**NATIONAL TRANSPORTATION SAFETY BOARD**
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594


07/11/2022

MATERIALS LABORATORY REVIEW REPORT Report No. 022-052F

## A. ACCIDENT

| | | |
|---|---|---|
| Place | : | Oklaunion, Texas |
| Date | : | January 8, 2022 |
| Vehicle | : | BNSF Railway freight train/Ethanol tank car |
| NTSB No. | : | HMD22LR001 |
| Investigator | : | Paul Stancil<br>RPH-20 |

## B. REPORT REVIEWED

Engineering Systems Inc. (ESi) report "Thermal Testing of Polymeric Railcar Gasket"

## C. DETAILS OF THE EXAMINATION

ESi was contracted by the NTSB to evaluate the thermal response of the nitrile rubber gaskets used on the accident ethanol tank cars. Here is a summary of the findings. The complete report is attached to this report.

To determine if the different surface appearance observed on a thermally damaged gasket from an accident tank car (HMD22LR001-HAZ-004 taken from TILX731758 (line 65)) could be replicated in a lab environment under controlled thermal exposure, ESi evaluated sections of an exemplar gasket (HMD22LR001-HAZ-005 taken from TILX731779 (line 37)) at four different temperatures. Sections of the exemplar rubber gasket were cut, and each piece was placed in a ceramic crucible and exposed to a test temperature inside a ceramic lined furnace at four different temperatures: 250, 300, 350, and 400°C for 15 minutes.

The sample weight was measured before and after the thermal exposure to obtain additional information. Testing beyond 400°C was not done as at this temperature the rubber gasket material ignited in the furnace and was mostly consumed. The surface appearance of the accident gasket most closely resembled the surface appearance of the lab samples evaluated in the range of 250 to 350°C. The thermal exposure in the range of 250–300°C led to formation of micro-cracks on the surface, and as temperature increased to 350°C, tearing, separation of material between the network of cracks, and hardening of the rubber material appeared.

Nancy B McAtee
Fire and Explosion Specialist

# Thermal Testing of Polymeric Railcar Gasket

ESi Matter No: 90038

**Report Prepared For**

Nancy B McAtee
Fire and Explosion Specialist/RE-30
NTSB
490 L Efant Plaza East, SW
Washington DC, 20594

**Submitted by:**

[redacted]


Anand R. Shah, M.S., M.B.A., P.E.
Principal, Director of Polymeric, Composite & Non-Metallic Materials Practice
IL PE Expires: 11/30/2023


LICENSED PROFESSIONAL ENGINEER
ANAND R. SHAH, P.E.
062.058788
STATE OF ILLINOIS

June 24, 2022
Date

**Technical Review by:**

[redacted]


Joseph F. Grzetic
Senior Staff Consultant


June 24, 2022
Date




**Phone: 630-851-4566 | Fax: 630-851-4870 | Toll Free: 866-596-3994**

www.engsys.com

# Introduction

National Transportation Safety Board (NTSB) retained Engineering Systems Inc., (ESi) to perform laboratory scale thermal exposure testing and to document the subsequent surface appearance of a railcar manway rubber gasket material. The objective of this study was to develop a method to compare the appearance of the rubber gasket material after degradation due to thermal exposure with the appearance of a gasket (subject gasket) removed from the field after a fire incident involved in a derailment. The approach would provide a relative assessment of the temperatures the subject gasket experienced in the incident. Based on information provided, the subject gasket was from BNSF operated DOT 117J Tank Car from an incident that occurred on 1/8/2022 around Oklaunion, TX.

This report provides the summary of the work ESi performed for this engagement. ESi photo documented the subject gasket provided by NTSB. ESi also performed thermal exposure testing at 250 C, 300 C, 350 C, and 400 C. The appearance of the subject gasket when compared with the appearance of an exemplar gasket material exposed to the temperature range of 250-400 C suggests that the subject gasket most-likely experienced temperatures up to 350 C.

# Documentation of the Subject Gasket

The subject gasket is circular in shape, approximately 12 inches in diameter, comprised of a black rubber material. The width of the gasket is 1.000 inch, and the thickness of the gasket is approximately 0.250 inches. The overall appearance of the two sides of the gasket is shown in Figures 1 and 2 of Appendix A.

In order to discuss the surface appearance of the two sides of the gasket at varying locations around the gasket, ESi photo documented one side of the gasket with white paper below which had 12 equally spaced-out sections similar to a clock with 12 o'clock position at the top of the gasket. For symmetry, when the gasket was flipped to document the appearance of the opposite side, the gasket was photographed on a paper with numbers increasing in a counter-clock orientation to discuss the back side at the same arbitrary location as defined by ESi.

ESi did not find any product identification printed or any embossed lettering on the subject gasket surface. There is a portion of the gasket material between the 5 o'clock and 7 o'clock position that is missing and was not provided. There is evidence of greater thermal exposure of the gasket around the outer edges of the gasket. There is material fracture at various locations on the gasket with the most noticeable fracture at the 4 o'clock to 5 o'clock location as well as directly opposite at the 11 o'clock location.

The gasket material near the section where there is gasket material missing appears to have the most affected surface. The rubber gasket at this location (4 o'clock, Figure 1) is significantly cracked and exhibits alligator skin type of morphology. Figures 3-10 in Appendix A show the appearance of the surface condition of the subject gasket around the four quadrants of the gasket.

# Thermal Exposure of Exemplar Gasket

In order to determine if the different surface appearance observed on the subject gasket can be replicated in a lab environment under controlled thermal exposure, ESi tested sections of an exemplar gasket at four different temperatures. Four 2-inch-long pieces of the exemplar rubber gasket were cut, and each piece was placed in a ceramic crucible and exposed to a test temperature inside a ceramic lined furnace. The test duration was 15 minutes. The test temperatures were as follows: 250, 300, 350, and 400 degrees Celsius.

The sample weight was measured before and after the thermal exposure to obtain additional information. The photos provided in Appendix B show the appearance of the rubber gasket samples prior to testing and after the thermal exposure testing.

There was no need to conduct testing beyond 400 degrees Celsius as at this temperature the rubber gasket material was mostly consumed due to igniting in the furnace leaving black soot and char. The measurements of weight loss associated with each of the experiment conducted are reported in Table 1 below.

| **Sample** | ***Weight*** | |
|---|---|---|
| **Description** | **Loss (%)** | **% Remains** |
| **250 Deg. C** | 1.24 | 98.76 |
| **300 Deg. C** | 2.67 | 97.33 |
| **350 Deg. C** | 25.55 | 74.45 |
| **400 Deg. C** | 52.98 | 47.02 |

**Table 1: Weight loss associated with thermal exposure testing.**

The photos after the thermal exposure testing showing the surface appearance of the lab samples tested in the range of 250 to 350 degrees Celsius show a surface that is comparatively similar to the different locations of the subject gasket material. The thermal exposure in the range of 250–300-degrees Celsius leads to formation of micro-cracks on the surface, and as temperature increases to 350, there is evidence of tearing, separation of material between the network of cracks, and hardening of the rubber material. Above 350 degrees Celsius, the rubber material ignited and formed very fragile char that broke easily.

The testing conducted is a valuable method in the determination of the thermal exposure of rubber gasket materials in service.

**<<< End of Report Text >>>**

## Appendices

Appendix A- Gasket Collage Front and Back

Appendix B- Testing at 250 C, 300 C, 350 C, 400 C

# APPENDIX A

Gasket Collage Front

Gasket Collage Back


Figure 1


Figure 2


Figure 3. Front quadrant close up between 12 & 3 o'clock


Figure 4. Front quadrant between 3 & 6 o'clock

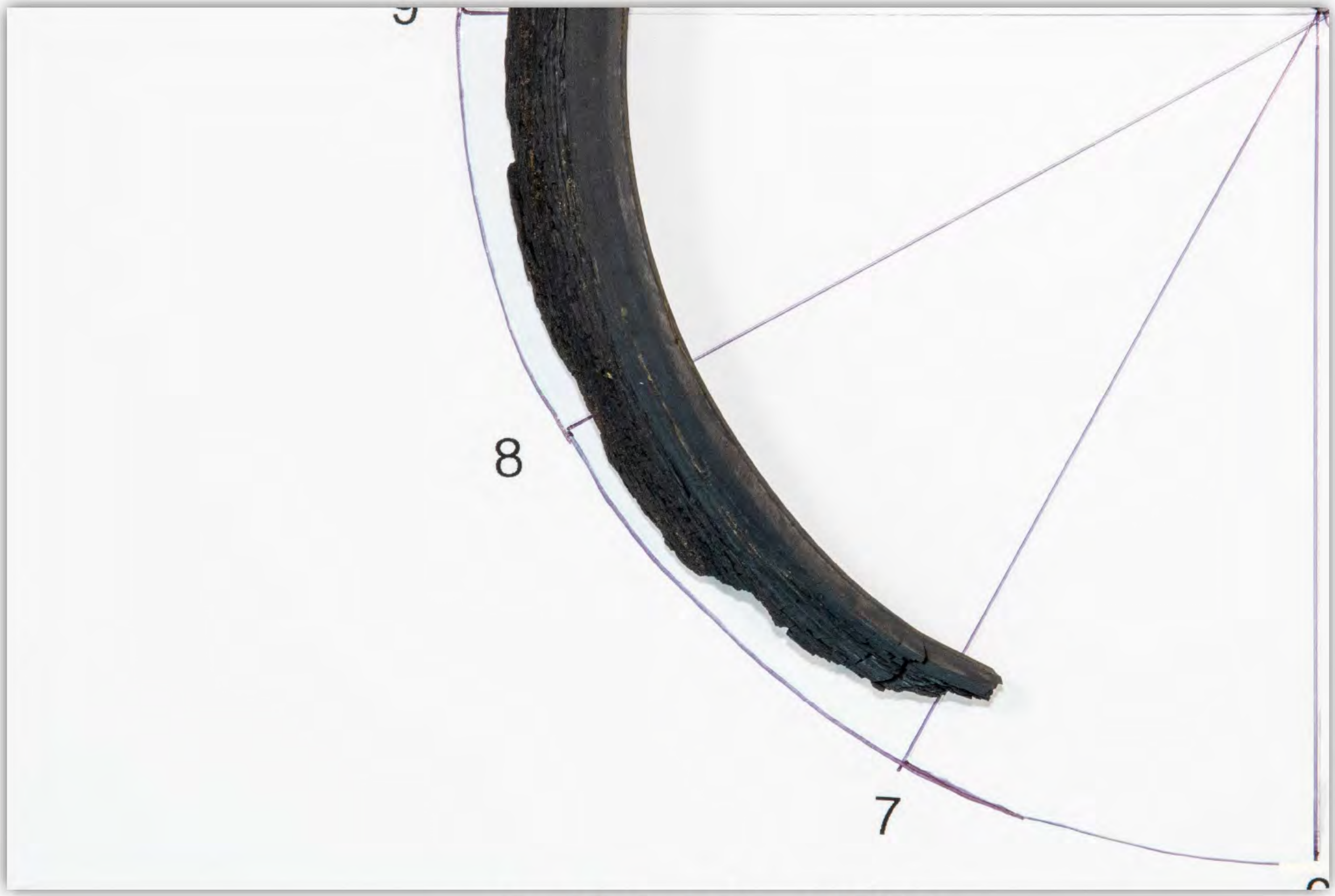



Figure 5. Front quadrant between 6 & 9 o'clock


Figure 6. Front quadrant between 9 & 12 o'clock


Figure 8. Backside quadrant between 12& 3 o'clock

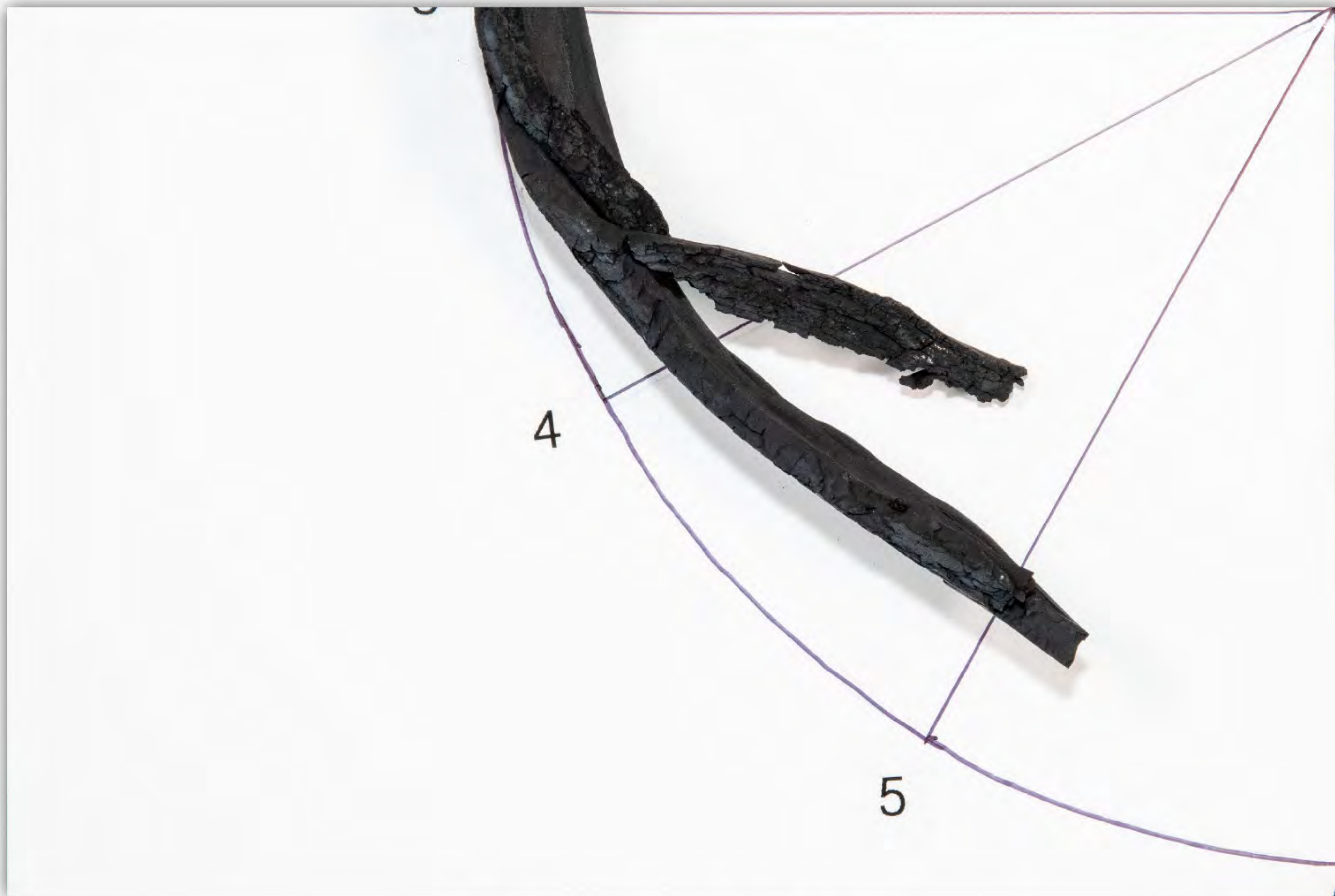



Figure 9. Backside quadrant between 3 & 6 o'clock

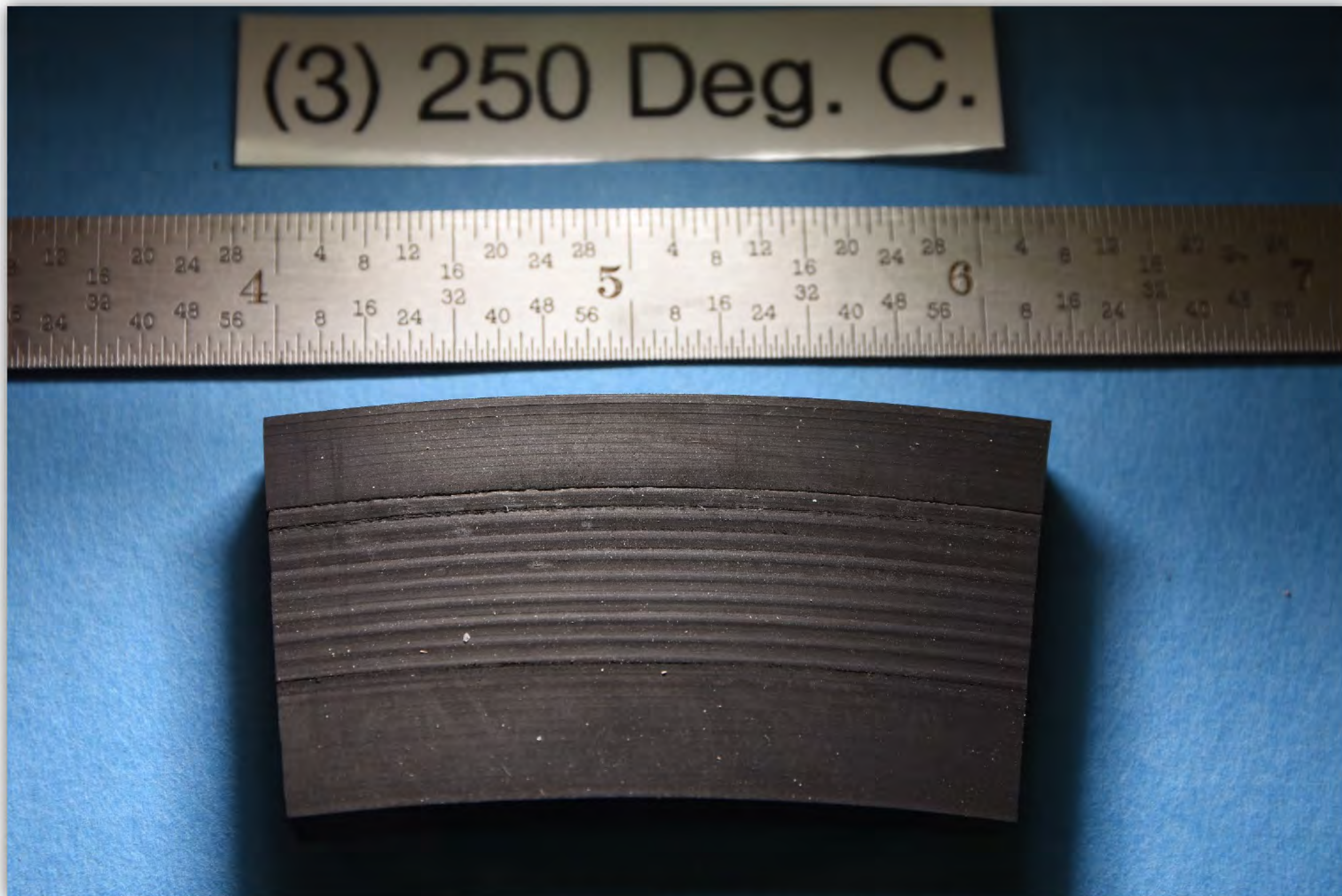

Figure 10. Backside quadrant between 6 & 9 o'clock


Figure 7. Backside quadrant between 9 & 12 o'clock

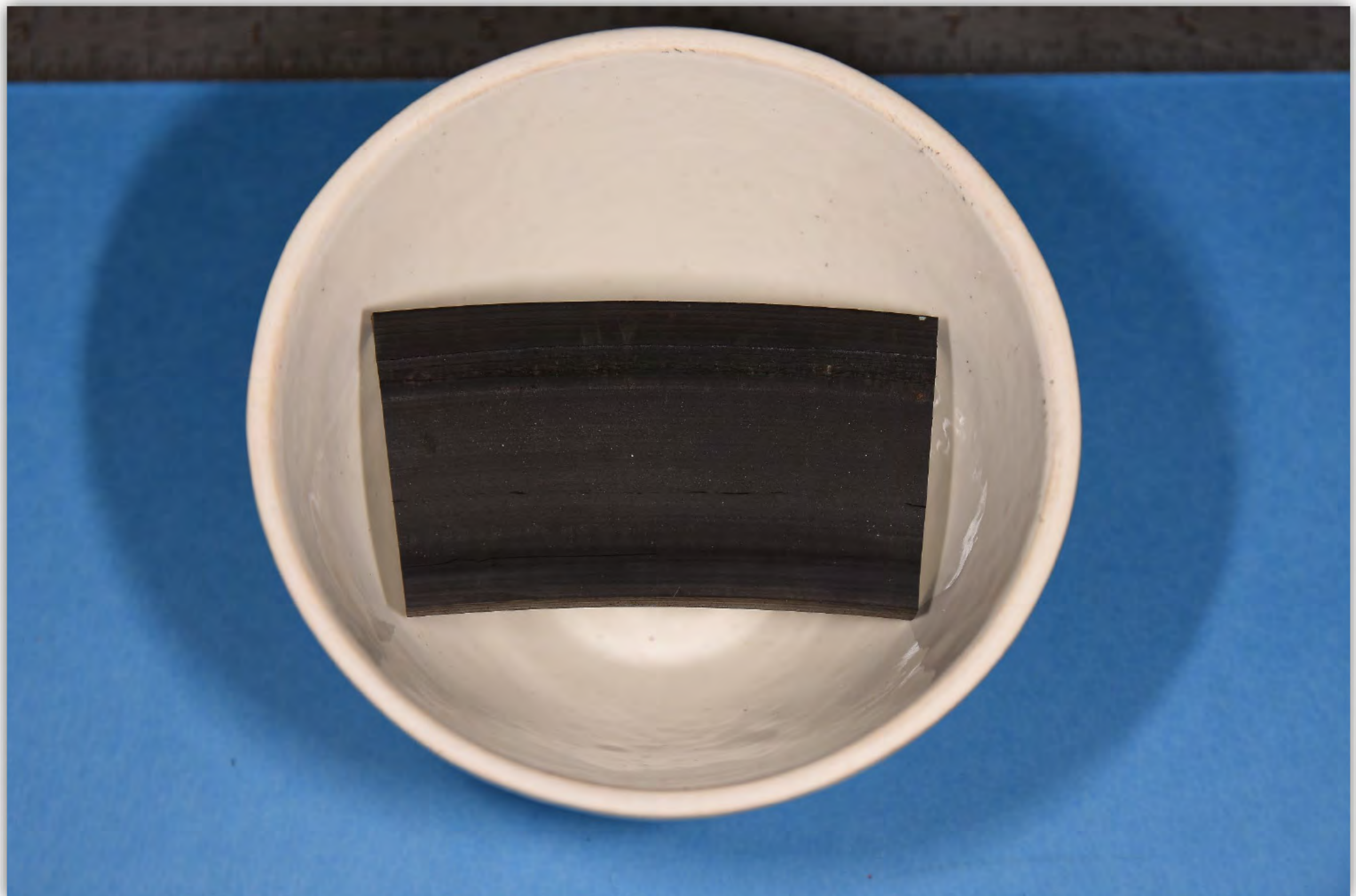
# APPENDIX B

**Testing at 250 C, 300 C, 350 C, 400 C**

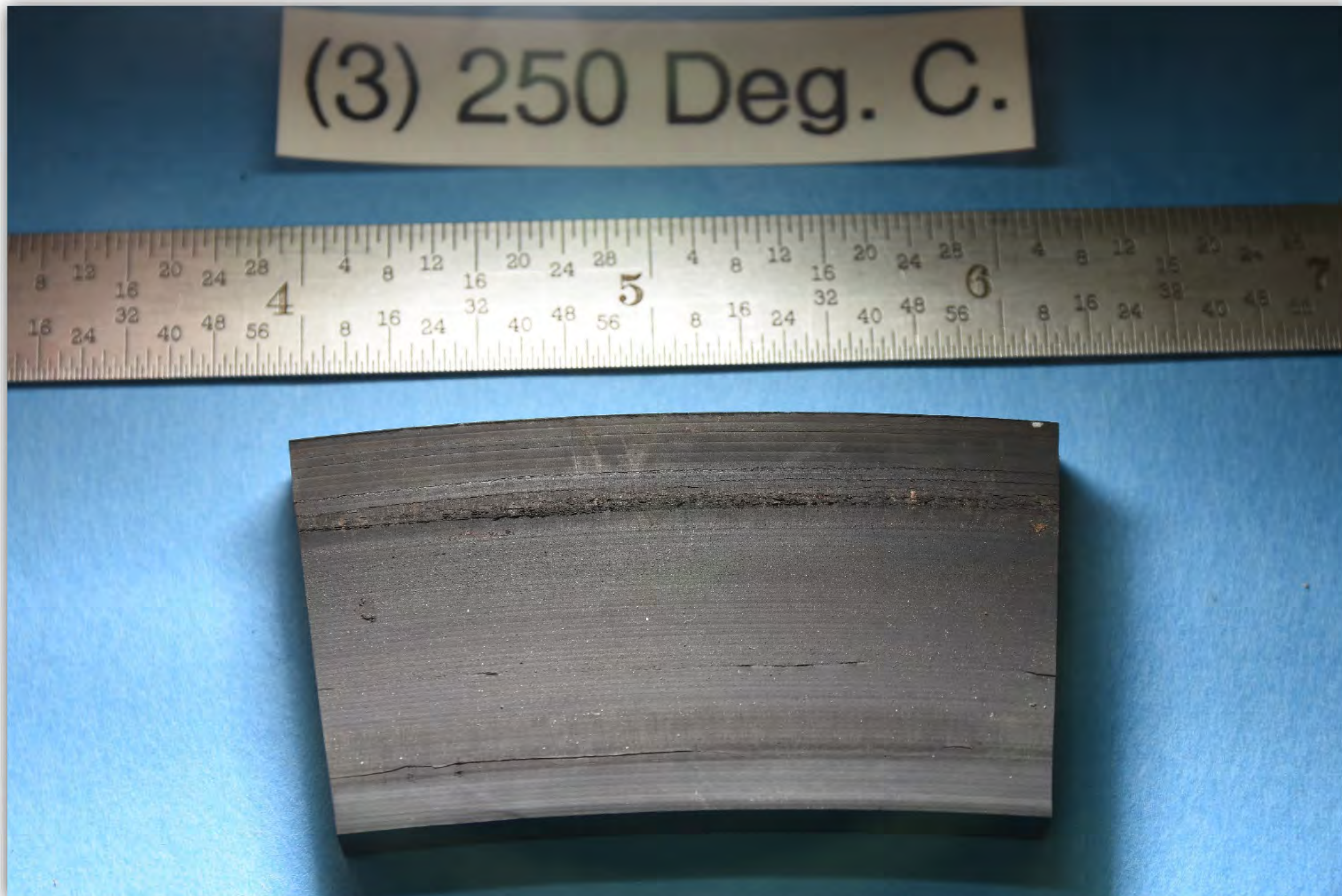

Testing at 250 degrees Celsius front side as received.



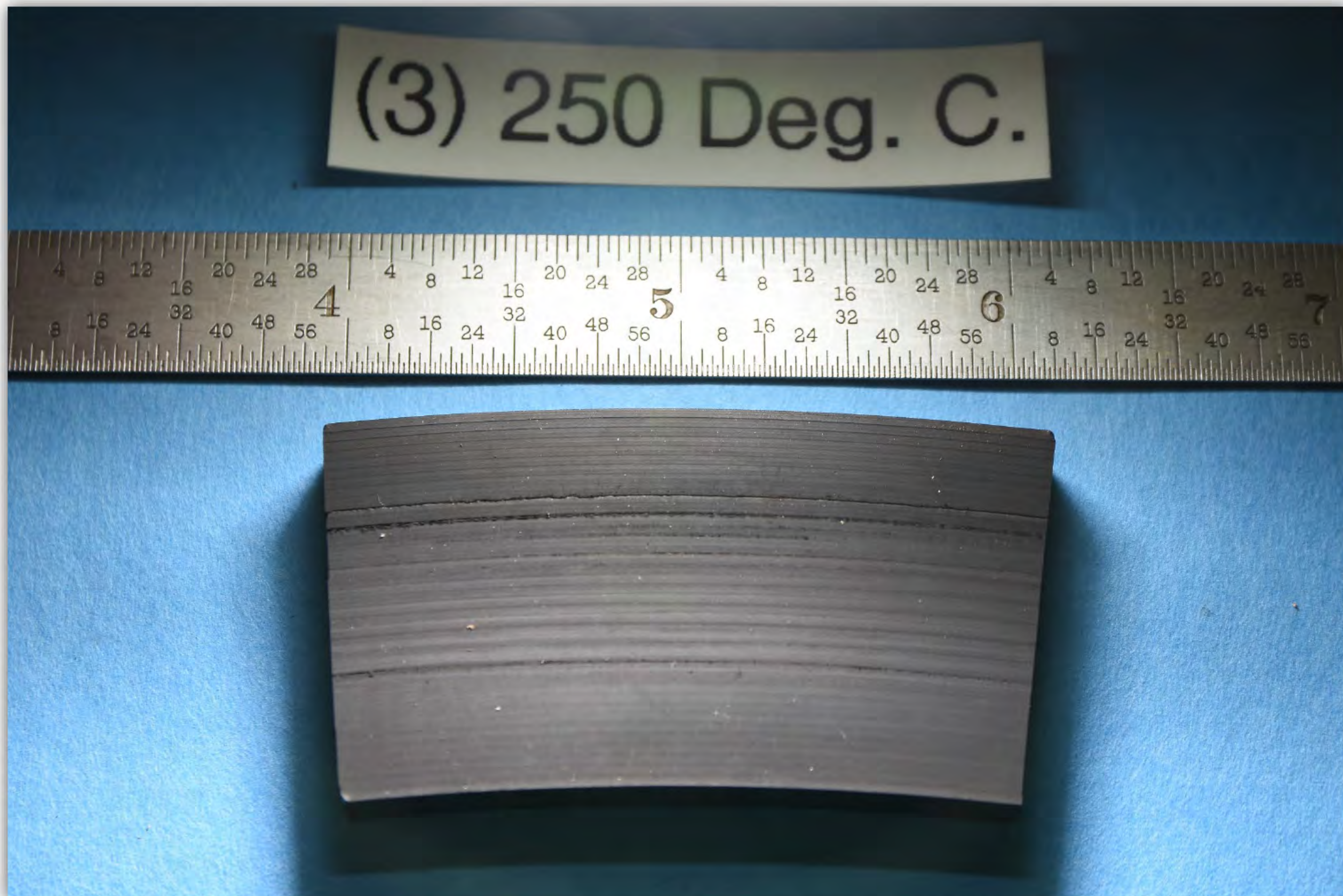

Testing at 250 degrees Celsius back side as received



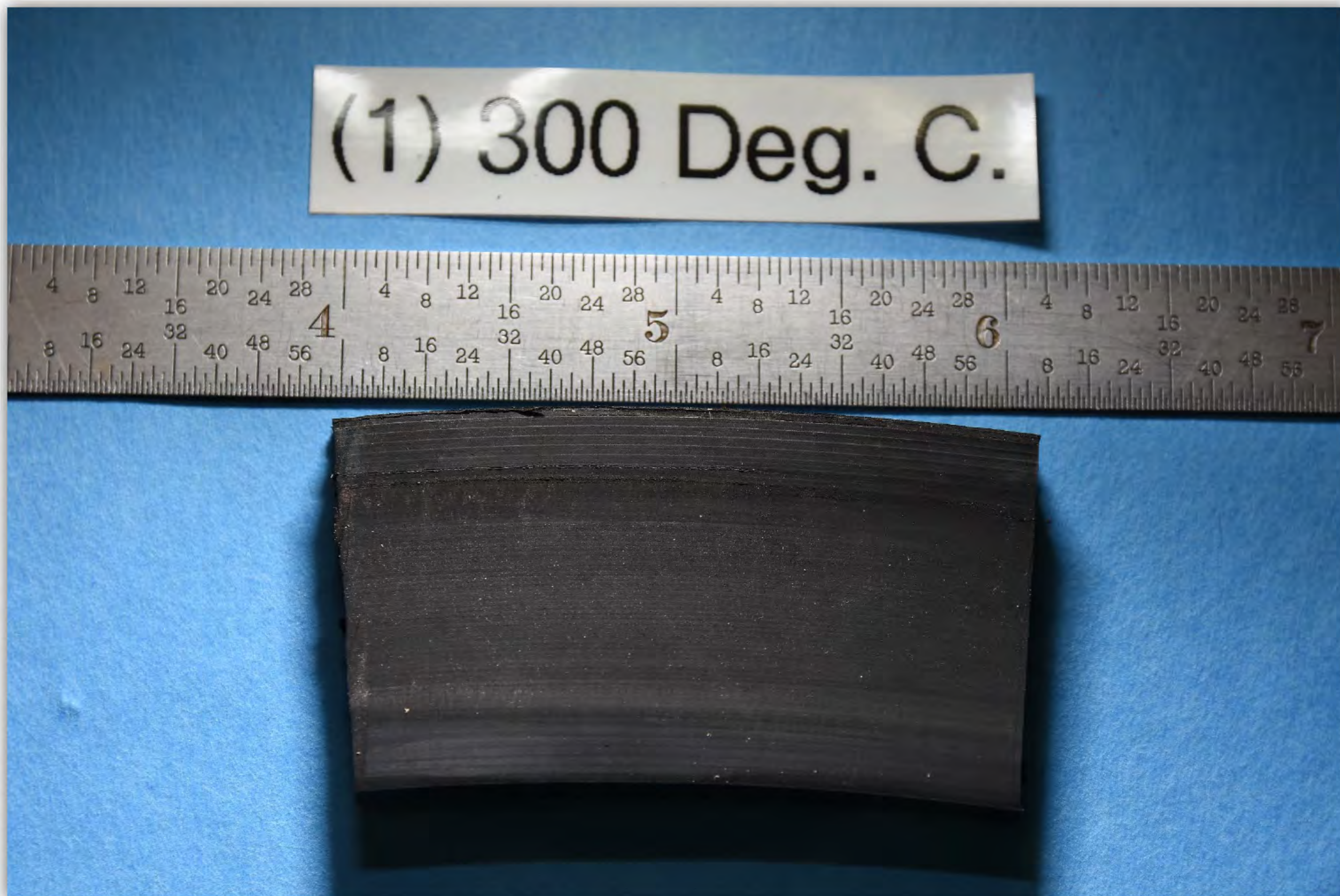
Testing at 250 degrees Celsius




Testing at 250 degrees Celsius front side burn tested

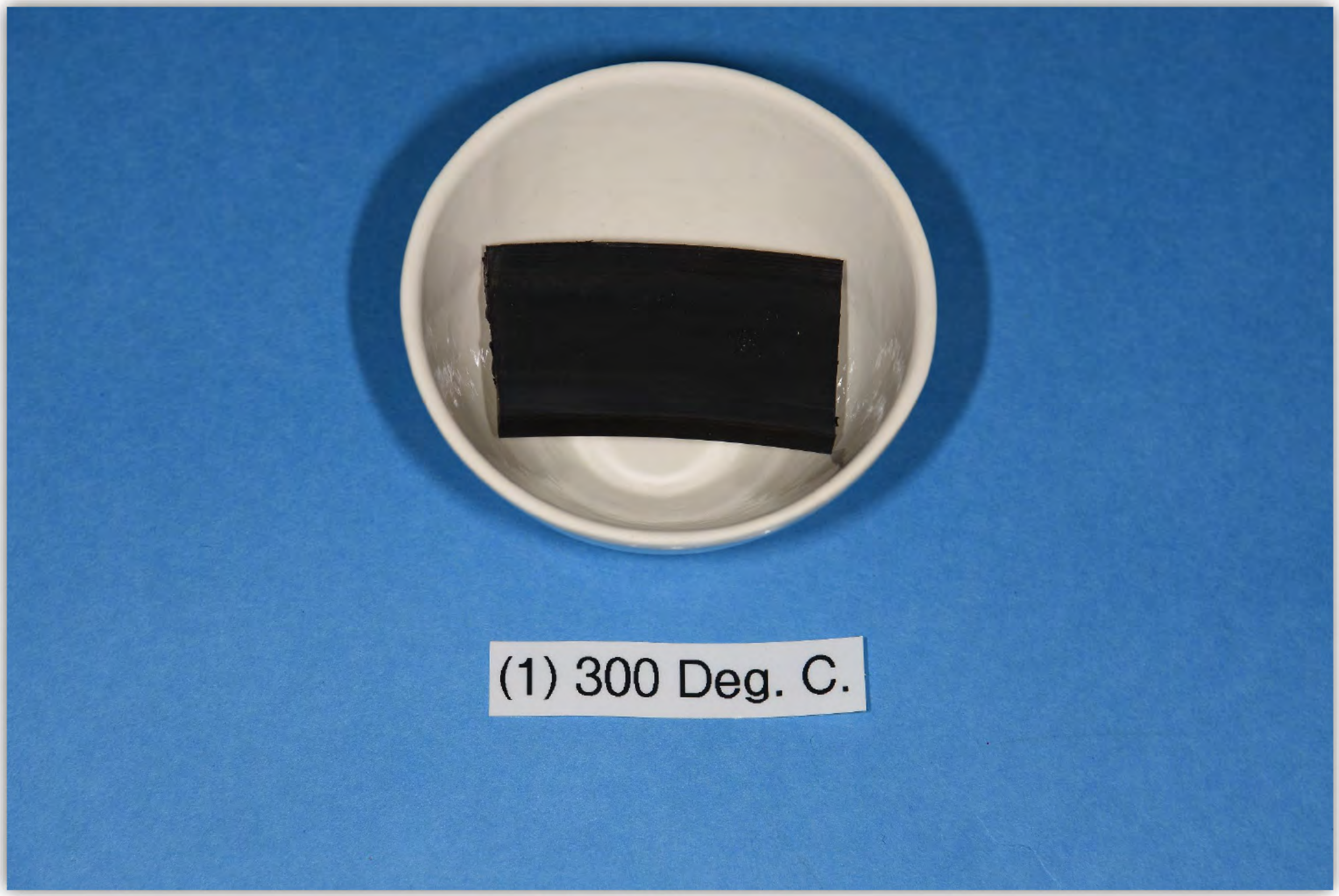



Testing at 250 degrees Celsius back side burn tested




Testing at 300 degree Celsius front side as received


Testing at 300 degree Celsius back side as received

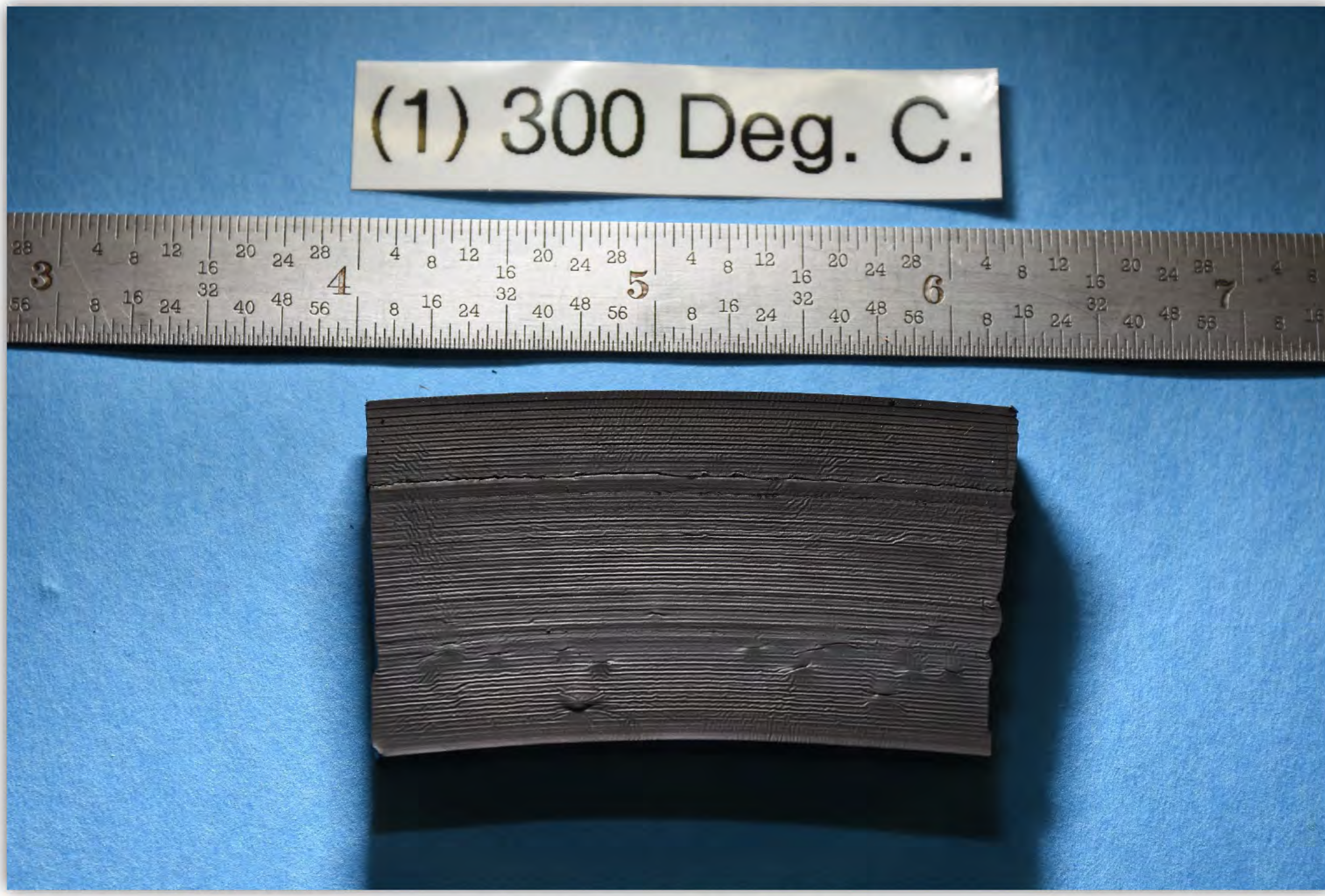



Testing at 300 degrees Celsius

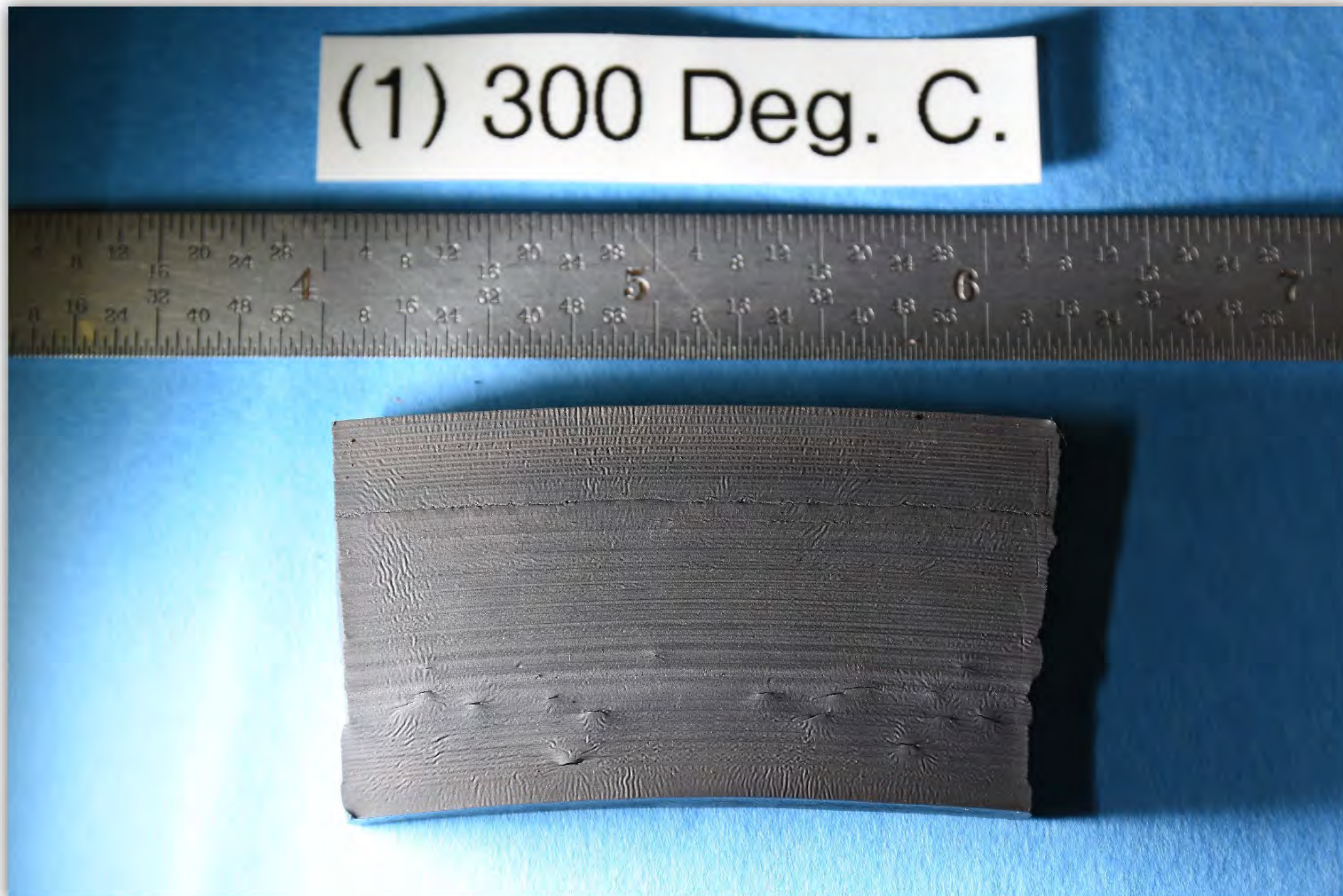

300 degrees Celsius front side burn tested

300 degrees Celsius front side burn tested

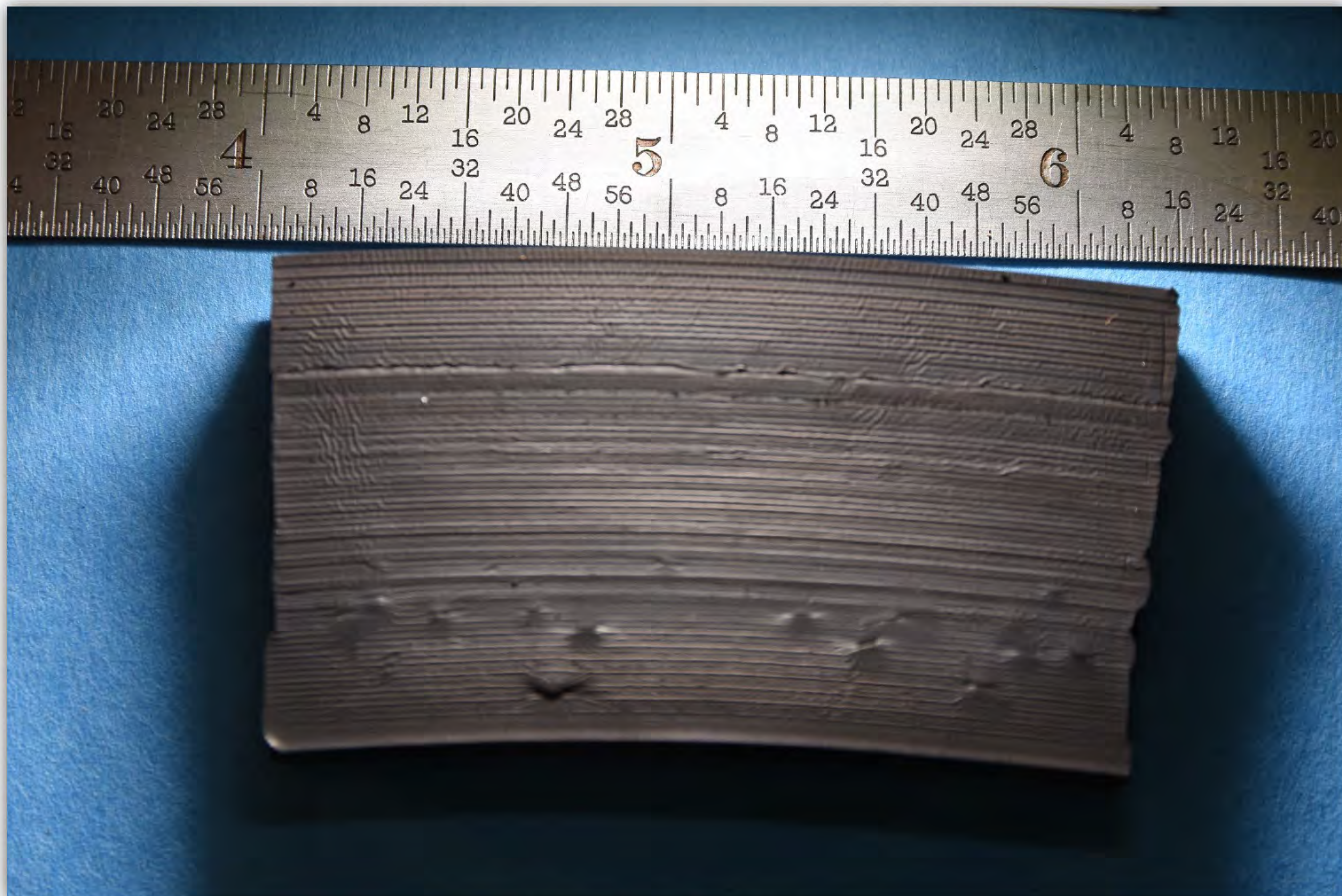

300 degrees Celsius front side burn tested



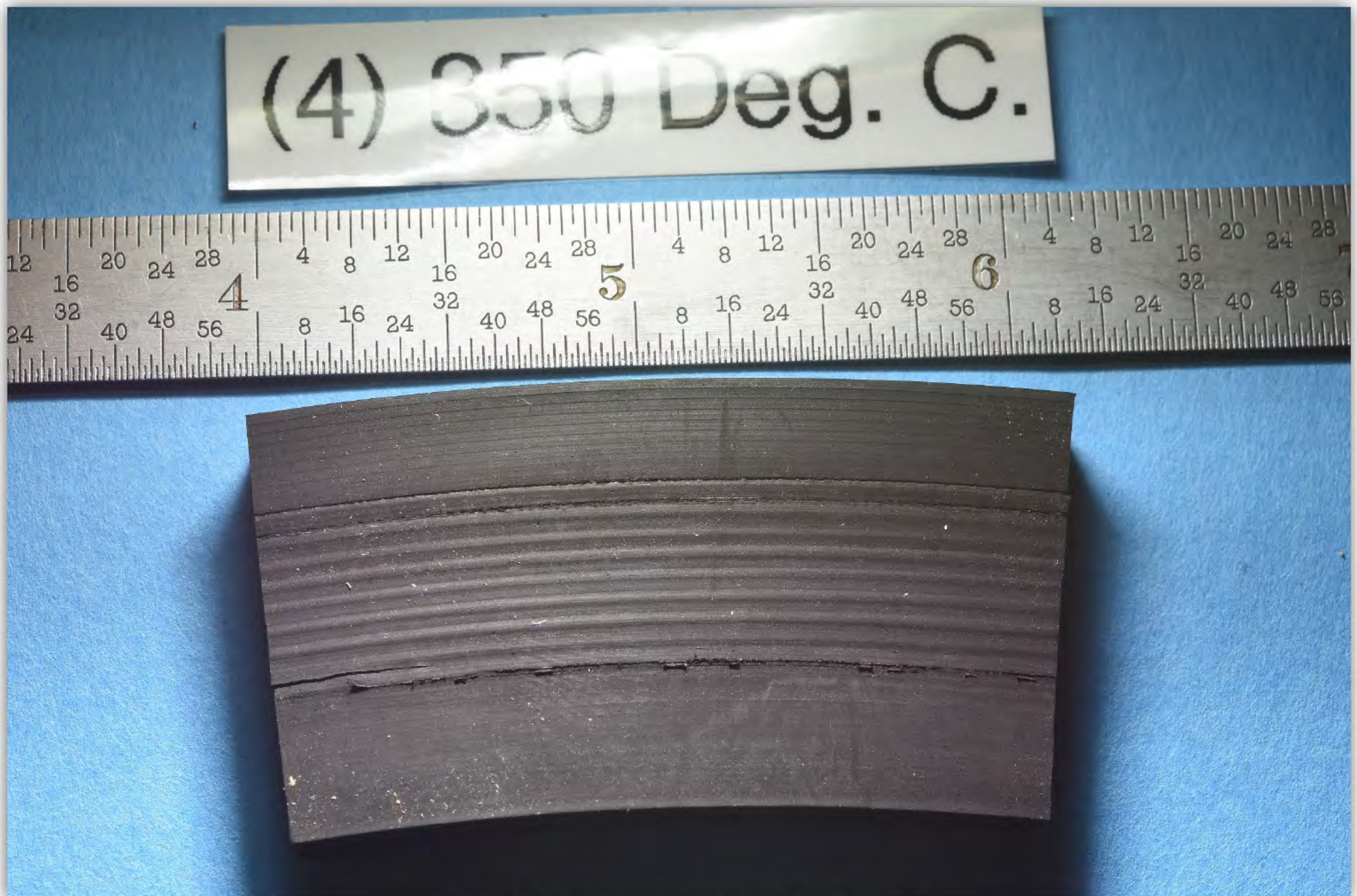

300 degrees Celsius back side burn tested




300 degrees Celsius back side burn tested



Testing at 300 degrees Celsius




Testing at 350 degrees Celsius back side as received


Testing at 350 degrees Celsius

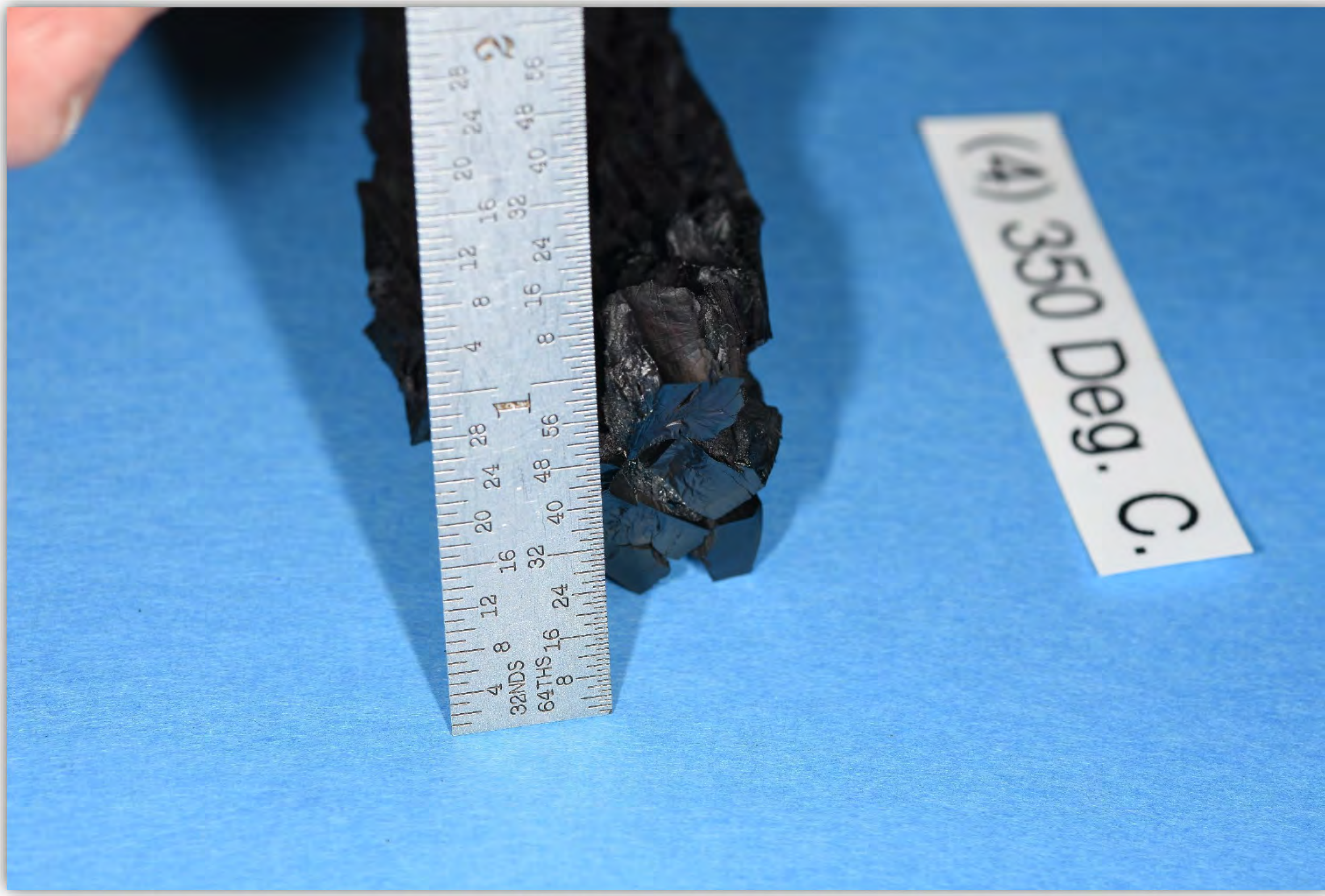

350 degrees Celsius burn tested

350 degrees Celsius burn tested

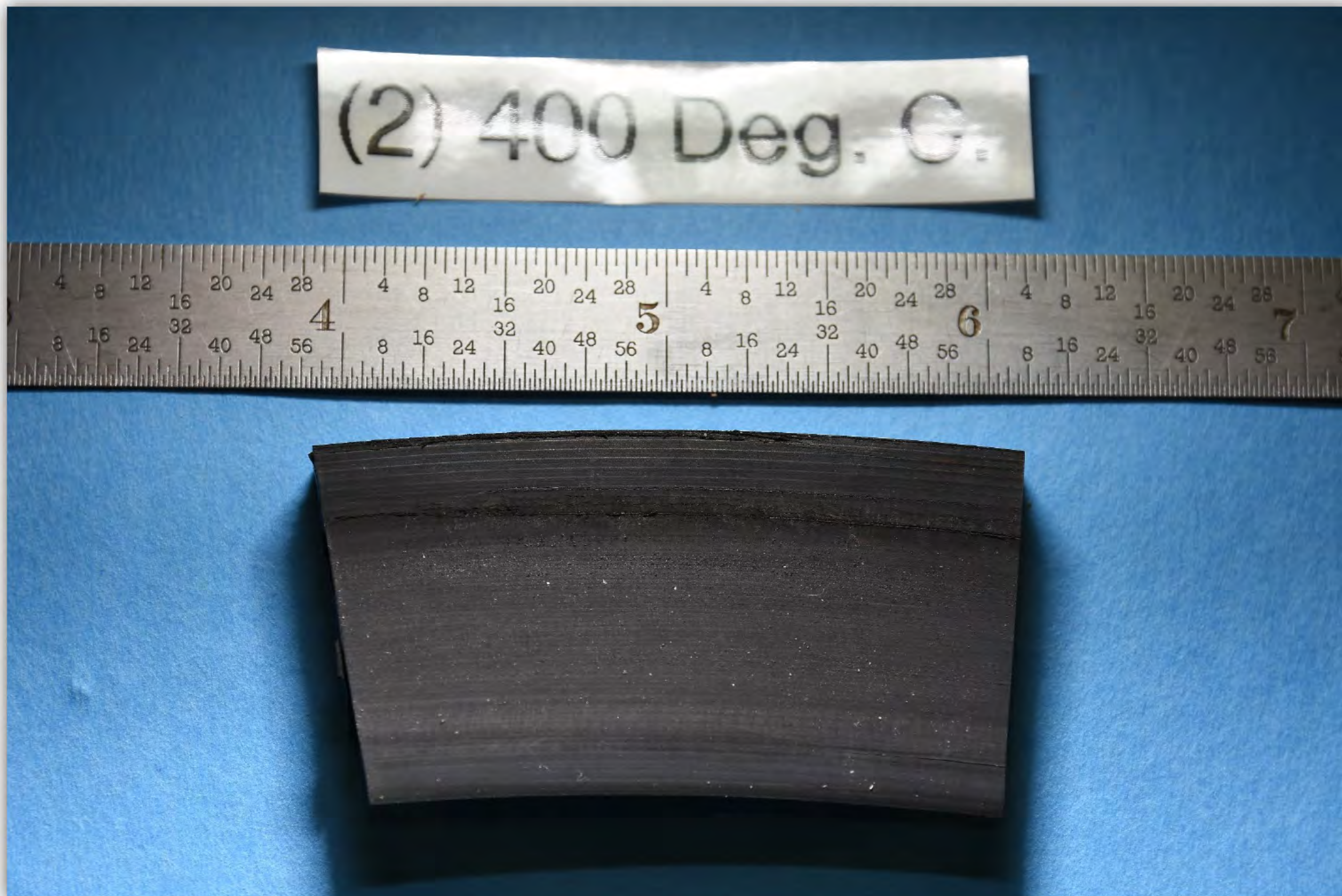

350 degrees Celsius burn tested

350 degrees Celsius burn tested

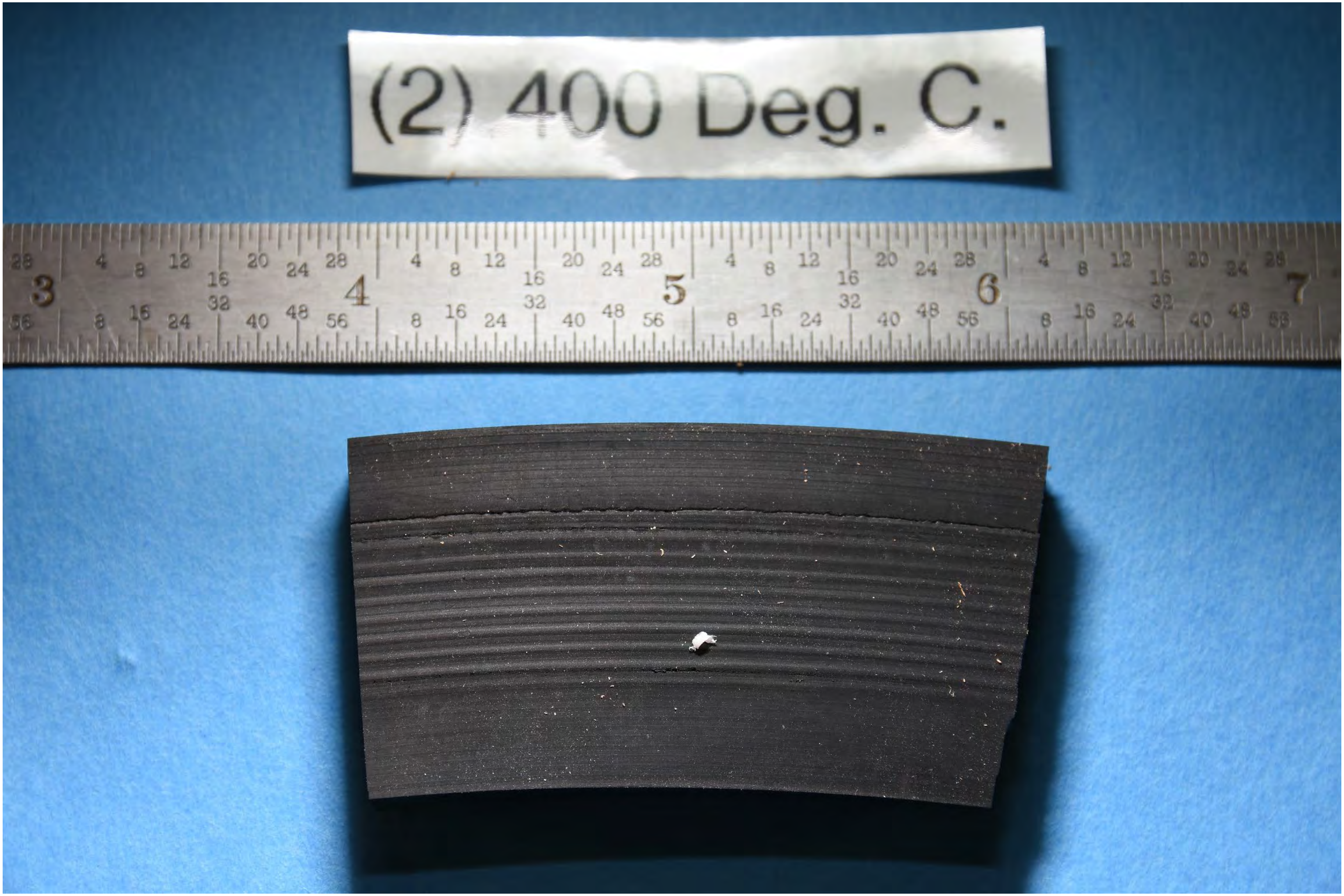

350 degrees Celsius burn tested



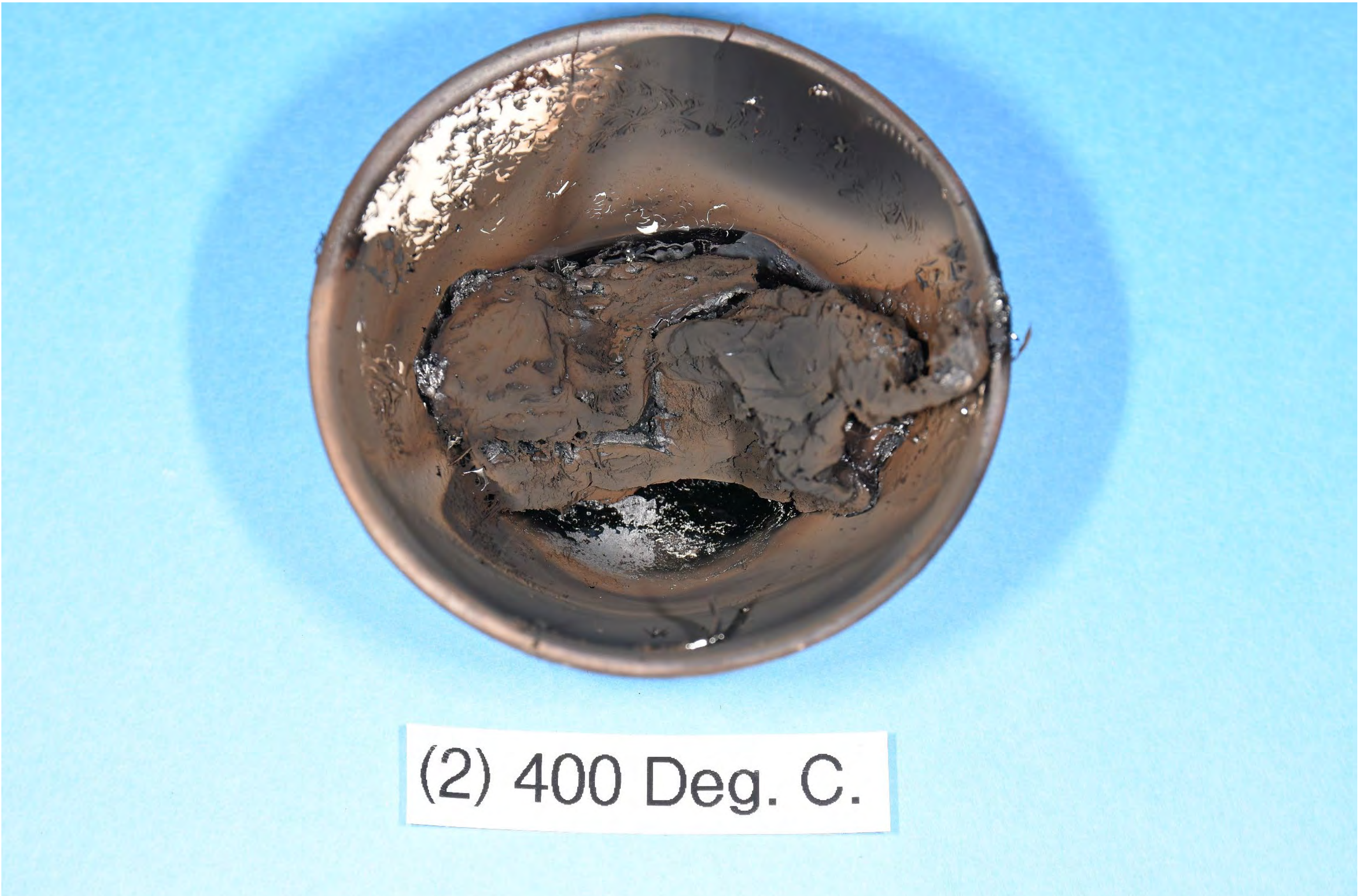

350 degrees Celsius burn tested




Testing at 400 degrees Celsius front side as received




Testing at 400 degrees Celsius back side as received




400 degrees Celsius burn tested

400 degrees Celsius burn tested