

	PRE-TEST H2		POST-TEST	
BAG AND SPECIMEN WEIGHT			57.2074	
BAG WEIGHT ONLY			8.2043	
SPECIMEN WEIGHT ONLY			49.0031 ~~49.0098~~	
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.276	.548	.276	.548
THICKNESS AT POINT A	.277	.549	.285	.552
THICKNESS AT POINT B	.279	.549	.282	.554
THICKNESS AT POINT C	.279	.549	.282	.550
THICKNESS AT POINT D	.278	.548	.278	.549
			E. .271	.546
REFERENCE DISK THICKNESS	.267		.268	
TECH / QA / DATE	G.J. 12.8.89		WBm 12-12-89	





BOEING 23 QUALITY

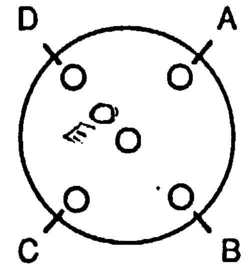
POST-TEST RESULTS/COMMENTS:

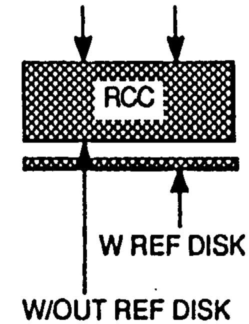
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 281 (9) RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	579250			
BAG WEIGHT ONLY	8.1990			
SPECIMEN WEIGHT ONLY	49.7260			
EMISSIVITY	.151			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.276	.547	.276	.548
THICKNESS AT POINT A	.278	.547	.285	.552
THICKNESS AT POINT B	.279	.549	.282	.554
THICKNESS AT POINT C	.281	.549	.282	.550
THICKNESS AT POINT D	.279	.549	.278	.549 546
			E – .271	
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BB BOEING QUALITY 9/19/89			



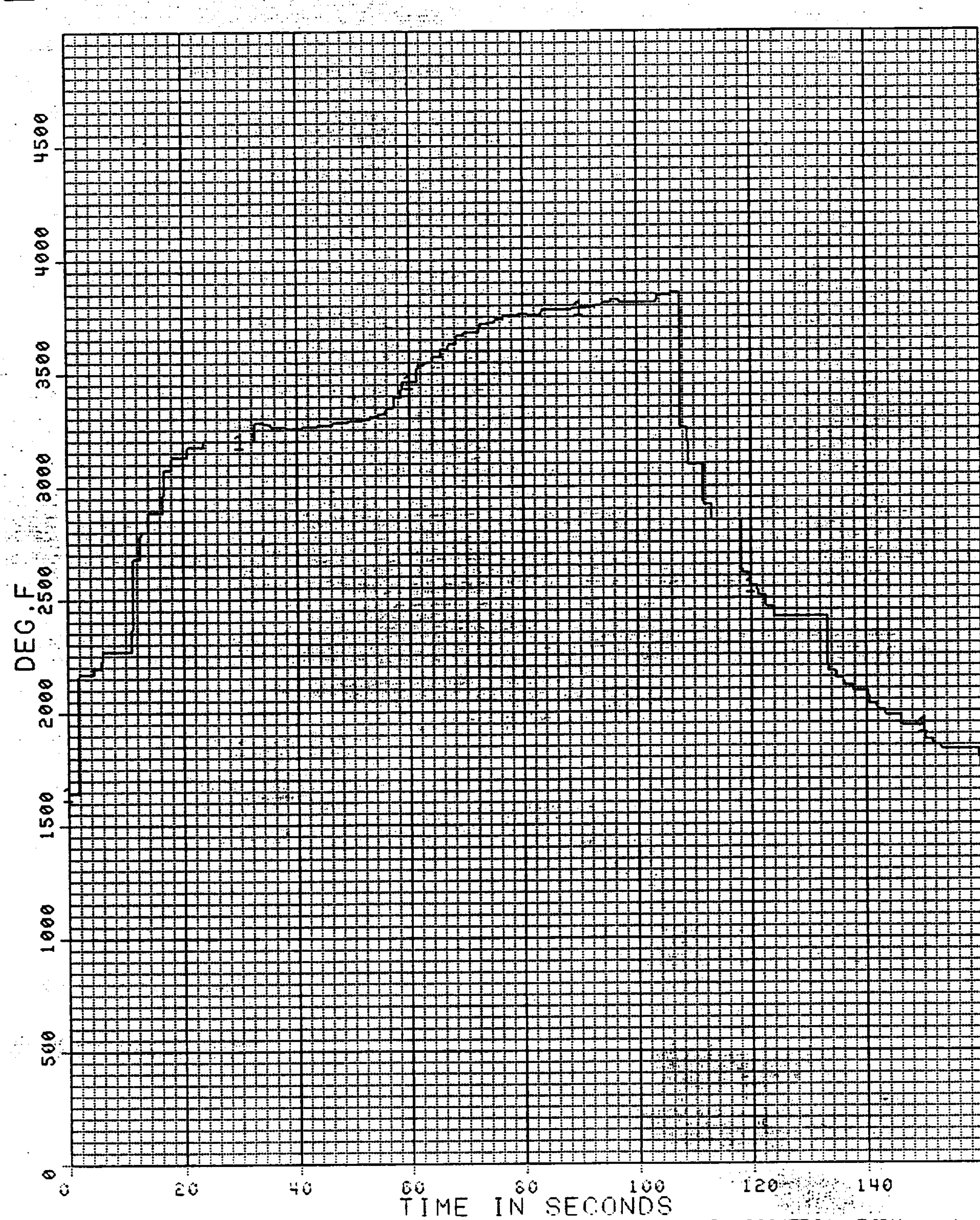


POST-TEST RESULTS/COMMENTS:

1-196-DD
DATE = 2/16/90 AVERAGE INTERVAL 0.1 SEC TIME = 18:13:48.0 TO 18:16:28.0

PROCESSING DATE 02/16/90

L PYR X CHANNEL NO. 62

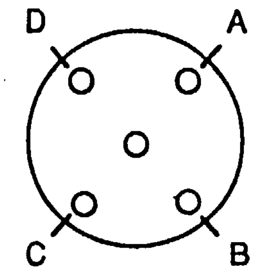


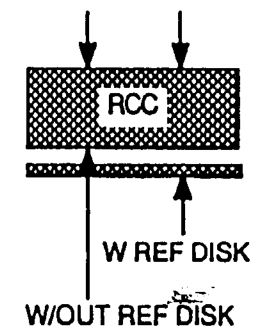
RCC TAL ABORT VERIFICATION TSTS L ARM MOD 282/10 & R 500 HR 90047R01 RCD4 1

PAGE 5 OF TPS TA-2-75
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 282 (10) RUN NO: ______ TEST CONDITION: 3300 F 320 psf
Am = 8.6131





	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	58.3311		49.718	
BAG WEIGHT ONLY	8.1210		8.1216	
SPECIMEN WEIGHT ONLY	~~50.2110~~ 50.2101		41.597	
EMISSIVITY	.156			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.278	.547	.230	.503
THICKNESS AT POINT A	.279	.548	.250	.519
THICKNESS AT POINT B	.280	.548	.255	.525
THICKNESS AT POINT C	.281	.550	.245	.517
THICKNESS AT POINT D	.281	.550	.238	.513
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ 12 18 89		BZ FORD 23 2 16 90	

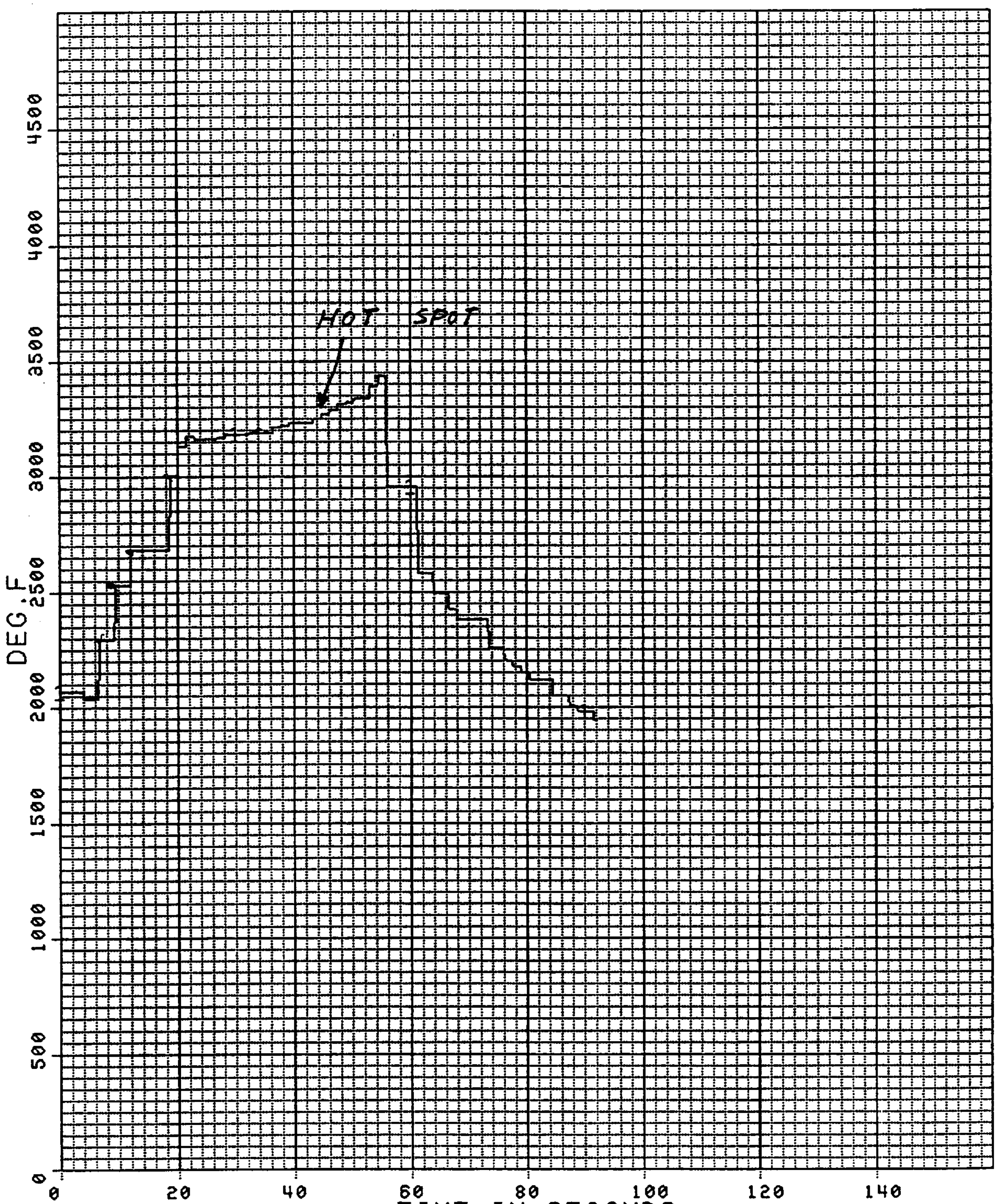
POST-TEST RESULTS/COMMENTS:

QA NOTE: PER DR AT930002 THIS TEST MODEL WAS BAKED OUT + REWEIGHED

1-156-DD
DATE = 12/19/89 AVERAGE INTERVAL 0.1 SEC TIME = 18:48:22.0 TO 18:49:54.0

PROCESSING DATE 12/19/89

L PYR X CHANNEL NO. 62

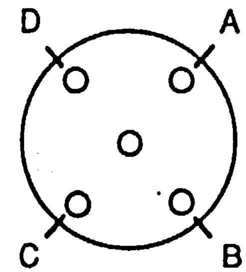


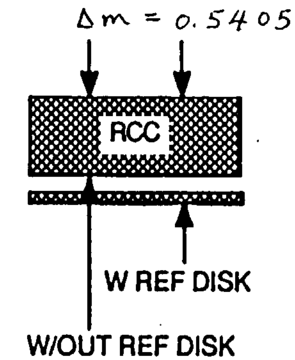
ROC TAL ABORT VERIFICATION TESTS L ARM 283/13 / R 500 BTU HRS 9353R01 ROD4 1

PAGE 5 OF TPS TA-2275
9/18/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 283 (13) RUN NO: ______ TEST CONDITION: 3300 F, 200 psf, 45 sec.





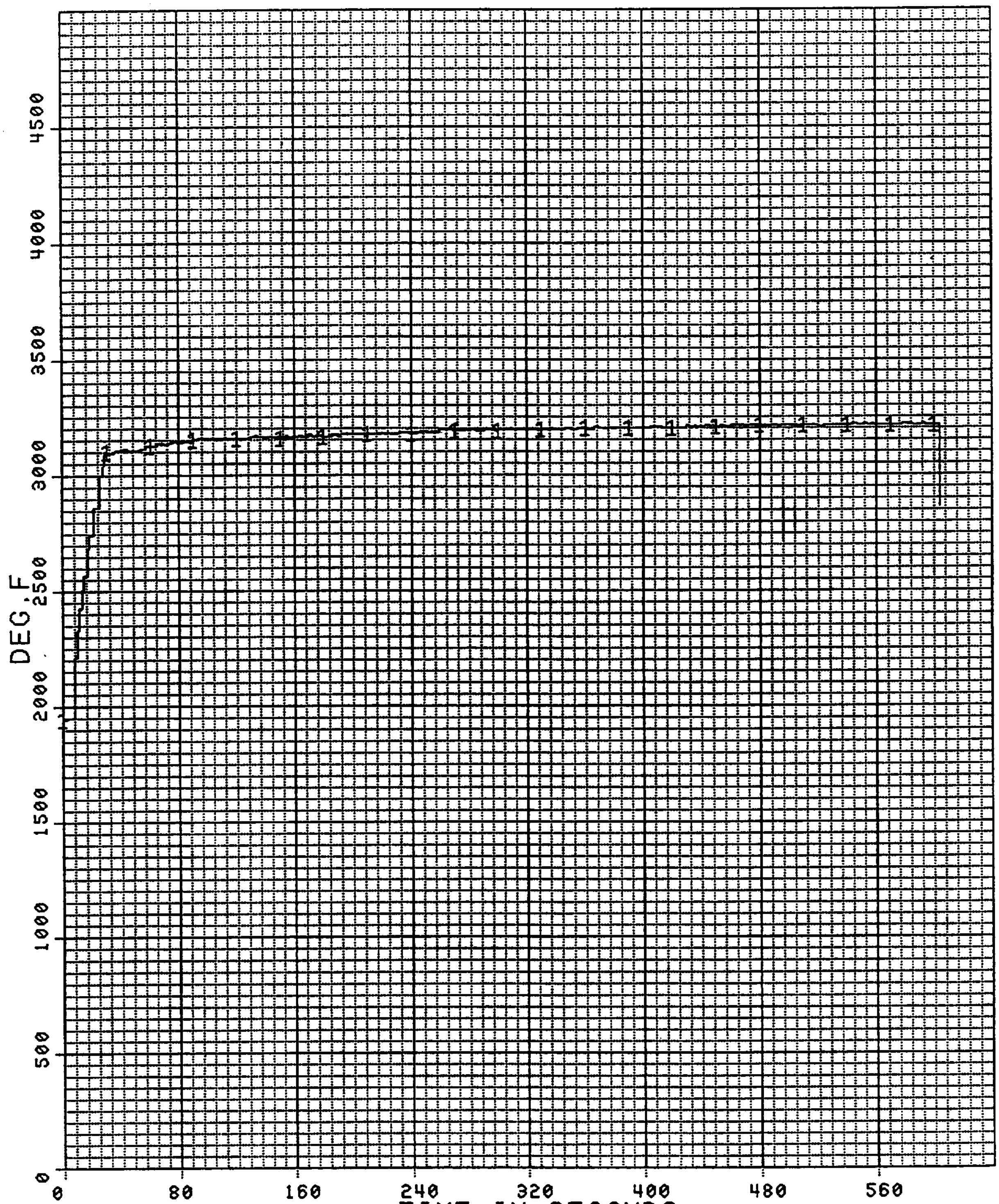
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	55.2655		54.725	
BAG WEIGHT ONLY	8.0287		8.0287	
SPECIMEN WEIGHT ONLY	47.2368		46.6963	
EMISSIVITY	.138			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.278	.548	.283	.546
THICKNESS AT POINT A	.280	.548	.285	.555
THICKNESS AT POINT B	.280	.548	.288	.557
THICKNESS AT POINT C	.280	.548	.287	.555
THICKNESS AT POINT D	.279	.548	.288	.557
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ / BOEING QUALITY / 9/19/89		BZ / 12 20 89	

POST-TEST RESULTS/COMMENTS:

1-153-DD
DATE = 12/18/89 AVERAGE INTERVAL 0.1 SEC TIME = 19:14:13.0 TO 19:24:17.0

PROCESSING DATE 12/18/89

L PYR X CHANNEL NO. 62



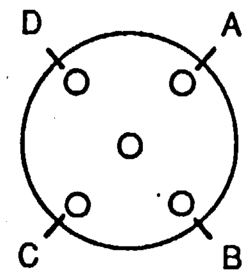
ROC TAL ABORT VERIFICATION TESTS L ARM 284/14 / R 500 BTU HRS 9352R01 ROD4 1

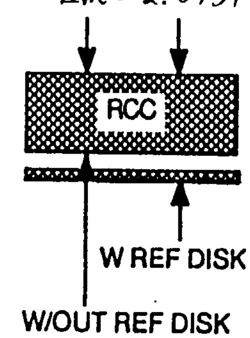
PAGE 5 OF TPS TA-2275
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 284 (14) RUN NO: ______ TEST CONDITION: 3200 F, 200psf, 600 sec

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	55.2791		53.186	
BAG WEIGHT ONLY	8.0510		8.0510	
SPECIMEN WEIGHT ONLY	47.2281		45.1350	
EMISSIVITY	.143			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.277 .278	.548 .548	.219	.564
THICKNESS AT POINT A	.277 .280	.548 .548	.287	.565
THICKNESS AT POINT B	.279 .281	.546 .549	.284	.559
THICKNESS AT POINT C	.277 .280	.547 .548	.284	.567
THICKNESS AT POINT D	.278 .280	.547 .548	.287	.563
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ	BOEING QUALITY 9/19/89	BZ 12 19 89	QUALITY

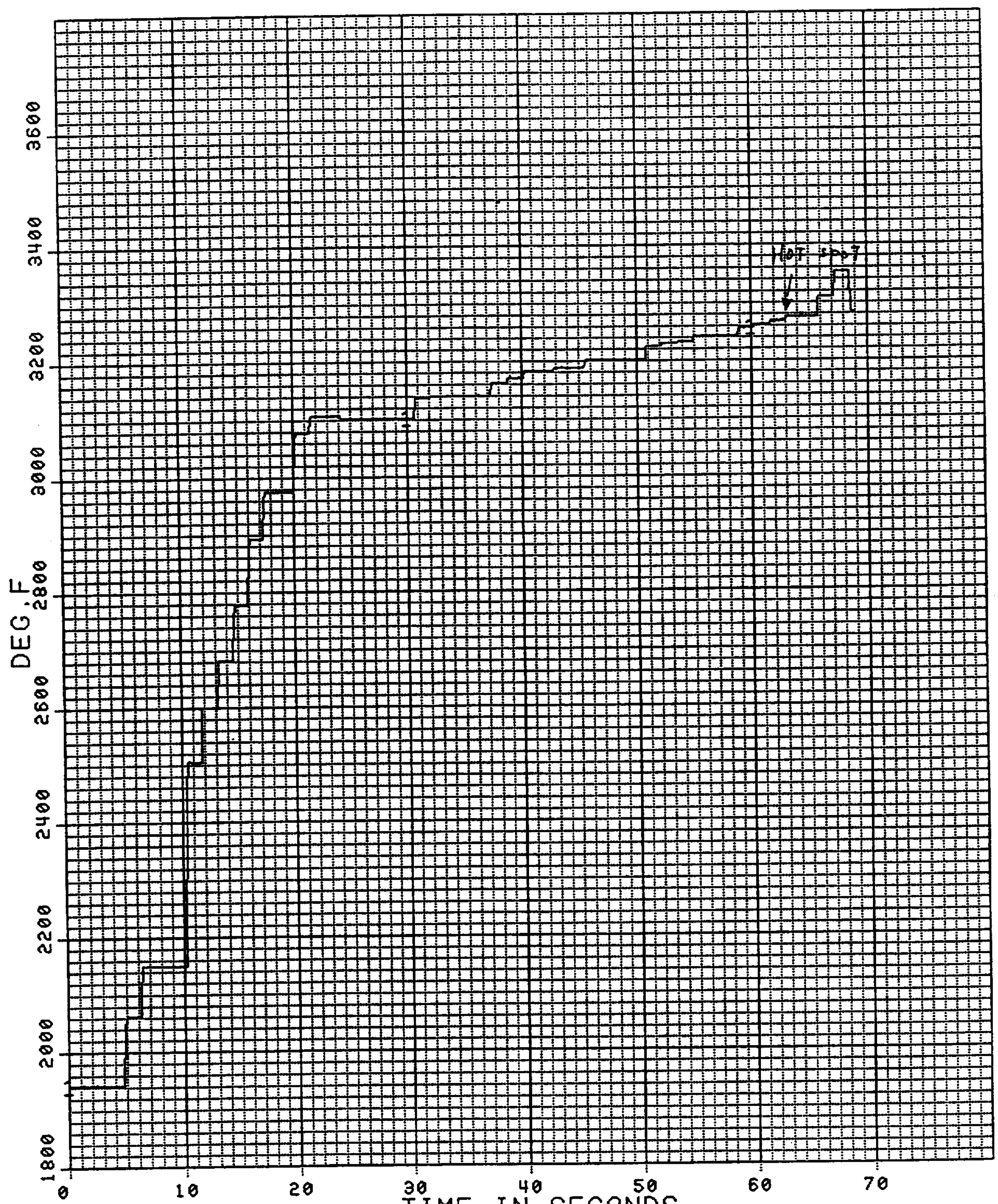




POST-TEST RESULTS/COMMENTS:

1-162-DD PROCESSING DATE 01/12/90
DATE = 1/11/90 AVERAGE INTERVAL 0.1 SEC TIME = 21: 7:46.0 TO 21: 8:55.0

L PYR X CHANNEL NO. 62

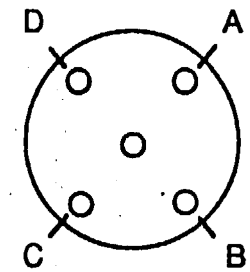


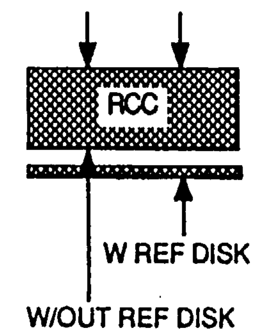
ROC TAL ABORT VERIFICATION TESTS LFT ARM MOD 285/15 & RT 500 BTU HRS R01 ROD4 3

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 285 (15) RUN NO: 1-162-DD TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	55.8422		55.067	
BAG WEIGHT ONLY	8.3514		8.3514	
SPECIMEN WEIGHT ONLY	47.4908			
EMISSIVITY	.134			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.278	.547	.285	.550
THICKNESS AT POINT A	.282	.549	.290	.557
THICKNESS AT POINT B	.280	.547	.287	.558
THICKNESS AT POINT C	.279	.547	.287	.554
THICKNESS AT POINT D	.280	.549	.289	.558
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ BOEING 7 QUALITY 9/19/89		BZ BOEING 23 QUALITY 1 13 90	



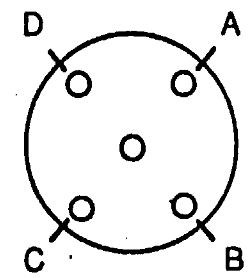


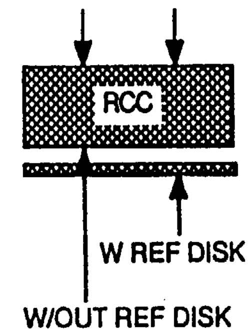
POST-TEST RESULTS/COMMENTS:
PRE-TEST OBSERVATION: METAL SHAVING LOCATED AT APPROX. "C" LOCATION, APPEARS TO BE ALUMINUM.
REF. DR # AT930003 (SEE ATTACHED SHEET FOR REWEIGHT)

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 285 (15) RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	55.8391			
BAG WEIGHT ONLY				
SPECIMEN WEIGHT ONLY				
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE				
THICKNESS AT POINT A				
THICKNESS AT POINT B				
THICKNESS AT POINT C				
THICKNESS AT POINT D				
REFERENCE DISK THICKNESS				
TECH / QA / DATE				





POST-TEST RESULTS/COMMENTS:

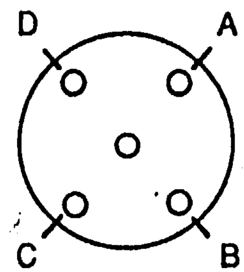
QA NOTE: PER DR AT930003, THIS MODEL WAS BAKED OUT + REWEIGHED.

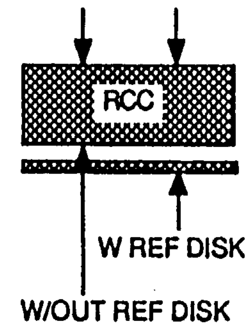
PAGE 5 OF TPS TA-2275
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 286 (16) RUN NO: 1-163 + DD TEST CONDITION: ____

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	55.6938		54.884	
BAG WEIGHT ONLY	8.1886		8.1886	
SPECIMEN WEIGHT ONLY	47.5052			
EMISSIVITY	.143			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.277	.547	.282	.555
THICKNESS AT POINT A	.279	.548	.292	.557
THICKNESS AT POINT B	.277	.547	.284	.555
THICKNESS AT POINT C	.278	.548	.281	.554
THICKNESS AT POINT D	.279	.549	.280	.554
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ / BOEING 7 QUALITY / 9/19/89		BZ / BOEING 23 QUALITY / 1 T3 90	



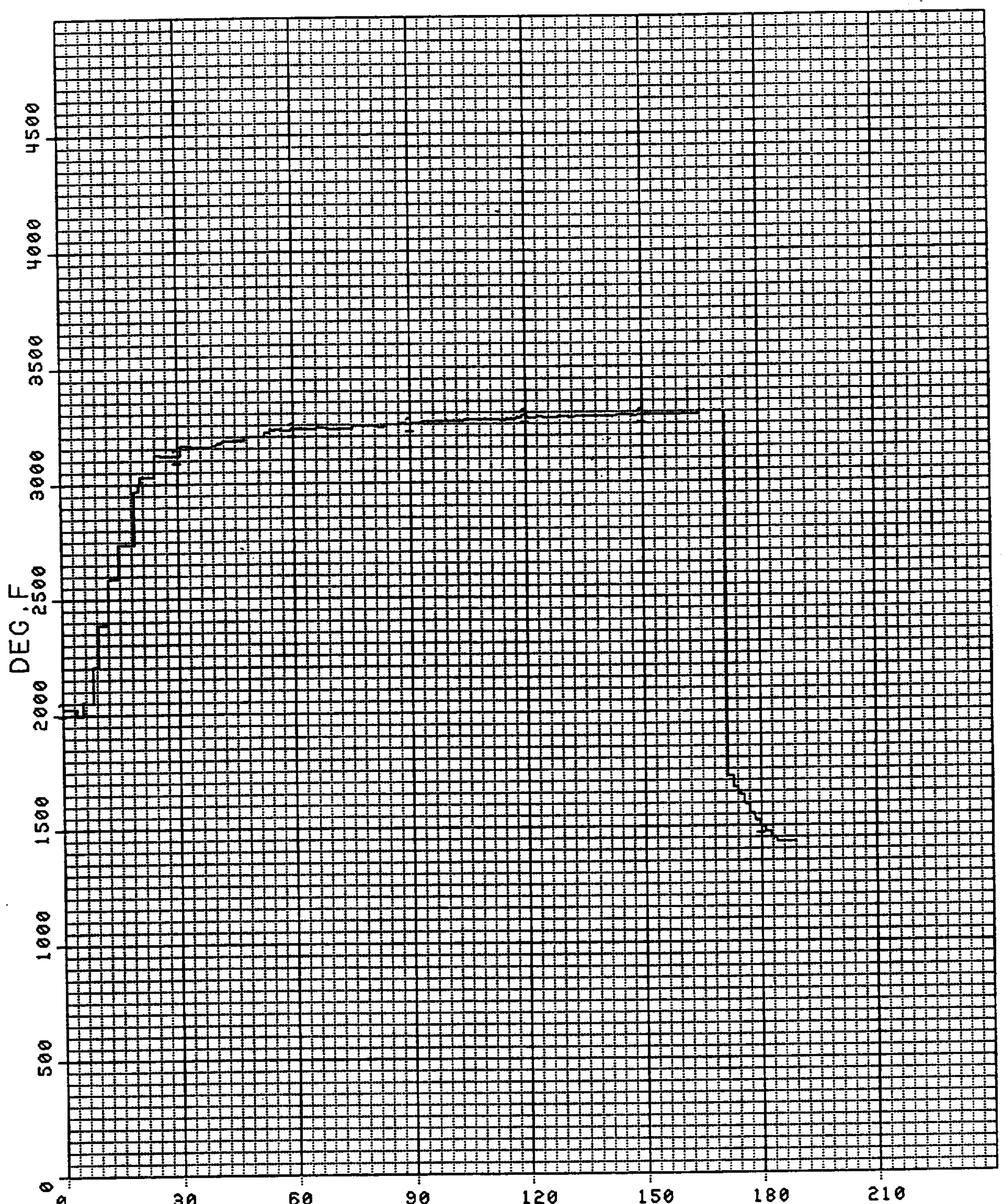


POST-TEST RESULTS/COMMENTS: This model # is 286-18

1-155-DD
DATE = 12/19/89 AVERAGE INTERVAL 0.1 SEC TIME = 16:41:17.0 TO 16:44:26.0

PROCESSING DATE 12/19/89

L PYR X CHANNEL NO. 62



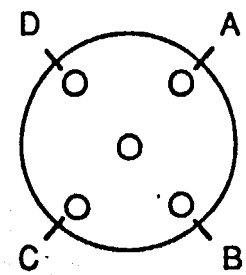
RCC TAL ABORT VERIFICATION TESTS L ARM 287/17 / R 500 BTU HRS 9353R01 RCD4 1

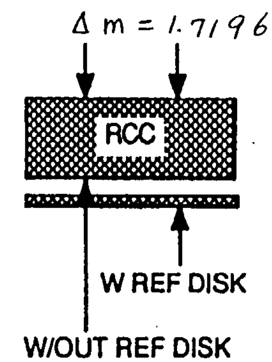
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

9/8/89

TEST ARTICLE NO: 287 (17) RUN NO: ______ TEST CONDITION: 3300 F, 200psf, 150 sec.

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	55.8696		54.150	
BAG WEIGHT ONLY	8.3736		8.3736	
SPECIMEN WEIGHT ONLY	47.4960		45.7764	
EMISSIVITY	.144			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.277	.545	.273	.544
THICKNESS AT POINT A	.279	.548	.285	.554
THICKNESS AT POINT B	~~.28~~ .277	.545	.279	.544
THICKNESS AT POINT C	.278	.547	.280	.545
THICKNESS AT POINT D	.279	.547	.287	.555
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ	BOEING 7 QUALITY 9/19/89	BZ 122089	BOEING 23 QUALITY

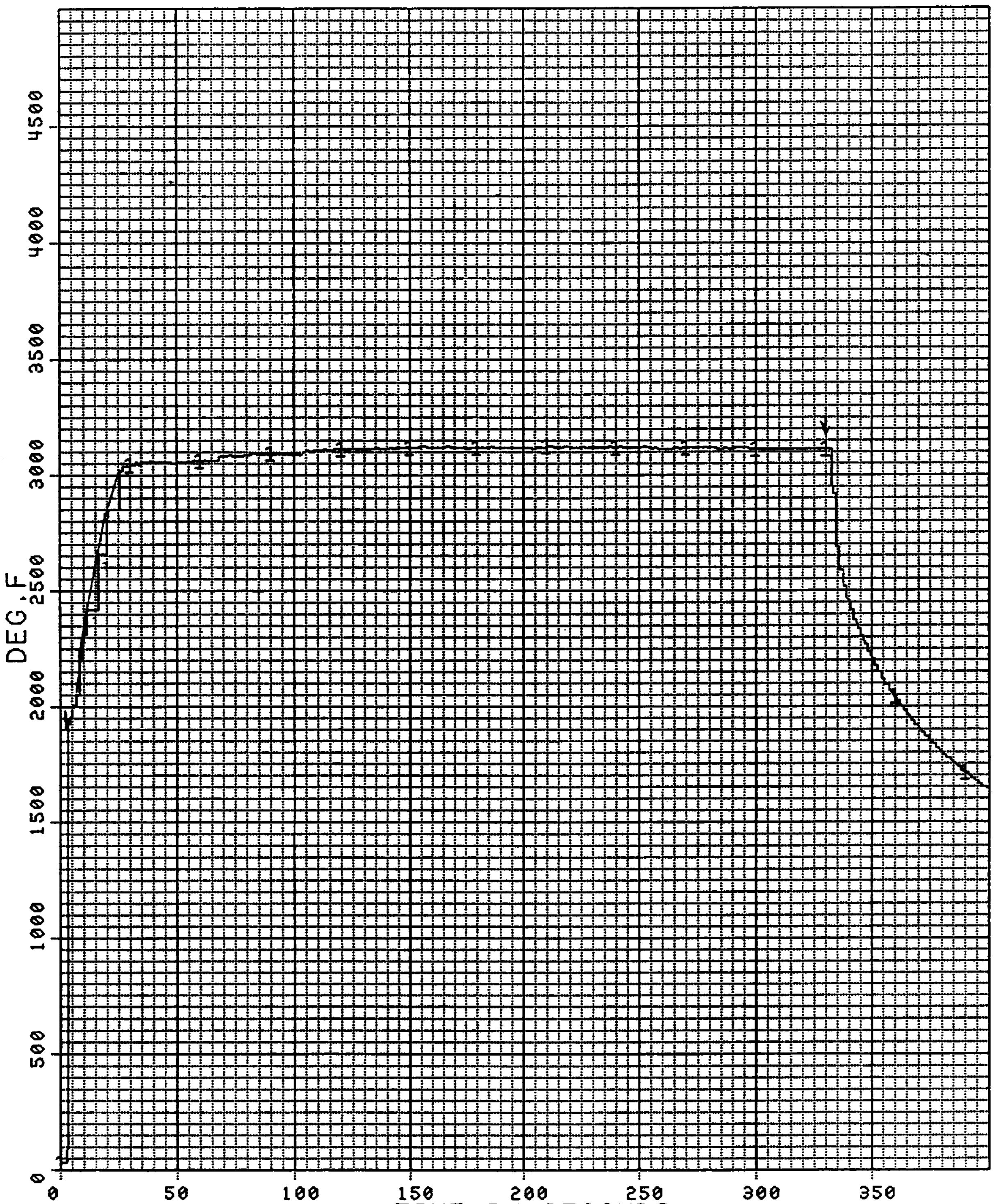




POST-TEST RESULTS/COMMENTS:

1-168-DD PROCESSING DATE 01/22/90
DATE = 1/19/90 AVERAGE INTERVAL 0.1 SEC TIME = 22:52:22.0 TO 22:59: 2.0

L PYR X CHANNEL NO. 62



ROC TAL ABORT VERIFICATION TESTS LFT ARM MOD 288-18 & RT 500 BTU HRS R01 ROD4 1

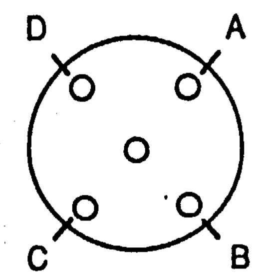
C-3

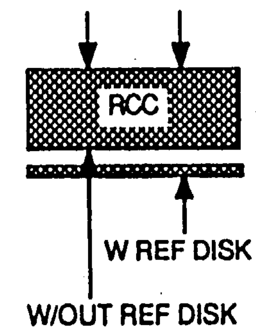
3200F

9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 288 (18) RUN NO: ______ TEST CONDITION: 3200F, 200 psf





Δm = 1.7374

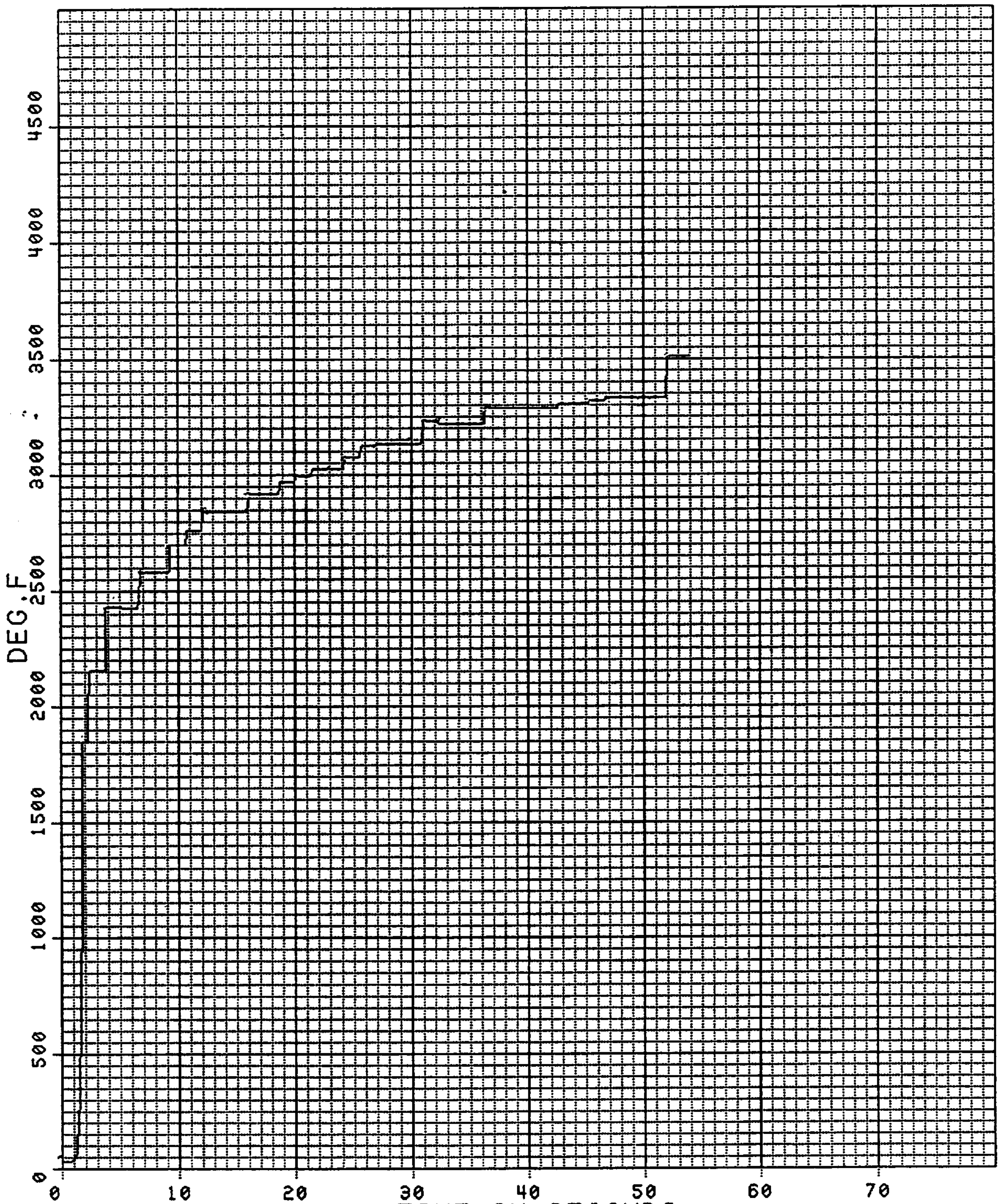
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	64.7874		63.050	
BAG WEIGHT ONLY	16.8400		16.8400	
SPECIMEN WEIGHT ONLY	47.9474		46.2100	
EMISSIVITY	.132			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.280	.548	.282	.556
THICKNESS AT POINT A	.280	.548	.287	.560
THICKNESS AT POINT B	.281	.549	.282	.549
THICKNESS AT POINT C	.281	.550	.285	.556
THICKNESS AT POINT D	.281	.550	.284	.555
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ / BOEING 7 QUALITY / 9/19/89		BZ / BOEING 23 QUALITY / 23	

POST-TEST RESULTS/COMMENTS:

1-146-DD
DATE = 12/13/89 AVERAGE INTERVAL 0.1 SEC TIME = 17: 3: 8.0 TO 17: 4: 2.0

PROCESSING DATE 12/13/89

L PYR X CHANNEL NO. 62

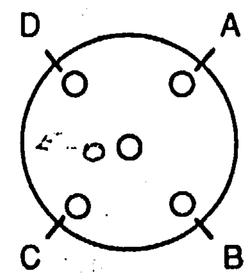


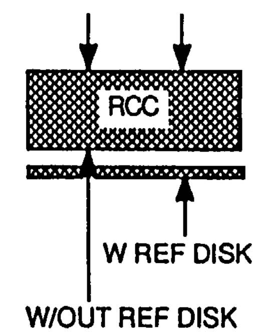
ROC TAL ABORT VERIFICATION TESTS L ARM 171/AB-12 7 R 500 BTU HRS 9347R01 ROD4 1

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 171/AB-12 RUN NO: ______ TEST CONDITION: 3300 F, 100psf, 58 sec.

$\Delta m = 0.3525$





	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	56.9821		56.6396	
BAG WEIGHT ONLY	12.5579		12.5579	
SPECIMEN WEIGHT ONLY	44.4242		44.0717	
EMISSIVITY	.164			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.264	.534	.265	.534
THICKNESS AT POINT A	.267	.534	.269 ~~.278~~	.539
THICKNESS AT POINT B	.265	.533	.267 ~~.277~~	.536
THICKNESS AT POINT C	.264	.535	.265 ~~.276~~	.537
THICKNESS AT POINT D	.265	.536	.269 ~~.271~~	.537
			E .260	E .5360
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BZ		BZ	12 13 89

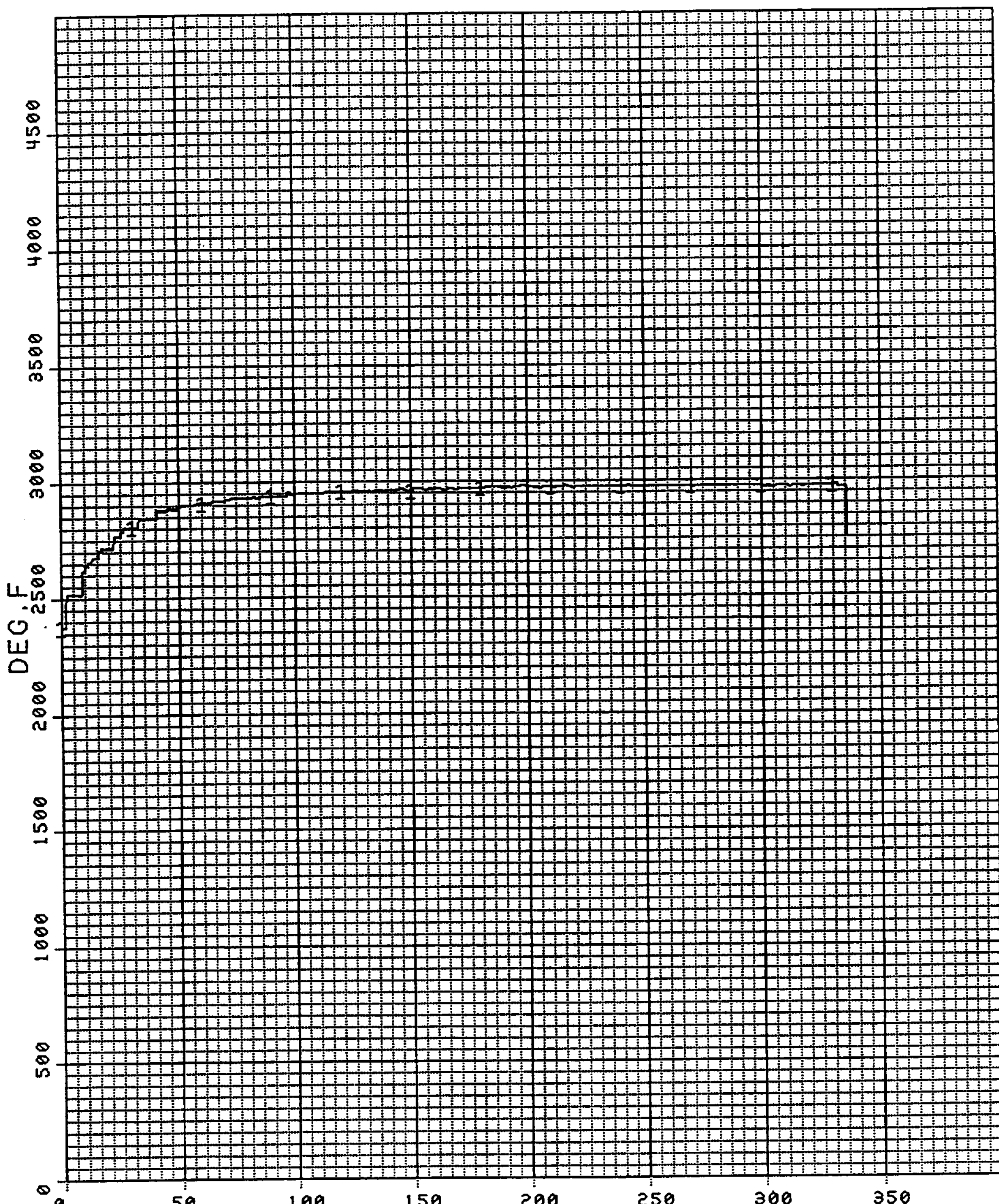
BOEING 23 QUALITY

BOEING 23 QUALITY

POST-TEST RESULTS/COMMENTS:

1-148-DD
PROCESSING DATE 12/14/89
DATE = 12/14/89 AVERAGE INTERVAL 0.1 SEC TIME = 17:20: 5.0 TO 17:25:41.0

L PYR X CHANNEL NO. 62

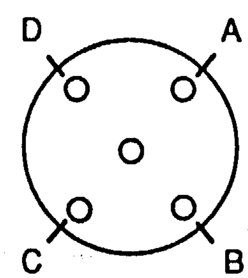


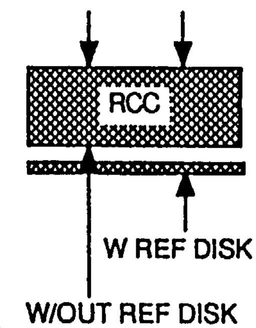
ROC TAL ABORT VERIFICATION TESTS L ARM 173/AB-13 / R 500 BTU HRS 9348R01 ROD4 1

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 173/AB-13 RUN NO: ______ TEST CONDITION: 2975 F, 100 psf, 353 sec

$\Delta m = 0.3032$



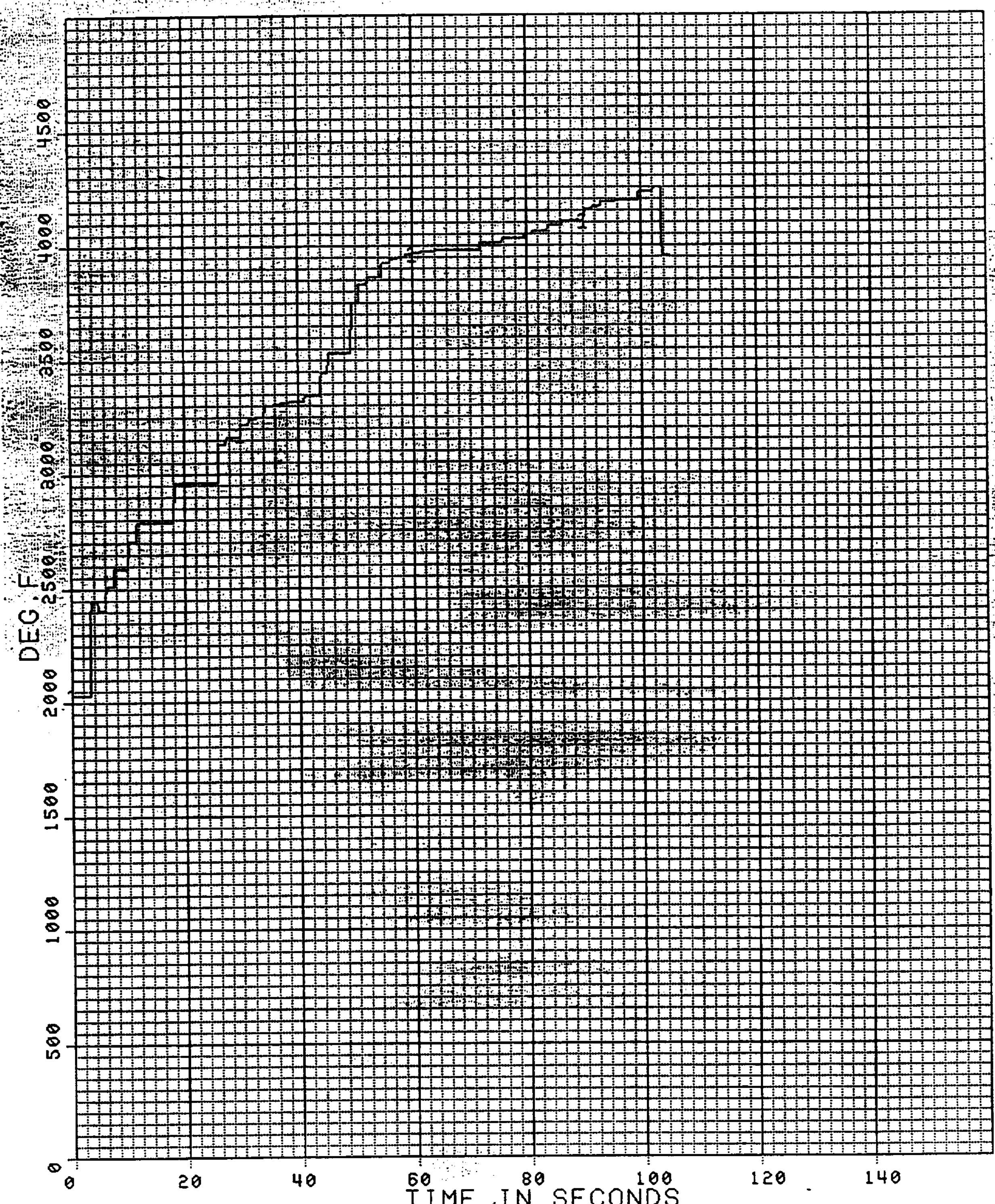


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.6922		57.389	
BAG WEIGHT ONLY	12.5980		12.5980	
SPECIMEN WEIGHT ONLY	45.0942		44.791	
EMISSIVITY	.167			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.270	.539	.270	.542
THICKNESS AT POINT A	.271	.542	.271	.542
THICKNESS AT POINT B	.273	.539	.271 ~~.276~~	.539
THICKNESS AT POINT C	.269	.539	.269	.539
THICKNESS AT POINT D	.271	.542	.272	.539
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BZ	BOEING 23 QUALITY	BZ	BOEING 23 QUALITY 12 15 89

POST-TEST RESULTS/COMMENTS:

1-193-DD
DATE = 2/14/90 AVERAGE INTERVAL 0.1 SEC TIME = 18:29:26.0 TO 18:31:11.0
PROCESSING DATE 02/14/90

L PYR X CHANNEL NO. 62



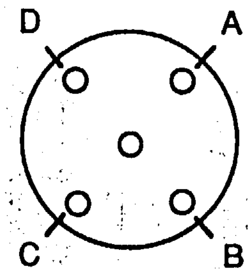
RCC TAL ABORT VERIFICATION TSTS L ARM #175/AB 14 & R 500 HR 9004HR01 RCD4 1

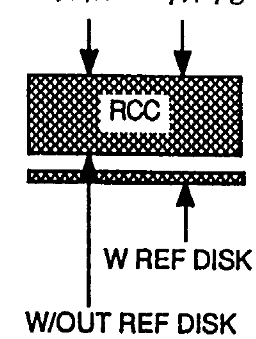
PAGE 2 OF 2
TPS TA-23
2/14/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 175/AB-14 RUN NO: ______ TEST CONDITION: 3300 F, 100 psf

$\Delta m = 9.176$





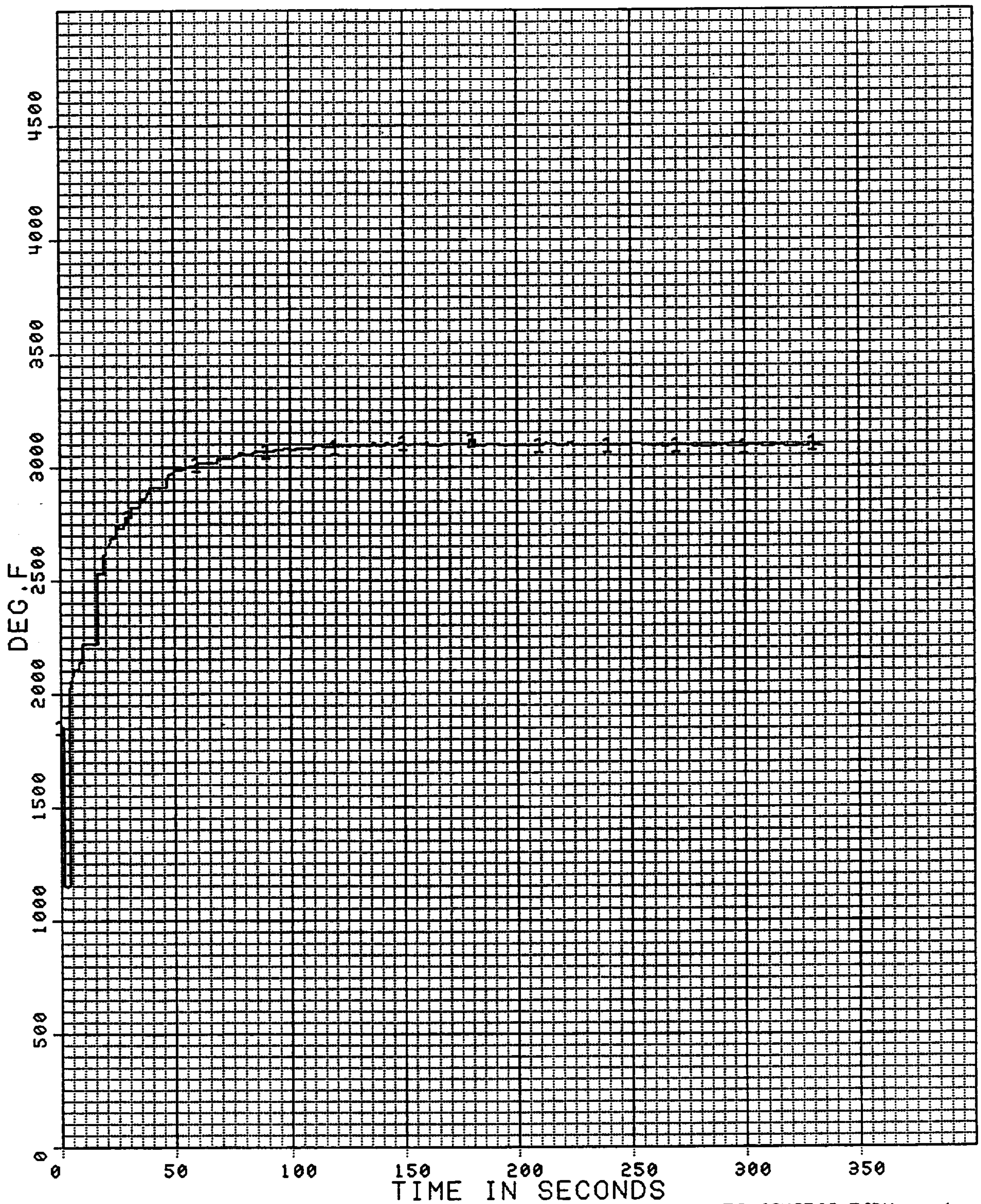
	PRE-TEST W/OUT REF DISK	PRE-TEST W REF DISK	POST-TEST W/OUT REF DISK	POST-TEST W REF DISK
BAG AND SPECIMEN WEIGHT	57.8976		48.721	
BAG WEIGHT ONLY	12.190		12.190	
SPECIMEN WEIGHT ONLY	45.707		36.531	
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.274	.544	.228	.502
THICKNESS AT POINT A	.273	.542	.245	.514
THICKNESS AT POINT B	.272	.541	.248	.515
THICKNESS AT POINT C	.274	.543	.245	.515
THICKNESS AT POINT D	.274	.543	.242	.514
REFERENCE DISK THICKNESS	.262		.267	
TECH / QA / DATE	BZ / FORD 38	2 14 90	BZ / FORD 23	2 15 90

POST-TEST RESULTS/COMMENTS:

1-149-DD
DATE = 12/14/89 AVERAGE INTERVAL 0.1 SEC TIME = 18:28:23.0 TO 18:33:57.0

PROCESSING DATE 12/14/89

L PYR X CHANNEL NO. 62



ROC TAL ABORT VERIFICATION TESTS L ARM 177/AB-15 / R 500 BTU HRS 9348R02 ROD4 1

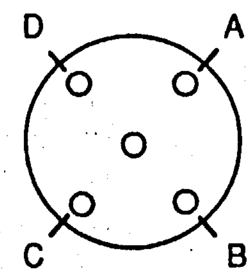
PAGE 3 OF 3 TT'S 1A-2179
12/11/89

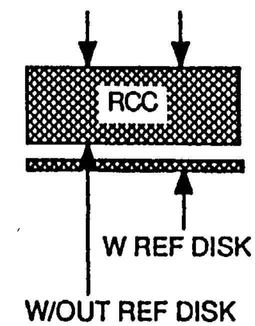
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 177/AB-15 RUN NO: ______ TEST CONDITION: 3100 F, 100 psf 330 sec.

Δm = 6278

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.8388		57.211	
BAG WEIGHT ONLY	12.4051		12.4051	
SPECIMEN WEIGHT ONLY	45.4337		44.8059	
EMISSIVITY	.162			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.273	.542	.278	.547
THICKNESS AT POINT A	.273	.541	.274	.545
THICKNESS AT POINT B	.274	.540	.271	.542
THICKNESS AT POINT C	.274	.543	.273	.543
THICKNESS AT POINT D	~~.273~~ .271	.543	.271	.543
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BZ	BOEING 23 QUALITY	BZ	BOEING 23 QUALITY 12 15 89



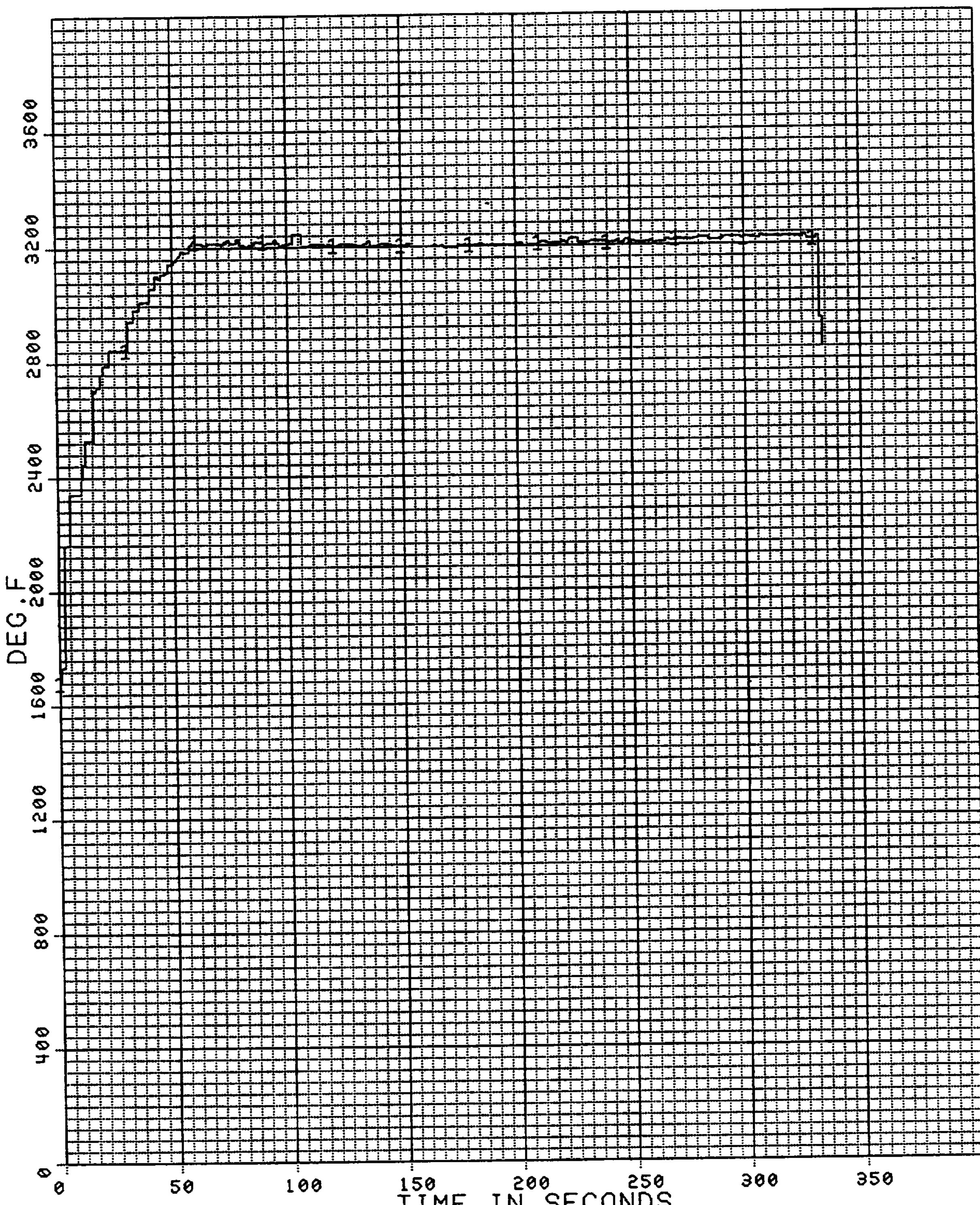


POST-TEST RESULTS/COMMENTS:

1-150-DD
DATE = 12/15/89 AVERAGE INTERVAL 0.1 SEC TIME = 16:31:25.0 TO 16:36:59.0

PROCESSING DATE 12/15/89

L PYR X CHANNEL NO. 62

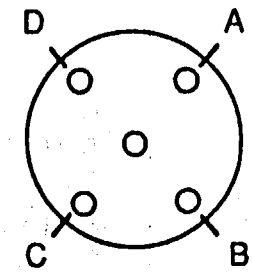


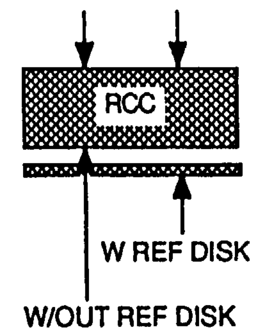
RCC TAL ABORT VERIFICATION TESTS L ARM.I 79/AB16 / R 500 BTU HRS 9349R01 RCD4 1

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 179/AB-16 RUN NO: ______ TEST CONDITION: 3200 F, 100 psf, 330 sec

Δm = 1.2443





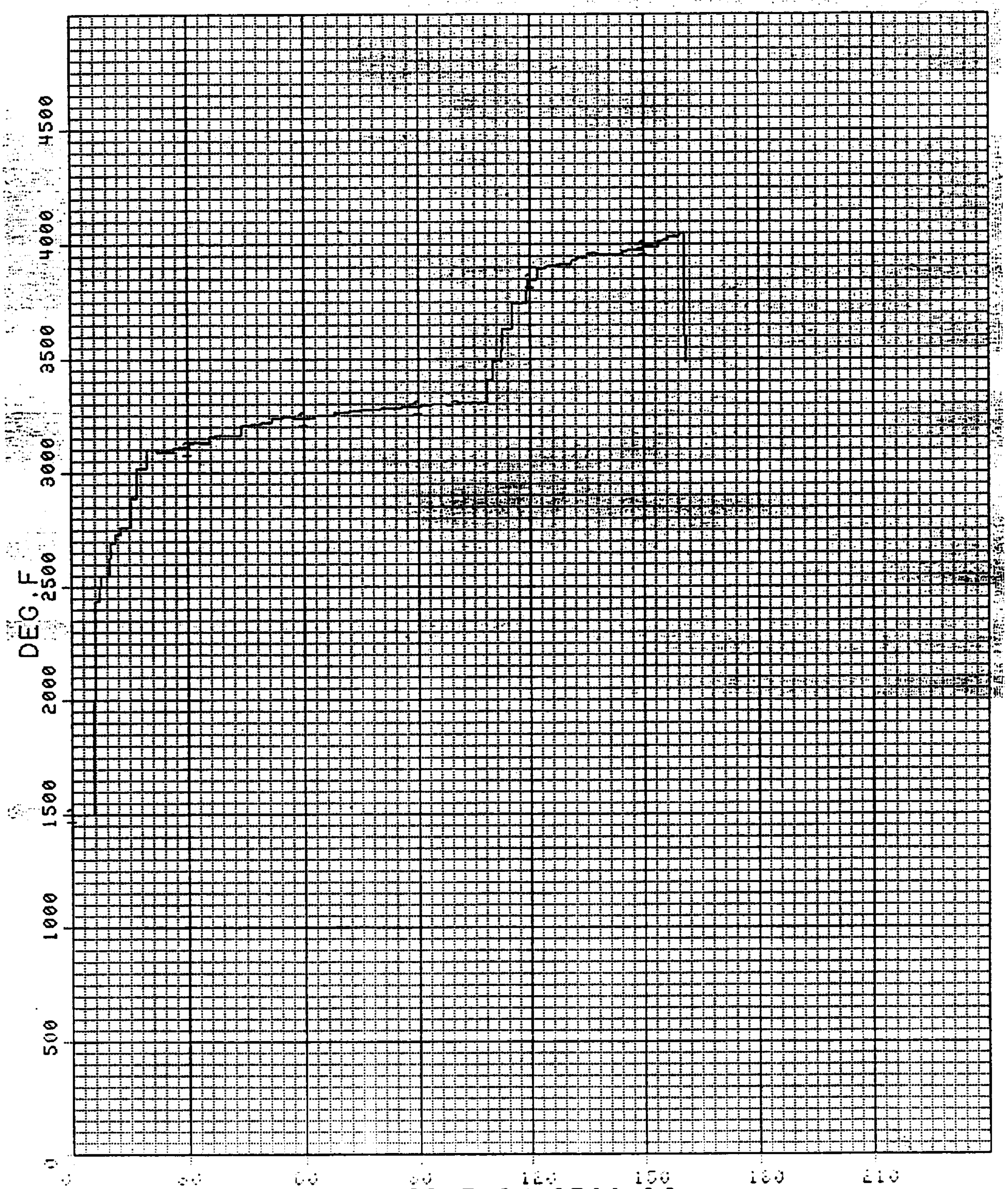
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.1103		55.866	
BAG WEIGHT ONLY	11.9570 ~~11.9470~~		11.9570	
SPECIMEN WEIGHT ONLY	45.1533		43.909	
EMISSIVITY	.165			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.273	.540 ~~.505~~	.274	.542
THICKNESS AT POINT A	.272	.542	.276	.542
THICKNESS AT POINT B	.271	.540	.272	.541
THICKNESS AT POINT C	.272	.541	.273	.541
THICKNESS AT POINT D	.272	.542	.273	.543
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BZ		BZ 12 15 89	

POST-TEST RESULTS/COMMENTS:

1-197-DD
DATE = 2/28/90 AVERAGE INTERVAL 0.1 SEC TIME = 18:29:21.0 TO 18:32: 2.0

PROCESSING DATE 02/28/90

L PYR X CHANNEL NO. 62

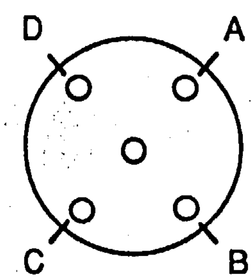


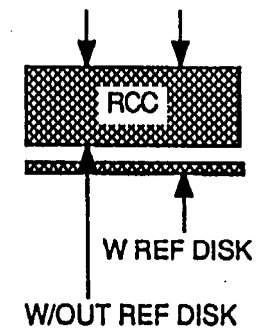
TR ... TA-2331
2/26/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 172/AU 01 RUN NO: ______ TEST CONDITION: 3300 F, 200 psf

$\Delta m = 7.03$





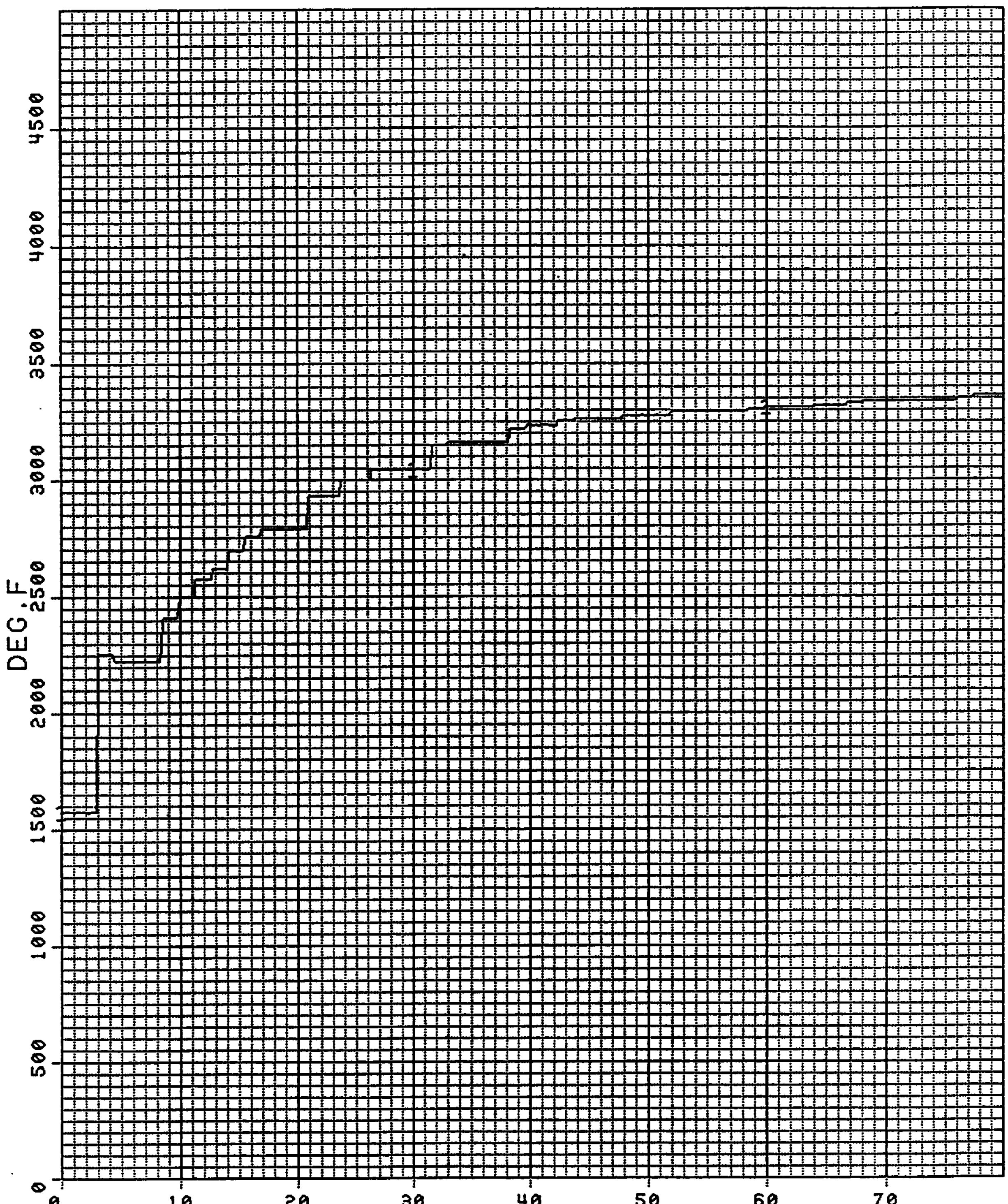
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	61.014		53.984	
BAG WEIGHT ONLY	12.543		12.543	
SPECIMEN WEIGHT ONLY	48.471		41.441	
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.277	.547	.224	.497
THICKNESS AT POINT A	.277	.544	.256	.527
THICKNESS AT POINT B	.279	.546	.257	.532
THICKNESS AT POINT C	.279	.546	.246	.516
THICKNESS AT POINT D	.274 ~~.276~~	.541	.242	.517
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ	FORD 23 2 26 90	BZ	FORD 23 2 28 90

POST-TEST RESULTS/COMMENTS:

1-347-DD
DATE = 10/ 5/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:34:18.0 TO 0:35:38.0

PROCESSING DATE 10/05/90

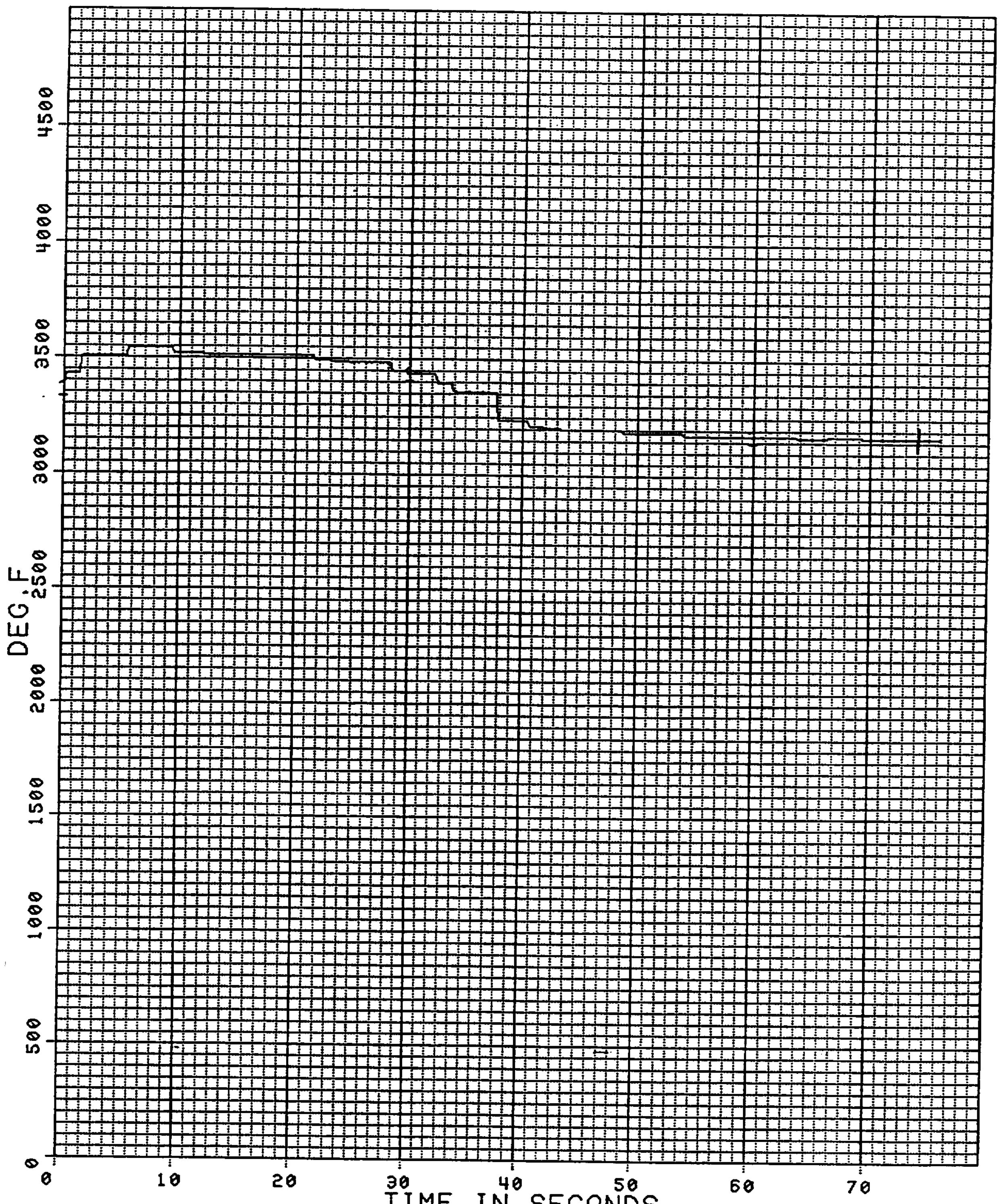
L PYR X CHANNEL NO. 55



ROC-ENKA TAL ABORT TESTS L. ARM AU05/180 SIMULATION RUN F 0278R01 ROD4 2

1-347-DD
DATE = 10/ 5/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:35:38.0 TO 0:36:54.0 PROCESSING DATE 10/05/90

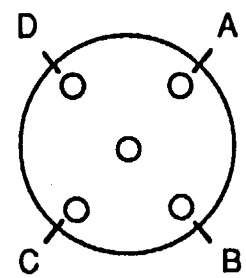
L PYR X CHANNEL NO. 55

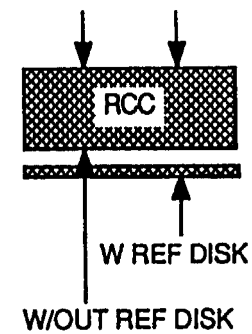


ROC-ENKA TAL ABORT TESTS L. ARM AU05/180 SIMULATION RUN F 0278R01 ROD4 2

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: AU05/180 RUN NO: ______ TEST CONDITION: ______



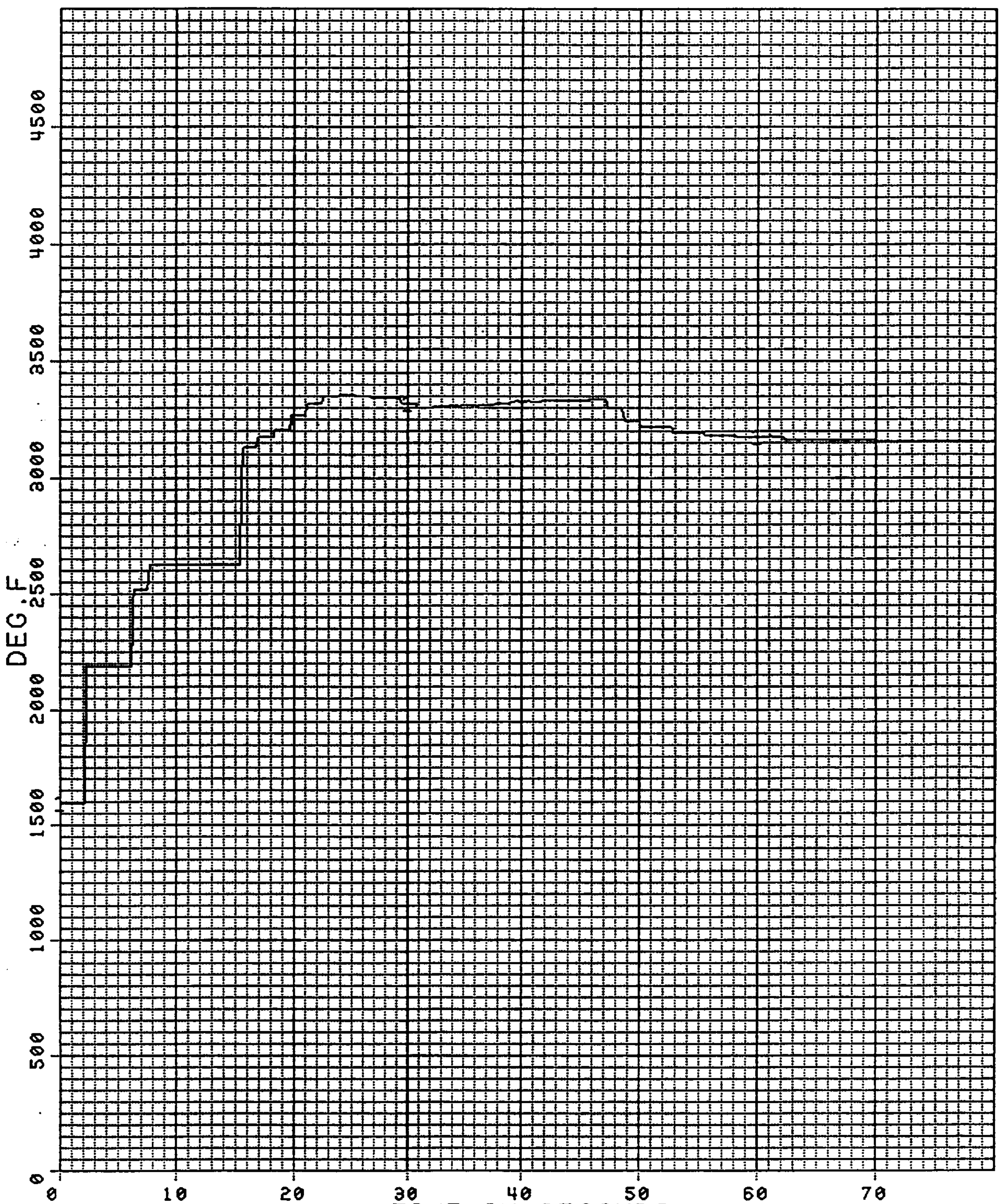


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	60.798		58.087	
BAG WEIGHT ONLY	12.487		12.487	
SPECIMEN WEIGHT ONLY				
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.277	.546	.252	.519
THICKNESS AT POINT A	.277	.546	.278	.545
THICKNESS AT POINT B	.279	.548	.278	.545
THICKNESS AT POINT C	.276	.545	.283	.550
THICKNESS AT POINT D	.275	.543	.280	.547
REFERENCE DISK THICKNESS	.267	FORD 23	.267	FORD 23
TECH / QA / DATE	B.J. 10/1/90		B.J. 10/5/90	

POST-TEST RESULTS/COMMENTS:

1-348-DD PROCESSING DATE 10/09/90
DATE = 10/ 9/90 AVERAGE INTERVAL 0.1 SEC TIME = 5:55: 1.0 TO 5:56:26.0

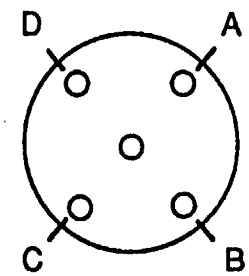
L PYR X CHANNEL NO. 55

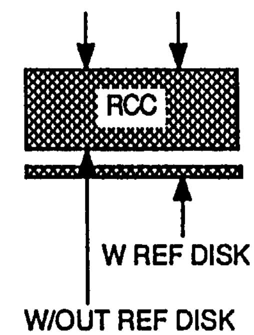


RCC-ENKA TAL ABORT TESTS L. ARM AU08/184 SIMULATION RUN 0282R01 ROD4 2

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 184/AU 08 RUN NO: ______ TEST CONDITION: ______





	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	60.735		60.512	
BAG WEIGHT ONLY	12.468		12.468	
SPECIMEN WEIGHT ONLY				
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.279	.547	.291	.557
THICKNESS AT POINT A	.281	.549	.293	.560
THICKNESS AT POINT B	.280	.548	.293	.562
THICKNESS AT POINT C	.282	.549	.295	.561
THICKNESS AT POINT D	.280	.548	.293	.560
REFERENCE DISK THICKNESS	.267	FORD 23	.267	FORD 23
TECH / QA / DATE	BJ 10/9/90		BJ 10/10/90	

POST-TEST RESULTS/COMMENTS:

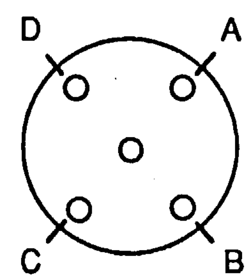
RUN 1-311-OD
8-31-90

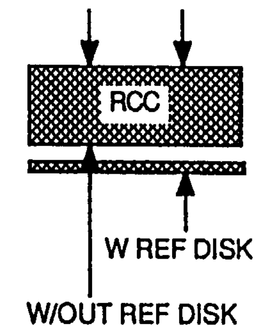
ITS.IH-2551

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 191/AC13 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.387		53.184	
BAG WEIGHT ONLY	12.539		12.539	
SPECIMEN WEIGHT ONLY				
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.265	.538	.229	.528
THICKNESS AT POINT A	.265	.536	.269	.534
THICKNESS AT POINT B	.265	.538	.264	.535
THICKNESS AT POINT C	.266	.536	.267	.534
THICKNESS AT POINT D	.266	.536	.265	.537
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 8/31/90 RUN 1-311-OD FORD 23		B.J. 8/31/90 RUN 1-312-OD 8-31-90 FORD 23	



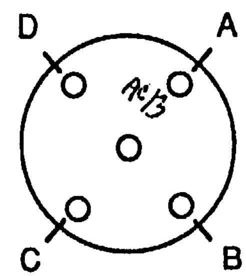


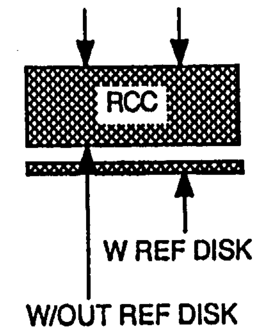
POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 191/AC 13 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	57.679		57.622	
BAG WEIGHT ONLY	12.535		12.539	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	NA			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.264	.534	.265 WDM	
THICKNESS AT POINT A	.265	.532	.265 WDM	
THICKNESS AT POINT B	.265	.534	.265 WDM	
THICKNESS AT POINT C	.266	.534	.267 WDM	
THICKNESS AT POINT D	.265	.534	.267 WDM	
REFERENCE DISK THICKNESS	.267			
TECH / QA / DATE	RJ. 8/23/90 FORD 23			





POST-TEST RESULTS/COMMENTS:

VTEX MATERIAL

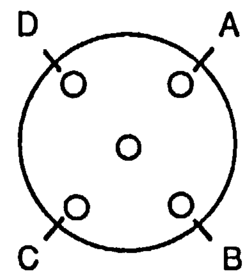
PAGE 2 OF 2

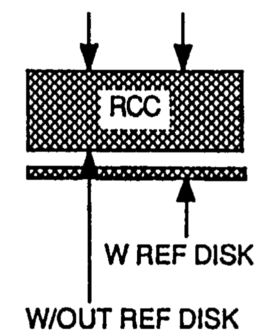
TPS -233.1
2/ /90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 207/AC 22 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	54.765 ~~56.765~~		54.035 ~~NA~~	
BAG WEIGHT ONLY	12.419		~~NA~~	
SPECIMEN WEIGHT ONLY			~~NA~~	
EMISSIVITY	NA		~~NA~~	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.264	.533 ~~.535~~	.250	.525
THICKNESS AT POINT A	.265	.534	.264	.535
THICKNESS AT POINT B	.266	.533	.262	.538
THICKNESS AT POINT C	.265	.534	.266	.538
THICKNESS AT POINT D	.266	.534	.267	.540
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ 8/21/90 FORQ 23		BJ 8/22/90 FORQ 23	



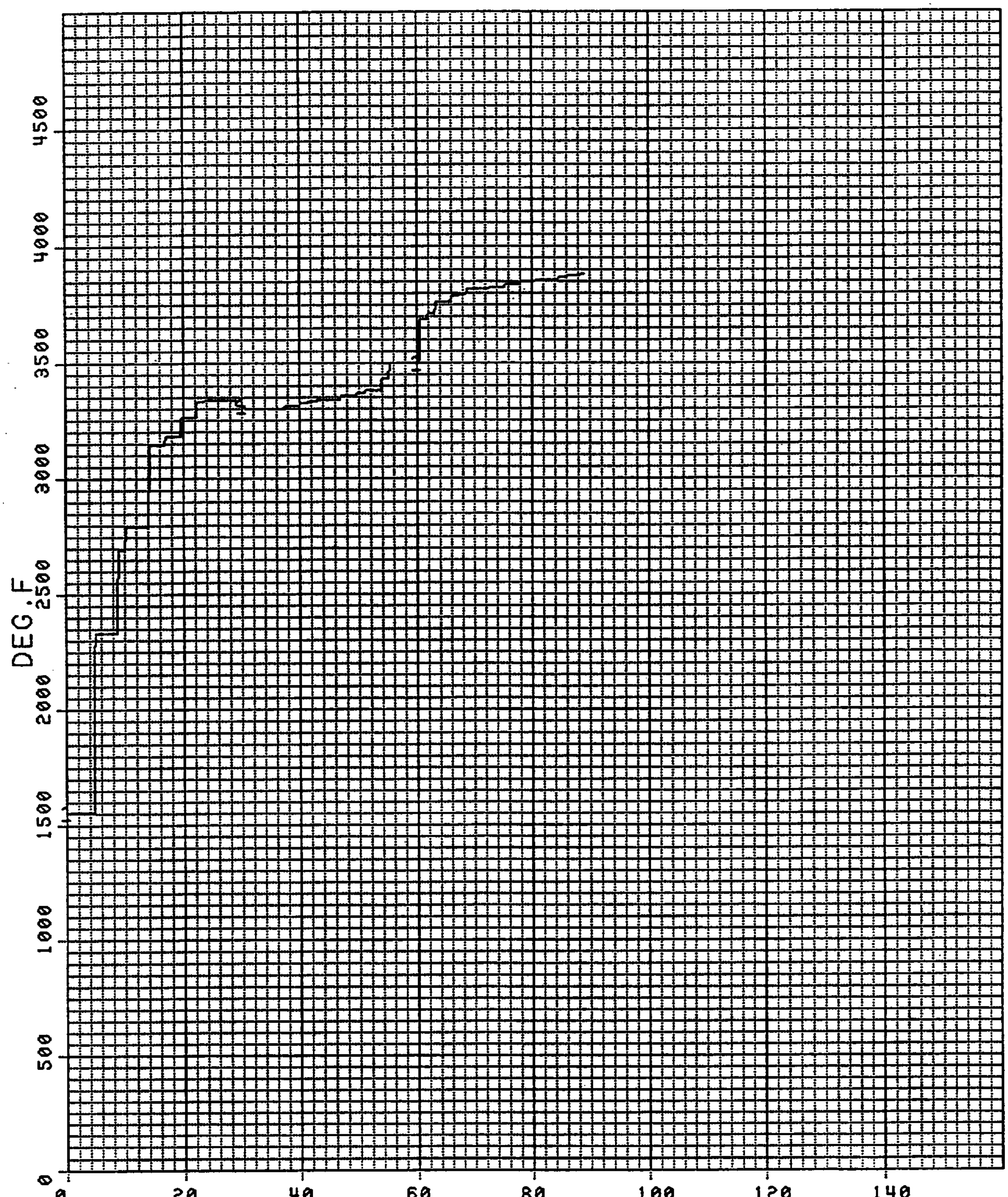


POST-TEST RESULTS/COMMENTS:

1-351-DD
DATE = 10/11/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:24: 3.0 TO 0:25:32.0

PROCESSING DATE 10/11/90

L PYR X CHANNEL NO. 55

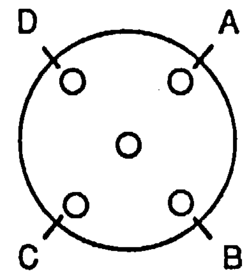


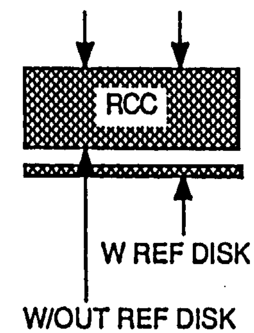
ROC-AVTEX TAL ABORT TESTS L.ARM AT15/183 3320 DEG.F @ 300 PSF 0284R01 ROD4 2

PAGE 2 OF 2 TPS-TA-2331
2/26/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 183/AT 15 RUN NO: ______ TEST CONDITION: ______





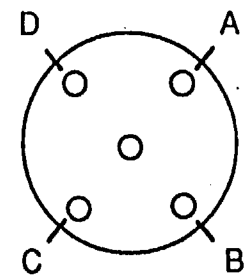
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	59.674		53.803	
BAG WEIGHT ONLY	12.329		12.329	
SPECIMEN WEIGHT ONLY				
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.272	.542	.236	.508
THICKNESS AT POINT A	.274	.541	.271	.538
THICKNESS AT POINT B	.275	.542	.272	.540
THICKNESS AT POINT C	.275	.542	.273	.538
THICKNESS AT POINT D	.275	.543	.265	.528
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BY 10/10/90		BY 10/11/90	

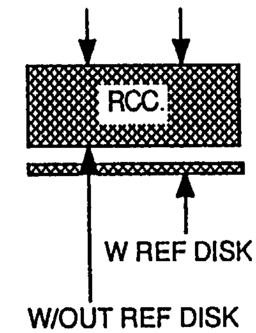
POST-TEST RESULTS/COMMENTS:

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN25/394 RUN NO: ______ TEST CONDITION: ______



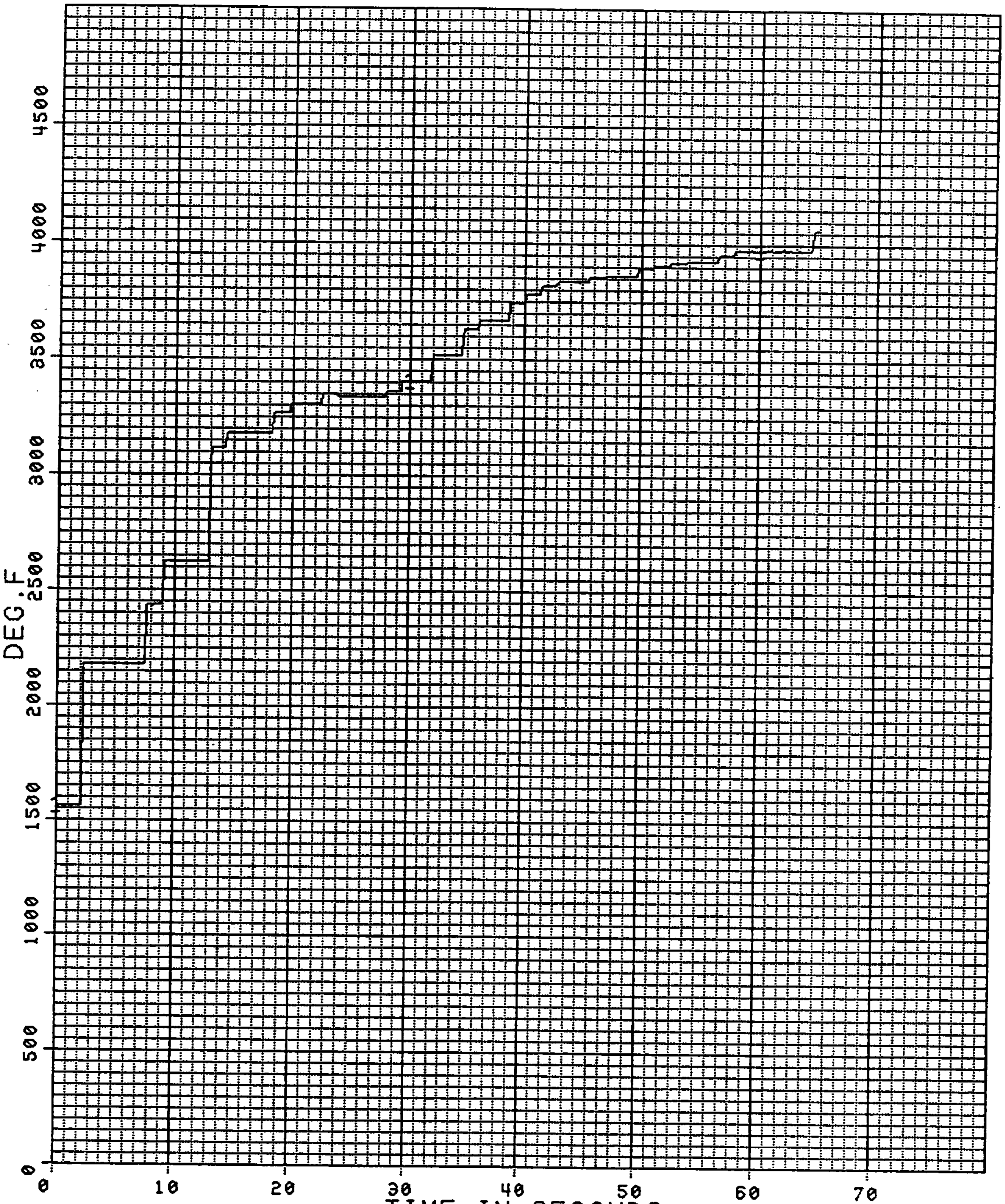


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	49.438 ~~49.356~~		46.090	
BAG WEIGHT ONLY	10.590		10.590	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.146			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.241	.513	.219	.503
THICKNESS AT POINT A	.243	.512	.244	.517
THICKNESS AT POINT B	.242	.511	.242	.516
THICKNESS AT POINT C	.243	.513	.243	.512
THICKNESS AT POINT D	.244	.513	.240	.513
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BG 9/6/90 FORD 23		B.J. 9/10/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
COATED AVTEX/TEOS/TYPE A
No'S NOT LEGIBLE

1-350-DD
DATE = 10/10/90 AVERAGE INTERVAL 0.1 SEC TIME = 1:52:48.0 TO 1:53:53.0
PROCESSING DATE 10/10/90

L PYR X CHANNEL NO. 55



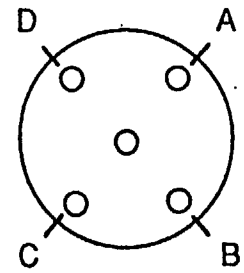
ROC-AVTEX TAL ABORT TESTS L.ARM IN26/395 3320 DEG.F @ 300 PSF 0283R02 ROD4 2

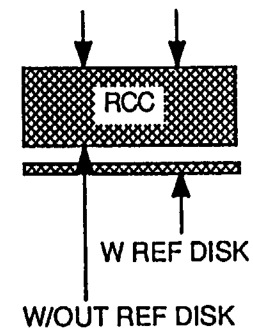
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN26/395 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.203		41.961	
BAG WEIGHT ONLY	10.495		10.495	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.149			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.244	.518	.227	.496
THICKNESS AT POINT A	.246	.514	.188	.418
THICKNESS AT POINT B	.246	.518	.241	.508
THICKNESS AT POINT C	.247	.516	.241	.510
THICKNESS AT POINT D	.248	.516	.216	.484
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 10/9/92		B.J. 10/11/90	





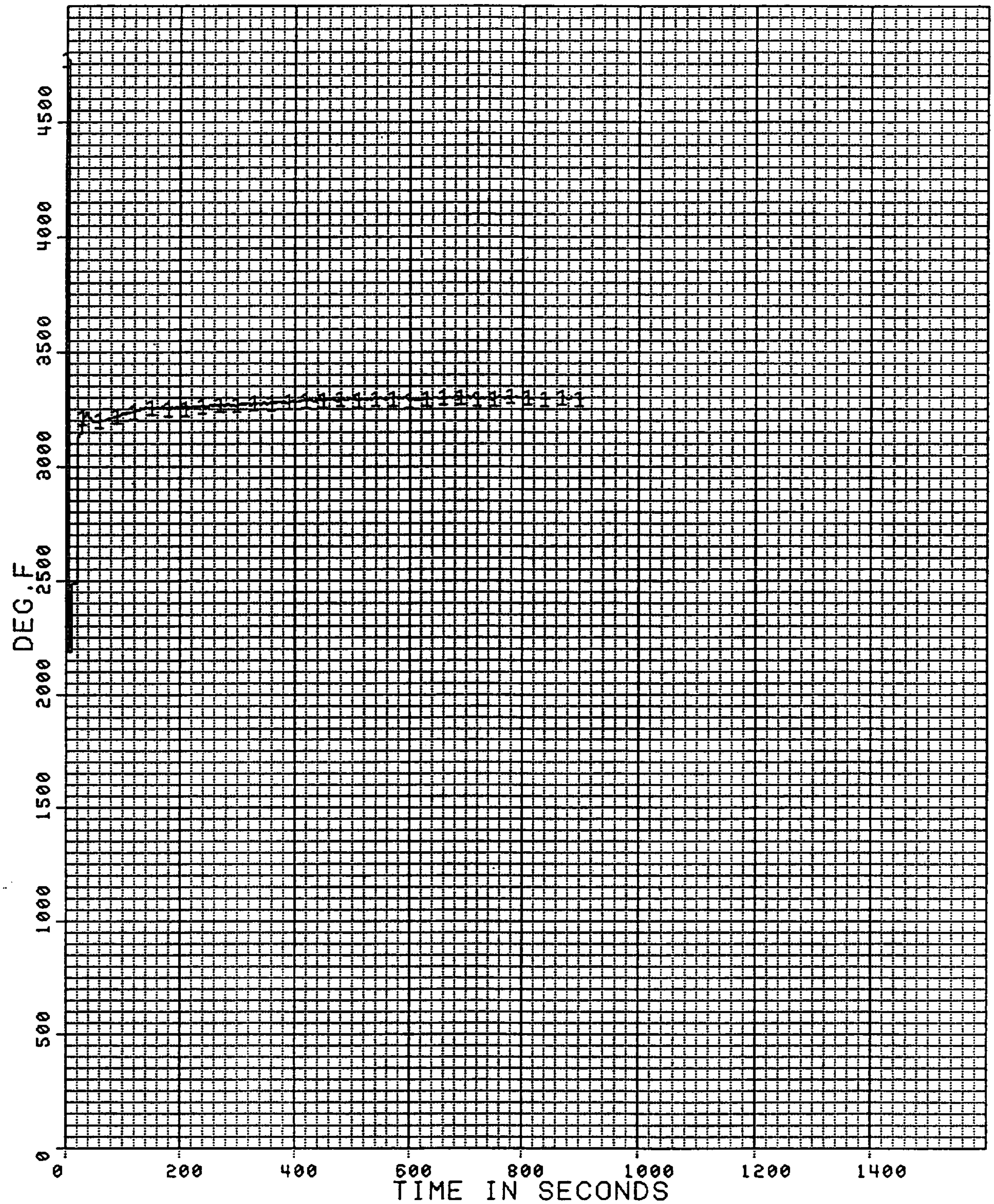
FORD 23

FORD 23

POST-TEST RESULTS/COMMENTS:
COATED AVTEX/TEOS/TYPE A
NO'S ON BAG

1-354-DD PROCESSING DATE 10/15/90
DATE = 10/15/90 AVERAGE INTERVAL 0.1 SEC TIME = 21: 2:55.0 TO 21:18: 1.0

L PYR X CHANNEL NO. 55



ROC-ENKA TAL ABORT TESTS L.ARM IN28/396 3225 DEG F @ 300 PSF 0288R01 RC04 2

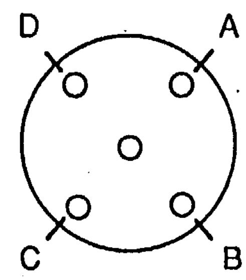
8/7/90

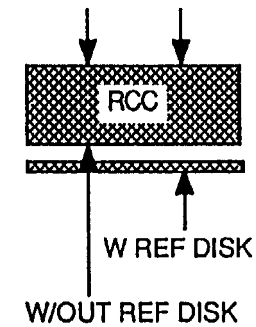
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 28/396 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	51.888		46.797	
BAG WEIGHT ONLY	10.626		10.626	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.149			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.253	.522	.227	.497
THICKNESS AT POINT A	.254	.521	.251	.517
THICKNESS AT POINT B	.255	.522	.252	.517
THICKNESS AT POINT C	.253	.521	.231	.517
THICKNESS AT POINT D	.255	.522	.246	.502
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 10/10/90		B.J. 10/16/90	

FORD 23

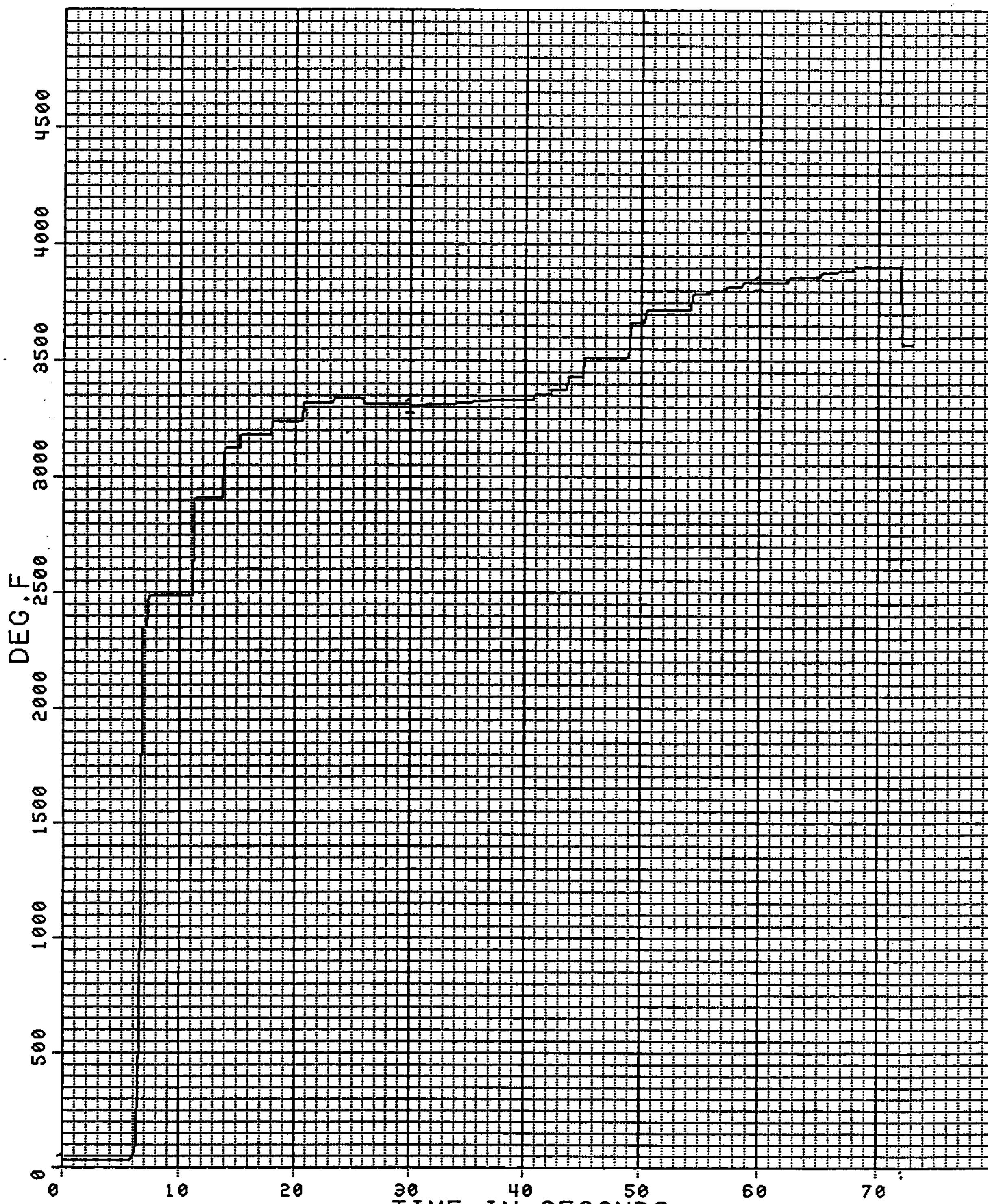




POST-TEST RESULTS/COMMENTS:
- COATED AVTEX/TEOS/TYPE A
NO'S NOT LEGIBLE ON
BAG OR MODEL

1-346-DD
PROCESSING DATE 10/04/90
DATE = 10/ 4/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:23:39.0 TO 0:24:52.0

L PYR X CHANNEL NO. 55



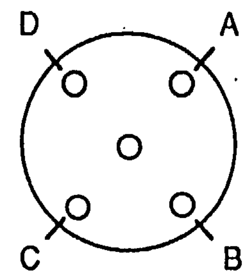
RCC-ENKA TAL ABORT TESTS L. ARM IN04/384 3350 DEGF @ 300 PSF 0277R01 ROD4 2

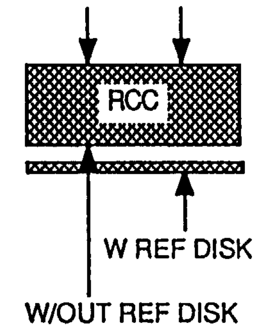
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN04/384 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	51.014		46.633	
BAG WEIGHT ONLY	10.579		10.579	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.149			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.246	~~.517~~	.217	
THICKNESS AT POINT A	.247	~~.514~~	.247	
THICKNESS AT POINT B	.248	~~.516~~	.249	
THICKNESS AT POINT C	.247	~~.517~~	.241	
THICKNESS AT POINT D	.248	~~.517~~	.226	
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ 8/21/90 FORD 23		B.J. 10/4/90 FORD 23	



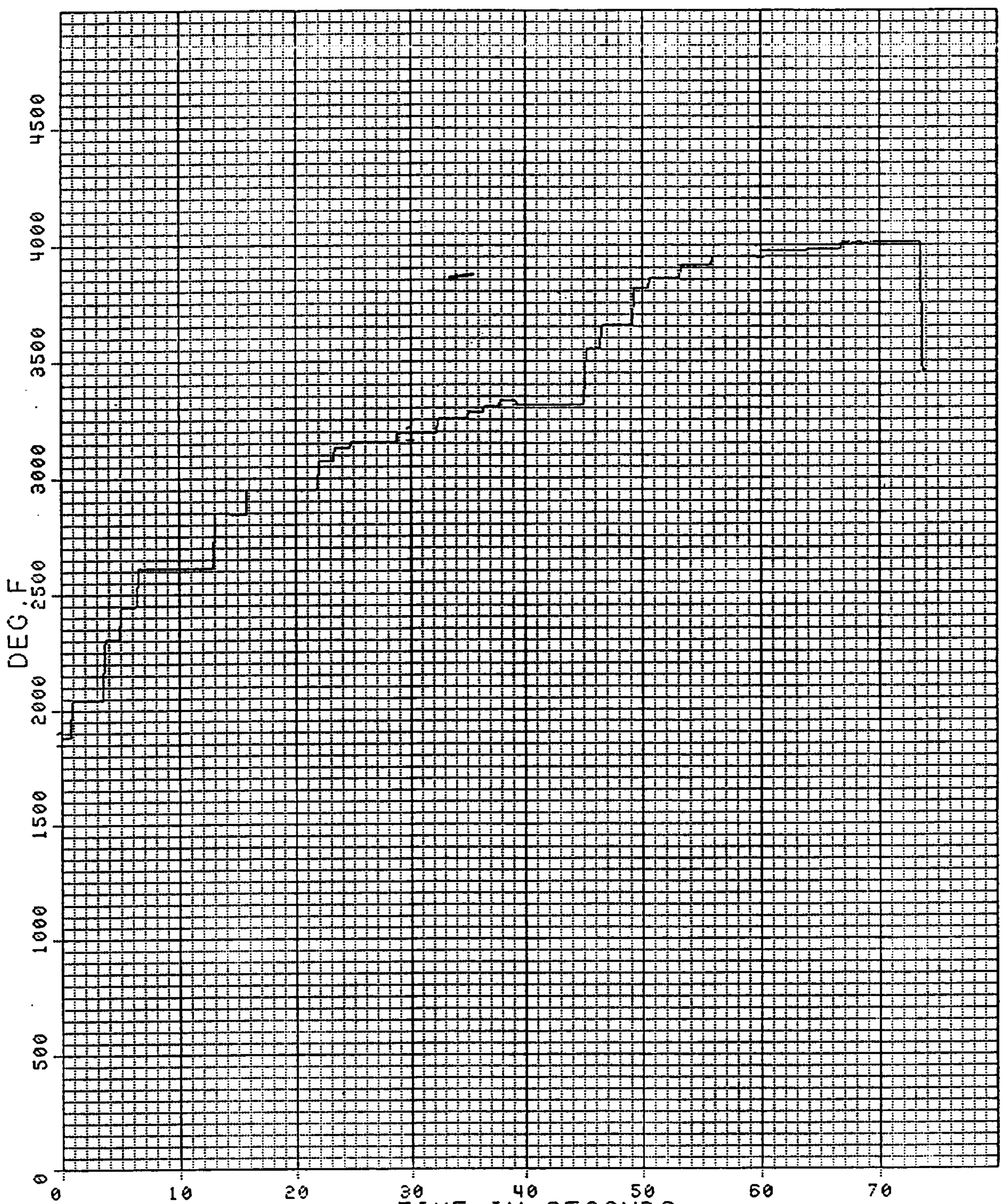


POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEDS/TYPEA
* No'S NOT LEGIBLE

Model SURFACE IS CURVED, CANNOT MEASURE with REFERENCE DISK. RQB

1-317-DD PROCESSING DATE 09/07/90
DATE = 9/ 7/90 AVERAGE INTERVAL 0.1 SEC TIME = 5:27:34.0 TO 5:28:48.0

L PYR X CHANNEL NO. 55

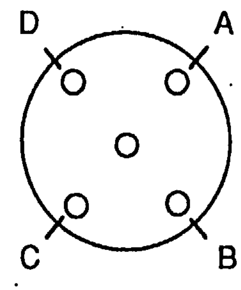


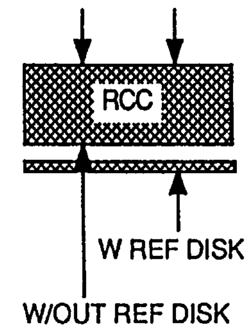
ROC-ENKA TAL ABORT TESTS L. ARM IN06 3350 DEG F @ 100PSF 0250R02 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN06/385 RUN NO: ______ TEST CONDITION: ______





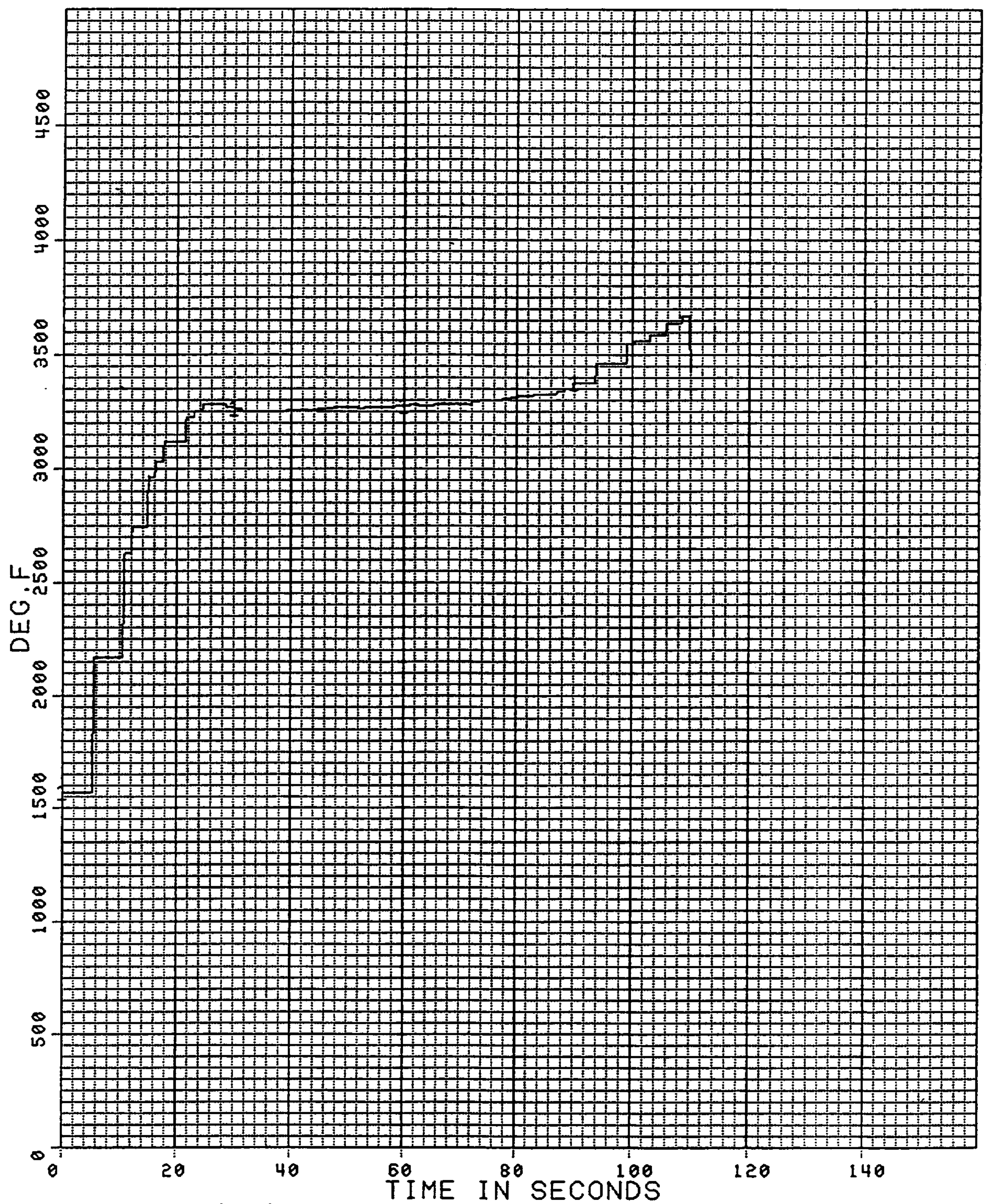
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	49.678 ~~49.632~~		46.747	
BAG WEIGHT ONLY	10.467		10.469	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.154			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.242	.514	.220	.513
THICKNESS AT POINT A	.244	.512	.234	.507
THICKNESS AT POINT B	.244	.512	.233	.507
THICKNESS AT POINT C	.248	.515	.246	.519
THICKNESS AT POINT D	.244	.514	.243	.516
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ 9/6/90 FORD 23		BJ 9/10/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS/TYPE A
NO'S NOT LEGIBLE

1-341-DD
DATE = 9/28/90 AVERAGE INTERVAL 0.1 SEC TIME = 4: 3:31.0 TO 4: 5:21.0

PROCESSING DATE 09/28/90

L PYR X CHANNEL NO. 55

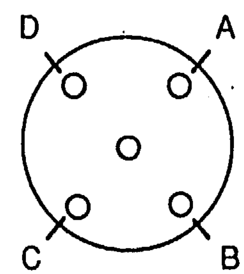


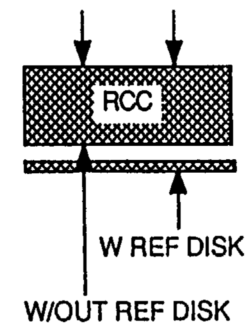
ROC-ENKA TAL ABORT TESTS L. ARM IN08/386 3350 DEG F @ 300 PSF 0271R03 ROD4 2

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN08/386 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST W/OUT REF DISK	PRE-TEST W REF DISK	POST-TEST W/OUT REF DISK	POST-TEST W REF DISK
BAG AND SPECIMEN WEIGHT	49.946		46.712	
BAG WEIGHT ONLY	10.284		10.264	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.154			
MEASUREMENTS OF SPECIMEN				
THICKNESS AT CENTERLINE	.242	.515 ~~.490~~	.227	.498 ~~.5~~
THICKNESS AT POINT A	.244	.512	.246	.511
THICKNESS AT POINT B	.245	.514	.251	.497 ~~.5~~
THICKNESS AT POINT C	.243	.512	.244	.513
THICKNESS AT POINT D	.243	.511	.216	.515
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 9/20/90	FORD 23	B.J. 9/28/90	FORD 23





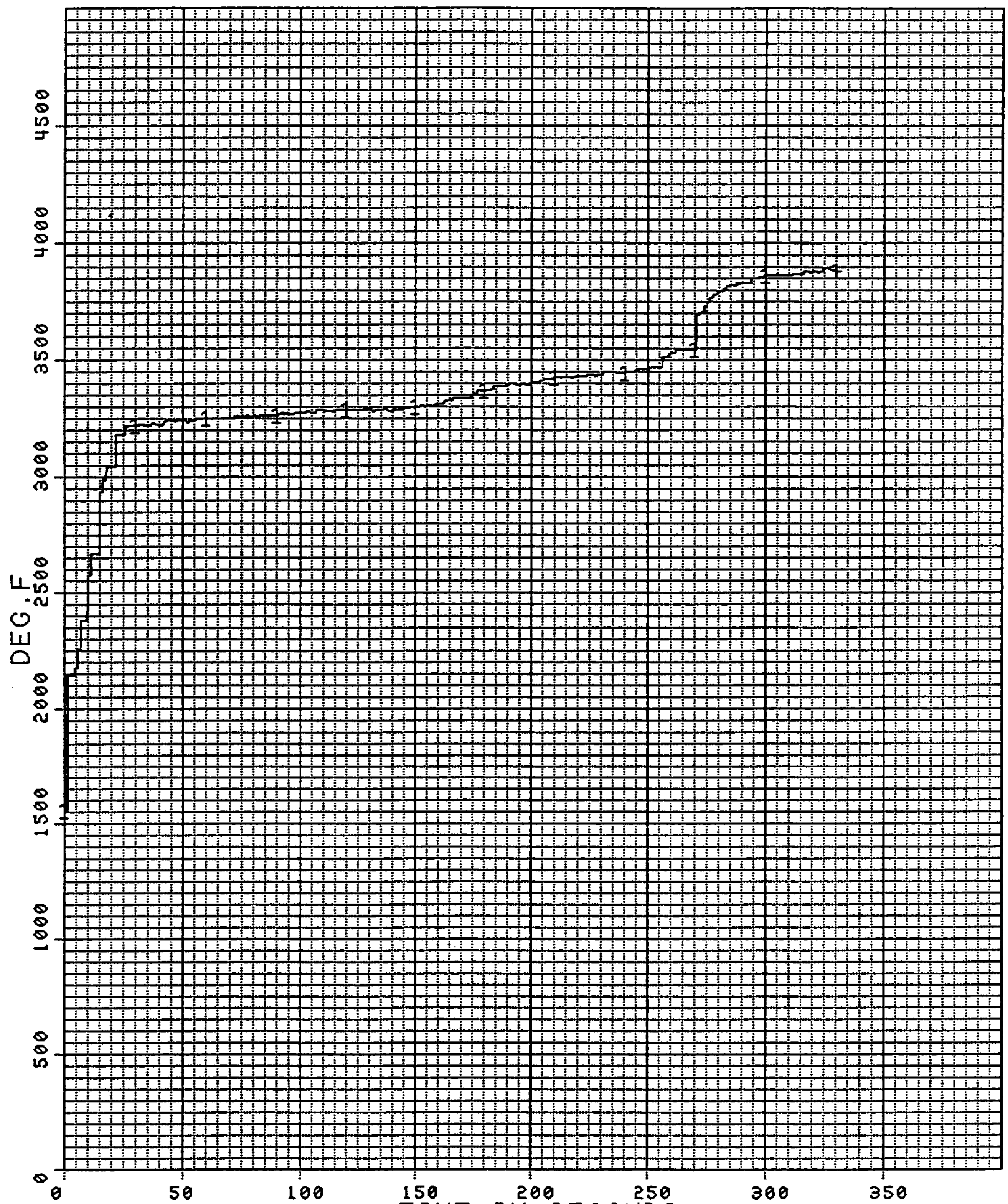
POST-TEST RESULTS/COMMENTS:

COATED ENKA/TEOS/TYPE A
No'S NOT LEGIBLE

1-342-DD
DATE = 10/ 1/90 AVERAGE INTERVAL 0.1 SEC TIME = 23:38:56.0 TO 23:44:28.0

PROCESSING DATE 10/01/90

L PYR X CHANNEL NO. 55

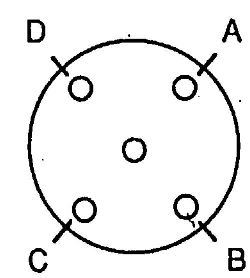


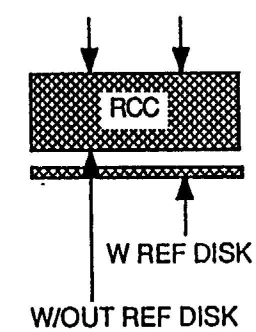
ROC-ENKA TAL ABORT TESTS L. ARM IN12/387 3300DEG F @ 300PSF 0275R01 ROD4 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN12/387 RUN NO: ______ TEST CONDITION: ______





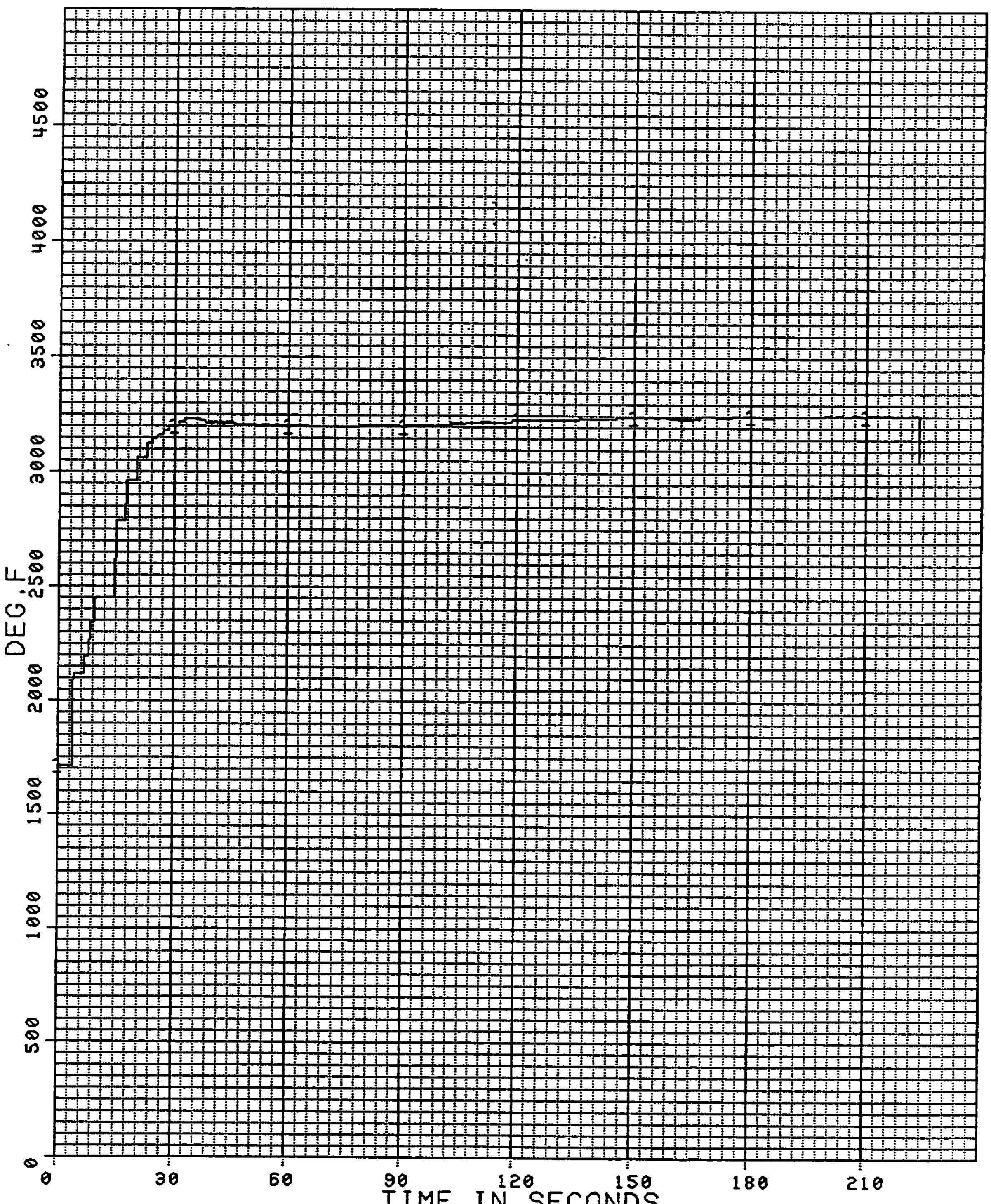
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.761		40.506	
BAG WEIGHT ONLY	10.379		10.379	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.150			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.250	.525	.150	.436
THICKNESS AT POINT A	.251	.520	.248	.529
THICKNESS AT POINT B	.251	.520	.233	.517
THICKNESS AT POINT C	.253	.522	.245	.512
THICKNESS AT POINT D	.251	.523	.245	.515
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 9/20/90		B.J. 10/4/90	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS/TYPE A
No's NOT LEGIBLE

1-343-DD
DATE = 10/ 2/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:48:33.0 TO 0:52:18.0

PROCESSING DATE 10/02/90

L PYR X CHANNEL NO. 55



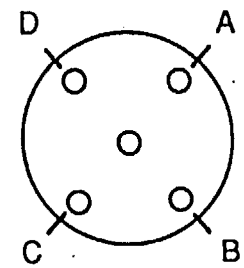
ROC-ENKA TAL ABORT TESTS L. ARM IN14/388 3250 DEG F.@ 300PSF 0275R02 ROD4 2

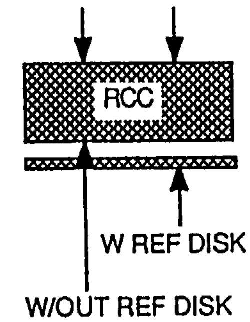
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN14/388 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.986		50.326	
BAG WEIGHT ONLY	10.464		10.464	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.146			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.245	.516	.243	.518
THICKNESS AT POINT A	.248	.517	.252	.527
THICKNESS AT POINT B	.246	.516	.258	.531
THICKNESS AT POINT C	.246	.516	.260	.525
THICKNESS AT POINT D	.249	.516	.261	.528
REFERENCE DISK THICKNESS	.267 FORD 23		.267 FORD 23	
TECH / QA / DATE	B.J. 10/1/90		B.J. 10/2/90	

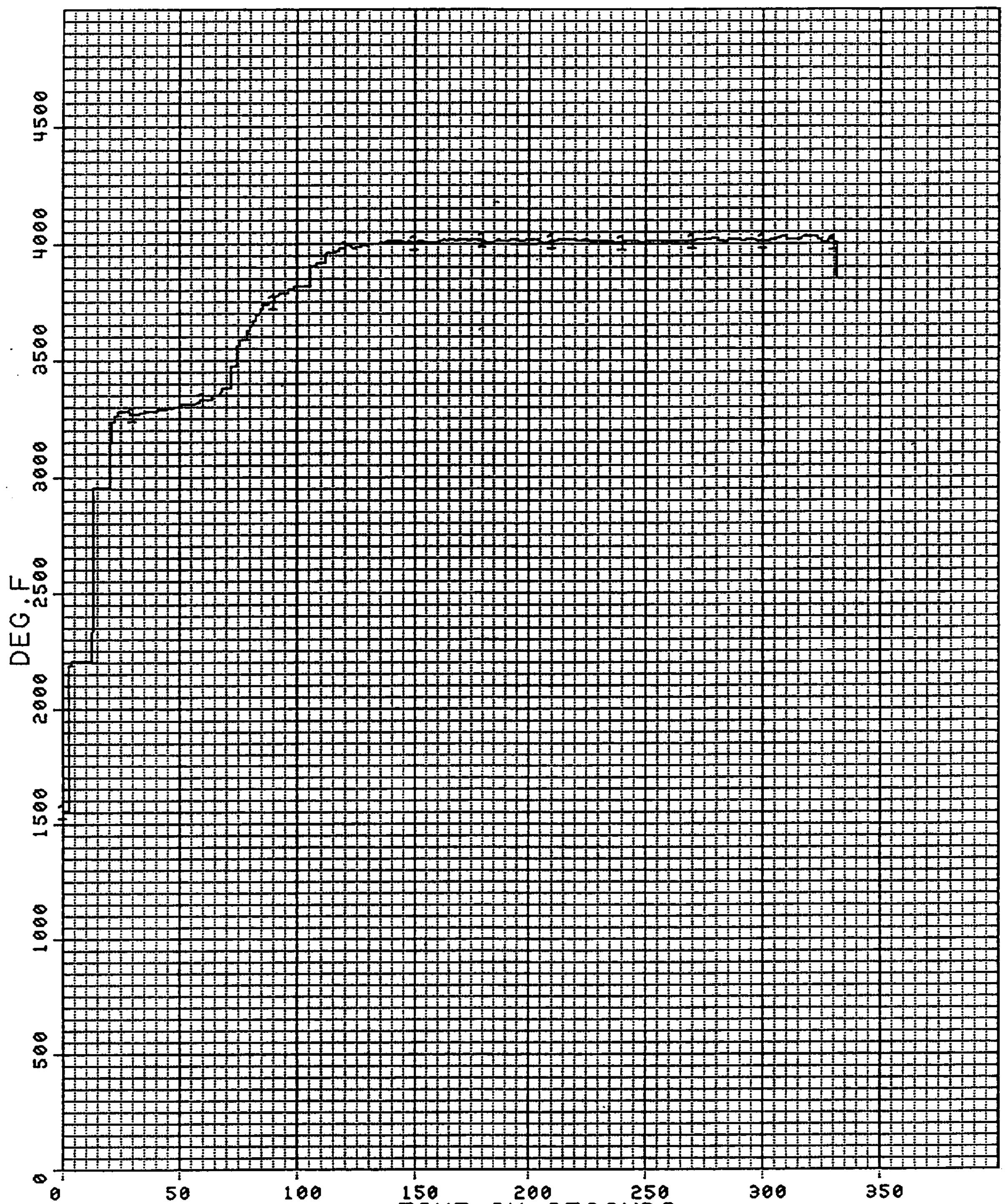




POST-TEST RESULTS/COMMENTS:
COATED ENKATEOS/TYPEA

1-344-DD PROCESSING DATE 10/02/90
DATE = 10/ 2/90 AVERAGE INTERVAL 0.1 SEC TIME = 23:38:35.0 TO 23:44: 8.0

L PYR X CHANNEL NO. 55



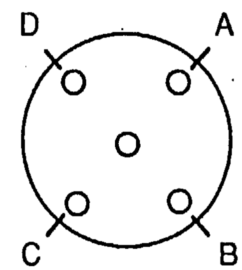
ROC-ENKA TAL ABORT TESTS L. ARM IN18/389 3350 DEG F.@ 300PSF 0275R01 ROD4 2

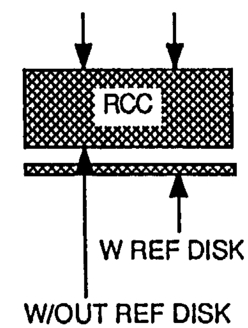
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 18/389 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	51.328		19.971	
BAG WEIGHT ONLY	10.814		10.814	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.145			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.248	.517		
THICKNESS AT POINT A	.250	.519		
THICKNESS AT POINT B	.250	.519		
THICKNESS AT POINT C	.248	.517		
THICKNESS AT POINT D	.247	.519		
REFERENCE DISK THICKNESS	.267			
TECH / QA / DATE	BJ 10/1/90		BJ 10/4/90	



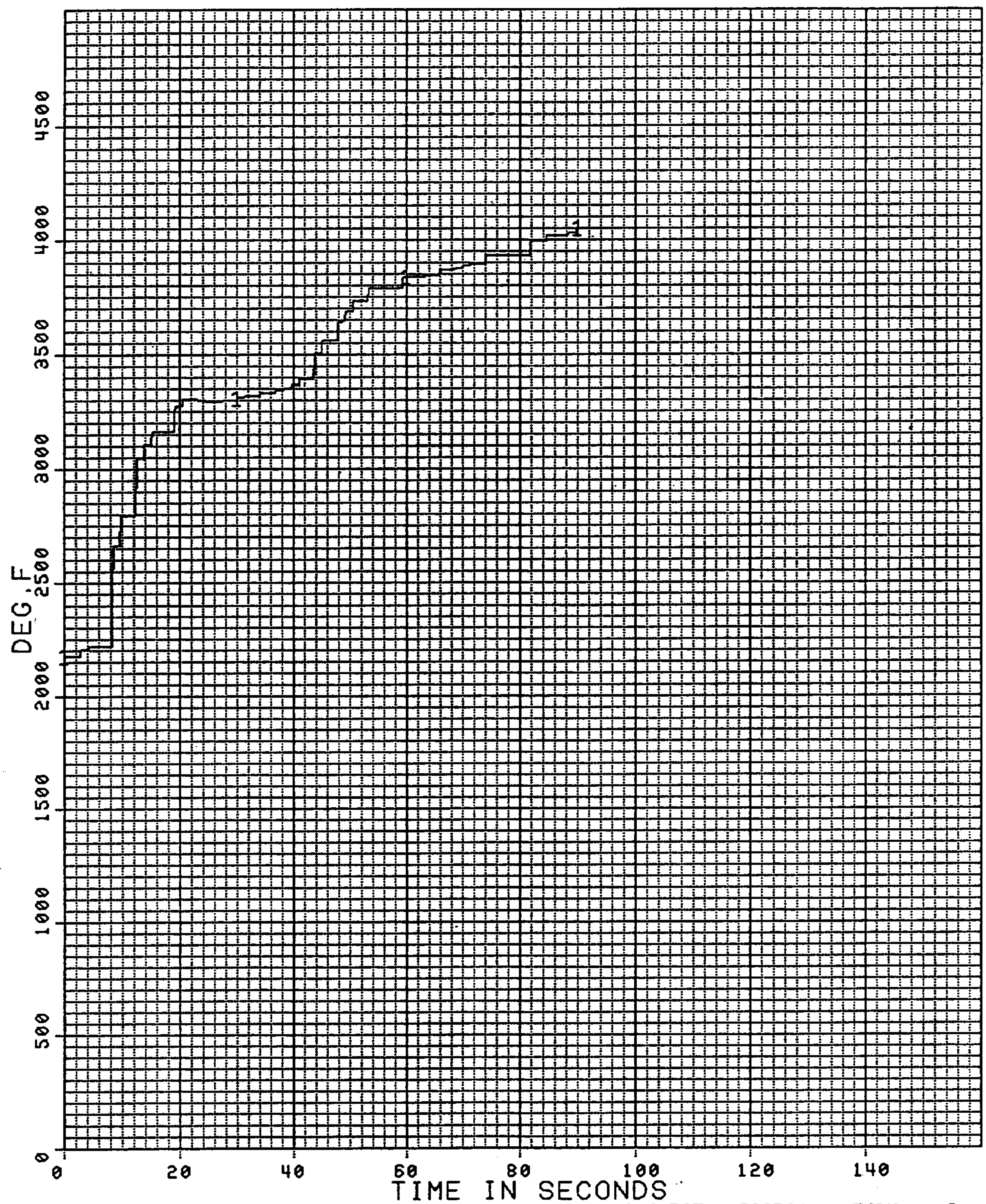


FORD 23

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS/TYPE A
No's NOT LEGIBLE

1-349-DD
PROCESSING DATE 10/10/90
DATE = 10/10/90 AVERAGE INTERVAL 0.1 SEC TIME = 0: 7:23.0 TO 0: 8:58.0

L PYR X CHANNEL NO. 55



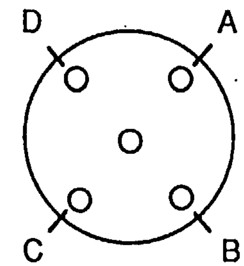
ROC-ENKA TAL ABORT TESTS L. ARM IN20/390 3320 DEG.F @ 300 PSF 0283R01 ROD4 2

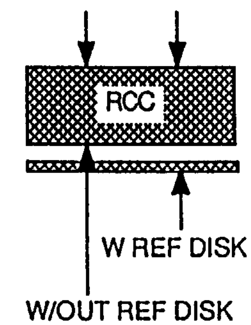
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 20/390 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	49.532		40.973	
BAG WEIGHT ONLY	10.217		10.217	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.150			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.242	.510	~~2~~.193	~~8~~.466
THICKNESS AT POINT A	.245	.513	.237	~~8~~.499
THICKNESS AT POINT B	.242	.513	.232	.502
THICKNESS AT POINT C	.244	.510	.209	~~8~~.480
THICKNESS AT POINT D	.245	.512	.225	~~8~~.496
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 10/7/90 FORD 23		B.J. 10/11/90 FORD 23	



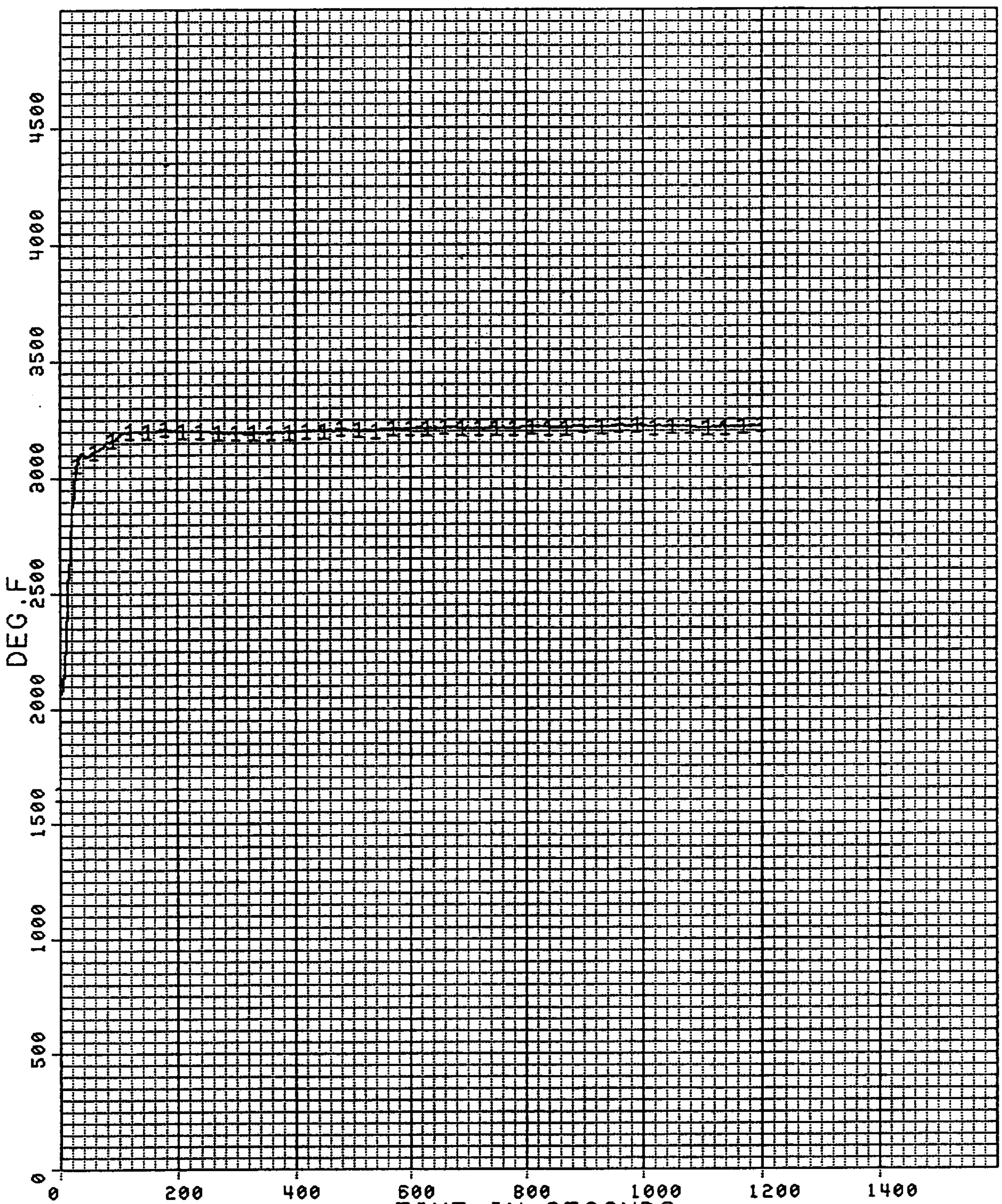


POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS/TYPE A
NO'S NOT LEGIBLE

1-337-DD
DATE = 9/27/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:29:38.0 TO 0:49:40.0

PROCESSING DATE 09/27/90

L PYR X CHANNEL NO. 55

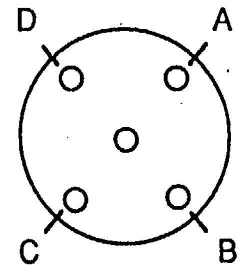


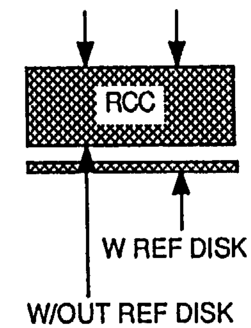
ROC-ENKA TAL ABORT TESTS L. ARM IN21/391 3200 DEG F @ 300 PSF 0270R01 -- ROD4 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 21/391   RUN NO: ________   TEST CONDITION: ________



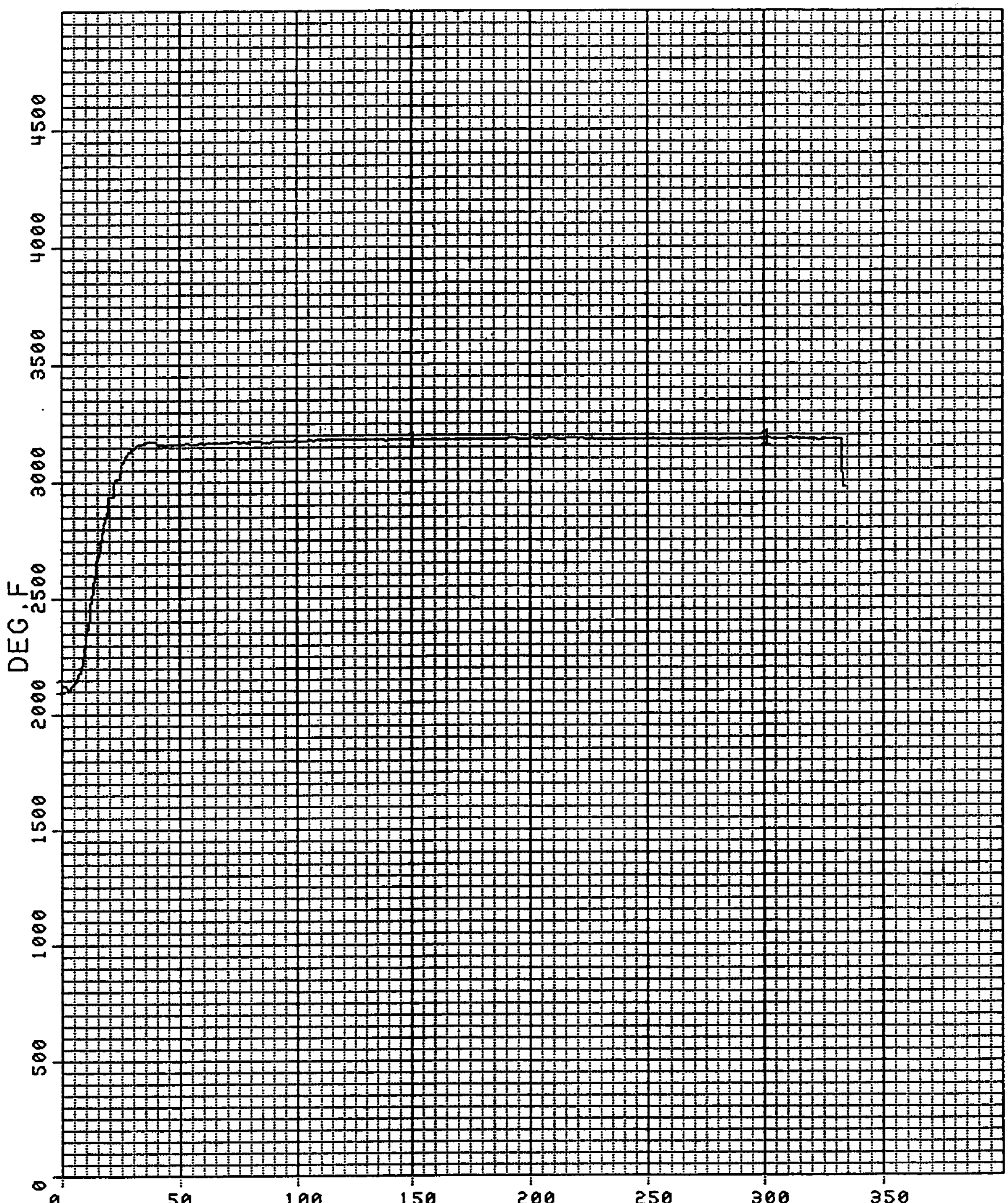


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	47.729		46.147	
BAG WEIGHT ONLY	10.437		10.437	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.145			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.232	.504	.231	.509
THICKNESS AT POINT A	.235	.504	.238	.516
THICKNESS AT POINT B	.233	.502	.235	.511
THICKNESS AT POINT C	.231	.501	.242	.511
THICKNESS AT POINT D	.235	.503	.243	.503
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 9/26/90 FORD 23		B.J. 9/27/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS/TYPE A
NO'S NOT LEGIBLE

1-338-DD
PROCESSING DATE 09/27/90
DATE = 9/27/90 AVERAGE INTERVAL 0.5 SEC TIME = 3:12: 5.0 TO 3:17:39.2

L PYR X CHANNEL NO. 55

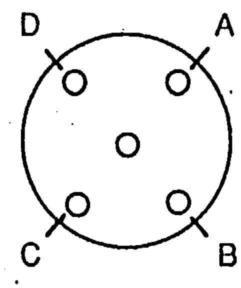


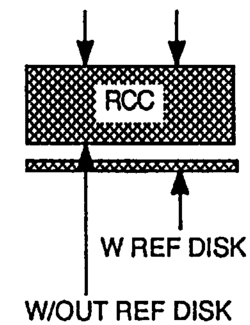
ROC-ENKA TAL ABORT TESTS L. ARM IN22/392 3200 DEG F @ 300 PSF 0270R02 ROD4 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 22/392 RUN NO: ________ TEST CONDITION: ________



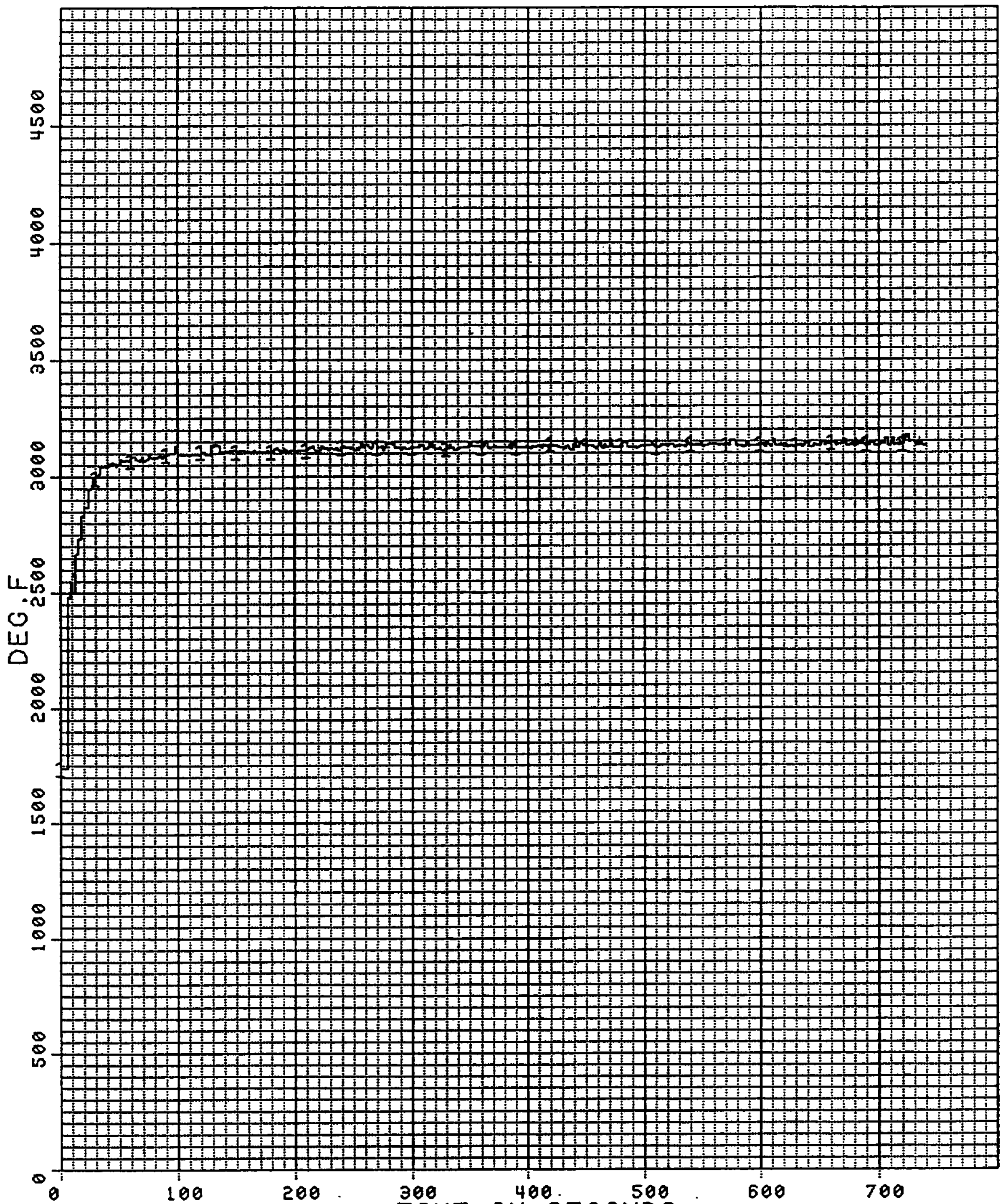


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	48.602		48.210	
BAG WEIGHT ONLY	10.571		10.571	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.143			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.235	.505	.241	.512
THICKNESS AT POINT A	.236	.505	.245	.518
THICKNESS AT POINT B	.235	.504	.241	.517
THICKNESS AT POINT C	.234	.504	.243	.518
THICKNESS AT POINT D	.235	.504	.243	.511
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 9/26/90 FORD 23		B.J. 9/27/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS/TYPE A
No'S NOT LEGIBLE

1-318-DD PROCESSING DATE 09/11/90
DATE = 9/11/90 AVERAGE INTERVAL 0.1 SEC TIME = 3:31:51.0 TO 3:44:10.0

L PYR X CHANNEL NO. 55



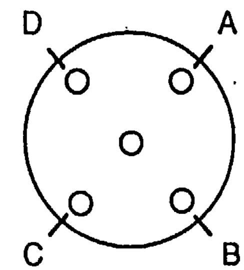
ROC-ENKA TAL ABORT TEST RUN L. ARM IN05/373 3200 DEG F @ 100 PSF 0253R01 ROD4 2

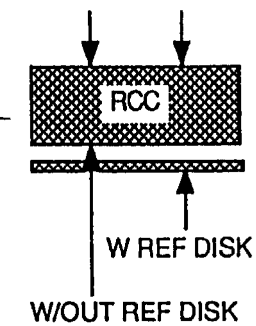
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 05/373 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	47.921 ~~47.946~~		~~47.229~~	
BAG WEIGHT ONLY	10.285		10.266	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.200			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.239	.511	.235	.510
THICKNESS AT POINT A	.239	.510	.240	.509
THICKNESS AT POINT B	.242	.508	.239	.507
THICKNESS AT POINT C	.238	.510	.242	.510
THICKNESS AT POINT D	.243	.510	.237	.509
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BZ 9 6 90 FORD 23		BJ. 9/11/90 FORD 23	



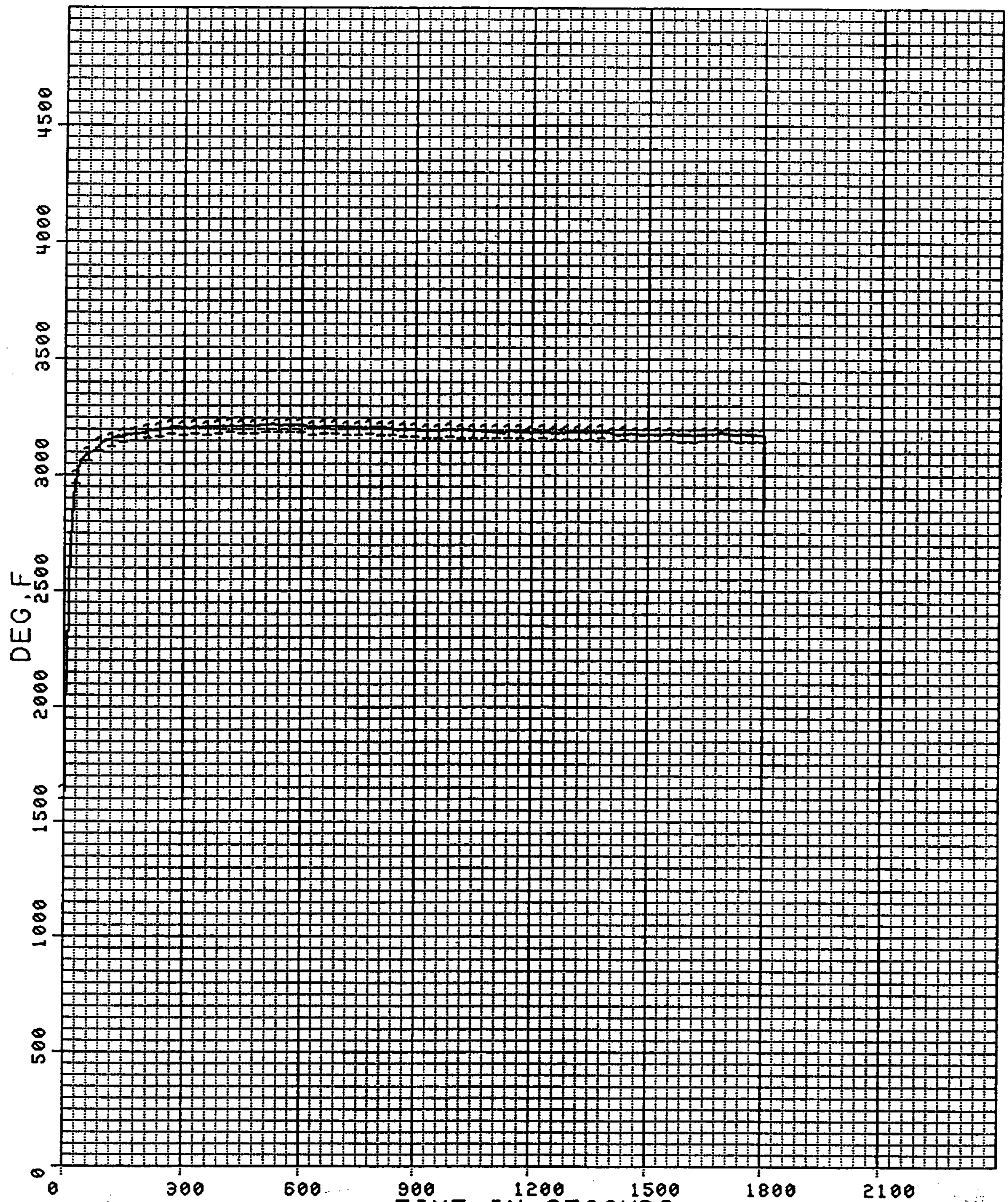


POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

1-320-DD
DATE = 9/12/90 AVERAGE INTERVAL 0.1 SEC TIME = 1:16:24.0 TO 1:46:27.0

PROCESSING DATE 09/12/90

L PYR X CHANNEL NO. 55



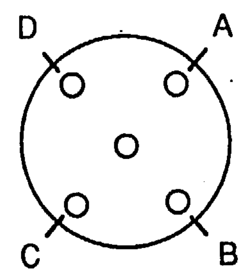
ROC-ENKA TAL ABORT TEST RUN L. ARM IN09/374 3200 DEG F @ 100 PSF 0254R02 ROD4 2

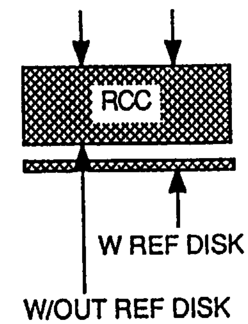
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN09/374 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	49.026		44.014 ~~47.012~~	
BAG WEIGHT ONLY	10.362		10.362	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.186			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.241	.509	.186	.486
THICKNESS AT POINT A	.239	.509	.234	.501
THICKNESS AT POINT B	.241	.506	.239	.510
THICKNESS AT POINT C	.241	.507	.241	.520
THICKNESS AT POINT D	.238	.510	.244	.512
REFERENCE DISK THICKNESS	267		267	
TECH / QA / DATE	B.J. 9/10/90 FORD 23		R.J. 9/25/90 FORD 23	

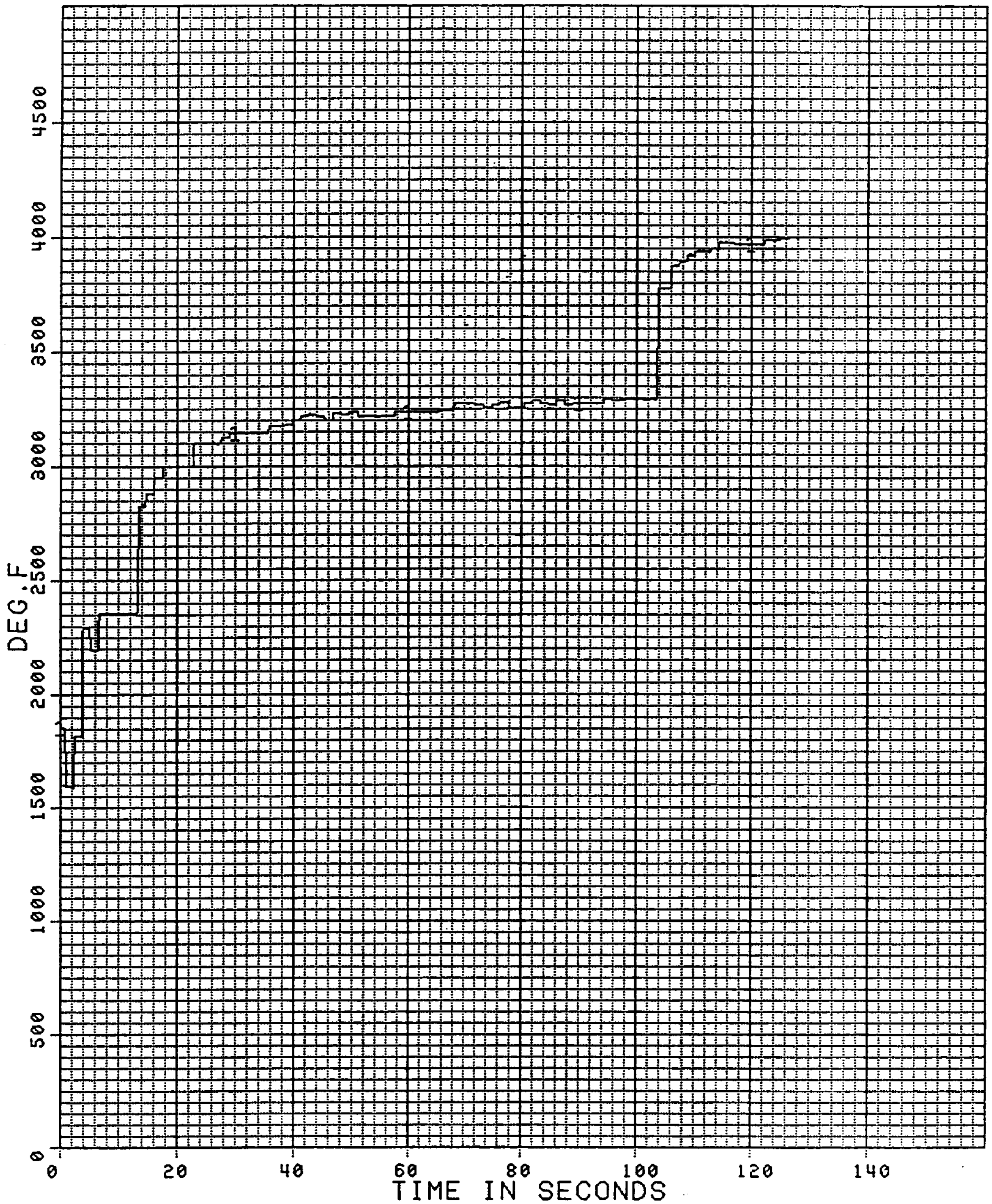




POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

1-322-DD PROCESSING DATE 09/13/90
DATE = 9/13/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:15:51.0 TO 0:17:59.0

L PYR X CHANNEL NO. 55

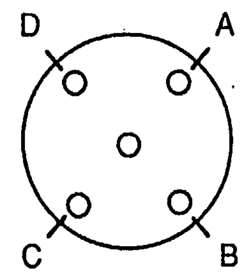


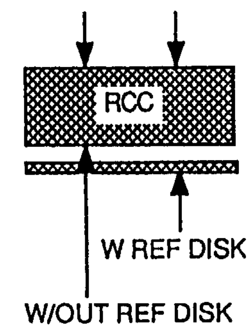
RCC-ENKA TAL ABORT TEST RUN L. ARM IN11/375 3350 DEG F @ 100 PSF 0256R01 RCD4 2

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

8/7/90

TEST ARTICLE NO: IN11/375 RUN NO: ______ TEST CONDITION: ______





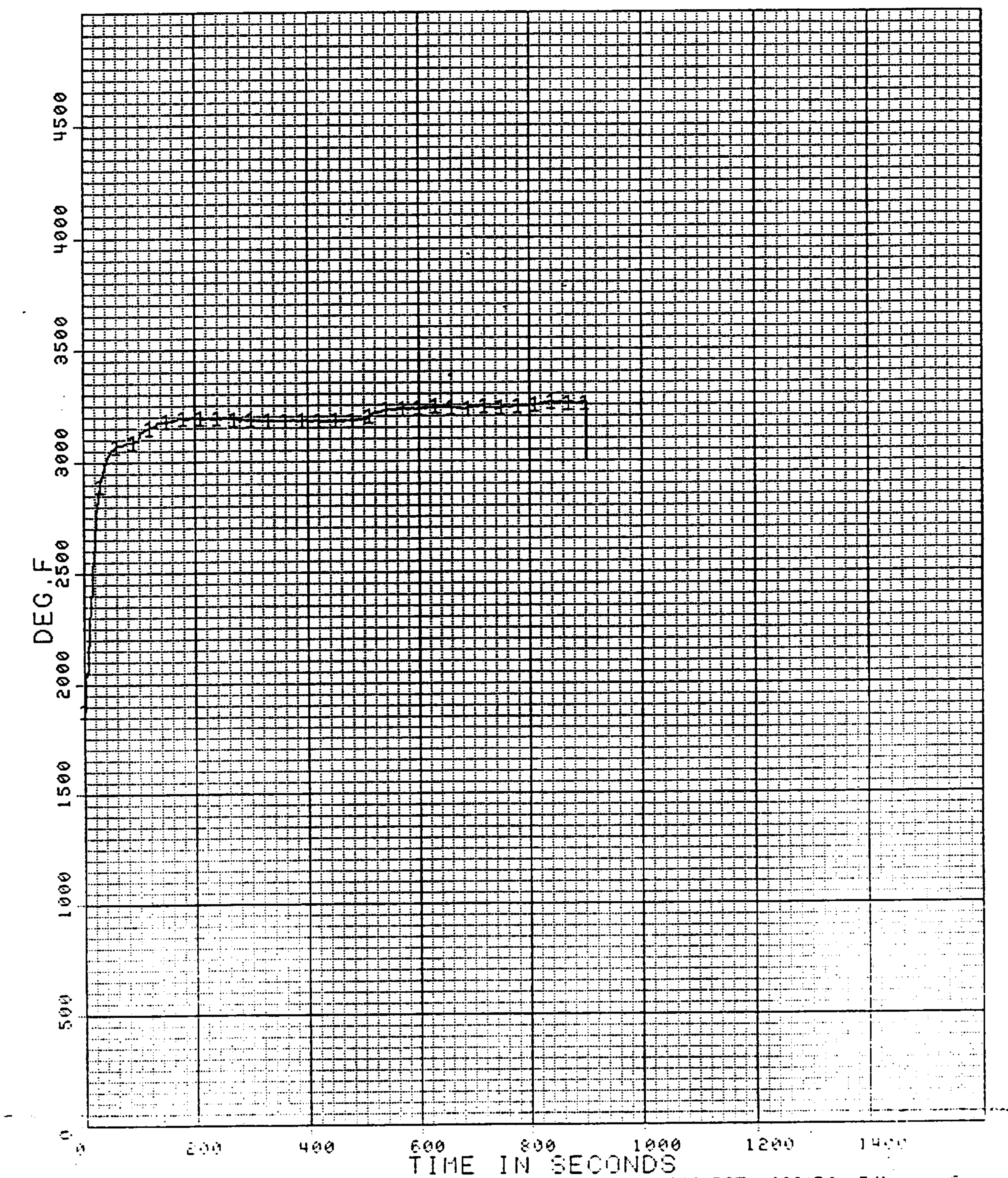
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.341		46.707	
BAG WEIGHT ONLY	10.484		10.484	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.178			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.246	.518	.227 ~~.237~~	.520
THICKNESS AT POINT A	.250	.518	.250	.515
THICKNESS AT POINT B	.249	.518	.236	.511
THICKNESS AT POINT C	.249	.517	.234	.506
THICKNESS AT POINT D	.249	.518	.245	.502
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ. 9/12/90 FORD 24		BJ. 9/25/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

1-326-DD
DATE = 9/18/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:47:42.0 TO 1: 2:45.0

PROCESSING DATE 09/18/90

L PYR X CHANNEL NO. 55

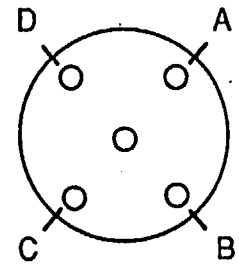


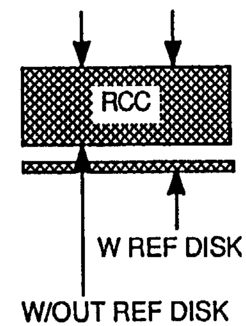
RCC-ENKA TAL HEAT TEST RUN L. ARM IN17/375 3200 DEG F 300 PSF

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 17/376 RUN NO: ______ TEST CONDITION: ______



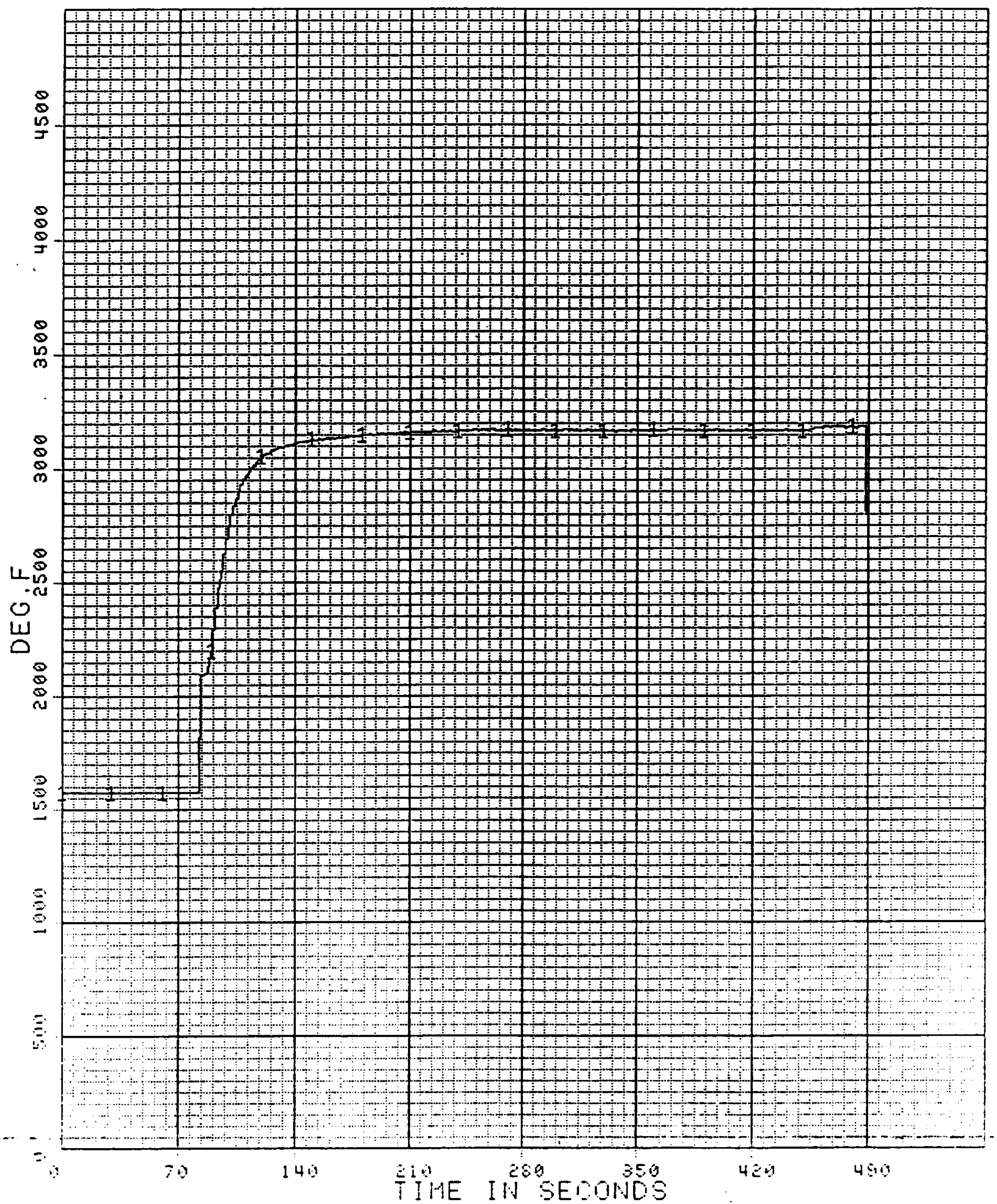


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.652		48.753	
BAG WEIGHT ONLY	10.586		10.586	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.181			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.247	.518 ~~.517~~	.245	.512 ~~.492~~
THICKNESS AT POINT A	.248	.516	.249	.515 ~~.488~~
THICKNESS AT POINT B	.249	.516	.249	.515 ~~.480~~
THICKNESS AT POINT C	.248	.516	.249	.515 ~~.478~~
THICKNESS AT POINT D	.248	.517	.249	.515 ~~.478~~
REFERENCE DISK THICKNESS	.267	FORD 23	BURNED NT SPOT .267	FORD 23
TECH / QA / DATE	9/14/90 BJ		BJ. 9/24/90	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

1-327-DD PROCESSING DATE 09/18/90
DATE = 9/18/90 AVERAGE INTERVAL 0.1 SEC TIME = 3:24: 4.0 TO 3:32:14.0

L PYR X CHANNEL NO. 55

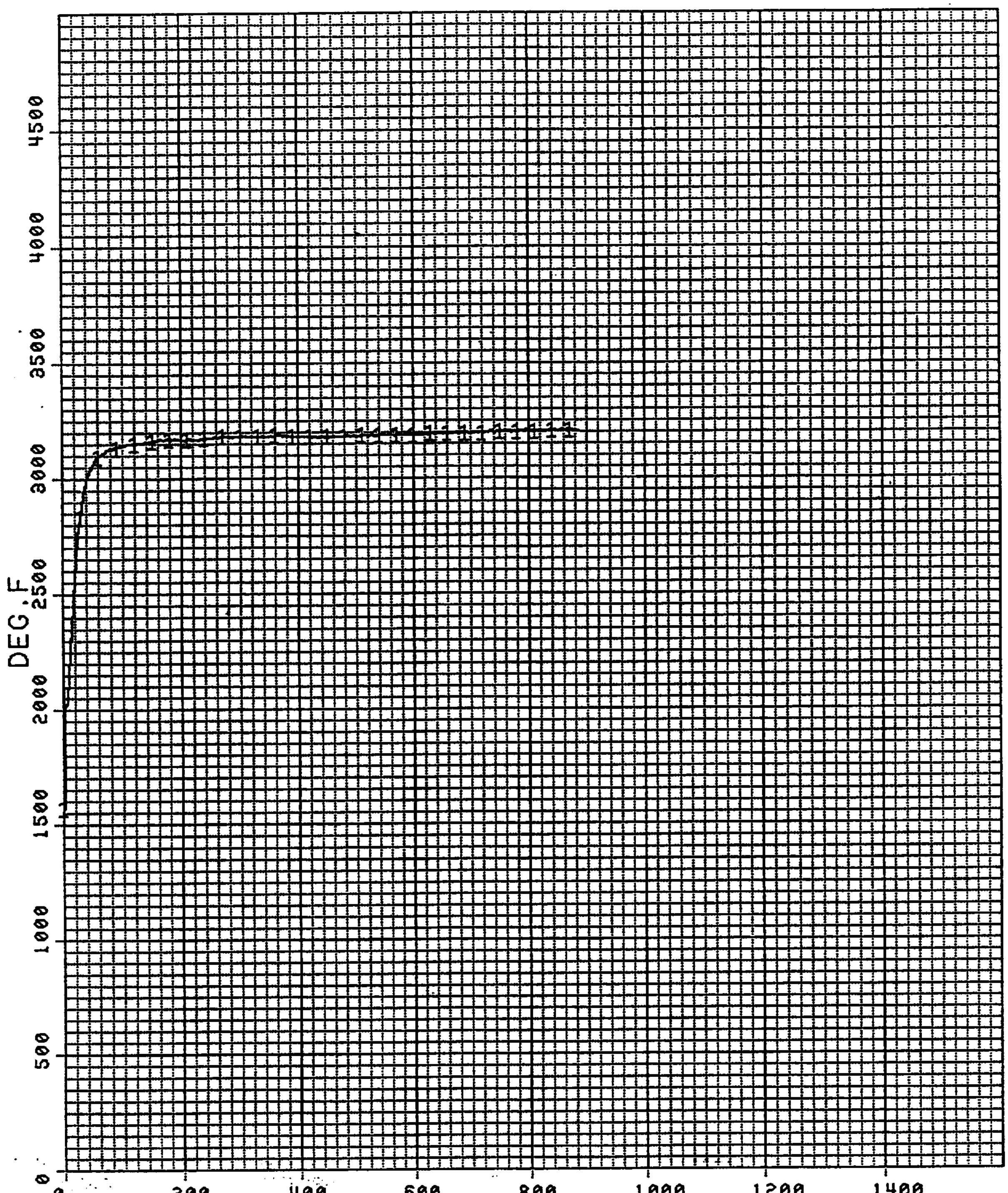


ROCKETDYNE TAL ABORT TEST RUN L. ARM IN19/377 3300 DEG F 300 PSF 086JR01 R0C4 2

1-328-DD
DATE = 9/19/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:11:18.0 TO 0:26: 2.0

PROCESSING DATE 09/19/90

L PYR X CHANNEL NO. 55

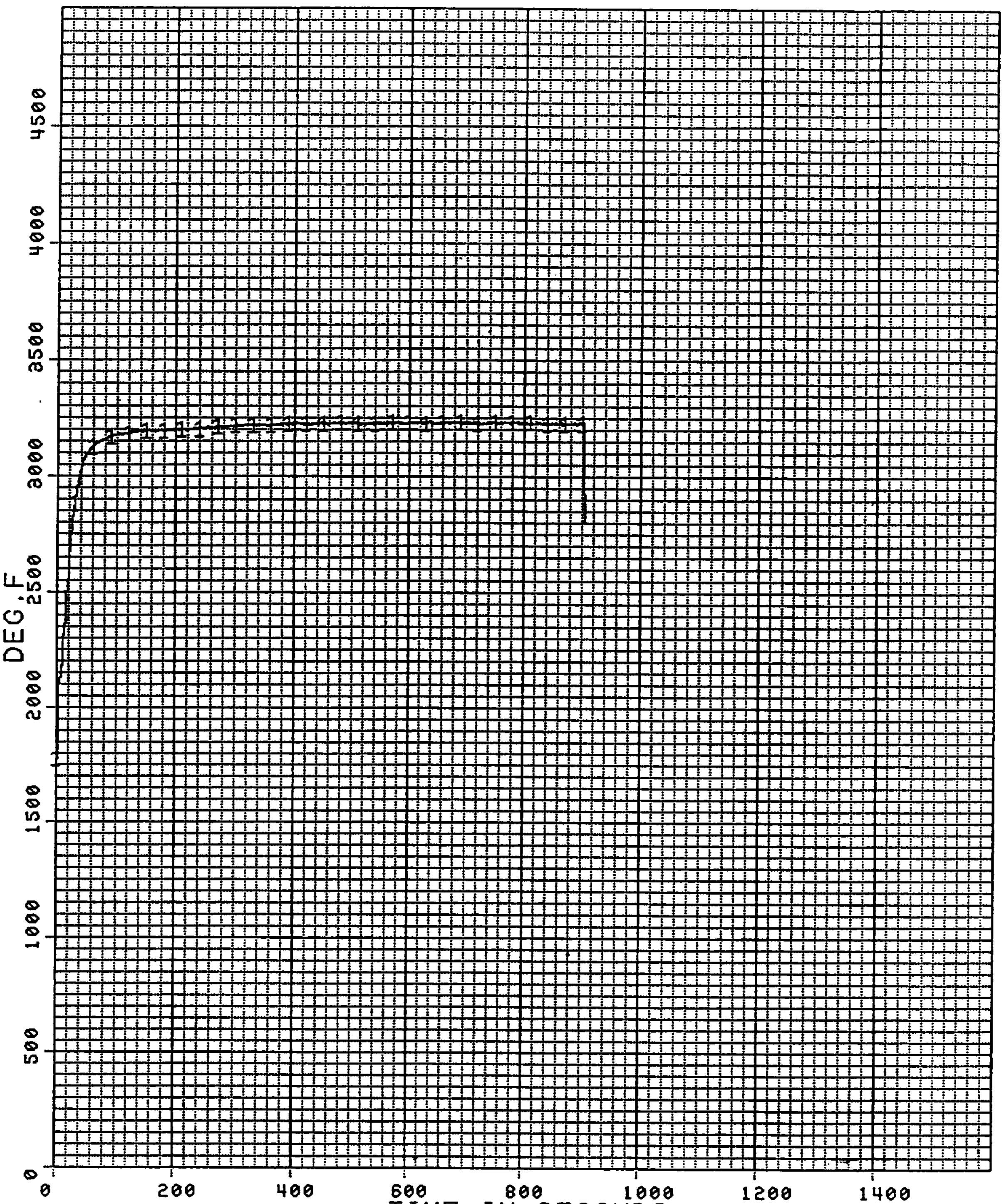


RCC-ENKA TAL ABORT TEST RUN L. ARM IN19/377 3200 DEG F 300 PSF 0262R01 ROD4 2

1-329-DD
DATE = 9/19/90 AVERAGE INTERVAL 0.1 SEC TIME = 2:37:13.0 TO 2:52:18.0

PROCESSING DATE 09/19/90

L PYR X CHANNEL NO. 55

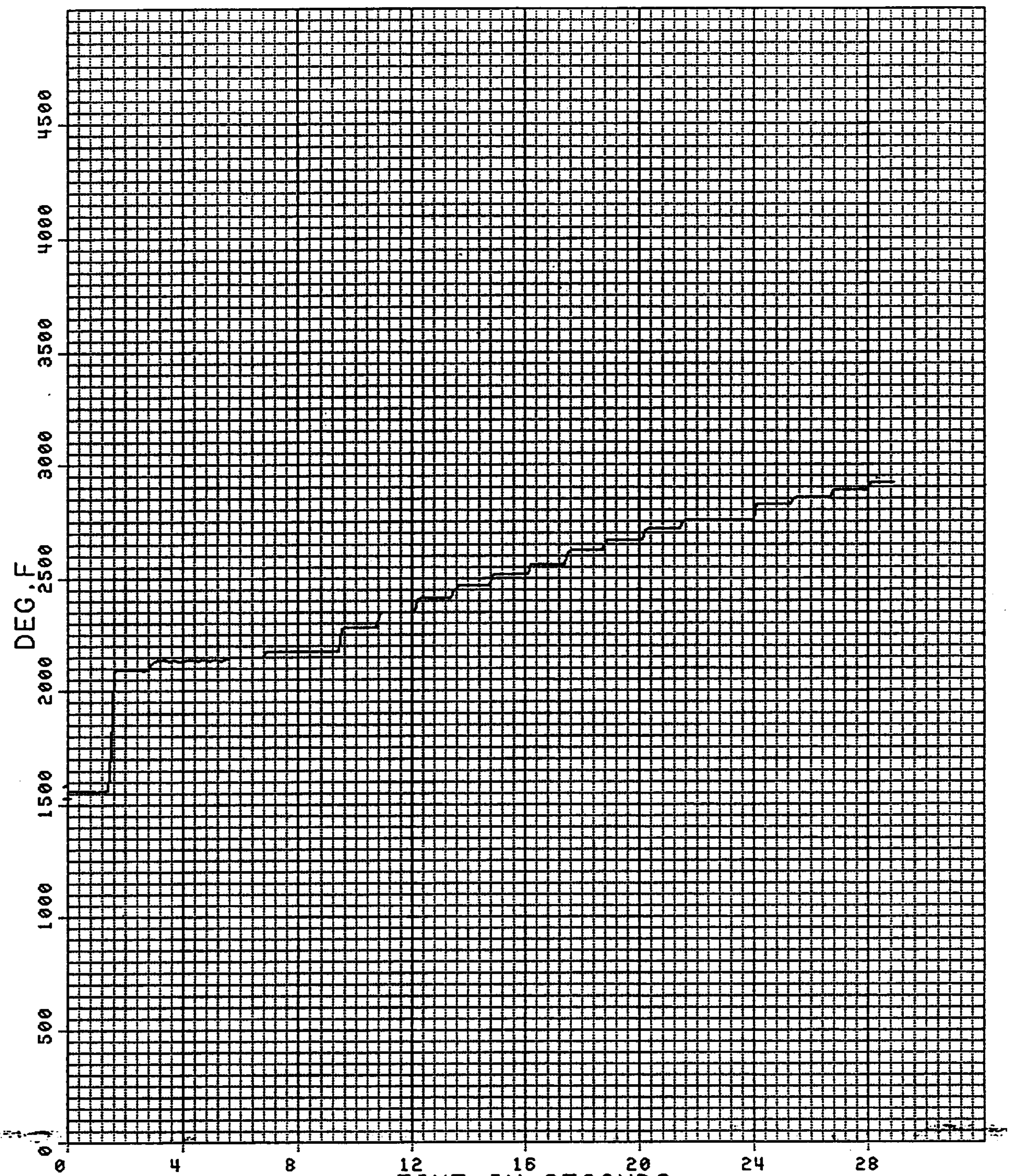


ROC-ENKA TAL ABORT TEST RUN L. ARM IN19/377 3200 DEG F 300 PSF 0262R02 ROD4 2

1-330-DD
DATE = 9/19/90 AVERAGE INTERVAL 0.1 SEC TIME = 4: 6:34.0 TO 4: 7: 3.0

PROCESSING DATE 09/19/90

L PYR X CHANNEL NO. 55

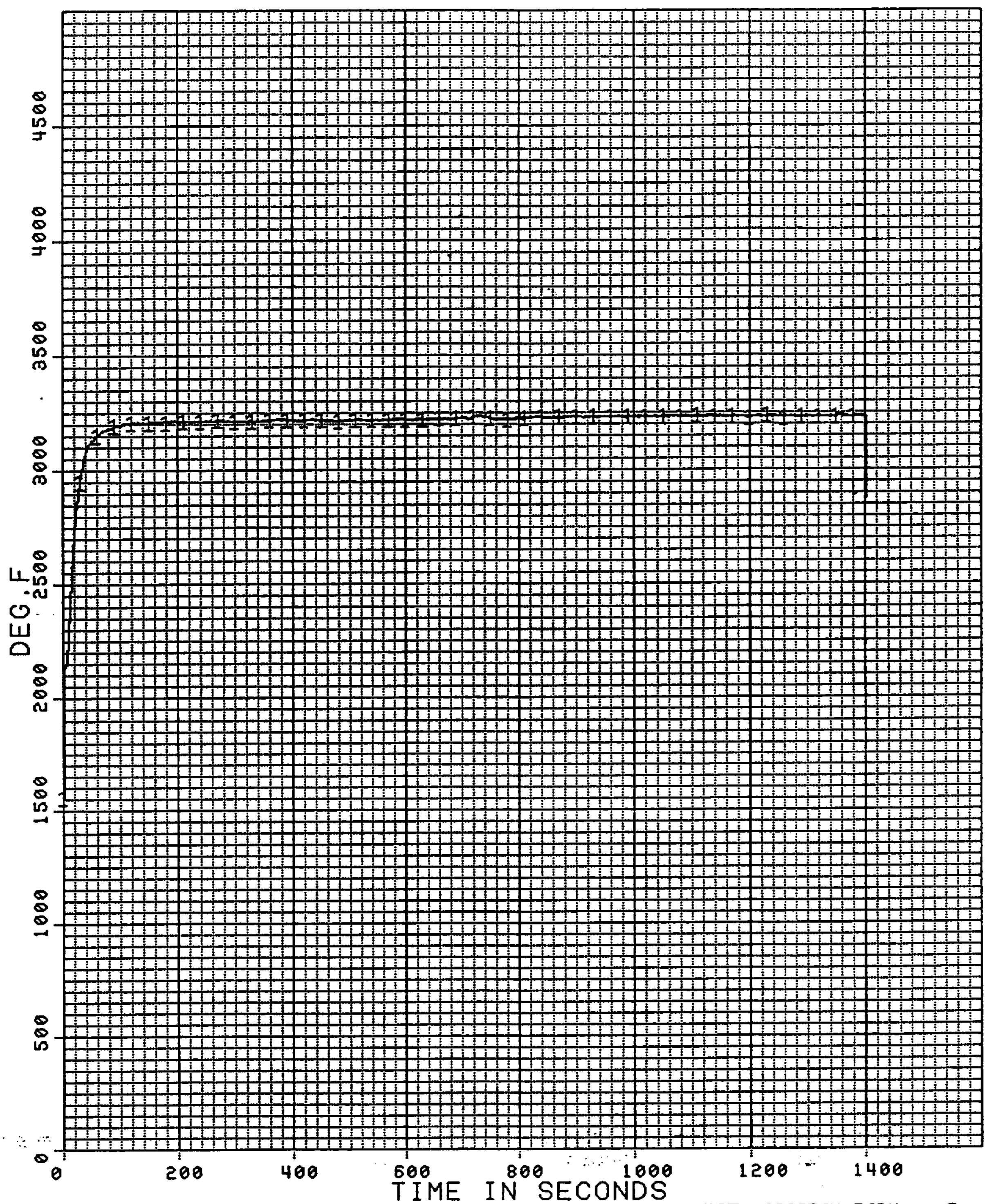


ROC-ENKA TAL ABORT TEST RUN L. ARM IN19/377 3200 DEG F 300 PSF 0262R03 ROD4 2

1-331-DD
DATE = 9/19/90 AVERAGE INTERVAL 0.1 SEC TIME = 5: 0:57.0 TO 5:24:20.0

PROCESSING DATE 09/19/90

L PYR X CHANNEL NO. 55



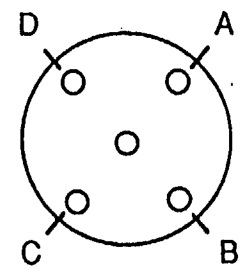
ROC-ENKA TAL ABORT TEST RUN L. ARM IN19/377 3200 DEG F 300 PSF 0262R04 ROD4 2

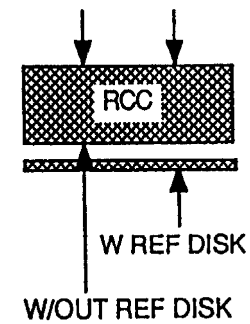
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 19/377 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	49.801		47.757	
BAG WEIGHT ONLY	10.471		10.471	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.183			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.244	.513	.241	.528 ~~.475~~
THICKNESS AT POINT A	.244	.513	.255	.522 ~~.484~~
THICKNESS AT POINT B	.244	.512	.250	.517 ~~.472~~
THICKNESS AT POINT C	.243	.512	.247	.514 ~~.481~~
THICKNESS AT POINT D	.245	.513	.254	.521 ~~.484~~
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ 9/14/90 FORD 23		BJ 9/24/37 FORD 23	



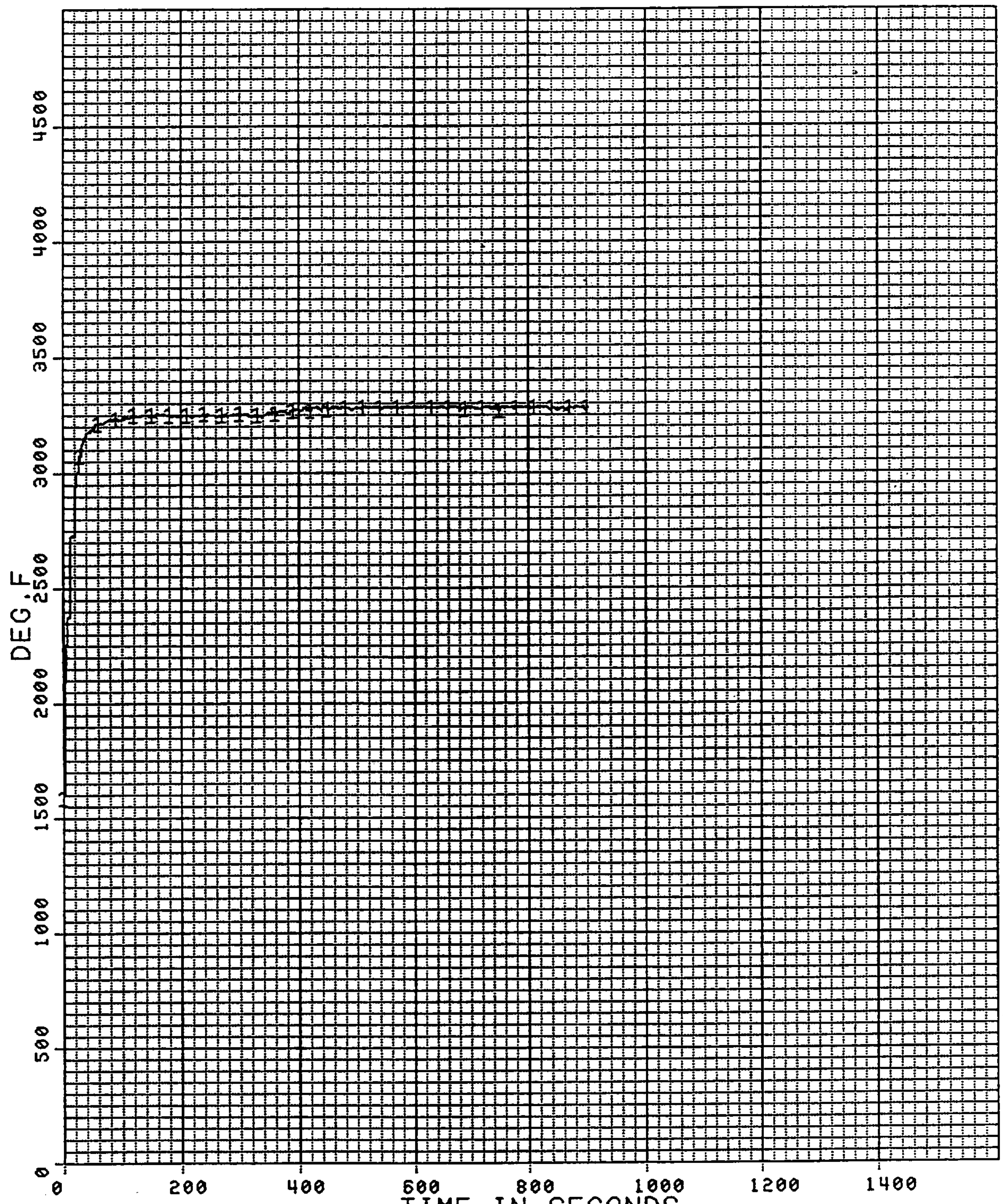


POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

1-339-DD
DATE = 9/28/90 AVERAGE INTERVAL 0.1 SEC TIME = 0:25:10.0 TO 0:40:12.0

PROCESSING DATE 09/28/90

L PYR X CHANNEL NO. 55

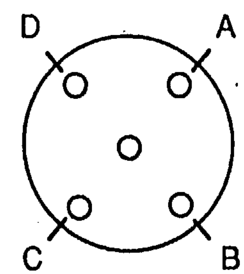


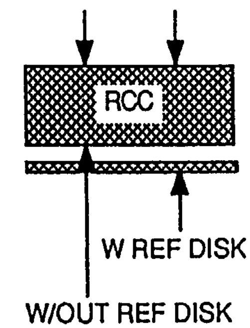
RCC-ENKA TAL ABORT TESTS L. ARM IN23/378 3300 DEG F @ 300 PSF 0271R01 RCD4 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 23/378 RUN NO: ______ TEST CONDITION: ______





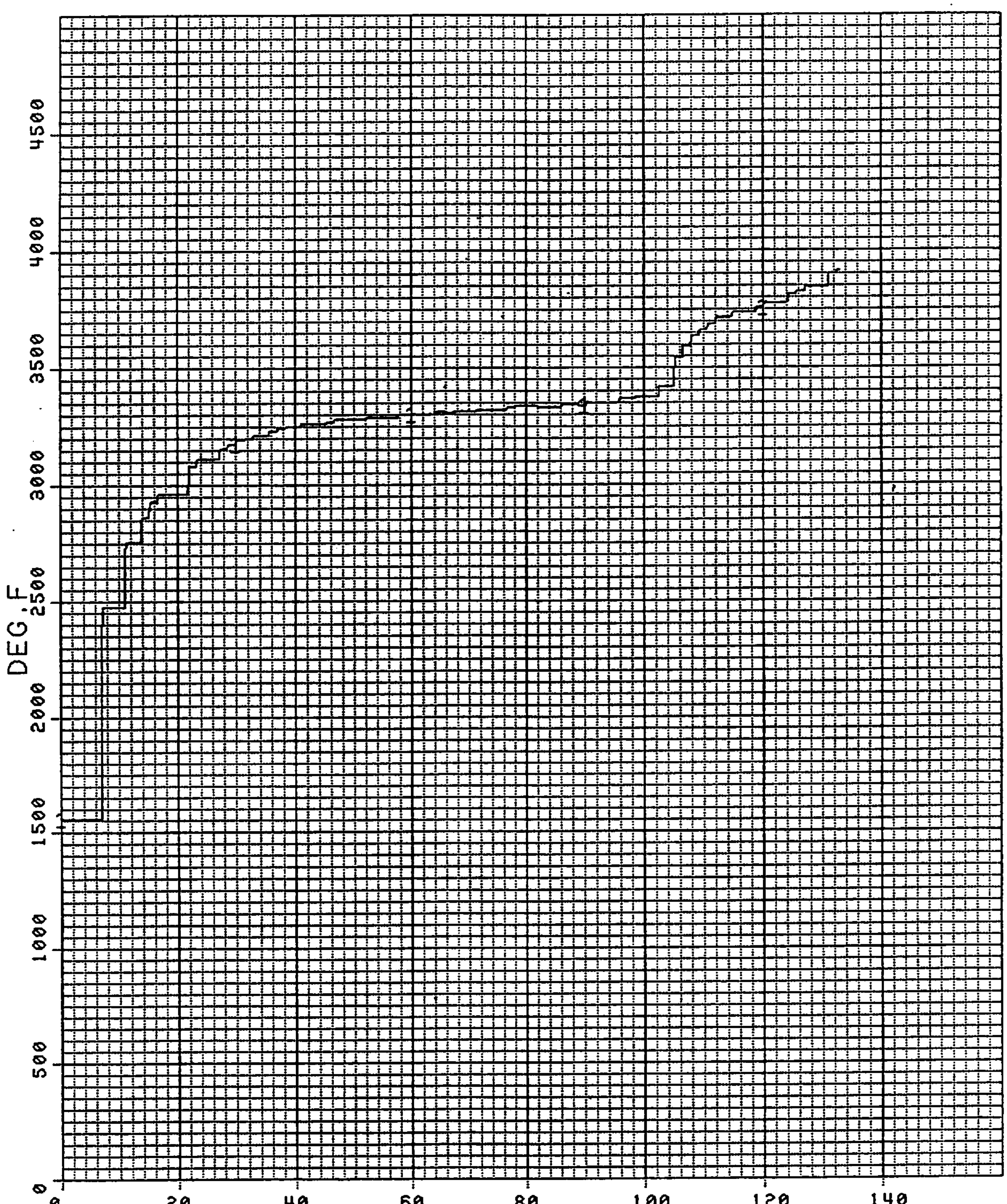
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	48.633		46.286	
BAG WEIGHT ONLY	9.747		9.747	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.175			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.242	.512	.216	.500
THICKNESS AT POINT A	.241	.509	.246	.518
THICKNESS AT POINT B	.242	.509	.243	.515
THICKNESS AT POINT C	.242	.511	.243	.516
THICKNESS AT POINT D	.242	.511	.247	.519
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 9/27/90	FORD 23	B.J. 9/28/90	FORD 23

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

1-340-DD
DATE = 9/28/90 AVERAGE INTERVAL 0.1 SEC TIME = 2:58:38.1 TO 3: 0:51.0

PROCESSING DATE 09/28/90

L PYR X CHANNEL NO. 55

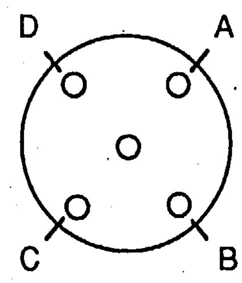


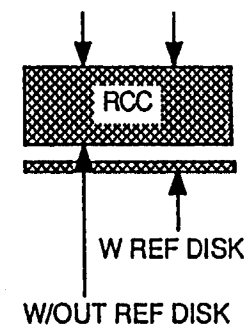
ROC-ENKA TAL ABORT TESTS L. ARM IN29/379 3350 DEG F @ 300 PSF 0271R02 ROD4 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN29 / 379 RUN NO: ______ TEST CONDITION: ______





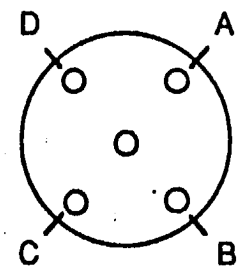
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	46.504		42.426	
BAG WEIGHT ONLY	10.226		10.226	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.178			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.224	.497	.197	.473
THICKNESS AT POINT A	.227	.496	.224	.492
THICKNESS AT POINT B	.227	.494	.224	.492
THICKNESS AT POINT C	.225	.495	.223	.493
THICKNESS AT POINT D	.225	.496	.224 ~~.224~~	.492
REFERENCE DISK THICKNESS	.267 FORD 23		.267	
TECH / QA / DATE	B.J. 9/27/90		B.J. 9/28/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
COATED ENKA/TEOS

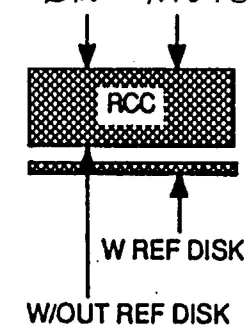
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 266 (23) RUN NO: 1-178 DD TEST CONDITION: 2850F, 59 psf



$\Delta m = 7.1098$ g



	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.1258		37.016	
BAG WEIGHT ONLY	8.1474		8.1474	
SPECIMEN WEIGHT ONLY	35.9784		28.8686	
EMISSIVITY	.58			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.271	.541	.216	.482
THICKNESS AT POINT A	.275	.542	.220	.490
THICKNESS AT POINT B	.275	.544	.223	.493
THICKNESS AT POINT C	.275	.544	.222	.494
THICKNESS AT POINT D	.275	.543	.221	.490
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ	BOEING 23 QUALITY	BZ 1 31 90	BOEING 23 QUALITY

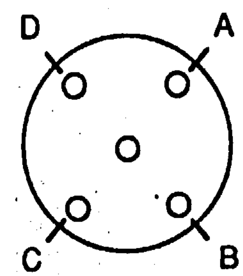
POST-TEST RESULTS/COMMENTS:

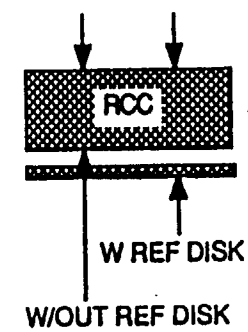
ORIGINAL PAGE IS OF POOR QUALITY

PAGE 5 OF TPS 7A-2215
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 268 (25) RUN NO: ________ TEST CONDITION: ________



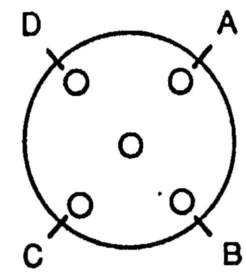


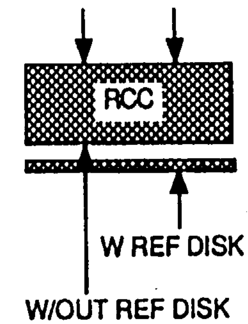
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.2626		38.232	
BAG WEIGHT ONLY	7.9852		7.9852	
SPECIMEN WEIGHT ONLY	36.2774			
EMISSIVITY	.517			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.274	.545	.233	.498
THICKNESS AT POINT A	.276	.545	.245	.515
THICKNESS AT POINT B	.277	.545	.239	.507
THICKNESS AT POINT C	.276	.545	.234	.506
THICKNESS AT POINT D	.277	.547	.235	.506
REFERENCE DISK THICKNESS	BJ .268		.268	
TECH / QA / DATE			BJ 4 16 90	

POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 269 (26) RUN NO: ______ TEST CONDITION: ______





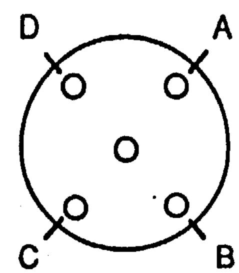
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.3202		36.005	
BAG WEIGHT ONLY	8.0813		8.0813	
SPECIMEN WEIGHT ONLY	36.2389			
EMISSIVITY	.508			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.277	.545	.215	.467
THICKNESS AT POINT A	.275	.544	.207	.476
THICKNESS AT POINT B	.277	.545	.220	.489
THICKNESS AT POINT C	.277	.546	.226	.496
THICKNESS AT POINT D	.277	.545	.231	.501
REFERENCE DISK THICKNESS	BZ .268 FORD 23		.268 FORD 23	
TECH / QA / DATE			BZ 4 19 90	

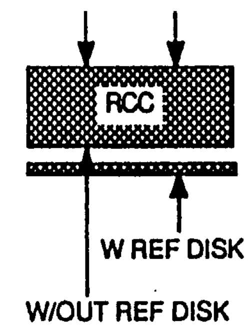
POST-TEST RESULTS/COMMENTS:

9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 270 (27) RUN NO: ______ TEST CONDITION: ______



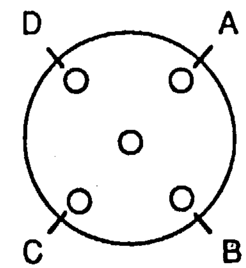


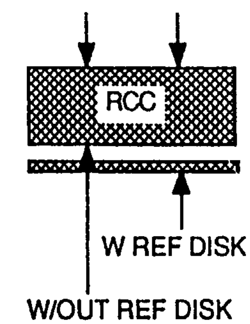
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.8033		39.963	
BAG WEIGHT ONLY	8.4029		8.4029	
SPECIMEN WEIGHT ONLY	36.4004			
EMISSIVITY	.495			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.274	.544	.241	.510
THICKNESS AT POINT A	.275	.544	.242	.511
THICKNESS AT POINT B	.276	.544	.244	.513
THICKNESS AT POINT C	.276	.544	.244	.511
THICKNESS AT POINT D	.276	.545	.243	.514
REFERENCE DISK THICKNESS	BZ .268		BZ .268	
TECH / QA / DATE			3 23 90	

POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 270/27 BACKFACE RUN NO: 1-251-DD TEST CONDITION: 3100F





	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	39.977		32.056	
BAG WEIGHT ONLY	8.401		8.401	
SPECIMEN WEIGHT ONLY				
EMISSIVITY				
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.237	.525	.162	.449
THICKNESS AT POINT A	.241	.526	.196	.476
THICKNESS AT POINT B	.242	.524	.194	.471
THICKNESS AT POINT C	.241	.521	.190	.470
THICKNESS AT POINT D	.243	.523	.197	.478
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BOZ 4 12 90		BOZ 4 19 90 FORD 23	

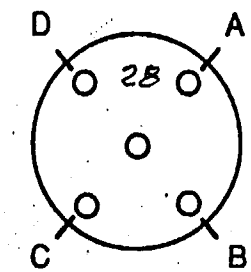
POST-TEST RESULTS/COMMENTS:

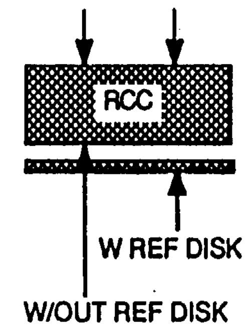
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 271 (28) RUN NO: 1-232-DD TEST CONDITION: 1440°F/100PSF 75MINUTES

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.9569		36.403	
BAG WEIGHT ONLY	8.4154		8.4154	
SPECIMEN WEIGHT ONLY	36.5415			
EMISSIVITY	.497			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.275	.545	.236	.504
THICKNESS AT POINT A	.275	.544	.256	.522
THICKNESS AT POINT B	.275	.544	.248	.517
THICKNESS AT POINT C	.276	.545	.222	.492
THICKNESS AT POINT D	.277	.545	.227	.499
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ		BZ 4 2 90	





POST-TEST RESULTS/COMMENTS:

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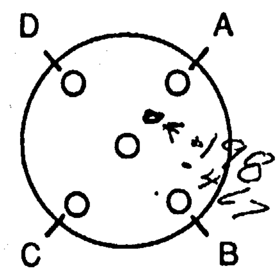
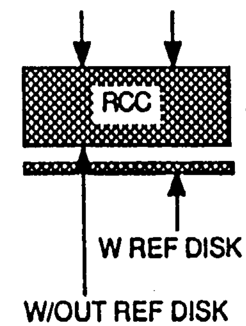
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 272 (29) RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.7400		35.348	
BAG WEIGHT ONLY	8.3070		8.3070	
SPECIMEN WEIGHT ONLY	36.4330			
EMISSIVITY	.498			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.274	.546	.203	.477
THICKNESS AT POINT A	.277	.545	.201	.475
THICKNESS AT POINT B	.277	.545	.207	.477
THICKNESS AT POINT C	.276	.545	.212	.481
THICKNESS AT POINT D	.278	.547	.211	.481
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BZ		BZ 32290	





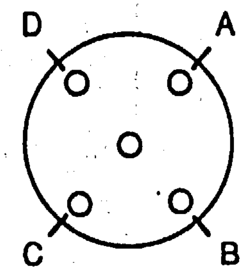
FORD 23

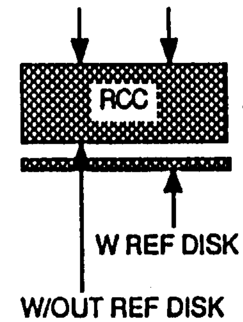
POST-TEST RESULTS/COMMENTS:

PAGE 5 OF TPS TA-2275
9/8/89

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: 273 (32) RUN NO: ______ TEST CONDITION: ______





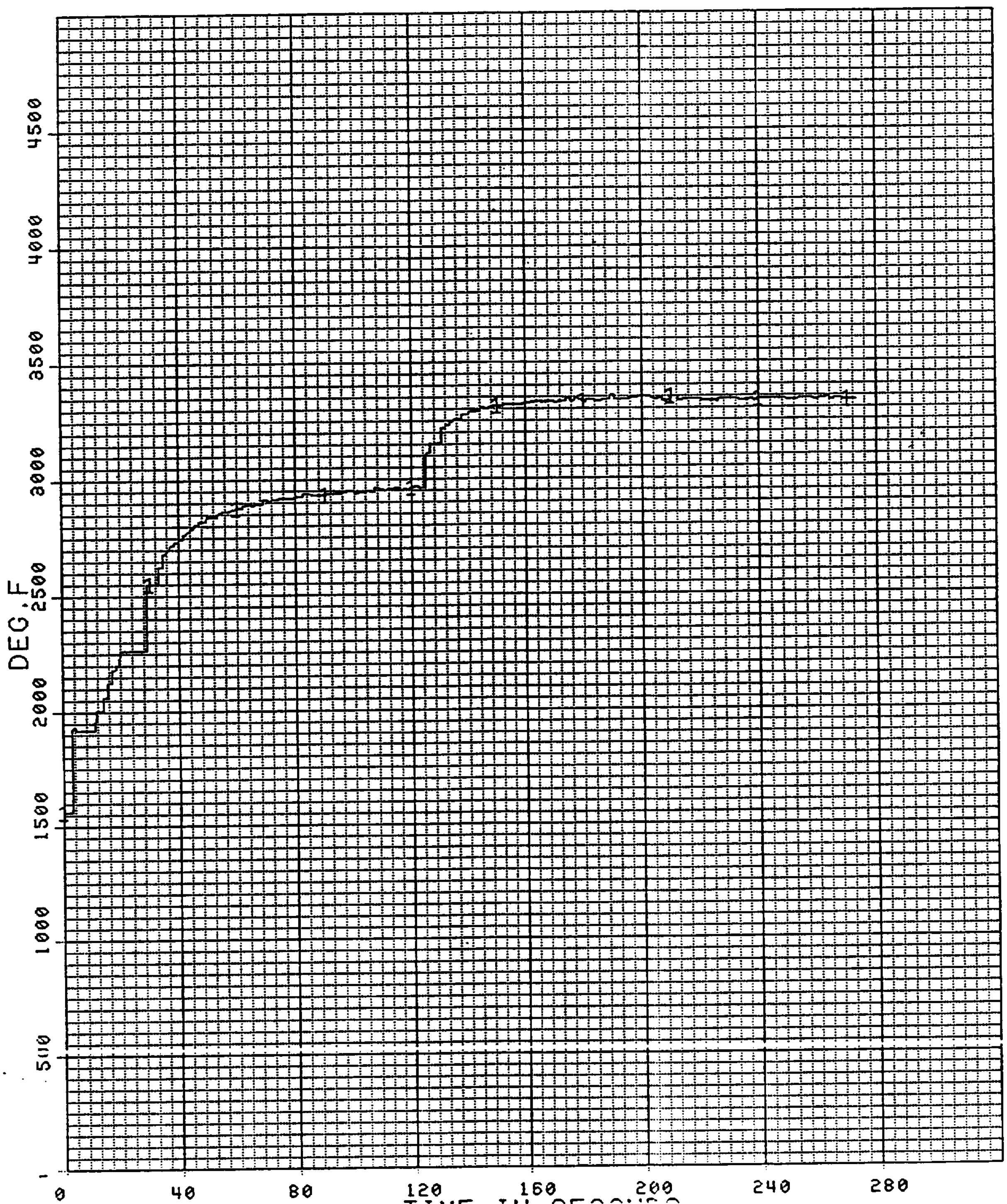
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	44.5505		32.698	
BAG WEIGHT ONLY	8.3779		8.3779	
SPECIMEN WEIGHT ONLY	36.1726			
EMISSIVITY	.520			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.274	.543	.168	.436
THICKNESS AT POINT A	.275	.542	.190	.456
THICKNESS AT POINT B	.276	.542	.174	.440
THICKNESS AT POINT C	.275	.543	.179	.448
THICKNESS AT POINT D	.275	.544	.194	.459
REFERENCE DISK THICKNESS	BZ .268		BZ .268	
TECH / QA / DATE			3 22 90 FORD 23	

POST-TEST RESULTS/COMMENTS:

1-356-DD
DATE = 10/16/90 AVERAGE INTERVAL 0.1 SEC TIME = 19:10:26.0 TO 19:14:59.0

PROCESSING DATE 10/16/90

L PYR X CHANNEL NO. 55

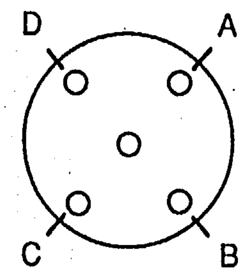


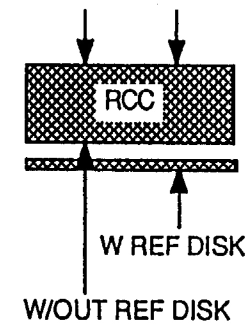
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN24/380 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST W/OUT REF DISK	PRE-TEST W REF DISK	POST-TEST W/OUT REF DISK	POST-TEST W REF DISK
BAG AND SPECIMEN WEIGHT	43.292		30.103	
BAG WEIGHT ONLY	10.104		10.104	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.363			
MEASUREMENTS OF SPECIMEN				
THICKNESS AT CENTERLINE	.238	.511	~~.423~~ .144	.423
THICKNESS AT POINT A	.242	.508	~~.436~~ .153	.436
THICKNESS AT POINT B	.242	.509	~~.430~~ .165	.430
THICKNESS AT POINT C	.240	.510	~~.422~~ .176	.422
THICKNESS AT POINT D	.241	.510	.156	.420
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ 10/14/90		BJ 10/16/90	



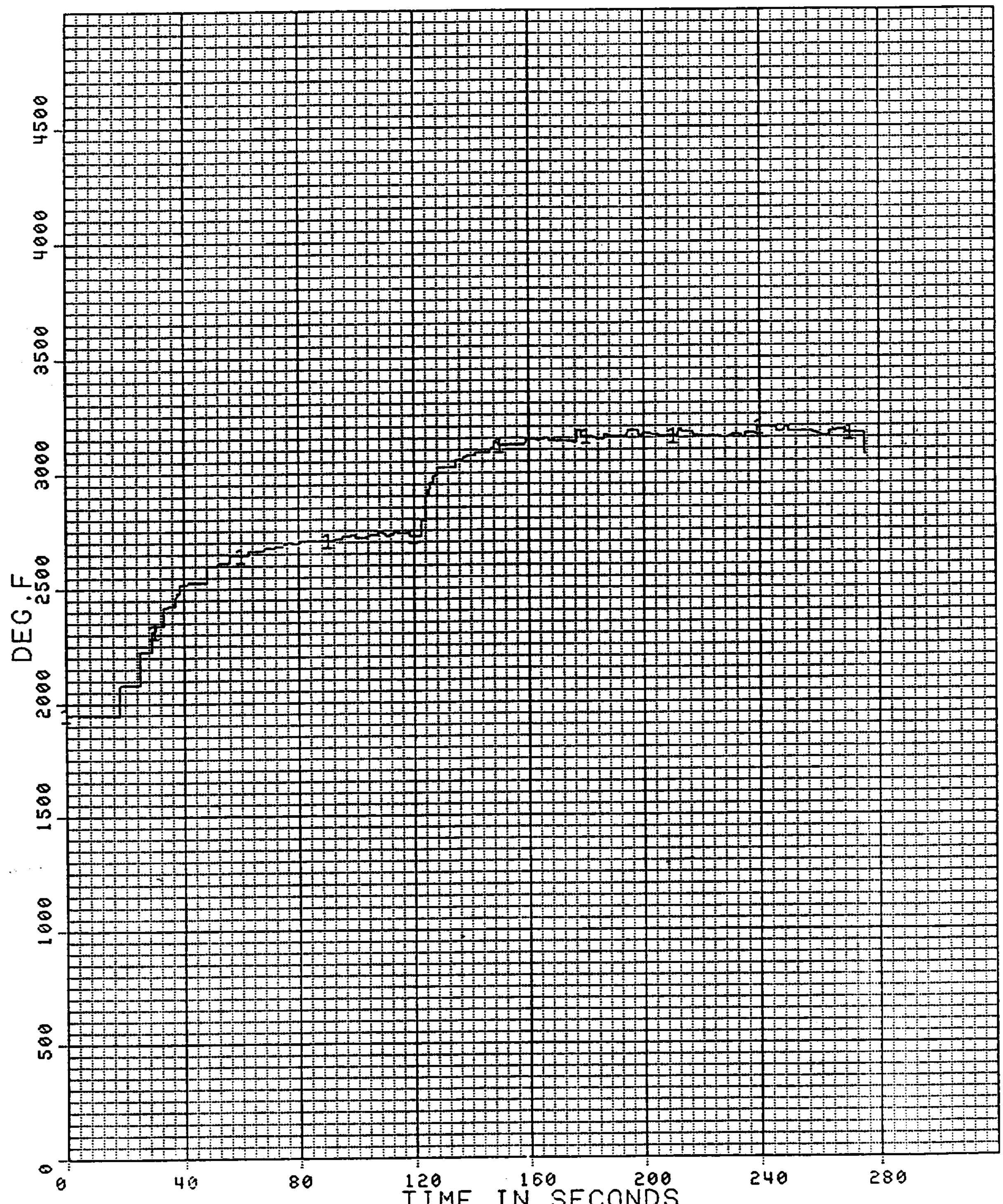


POST-TEST RESULTS/COMMENTS:
UNCOATED ENKA/TEOS

1-360-DD
DATE = 10/18/90 AVERAGE INTERVAL 0.1 SEC TIME = 17:40:34.0 TO 17:45:10.0

PROCESSING DATE 10/19/90

L PYR X CHANNEL NO. 55

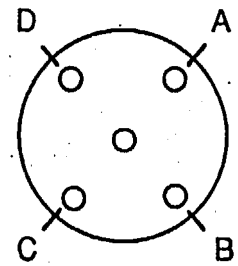


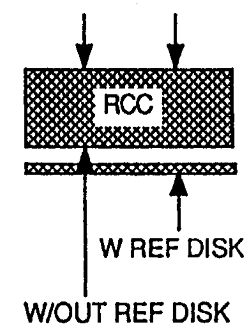
ROC-ENKA TAL ABORT TEST L ARM IN30/381 2600 DEG F @ 200 PSF 0 291R01 ROD4 2

PAGE 8 OF 8 [illegible]
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN 30/381 RUN NO: ________ TEST CONDITION: ________





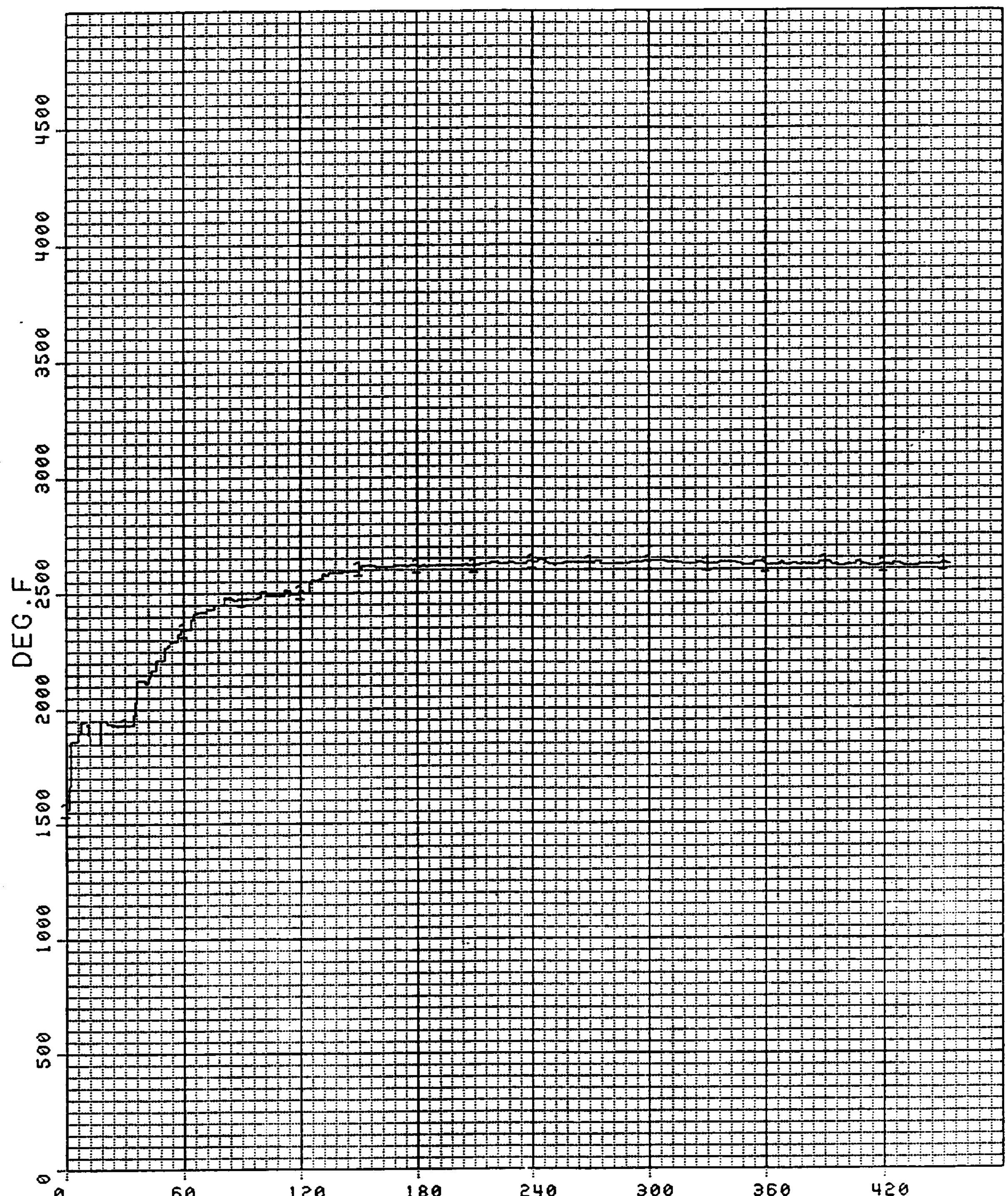
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	41.311		29.991	
BAG WEIGHT ONLY	10.258		10.258	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.320			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.224	.491	.142	.411
THICKNESS AT POINT A	.225	.493	.166	.433
THICKNESS AT POINT B	.225	.494	.150	.416
THICKNESS AT POINT C	.225	.493	.148	.415
THICKNESS AT POINT D	.226	.492	.154	.429
REFERENCE DISK THICKNESS	.267 FORD 23		.267 FORD 23	
TECH / QA / DATE	B.Y. 10/12/90		B.J. 10/18/90	

POST-TEST RESULTS/COMMENTS:
UNCOATED ENKA/TEOS

1-361-DD
DATE = 10/18/90 AVERAGE INTERVAL 0.1 SEC TIME = 19: 0:38.0 TO 19: 8:11.0

PROCESSING DATE 10/19/90

L PYR X CHANNEL NO. 55

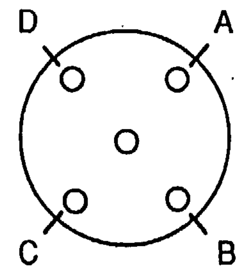


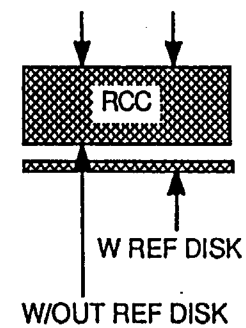
ROC-ENKA TAL ABORT TEST L ARM IN31/382 2600 DEG F @ 200 PSF 0290R02 ROD4 2

8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN31/382 RUN NO: ______ TEST CONDITION: ______





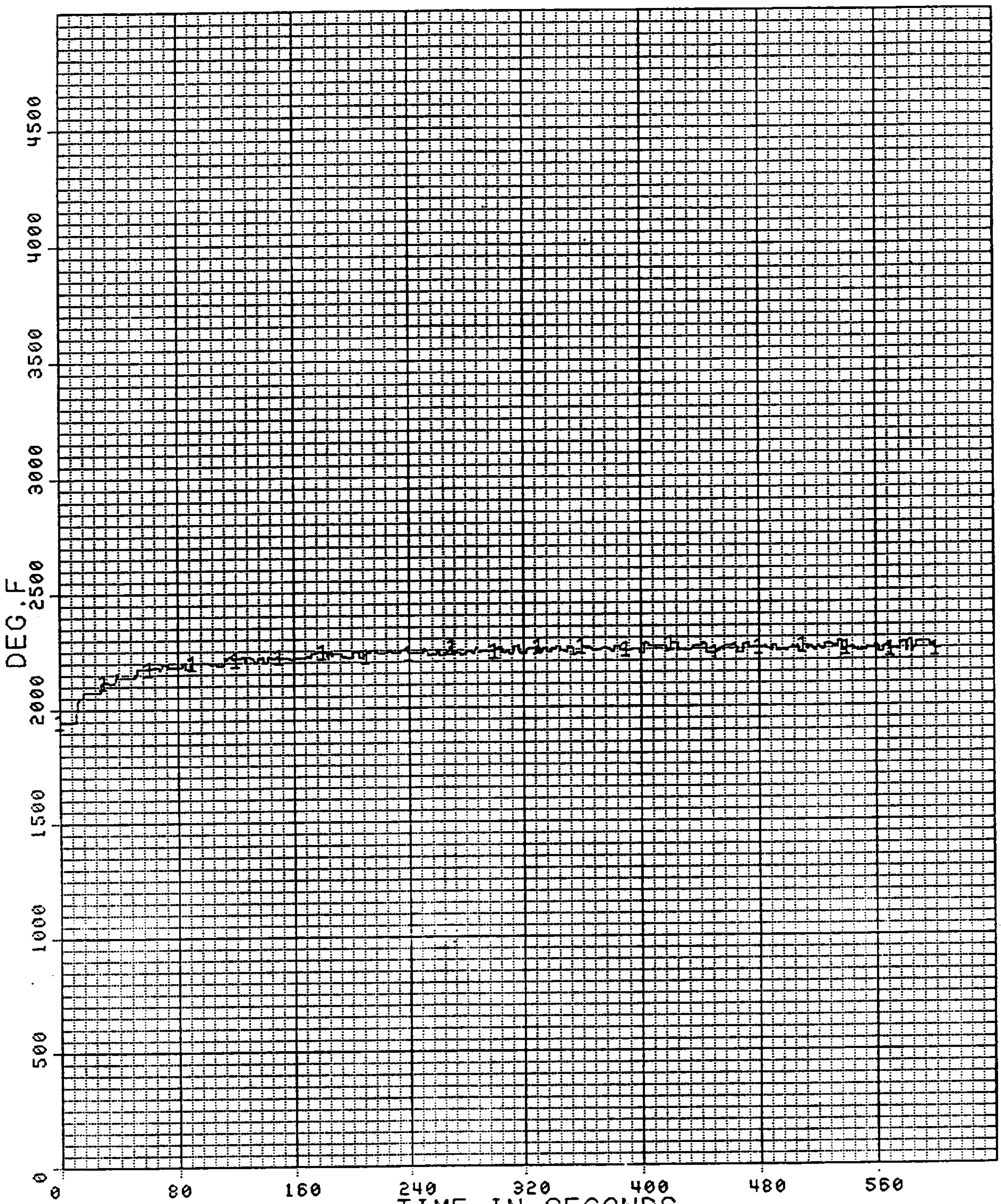
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	41.599		28.933	
BAG WEIGHT ONLY	10.608		10.608	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.393			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.225	.496	.139 ~~.142~~	.411 ~~.411~~
THICKNESS AT POINT A	.224	.493	.136 ~~.140~~	.409 ~~.433~~
THICKNESS AT POINT B	.228	.495	.151 ~~.150~~	.420 ~~.416~~
THICKNESS AT POINT C	.227	.495	.143 ~~.145~~	.414 ~~.415~~
THICKNESS AT POINT D	.227	.495	.146 ~~.154~~	.414 ~~.429~~
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	B.J. 10/17/90 FORD 23		B.J. 10/19/90 FORD 23	

POST-TEST RESULTS/COMMENTS:
UNCOATED ENKA/TEOS

1-362-DD
DATE = 10/18/90 AVERAGE INTERVAL 0.1 SEC TIME = 22: 5: 7.0 TO 22:15:10.0

PROCESSING DATE 10/19/90

L PYR X CHANNEL NO. 55



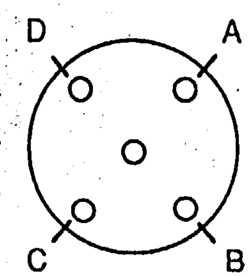
ROC-ENKA TAL ABORT TEST L ARM IN34/383 2050 DEG F @ 100 PSF 0290R03 ROD4 2

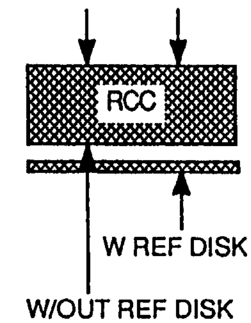
8/7/90

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: IN34/383 RUN NO: ______ TEST CONDITION: ______

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	42.229		31.640	
BAG WEIGHT ONLY	10.625		10.625	
SPECIMEN WEIGHT ONLY				
EMISSIVITY	.316			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.229	.498	.152	~~.446~~ .421
THICKNESS AT POINT A	.230	.497	.165	.433
THICKNESS AT POINT B	.230	.497	.160	.433
THICKNESS AT POINT C	.230	.495	.170	.438
THICKNESS AT POINT D	.231	.499	.162	.431
REFERENCE DISK THICKNESS	.267		.267	
TECH / QA / DATE	BJ 10/17/90 FORD 23		BJ 10/19/90 FORD 23	





POST-TEST RESULTS/COMMENTS:
UNCOATED ENKA/TEOS

Test Series 3

Conducted from

January 30, 1992 to March 5, 1992

1.0 SUMMARY

An arc jet test of non-sealed Reinforced Carbon-Carbon (RCC) was performed in the Johnson Space Center's (JSC) Atmospheric Reentry Material & Structures Evaluation Facility (ARMSEF) from 1/30/1992 through 3/05/1992. The test was needed to expand the current data base for quantifying coated and uncoated non-sealed RCC surface recession as a function of temperature and pressure in environment regimes representative of a Transatlantic Abort Landing (TAL) trajectory. Eight test specimens (6 coated and 2 uncoated) were subjected to temperatures ranging from 1477°C (2690°F) to 1893°C (3440°F) and pressures ranging from 14.988 KPa (313 psf) to 19.154 KPa (400 psf). For the coated specimens, silicon carbide coating failure occurred at a temperature as low as 1824°C (3315°F), which is approximately 10°C (50°F) higher than RCC with sealants. Test data were transferred to the test requester for surface recession rate determination.

2.0 INTRODUCTION

In the early part of 1987, a concern was expressed that the Orbiter's wing leading edge temperatures predicted for a Transatlantic Abort Landing (TAL) would exceed the upper temperature range of the RCC ground test data base. A series of three test programs were performed in December 1987 (ref. 1), November 1989 (ref. 2), and August 1990 (ref. 2) to extend the ground test data base for RCC up to 1871°C (3400°F). Data from these tests helped establish mass loss correlations for the silicon carbide coating and the carbon substrate. During the development of these correlations, it became apparent that the surface sealants (Tetraethyl Orthosilicate (TEOS) and Type A enhancement) may play a significant role in the performance of RCC in this temperature range. Rockwell Test Request number SE-PSE-91-031 was developed to investigate the role of surface sealants in RCC performance through the testing of unsealed test specimens.

3.0 OBJECTIVE

The objective of the Non-sealed RCC Test Program is to develop a data base for assessing the influence of TEOS and Type A enhancement surface sealants on surface heating and chemistry and to empirically determine the surface recession rate of non-sealed RCC at the predicted TAL temperature and pressure levels.

4.0 TEST SPECIMENS

A total of 8 test specimens (6 coated and 2 uncoated) and one calibration specimen of each type were fabricated by LTV Aerospace and Defense Company for this test program. All ten specimens are 7.11 cm (2.8") in diameter and have a 19-ply thickness of ENKA based RCC.

The calibration specimens have three type C (tungsten - 5% rhenium vs. tungsten - 26% rhenium) thermocouples installed as shown in Figure 1. TC1 and TC3 sense front surface temperatures and TC2 senses the back surface temperature. Although there was a conduction heat loss through the thermocouple lead wires, thermal analysis from previous RCC test programs indicated that the actual surface temperature should not be more than 8.3°C (15°F) higher than the measured values.

The coated specimens have the outer surface layers converted to silicon carbide in a diffusion coating process for oxidation protection. Except for the absence of TEOS and Type A sealants, these specimens are representative of RCC in the stagnation region of Orbiter panel #9. The uncoated specimens were used to evaluate substrate erosion that would occur following silicon carbide coating failure at high temperatures.

All specimens have four slots on the edge at 90° apart to accept the pins which hold the specimens in the siliconized graphite holders (see Figure 2). The pre-test photographs of a holder and the test specimens are shown in Figures A-1 through A-9 in Appendix A.

5.0 TEST FACILITY

The test program was performed in test position #1 (TP1) of the ARMSEF. Test gases (23% O_2 and 77 % N_2 by mass) are heated by a segmented, constricted arc heater and injected in a vacuum chamber through a water-cooled 12.7 cm (5") diameter conical nozzle that has a 15° half angle. During testing, the chamber static pressure was kept below 40 Pa (0.3 millimeter of mercury). Desired test pressure were generated by the impact pressure of the hypervelocity flow field as determined by a water-cooled Pitot probe.

Two different heater configurations were set up to achieve all eight test points. The arc heater configuration for all but one test point is shown in Figure 3. To maintain the high stagnation pressure while achieving the low temperature for an uncoated specimen (NH7), the same arc heater configuration was used with an addition of four 9.53 mm (3/8") N_2 gas lines to the plenum (see Figure 4).

A test specimen and its holder were mounted on the left water-cooled, remotely actuated sting arm while a calorimeter (Medtherm # 620834) was mounted on the right. The target distance, distance from the nozzle's exit plane to the test specimen or to the calorimeter or to the Pitot probe, was set at 26.67 cm (10.5").

6.0 TEST PROCEDURES

Test specimens were photographed, weighted, and measured before and after testing unless waived by the Rockwell Test Article Engineer or the NASA Test Director. Specimens were handled with clean white gloves and weighted within 0.001 gram. Test specimens were stored in a desiccator that was maintained under supervised control by EBASCO Quality personnel.

Aluminum bags were used to prevent the absorption of atmospheric moisture while specimens were being weighted. Prior to weighing, the specimens were placed inside opened aluminum bags and then both specimens and bags were placed inside a 112°C (233°F) oven for four hours to remove water of hydration. The aluminum bags were sealed and the specimens were allowed to cool prior to weighing. All weights and measures were witnessed by EBASCO quality assurance inspectors.

After each test run, the specimen was left in vacuum for 20 minutes so that the temperature of the specimen would fall below 260°C (500°F) to eliminate extraneous oxidation of the carbon substrate.

For uncoated test specimens, nitrogen preheat was performed by operating the arc heater on 100% Nitrogen for 120 seconds following specimen insertion. This action minimized oxidation of the substrate while the specimen temperature was increasing rapidly.

Rigorous test management and control were implemented by formal documentations (e.g., Discrepancy Reports, Anomaly Logs, Standard Operating Procedures, and Test Preparation Sheet). Quality assurance representatives witnessed all pre-test and post-test measurements, monitored test systems configurations, insured metrology requirements were met, and participated as test observers.

7.0 TEST CONDITIONS AND CALIBRATIONS

The desired test temperatures ranged from 1760°C (3200°F) to 1871°C (3400°F) at a desired pressure of 14.366 KPa (300 psf). Experience from previous test programs has shown that the test pressure on the 10.16-cm (4-inch) model face is uniform to within about 14% and is 1.33 times the value measured with the 1.27cm (0.5") diameter Pitot probe. The requested test conditions are summarized in Table 1. The facility test parameters are presented in Appendix B.

Due to the limited number of calibration specimens, the primary purpose of the specimens was to reestablish the validity of the laser pyrometer (NASA G22618) and the surface thermocouples relationship that was utilized successfully during the earlier test programs. Actual test points were then identified with the laser pyrometer. Thus, achieving the requested surface temperatures for the specimens was chosen to be the primary requirement while meeting the requested surface pressure was the secondary.

The laser pyrometer operates in a narrow wavelength band centered on 0.865 micron. When commanded, it sends a modulated laser light beam to the target and measures the power level of the fraction of the beam that has returned after reflection from the target. It performs the appropriate computations to infer the emissivity of the target from these data and automatically displays the corrected temperature readings.

Although the automatic emittance measuring feature was found to be unusable due to fluctuations in the boundary layer emissions, this instrument still provides accurate

RCC temperature measurements since the specimen optical properties proved to be very stable at 0.865 micron. An emittance/window correction of 0.68 was found to correlate within 5.6°C (10°F) with coated and uncoated RCC over the complete range of temperatures under investigation.

8.0 RESULTS & DISCUSSION

Test results are summarized in Table 2. The term "hot spot" refers to the surface condition of the test specimen at which the coating failure occurred. This phenomenon can be visually observed through a television monitor or graphically seen as a rapid increase in the surface temperature plots.

Transient surface temperature plots are presented in Figures 5 through 16. The laser pyrometer analog output is programmed not to update if the radiant level is out of range. Therefore, the initial values shown on these temperature plots are not valid until the test specimen temperature has risen to approximately 815°C (1500°F).

During the first and second run of NH2 specimen and during the first run of NH3 specimen (run identification # 1-403-DD, # 1-410-DD, and # 1-404-DD), a vacuum abort occurred. These test runs were resumed quickly. Therefore, there was a short discontinuity in the transient temperature curve on each of the plots (see Figures 5, 6, and 9).

During the second run of the NH3 specimen (run # 1-411-DD), the data acquisition system stopped updating 434 seconds after the specimen had been inserted in the flow. Because the test specimen has already reached a steady state temperature and the flow conditions were kept constant, a decision was made to continue the test. However, the test was later aborted due to a hydraulic system failure 918 seconds after specimen insertion. Thus, the transient temperature plot for this run stops at 434 seconds (see Figure 10), and the post test specimen's measurements are for a 918 seconds duration run.

For specimens NH5, NH9, and NH10 which were tested at 1871°C, 1843°C, and 1824°C (3400°F, 3350°F, and 3315°F), respectively, a hot spot was developed approximately 27, 100, and 132 seconds after specimen insertion (see Figures 8, 13, and 14).

For the uncoated specimens (NH7 and NH8), there were 120 seconds of nitrogen preheat to reduce extraneous oxidation before steady state temperatures were achieved. After the nitrogen preheat, oxygen was injected into the heater to simulate an oxygen level of 23%. The injection of oxygen resulted in increasing total gas enthalpy. Therefore, there was a sudden increase in surface temperature at 120 seconds after specimen insertion (see Figures 15 and 16).

Pre and post-test thickness and weight measurements for all test specimens are summarized in Appendix C. On the third run of specimens NH2 and NH3 (run # 1-412-DD and 1-413-DD), the surface recessed so much into the carbon that the post-test measurements were waived.

Post-test photographs of the specimens are shown in Figures A-10 through A-17 in Appendix A. For the multiple run specimens (NH2 and NH3), there were no photographs taken prior to their last runs (1-412-DD and 1-413-DD) because the photographs were taken at the end of the test program.

9.0 CONCLUSIONS

The test objective of developing a data base for assessing the influence of TEOS and Type A enhancement surface sealants on surface heating and chemistry at the predicted TAL temperature and pressure levels was achieved.

The test results indicated that RCC coating failure occurred between 1816°C (3300°F) and 1824°C (3315°F). Compared to the previous test program with sealed RCC, this is about 28°C (50°F) higher. Thus, the thermal effect of the sealants on coated RCC is negligible under a TAL condition. All test data were transferred to the test requester for surface recession rate determination.

COATED SPECIMENS

Specimen ID	Pressure (psf)	Temperature (°F)	Duration (sec)
NH2	300	3200	1200
	300	3200	1200
	300	3200	1200
NH3	300	3250	1200
	300	3250	1200
	300	3250	1200
NH4	300	3300	600
NH5	300	3400	#
NH9	300	3350	#
NH10	300	3325	#

Test for 40 seconds after coating failure "hot spot" occurred.

UNCOATED SPECIMENS

Specimen ID	Pressure (psf)	Temperature (°F)	Duration (sec)
NH7	300	2650	300*
NH8	300	3400	120*

* Excluding 120 seconds of nitrogen preheat.

Table 1: Requested Test Conditions

COATED SPECIMENS

Specimen ID	Pressure (psf)	Temperature (°F)	Duration (sec)	Run ID #
NH2	338	3170	1200	1-403-DD
	348	3150	1200	1-410-DD
	348	3150	1200	1-413-DD
NH3	345	3235	750	1-404-DD
	354	3220	918	1-411-DD
	354	3210	1200	1-412-DD
NH4	373	3238	600	1-408-DD
NH5	400	3440	83#	1-409-DD
NH9	377	3340	143#	1-414-DD
NH10	369	3315	165#	1-416-DD

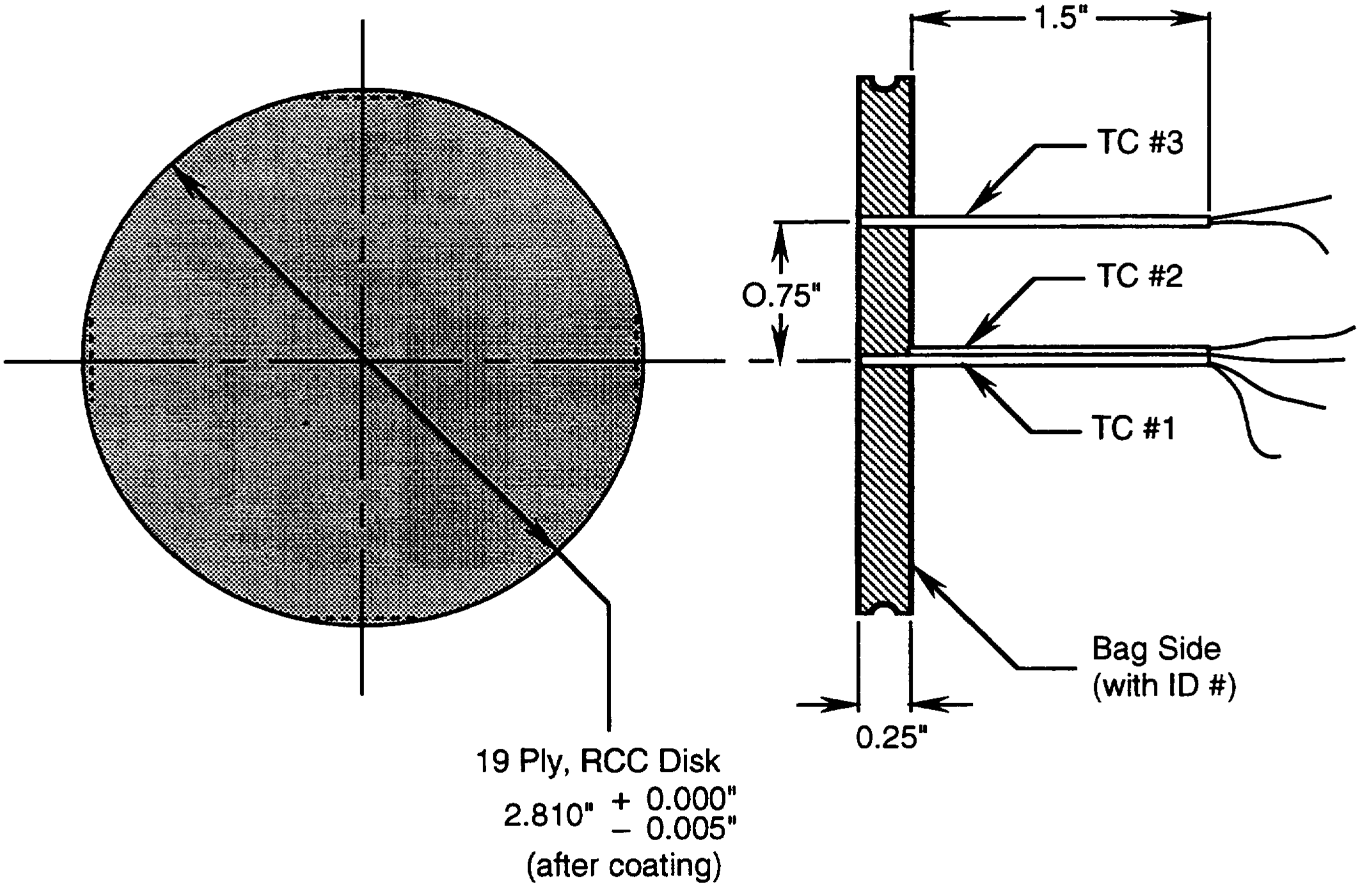
Hot spot occurred.

UNCOATED SPECIMENS

Specimen ID	Pressure (psf)	Temperature (°F)	Duration (sec)	Run ID #
NH7	313	2690	300*	1-419-DD
NH8	316	3275	120*	1-420-DD

* Excluding 120 seconds of nitrogen preheat.

Table 2: Actual Test Conditions



NOTE:
1. TC #1, TC #2, and TC #3 are type C thermocouples (Tungsten 5% Rhenium / Tungsten 26% Rhenium).
2. TC #1 and TC #3 are inserted from the back face (bag side) to the back of the front face coating through 1/16" diameter alumina insulators.
3. TC #2 is bonded to the back face.
4. Alumina isolators for both TC #1 and TC #2 are bonded together.
5. All alumina insulators are extended 1.5" from the back face.
6. Total length of thermocouple wire and the compensating lead wires is 42".

Figure 1: Calibration Specimen

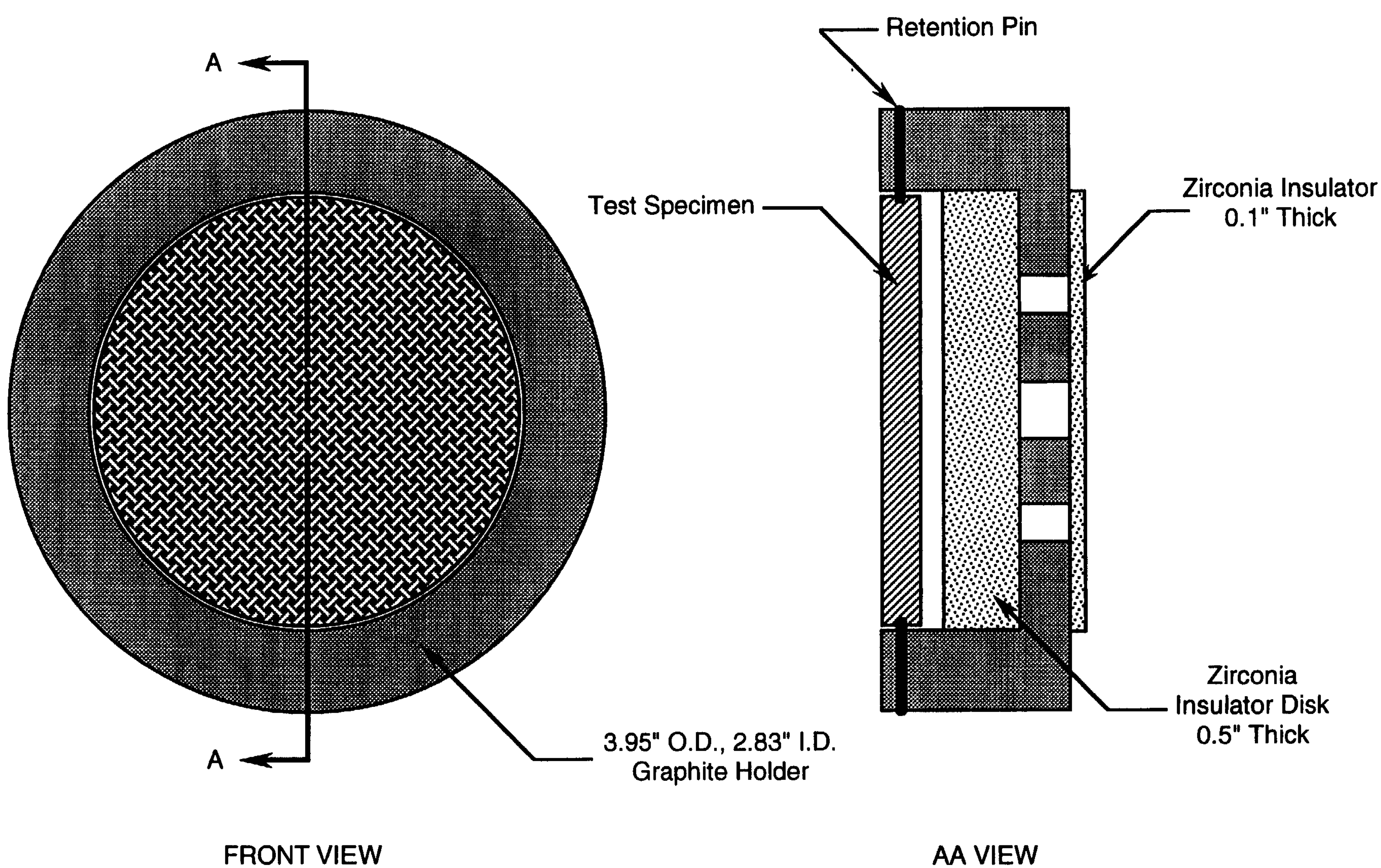


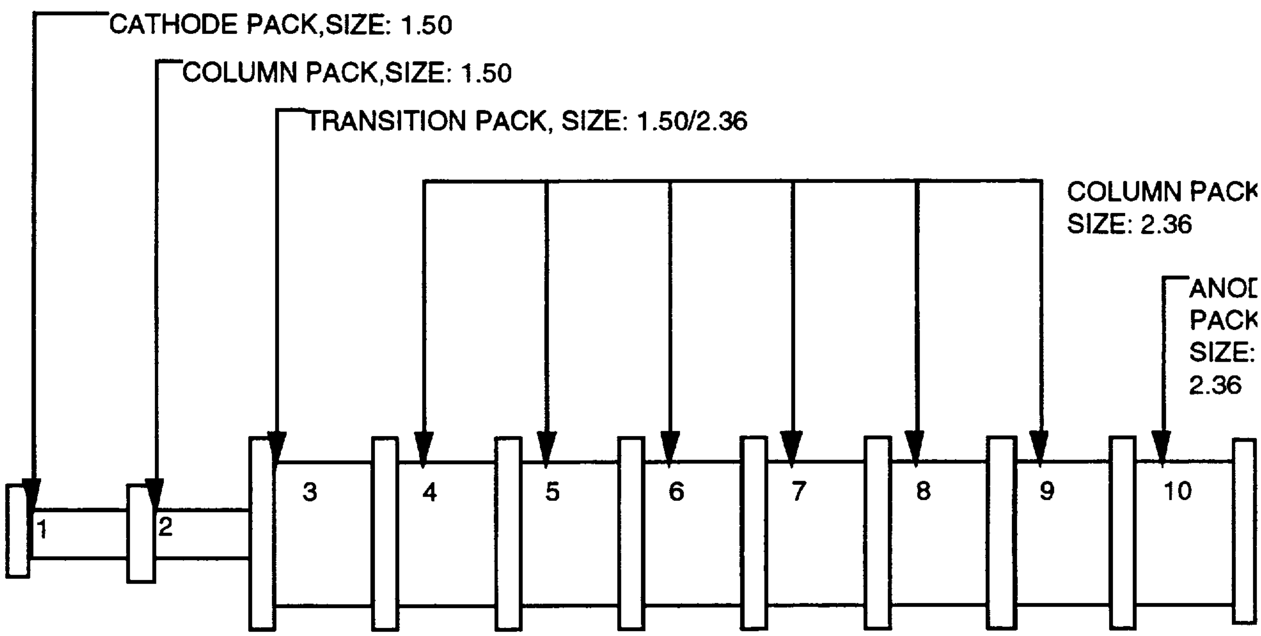
Figure 2: Test Specimen and Specimen Holder Assembly

DUAL DIAMETER
CONFIGURATION RECORD #1-2

PAGE 2 OF 2 TPS AK9220002
NON-SEALED RCC TAL TEST
DATE:02-05-92
CATHODE: TUNGSTEN
COLUMN LENGTH: 10 PACKS
TYPE PACKS: 1.25" -0-
1.50" 2
1.50/2.36" 1
2.36" 7

TEST NO: 1-403-DD
NOZZLE: 5" CONICAL NOZZLE MOUNTED
OUTSIDE; ADAPTER PLATE MOUNTED
INSIDE

COOLANT MANIFOLD: SINGLE PASS,
COOLANT INLET SET @ 580 PSIG OR MAX OUTPUT
THROAT DIAMETER: 2.25"



COLUMN GAS INJECTION CONFIGURATION		
GAS	PACK	SEGMENTS
N2	1	2, 4, 6
N2	4	3, 13
N2	5	3
N2	10	17, 18, 19
O2	6	3, 8, 13, 18
O2	7	3, 8

PRESSURE TRANSDUCER LOCATIONS: N2 MANIFOLD; PACK 1/SEG 10; PACK 5/SEG 8; PACK 10/SEG 16; ANODE PLENUM; O2 MANIFOLD.
5.0 OHM RIBBON WIRE RESISTOR BETWEEN ORIFICES IN ANODE PLENUM.
COMMENTS: EIGHT (8) 0.0635" DIAMETER ORIFICES IN ANODE PLENUM.
1.50" DIA. TO 2.36" DIA. TRANSITION AT SEGMENTS 4, 5 & 6 IN PACK 3.
VENT ORIFICES: GN2=0.3750" DIA. ; GO2=0.4375"DIA.

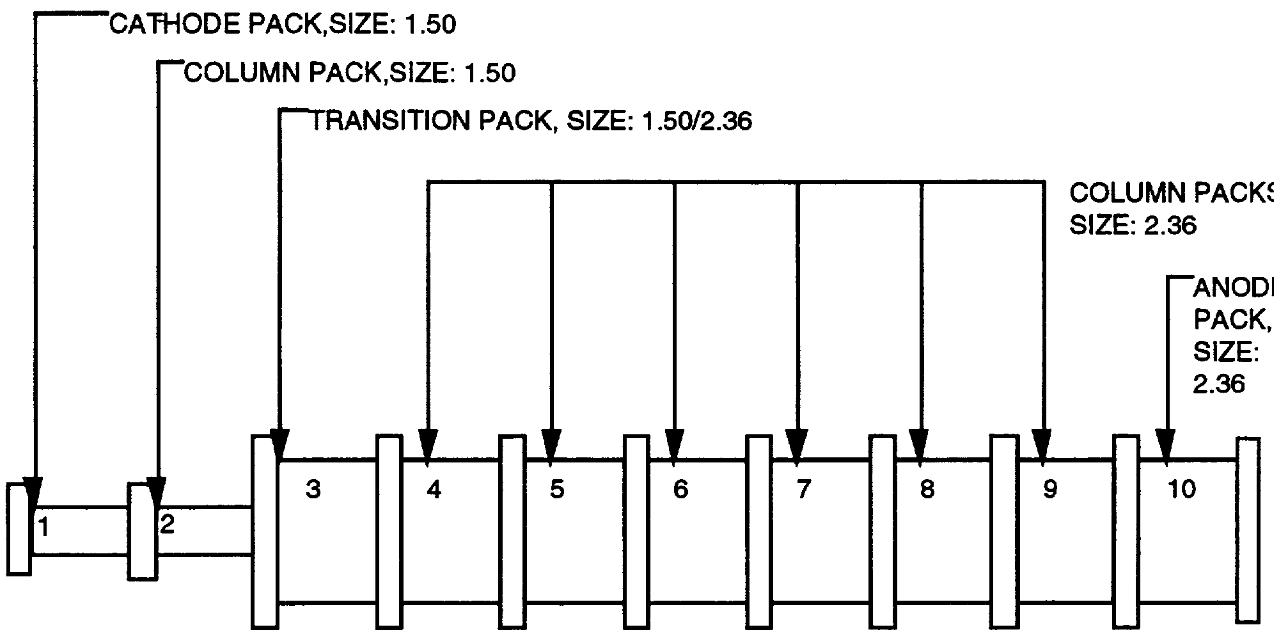
Figure 3: Heater Configuration for Test Points above 3200°F

DUAL DIAMETER
CONFIGURATION RECORD #1-4

PAGE 2 OF 2 TPS AK9220004
NON-SEALED RCC TAL TEST
DATE: 03-02-92
CATHODE: TUNGSTEN
COLUMN LENGTH: 10 PACKS
TYPE PACKS: 1.25" -0-
1.50" 2
1.50/2.36" 1
2.36" 7

TEST NO: 1-418-DD
NOZZLE: 5" CONICAL NOZZLE MOUNTED OUTSIDE; ADAPTER PLATE MOUNTED INSIDE

COOLANT MANIFOLD: SINGLE PASS, COOLANT INLET SET @ 580 PSIG OR MAX OUTPUT
THROAT DIAMETER: 2.25"



COLUMN GAS INJECTION CONFIGURATION		
GAS	PACK	SEGMENTS
N2	1	2, 4, 6
N2	4	3, 13
N2	5	3
N2	10	17, 18, 19
O2	6	3, 8, 13, 18
O2	7	3, 8
N2		Four 3/8" OD lines to Anode Plenum

PRESSURE TRANSDUCER LOCATIONS: N2 MANIFOLD; PACK 1/SEG 10; PACK 5/SEG 8; PACK 10/SEG 16; ANODE PLENUM; O2 MANIFOLD.
5.0 OHM RIBBON WIRE RESISTOR BETWEEN ORIFICES IN ANODE PLENUM.
COMMENTS: EIGHT (8) 0.1085" DIAMETER ORIFICES IN ANODE PLENUM.
1.50" DIA. TO 2.36" DIA. TRANSITION AT SEGMENTS 4, 5 & 6 IN PACK 3.
VENT ORIFICES: GN2=0.3750" DIA. ; GO2=0.2187" DIA.

Figure 4: Heater Configuration for NH7 Specimen

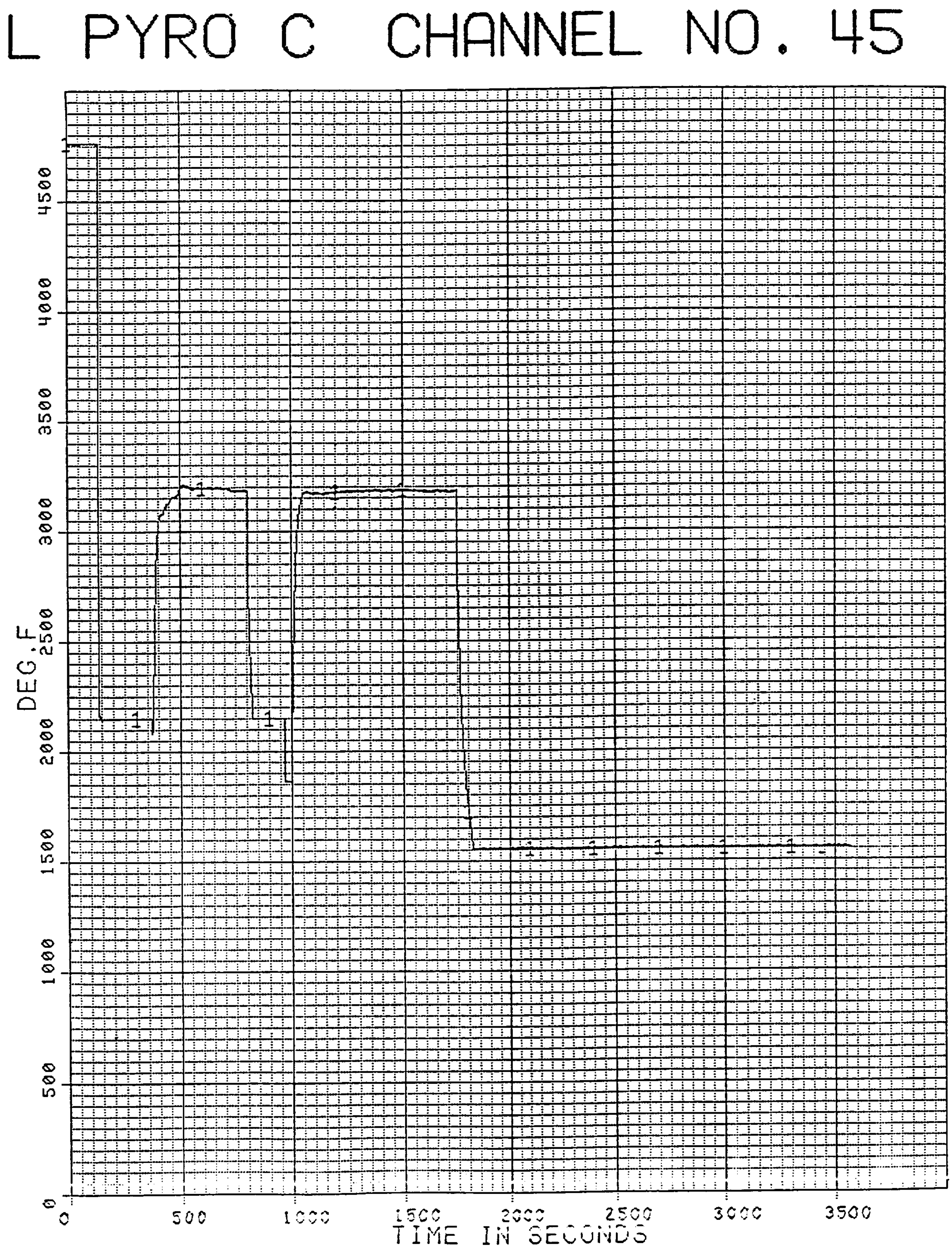


Figure 5: First Run of NH2 (Run ID # 1-403-DD)

Figure 6: First Run of NH3 (Run ID # 1-404-DD)

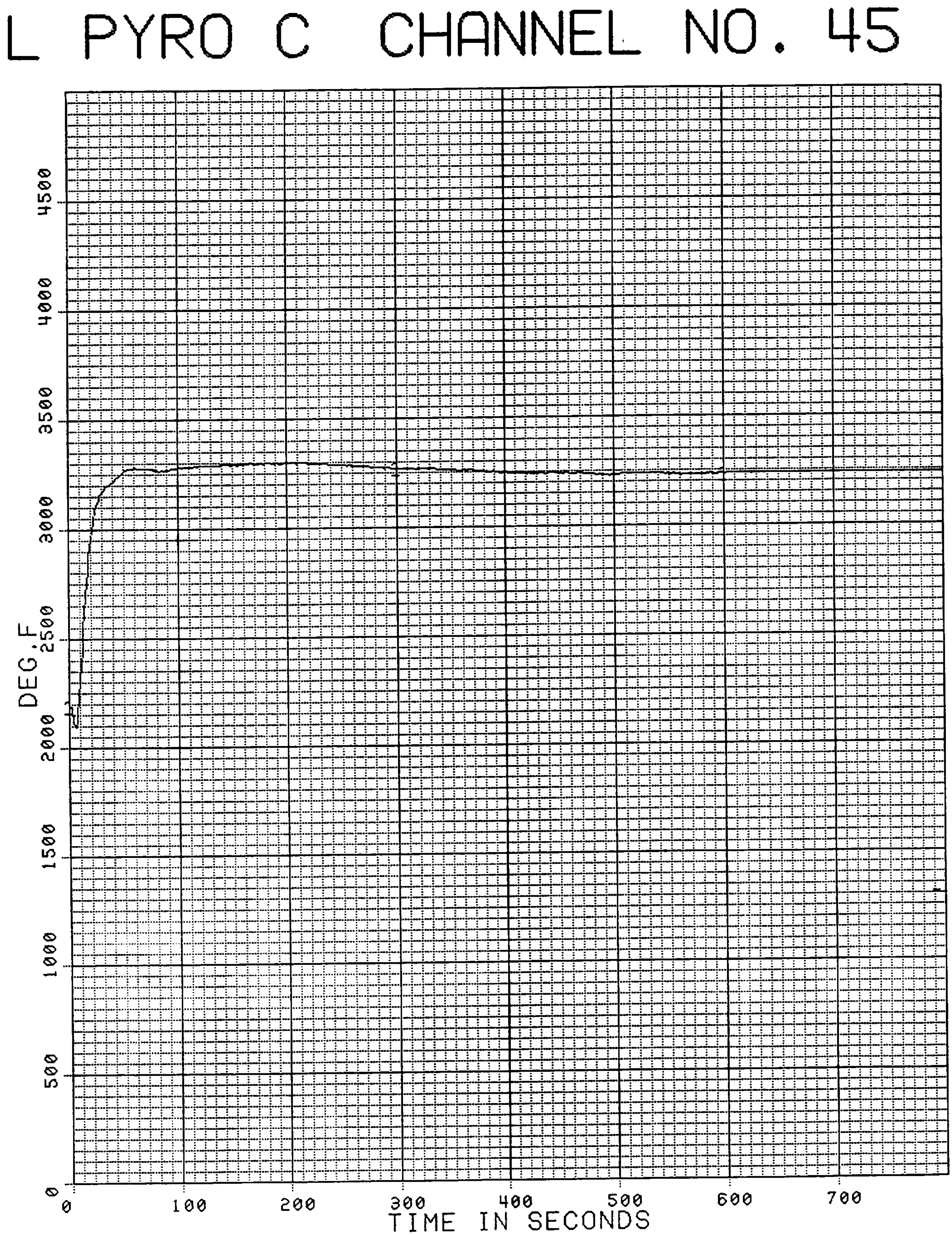


Figure 7: First and Final Run of NH4 (Run ID # 1-408-DD)

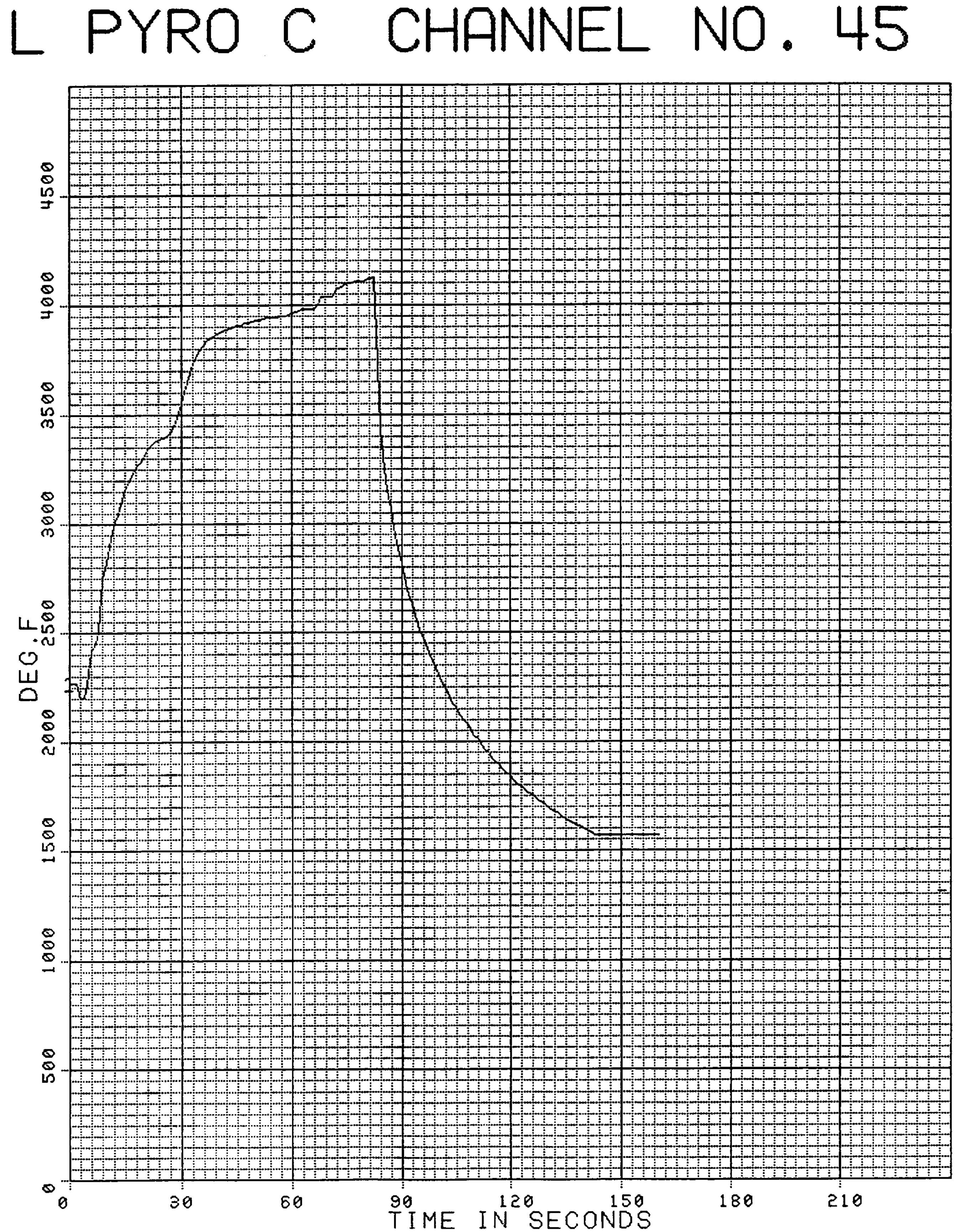


Figure 8: First and Final Run of NH5 (Run ID # 1-409-DD)

Figure 9: Second Run of NH2 (Run ID # 1-410-DD)

L PYRO C CHANNEL NO. 45

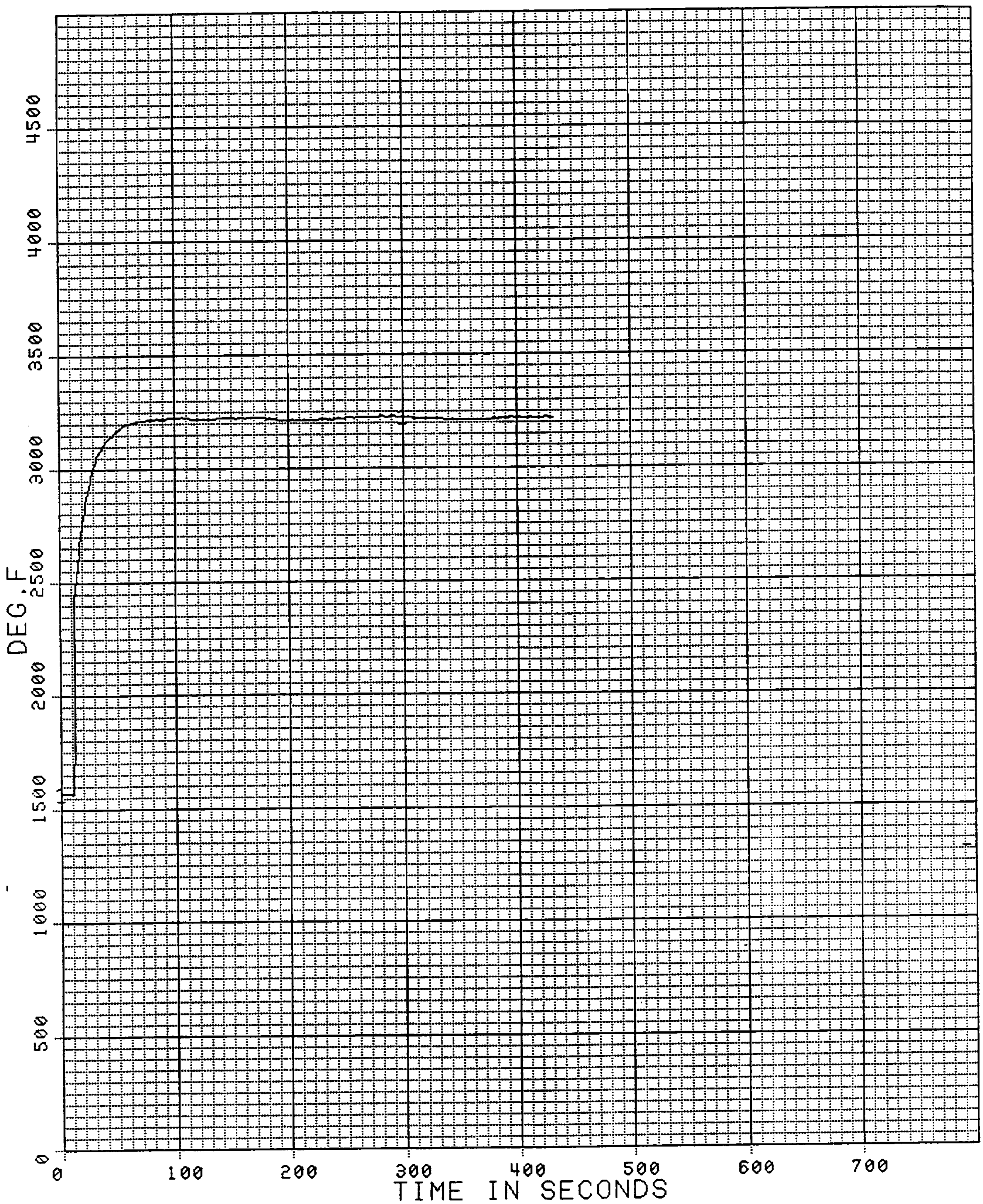


Figure 10: Second Run of NH3 (Run ID # 1-411-DD)

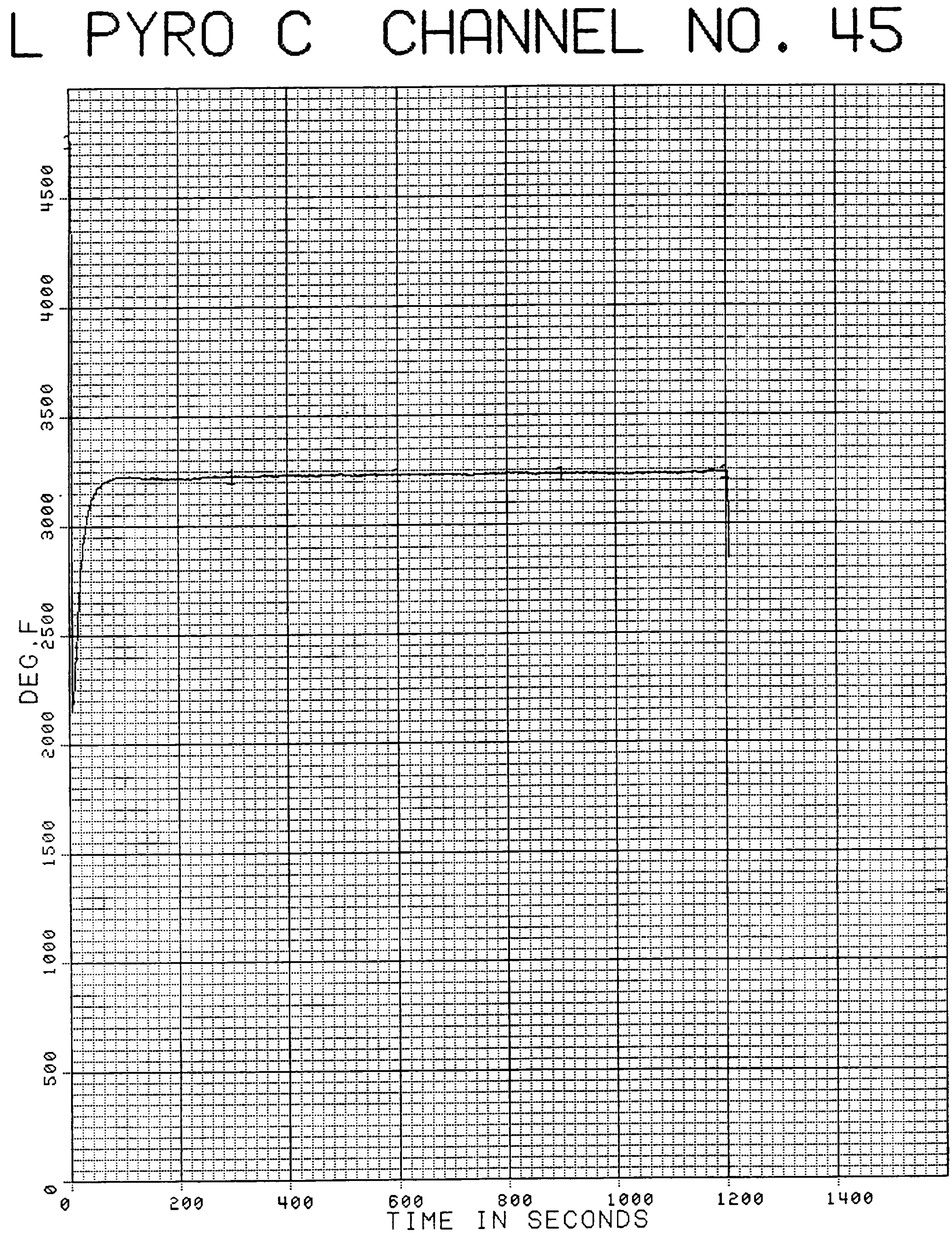


Figure 11: Third Run of NH3 (Run ID # 1-412-DD)

L PYRO C CHANNEL NO. 45

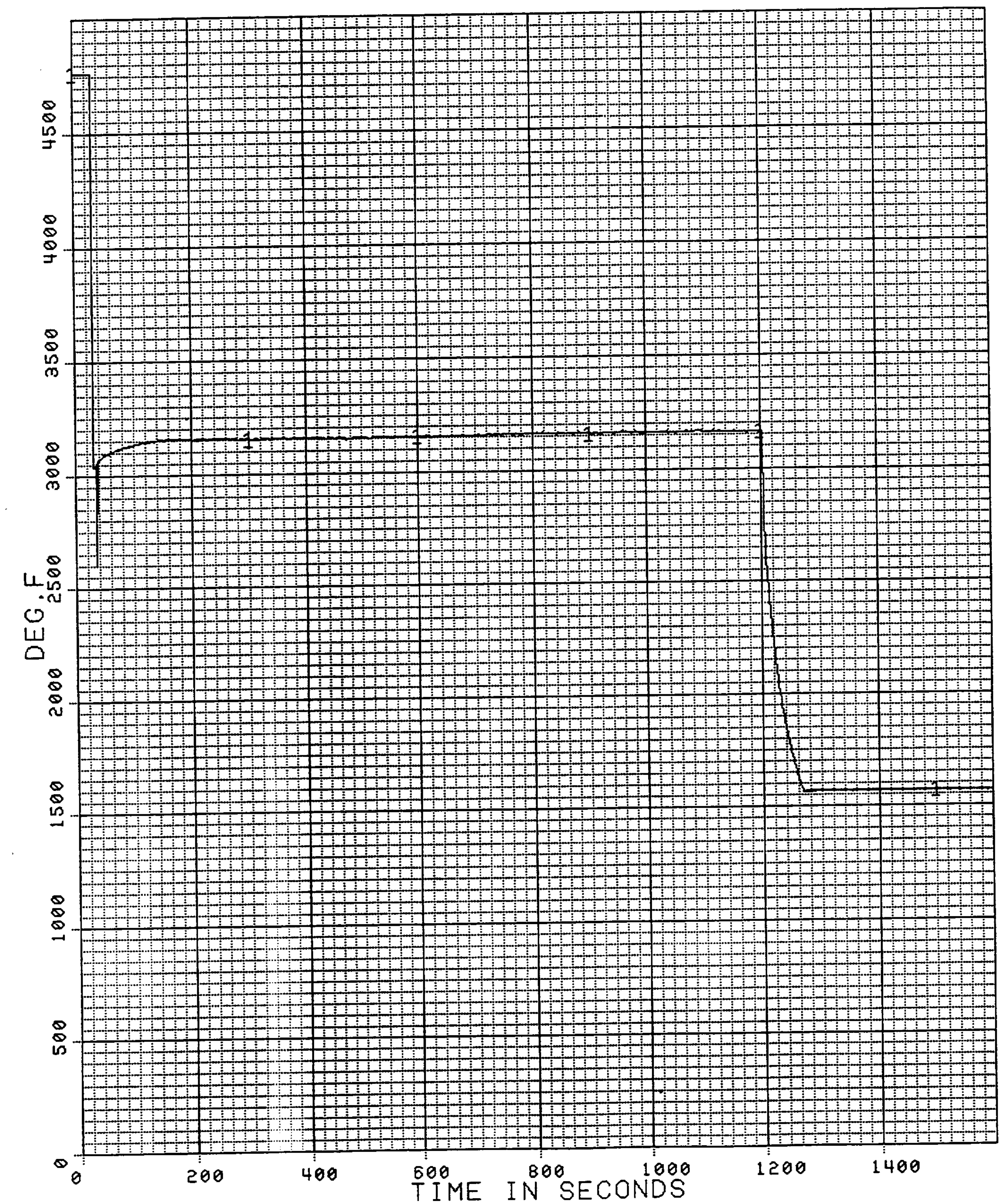


Figure 12: Third Run of NH2 (Run ID # 1-413-DD)

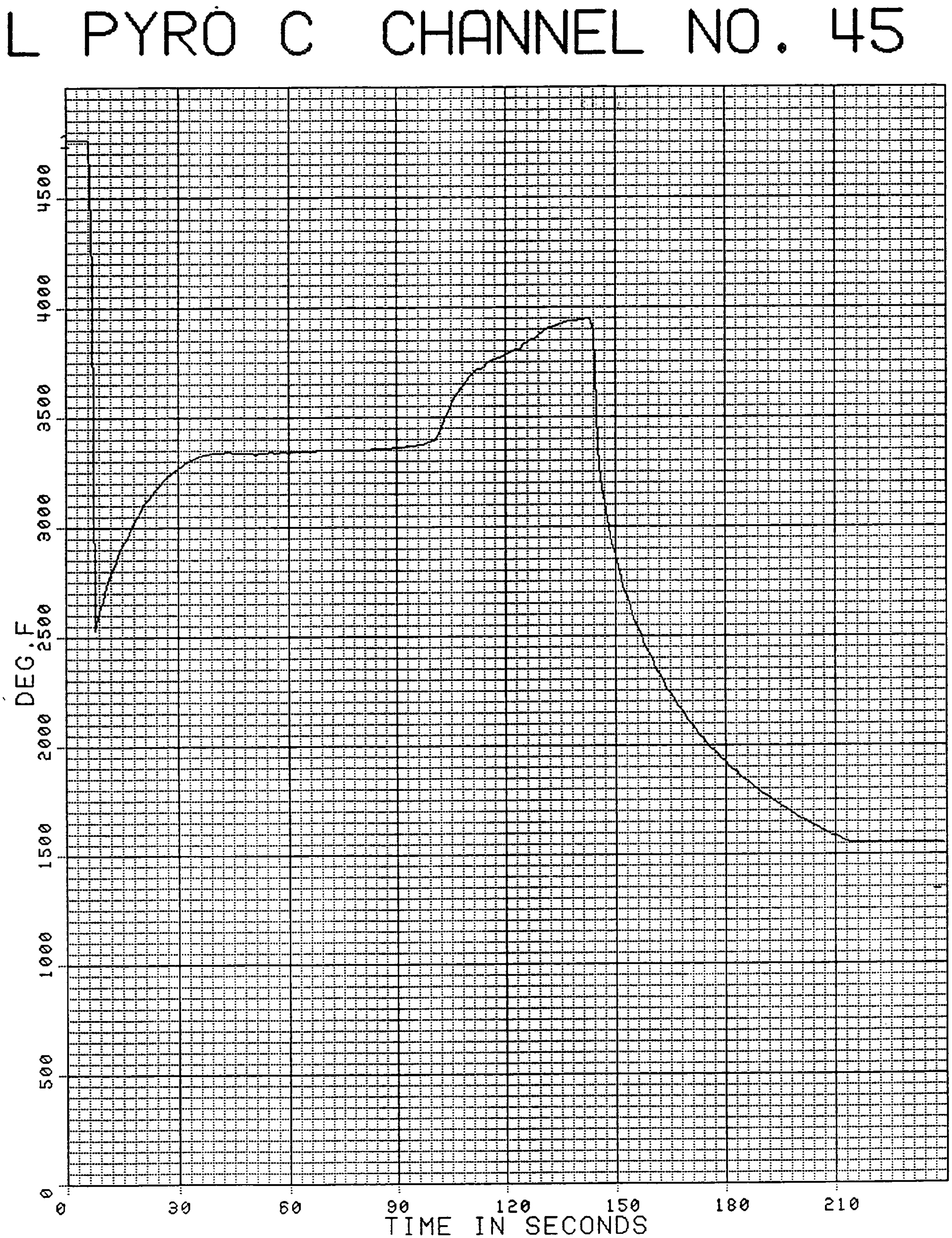


Figure 13: First and Final Run of NH9 (Run ID # 1-414-DD)

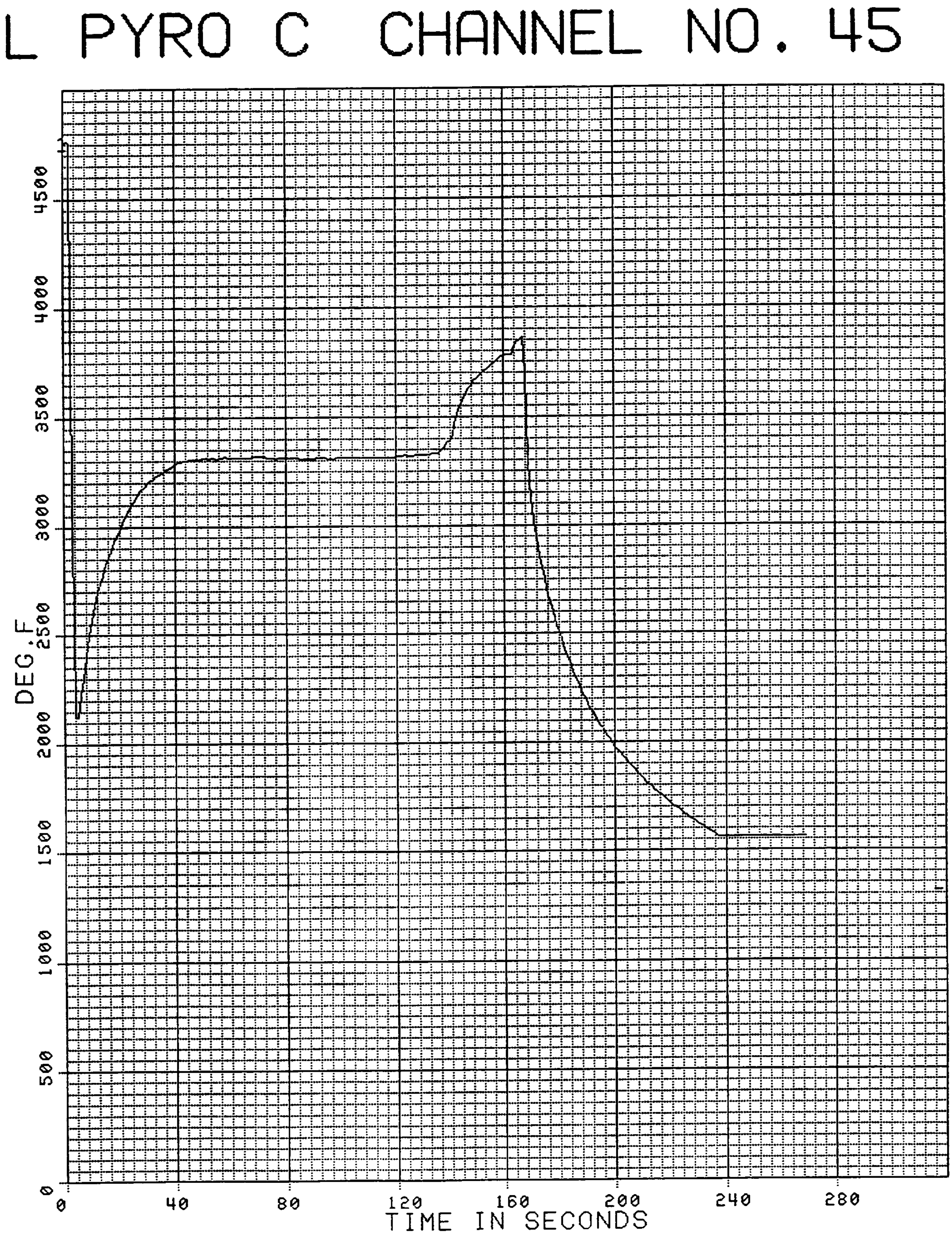


Figure 14: First and Final Run of NH10 (Run ID # 1-416-DD)

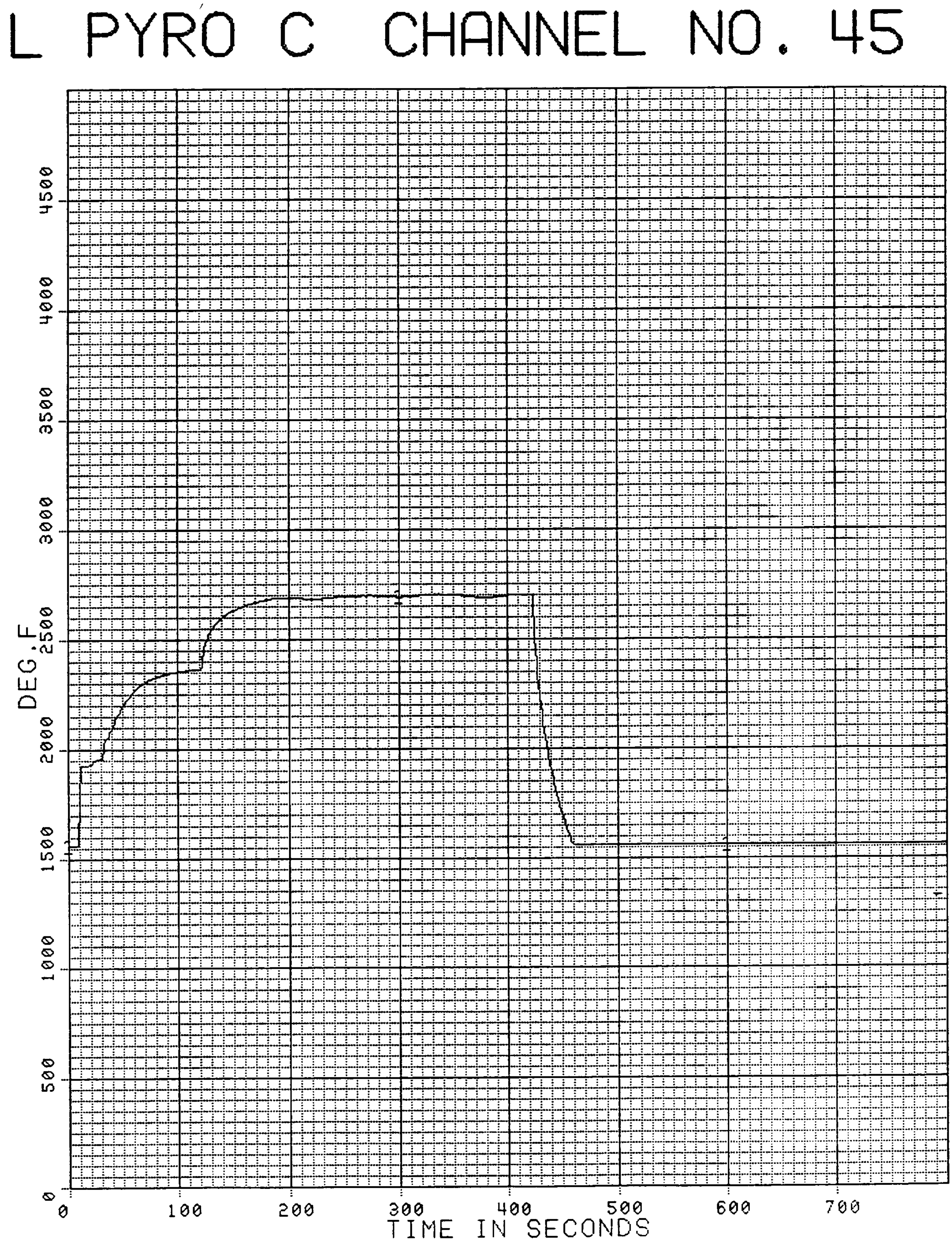


Figure 15: First and Final Run of NH7 (Run ID # 1-419-DD)

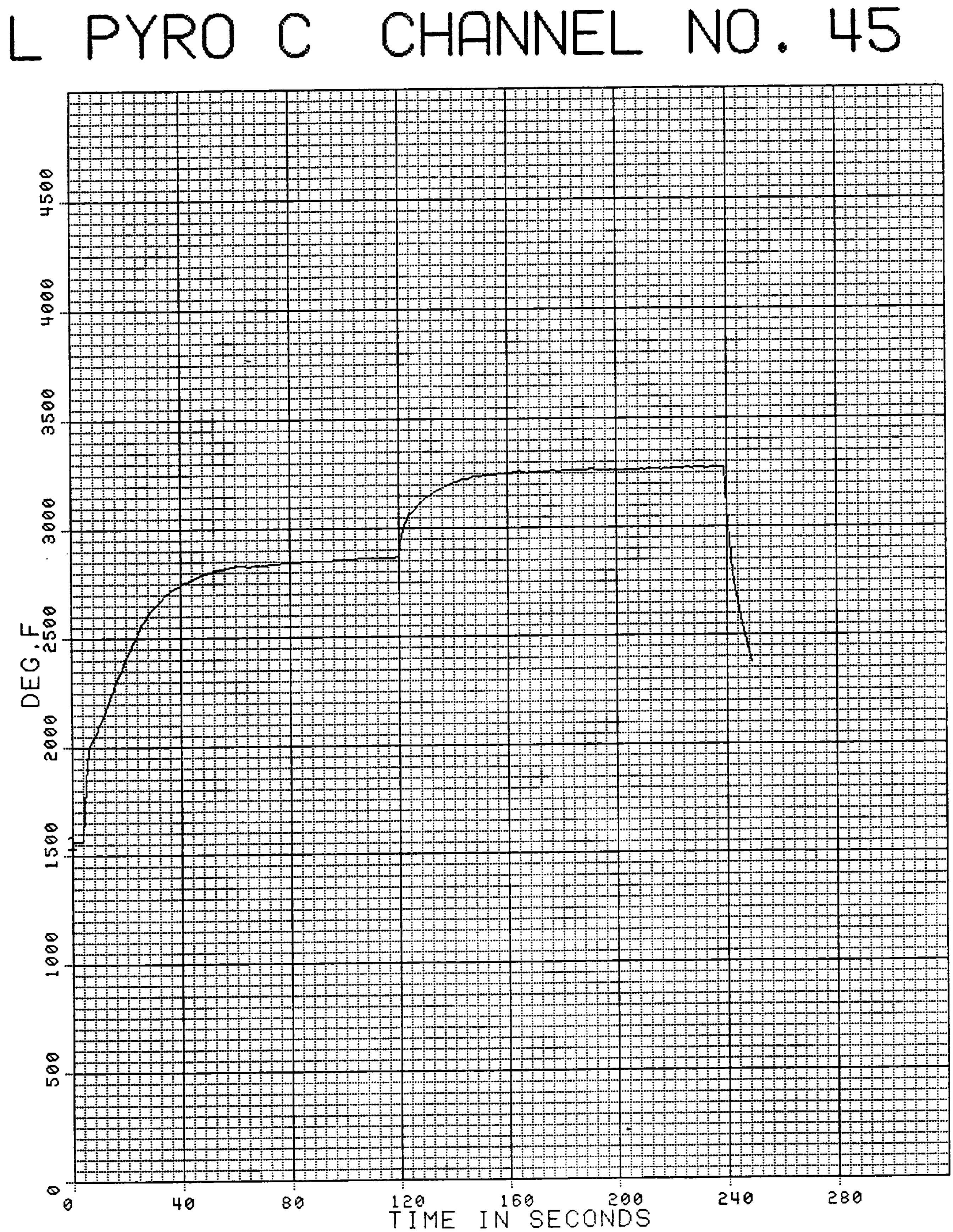


Figure 16: First and Final Run of NH8 (Run ID # 1-420-DD)

REFERENCES

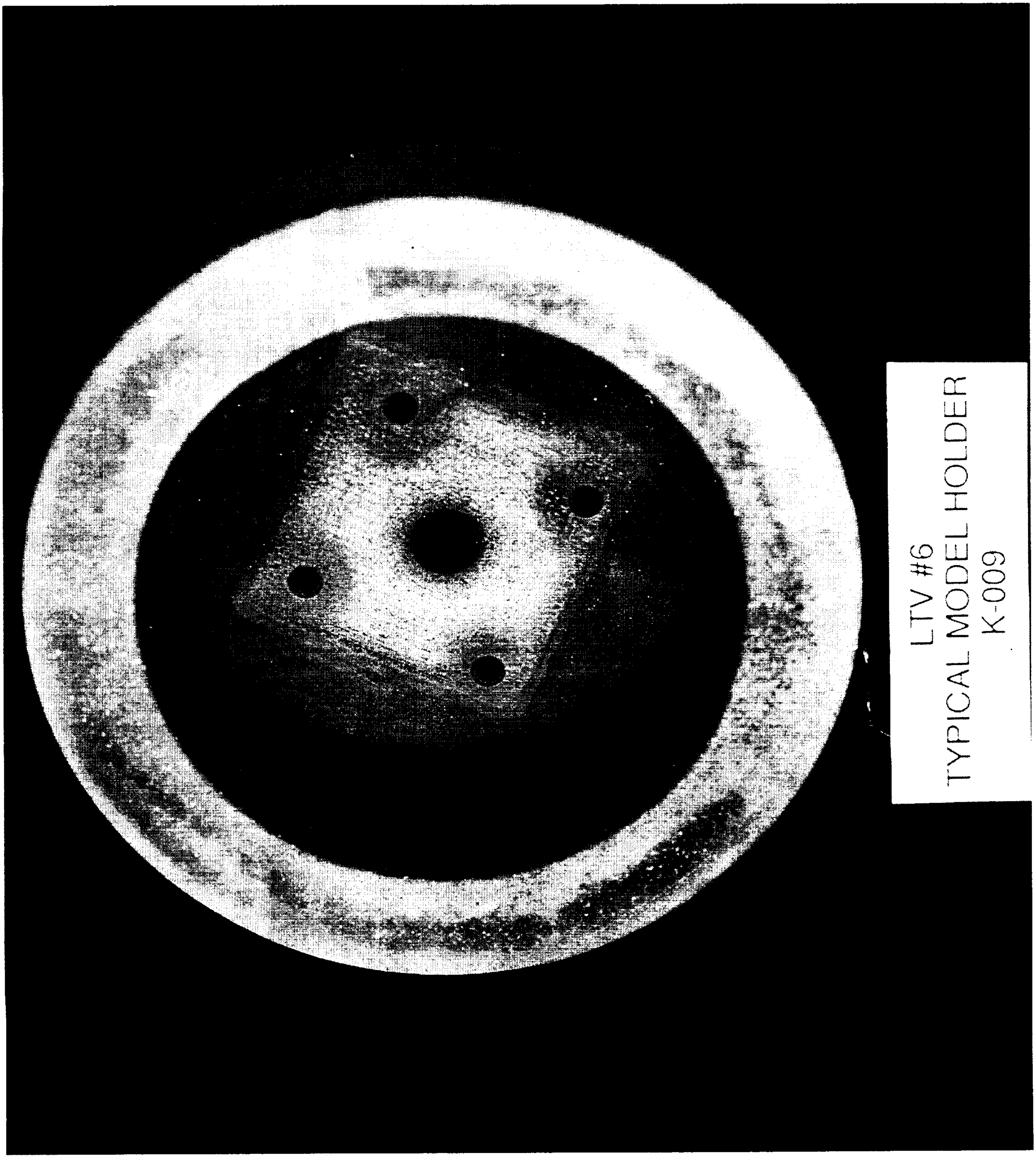
1. Milhoan, J. D., "Reinforced Carbon-Carbon (RCC) Overtemperature Test," Thermal Branch Report, JSC-22934, Lyndon B. Johnson Space Center, Houston, Texas, March 1988.

2. Yuen, E. H., "Reinforced Carbon-Carbon (RCC) TAL Abort Verification Test," Thermal Branch Report, JSC-24829, Lyndon B. Johnson Space Center, Houston, Texas, December 1990.

Test Series 3

APPENDIX A

PRE- AND POST-TEST SPECIMEN PHOTOGRAPHS



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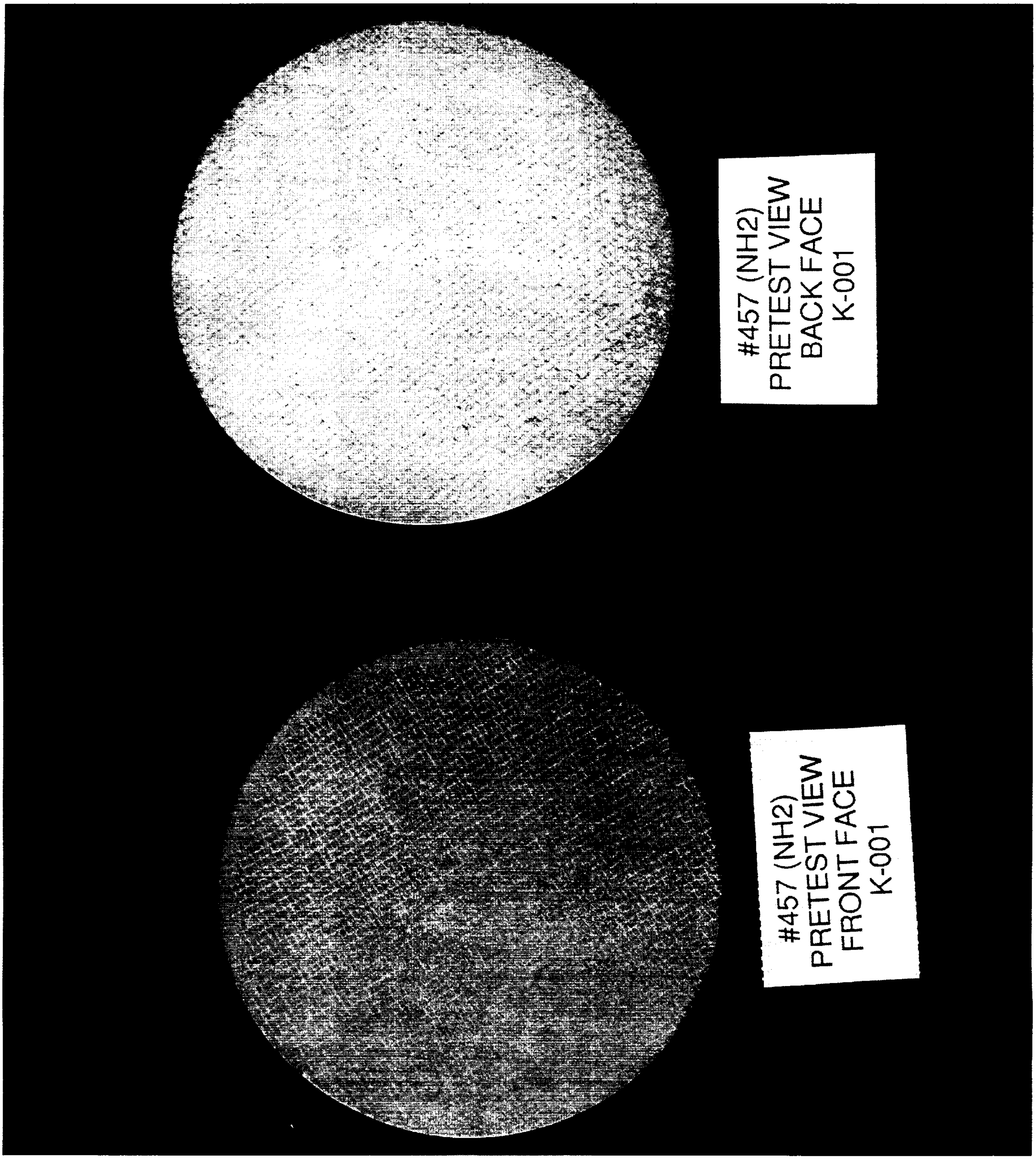
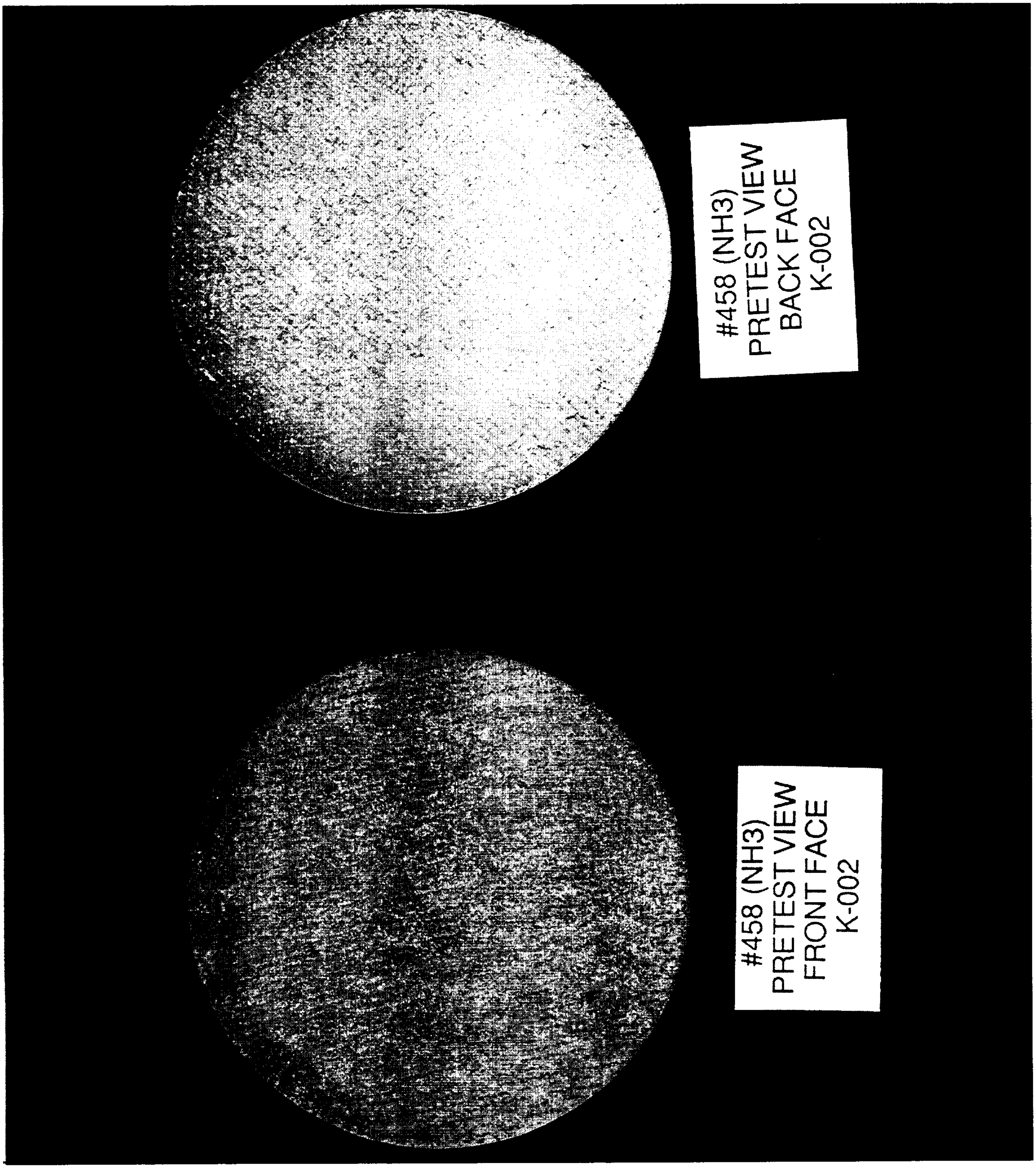
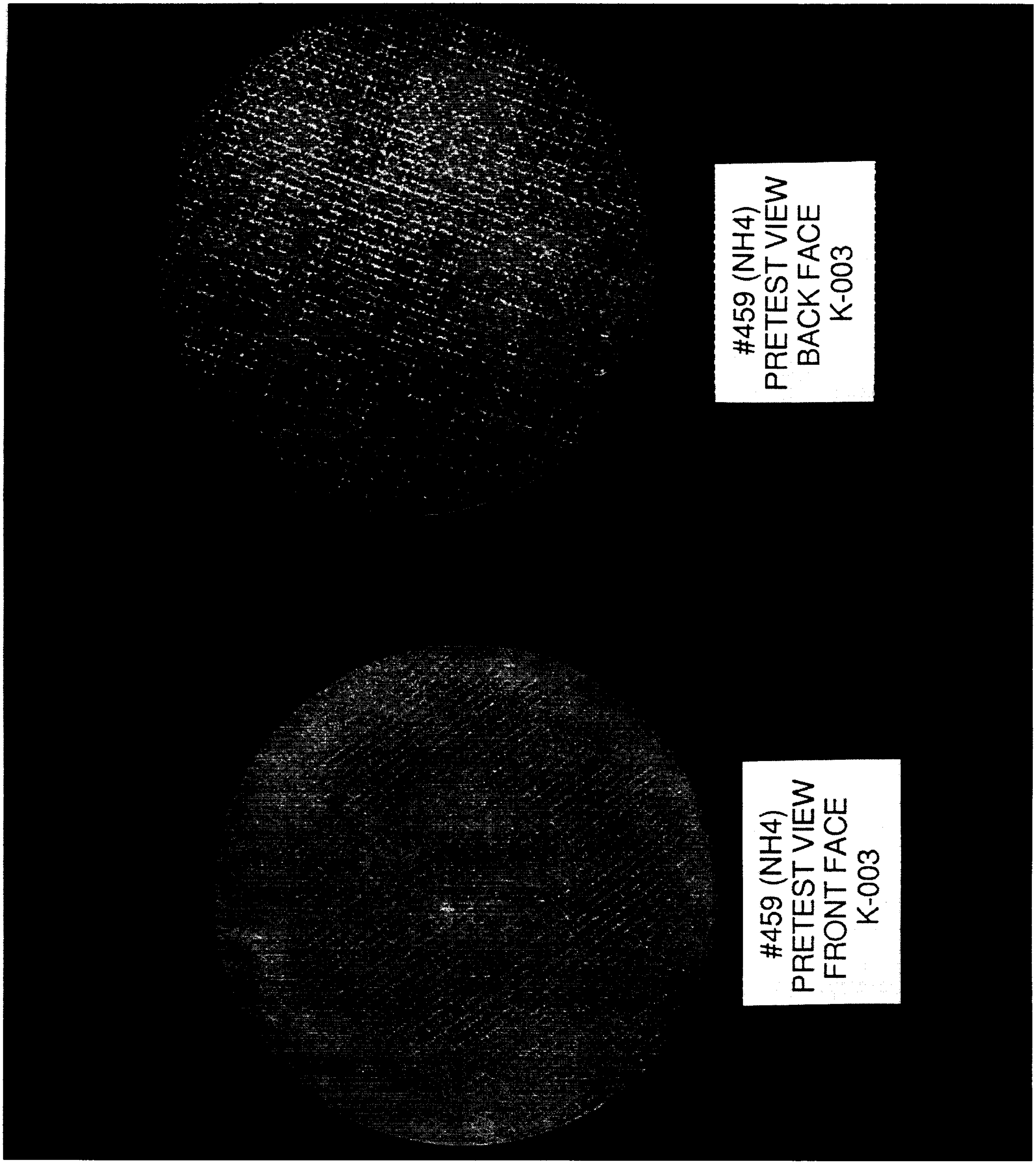
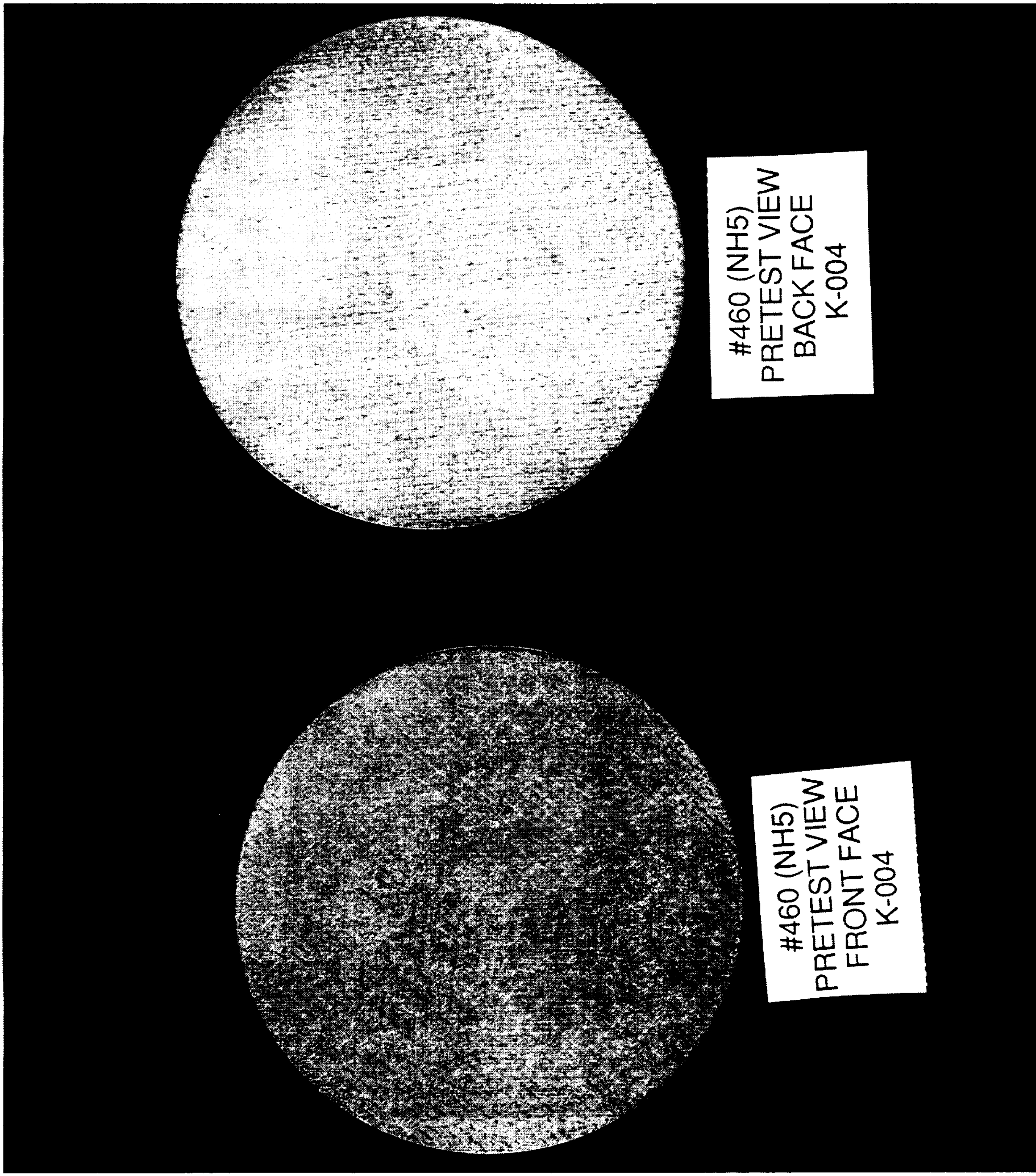
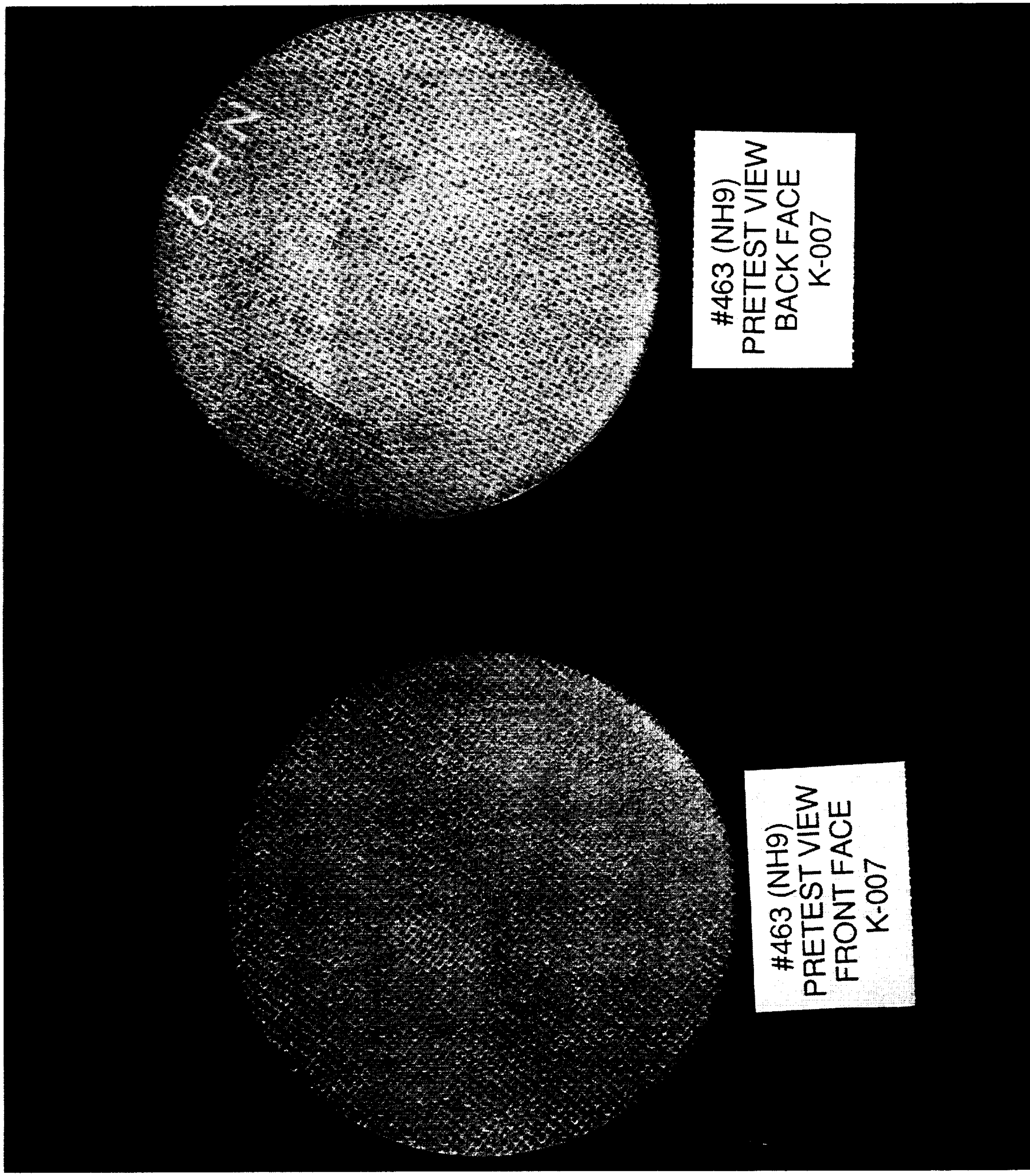
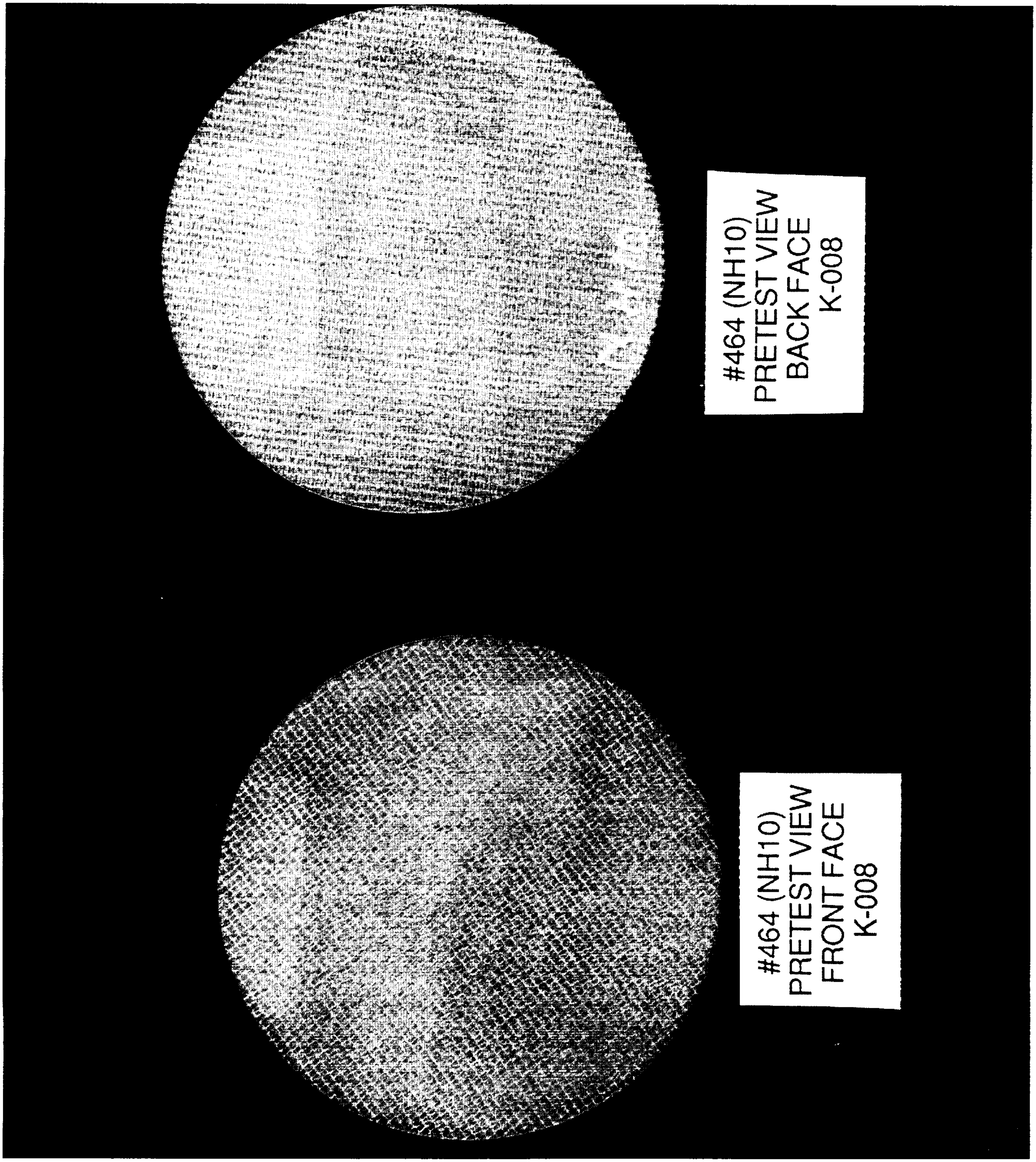

#457 (NH2)
PRETEST VIEW
BACK FACE
K-001
#457 (NH2)
PRETEST VIEW
FRONT FACE
K-001

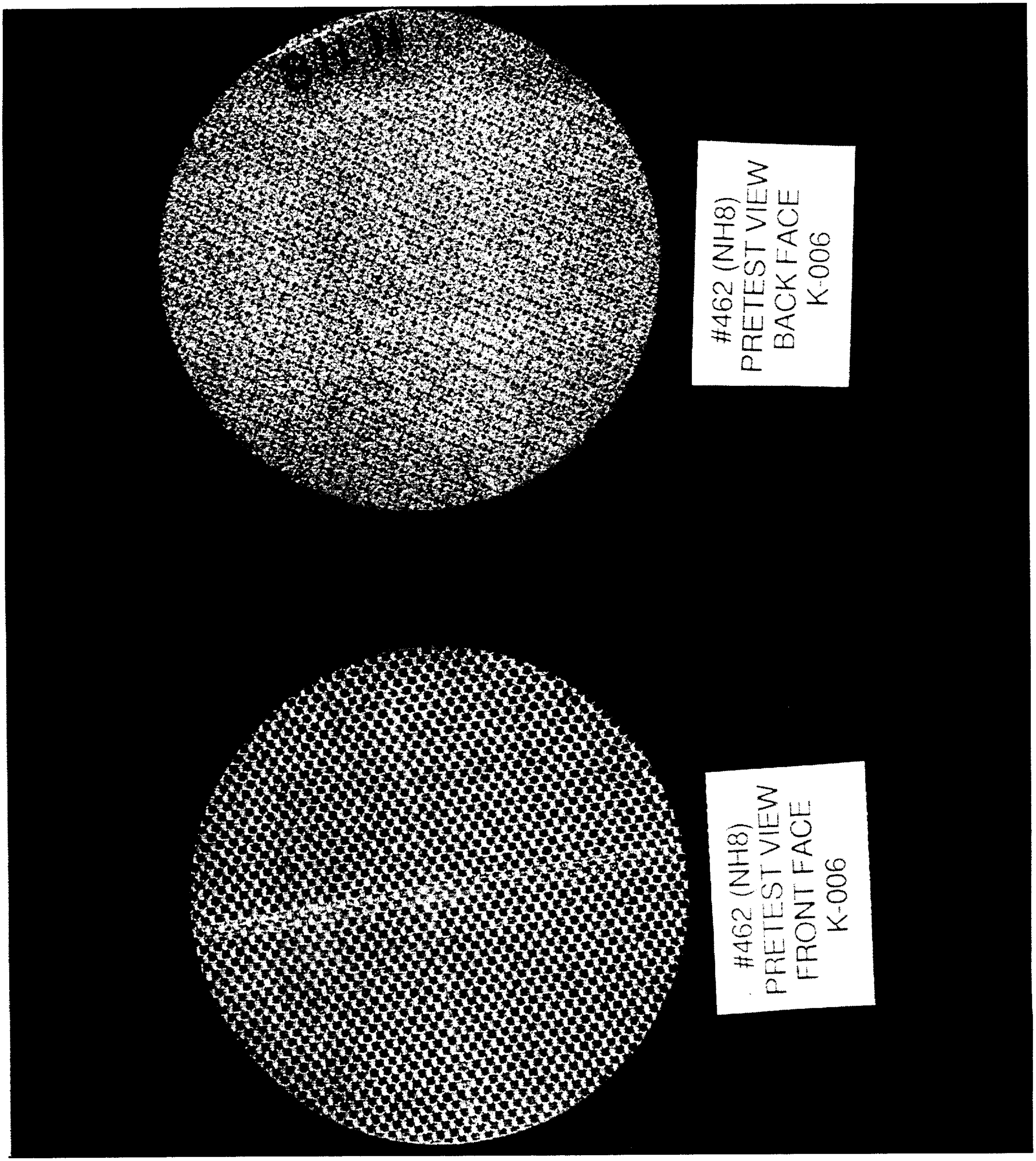

#458 (NH3)
PRETEST VIEW
FRONT FACE
K-002
#458 (NH3)
PRETEST VIEW
BACK FACE
K-002

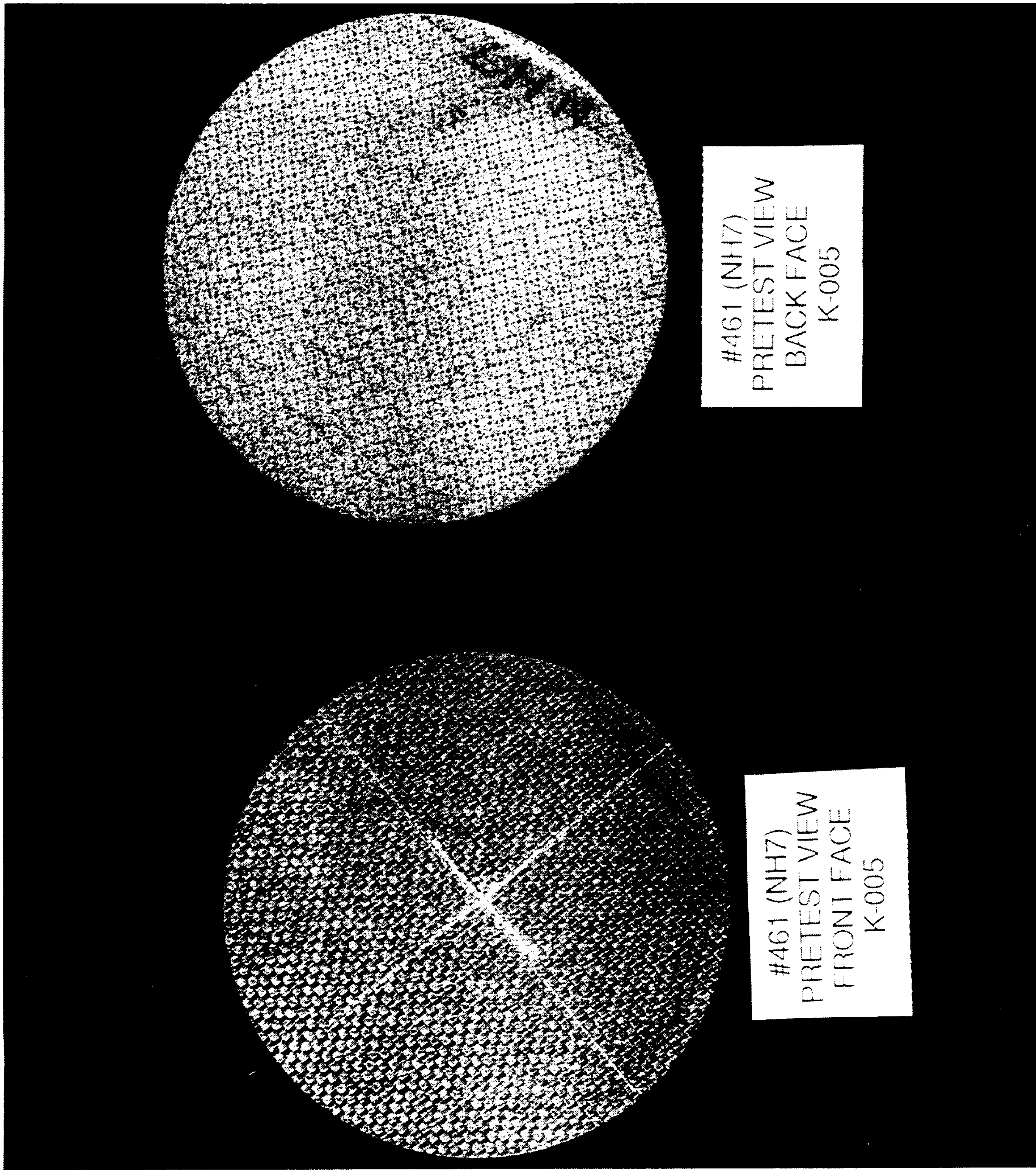

#459 (NH4)
PRETEST VIEW
BACK FACE
K-003
#459 (NH4)
PRETEST VIEW
FRONT FACE
K-003

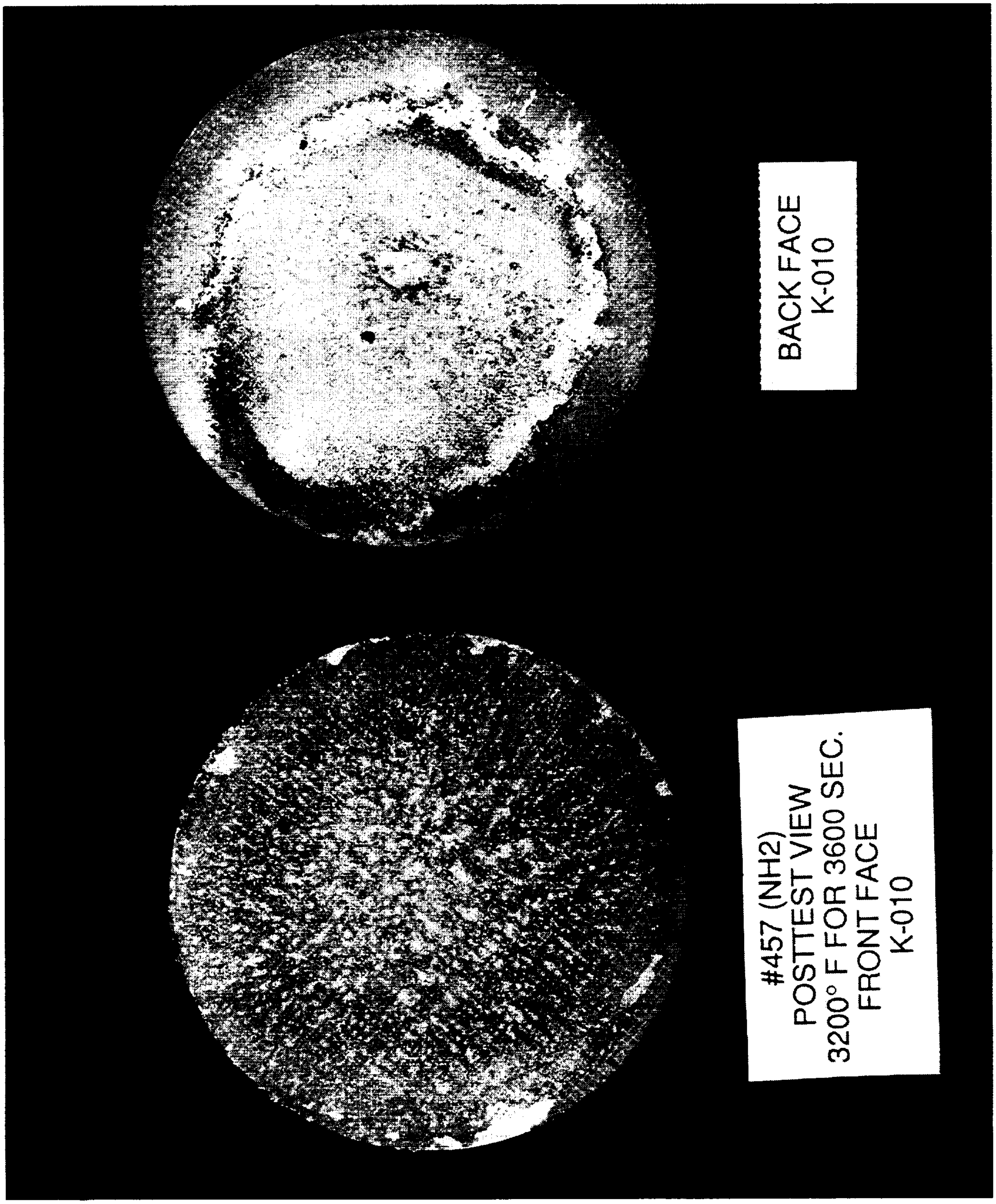

#460 (NH5)
PRETEST VIEW
BACK FACE
K-004
#460 (NH5)
PRETEST VIEW
FRONT FACE
K-004

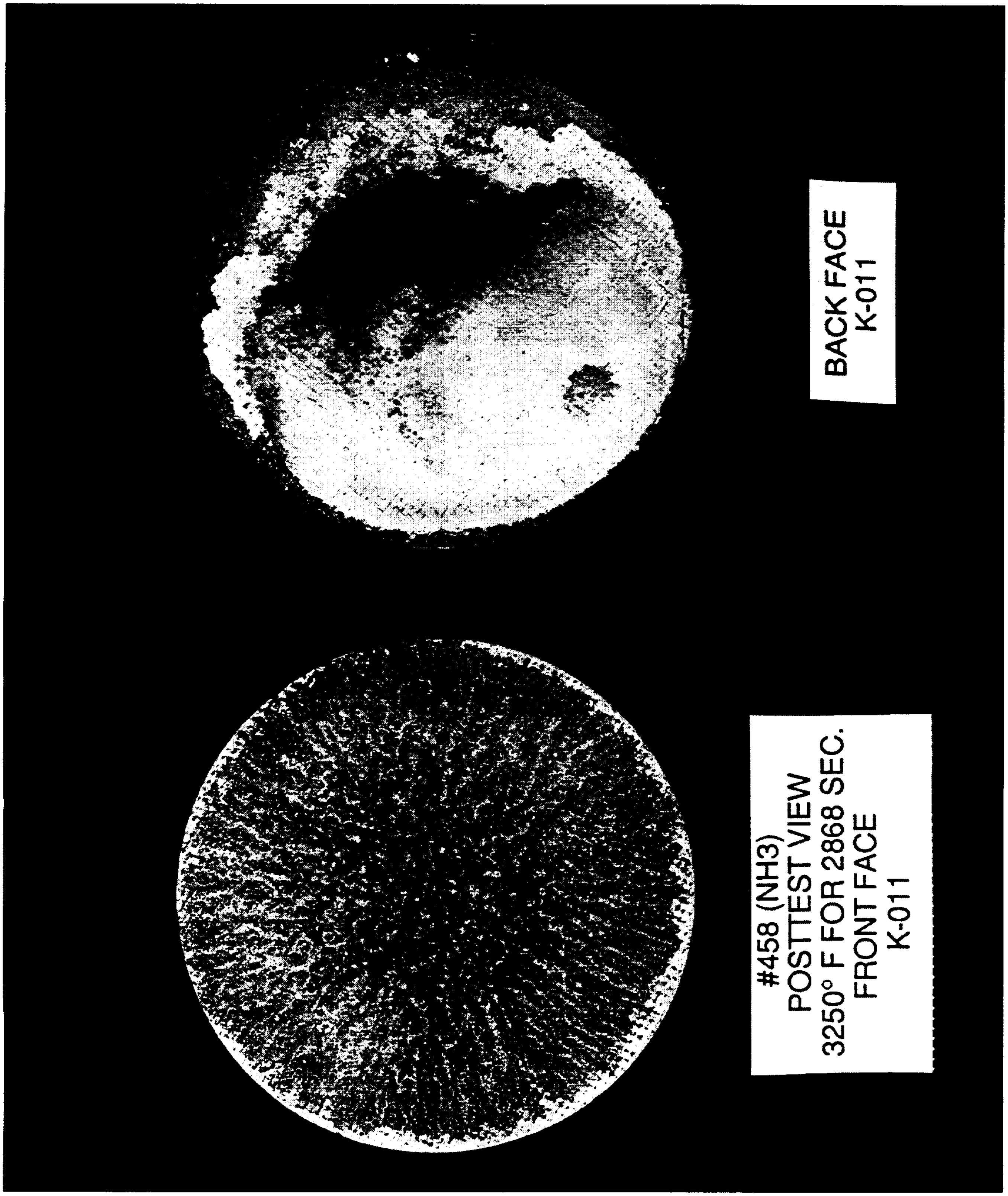

#463 (NH9)
PRETEST VIEW
BACK FACE
K-007
#463 (NH9)
PRETEST VIEW
FRONT FACE
K-007

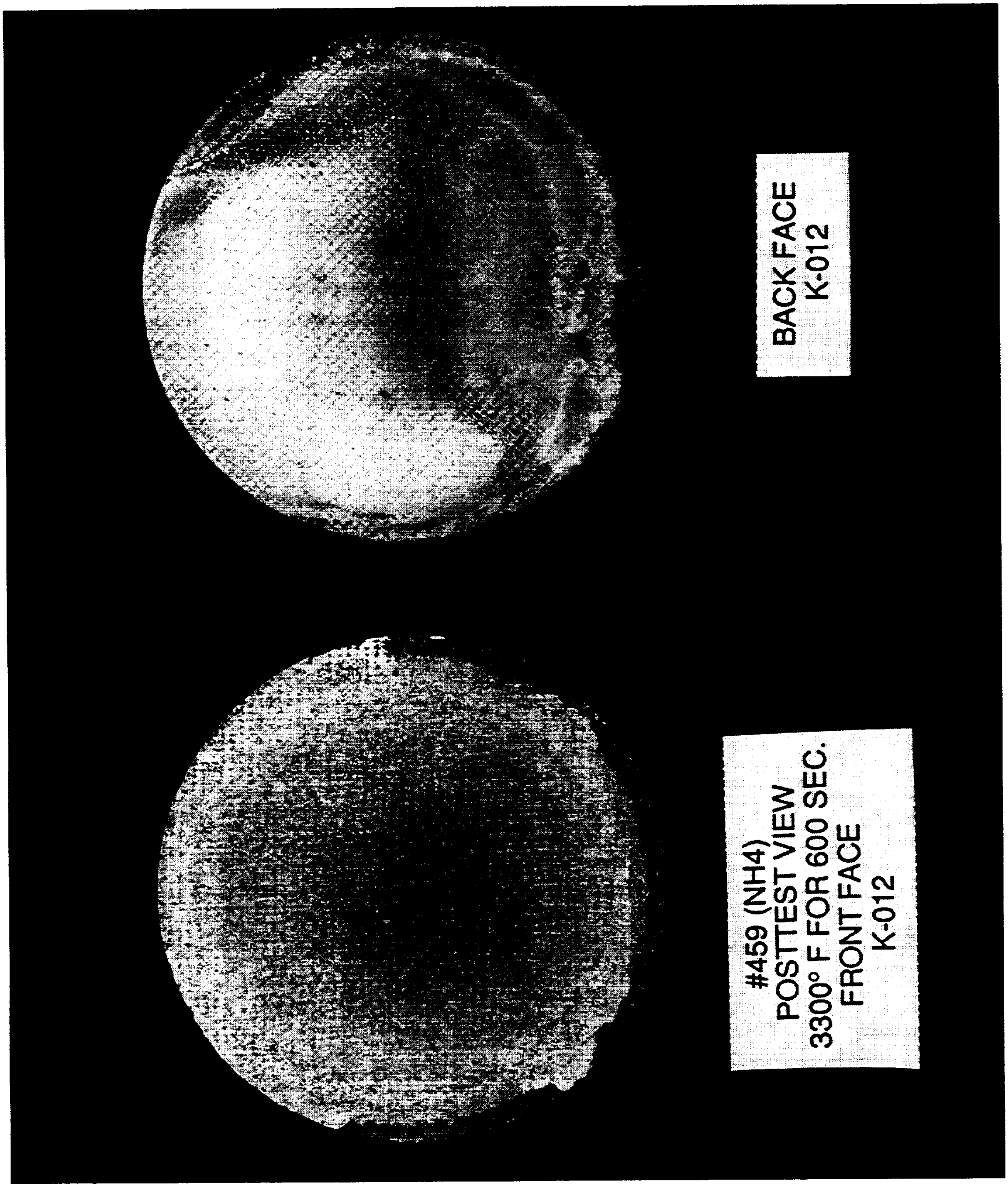

#464 (NH10)
PRETEST VIEW
BACK FACE
K-008
#464 (NH10)
PRETEST VIEW
FRONT FACE
K-008

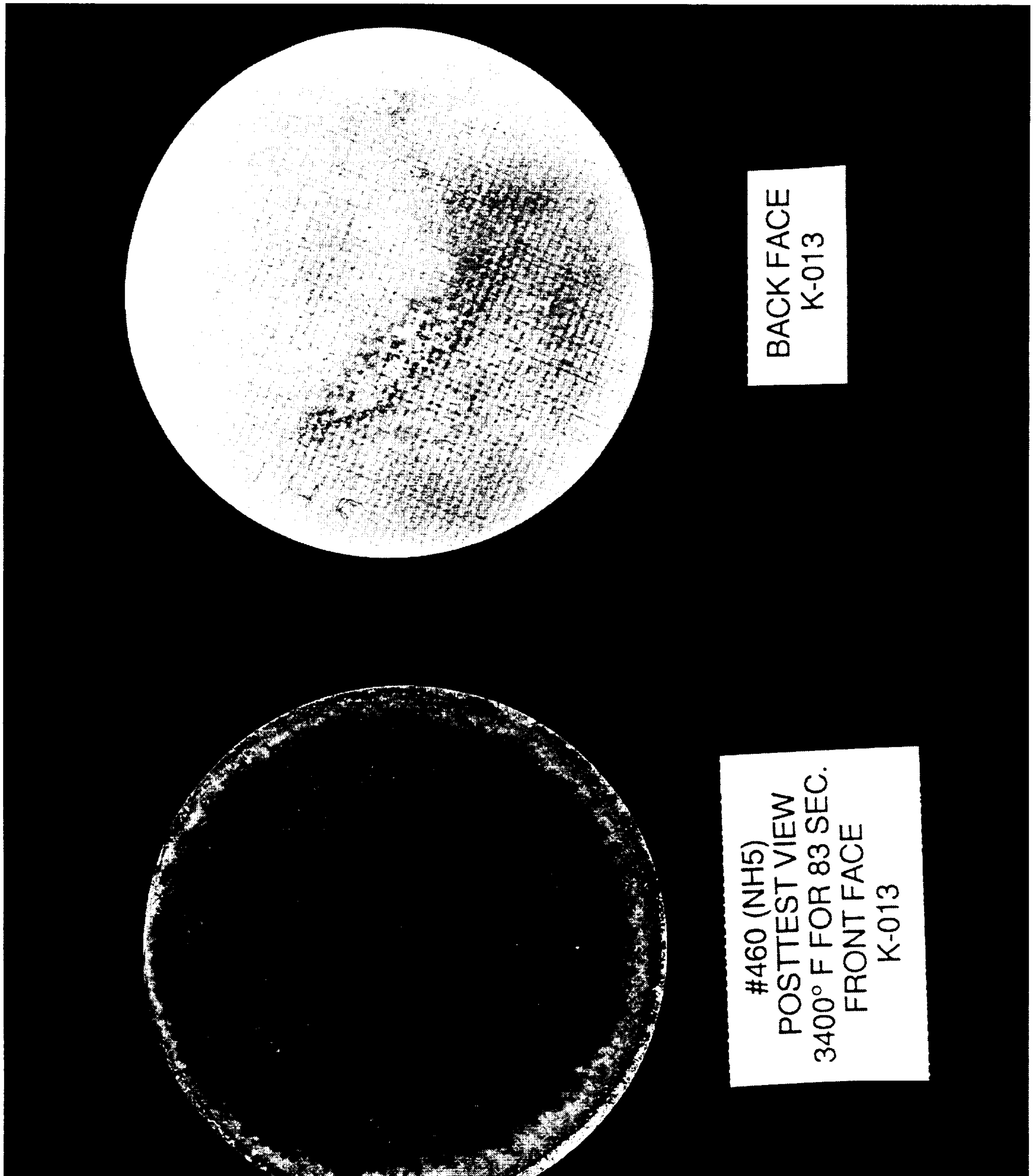

#462 (NH8)
PRETEST VIEW
BACK FACE
K-006
#462 (NH8)
PRETEST VIEW
FRONT FACE
K-006

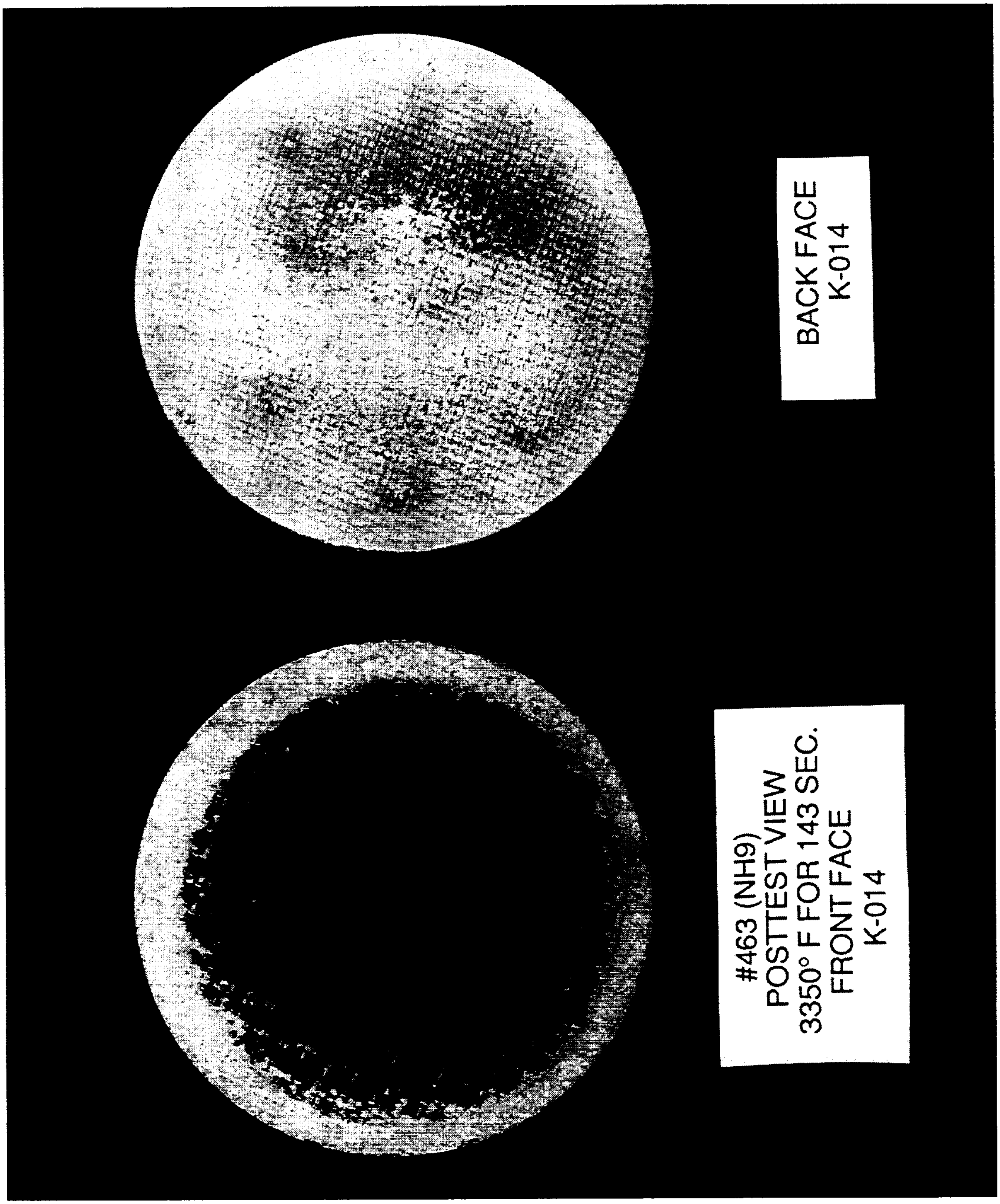

#461 (NH7)
PRETEST VIEW
BACK FACE
K-005
#461 (NH7)
PRETEST VIEW
FRONT FACE
K-005

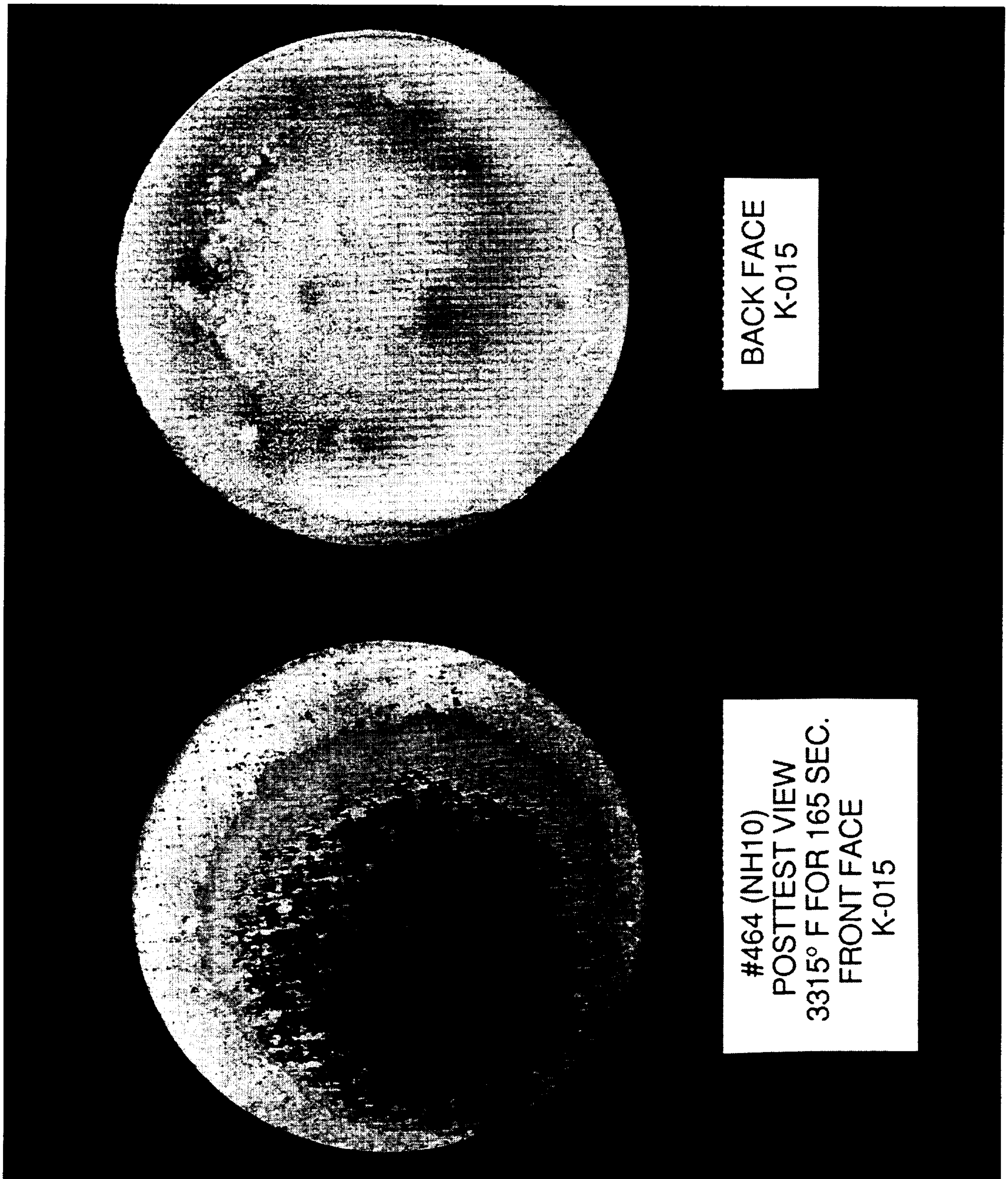

#457 (NH2)
POSTTEST VIEW
3200° F FOR 3600 SEC.
FRONT FACE
K-010
BACK FACE
K-010

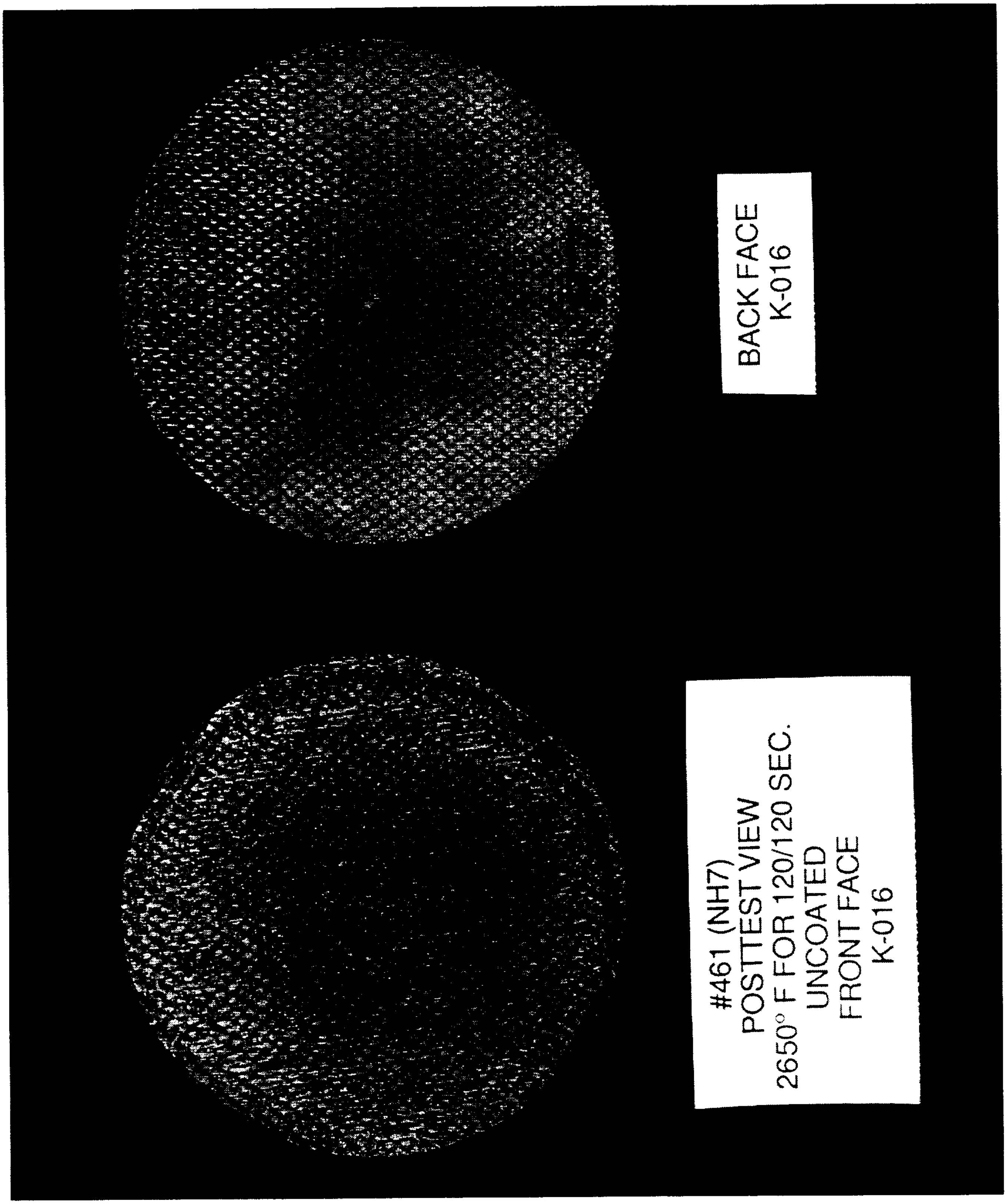

BACK FACE
K-011
#458 (NH3)
POSTTEST VIEW
3250° F FOR 2868 SEC.
FRONT FACE
K-011

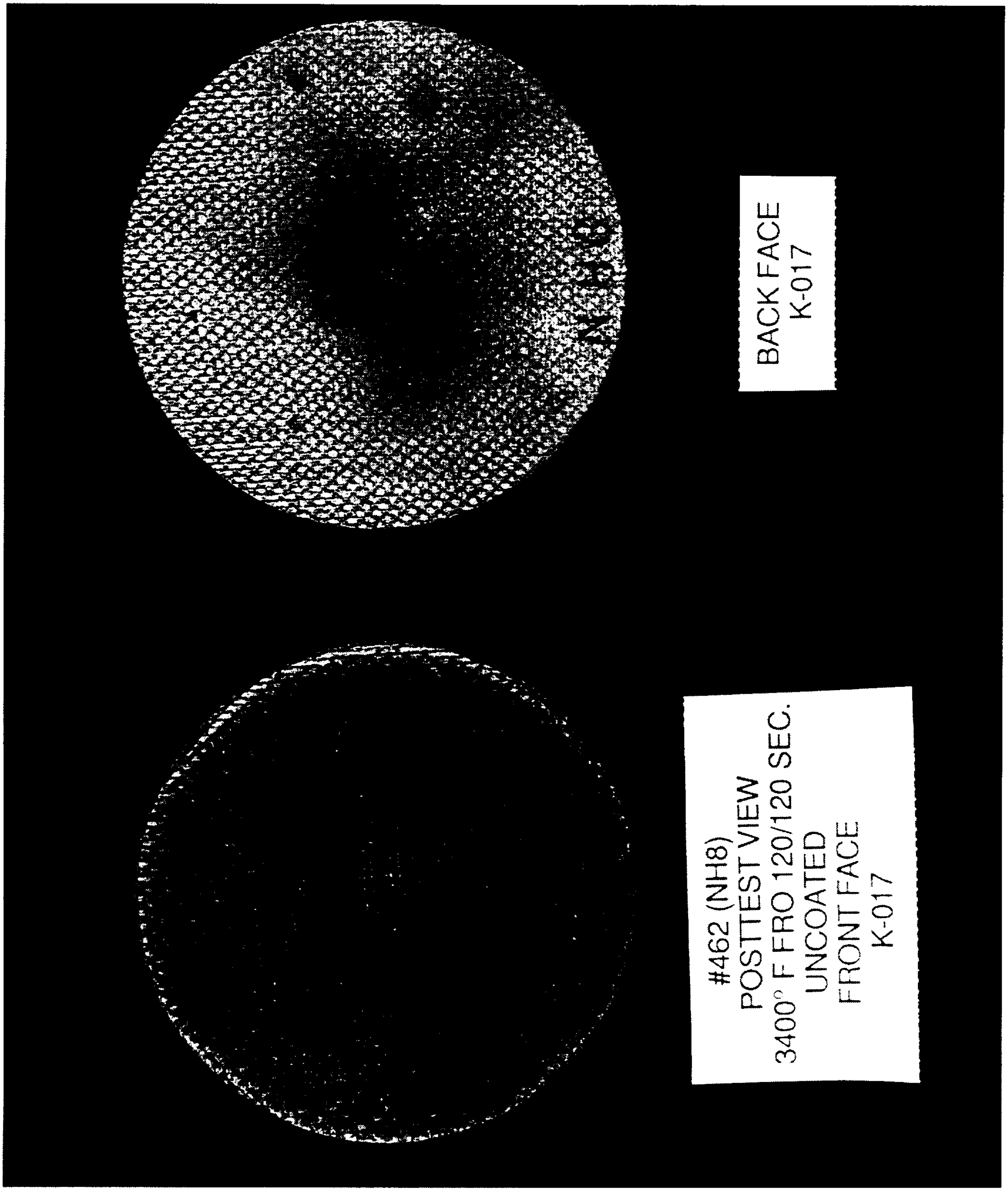

BACK FACE
K-012
#459 (NH4)
POSTTEST VIEW
3300° F FOR 600 SEC.
FRONT FACE
K-012


BACK FACE
K-013
#460 (NH5)
POSTTEST VIEW
3400° F FOR 83 SEC.
FRONT FACE
K-013


BACK FACE
K-014
#463 (NH9)
POSTTEST VIEW
3350° F FOR 143 SEC.
FRONT FACE
K-014


BACK FACE
K-015
#464 (NH10)
POSTTEST VIEW
3315° F FOR 165 SEC.
FRONT FACE
K-015

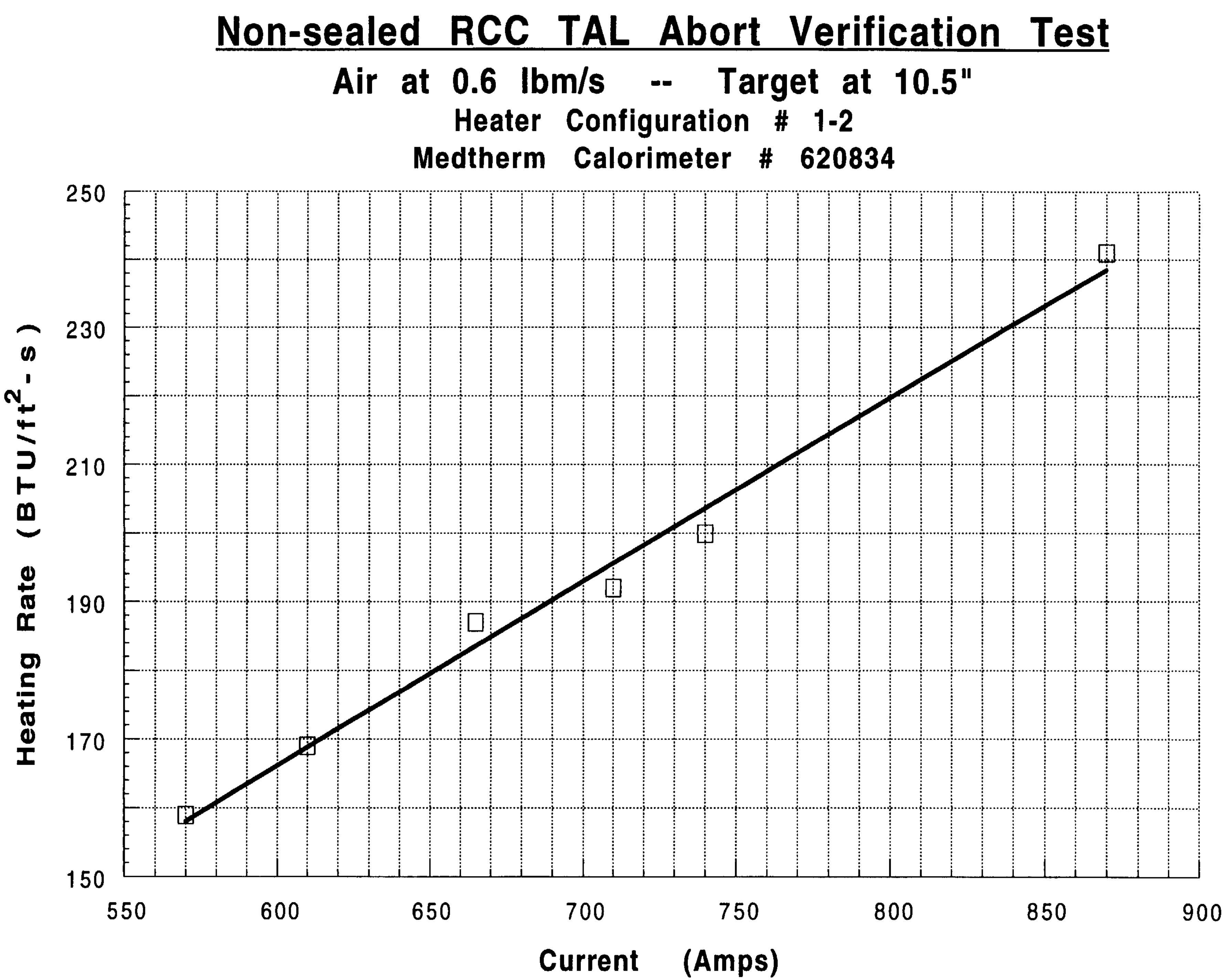

#461 (NH7)
POSTTEST VIEW
2650° F FOR 120/120 SEC.
UNCOATED
FRONT FACE
K-016
BACK FACE
K-016


BACK FACE
K-017
#462 (NH8)
POSTTEST VIEW
3400° F FRO 120/120 SEC.
UNCOATED
FRONT FACE
K-017

Test Series 3

APPENDIX B

FACILITY TEST PARAMETERS

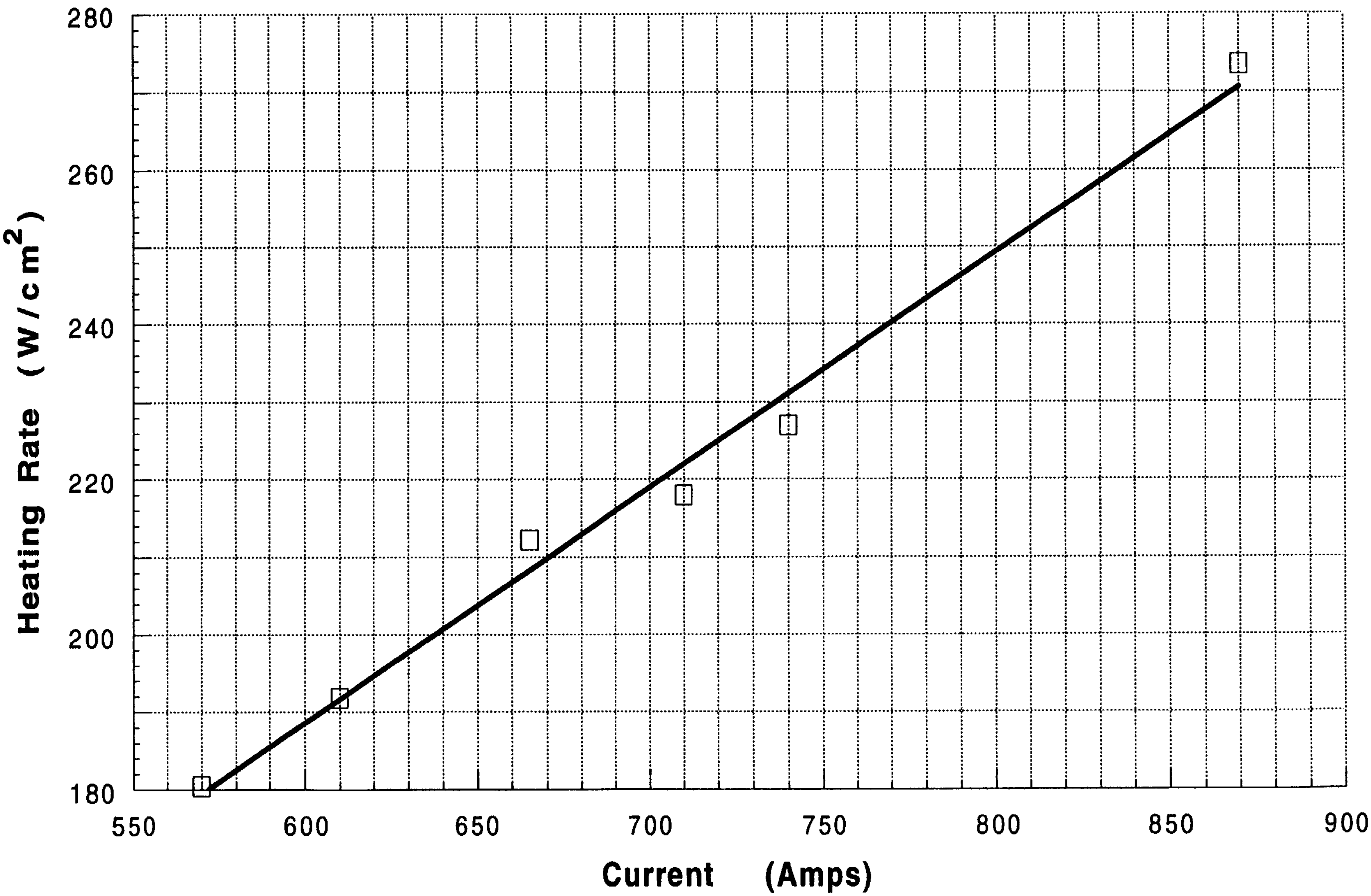

Non-sealed RCC TAL Abort Verification Test
Air at 0.6 lbm/s -- Target at 10.5"
Heater Configuration # 1-2
Medtherm Calorimeter # 620834
Heating Rate (BTU/ft^2 - s)
250
230
210
190
170
150
550
600
650
700
750
800
850
900
Current (Amps)

Non-sealed RCC TAL Abort Verification Test

Air at 0.272 kg/s -- Target at 26.67 cm

Heater Configuration # 1-2

Medtherm Calorimeter # 620834



Test Series 3

APPENDIX C

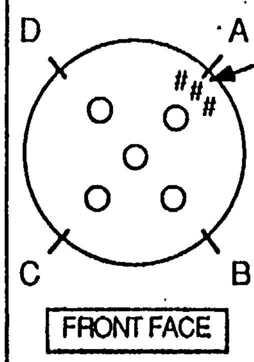
PRE- AND POST-TEST SPECIMEN MEASUREMENTS

U.S. Gov't

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

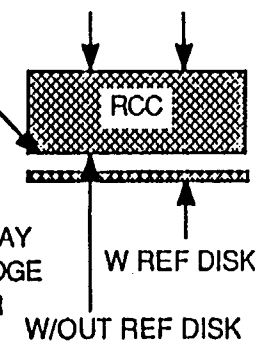
TEST ARTICLE NO: NH-2 RUN NO: 1-403-OD 2-5-92

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	51.663		50.977	
BAG WEIGHT ONLY	12.960		12.960	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.198		.130	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.2321	.5052	.233	.521
THICKNESS AT POINT A	.2314	.5025	.240	.510
THICKNESS AT POINT B	.2324	.5032	.232	.516
THICKNESS AT POINT C	.2320	.5034	.238	.514
THICKNESS AT POINT D	.2322	.5022	.237	.511
REFERENCE DISK THICKNESS	.2181		.268	
TECH / QA / DATE	BJ. 2-5-92 FORD 23		B.J. 2-5-92 FORD 23	



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



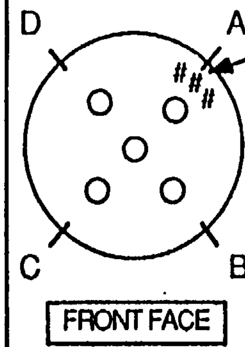
POST-TEST RESULTS/COMMENTS:

PRECEDING PAGE BLANK NOT FILMED

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

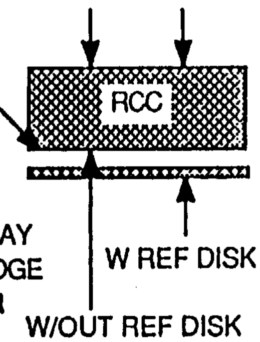
TEST ARTICLE NO: NH-3 RUN NO: 1-404-DD 2-2-92 1.41 DD 2-13-92 2ND RUN.

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	52.390		51.180	
BAG WEIGHT ONLY	12.507 ~~12.9~~		12.507	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.197		.136	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.239	.515	.233	.518
THICKNESS AT POINT A	.240	.513	.248	.520
THICKNESS AT POINT B	.240	.515	.249	.517
THICKNESS AT POINT C	.239	.513	.263	.510
THICKNESS AT POINT D	.240	.514	.251	.527
REFERENCE DISK THICKNESS	.2681		.268	
TECH / QA / DATE	B.J. 2-5-92 FORD 25		BJ 2-6-92 FORD 23	



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN

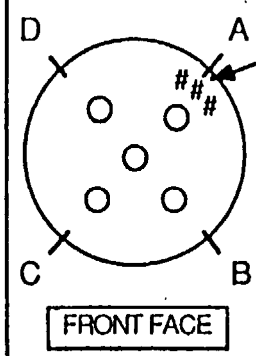


POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

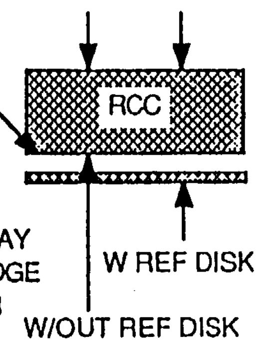
TEST ARTICLE NO: NH-4 RUN NO: 1-408OO 2-11-92

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.411		48.239	
BAG WEIGHT ONLY	12.427		12.427	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.197 ~~.187~~		.110	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.233	.505	.217	.502
THICKNESS AT POINT A	.234	.503	.228	.500
THICKNESS AT POINT B	.234	.503	.230	.503
THICKNESS AT POINT C	.233	.503	.230	.503
THICKNESS AT POINT D	.234	.503	.231	.505
REFERENCE DISK THICKNESS	.2681		.268	
TECH / QA / DATE	BJ. 2-5-92		BJ. 2-11-92	



MODEL ID.# ARE ON BACK SIDE

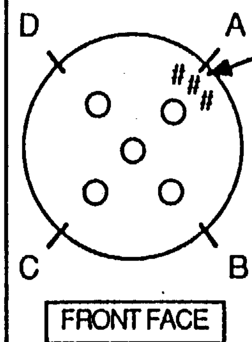
MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



POST-TEST RESULTS/COMMENTS:

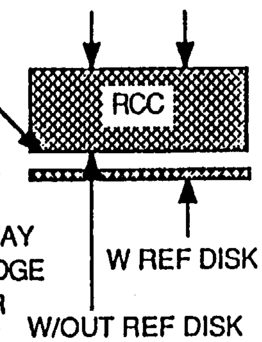
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: NH-5 RUN NO: 2-12-92 1-409.00



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



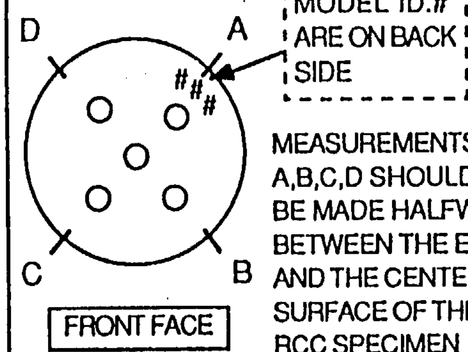
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	51.793		42.202	
BAG WEIGHT ONLY	13.337		13.337	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.207		.231	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.230	.506	.174	.450
THICKNESS AT POINT A	.234	.506	.183	.454
THICKNESS AT POINT B	.235	.506	.188	.457
THICKNESS AT POINT C	.234	.504	.187	.457
THICKNESS AT POINT D	.233	.506	.190	.456
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BJ. 2-5-92		BJ. 2-12-92	

FORD 23

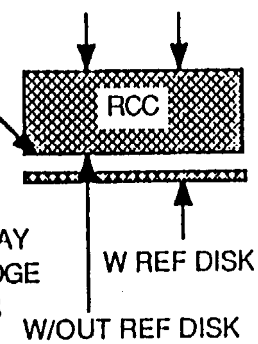
POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: NH-2 RUN NO: 1-410-00 2-13-92



MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN

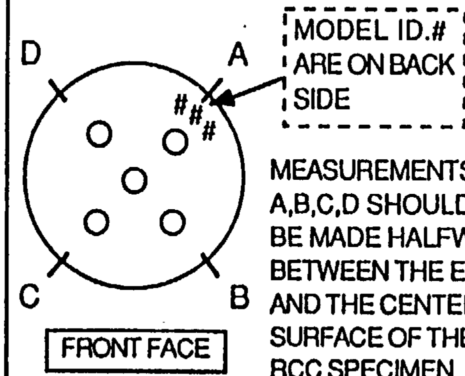


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.977		50.412	
BAG WEIGHT ONLY	12.960		12.960	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.130		.135	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.233	.521	.240	.533
THICKNESS AT POINT A	.240	.510	.237	.507
THICKNESS AT POINT B	.232	.516	.250	.513
THICKNESS AT POINT C	.238	.514	.240	.518
THICKNESS AT POINT D	.237	.511	.239	.515
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	B.J. 2-5-92 FORD 23		2-13-92 B.J. FORD 23	

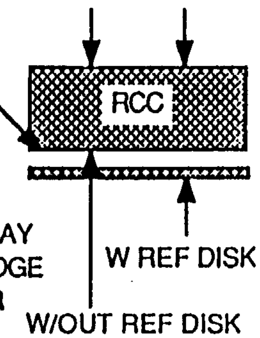
POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: NH3 RUN NO: 1-41 DO 2-14-92 (2ND RUN)



MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



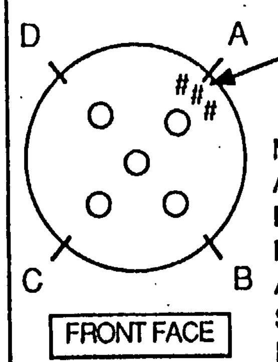
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	51.180		48.204	
BAG WEIGHT ONLY	12.507		12.507	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.197		.126	
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.233	.518	.180	.505
THICKNESS AT POINT A	.248	.520	.248	.520
THICKNESS AT POINT B	.249	.517	.256	.530
THICKNESS AT POINT C	.263	.510	.245	.539
THICKNESS AT POINT D	.251	.527	.247	.522
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BJ. 2-14-92		BY. 2-18-92	

POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

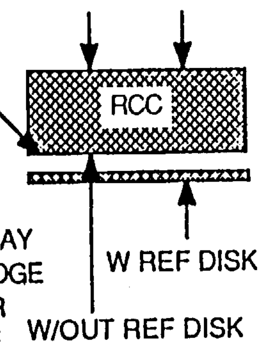
TEST ARTICLE NO: NH3 RUN NO: 1-412-DD 3RD RUN

	PRE-TEST	POST-TEST
BAG AND SPECIMEN WEIGHT	48.204	
BAG WEIGHT ONLY	12.507	
SPECIMEN WEIGHT ONLY		
REFLECTIVITY	.126	



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



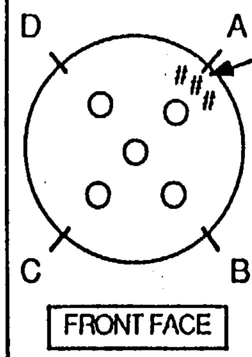
MEASUREMENTS OF SPECIMEN	PRE-TEST W/OUT REF DISK	PRE-TEST W REF DISK	POST-TEST W/OUT REF DISK	POST-TEST W REF DISK
THICKNESS AT CENTERLINE	.180	.505	POST	
THICKNESS AT POINT A	.248	.520		
THICKNESS AT POINT B	.256	.530	TEST	
THICKNESS AT POINT C	.245	.539	WAVED	
THICKNESS AT POINT D	.247	.522		
REFERENCE DISK THICKNESS	.268			
TECH / QA / DATE	B. Y. 2-18-92			

FORD 23

POST-TEST RESULTS/COMMENTS:

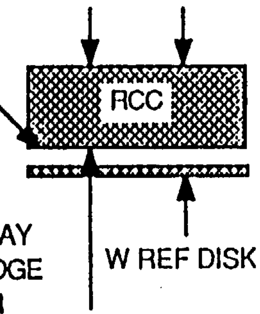
TEST ARTICLE NO: NH 2 RUN NO: 3RD Run

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.972			
BAG WEIGHT ONLY	12.960			
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.130			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.235	.521		
THICKNESS AT POINT A	.240	.510	WAIVED	
THICKNESS AT POINT B	.232	.516		
THICKNESS AT POINT C	.238	.514		
THICKNESS AT POINT D	.237	.511		
REFERENCE DISK THICKNESS	.268			
TECH / QA / DATE				



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN

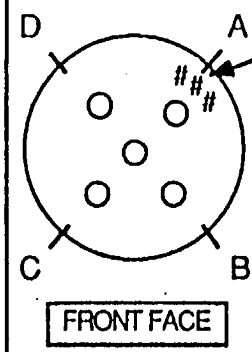


POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

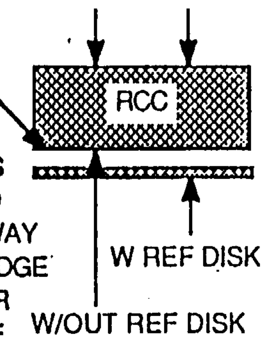
TEST ARTICLE NO: NH-9 RUN NO: 414DB

	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	50.612		44.457 ~~45.114~~	
BAG WEIGHT ONLY	12.799		12.799	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	172			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.243	.515	.196	.474
THICKNESS AT POINT A	.242	.513	.235	.502
THICKNESS AT POINT B	.242	.512	.228	.513
THICKNESS AT POINT C	.242	.513	.213	.493
THICKNESS AT POINT D	.244	.514	.223	.496
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BJ 2-5-92	FORD 7	BJ.	2-27-92 FORD 7



MODEL ID.# ARE ON BACK SIDE

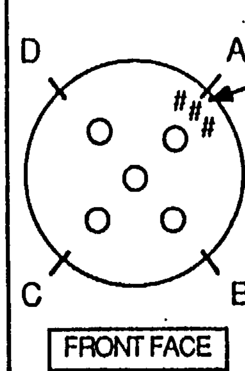
MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



POST-TEST RESULTS/COMMENTS:

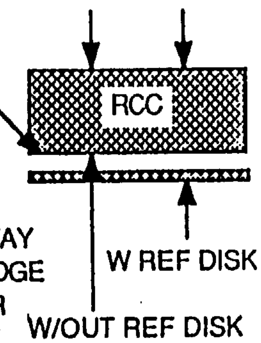
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: NH-10 RUN NO: ______



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN

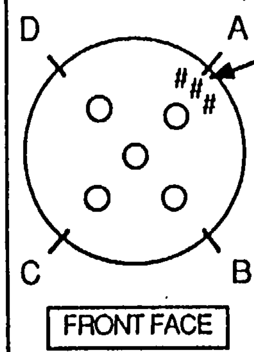


	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	49.999		45.558	
BAG WEIGHT ONLY	13.458		13.458	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.163			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.233	.503	.199	.473
THICKNESS AT POINT A	.234	.502	.231	.498
THICKNESS AT POINT B	.234	.504	.207	.476
THICKNESS AT POINT C	.234	.504	.232	.499
THICKNESS AT POINT D	.233	.502	.233	.499
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	B.J. 2-5-92 FORD 23		B.J. 2-29-92 FORD 23	

POST-TEST RESULTS/COMMENTS:

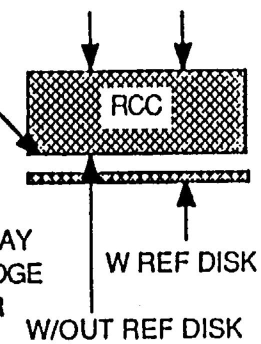
NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

TEST ARTICLE NO: NH-7 (uncoated RUN NO: 1-419-DO 3-4-92



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



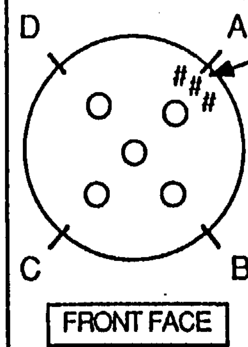
	PRE-TEST		POST-TEST	
BAG AND SPECIMEN WEIGHT	43.771		30.456	
BAG WEIGHT ONLY	12.943		12.943	
SPECIMEN WEIGHT ONLY				
REFLECTIVITY	.362			
MEASUREMENTS OF SPECIMEN	W/OUT REF DISK	W REF DISK	W/OUT REF DISK	W REF DISK
THICKNESS AT CENTERLINE	.227	.497	.132	.403
THICKNESS AT POINT A	.229	.497	.148	.414
THICKNESS AT POINT B	.229	.497	.139	.406
THICKNESS AT POINT C	.229	.496	.140	.403
THICKNESS AT POINT D	.230	.496	.145	.408
REFERENCE DISK THICKNESS	.268		.268	
TECH / QA / DATE	BJ. 2-5-92		BJ. 3-4-92 FORD 23	

POST-TEST RESULTS/COMMENTS:

NASA/JSC RCC TAL ABORT VERIFICATION TEST DATA SHEET

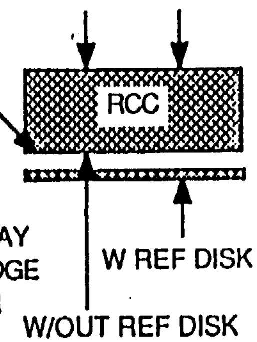
TEST ARTICLE NO: NH-B (uncoated) RUN NO: ________

	PRE-TEST	POST-TEST
BAG AND SPECIMEN WEIGHT	44.658	33.898
BAG WEIGHT ONLY	12.434	12.434
SPECIMEN WEIGHT ONLY	~~12.4~~	
REFLECTIVITY	.380	



MODEL ID.# ARE ON BACK SIDE

MEASUREMENTS A,B,C,D SHOULD BE MADE HALFWAY BETWEEN THE EDGE AND THE CENTER SURFACE OF THE RCC SPECIMEN



MEASUREMENTS OF SPECIMEN	PRE-TEST W/OUT REF DISK	PRE-TEST W REF DISK	POST-TEST W/OUT REF DISK	POST-TEST W REF DISK
THICKNESS AT CENTERLINE	.239	.506	.163	.436
THICKNESS AT POINT A	.238	.506	.175	.438
THICKNESS AT POINT B	.238	.506	.167	.436
THICKNESS AT POINT C	.239	.506	.161	.431
THICKNESS AT POINT D	.238	.506	.167	.434
REFERENCE DISK THICKNESS	.268	FORD 25	.268	
TECH / QA / DATE	BJ. 2-5-92		BJ. 3-5-92	FORD 23

POST-TEST RESULTS/COMMENTS:

REPORT DOCUMENTATION PAGE

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OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE December 1993	3. REPORT TYPE AND DATES COVERED Study/test results 12/87 to 3/92

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Springfield, VA 22161
(703) 487-4600
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12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This document consists of the entire test database generated to support the Reinforced Carbon-Carbon Transatlantic Abort Landing Study. RCC components used for Orbiter nose cap and wing leading edge thermal protection were originally designed to have a multi-mission entry capability of 2800°F. Increased Orbiter range capability required a predicted increase in excess of 3300°F. Three test series were conducted. Test series #1 used ENKA-based RCC specimans coated with silicon carbide, treated with tetraethyl orthosilicate, sealed with Type A surface enhancement, and tested at 3000-3400°F with surface pressure of 60-101 psf. Series #2 used ENKA- or AVTEX-based RCC, with and without silicon carbide, Type A or double Type AA surface enhancement, all impregnated with TEOS, and at temperatures from 1440-3350°F with pressures from 100-350 psf. Series #3 tested ENKA-based RCC, with and without silicon carbide coating. No specimens were treated with TEOS or sealed with Type A. Surface temperatures ranged from 2690-3440°F, and pressures ranged from 313-400 psf. These combined test results provided the database for establishing RCC material single-mission-limit temperature and developing surface recession correlations used to predict mass loss for abort conditions.

14. SUBJECT TERMS
carbon-carbon composites, thermal protection, re-entry shielding, coatings, high temperature tests

15. NUMBER OF PAGES
337

16. PRICE CODE

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