Safety
Management
Services, Inc.

Hazco Environmental Services
A Division of CCS Income Trust
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October 22, 2007
SMS-1433-R1.1

Attention: Mr. Robert Mann

Subject: Results of Thermal Testing on Sodium chlorate, Sulfur, and Oat Flour.

Reference: DM Leahy & Associates. 2007. Volume IIA, Section 2: Climate and Air Quality, Bruderheim Sulphur Forming and Shipping Facility Environmental Impact Assessment. Prepared for Alberta Sulphur Terminals Ltd., Calgary, Alberta.

From: Kirt N. Sasser

1 INTRODUCTION

Hazco Environmental Services retained Safety Management Service, Inc. (SMS) to perform a series of reaction tests between chlorate and sulphur, and chlorate and oat flour. The testing was completed to investigate questions raised by the operator of the chlorate plant, Canexus, who were concerned that chlorate, which is a strong oxidizer, could react violently with sulphur, which can oxidize exothermically to form sulphur dioxide. Canexus operates a sodium chlorate plant that is located adjacent to the proposed Bruderheim sulphur forming and shipping facility.

The objective of the testing was to quantify the reaction potential between chlorate and sulphur. A parallel suite of tests was completed using oat flour and chlorate to provide perspective to the sulphur/chlorate testing. Oats are a common agricultural crop in the area, and may be oxidized exothermically.

The following tests were completed in SMS's Utah testing facility in this regard:
- Ramped Simulated Bulk Auto-ignition Temperature (SBAT);
- Modified Taliani; and
- Small-Scale Burn Test.

A suite of ramped Accelerated Rate Calorimeter (ARC) tests were originally planned; however, these tests were not completed because the results of the SBAT tests were considered sufficient to evaluate the auto-ignition properties of the individual substances and mixtures. The ARC test results would be expected to mirror the results of the SBAT tests.

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This letter describes the objectives and methodology of each of these tests, the testing suite that was completed, the results of the testing, and provides interpretations and conclusions for the battery of tests that were completed.

2 TESTING PROGRAM AND METHODOLOGIES

2.1 Testing Program

SBAT, Modified Taliani, and Small-Scale Burn Test tests were performed on the following samples:

- sodium chlorate;
- sulphur; sodium chlorate (99.998%) with sulphur (0.002%) by weight percent;
- sodium chlorate (99.998%) with oat flour (0.002%) by weight percent;
- sodium chlorate (90%) with sulphur (10%) by weight percent; and
- sodium chlorate (90%) with oat flour (10%) by weight percent.

The 0.002% sulphur/99.998% sodium chlorate mixture represents the anticipated mixture proportions resulting from the Maximum Yearly Cumulative Deposition of elemental sulphur over a 5 year period as reported by DM Leahey & Associates (2007). This is considered appropriate because the potential contact pathway between sulphur and sodium chlorate is through deposition of fugitive sulphur dust emanating from the sulphur forming and shipping facilities and depositing on the chlorate facility. The 10% sulphur/ 90% sodium chlorate mixtures were chosen to represent much higher mixtures rations.

Oat flour was used as a surrogate to represent organic matter associated with harvesting of crops in the area. Because farming is prevalent, this battery of tests is expected to provide reasonable estimation of the background risk associated with the sodium chlorate manufacturing operations.

2.2 Sample Preparation

Sodium chlorate crystals from the Bruderheim facility were provided by Hazco, who in turn received these crystals from Canexus. SMS purchased elemental sulphur and oat flour samples. The sodium chlorate/ sulphur and oat flour samples were prepared by weighing appropriate proportions of dry samples of each of these constituents and then mixing the samples together by hand. For the 0.002% samples, 249.995 grams of sodium chlorate was mixed with 0.005 grams of either sulphur or oat flour. For the 10% samples, 225 grams of sodium chlorate was mixed with 25 grams of either sulphur or oat flour.

2.3 Ramped Simulated Bulk Auto-ignition Temperature (SBAT) Test

The Simulated Bulk Auto-Ignition Temperature (SBAT) test is a modern method for determining the critical temperature for auto-ignition of a substance or mixture. This apparatus utilizes a 2 - 5 gram sample and a heavily insulated sample holder to accurately simulate the ignition behavior of a bulk material sample or mixture in response to increasing temperature. The SBAT test consists of increasing a sample's temperature by 24°F per hour, and observing the sample's response to increasing temperature.

This test is started by allowing the SBAT apparatus to come to equilibrium with the ambient room temperature. Next, a 2 - 5 gram sample is placed inside the heavily insulated sample holder of the apparatus. The temperature of the sample within this apparatus is monitored relative to the temperature of a reference sample using thermocouple sensors. The sample is withdrawn from the apparatus after either; a) an ignition has occurred, or b) the sample has shown insignificant activity over a specified time period.

2.4 Modified Taliani Test

This test establishes the stability of a material by measuring the rise in pressure in a closed, inert atmosphere system at 93.3°C (200°F) over a 23 hour period. A pressure rise more than 200 mm Hg indicates instability. Reactions such as burning, frothing, or other reactions can be observed and may indicate instability or incompatibility. Trials are run in duplicate and the pressure rise averaged.

2.5 Small-Scale Burn Test

This test is used to determine if samples, once ignited, continue burning or transit to an explosion or detonation. The results of the test help establish the unconfined burning properties of the exothermic reaction of the mixed materials. A 100 gram sample is placed on a bed of sawdust soaked with kerosene or diesel fuel approximately 30 cm square and 1.3-2.5 cm thick. The sawdust is ignited with an electric match or similar device and the burn time is measured. The test is performed two times unless an explosion or detonation occurs on the first test.

3 TEST RESULTS AND DISCUSSION

Results of all tests are summarized in Table 1. The underlying sub-sections provide descriptions of the results of each of the test groups.

3.1. Ramped Simulated Bulk Auto-ignition Temperature (SBAT) Test

The six samples were heated from 38°C (100°F) to 260°C (500°F) in the SBAT apparatus, increasing the temperature 13.3°C (24°F) per hour for 17 hours (see Appendix Figures A1 – A6). The following observations and/or results were observed.

- No reaction was observed for the sodium chlorate, sulphur, and the sodium chlorate/oat flour samples (Samples 1, 2, & 4).
- For the sodium chlorate/sulphur (99.998%/0.002%) sample (Sample 3), there was a small exotherm at 218°F of approximately 10°F (Figure A3).
- The 90/10 sodium chlorate/sulphur and sodium chlorate/oat flour samples (Samples 5 & 6) showed significant exotherms of 211°F and 370°F, respectively. The exothermic decomposition did not result in ignition of the 90/10 sodium chlorate/sulphur sample. The sodium chlorate/oat flour sample ignited and burned.

The bulk decomposition temperatures for the sodium chlorate, sulphur, and the sodium chlorate/oat flour mixture in the predicted proportions (99.998%/0.002%) are greater than 500°F. There is no predicted reaction hazard for these samples for temperatures below 500°F.

For the sodium chlorate/sulphur mixture in the predicted proportions (99.998%/0.002%), the reaction hazard is a small exothermic decomposition, but no burning or rapid reaction, at temperatures of approximately 200°F.

The mixtures of high proportions of sulphur and oat flour showed significant exothermic reactions giving decomposition temperatures of 211°F and 325°F, respectively. The mixture of sulphur and sodium chlorate did not ignite but the mixture of oat flour and sodium chlorate did ignite.

3.2. Modified Taliani Test

The sodium chlorate and sulphur samples (Samples 1 & 2) were tested first to determine the baseline. The average pressure rise for the chlorate and sulphur samples was 5.5 and 4.5 mm Hg, respectively. No reactions were observed.

Similarly the sodium chlorate/oat flour mixture (99.998%/0.002%) had an average pressure rise of 13 mm Hg and no reactions were observed.

The sodium chlorate/sulphur sample (99.998%/0.002%) showed an average pressure rise of 858.5 mm Hg exceeding the 200 mm Hg limit, indicating instability. This value corresponds very closely the SBAT test data which indicated showing an exothermic response around 200°F. Consistent with the results of the SBAT test for this sample, no reactions were observed.

The Modified Taliani Test was not performed on the additional Samples 5 & 6 as the thermal trends for these samples were anticipated to mirror the SBAT as established by the modified Taliani tests for Samples 1-4.

Based on the results of the Modified Taliani, the predicted mixture of sodium chlorate and sulphur becomes unstable at approximately 200°F. However, from the results of the SBAT tests, the exothermic response for this mixture, at this temperature is relatively low and does not result in combustion or potentially violent reaction.

3.3. Small-Scale Burn Test

No explosions were observed in any of the trials. The results of the individual tests are summarized as follows.

- The sodium chlorate sample ignited and burned for 28 seconds with a bright producing a 6-inch flame. All the sodium chlorate samples ignited and burned for approximately 20-30 seconds.
- The pure sulphur sample melted and burned over a 4 minute period with no visual flame above that of the burning sawdust.
- The 99.998/0.002 sodium chlorate/sulphur and sodium chlorate/oat flour samples ignited and burned for approximately 20 seconds producing a bright, 6-inch flame.
- The 90/10 sodium chlorate/sulphur and sodium chlorate/oat flour samples ignited and burned for approximately 15 seconds producing a bright, 16-inch flame

No explosions were observed for any of these tests. The test results indicate that sodium chlorate samples burn the fastest. The addition of oat flour and sulphur results in faster burning, and the addition of both samples provide comparable effects.

4 CONCLUSIONS

The test results suggest that the risks associated with the presence of fugitive sulphur dust in the vicinity of the Canexus chlorate plant are similar to the risks associated with the presence of crop dust, assuming that these materials are present in similar proportions.

Mixtures of 99.998% sodium chlorate to 0.002% sulphur, as predicted by DM Leahey & Associates, can generate a small exothermic response of less than 10°F at a temperature of approximately 200°F. This small exothermic response is not considered to be an explosive hazard and occurs at a temperature well above the expected ambient air temperature of the area.

Stronger exothermic responses are associated with the mixtures of 90% sodium chlorate with 10% oat flour or sulphur. Again, these mixtures are not expected to present an explosive hazard, and the exothermic responses occurred at temperatures well above expected ambient temperatures.

Based on the results of these tests, there is an optimum ration of sodium chlorate to sulphur or oat flour that would create a potentially explosive mixture. Mixtures of 70% sodium chlorate and 30% sulphur or oat flour are potentially explosive.

APPENDIX

SBAT Plots

Figure A1: SBAT for Sodium Chlorate Sample

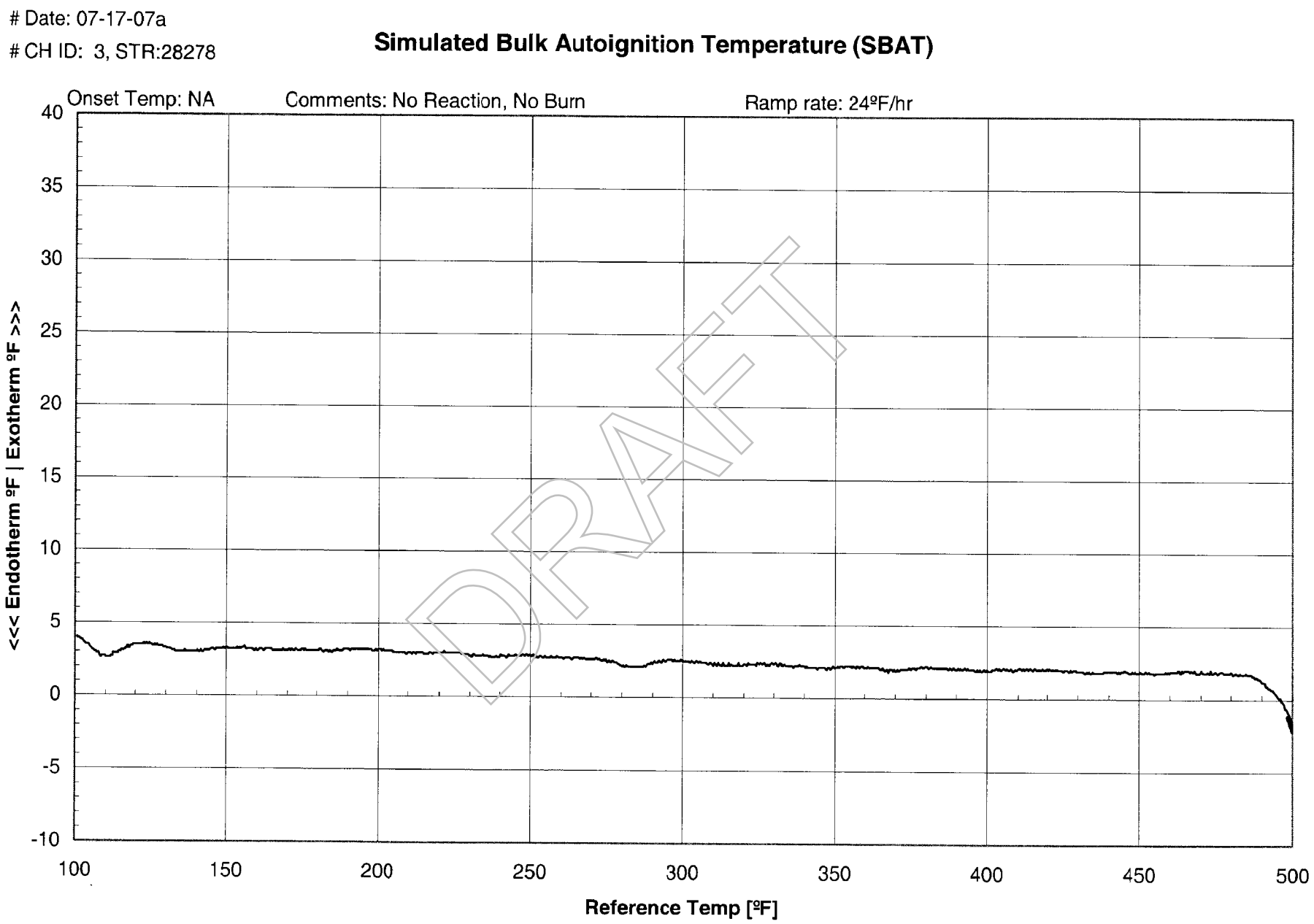

Figure A2: SBAT for Sulfur Sample

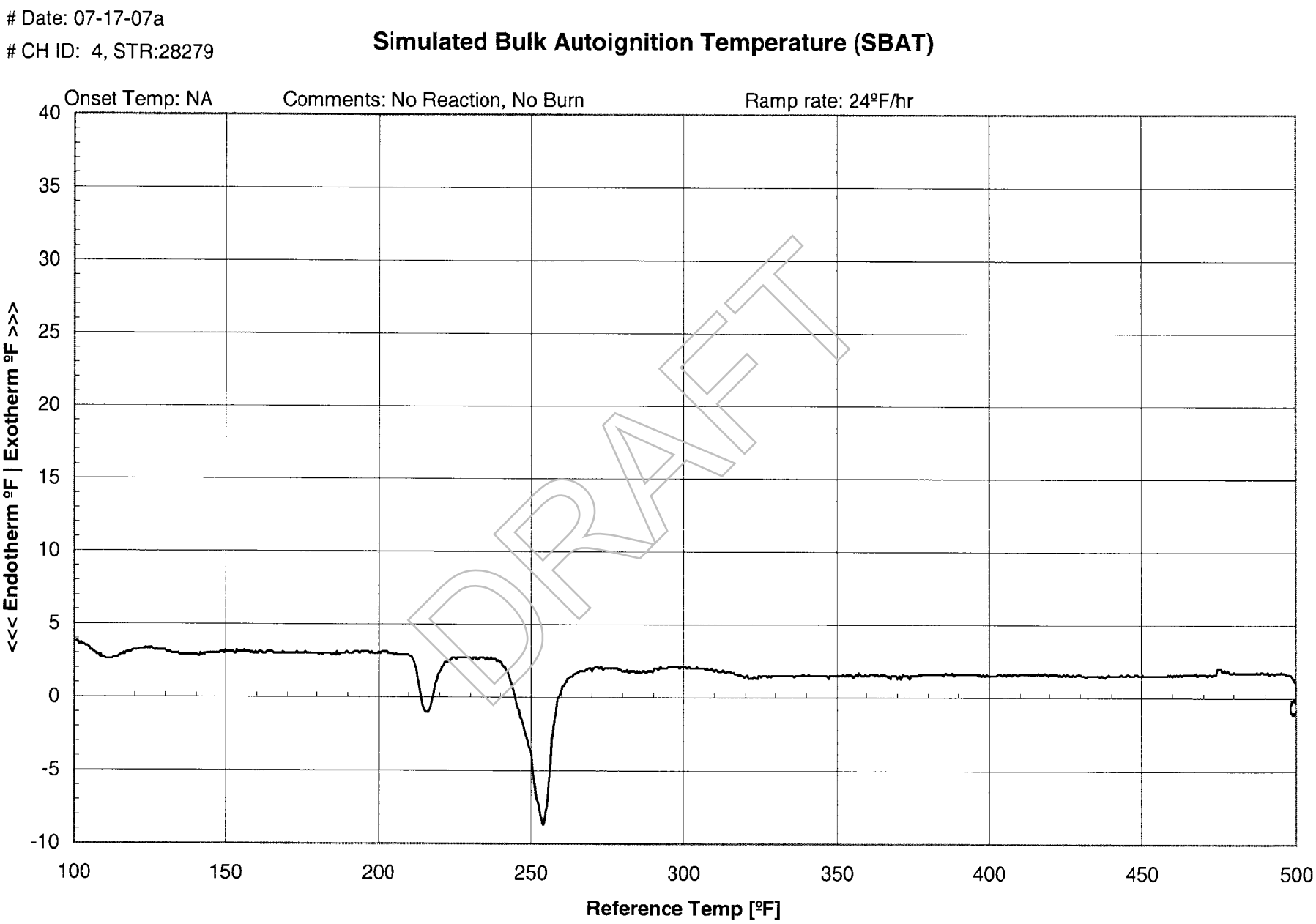

Figure A3: SBAT for 99.998/0.002 Sodium Chlorate/Sulfur Sample

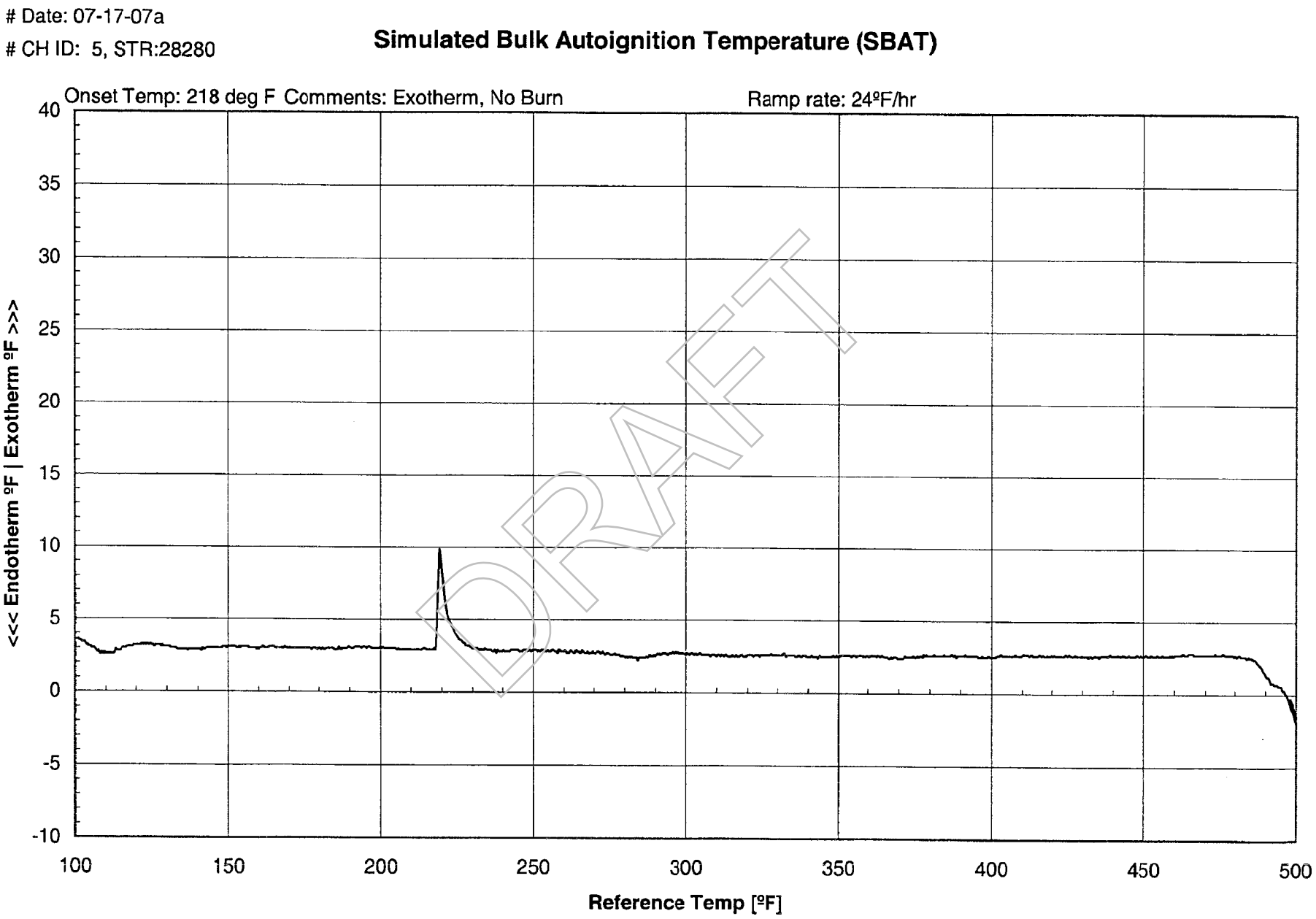

Figure A4: SBAT for 99.998/0.002 Sodium Chlorate/Oat Flour Sample

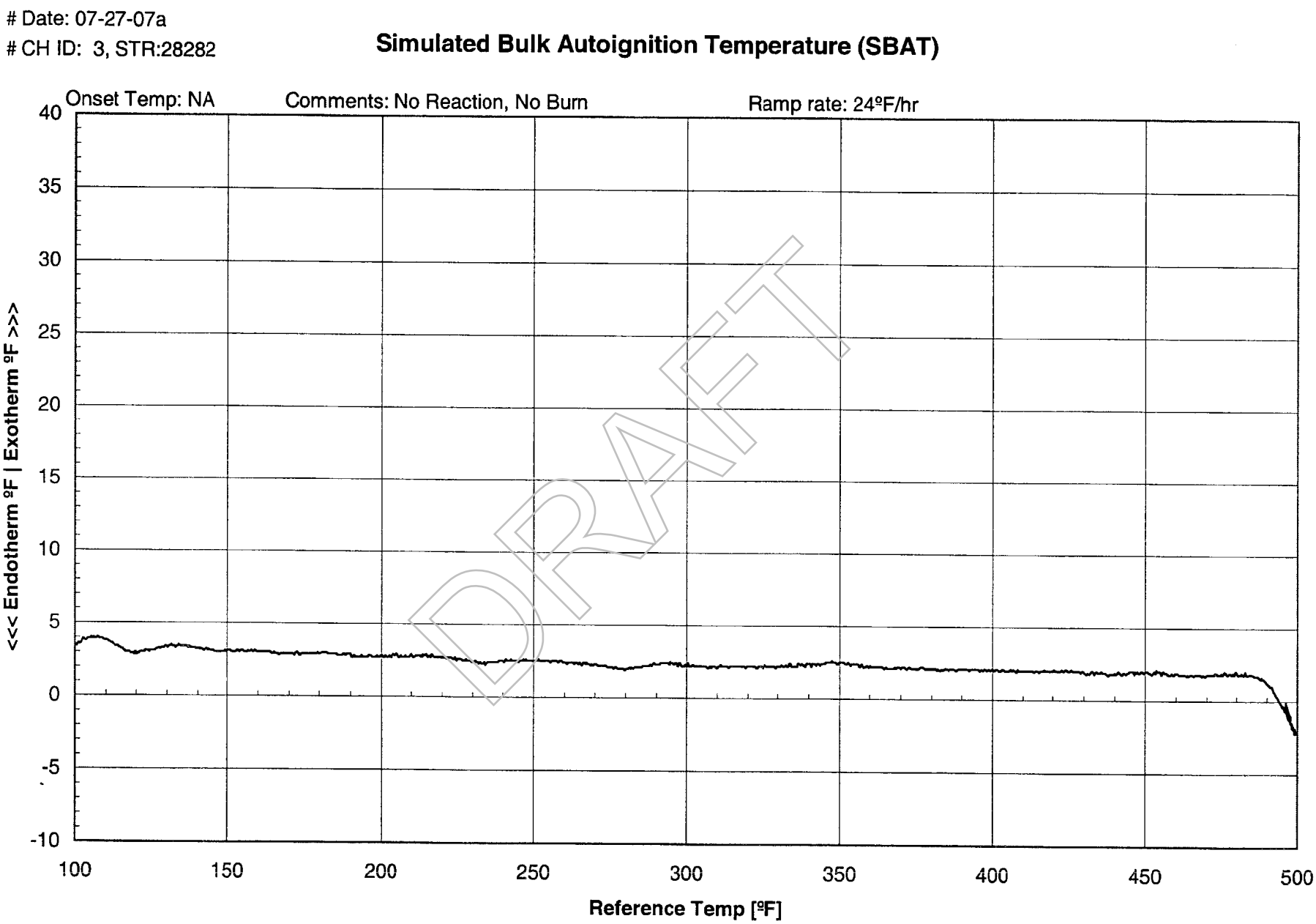

Figure A5: SBAT for 99/10 Sodium Chlorate/Sulfur Sample

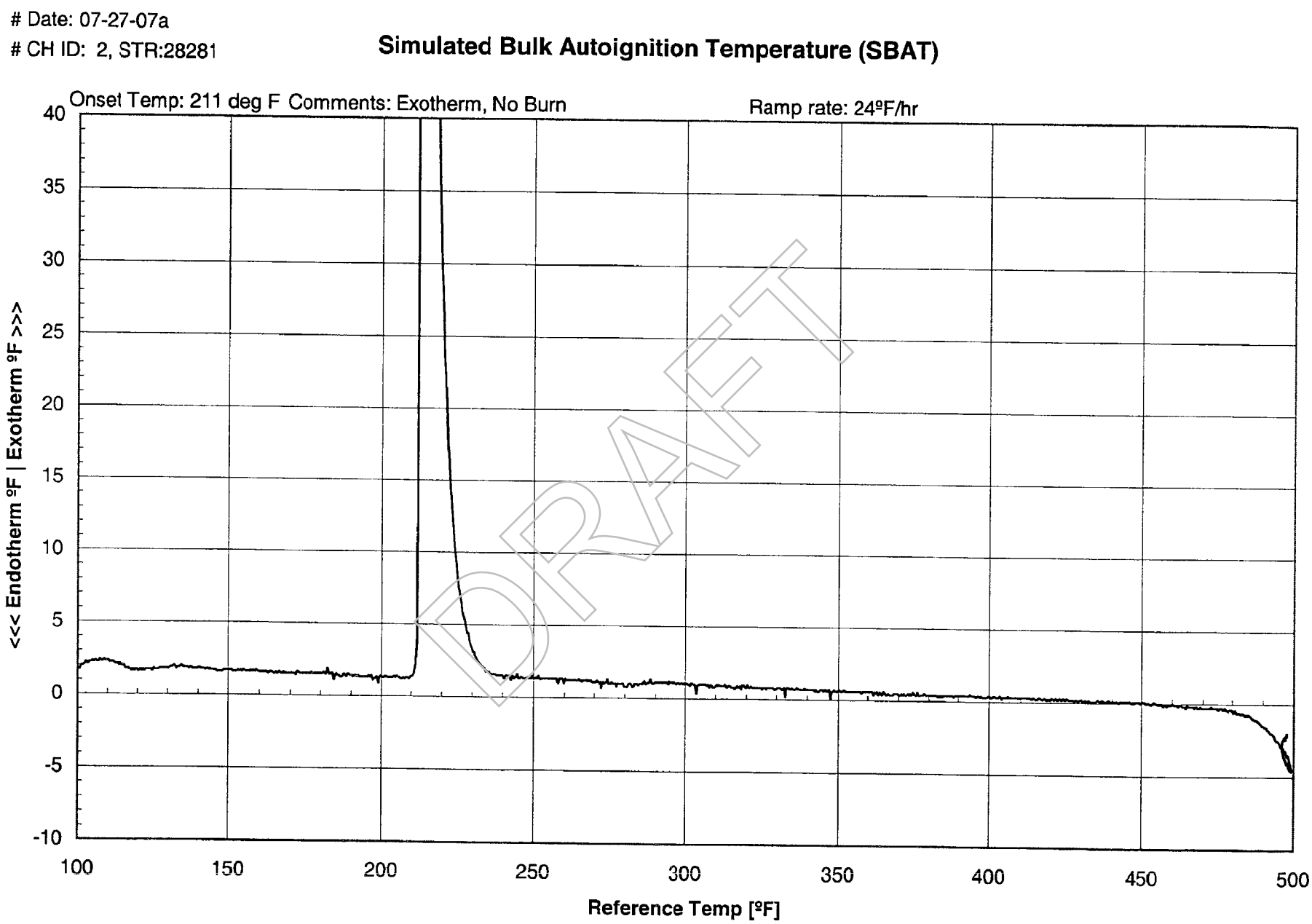

Figure A6: SBAT for 99/10 Sodium Chlorate/Oat Flour Sample