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# EVALUATION OF SILICONE POLYMERS

SwRI Project No. 02-5814-118
FINAL REPORT

Prepared for

Stone & Webster Engineering Corporation
P. O. Box 2325
Boston, Massachusetts 02107

June 9, 1980

APPROVED:

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Department of Materials Sciences

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SAN ANTONIO, HOUSTON, TEXAS, AND WASHINGTON, D.C.

## INTRODUCTION

Three pieces of irradiated silicone polymer were received at Southwest Research Institute (SwRI) from Wyle Laboratories on March 12, 1980. The specimens were packaged in plastic bags contained in lead pigs, which were in turn contained in a smaller box within the wooden shipping crate. The package was identified as containing radioactive material. The specimens were weighed and measured upon receipt to provide information for the design of sabots to guide them in the gun tube and for the determination of the gas pressure required to obtain the required velocity of 1500 fps. The information given on the labels affixed to the lead pigs is given in Table I, along with the initial and as-tested weights of the specimens and the muzzle velocities measured for each firing.

## PROCEDURE

The specimens were received in the form of rectangular solid pieces. In order to fire them from the 1-in. bore diameter cold gas gun, they had to be sanded into smooth blocks and fitted with sabots to guide them down the gun barrel and contain the pressure behind them. The sabots were made of low-density urethane foam cast into a 1-in. inside diameter tube with a rectangular block inserted to form the cavity into which the specimen was placed for firing. Each sabot was cast as one piece, then cut into two side pieces plus a round pusher disk as shown in Figure 1. The projectile was then assembled by placing the specimen between the side pieces and inserting this assembly into the breech end of the gun, which opens at Joint A in Figure 2. The pusher disk was then inserted behind the specimen.

Occasionally, paper shims were inserted between the specimen and side pieces in order to achieve a good seal between the sabot and the gun tube to minimize the leakage of propellant gas past the projectile.

The gun used to accelerate the specimens uses compressed gas as propellant. A series of reservoirs accumulates the required pressure, and the gun is fired by venting the main reservoir into the gun tube behind the projectile. Two photodiodes are mounted near the muzzle of the gun to detect the passage of the front of the projectile. The photodiode output signals are fed to a waveform generator for direct display and to a signal conditioner which passes a step function to the waveform generator. The four waves are displayed on an oscilloscope. A camera attachment fixture on the oscilloscope allows the waves to be photographed for measurement. The first photodiode also detects the turbulent compressed gas which precedes the projectile down the barrel, so its output must be interpreted accordingly. The projectile passage is taken to be at the discontinuity in the slope of the output of the first photodiode. The muzzle velocity of the projectile is then calculated by dividing the distance between the photodiodes by the time required for the projectile to travel that distance. Figure 3 shows the oscilloscope traces obtained for the live specimens.

Figure 2 shows the gun and the specimen containment structure. Box A is open at both ends and serves to contain the fragments resulting from the stripping of the sabot from the specimen. Box B is the catch box, and contains the 34-lb concrete block target. Box B is lined with plastic sheeting and is sealed with a lid secured by four screws. Duct tape is used to seal the lid to the box. A 2-in. diameter aperture is provided for the passage of the projectile, with crossed slits in the plastic liner to allow free entry of the specimen while containing the resulting debris. The distance from the muzzle of the gun to the target is 69.5 in. The Special Operating Procedure required by the SwRI Radiation Hazards Officer is included as an Appendix to this report.

## CALIBRATION

The gun was calibrated by firing a series of dummy specimens cut from a block of unirradiated material supplied by Stone & Webster Engineering Corporation. The calibration firings provided information on the relationship between reservoir pressure and muzzle velocity. The required velocity of 1500 fps could only be obtained by exceeding the 600 psi rating of the gun, and then only with relatively poor reliability. When attempting to achieve a velocity of 1500 fps, the actual velocity fell in a range of ± 100 fps of the desired value. This limitation is presumed to be caused by variations in the fit of the sabot in the gun tube, in the leakage of propellant gas past the sabot, and in the limits of resolution of photodiodes and associated electronic gear.

## TESTING

The two live specimens were sanded to fit the sabots, then weighed. The sabots were also weighed to obtain the net projectile weight. Specimen A was fired first. The oscilloscope traces are given in Figure 3(a). Several minutes were allowed for the dust to settle inside the catch box before the box was opened and the remains of the specimen removed. The concrete block showed some damage as a result of the impact of the specimen. A region approximately 1 in. in diameter was chipped out to a maximum depth of approximately .13 in. (visual estimate). The fragments of specimen, sabot, and concrete were removed from the box and returned to a plastic specimen bag. Since the specimen was reduced to a fine powder, and since other debris was also present, no attempt was made to quantify the particle size distribution.

Specimen B was fired next, using a fresh face of the target block. The oscilloscope trace is given in Figure 3(b). Again, the specimen was reduced to a fine powder on impact. The damage to the target block was less severe, with a maximum penetration of only about .07 in. by visual estimate. The powder was removed from the box to a separate specimen bag, which was placed inside another specimen bag containing a chip removed from this specimen before firing.

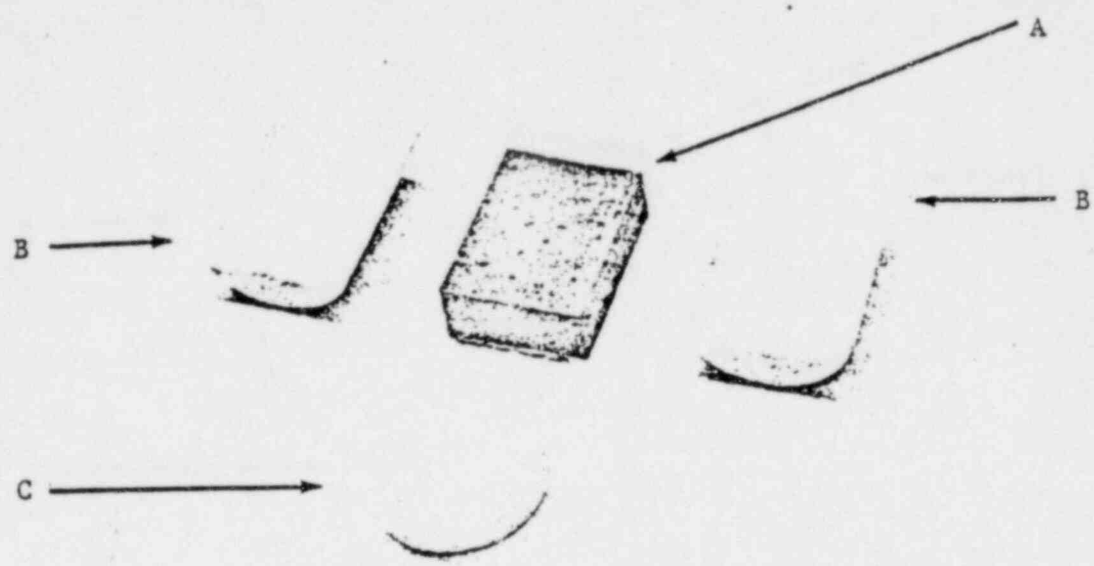
## CONCLUSION

The fragments from each specimen were collected and placed in plastic specimen bags marked with the specimen designation. The bagged specimens were then placed in the lead slugs and returned to the SwRI "Hot Lab" for packing prior to shipment back to Wyle Labs. Both sets of fragments also contain bits of urethane foam from the sabot and bits of concrete from the target.

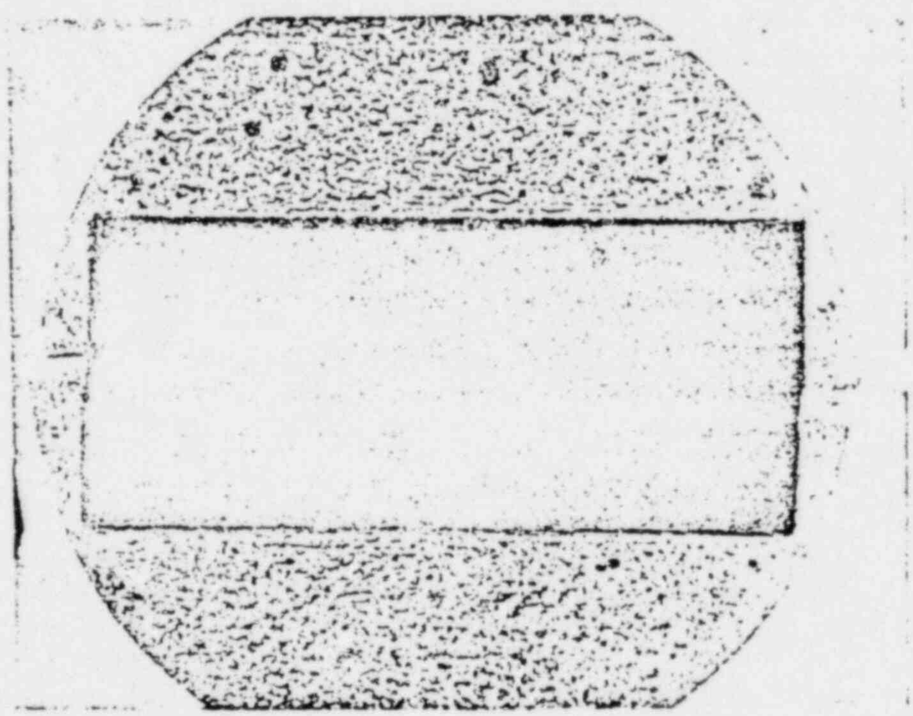
## TABLE I

## SPECIMEN DATA

| | | |
|---|---|---|
| Specimen: | A | B |
| Type: | Chemtrol CT-40-NS Type B | Chemtrol CT-40-NS Type B |
| Exposure: | | |
| • Time, hr: | 545.6 | 110 |
| • Temperature, °F: | 380 ± 20 | 380 ± 20 |
| • Power, MW: | 2 | 2 |
| • $\gamma$ radiation, rads: | $4.1 \times 10^{10}$ | $8.4 \times 10^{9}$ |
| • Isotope: | $Zn^{65}$ | $Zn^{65}$ |
| • $\beta$ rate, mR/hr: | 21 | 195 |
| • $\gamma$ rate, mR/hr: | 18 | 15 |
| Approximate Initial Weight, g: | 12.4 | 10.7 |
| Approximate Initial Dimensions, mm: | 35 x 22 x 10 | 35 x 22 x 10 |
| Weight as Tested, g: | 10.00 | 9.42 |
| Projectile Weight, g: | 16.04 | 15.49 |
| Muzzle Velocity, fps: | 1450 | 1410 |




(a) Sample Specimen and Sabot Disassembled to Show Components: A - Specimen; B - Sabot Side; and C - Pusher Disk.



(b) Front View of Assembled Projectile, 4X.

FIGURE 1. SPECIMEN AND SABOT

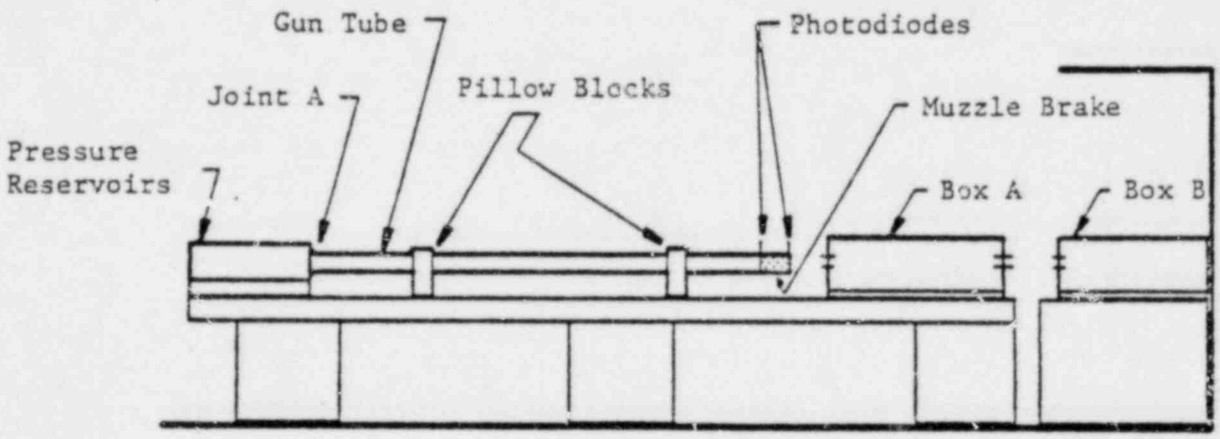
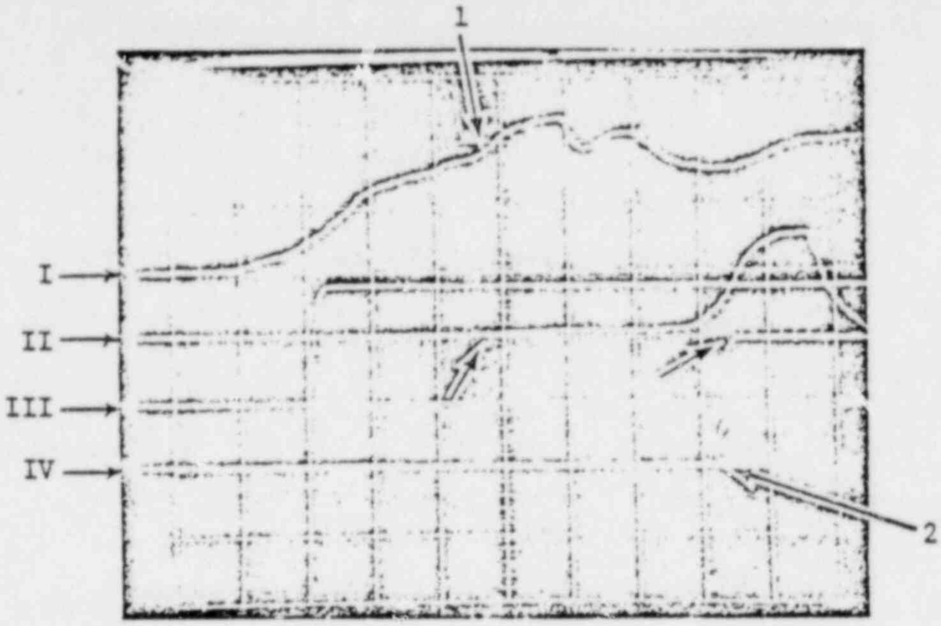
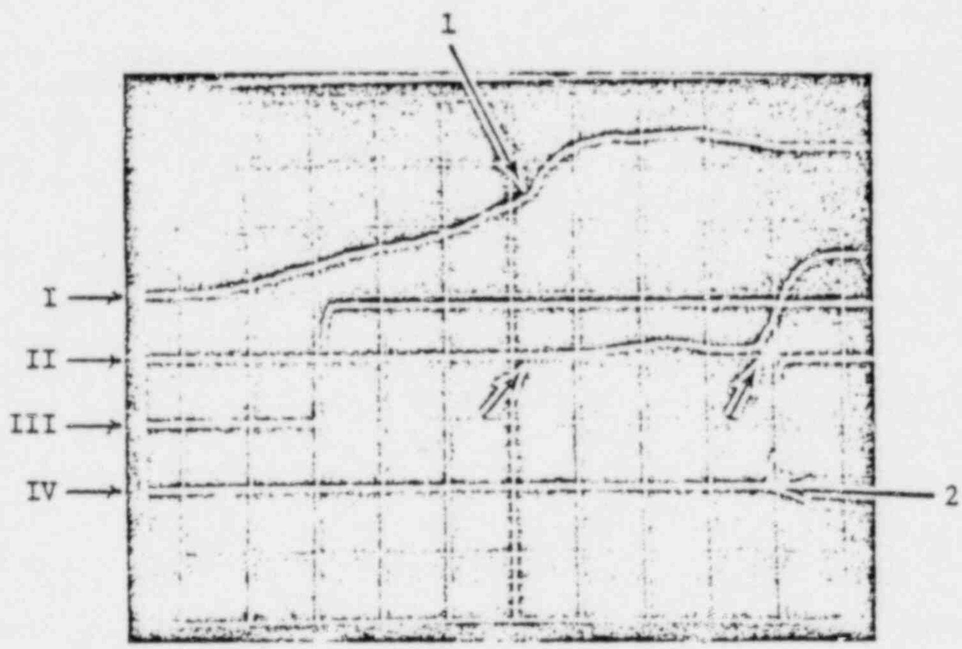



FIGURE 2. GUN AND CONTAINMENT ARRANGEMENT (SCHEMATIC)




(a) Specimen A




(b) Specimen B

FIGURE 3. OSCILLOSCOPE TRACES OF PHOTODIODE OUTPUTS

1 Division = 100 μs

I = First photodiode output
II = Second Photodiode output
III = Conditioned signal from first photodiode
IV = Conditioned signal from second photodiode

1 = Projectile at first photodiode
2 = Projectile at second photodiode

APPENDIX

SPECIAL OPERATING PROCEDURE

PURPOSE:

Because of the hazards involved with radioactive materials, this operating procedure is provided to implement special procedures in support of Project 02-5845-118. This addendum is intended to supplement the SwRI Radiological Health and Safety Manual.

HAZARDS:

The tests will involve the firing of two active silicone polymer samples from an air gun at the Ballistics Range. The projectile will impact on a concrete target within a containment chamber. Methods of containment, protection, and monitoring will be covered in this procedure.

SPECIAL PROCEDURES:

The area to be used for testing will be divided and marked as a controlled area with ropes and radiation warning signs.

The projectile will be fired as received. However, should any sizing be necessary it will be done at the "Hot Lab."

The active projectile will be fired into a containment box through a small opening. Within the box, the projectile will impact the concrete target. Should any fragmentation of the projectile occur, it will be contained within the box. During removal of the fragments, the operator will be required to wear a respirator, surgical gloves, and a disposable lab coat. After the test, the fragments will be recovered for subsequent measurements in an area approved by the Radiation Safety Officer.

Personnel handling the projectile and fragments will be required to wear TDL badges and surgical gloves. Additionally, pocket dosimeters will be used to monitor "current" dosages.

All contaminated waste products, such as used gloves and concrete fragments, will be disposed of in plastic bags provided by the Radiation Safety Officer. These bags will then be disposed of by the "Hot Lab."

After completion of these tests, the area will be monitored carefully for contamination. If contamination is indicated, the area will be cleaned in accordance with the SwRI Radiological Health and Safety Manual.

5/15/80

# QUALIFICATION TEST REPORT

ON

NEUTRON SHIELDING MATERIAL

FOR

CHEMTROL CORPORATION
HOUSTON, TEXAS

# NEQ

Nuclear Environmental Qualification

## Test Report

REPORT NO. 44925-1

WYLE JOB NO. 44925

CUSTOMER P. O. NO. 4087

PAGE i OF 33 PAGE REPORT

DATE September 10, 1980

SPECIFICATION (S) See Paragraph 5.0

A [redacted] B [redacted]

1.0 CUSTOMER Chemtrol Corporation

ADDRESS 330 North Belt East, Houston, Texas 77060

2.0 TEST SPECIMEN Neutron Shielding Material Samples

3.0 MANUFACTURER Chemtrol Corporation

## 4.0 SUMMARY


Two samples of Neutron Shielding Material were subjected to a Qualification Test Program to verify functional integrity when subjected to the environmental tests specified herein.

A description of the Neutron Shielding Material (specimens) is presented in Paragraph 6.0.


STATE OF ALABAMA } ss.
COUNTY OF MADISON

Alabama Professional Eng. Reg. No. 7913

Robert A. Hall, being duly sworn, deposes and says: The information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

Robert A. Hall

SEAL

SUBSCRIBED and sworn to before me this 24th day of Sept, 1980

Joyce Oliver

Notary Public in and for the County of Madison, State of Alabama.

My Commission expires June 3, 1984

TEST BY NEQ Department

PROJ. ENGINEER Joe Mayhall
Joe Mayhall

WYLE Q. A. Murvin Kimbrell
Murvin Kimbrell

**WYLE LABORATORIES**
SCIENTIFIC SERVICES AND SYSTEMS GROUP
HUNTSVILLE, ALABAMA

4.0 SUMMARY (CONTINUED)

The Qualification Test Program was performed in accordance with References 5.1 and 5.2. The Shielding Material showed no visual physical effects from the Steam Impingement Tests. Test results are presented in Section I of this report. The test results of the Borated Water Submersion Test are presented in Section III.

This Qualification Test Report contains three sections as listed below. The test program was conducted in the sequence indicated by the section number.

- o Section I Steam Impingement Test
- o Section II Impact Test
- o Section III Borated Water Submersion Test

5.0 REFERENCES

5.1 Wyle Quotation No. 543/1640-2/ES

5.2 Chemtrol Corporation Purchase Order No. 4087

6.0 TEST ITEM AND EQUIPMENT DESCRIPTION

6.1 Test Item Description

Sample A: CT-40-NS, gamma dose = $4.1 \times 10^{10}$ rads--Sample A is in one piece approximately 1" x 3/4" x 3/8".

Sample B: CT-40-NS, gamma dose = $8.4 \times 10^{9}$ rads--Sample B is in two pieces approximately 1" x 3/4" x 3/8" and 3/4" x 3/4" x 3/8".

6.2 Test Equipment Description

The test equipment used in recording data is shown on Instrumentation Equipment Sheets located in the appendices of the appropriate sections of this report.

# STEAM IMPINGEMENT TEST

# SECTION I

# STEAM IMPINGEMENT TEST

## 1.0 REQUIREMENTS

Each of the Neutron Shielding Materials will be subjected to a Steam Impingement Test.

The specimens will be exposed to a 600°F steam jet impinging directly on the free surface of the samples for 120 seconds.

## 2.0 PROCEDURES

A 1/4-inch fitting for an exit nozzle was located 6 inches from the Shielding Material sample surface. A 1/4-inch line from a high pressure/temperature steam source, with a valve for regulating the flow, furnished the steam supply to the exit nozzle. A bleed valve was provided upstream of the flow regulating valve to condition the steam in the line prior to starting the impingement. A thermocouple was installed in the steam line, approximately 18 inches upstream of the exit nozzle, for measuring the steam temperature. The Shielding Material sample was placed flat in a holding basket located under the exit nozzle, the bleed valve opened to condition the steam, the flow control valve opened and the 600°F steam allowed to impinge on the as-molded free surface for 120 seconds.

The specimen weights were recorded prior to and after impingement.

## 3.0 RESULTS

The test specimens were subjected to the requirements as specified in Paragraph 1.0 and as described in Paragraph 2.0. No visual degradation was evident. The samples were cracked and discolored to some degree when received. Small powder-like specks of material fell from the specimens whenever handled.

The weight of each specimen prior to and after test is presented in Appendix II, Table I.

Photographs are presented in Appendix II. Photographs I-1 through I-4 are pretest specimens. Photographs I-5 and I-6 show the test setup. Photographs I-7 through I-10 show the post-test specimens.

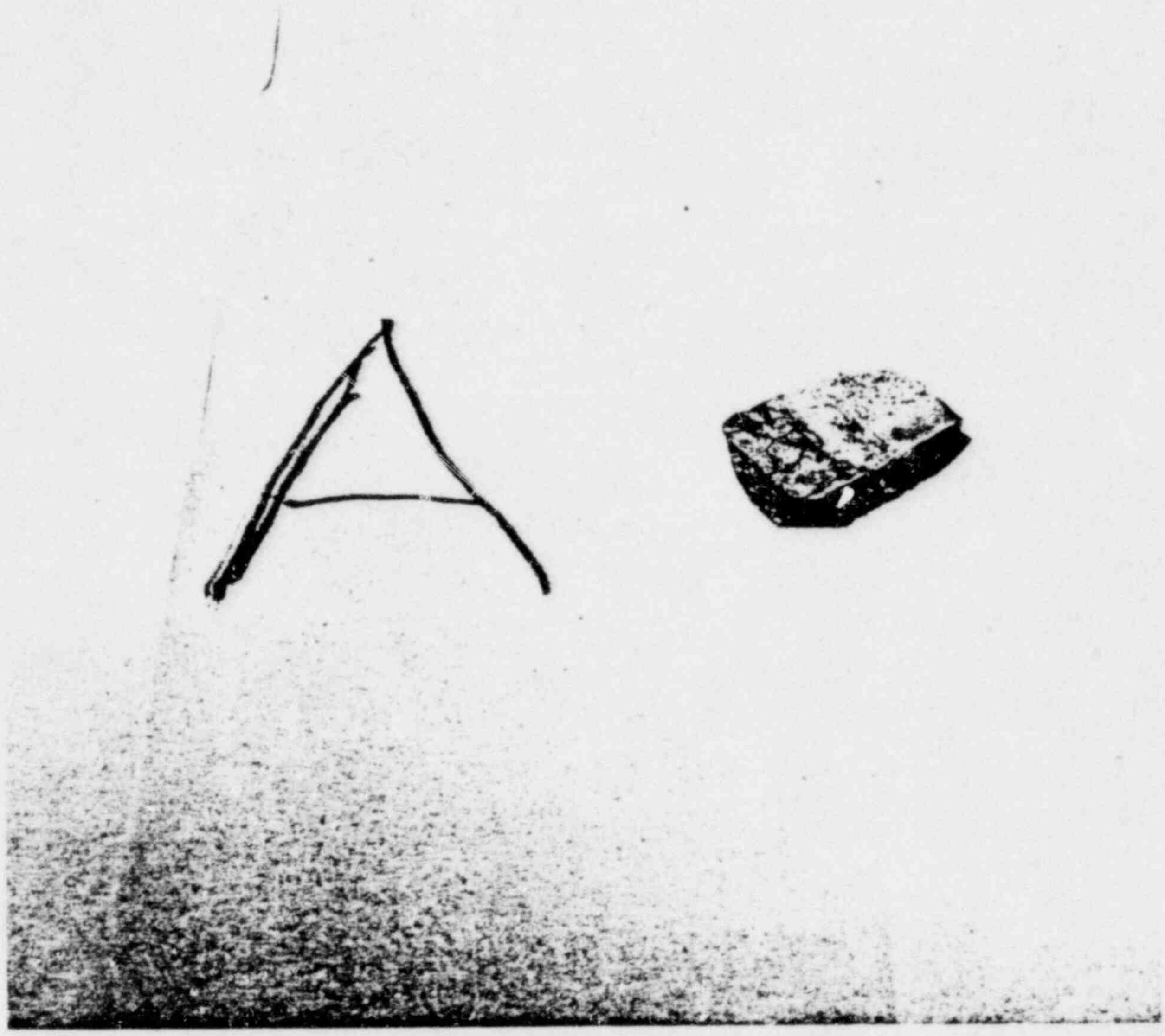
An Instrumentation Equipment Sheet listing the equipment used in this test is presented in Appendix III.

APPENDIX I

TABLE

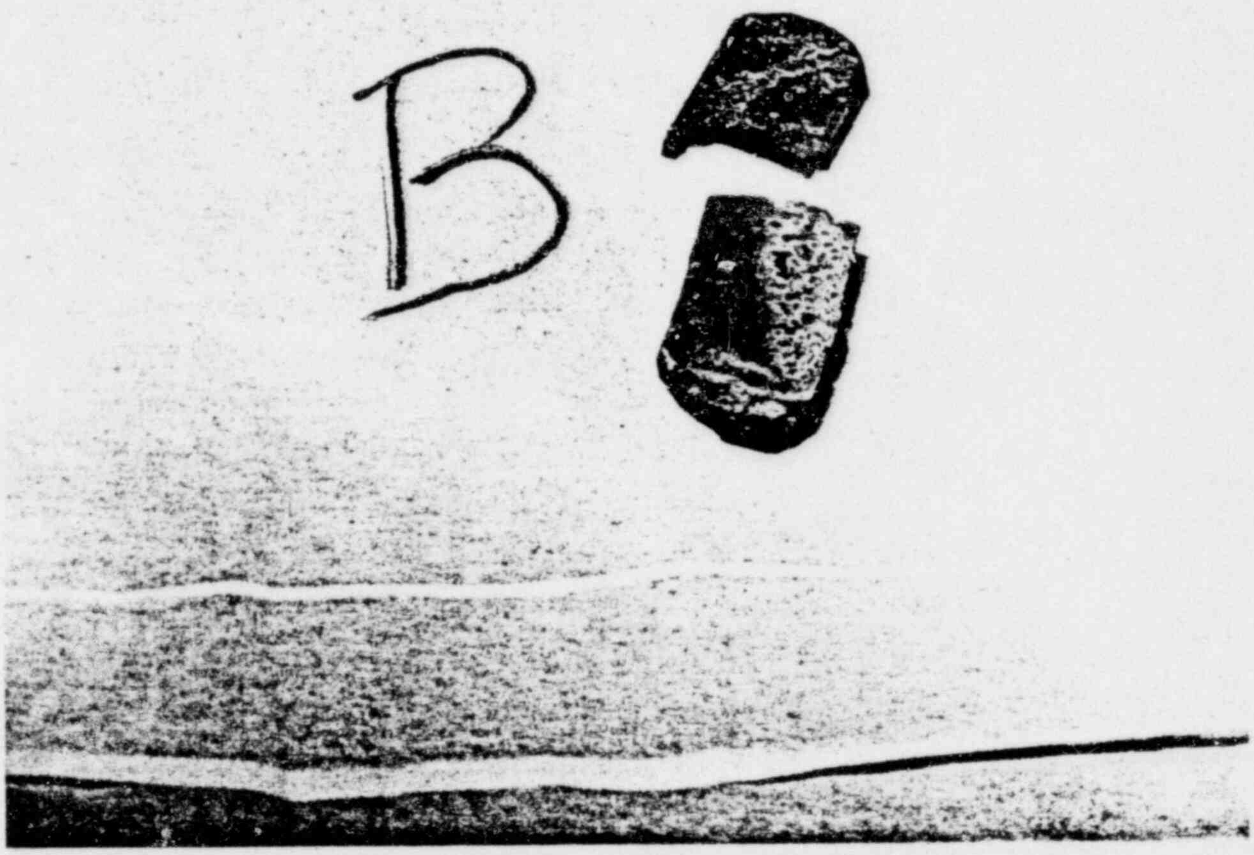
APPENDIX II

PHOTOGRAPHS



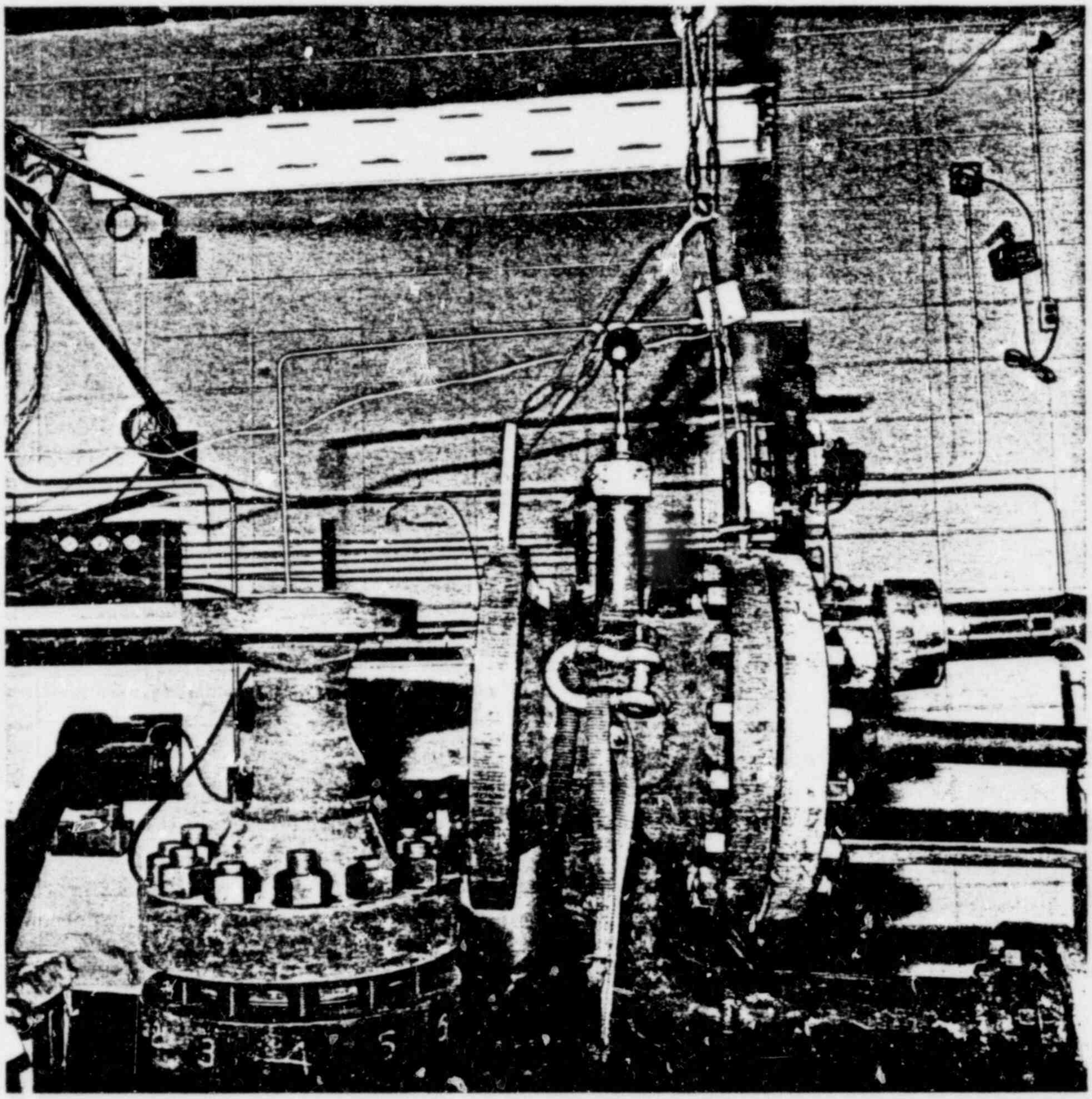
PHOTOGRAPH I-2

PRIOR TO STEAM IMPINGEMENT




PHOTOGRAPH 1-4

PRIOR TO STEAM IMPINGEMENT



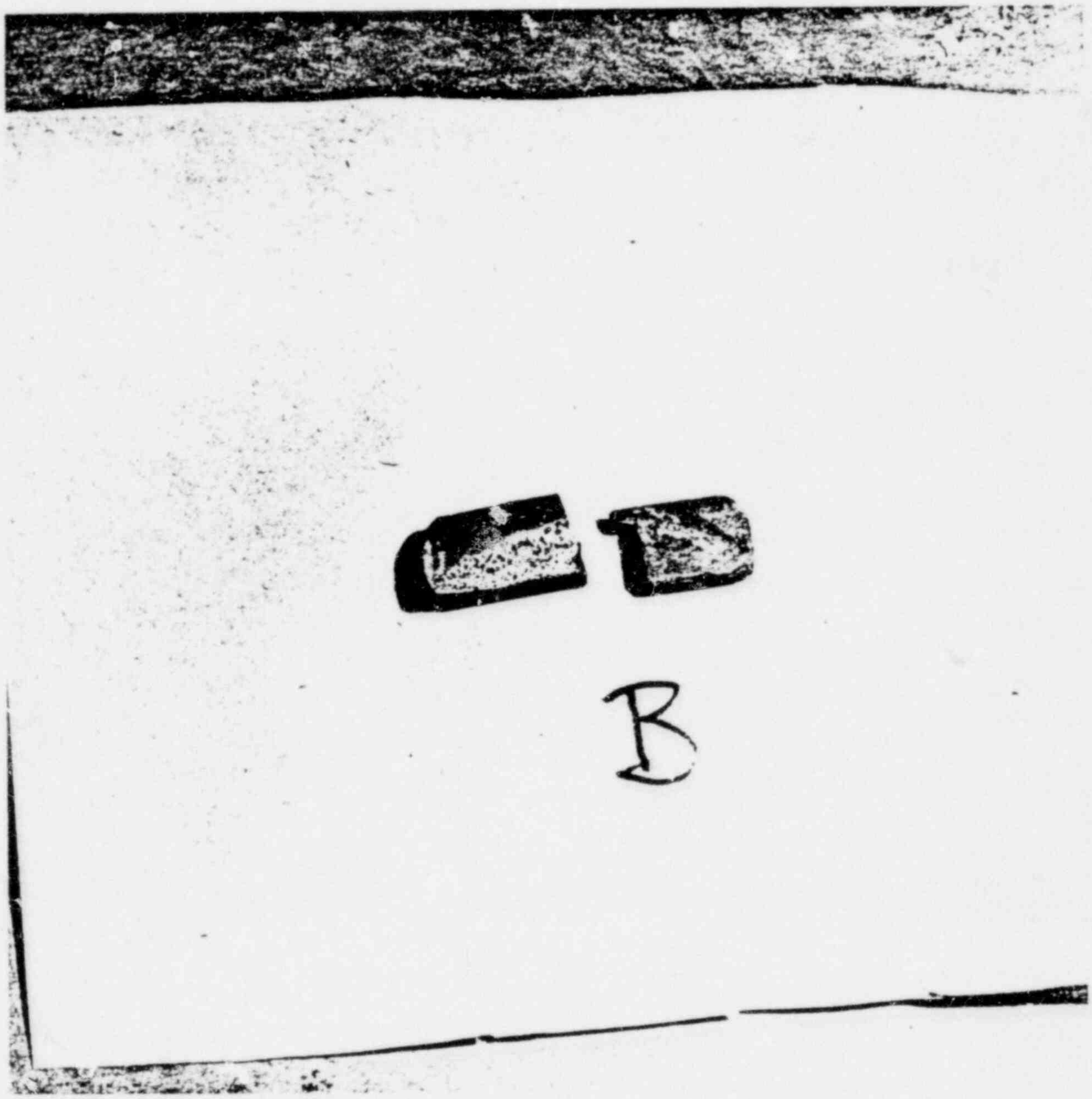
PHOTOGRAPH I-6

TEST SETUP STEAM IMPINGEMENT

A

PHOTOGRAPH I-8

POST-STEAM IMPINGEMENT




PHOTOGRAPH I-10

POST-STEAM IMPINGEMENT

APPENDIX III

INSTRUMENTATION EQUIPMENT SHEET

# SECTION II

# IMPACT TEST

1.0 REQUIREMENTS

Ship the Neutron Shielding Material to:

*Southern Research Institute
6220 Culebra Road
San Antonio, TX 78284

Attention: Mr. David K. Curtice

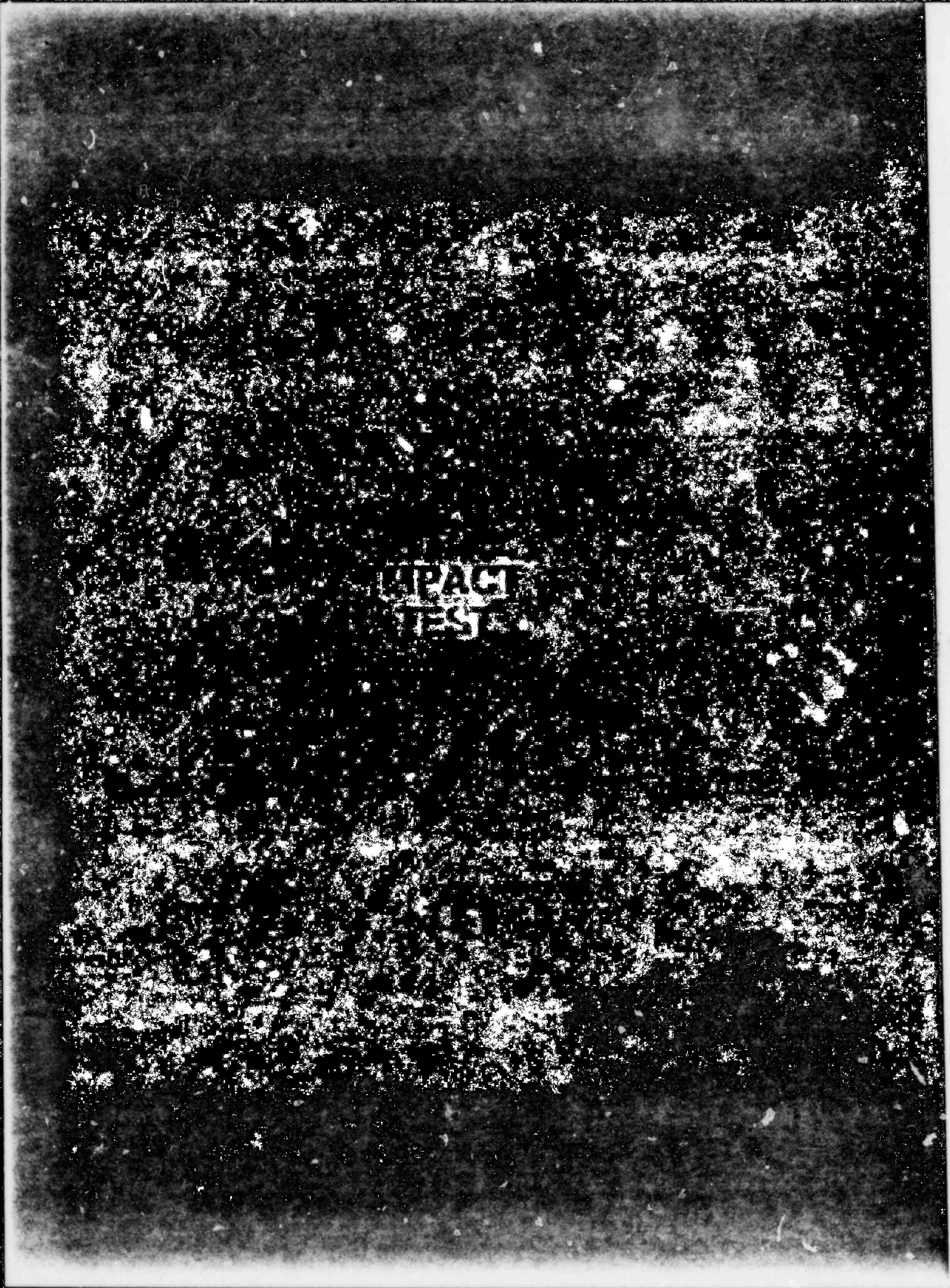
2.0 PROCEDURES

Upon receipt of*Southern Research Institute's Radioactive Material License, the specimens were properly prepared and shipped. *Southern Research completed the Impact Test and returned the specimens to Wyle Laboratories for completion of the test program.

3.0 RESULTS

The specimens were received as a powered and granular substance.

*Southwest Research Institute



# BORATED WATER SUBMERSION TEST

SECTION III

# BORATED WATER SUBMERSION TEST

## 1.0 REQUIREMENTS

The Borated Water Submersion Test shall consist of maintaining the specimens at 150°F for 30 days in a solution of 2000 to 2500 ppm of boron concentration. Solium hydroxide shall be used to adjust the pH between 7.0 and 9.0. Gas samples shall be taken at the 24th and 30th day of exposure and a chromatograph analysis performed to determine the hydrogen, methane and ethane gas contents.

## 2.0 PROCEDURES

The samples of shielding material were placed in separate containers and filled with the specified borated water to approximately 75% of the container volume, the remaining 25% being available for gas evolution sampling. The borated water was mixed 2000 to 2500 ppm boron concentrate sodium hydroxide (NaOH) was added to the solution which produced a room temperature pH of 7.5. Foreign substances were observed within the solution. These substances were removed as requested by the Chemtrol Technical Representative. The containers were sealed and a gas sampling line, containing a hand valve and pressure gauge, was attached. The containers were placed in an environmental chamber and the 150°F temperature was maintained for 30 days.

Gas samples were taken on the 24th and 30th day of exposure. No pressure developed within the containers, therefore, the samples were removed by evacuating 250 cc sample bottles to 15 inches of mercury. The gas was then drawn into the sample bottles.

A gas chromatograph was performed to determine hydrogen, methane and ethane gas contents.

## 3.0 RESULTS

The test specimens were subjected to the requirements as specified in Paragraph 1.0 and as described in Paragraph 2.0. One equipment problem occurred. It is described in Notice of Anomaly No. 1.

The gas chromatograph was performed by Southern Research Institute, Birmingham, Alabama.

Notice of Anomaly No. 1 is presented in Appendix I.

APPENDIX I

NOTICE OF ANOMALY

APPENDIX II

GAS CHROMATOGRAPH RESULTS AND

CERTIFICATION LETTER

# USE OF THIS REPORT AND INFORMATION CONTAINED THEREIN

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Report No.: Project 4587, Report 1
SORI-EAS-80-641

To: Wyle Laboratories
7800 Governors Drive West
Huntsville, Alabama 35807

Date: September 2, 1980

# APPENDIX III

## PHOTOGRAPHS

PHOTOGRAPH III-2

SAMPLE B IN SOLUTION

APPENDIX IV

INSTRUMENTATION EQUIPMENT SHEET