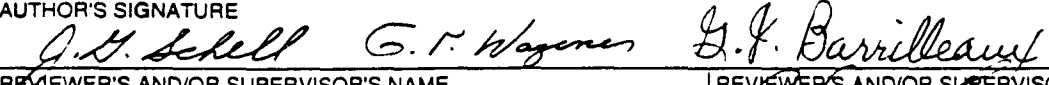
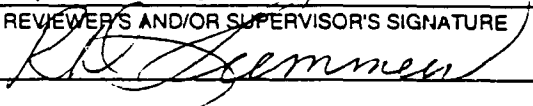


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R&D REPORT THE DOW CHEMICAL COMPANY		CRI NUMBER	
		LABORATORY REPORT CODE LAD-AR 93.05	
DEPARTMENT RESEARCH AND DEVELOPMENT	GEOGRAPHIC LOCATION LOUISIANA	DATE ISSUED April 26, 1993	
REPORT TITLE Accelerating Rate Calorimetry Testing of Process Leak Repair Sealants for Chlorine Service (Steam & Process SP-2026, SP-CM, SP-300D, and an Experimental Sealant, SP-TFLO)		_48_ PAGES IN FULL REPORT	
		LAB NO. 274	PROBLEM NO. 0000
AUTHOR'S LAST NAME AND INITIALS/MASTER NUMBER J. G. Schell (432167), G. P. Wagener (431616), G. J. Barrilleaux (430781)			
AUTHOR'S SIGNATURE 			
REVIEWER'S AND/OR SUPERVISOR'S NAME R. D. Summers		REVIEWER'S AND/OR SUPERVISOR'S SIGNATURE 	
DESCRIPTIVE SUMMARY WITH CONCLUSIONS:			
A commercial process leak repair sealant (Steam & Process SP-2026) which was in service for approximately one year on a process chlorine vapor line showed strong evidence of having reacted with chlorine. This necessitated a search for a replacement sealant. Several commercial sealants were recommended by Steam and Process, Inc. and were submitted to the Louisiana Division (LAD) Reactive Chemicals lab for testing by Accelerating Rate Calorimetry (ARC). MSDS sheets which accompanied the sealants were used in eliminating three of the sealants submitted (SP-2000T, SP-1011, SP-2000). The basis for elimination was known reactivity of the listed organic ingredients with chlorine. The sealants which were tested (SP-2026, SP-CM, and SP-300D) all reacted with liquid chlorine. This prompted LAD Reactive Chemicals lab personnel to develop a new sealant. The new sealant is composed of Deacon Teflon Fiber 311 and a fully halogenated grease, Fluorolube GR 544. Compatibility with liquid chlorine has been confirmed by ARC testing. A patent application has been filed on this work. The sealant is now designated as SP-TFLO and is available through Steam & Process, Inc.			
KEY WORDS Leak repair sealants, chlorine, Accelerating Rate Calorimetry, ARC			
PATENT STATUS: DISCLOSURE SUBMITTED ☒ CASE FILED NO ACTION REQUIRED			
ARE THE MATERIALS DESCRIBED IN THIS REPORT ON YOUR COUNTRY'S INVENTORY? (TSCA, EINECS, ELINCS, CEPA, ETC.) ☒ YES NO*			
WILL THIS PRODUCT BE SOLD/USED IN OTHER COUNTRIES? YES* ☒ NO			
*CONTACT YOUR LOCAL REGULATORY COMPLIANCE PERSON AND/OR CHIEF PRODUCT STEWARD			
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INTRODUCTION

The production plants often use commercial sealants to temporarily repair leaks in process lines until the leaks can be permanently repaired. This subject is addressed in the Louisiana Division (LAD) Safety and Loss Prevention Standard S-317 "Leak Repairs to Operating Lines or Equipment." A commercial process leak repair sealant (Steam & Process SP-2026), which was in service for approximately one year on a chlorine vapor line at the LAD Chlorine Plant, showed strong evidence of having reacted with chlorine. This was a Reactive Chemicals concern because chlorine in contact with a sealant containing hydrocarbon constituents can generate sufficient exothermic activity to initiate an iron-chlorine fire which could easily lead to an environmental event. The reactivity of SP-2026 with chlorine necessitated a search for a replacement sealant. Several commercial sealants were recommended by Steam & Process, Inc. and were submitted to the LAD Reactive Chemicals lab for testing by Accelerating Rate Calorimetry.

MSDS sheets which accompanied the sealants were used in eliminating three of the sealants submitted (SP-2000T, SP-1011, SP-2000). The basis for elimination was known reactivity of the listed organic ingredients with chlorine. The sealants which were tested (SP-2026, SP-CM, and SP-300D) all reacted with liquid chlorine. This prompted LAD Reactive Chemicals lab personnel to develop a new sealant.

The new sealant is composed of Deacon Teflon Fiber 311 and a fully halogenated grease, Fluorolube GR 544. Compatibility with liquid chlorine has been confirmed by ARC testing. A patent application has been filed on this work. The sealant is now designated as SP-TFLO and is available through Steam & Process, Inc.

EXPERIMENTAL

Accelerating Rate Calorimetry

The Accelerating Rate Calorimeter (ARC) was used to determine the compatibility of three commercial leak repair sealants (Steam & Process SP-2026, SP-CM, and SP-300D) and our newly formulated sealant (SP-TFLO) with liquid chlorine. Prior to ARC testing, the commercial sealants were cured in air overnight (SP-2026 at 75 degrees C, and SP-CM and SP-300D at room temperature). SP-TFLO did not have to be cured. For each ARC run, a sample of the sealant was rolled into a narrow strip, frozen with liquid nitrogen, and then loaded through the 1/8 inch tube opening of the Hastelloy C ARC sphere. This was necessary due to the tackiness of the sealants. The ARC sphere was then chilled in liquid nitrogen and loaded with liquid chlorine. After the sphere was attached to the calorimeter, the sphere and contents were allowed to reach ambient temperature before the ARC run was started. Appendices A, B, C, and D contain copies of the ARC reports for the four runs with detailed experimental conditions, tables of the raw data (time, temperature, self-heat rate, pressure, and pressure rate), and plots.

Formulation of New Sealant SP-TFLO

The weight ratio of Fluorolube GR 544 fully halogenated grease to Deacon Teflon Fiber 311 fibers was varied to determine the optimum weight ratio to make the leak repair sealant cohesive and pliable (Table I).

RESULTS AND DISCUSSION

SP-2026 + Chlorine (ARC 92-692)

An exothermic reaction was detected at ambient temperature (21 degrees C) with an initial self-heat rate of 0.075 degrees C/minute and continued to 165 degrees C where the pressure reached 2632 psia and the system rupture disc burst. At this point, the self-heat rate had reached a maximum of 55.5 degrees C/minute. This heat rate is in excess of the system detection rate (20 degrees C/minute) and could have been higher.

SP-CM + Chlorine (ARC 92-708)

An exothermic reaction was detected at ambient temperature (23 degrees C) with an initial self-heat rate of 2.075 degrees C/minute. This reaction was more exothermic than the previous run (ARC 92-692). The reaction continued to 130 degrees C where the pressure reached 986 psia and the system rupture disc burst. At this point, the self-heat rate had reached a maximum of 391 degrees C/minute. Again, the system is not accurate for self-heat rates exceeding 20 degrees C/minute and the actual rate could have been higher.

Table I. Effect of Grease/Fiber Ratio on Cohesiveness of New Sealant

Fluorolube Weight (g)	Teflon Fiber Weight (g)	Grease/Fiber Weight Ratio	Cohesiveness
1.00	2.00	1.0/2.0	poor
2.90	3.90	1.0/1.3	poor
2.70	2.70	1.0/1.0	good
5.65	2.82	2.0/1.0	good
7.10	2.34	3.0/1.0	good
9.04	2.26	4.0/1.0	good

SP-300D + Chlorine (ARC 92-711)

An exothermic reaction was detected at ambient temperature (22 degrees C) with an initial self-heat rate of 0.08 degrees C/minute and continued to 175 degrees C where a maximum pressure of 1361 psia occurred. The maximum self-heat rate of 2.35 degrees C/minute occurred at 169 degrees C.

Other Commercial Sealants

ARC testing of SP-2000T, SP-1011, SP-2000 was not performed since MSDS information listed organic ingredients which are known to react with chlorine (acetic acid, silicone rubber, methanol, petroleum and vegetable oils).

Formulation of New Sealant SP-TFLO

After all the tested commercial sealants were found to be reactive with chlorine, a new formulation which would be non-reactive with chlorine was designed by the Reactive Chemicals lab. This sealant was composed of Deacon Teflon Fiber 311 fibers (polytetrafluoroethylene fibers) and Fluorolube GR 544 grease (a polychlorotrifluoroethylene grease). The weight ratio of Fluorolube GR 544 grease to Deacon Teflon Fiber 311 was varied to determine the optimum ratio to make the leak repair sealant cohesive and pliable. Grease/fiber weight ratios from 1.0/1.0 to 4.0/1.0 gave good cohesive, slightly flowable masses which were viscous and strong enough to contain the pressures within a line being repaired, and yet flowable enough to be pumped into place in a clamp. The actual weight ratio used to repair a leak would depend on the temperature and pressure of the line being repaired. The sealant (1.0/1.0 weight ratio) was prepared by Steam & Process, Inc. according to our formulation (named SP-TFLO) and tested by ARC for compatibility with liquid chlorine.

SP-TFLO + Chlorine (ARC 92-715)

There was no thermal activity detected up to 120 degrees C. Exothermic reactions were detected at 124, 139, 158, and 173 degrees C; however, the maximum self-heat rate of all these exotherms was only 0.03 degrees C/minute, which is just above the detection threshold of the ARC. These reactions were not sustained. The low 0.03 degrees C/minute self-heat rates may have resulted from minor contamination of the sealant during handling. The results of this test indicate that there is no significant exothermic reactivity between the SP-TFLO sealant and liquid chlorine. Thus, the compatibility of the SP-TFLO sealant with chlorine has been confirmed by ARC testing. Table II presents a comparison of the reactivities of the tested sealants with chlorine.

The SP-TFLO sealant is now available through Steam & Process, Inc. It has been successfully used several times at the LAD Chlor-Alkali 2 production plant for the repair of leaking chlorine lines and the replacement of a leaking valve packing.

Table II. Reactivity of Sealants with Chlorine

Leak Repair Sealant	Onset Temp (C)	Maximum Self-Heat Rate (C/min)	Temp (C) at Maximum Self-Heat Rate	Chlorine Reactivity
SP-2026	ambient	55.5	165	reactive
SP-CM	ambient	391	130	reactive
SP-300D	ambient	2.35	169	reactive
SP-TFLO	-	-	-	non-reactive

CONCLUSIONS

1. ARC testing of commercial leak repair sealants SP-2026, SP-CM and SP-300D made by Steam & Process, Inc. indicate that they react with liquid chlorine at ambient temperature and are not suitable for leak repair of chlorine lines.
2. Commercial leak repair sealants SP-2000T, SP-1011, SP-2000 made by Steam & Process, Inc. are not suitable for leak repair of chlorine lines since the MSDS sheets for these sealants list organic ingredients which are known to react with chlorine.
3. A new leak repair sealant composed of Deacon Teflon Fiber 311 and a fully halogenated grease, Fluorolube GR 544, has been formulated by the LAD Reactive Chemicals lab. Compatibility with chlorine has been confirmed by ARC testing. The sealant is now designated as SP-TFLO and is available through Steam and Process, Inc. The SP-TFLO sealant has been successfully used several times at the LAD Chlor-Alkali 2 production plant for repair of leaking chlorine lines and a valve packing.

ACKNOWLEDGEMENTS

The authors would like to acknowledge and thank Clark Ponthier from the LAD Chlorine plant for his help and cooperation with this project.

DOW CONFIDENTIAL INFORMATION

ANALYTICAL REPORT Noah 3.17

RCL: 92-0692

Analytical Sciences, Louisiana Division, Dow Chemical Company

TO: Clark Ponthier

Chlorine Plant

Charge # 25

TITLE: Accelerating Rate Calorimetry Study of Steam & Process SP-2026
Sealant + Chlorine

AUTHOR(S)
Gerald Barrilleaux

Reviewed by

Gerald Barrilleaux

Ran on: 03-24-92 at 09:25 -- Analyzed on: 03-24-92 at 16:38

ARC: ARC SYSTEM 2

SUMMARY

The following results have been obtained by Accelerating Rate Calorimetry (ARC). Refer to data plots contained within this report for more detail.

CAUTION: The following data were generated under specific phi factor conditions. These data should NOT be applied to larger scale operations without considering the effect of phi on the ARC results. Please contact Reactive Chemicals personnel for further interpretations and applications of these data.

RCL: 92-0692 Steam & Process SP-2026 Sealant + Chlorine

A 7.530 g sample was loaded into a No. 3.00, Hastalloy C ARC sample container which yields a phi factor of 1.50 assuming an average sample specific heat of 0.500 cal/g deg C. The sample atmosphere was Chlorine.

The programmed step heating was initiated at 20 deg C with a heat step of 5.0 deg C.

An exothermic reaction was detected at 21 deg C and 114.6 psia with a self-heating rate of 0.08 deg C/min. This exotherm was terminated at 165 deg C and a pressure of 2632 psi, due to reaching the specified pressure transducer limit of 2500 psi. If the exotherm had been allowed to continue, it may have reached significantly higher temperatures and/or pressures. Therefore, these data may not represent the full potential of this exothermic reaction.

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----- ACCELERATING RATE CALORIMETRY Noah 3.17-----

Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0692 -- Ran on: 03-24-92 at 09:25 -- Analyzed on: 03-24-92 at 16:38

Sample description:

Steam & Process SP-2026 Sealant + Chlorine

Steam & Process SP-2026, 3.00 g + Chlorine, 4.53 g

Submitted by: Clark Ponthier

Phone Number: (504) 389-8167

Operator: Gerald Barrilleaux

Analyst: Gerald Barrilleaux

From: Chlorine Plant

Charge Number: 25

ARC: ARC SYSTEM 2

Experimental Conditions

Tape Run number -----	692.00
Container type -----	3.00
Container material-----	Hastalloy C
Container weight, Mb -----	18.899 g
Sample weight, Ms -----	7.530 g
Total System Volume, Vb (approx) -----	10.000 mL
Sample Volume, Vs (approx) -----	7.500 mL
Head space volume, Vg (approx) -----	2.500 mL
Head space atmosphere-----	Chlorine
Container Heat Capacity, Cb -----	0.100 cal/deg C g
Heat Capacity of the sample, Cs (assumed) -----	0.500 cal/deg C g
Starting temperature -----	20.0 deg C
End temperature (specified) -----	175.0 deg C
End temperature (actual) -----	164.9 deg C
Heat step -----	5.0 deg C
Wait time -----	10 min
Isothermal wait time -----	0 min
Calorimetric rate threshold -----	0.020 deg C/min
Stirring rate -----	0 RPM

Thermal Ratio, $\Phi = 1 + (Mb C_b)/(Ms C_s)$ ----- 1.50

RUN PREPARATIONS:

A Hastelloy C ARC sphere was loaded with thin slices of SP-2026 sealant, chilled with liquid nitrogen and chlorine was added via syringe. The sphere was kept cold and air-free until it was attached to the calorimeter. The ARC experiment was begun when the sphere temperature reached 19 degrees C.

RUN COMMENTS:

At approximately 165 deg. C the maximum self-heat rate of 55.5 d g. C/min was achieved. At this temperature, pressure reached 2632 psia and the system rupture disc burst.

EXPERIMENTAL

The specified amount of the sample is introduced into the sample bomb which is in turn fitted to the calorimeter lid. The calorimeter is then

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rapidly heated to the initial temperature after which either an isothermal age mode or a WAIT-SEARCH-HEAT sequence is entered to look for exothermic reaction self-heating. When less than the self-heat rate threshold is observed during the SEARCH mode or at the end of the isothermal age time, a heat step is applied to the calorimeter contents. A WAIT-SEARCH-HEAT process is repeated until the self-heat rate of the bomb exceeds the threshold rate at which time the reaction is allowed to proceed on its own under nearly adiabatic conditions. Detailed procedures for the ARC can be found in the CSI operating manual.

GENERAL PRECAUTIONS

Accelerating rate calorimetry offers a useful method for evaluating exothermic run-away processes. However, caution should be used when relating the ARC data to an actual plant process since ϕ for an ARC experiment is usually very different from ϕ for a large-scale reaction. In addition, special consideration is needed when kinetic complications are present in the ARC data. For example, the effects of autocatalysis or inhibitors can vastly change the runaway reaction in chemical storage situations.

Consultation with Reactive Chemicals is recommended in the applications of ARC data to plant processes. Extrapolation of the data outside the experimental range is generally unwise.

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----- ACCELERATING RATE CALORIMETRY Noah 3.17-----

Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0692 -- Ran on: 03-24-92 at 09:25 -- Analyzed on: 03-24-92 at 16:38

Sample description:

Steam & Process SP-2026 Sealant + Chlorine

Steam & Process SP-2026, 3.00 g + Chlorine, 4.53 g

Submitted by: Clark Ponthier

Phone Number: (504) 389-8167

Operator: Gerald Barrilleaux

Analyst: Gerald Barrilleaux

From: Chlorine Plant

Charge Number: 25

ARC: ARC SYSTEM 2

DATA LIST

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	Time (min)	Temperature (C)	Heat Rate (C/min)	Pressure (psia)	Pressure Rate (psia/min)
START LISTING	0.00	0.00	0.000	0.0	0.00
START Exotherm	0.00	0.00	0.000	0.0	0.00
EXOTHERM	19.19	21.47	0.075	114.6	5.97
EXOTHERM	36.07	22.47	0.059	117.6	0.18
EXOTHERM	57.51	23.48	0.047	121.1	0.16
EXOTHERM	81.95	24.50	0.041	124.9	0.16
EXOTHERM	108.79	25.52	0.038	128.8	0.15
EXOTHERM	136.15	26.52	0.036	132.6	0.14
EXOTHERM	165.49	27.54	0.034	136.5	0.13
EXOTHERM	195.01	28.55	0.034	140.8	0.15
EXOTHERM	223.99	29.57	0.035	145.2	0.15
EXOTHERM	251.71	30.58	0.036	149.6	0.16
EXOTHERM	279.25	31.61	0.037	154.3	0.17
EXOTHERM	305.05	32.64	0.039	159.2	0.19
EXOTHERM	330.35	33.66	0.040	164.2	0.20
EXOTHERM	348.43	34.47	0.044	167.9	0.20
EXOTHERM	369.83	35.47	0.046	173.0	0.24
EXOTHERM	390.79	36.47	0.047	178.3	0.25
EXOTHERM	410.31	37.49	0.052	183.7	0.28
EXOTHERM	429.03	38.50	0.053	189.4	0.30
EXOTHERM	446.79	39.53	0.057	194.9	0.31
EXOTHERM	464.61	40.57	0.058	201.1	0.35
EXOTHERM	480.21	41.59	0.065	206.8	0.37
EXOTHERM	495.33	42.61	0.067	213.0	0.41
EXOTHERM	509.89	43.62	0.069	219.1	0.42
EXOTHERM	523.29	44.63	0.075	225.2	0.46
EXOTHERM	536.33	45.65	0.078	231.4	0.48
EXOTHERM	549.09	46.66	0.079	238.2	0.53
EXOTHERM	558.73	47.48	0.085	243.6	0.56
EXOTHERM	570.71	48.50	0.085	251.0	0.62
EXOTHERM	581.61	49.53	0.094	258.2	0.66
EXOTHERM	591.69	50.54	0.100	265.3	0.70
EXOTHERM	601.77	51.56	0.101	272.9	0.75
EXOTHERM	611.25	52.61	0.110	280.6	0.81

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EXOTHERM	620.13	53.63	0.114	288.5	0.89
EXOTHERM	627.09	54.47	0.120	295.0	0.93
EXOTHERM	634.79	55.48	0.131	302.8	1.01
EXOTHERM	642.29	56.51	0.137	311.0	1.09
EXOTHERM	649.49	57.54	0.143	319.2	1.14
EXOTHERM	656.35	58.58	0.151	327.8	1.25
EXOTHERM	662.45	59.58	0.163	336.1	1.36
EXOTHERM	668.89	60.62	0.161	345.3	1.43
EXOTHERM	674.79	61.64	0.172	354.4	1.54
EXOTHERM	680.37	62.66	0.182	363.3	1.59
EXOTHERM	684.55	63.47	0.193	370.6	1.75
EXOTHERM	689.59	64.49	0.202	379.7	1.81
EXOTHERM	694.55	65.52	0.207	389.3	1.94
EXOTHERM	699.19	66.54	0.219	399.0	2.09
EXOTHERM	703.75	67.58	0.228	409.2	2.24
EXOTHERM	707.83	68.59	0.247	419.0	2.40
EXOTHERM	711.75	69.60	0.257	429.1	2.58
EXOTHERM	715.65	70.66	0.271	440.0	2.79
EXOTHERM	718.55	71.48	0.282	448.6	2.97
EXOTHERM	721.91	72.49	0.300	459.1	3.12
EXOTHERM	725.17	73.52	0.315	470.1	3.37
EXOTHERM	728.23	74.55	0.336	480.8	3.50
EXOTHERM	731.11	75.57	0.354	491.8	3.82
EXOTHERM	733.99	76.62	0.364	503.6	4.10
EXOTHERM	736.63	77.65	0.390	514.4	4.09
EXOTHERM	738.69	78.48	0.402	524.0	4.66
EXOTHERM	741.21	79.51	0.408	535.9	4.72
EXOTHERM	743.55	80.55	0.444	547.6	5.00
EXOTHERM	745.79	81.57	0.455	558.9	5.04
EXOTHERM	747.95	82.60	0.476	570.7	5.46
EXOTHERM	750.09	83.62	0.476	582.4	5.47
EXOTHERM	752.13	84.64	0.500	594.3	5.83
EXOTHERM	754.19	85.68	0.504	605.5	5.44
EXOTHERM	755.87	86.49	0.482	614.1	5.12
EXOTHERM	758.09	87.50	0.454	624.1	4.50
EXOTHERM	761.03	88.52	0.346	631.9	2.65
EXOTHERM	764.45	89.55	0.301	638.0	1.78
EXOTHERM	768.37	90.58	0.262	642.5	1.15
EXOTHERM	772.89	91.62	0.230	646.2	0.82
EXOTHERM	777.93	92.63	0.200	650.5	0.85
EXOTHERM	783.43	93.67	0.189	656.6	1.11
EXOTHERM	787.43	94.48	0.202	662.2	1.40
EXOTHERM	792.57	95.50	0.198	670.7	1.65
EXOTHERM	797.69	96.54	0.203	680.6	1.93
EXOTHERM	802.39	97.56	0.217	692.2	2.47
EXOTHERM	806.39	98.59	0.257	705.0	3.20
EXOTHERM	810.15	99.67	0.287	719.0	3.72
EXOTHERM	812.73	100.49	0.317	730.6	4.50
EXOTHERM	815.67	101.53	0.353	744.6	4.76
EXOTHERM	818.49	102.55	0.361	759.4	5.25
EXOTHERM	821.01	103.60	0.416	773.9	5.75
EXOTHERM	823.41	104.62	0.425	788.4	6.04
EXOTHERM	825.29	105.47	0.452	801.0	6.70
EXOTHERM	827.41	106.51	0.490	815.9	7.03
EXOTHERM	829.37	107.59	0.551	831.2	7.81
EXOTHERM	831.13	108.62	0.585	846.9	8.92
EXOTHERM	832.53	109.49	0.621	858.0	7.93
EXOTHERM	834.21	110.52	0.613	873.3	9.11
EXOTHERM	835.73	111.59	0.703	887.7	9.47
EXOTHERM	837.21	112.63	0.702	903.1	10.41

EXOTHERM	838.25	113.48	0.817	916.9	13.27
EXOTHERM	839.45	114.57	0.908	930.1	11.00
EXOTHERM	840.77	115.66	0.825	944.0	10.53
EXOTHERM	841.77	116.49	0.830	955.0	11.00
EXOTHERM	842.97	117.61	0.933	967.7	10.58
EXOTHERM	844.05	118.65	0.962	980.0	11.39
EXOTHERM	844.85	119.47	1.025	989.0	11.25
EXOTHERM	845.85	120.53	1.060	1000.2	11.20
EXOTHERM	846.79	121.56	1.095	1010.3	10.74
EXOTHERM	847.71	122.60	1.130	1021.7	12.39
EXOTHERM	848.53	123.63	1.256	1032.7	13.41
EXOTHERM	849.31	124.68	1.346	1044.1	14.62
EXOTHERM	849.87	125.53	1.517	1052.8	15.54
EXOTHERM	850.57	126.62	1.557	1064.5	16.71
EXOTHERM	851.09	127.47	1.634	1073.6	17.50
EXOTHERM	851.69	128.56	1.816	1084.4	18.00
EXOTHERM	852.23	129.60	1.925	1095.1	19.81
EXOTHERM	852.77	130.67	1.981	1107.8	23.52
EXOTHERM	853.17	131.57	2.250	1117.9	25.25
EXOTHERM	853.55	132.51	2.473	1128.4	27.63
EXOTHERM	853.97	133.57	2.523	1141.6	31.43
EXOTHERM	854.37	134.66	2.725	1155.5	34.75
EXOTHERM	854.69	135.62	3.000	1167.9	38.75
EXOTHERM	854.97	136.53	3.250	1179.7	42.14
EXOTHERM	855.27	137.59	3.533	1184.9	17.33
EXOTHERM	855.57	138.68	3.633	1195.6	35.67
EXOTHERM	855.81	139.56	3.666	1206.0	43.33
EXOTHERM	856.05	140.52	4.000	1217.0	45.83
EXOTHERM	856.29	141.54	4.250	1220.4	14.17
EXOTHERM	856.53	142.59	4.375	1198.4	-91.67
EXOTHERM	856.77	143.66	4.458	1205.3	28.75
EXOTHERM	856.93	144.49	5.187	1212.9	47.50
EXOTHERM	857.13	145.66	5.850	1227.3	72.00
EXOTHERM	857.29	146.69	6.437	1243.2	99.37
EXOTHERM	857.41	147.54	7.083	1257.5	119.17
EXOTHERM	857.57	148.76	7.625	1280.0	140.62
EXOTHERM	857.69	149.78	8.500	1300.6	171.67
EXOTHERM	857.77	150.52	9.250	1316.9	203.75
EXOTHERM	857.87	151.52	10.000	1341.3	244.00
EXOTHERM	857.97	152.61	10.900	1373.2	319.00
EXOTHERM	858.05	153.57	12.000	1408.0	435.00
EXOTHERM	858.13	154.64	13.375	1455.7	596.25
EXOTHERM	858.19	155.51	14.500	1500.0	738.33
EXOTHERM	858.25	156.49	16.333	1554.4	906.67
EXOTHERM	858.31	157.63	19.000	1624.0	1160.00
EXOTHERM	858.35	158.48	21.250	1685.6	1540.00
EXOTHERM	858.41	159.99	25.166	1829.2	2393.33
EXOTHERM	858.43	160.58	29.500	1909.9	4035.00
EXOTHERM	858.47	161.97	34.750	2172.7	6570.00
EXOTHERM	858.49	162.80	41.500	2339.9	8360.00
EXOTHERM	858.51	163.76	48.000	2486.4	7325.00
EXOTHERM	858.53	164.87	55.500	2596.5	5505.00
EXOTHERM	858.53	164.87	0.002	2632.3	0.00
END LIST	0.00	0.00	0.000	0.0	3.07

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DO A 022143
CONFIDENTIAL

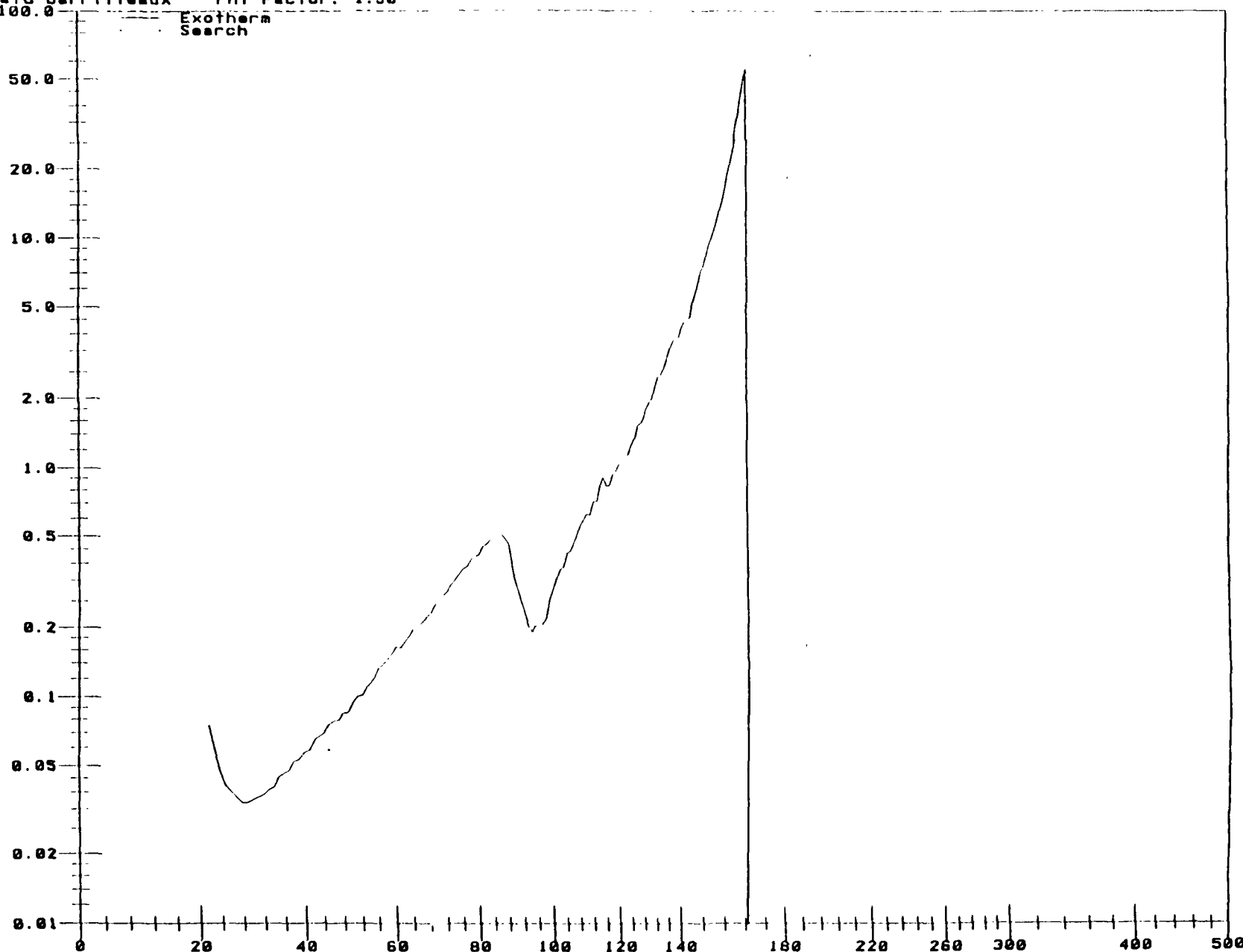
AR

SELF-HEAT RATE VS. TEMPERATURE

Sample: Steam & Process SP-2026 Sealant + Chlorine
ARC: System 2 Height (cm): 7.550
Customer: Clariant Anstler Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.50

Run Date: 03-24-92 Time: 07:25
Plotted Date: 03-24-92 Time: 16:40

Self Heat Rate, deg C/min



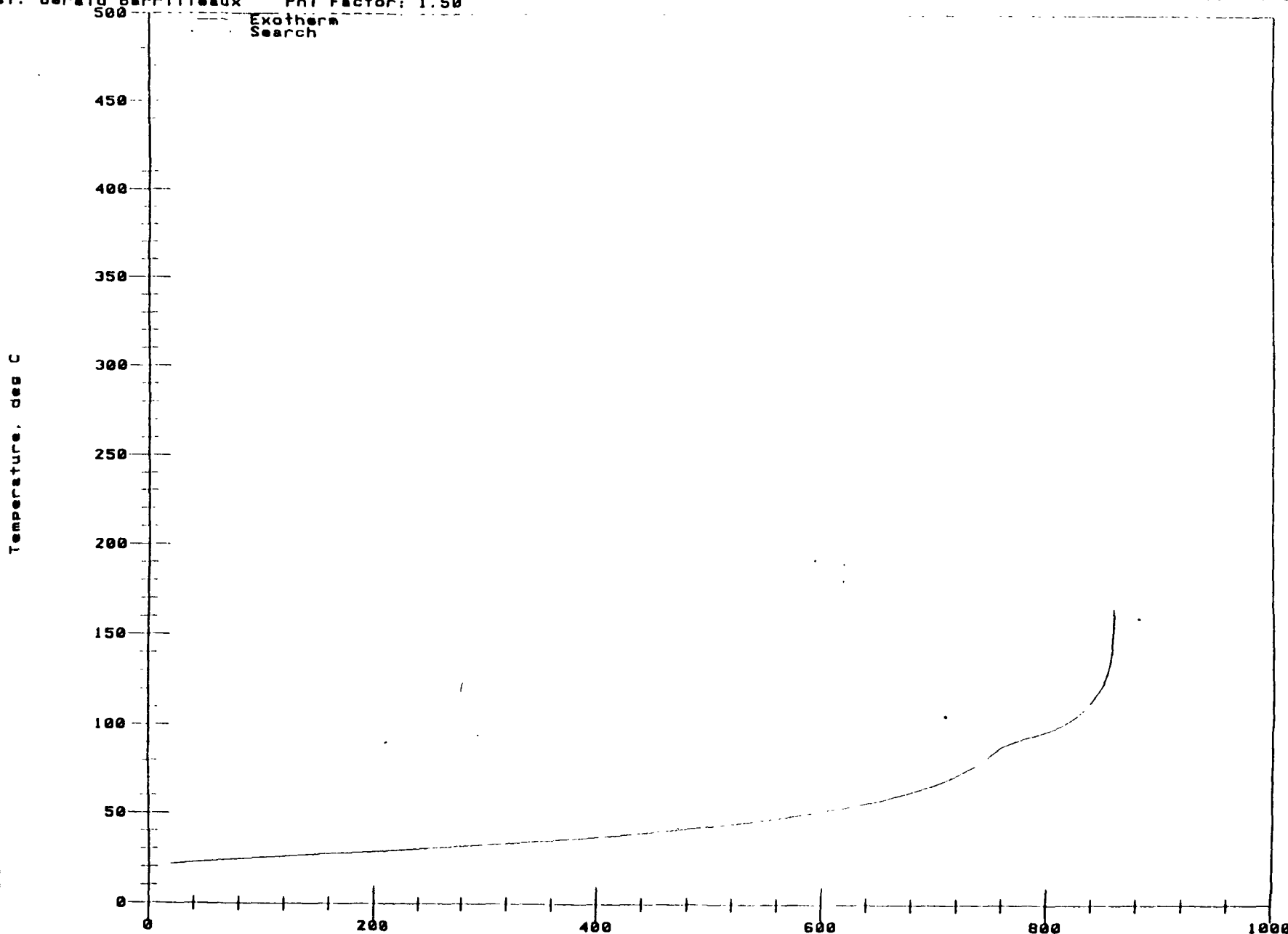
DO A 022144
CONFIDENTIAL

ARC

TEMPERATURE VS. TIME PLOT

Sample : Steam & Process SP-2026 Sealant + Chlorine
ARC: ARC SYSTEM 2 Weight (gm): 7.530
Customer: Clark Bonthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.50

Run Date: 03-24-92 Time: 07:25
Plotted Date: 03-24-92 Time: 16:51



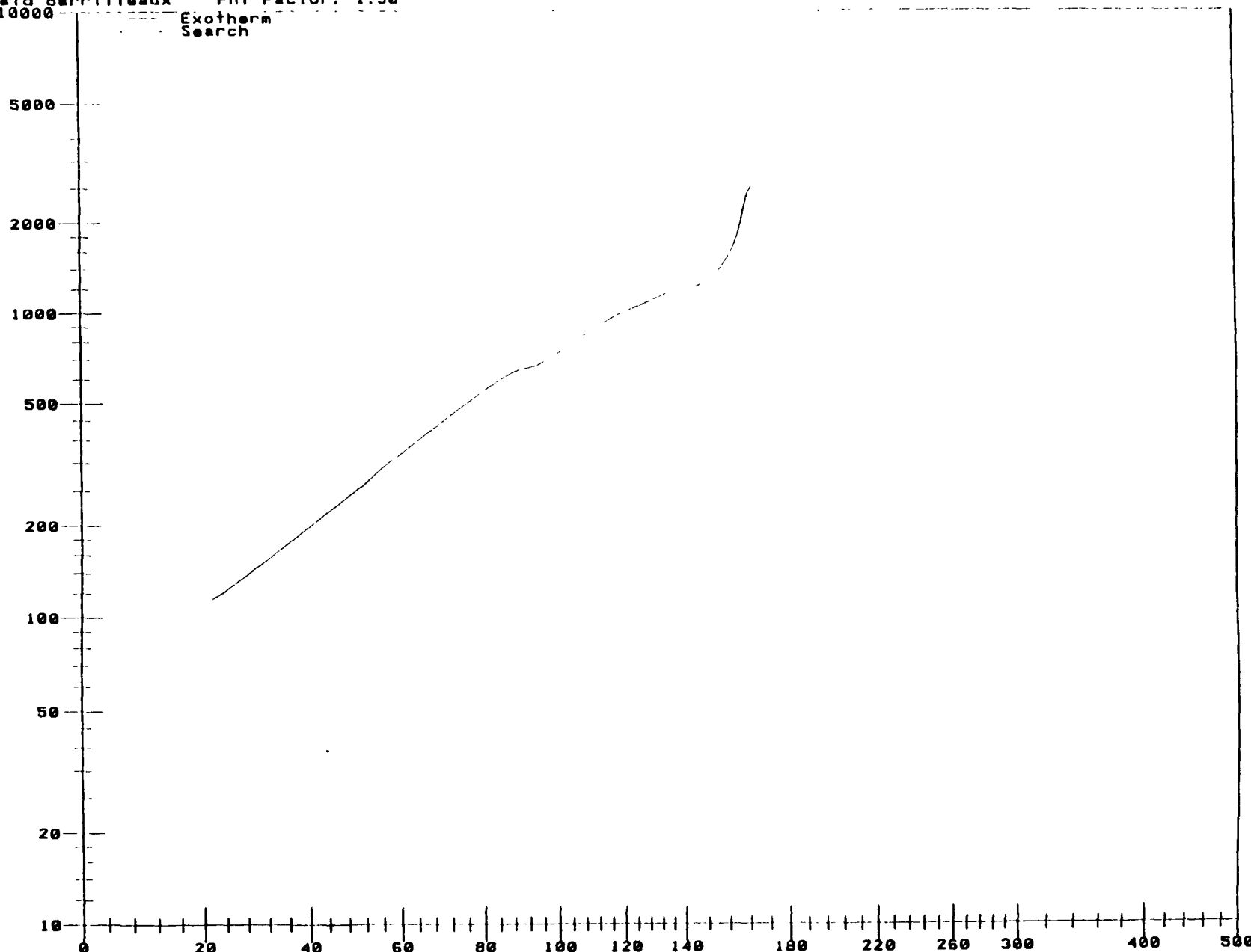
DO A 027145
CONFIDENTIAL

AR~ PRESSURE VS. TEMPERATURE

Sample: Steam & Process SP-2026 Sealant + Chlorine
ARC: ARC SYSTEM 2 Weight (gm): 7.530
Customer: Clark Conthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phil Factor: 1.50

Run Date: 03-24-92 Time: 07:25
Plotted Date: 03-24-92 Time: 16:46

Pressure [PSIA]



Exotherm
Search

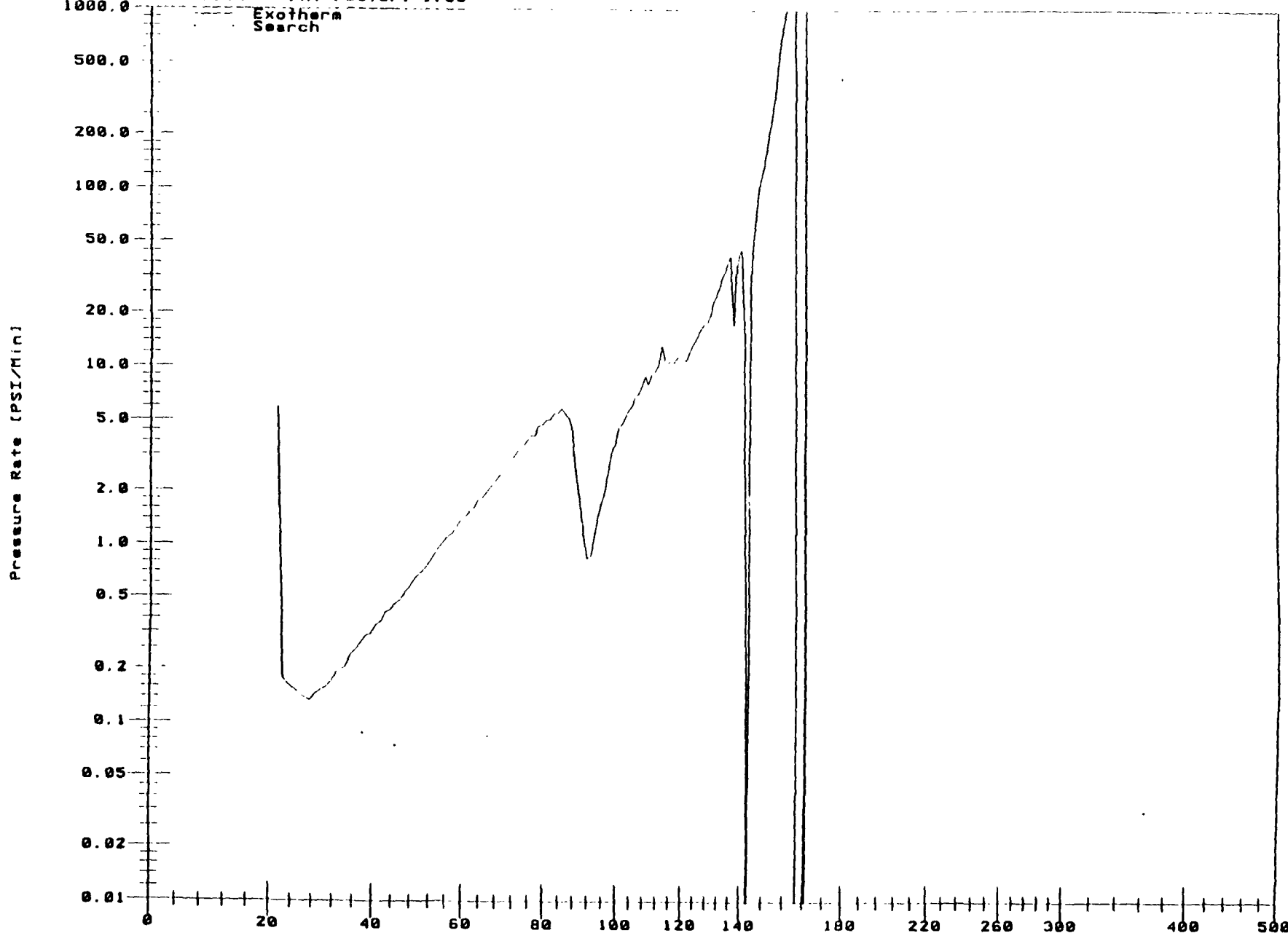
DO A 022146
CONFIDENTIAL

ARC

PRESSURE RATE VS. TEMPERATURE

Sample : Steep & Process SP-2026 Sealant + Chlorine
ARC SYSTEM 2 Weight (gm): 7.530
Customer: Clark Bonthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.50

Run Date: 03-24-92 Time: 09:25
Plotted Date: 03-24-92



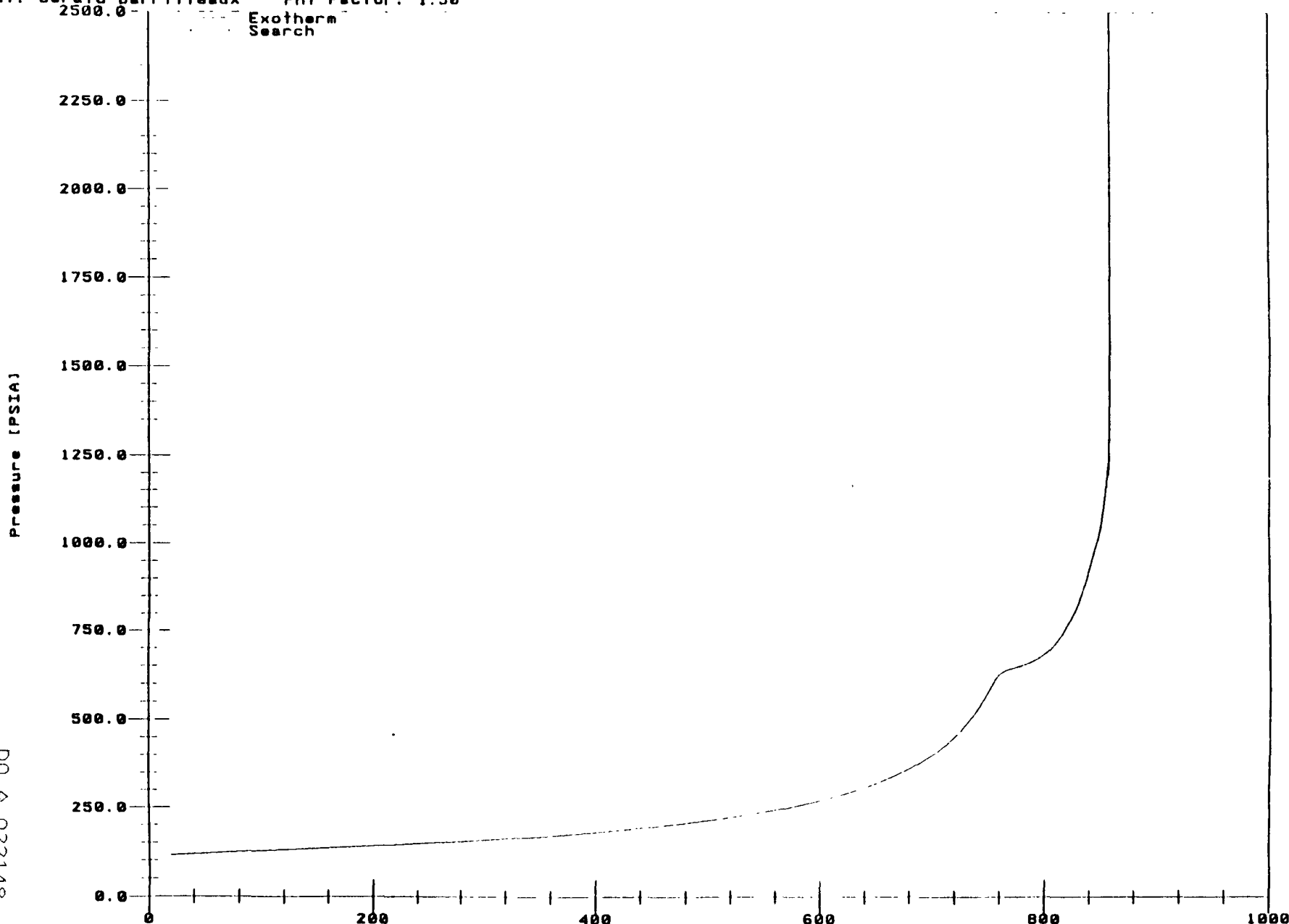
DO A 022147
CONFIDENTIAL

AR

PRESSURE VS. TIME

Sample: Steam & Process SP-2026 Sealant + Chlorine
ARC: ARC SYSTEM 2 Weight (gm): 7.550
Customer: Clark Pontier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phil Factor: 1.50

Run Date: 03-24-92 Time: 07:25
Plotted Date: 03-24-92 Time: 16:56



Exotherm
Search

DO A 022148
CONFIDENTIAL

DOW CONFIDENTIAL INFORMATION

ANALYTICAL REPORT Noah 3.17

RCL: 92-0708

Analytical Sciences, Louisiana Division, Dow Chemical Company

TO: Clark Ponthier

Chlorine

Charge # 25

TITLE: Accelerating Rate Calorimetry Study of Steam & Process SP-CM
Sealant + Liquid Chlorine

AUTHOR(S)
Gerald Barrilleaux

Reviewed by

Ran on: 04-24-92 at 16:49 -- Analyzed on: 04-27-93 at 00:09
ARC: ARC SYSTEM 2

SUMMARY

=====

The following results have been obtained by Accelerating Rate Calorimetry (ARC). Refer to data plots contained within this report for more detail.

CAUTION: The following data were generated under specific phi factor conditions. These data should NOT be applied to larger scale operations without considering the effect of phi on the ARC results. Please contact Reactive Chemicals personnel for further interpretations and applications of these data.

RCL: 92-0708 Steam & Process SP-CM Sealant + Liquid Chlorine

A 6.330 g sample was loaded into a No. 3.00, Hastalloy C ARC sample container which yields a phi factor of 1.62 assuming an average sample specific heat of 0.500 cal/g deg C. The sample atmosphere was Chlorine.

The programmed step heating was initiated at 20 deg C with a heat step of 10.0 deg C.

An exothermic reaction was detected at 23 deg C and 134.0 psia with a self-heating rate of 2.08 deg C/min. The maximum self-heat rate observed during this exotherm was 391.00 deg C/min at 130 deg C with a pressure of 15 psi. The observed temperature rise for this exotherm was 142 deg C. Using a phi factor of 1.62, the estimated adiabatic temperature rise is 231 deg C and the heat of reaction is 116 cal/g of total sample. This calculation assumes that any PV energy change during the reaction was negligible.

DOW CONFIDENTIAL INFORMATION

----- ACCELERATING RATE CALORIMETRY Noah 3.17-----
 Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0708 -- Ran on: 04-24-92 at 16:49 -- Analyzed on: 04-27-93 at 00:09

Sample description:

Steam & Process SP-CM Sealant + Liquid Chlorine

Steam & Process SP-CM, 3.50 grams + Liquid Chlorine, 3.98 grams

Submitted by: Clark Ponthier
 Phone Number: (504) 389-8167
 Operator: Gerald Barrilleaux
 Analyst: Gerald Barrilleaux

From: Chlorine
 Charge Number: 25
 ARC: ARC SYSTEM 2

Experimental Conditions

Tape Run number -----	708.00
Container type -----	3.00
Container material-----	Hastalloy C
Container weight, Mb -----	19.719 g
Sample weight, Ms -----	6.330 g
Total System Volume, Vb (approx) -----	10.000 mL
Sample Volume, Vs (approx) -----	5.150 mL
Head space volume, Vg (approx) -----	4.850 mL
Head space atmosphere-----	Chlorine
Container Heat Capacity, Cb -----	0.100 cal/deg C g
Heat Capacity of the sample, Cs (assumed) -----	0.500 cal/deg C g
Starting temperature -----	20.0 deg C
End temperature (specified) -----	250.0 deg C
End temperature (actual) -----	165.9 deg C
Heat step -----	10.0 deg C
Wait time -----	10 min
Isothermal wait time -----	0 min
Calorimetric rate threshold -----	0.020 deg C/min
Stirring rate -----	0 RPM
Thermal Ratio, $\Phi = 1 + (Mb C_b)/(Ms C_s)$ -----	1.62

RUN PREPARATIONS:

A Hastelloy C ARC sphere was loaded with SP-Cm sealant by rolling the sealant into strands which were immersed into liquid nitrogen to facilitate insertion into the sphere. The sealant was then no longer tacky and could be forced down the neck of the sphere. The sphere and SP-CM was then chilled in liquid nitrogen and chlorine was added. The sphere was attached immediately to the calorimeter and allowed to gradually reach ambient temperature.

RUN COMMENTS:

Start temperature was set at 20 deg. C, slightly below ambient so that exotherm mode could be forced immediately after the run was started in order to monitor any exotherms near ambient temperature. At 47 minutes into the experiment a large self-heat rate occurred, 391 d g. C/minute. At this time, pressure was 986 psia and the rupture disc burst.

EXPERIMENTAL

The specified amount of the sample is introduced into the sample bomb which is in turn fitted to the calorimeter lid. The calorimeter is then rapidly heated to the initial temperature after which either an isothermal age mode or a WAIT-SEARCH-HEAT sequence is entered to look for exothermic reaction self-heating. When less than the self-heat rate threshold is observed during the SEARCH mode or at the end of the isothermal age time, a heat step is applied to the calorimeter contents. A WAIT-SEARCH-HEAT process is repeated until the self-heat rate of the bomb exceeds the threshold rate at which time the reaction is allowed to proceed on its own under nearly adiabatic conditions. Detailed procedures for the ARC can be found in the CSI operating manual.

GENERAL PRECAUTIONS

Accelerating rate calorimetry offers a useful method for evaluating exothermic run-away processes. However, caution should be used when relating the ARC data to an actual plant process since ϕ for an ARC experiment is usually very different from ϕ for a large-scale reaction. In addition, special consideration is needed when kinetic complications are present in the ARC data. For example, the effects of autocatalysis or inhibitors can vastly change the runaway reaction in chemical storage situations.

Consultation with Reactive Chemicals is recommended in the applications of ARC data to plant processes. Extrapolation of the data outside the experimental range is generally unwise.

DOW CONFIDENTIAL INFORMATION

----- ACCELERATING RATE CALORIMETRY Noah 3.17-----

Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0708 -- Ran on: 04-24-92 at 16:49 -- Analyzed on: 04-27-93 at 00:09

Sample description:

Steam & Process SP-CM Sealant + Liquid Chlorine

Steam & Process SP-CM, 3.50 grams + Liquid Chlorine, 3.98 grams

Submitted by: Clark Ponthier

Phone Number: (504) 389-8167

Operator: Gerald Barrilleaux

Analyst: Gerald Barrilleaux

From: Chlorine

Charge Number: 25

ARC: ARC SYSTEM 2

DATA LIST

=====

	Time (min)	Temperature (C)	Heat Rate (C/min)	Pressure (psia)	Pressure Rate (psia/min)
START LISTING	0.00	0.00	0.000	0.0	0.00
START Exotherm	0.00	0.00	0.000	0.0	0.00
EXOTHERM	9.01	23.35	2.075	134.0	14.87
EXOTHERM	9.51	24.42	2.140	142.3	16.60
EXOTHERM	9.99	25.48	2.208	148.5	12.92
EXOTHERM	10.41	26.35	2.071	150.9	5.71
EXOTHERM	10.93	27.47	2.153	159.5	16.54
EXOTHERM	11.33	28.37	2.250	166.2	16.75
EXOTHERM	11.81	29.46	2.270	173.3	14.79
EXOTHERM	12.19	30.35	2.342	178.7	14.21
EXOTHERM	12.65	31.42	2.326	185.1	13.91
EXOTHERM	13.15	32.55	2.260	192.0	13.80
EXOTHERM	13.53	33.46	2.394	198.3	16.58
EXOTHERM	13.91	34.38	2.421	204.0	15.00
EXOTHERM	14.33	35.44	2.523	211.1	16.90
EXOTHERM	14.75	36.53	2.595	218.4	17.38
EXOTHERM	15.11	37.46	2.583	225.0	18.33
EXOTHERM	15.53	38.53	2.547	232.7	18.33
EXOTHERM	15.89	39.46	2.583	239.5	18.89
EXOTHERM	16.23	40.35	2.617	246.1	19.41
EXOTHERM	16.63	41.43	2.700	254.0	19.75
EXOTHERM	17.03	42.50	2.675	261.8	19.50
EXOTHERM	17.37	43.38	2.588	268.6	20.00
EXOTHERM	17.81	44.48	2.500	277.5	20.23
EXOTHERM	18.17	45.39	2.527	284.5	19.44
EXOTHERM	18.59	46.45	2.523	293.0	20.24
EXOTHERM	19.03	47.54	2.477	301.6	19.55
EXOTHERM	19.39	48.42	2.444	308.7	19.72
EXOTHERM	19.79	49.38	2.400	316.3	19.00
EXOTHERM	20.29	50.50	2.240	325.7	18.80
EXOTHERM	20.69	51.35	2.125	333.2	18.75
EXOTHERM	21.19	52.44	2.180	342.2	18.00
EXOTHERM	21.69	53.53	2.180	351.0	17.60

DO A 022152
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EXOTHERM	22.09	54.36	2.075	357.9	17.25
EXOTHERM	22.67	55.50	1.965	367.6	16.72
EXOTHERM	23.15	56.38	1.833	375.5	16.46
EXOTHERM	23.71	57.43	1.875	384.5	16.07
EXOTHERM	24.29	58.49	1.827	393.5	15.52
EXOTHERM	24.91	59.54	1.693	402.8	15.00
EXOTHERM	25.47	60.43	1.589	411.2	15.00
EXOTHERM	26.13	61.50	1.621	421.1	15.00
EXOTHERM	26.77	62.54	1.625	430.3	14.37
EXOTHERM	27.35	63.40	1.482	438.2	13.62
EXOTHERM	28.11	64.48	1.421	448.6	13.68
EXOTHERM	28.83	65.53	1.458	458.3	13.47
EXOTHERM	29.43	66.40	1.450	466.2	13.17
EXOTHERM	30.23	67.45	1.312	477.0	13.50
EXOTHERM	30.99	68.50	1.381	486.9	13.03
EXOTHERM	31.61	69.37	1.403	495.5	13.87
EXOTHERM	32.41	70.45	1.350	506.0	13.13
EXOTHERM	33.17	71.46	1.328	516.7	14.08
EXOTHERM	33.87	72.49	1.471	526.8	14.43
EXOTHERM	34.45	73.35	1.482	535.4	14.83
EXOTHERM	35.17	74.42	1.486	546.5	15.42
EXOTHERM	35.83	75.47	1.590	557.2	16.21
EXOTHERM	36.47	76.56	1.703	567.6	16.25
EXOTHERM	36.99	77.43	1.673	576.4	16.92
EXOTHERM	37.61	78.48	1.693	587.4	17.74
EXOTHERM	38.19	79.55	1.844	598.2	18.62
EXOTHERM	38.65	80.43	1.913	606.7	18.48
EXOTHERM	39.23	81.55	1.931	617.8	19.14
EXOTHERM	39.71	82.47	1.916	627.7	20.62
EXOTHERM	40.21	83.53	2.120	638.0	20.60
EXOTHERM	40.61	84.41	2.200	646.6	21.50
EXOTHERM	41.09	85.53	2.333	657.3	22.29
EXOTHERM	41.45	86.39	2.388	665.4	22.50
EXOTHERM	41.91	87.48	2.369	675.6	22.17
EXOTHERM	42.37	88.56	2.347	686.2	23.04
EXOTHERM	42.71	89.42	2.529	693.5	21.47
EXOTHERM	43.17	90.55	2.456	703.1	20.87
EXOTHERM	43.53	91.42	2.416	709.8	18.61
EXOTHERM	43.99	92.51	2.369	719.3	20.65
EXOTHERM	44.35	93.40	2.472	728.1	24.44
EXOTHERM	44.75	94.52	2.800	739.7	29.00
EXOTHERM	45.05	95.45	3.100	749.6	33.00
EXOTHERM	45.35	96.47	3.400	760.8	37.33
EXOTHERM	45.59	97.36	3.708	770.7	41.25
EXOTHERM	45.83	98.36	4.166	781.6	45.42
EXOTHERM	46.07	99.42	4.416	793.5	49.58
EXOTHERM	46.27	100.36	4.700	805.2	58.50
EXOTHERM	46.47	101.41	5.250	817.9	63.50
EXOTHERM	46.63	102.39	6.125	828.6	66.87
EXOTHERM	46.79	103.42	6.437	840.7	75.63
EXOTHERM	46.95	104.55	7.062	853.5	80.00
EXOTHERM	47.07	105.53	8.166	863.7	85.00
EXOTHERM	47.19	106.55	8.500	874.5	90.00
EXOTHERM	47.31	107.66	9.250	886.3	98.33
EXOTHERM	47.39	108.47	10.125	894.6	103.75
EXOTHERM	47.47	109.38	11.375	903.0	105.00
EXOTHERM	47.57	110.51	11.300	914.2	112.00
EXOTHERM	47.65	111.56	13.125	924.3	126.25
EXOTHERM	47.71	112.45	14.833	932.4	135.00
EXOTHERM	47.77	113.41	16.000	941.4	150.00

DO A 022153
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EXOTHERM	47.83	114.50	18.166	951.4	166.67
EXOTHERM	47.87	115.35	21.250	986.4	875.00
EXOTHERM	47.91	116.65	32.500	384.7	-1.504E+004
EXOTHERM	47.93	121.73	254.000	15.1	-1.848E+004
EXOTHERM	47.95	129.55	391.000	14.7	-20.00
EXOTHERM	47.97	137.13	379.000	14.6	-5.00
EXOTHERM	47.99	143.11	299.000	14.6	0.00
EXOTHERM	48.01	147.52	220.500	14.5	-5.00
EXOTHERM	48.03	150.79	163.500	14.4	-5.00
EXOTHERM	48.05	153.27	124.000	14.4	0.00
EXOTHERM	48.07	155.19	96.000	14.3	-5.00
EXOTHERM	48.09	156.67	74.000	14.3	0.00
EXOTHERM	48.11	157.83	58.000	14.3	0.00
EXOTHERM	48.13	158.80	48.500	14.3	0.00
EXOTHERM	48.15	159.60	40.000	14.2	-5.00
EXOTHERM	48.17	160.27	33.500	14.2	0.00
EXOTHERM	48.19	160.85	29.000	14.2	0.00
EXOTHERM	48.21	161.35	25.000	14.1	-5.00
EXOTHERM	48.23	161.79	22.000	14.1	0.00
EXOTHERM	48.25	162.18	19.500	14.1	0.00
EXOTHERM	48.27	162.52	17.000	14.1	0.00
EXOTHERM	48.29	162.82	15.000	14.0	-5.00
EXOTHERM	48.31	163.10	14.000	14.0	0.00
EXOTHERM	48.33	163.36	13.000	14.0	0.00
EXOTHERM	48.35	163.61	12.500	14.0	0.00
EXOTHERM	48.37	163.81	10.000	14.0	0.00
EXOTHERM	48.41	164.18	9.250	13.9	-2.50
EXOTHERM	48.45	164.50	8.000	13.8	-2.50
EXOTHERM	48.49	164.78	7.000	13.8	0.00
EXOTHERM	48.53	165.00	5.500	13.8	0.00
EXOTHERM	48.57	165.20	5.000	13.8	0.00
EXOTHERM	48.63	165.43	3.833	13.8	0.00
EXOTHERM	48.71	165.68	3.125	13.7	-1.25
EXOTHERM	48.85	165.88	1.428	13.5	-1.43
EXOTHERM	49.39	165.68	0.370	13.3	-0.37
END LIST	0.00	0.00	0.000	0.0	0.27

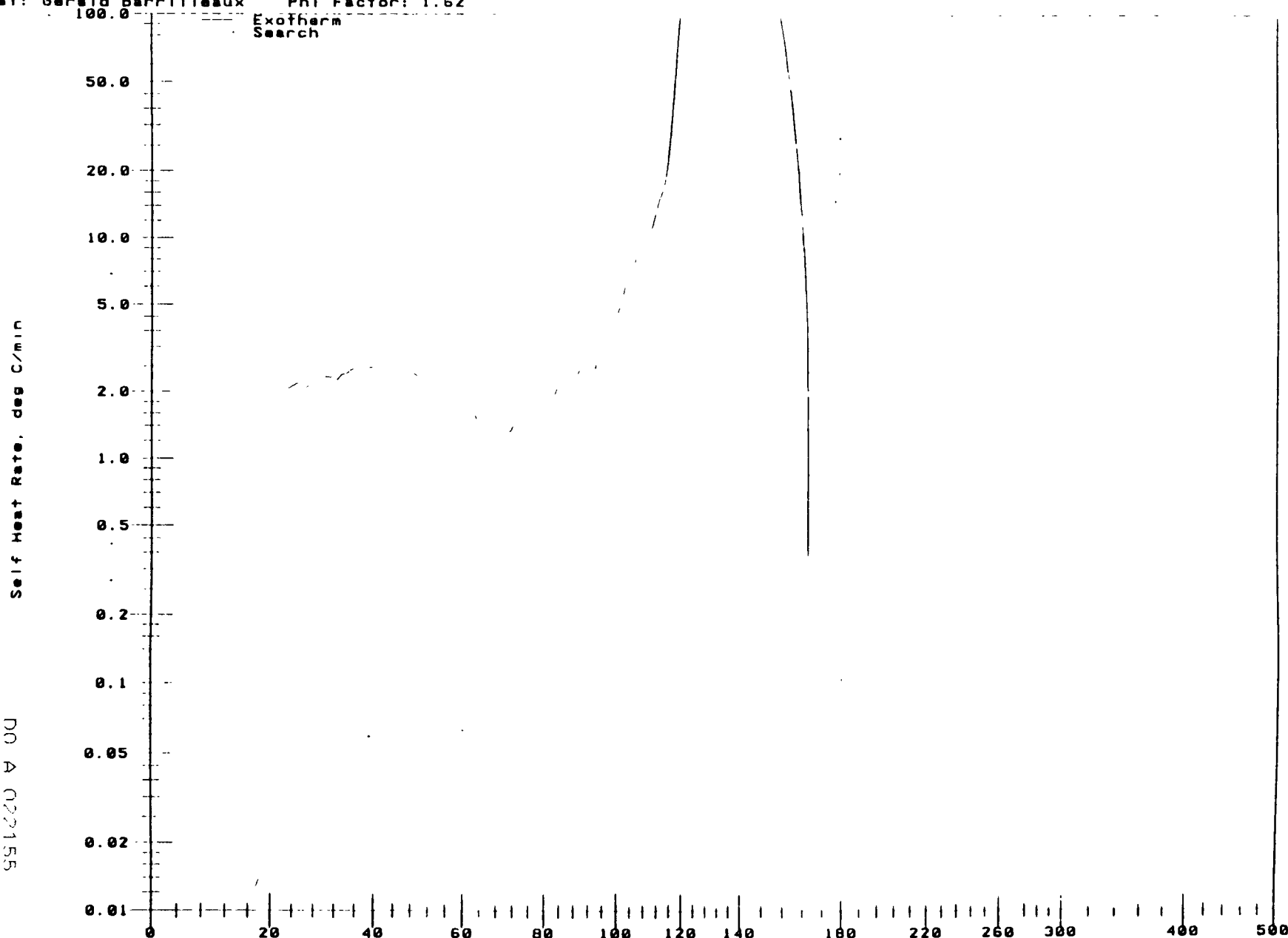
ARC

SELF-HEAT RATE VS. TEMPERATURE

Sample : Steam & Process SP-CM Sealant + Liquid Chlorine
ARC: ARC SYSTEM 2 Weight (gm): 6.330
Customer: Clark Pontlier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phil Factor: 1.62

Run Date: 04-24-92
Plotted Date: 04-27-93

Time : 16:49
Time : 00:11



DO A 027155
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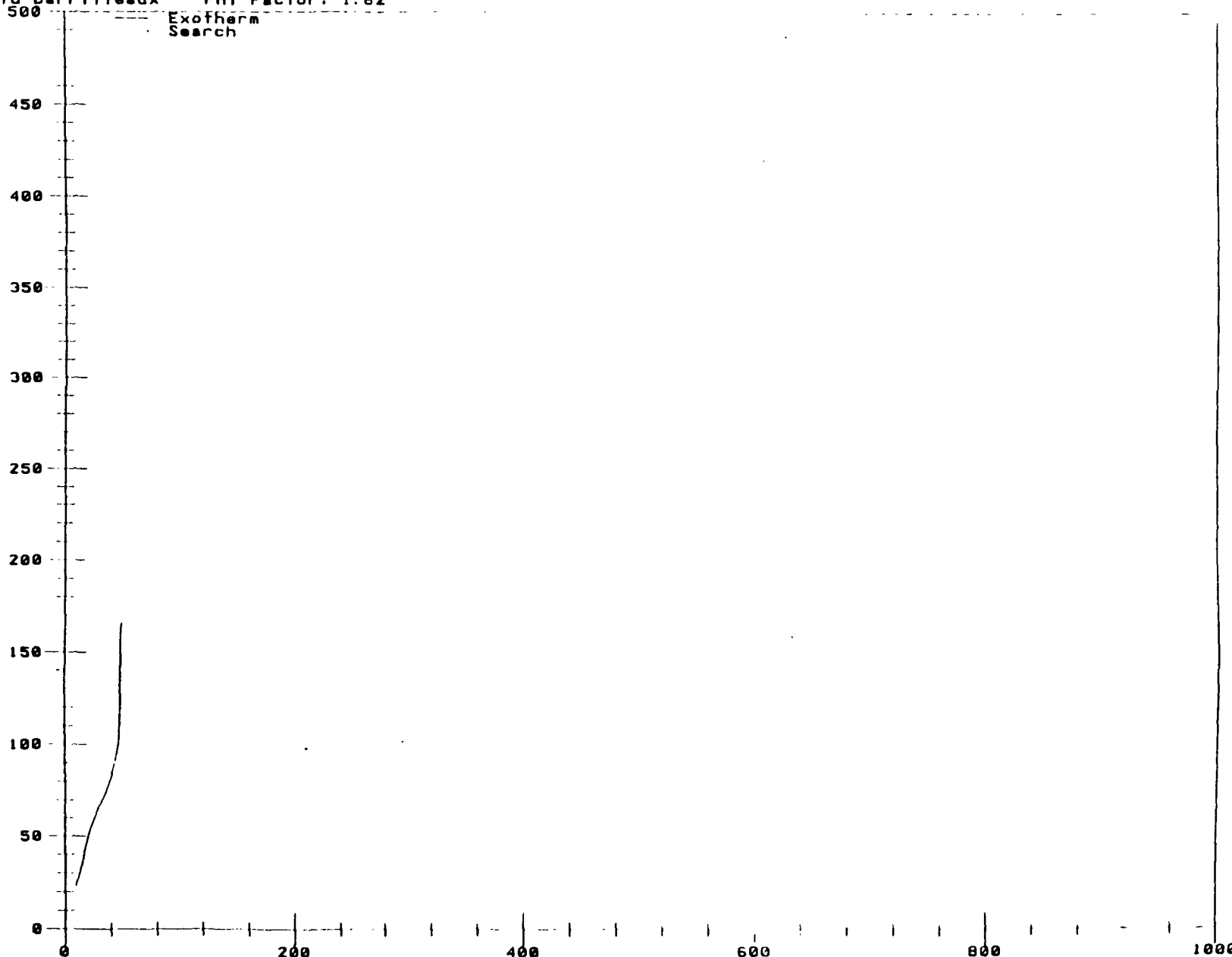
ARC

TEMPERATURE VS. TIME PLOT

Sample : Steam & Process SP-CH Separator + Liquid Chlorine
ARC: SYSTEM 2 Weight (gm): 6.338
Customer: Clark Pontlier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.62

Run Date: 04-24-92 Time : 16:49
Plotted Date: 04-27-93 Time : 08:22

Temperature, deg C



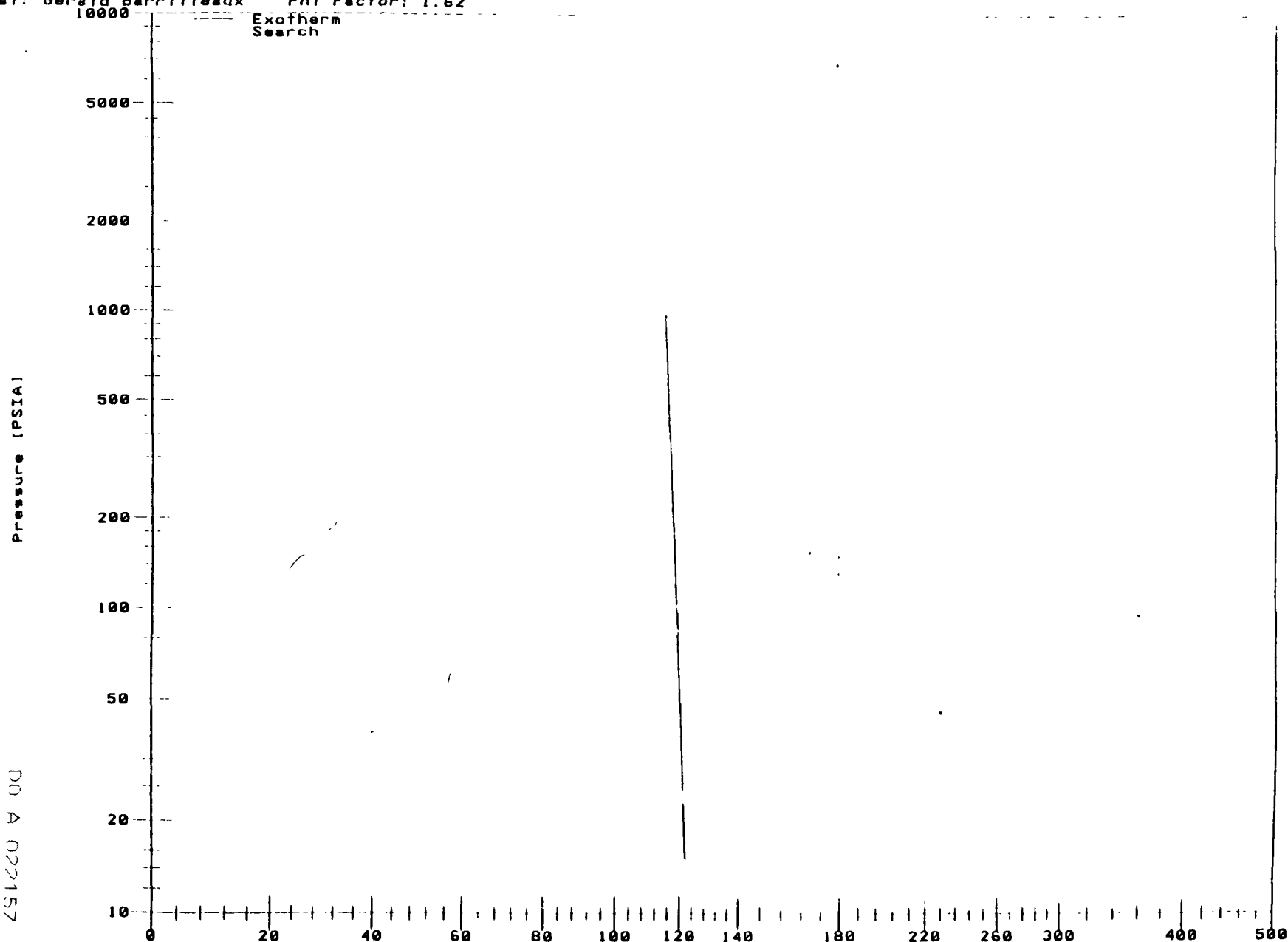
DO A 022156
CONFIDENTIAL

ARC

PRESSURE VS. TEMPERATURE

Sample: Steam & Process SP-CM Sealant + Liquid Chlorine
ARC: SYSTEM 2 Weight (gm): 6.330
Customer: Clark Ponthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.62

Run Date: 04-24-92 Time: 16:49
Plotted Date: 04-27-93 Time: 00:17



DO A 022157
CONFIDENTIAL

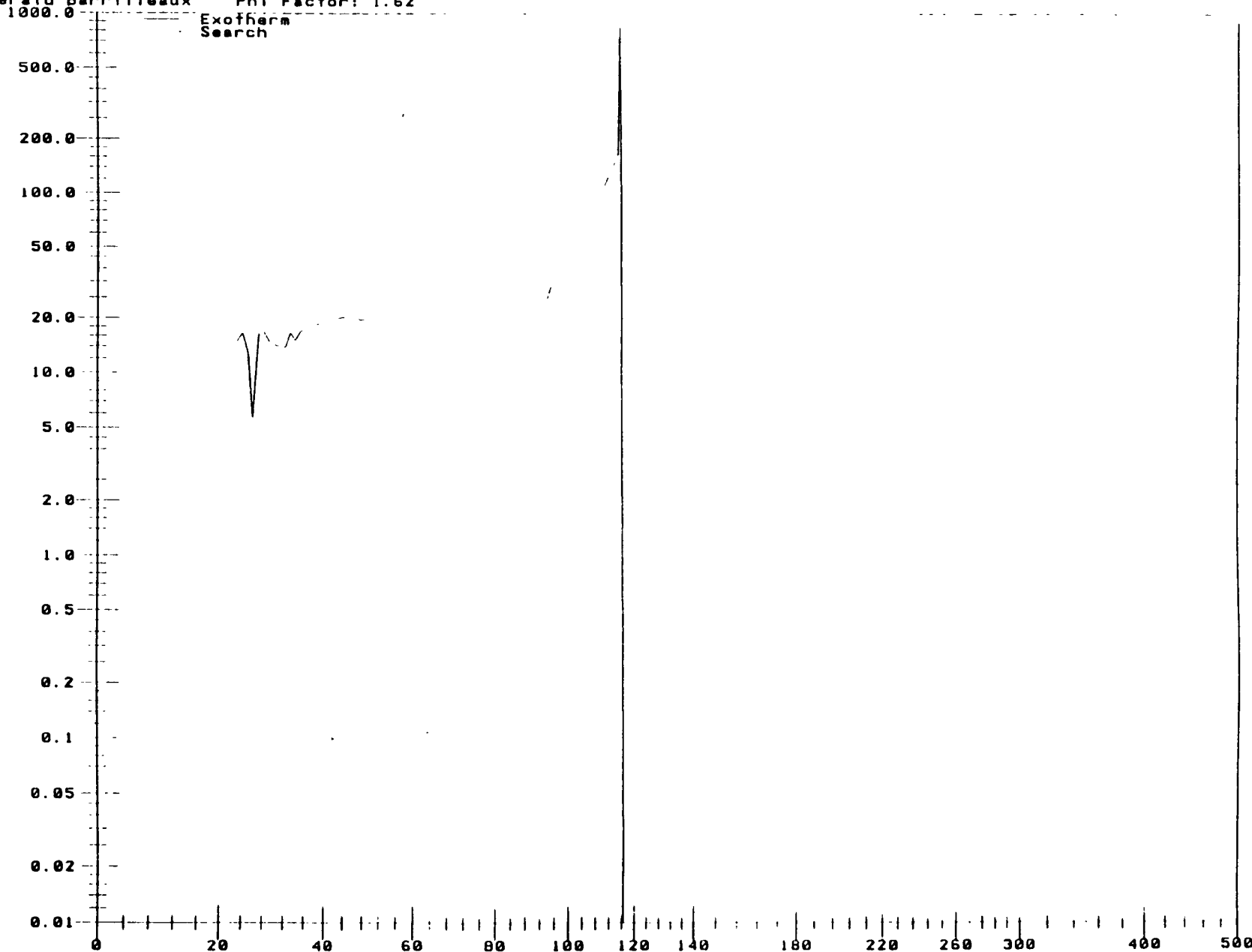
ARC

PRESSURE RATE VS. TEMPERATURE

Sample : Steam & Process SP-CM Sealant + Liquid Chlorine
ARC: SYSTEM 2 Weight (gm): 6.330
Customer: Clark Ponthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phil Factor: 1.62

Run Date: 04-24-92 Time : 16:49
Plotted Date: 04-27-93 Time : 00:32

Pressure Rate (PSI/Min)

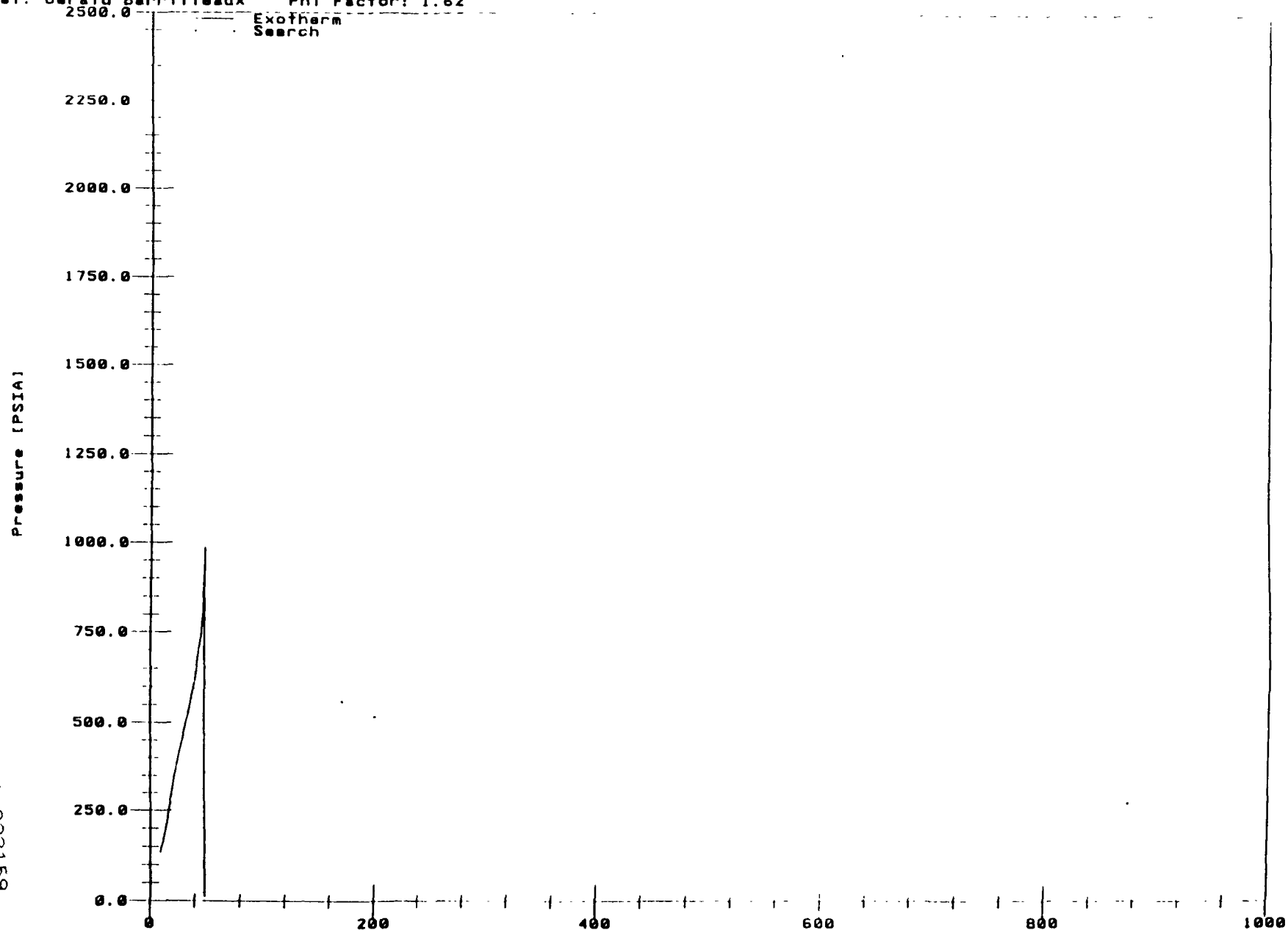


DO A 022158
CONFIDENTIAL

ARC PRESSURE VS. TIME

Sample : Steam & Process SP-CM Sealant + Liquid Chlorine
ARC : SYSTEM 2 Weight (gm) : 6.330
Customer : Clark Bonthier Operator : Gerald Barrilleaux
Analyst : Gerald Barrilleaux Phil Factor : 1.62

Run Date : 04-24-92 Time : 16:49
Plotted Date : 04-27-93 Time : 00:27



DO A 022159
CONFIDENTIAL

DOW CONFIDENTIAL INFORMATION
ANALYTICAL REPORT Noah 3.17 RCL: 92-0711
Analytical Sciences, Louisiana Division, Dow Chemical Company

TO: Clark Ponthier Chlorine Charge # 25

TITLE: Accelerating Rate Calorimetry Study of Steam & Process SP-300D + Chlorine

AUTHOR(S)
Gerald Barrilleaux

Reviewed by

Gerald Barrilleaux

Ran on: 04-30-92 at 13:50 -- Analyzed on: 04-30-92 at 15:35
ARC: ARC SYSTEM 2

SUMMARY

The following results have been obtained by Accelerating Rate Calorimetry (ARC). Refer to data plots contained within this report for more detail.

CAUTION: The following data were generated under specific phi factor conditions. These data should NOT be applied to larger scale operations without considering the effect of phi on the ARC results. Please contact Reactive Chemicals personnel for further interpretations and applications of these data.

RCL: 92-0711 Steam & Process SP-300D + Chlorine

A 7.670 g sample was loaded into a No. 3.00, Hastalloy C ARC sample container which yields a phi factor of 1.48 assuming an average sample specific heat of 0.500 cal/g deg C. The sample atmosphere was Chlorine.

The programmed step heating was initiated at 21 deg C with a heat step of 10.0 deg C.

An exothermic reaction was detected at 22 deg C and 111.0 psia with a self-heating rate of 0.08 deg C/min. This exotherm was terminated at 175 deg C and a pressure of 1361 psi, due to reaching the specified END TEMPERATURE of 175 deg C. If the exotherm had been allowed to continue, it may have reached significantly higher temperatures and/or pressures. Therefore, these data may not represent the full potential of this exothermic reaction.

DOW CONFIDENTIAL INFORMATION

----- ACCELERATING RATE CALORIMETRY Noah 3.17-----

Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0711 -- Ran on: 04-30-92 at 13:50 -- Analyzed on: 04-30-92 at 15:35

Sample description:

Steam & Process SP-300D + Chlorine

Steam & Process SP-300D + Liquid Chlorine

Submitted by: Clark Ponthier

Phone Number: (504) 389-8167

Operator: Gerald Barrilleaux

Analyst: Gerald Barrilleaux

From: Chlorine

Charge Number: 25

ARC: ARC SYSTEM 2

Experimental Conditions

Tape Run number -----	711.00
Container type -----	3.00
Container material-----	Hastalloy C
Container weight, Mb -----	18.389 g
Sample weight, Ms -----	7.670 g
Total System Volume, Vb (approx) -----	10.000 mL
Sample Volume, Vs (approx) -----	4.950 mL
Head space volume, Vg (approx) -----	5.050 mL
Head space atmosphere-----	Chlorine
Container Heat Capacity, Cb -----	0.100 cal/deg C g
Heat Capacity of the sample, Cs (assumed) -----	0.500 cal/deg C g
Starting temperature -----	21.0 deg C
End temperature -----	175.0 deg C
Heat step -----	10.0 deg C
Wait time -----	10 min
Isothermal wait time -----	0 min
Calorimetric rate threshold -----	0.020 deg C/min
Stirring rate -----	0 RPM

Thermal Ratio, $\Phi = 1 + (M_b C_b)/(M_s C_s)$ ----- 1.48

RUN PREPARATIONS:

Since the SP-300D is a very tacky sealant, it was rolled into narrow strips and chilled in liquid nitrogen in order to load a Hastalloy C ARC sphere via the 1/8" inlet. Once a sufficient amount of sealant was loaded, the sphere and contents were chilled in liquid nitrogen and liquid chlorine was added. The sphere remained in liquid nitrogen until it was attached to the calorimeter. Air intrusion was prevented.

RUN COMMENTS:

The sphere was allowed to equilibrate to ambient temperature, 21 deg. C, which was also set as start temperature, before the experiment was begun. The analysis ended at the temperature set, 175 deg. C, although self-heating was still increasing at this time. After cooling, pressure was 609 psia at 25.6 deg. C.

EXPERIMENTAL

DO A 022161
CONFIDENTIAL

The specified amount of the sample is introduced into the sample bomb which is in turn fitted to the calorimeter lid. The calorimeter is then rapidly heated to the initial temperature after which either an isothermal age mode or a WAIT-SEARCH-HEAT sequence is entered to look for exothermic reaction self-heating. When less than the self-heat rate threshold is observed during the SEARCH mode or at the end of the isothermal age time, a heat step is applied to the calorimeter contents. A WAIT-SEARCH-HEAT process is repeated until the self-heat rate of the bomb exceeds the threshold rate at which time the reaction is allowed to proceed on its own under nearly adiabatic conditions. Detailed procedures for the ARC can be found in the CSI operating manual.

GENERAL PRECAUTIONS

Accelerating rate calorimetry offers a useful method for evaluating exothermic run-away processes. However, caution should be used when relating the ARC data to an actual plant process since ϕ for an ARC experiment is usually very different from ϕ for a large-scale reaction. In addition, special consideration is needed when kinetic complications are present in the ARC data. For example, the effects of autocatalysis or inhibitors can vastly change the runaway reaction in chemical storage situations.

Consultation with Reactive Chemicals is recommended in the applications of ARC data to plant processes. Extrapolation of the data outside the experimental range is generally unwise.

DOW CONFIDENTIAL INFORMATION

----- ACCELERATING RATE CALORIMETRY Noah 3.17-----
 Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0711 -- Ran on: 04-30-92 at 13:50 -- Analyzed on: 04-30-92 at 15:35

Sample description:

Steam & Process SP-300D + Chlorine

Steam & Process SP-300D + Liquid Chlorine

Submitted by: Clark Ponthier

Phone Number: (504) 389-8167

Operator: Gerald Barrilleaux

Analyst: Gerald Barrilleaux

From: Chlorine

Charge Number: 25

ARC: ARC SYSTEM 2

DATA LIST

=====

	Time (min)	Temperature (C)	Heat Rate (C/min)	Pressure (psia)	Pressure Rate (psia/min)
START LISTING	0.00	0.00	0.000	0.0	0.00
START Exotherm	0.00	0.00	0.000	0.0	0.00
EXOTHERM	13.41	22.17	0.078	111.0	8.28
EXOTHERM	28.97	23.21	0.066	114.5	0.22
EXOTHERM	47.11	24.21	0.055	118.8	0.24
EXOTHERM	67.43	25.21	0.049	123.4	0.23
EXOTHERM	87.59	26.23	0.050	128.2	0.24
EXOTHERM	108.55	27.26	0.049	133.4	0.25
EXOTHERM	127.87	28.26	0.051	138.3	0.25
EXOTHERM	147.87	29.31	0.052	143.7	0.27
EXOTHERM	167.39	30.34	0.052	149.1	0.28
EXOTHERM	185.31	31.35	0.056	154.3	0.29
EXOTHERM	204.13	32.36	0.053	160.0	0.30
EXOTHERM	218.15	33.17	0.057	164.4	0.31
EXOTHERM	236.71	34.22	0.056	170.5	0.33
EXOTHERM	254.27	35.26	0.059	176.5	0.34
EXOTHERM	271.41	36.26	0.058	182.5	0.35
EXOTHERM	288.65	37.29	0.059	188.8	0.37
EXOTHERM	304.57	38.31	0.064	195.0	0.39
EXOTHERM	320.67	39.34	0.063	201.6	0.41
EXOTHERM	335.37	40.36	0.069	208.0	0.44
EXOTHERM	347.41	41.18	0.068	213.5	0.46
EXOTHERM	361.13	42.20	0.074	220.1	0.48
EXOTHERM	374.53	43.24	0.077	227.0	0.51
EXOTHERM	387.37	44.25	0.078	234.0	0.55
EXOTHERM	399.03	45.26	0.086	240.8	0.58
EXOTHERM	410.51	46.27	0.087	247.9	0.62
EXOTHERM	421.75	47.28	0.089	255.3	0.66
EXOTHERM	432.77	48.31	0.093	262.9	0.69
EXOTHERM	443.45	49.31	0.093	270.8	0.74
EXOTHERM	453.29	50.33	0.103	278.5	0.78
EXOTHERM	460.97	51.17	0.109	284.9	0.83
EXOTHERM	470.33	52.20	0.110	293.0	0.87

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 CONFIDENTIAL

EXOTHERM	479.33	53.21	0.112	301.3	0.92
EXOTHERM	487.37	54.22	0.125	309.2	0.98
EXOTHERM	495.63	55.25	0.124	317.9	1.05
EXOTHERM	503.23	56.27	0.134	326.3	1.11
EXOTHERM	510.53	57.29	0.139	334.8	1.16
EXOTHERM	517.73	58.33	0.144	343.7	1.24
EXOTHERM	524.17	59.37	0.161	352.3	1.34
EXOTHERM	529.47	60.19	0.154	359.7	1.40
EXOTHERM	535.55	61.22	0.169	368.5	1.45
EXOTHERM	541.59	62.25	0.170	377.9	1.56
EXOTHERM	547.11	63.27	0.184	387.1	1.67
EXOTHERM	552.33	64.30	0.197	396.4	1.78
EXOTHERM	557.55	65.32	0.195	406.0	1.84
EXOTHERM	562.67	66.34	0.199	415.9	1.93
EXOTHERM	567.31	67.36	0.219	425.5	2.07
EXOTHERM	570.99	68.18	0.222	433.5	2.17
EXOTHERM	575.47	69.18	0.223	443.6	2.25
EXOTHERM	579.79	70.21	0.238	453.8	2.36
EXOTHERM	583.95	71.25	0.250	464.0	2.45
EXOTHERM	587.93	72.28	0.258	474.6	2.66
EXOTHERM	591.81	73.32	0.268	485.0	2.68
EXOTHERM	595.57	74.34	0.271	495.5	2.79
EXOTHERM	599.17	75.36	0.283	506.1	2.94
EXOTHERM	602.01	76.17	0.285	514.9	3.10
EXOTHERM	605.53	77.20	0.292	525.7	3.07
EXOTHERM	609.07	78.24	0.293	536.7	3.11
EXOTHERM	612.37	79.25	0.306	546.8	3.06
EXOTHERM	615.65	80.29	0.317	557.0	3.11
EXOTHERM	618.95	81.32	0.312	567.1	3.06
EXOTHERM	622.37	82.36	0.304	577.4	3.01
EXOTHERM	625.19	83.18	0.290	585.7	2.94
EXOTHERM	628.77	84.22	0.290	595.4	2.71
EXOTHERM	632.53	85.27	0.279	604.9	2.53
EXOTHERM	636.23	86.31	0.281	614.8	2.68
EXOTHERM	640.23	87.36	0.262	624.3	2.38
EXOTHERM	644.37	88.36	0.241	632.9	2.08
EXOTHERM	647.75	89.19	0.245	640.9	2.37
EXOTHERM	652.31	90.23	0.228	650.8	2.17
EXOTHERM	657.27	91.24	0.203	660.6	1.98
EXOTHERM	662.73	92.26	0.186	670.5	1.81
EXOTHERM	668.67	93.28	0.171	680.1	1.62
EXOTHERM	675.91	94.31	0.142	690.3	1.41
EXOTHERM	684.91	95.33	0.113	699.9	1.07
EXOTHERM	696.05	96.36	0.092	709.7	0.88
EXOTHERM	705.87	97.18	0.083	717.7	0.81
EXOTHERM	719.73	98.21	0.074	727.5	0.71
EXOTHERM	734.85	99.23	0.067	736.8	0.62
EXOTHERM	751.69	100.24	0.059	744.6	0.46
EXOTHERM	769.61	101.24	0.055	752.2	0.42
EXOTHERM	787.73	102.27	0.056	758.8	0.36
EXOTHERM	804.13	103.28	0.061	764.9	0.37
EXOTHERM	818.97	104.28	0.067	770.4	0.37
EXOTHERM	833.53	105.33	0.072	775.8	0.37
EXOTHERM	846.23	106.36	0.081	781.7	0.46
EXOTHERM	855.35	107.18	0.089	786.6	0.54
EXOTHERM	865.91	108.20	0.096	792.1	0.52
EXOTHERM	875.51	109.22	0.106	797.7	0.58
EXOTHERM	884.51	110.25	0.114	803.5	0.64
EXOTHERM	892.37	111.25	0.127	809.4	0.75
EXOTHERM	899.31	112.25	0.144	816.6	1.04

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EXOTHERM	905.25	113.28	0.173	824.2	1.28
EXOTHERM	910.33	114.30	0.200	832.8	1.69
EXOTHERM	915.05	115.32	0.216	841.2	1.78
EXOTHERM	919.45	116.35	0.234	849.3	1.84
EXOTHERM	923.63	117.37	0.244	857.4	1.94
EXOTHERM	926.75	118.19	0.262	863.4	1.92
EXOTHERM	930.69	119.22	0.261	870.7	1.85
EXOTHERM	934.59	120.24	0.261	877.5	1.74
EXOTHERM	938.07	121.26	0.293	886.3	2.53
EXOTHERM	941.19	122.27	0.323	894.7	2.69
EXOTHERM	944.31	123.28	0.323	903.6	2.85
EXOTHERM	947.25	124.32	0.353	911.4	2.65
EXOTHERM	950.13	125.35	0.357	919.0	2.64
EXOTHERM	952.29	126.17	0.379	925.2	2.87
EXOTHERM	955.05	127.21	0.376	933.5	3.01
EXOTHERM	957.51	128.25	0.422	941.5	3.25
EXOTHERM	959.87	129.28	0.436	949.6	3.43
EXOTHERM	962.13	130.29	0.446	958.9	4.12
EXOTHERM	964.29	131.34	0.486	967.4	3.94
EXOTHERM	966.29	132.36	0.510	976.4	4.50
EXOTHERM	967.85	133.19	0.532	983.4	4.49
EXOTHERM	969.77	134.24	0.546	993.0	5.00
EXOTHERM	971.57	135.29	0.583	1003.0	5.56
EXOTHERM	973.25	136.34	0.625	1012.9	5.89
EXOTHERM	974.53	137.18	0.656	1021.0	6.33
EXOTHERM	976.01	138.18	0.675	1030.6	6.49
EXOTHERM	977.53	139.25	0.703	1041.3	7.04
EXOTHERM	978.93	140.29	0.742	1052.1	7.71
EXOTHERM	980.01	141.17	0.814	1060.4	7.69
EXOTHERM	981.33	142.26	0.825	1072.5	9.17
EXOTHERM	982.57	143.34	0.870	1084.4	9.60
EXOTHERM	983.53	144.26	0.958	1094.5	10.52
EXOTHERM	984.61	145.29	0.953	1106.4	11.02
EXOTHERM	985.57	146.32	1.072	1117.3	11.35
EXOTHERM	986.57	147.37	1.050	1129.8	12.50
EXOTHERM	987.29	148.20	1.152	1139.0	12.78
EXOTHERM	988.21	149.25	1.141	1151.2	13.26
EXOTHERM	989.05	150.33	1.285	1163.1	14.17
EXOTHERM	989.75	151.21	1.257	1173.0	14.14
EXOTHERM	990.53	152.27	1.358	1184.7	15.00
EXOTHERM	991.27	153.33	1.432	1195.8	15.00
EXOTHERM	991.87	154.19	1.433	1204.5	14.50
EXOTHERM	992.59	155.27	1.500	1212.7	11.39
EXOTHERM	993.29	156.35	1.542	1220.6	11.29
EXOTHERM	993.81	157.19	1.615	1226.8	11.92
EXOTHERM	994.43	158.25	1.709	1236.2	15.16
EXOTHERM	995.03	159.30	1.750	1246.3	16.83
EXOTHERM	995.61	160.36	1.827	1253.8	12.93
EXOTHERM	996.07	161.24	1.913	1257.4	7.83
EXOTHERM	996.61	162.30	1.962	1261.9	8.33
EXOTHERM	997.05	163.17	1.977	1271.1	20.91
EXOTHERM	997.57	164.25	2.076	1282.2	21.35
EXOTHERM	998.07	165.38	2.260	1292.6	20.80
EXOTHERM	998.47	166.27	2.225	1299.9	18.25
EXOTHERM	998.97	167.37	2.200	1310.0	20.20
EXOTHERM	999.37	168.28	2.275	1317.0	17.50
EXOTHERM	999.77	169.22	2.350	1324.0	17.50
EXOTHERM	1000.25	170.34	2.333	1332.0	16.67
EXOTHERM	1000.65	171.23	2.225	1338.1	15.25
EXOTHERM	1001.13	172.33	2.291	1345.4	15.21

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EXOTHERM	1001.53	173.27	2.350	1351.5	15.25
EXOTHERM	1002.01	174.39	2.333	1358.1	13.75
EXOTHERM	1002.21	174.84	2.250	1361.4	16.50
END LIST	0.00	0.00	0.000	0.0	1.36

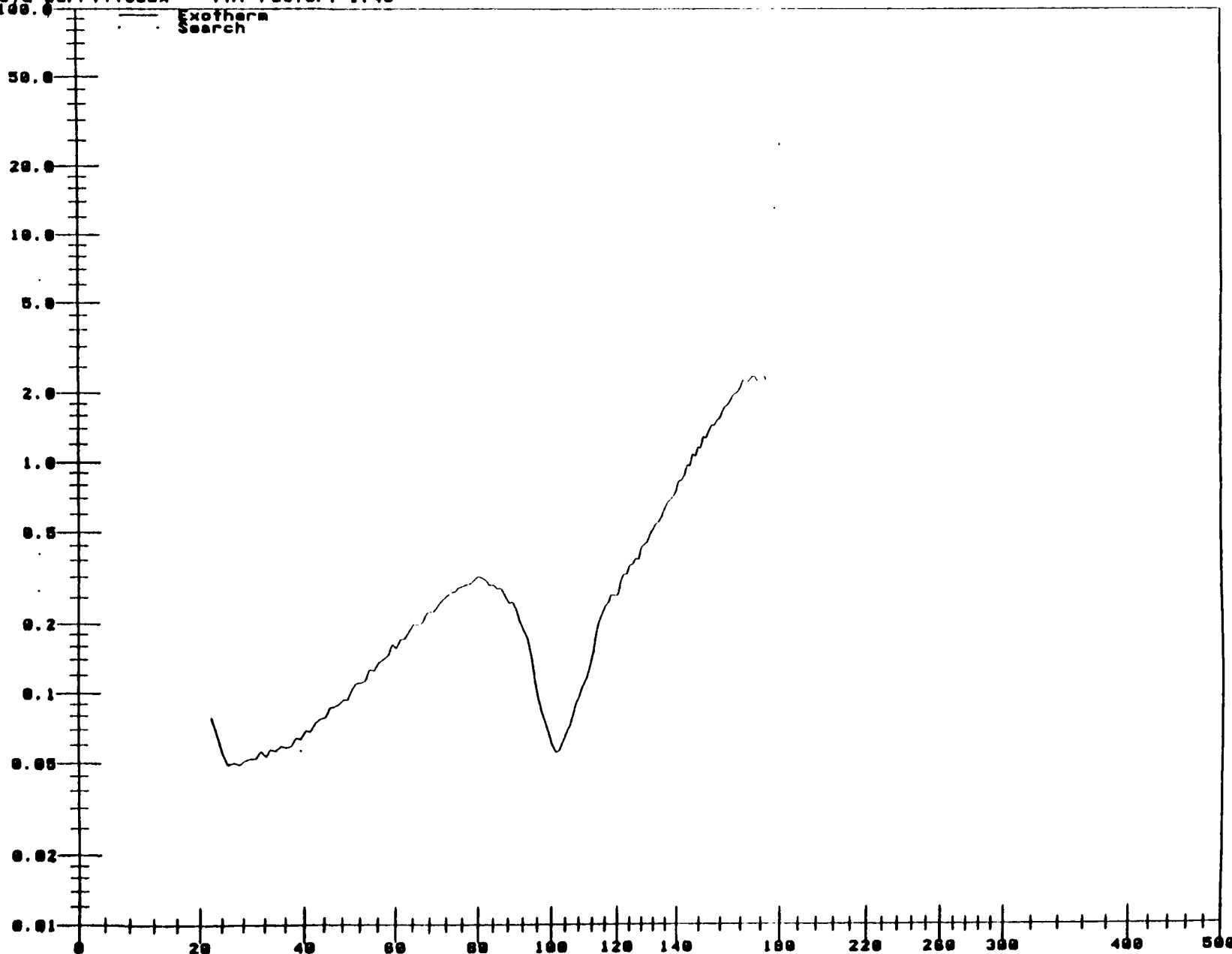
ARC

SELF-HEAT RATE VS. TEMPERATURE

Sample: Steam & Process SP-3000 + Chlorine
 ARC System 2 Weight (gms): 7.678
 Customer: Clark Pontler Operator: Gerald Barrilleaux
 Analyst: Gerald Barrilleaux PFI Factor: 1.48

Run Date: 04-30-92
 Plotted Date: 04-30-92 Time: 13:58

Self Heat Rate, deg C/min



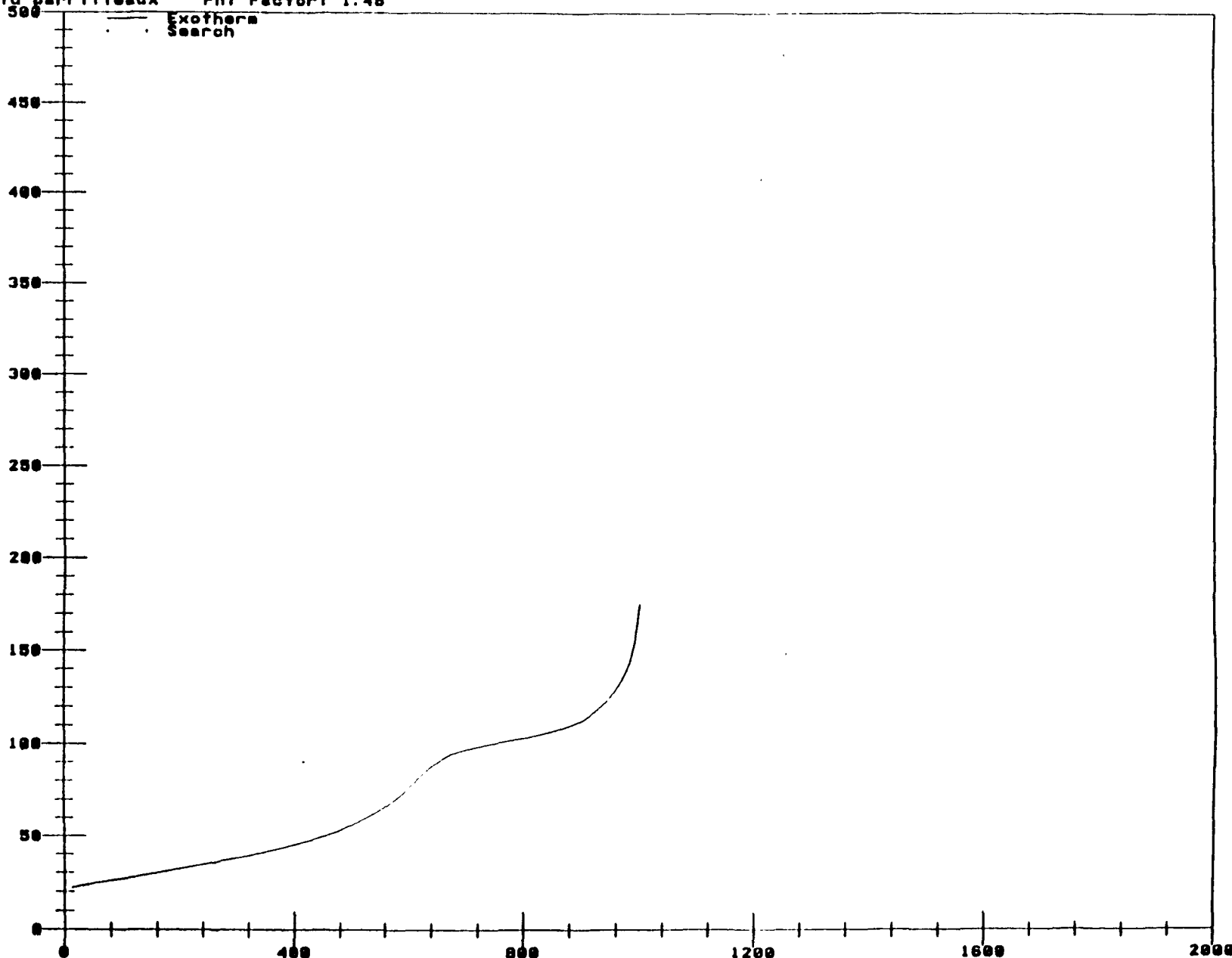
DO A 027167
 CONFIDENTIAL

TEMPERATURE VS. TIME PLOT

SAMPLE: Steep & Process SP-3880 + Chlorine
ARC SYSTEM 2 Weight (g): 7.67g
Customer: Clark Ponthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux PH Factor: 1.48

Run Date: 84-30-92 Time: 13:59
Plotted Date: 84-30-92

Temperature, deg C



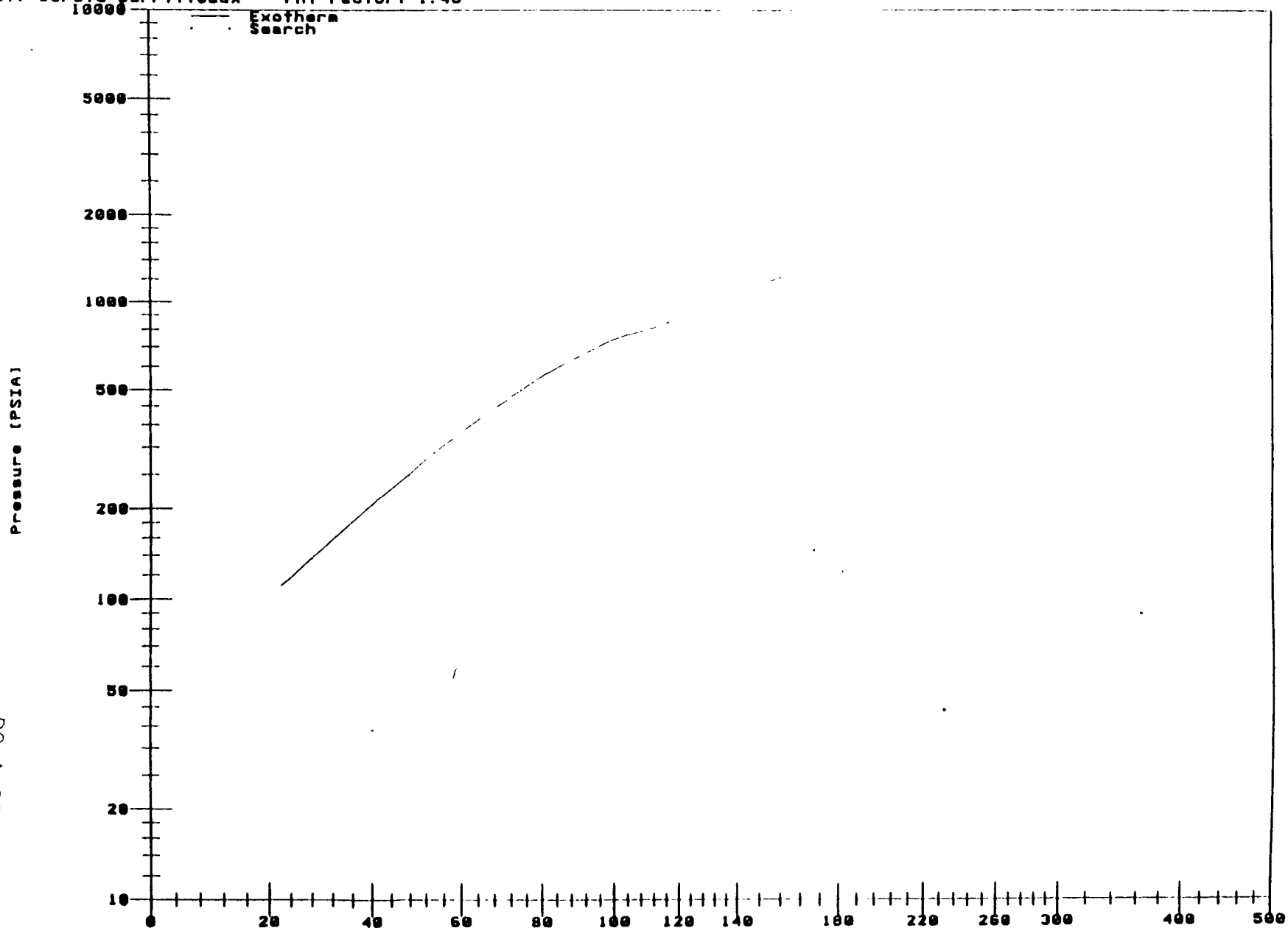
DO A 022168
CONFIDENTIAL

ARC

PRESSURE VS. TEMPERATURE

SAMPLE: Stearns & Process SP-3000 + Chlorine
ARC SYSTEM 2 Weight (gm): 7.670
Customer: Clark Conthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux PHF Factor: 1.48

Run Date: 04-30-92 Time: 13:50
Plotted Date: 04-30-92



DO A 022169
CONFIDENTIAL

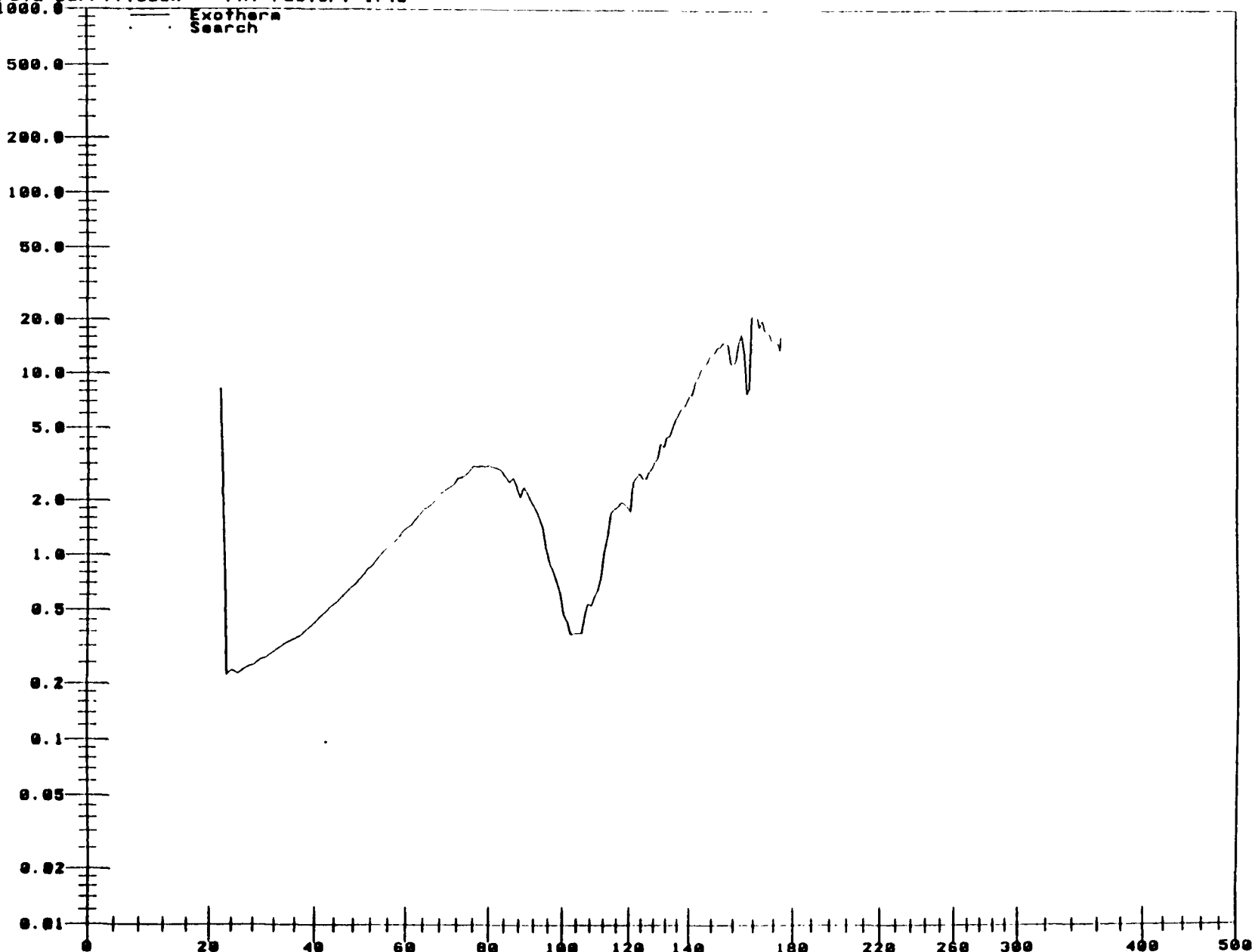
ARC

PRESSURE RATE VS. TEMPERATURE

Sample: Steam & Process SP-3000 + Chlorine
ARC: System 2 Weight (gm) 7.678
Customer: Clara Bonthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.48

Run Date: 04-30-92 Time: 13:50
Plotted Date: 04-30-92

Pressure Rate (PSI/Min)



Exotherm
Search

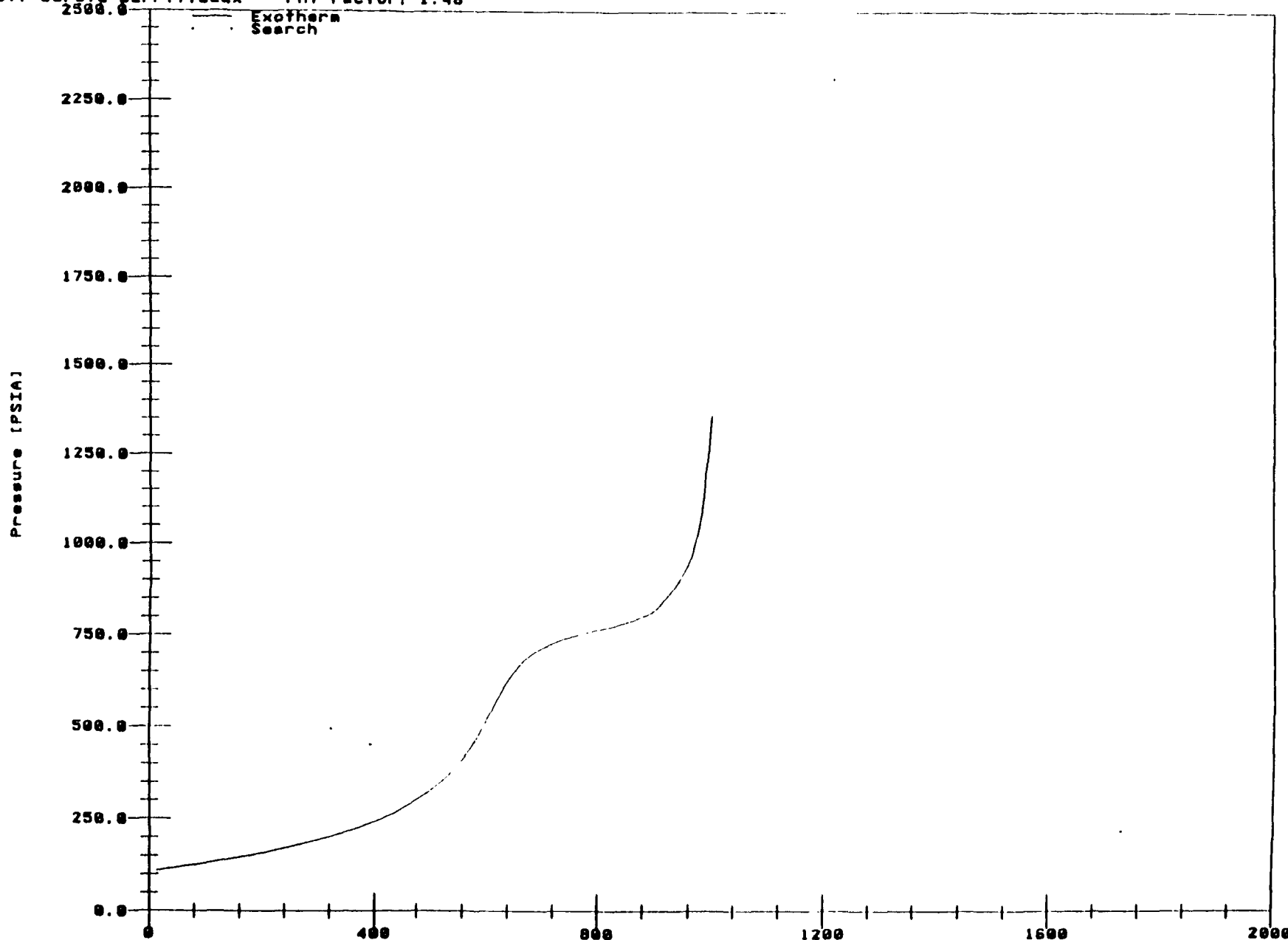
DO A 022170
CONFIDENTIAL

ARC

PRESSURE VS. TIME

Sample: SP-3000 + Chlorine
ARC SYSTEM 2
Customer: Clark Ponthier
Analyst: Gerald Barrilleaux
Height (cm): 7.670
Operator: Gerald Barrilleaux
Phi Factor: 1.48

Run Date: 04-30-92 Time: 13:59
Plotted Date: 04-30-92 Time: 13:52



DO A 022171
CONFIDENTIAL

DOW CONFIDENTIAL INFORMATION

ANALYTICAL REPORT Noah 3.17

RCL: 92-0715

Analytical Sciences, Louisiana Division, Dow Chemical Company

TO: Clark Ponthier

Chlorine Plant

Charge # 25

TITLE: Accelerating Rate Calorimetry Study of Steam & Process SP-TFLO + Liquid Chlorine

AUTHOR(S)

Gerald Barrilleaux

Reviewed by

Ran on: 05-28-92 at 07:55 -- Analyzed on: 05-28-92 at 15:53

ARC: ARC SYSTEM 1

SUMMARY

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The following results have been obtained by Accelerating Rate Calorimetry (ARC). Refer to data plots contained within this report for more detail.

CAUTION: The following data were generated under specific phi factor conditions. These data should NOT be applied to larger scale operations without considering the effect of phi on the ARC results. Please contact Reactive Chemicals personnel for further interpretations and applications of these data.

RCL: 92-0715 Steam & Process SP-TFLO + Liquid Chlorine

A 8.140 g sample was loaded into a No. 3.00, Hastalloy C ARC sample container which yields a phi factor of 1.46 assuming an average sample specific heat of 0.500 cal/g deg C. The sample atmosphere was Chlorine.

Isothermal aging of the sample was begun at 21 deg C.

An exothermic reaction was detected at 139 deg C and 793.4 psia with a self-heating rate of 0.03 deg C/min. The maximum self-heat rate observed during this exotherm was 0.03 deg C/min at 139 deg C with a pressure of 793 psi. The observed temperature rise for this exotherm was 8 deg C. Using a phi factor of 1.46, the estimated adiabatic temperature rise is 12 deg C and the heat of reaction is 6 cal/g of total sample. This calculation assumes that any PV energy change during the reaction was negligible.

Additional exotherms were detected at 32, 124, 159, and 173 d g C.

DOW CONFIDENTIAL INFORMATION

----- ACCELERATING RATE CALORIMETRY Noah 3.17-----
 Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0715 -- Ran on: 05-28-92 at 07:55 -- Analyzed on: 05-28-92 at 15:53

Sample description:

Steam & Process SP-TFLO + Liquid Chlorine

Sealant SP-TFLO + Chlorine

Submitted by: Clark Ponthier
 Phone Number: (504) 389-8167
 Operator: Gerald Barrilleaux
 Analyst: Gerald Barrilleaux

From: Chlorin Plant
 Charge Number: 25
 ARC: ARC SYSTEM 1

Experimental Conditions

Tape Run number -----	715.00
Container type -----	3.00
Container material-----	Hastalloy C
Container weight, Mb -----	18.820 g
Sample weight, Ms -----	8.140 g
Total System Volume, Vb (approx) -----	10.000 mL
Sample Volume, Vs (approx) -----	5.000 mL
H ad space volume, Vg (approx) -----	5.000 mL
Head space atmosphere-----	Chlorine
Container Heat Capacity, Cb -----	0.100 cal/deg C g
Heat Capacity of the sample, Cs (assumed) -----	0.500 cal/deg C g
Starting temperature -----	21.0 deg C
End temperature -----	175.0 deg C
Heat step -----	10.0 deg C
Wait time -----	10 min
Isothermal wait time -----	0 min
Calorimetric rate threshold -----	0.020 deg C/min
Stirring rate -----	0 RPM

Thermal Ratio, $\Phi = 1 + (Mb C_b)/(Ms C_s)$ ----- 1.46

RUN PREPARATIONS:

The Teflon/Fluorolube material was formulated according to recommendations by G. Wagener, G. Barrilleaux, and J. Schell to Clark Ponthier. Loading into the Hastelloy C ARC sphere was accomplished by first rolling the sealant into thin strands and then freezing in liquid nitrogen. After loading of the sealant was completed, the sphere was immersed in liquid nitrogen and chlorine was added. The sphere was immediately attached to the calorimeter and allowed to gradually reach ambient temperature where the experiment was started.

5.0g TFLO + 3.14g Cl₂

RUN COMMENTS:

After cool-down, pressure was 243 psia at 24.3 deg. C.

EXPERIMENTAL

DO A 022173
 CONFIDENTIAL

The specified amount of the sample is introduced into the sample bomb which is in turn fitted to the calorimeter lid. The calorimeter is then

rapidly heated to the initial temperature after which either an isothermal age mode or a WAIT-SEARCH-HEAT sequence is entered to look for exothermic reaction self-heating. When less than the self-heat rate threshold is observed during the SEARCH mode or at the end of the isothermal age time, a heat step is applied to the calorimeter contents. A WAIT-SEARCH-HEAT process is repeated until the self-heat rate of the bomb exceeds the threshold rate at which time the reaction is allowed to proceed on its own under nearly adiabatic conditions. Detailed procedures for the ARC can be found in the CSI operating manual.

GENERAL PRECAUTIONS

Accelerating rate calorimetry offers a useful method for evaluating exothermic run-away processes. However, caution should be used when relating the ARC data to an actual plant process since ϕ for an ARC experiment is usually very different from ϕ for a large-scale reaction. In addition, special consideration is needed when kinetic complications are present in the ARC data. For example, the effects of autocatalysis or inhibitors can vastly change the runaway reaction in chemical storage situations.

Consultation with Reactive Chemicals is recommended in the applications of ARC data to plant processes. Extrapolation of the data outside the experimental range is generally unwise.

DOW CONFIDENTIAL INFORMATION

----- ACCELERATING RATE CALORIMETRY Noah 3.17-----
 Analytical Sciences, Louisiana Division, Dow Chemical Company

RCL: 92-0715 -- Ran on: 05-28-92 at 07:55 -- Analyzed on: 05-28-92 at 15:53

Sample description:

Steam & Process SP-TFLO + Liquid Chlorine

Sealant SP-TFLO + Chlorine

Submitted by: Clark Ponthier
 Phone Number: (504) 389-8167
 Operator: Gerald Barrilleaux
 Analyst: Gerald Barrilleaux

From: Chlorine Plant
 Charge Number: 25
 ARC: ARC SYSTEM 1

DATA LIST

=====

	Time (min)	Temperature (C)	Heat Rate (C/min)	Pressure (psia)	Pressure Rate (psia/min)
START LISTING	0.00	0.00	0.000	0.0	0.00
START Exotherm	0.00	0.00	0.000	0.0	0.00
EXOTHERM	132.90	32.21	0.019	146.4	1.10
EXOTHERM	181.37	32.99	0.016	149.4	0.06
START Exotherm	0.00	0.00	0.000	0.0	0.82
EXOTHERM	562.76	124.10	0.031	687.3	1.41
EXOTHERM	598.66	125.16	0.029	695.8	0.24
EXOTHERM	643.11	126.21	0.023	701.7	0.13
EXOTHERM	689.89	127.25	0.022	707.7	0.13
EXOTHERM	735.07	128.10	0.018	712.5	0.11
EXOTHERM	747.58	128.29	0.015	713.7	0.10
START Exotherm	0.00	0.00	0.000	0.0	0.95
EXOTHERM	800.68	139.36	0.032	793.4	1.50
EXOTHERM	836.61	140.42	0.029	801.9	0.24
EXOTHERM	873.31	141.50	0.029	809.5	0.21
EXOTHERM	905.09	142.36	0.027	815.4	0.19
EXOTHERM	946.07	143.41	0.025	822.9	0.18
EXOTHERM	989.81	144.44	0.023	830.2	0.17
EXOTHERM	1035.89	145.48	0.022	838.1	0.17
EXOTHERM	1086.69	146.50	0.020	844.3	0.12
EXOTHERM	1136.61	147.32	0.016	848.9	0.09
START Exotherm	0.00	0.00	0.000	0.0	0.75
EXOTHERM	1196.18	158.50	0.026	926.3	1.30
EXOTHERM	1242.50	159.51	0.021	933.4	0.15
EXOTHERM	1298.41	160.54	0.018	939.8	0.11
EXOTHERM	1357.26	161.55	0.017	946.1	0.11
EXOTHERM	1393.87	162.11	0.015	949.6	0.10
START Exotherm	0.00	0.00	0.000	0.0	0.68
EXOTHERM	1452.05	173.24	0.027	1018.5	1.18
EXOTHERM	1498.63	174.25	0.021	1024.3	0.12
EXOTHERM	1530.45	174.86	0.019	1026.9	0.08

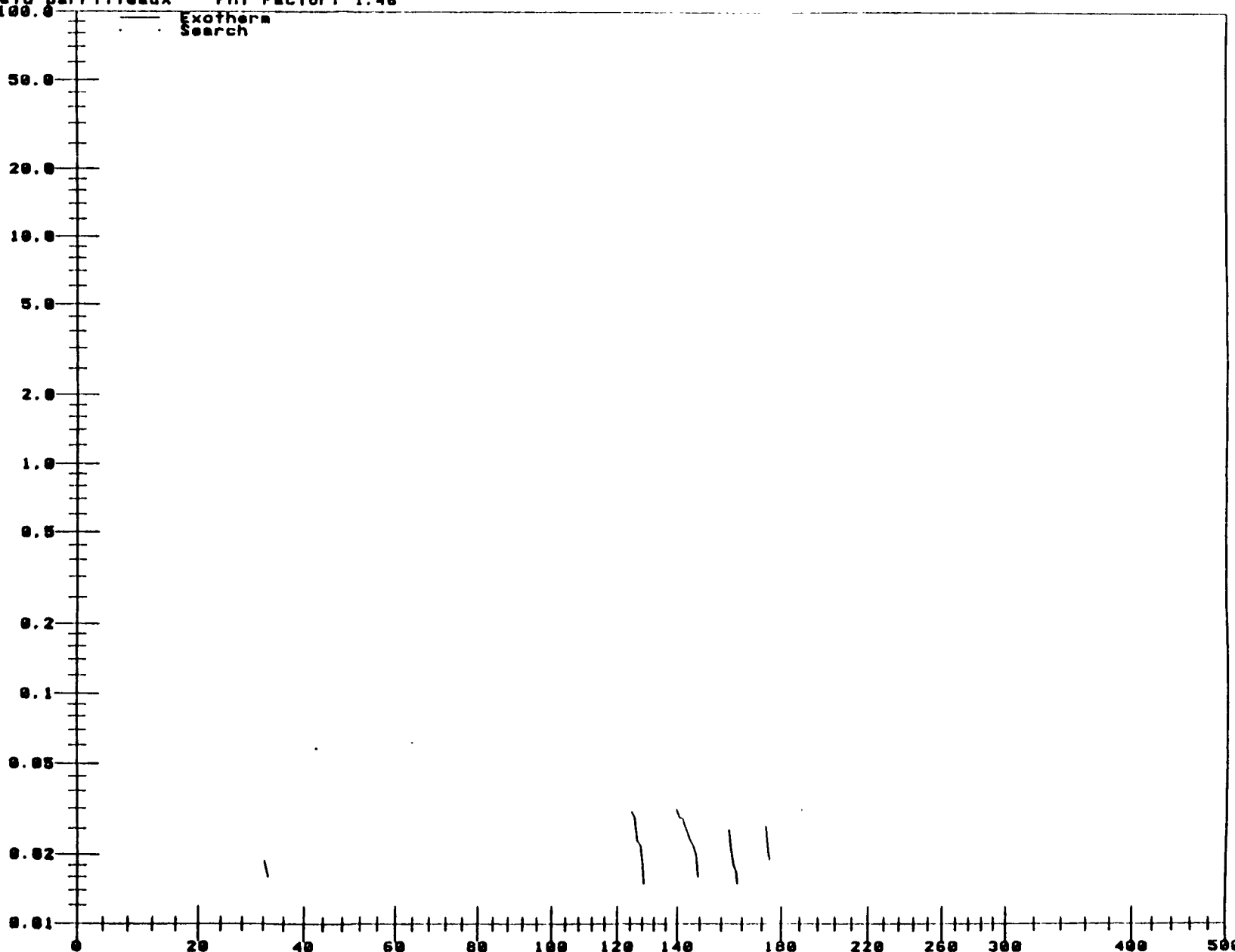
AKJ

SELF-HEAT RATE VS. TEMPERATURE

Sample: Steam & Process SP-TFLO + Liquid Chlorine
ARC SYSTEM Weight (gm): 8140
Customer: Clark Pontiller Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux Phi Factor: 1.48

Run Date: 05-28-92 Time: 07:55
Plotted Date: 05-28-92

Self Heat Rate, deg C/min



DO A 022176
CONFIDENTIAL

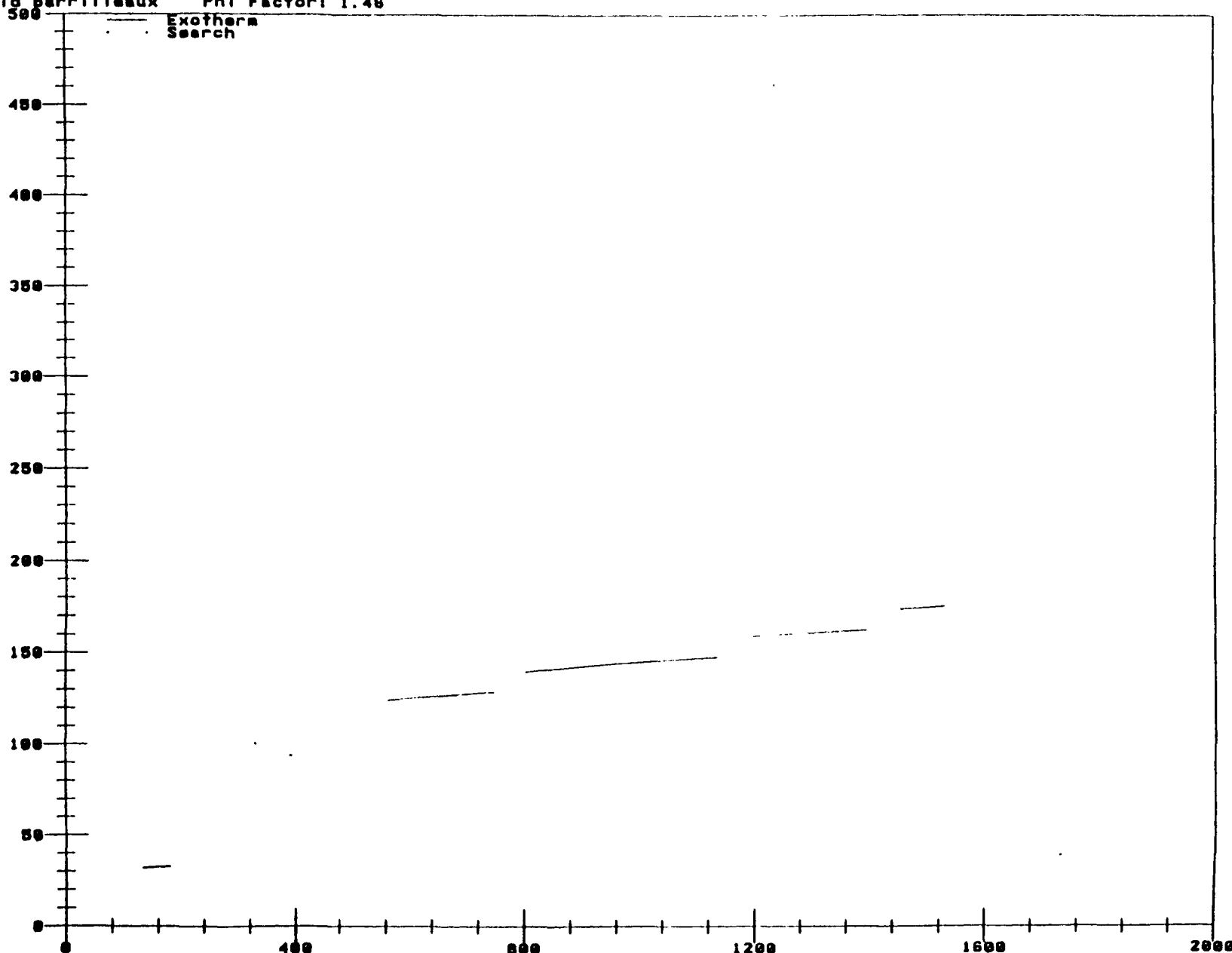
ARC

TEMPERATURE VS. TIME PLOT

Sample: Steep & Process SP-TFLO + Liquid Chlorine
ARC: ARC System
Customer: Clarks Lanthier
Analyst: Gerald Berrilleaux
Weight (gm): 8.148
Operator: Gerald Berrilleaux
Phi Factor: 1.48

Run Date: 05-28-92 Time: 07:55
Plotted Date: 05-28-92 Time: 16:03

Temperature, deg C



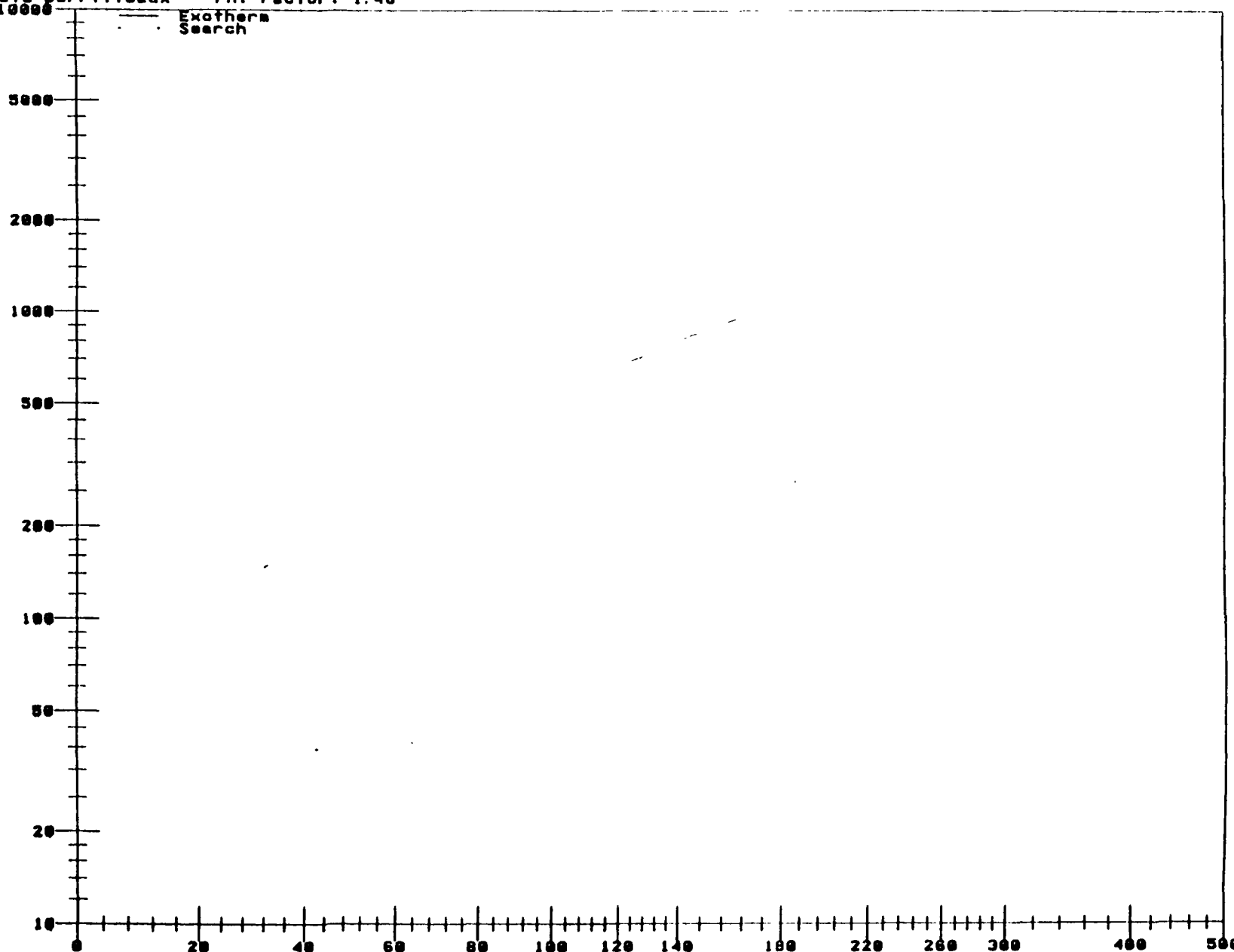
DO A 022177
CONFIDENTIAL

5

ARC PRESSURE VS. TEMPERATURE

Sample: Steep & Process SP-TFLO + Liquid Chlorine
ARC: ARC SYSTEM Weight (gm): 1.8148
Customer: Clark Ponthier Operator: Gerald Barrilleaux
Analyst: Gerald Barrilleaux PFI Factor: 1.48

Run Date: 05-28-92 Time: 07:55
Plotted Date: 05-28-92



Pressure [PSIA]
DO A 022178
CONFIDENTIAL

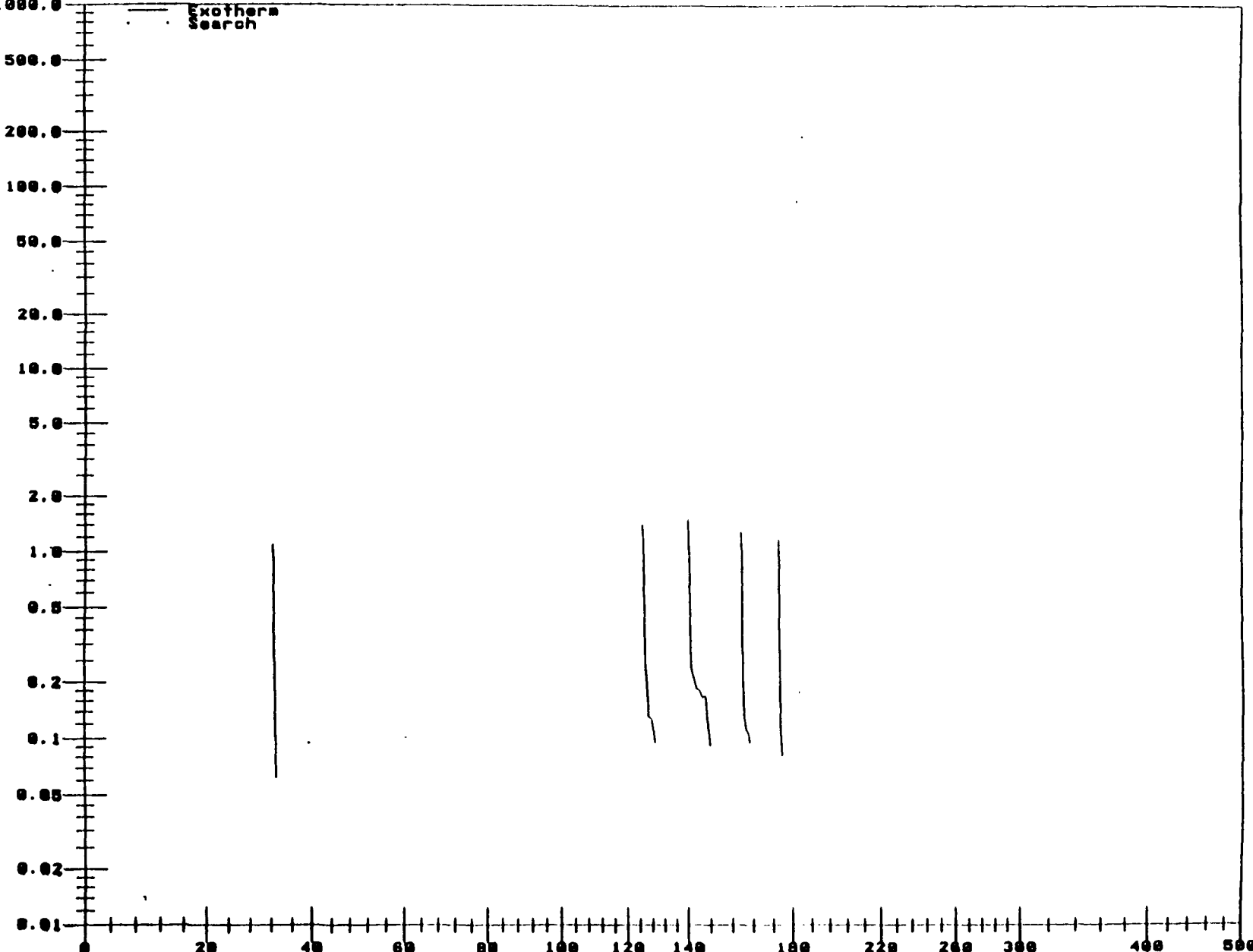
ARC

PRESSURE RATE VS. TEMPERATURE

SAMPLE: ARC
CUSTOMER: Shell
ANALYST: Gerald Barrilleaux
STEP: 1
PROCESS: SP-TFLO
LIQUID: Chlorine
HEIGHT (cm): 81.48
OPERATOR: Gerald Barrilleaux
PHI FACTOR: 1.48

Run Date: 05-28-92
Plotted Date: 05-28-92
Time: 07:58

Pressure Rate (PSI/Min)



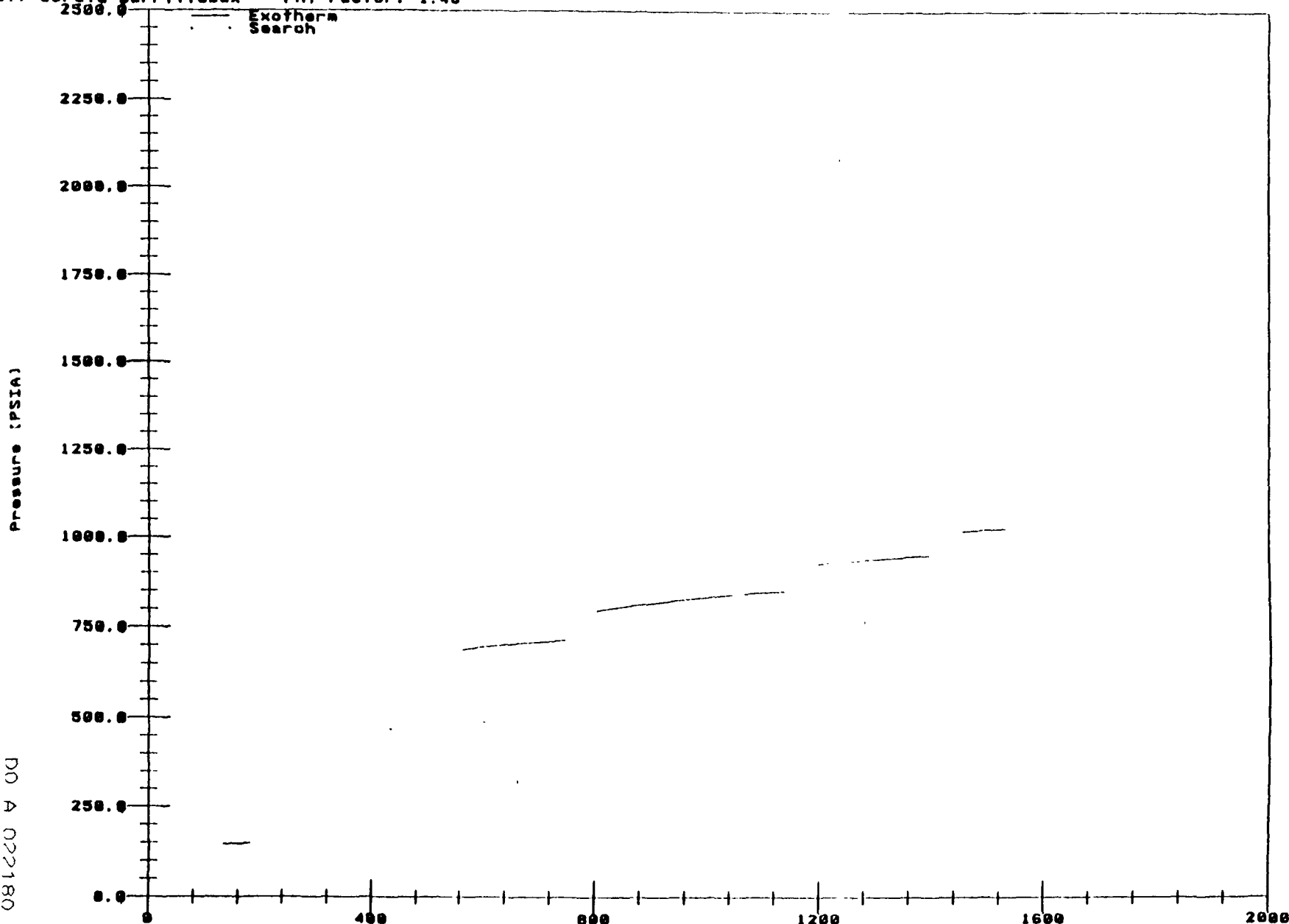
Exotherm Search

DO A 022179
CONFIDENTIAL

ARC PRESSURE VS. TIME

Sample: Steam & Process SP-TFLO + Liquid Chlorine
ARC: ARC SYSTEM
Customer: Clark Conthier
Analyst: Gerald Barrilleaux
Weight (g): 1.0
Operator: Gerald Barrilleaux
Phi Factor: 1.48

Run Date: 85-28-92 Time: 07:55
Plotted Date: 85-28-92 Time: 16:18



DO A 022180
CONFIDENTIAL

Distribution List

LOUISIANA

B. W. Bailey	- 3301W
C. B. Carpenter	- 6605
B. Cisneros	- 2510
S. Corbino	- 3801
K. D. Diamond	- 1901
J. W. Gross	- 2511
T. M. Gunn	- 1701
S. F. Hanrahan	- 3305
J. E. Henry	- 1501
R. D. Hudson	- 3601
D. S. Jones	- 3502W
V. E. McMurray	- 8601
C. D. Messelt	- 6601
W. S. Milligan	- 5301
M. T. Mitchell	- 807
J. C. Monroe	- 3305
C. J. Ponthier	- 2601
R. D. Summers	- 2510
R. D. Thornhill	- 2601
B. M. Williams	- 2509
B. G. Witt	- 2502
*Patent Department	- 2507
CRI (5)	- 2507

FORT SASKATCHEWAN

W. B. Ell	- 158
H. W. Vandenberg	- 91A
*R. A. Wagner	- 158

FREEPORT

W. H. Cook	- A-1230
*W. W. Henslee	- A-915
*L. M. Kroposki	- B-1225
D. J. Leggett	- B-1216
*D. C. Schulz	- B-101
W. E. Shewbart	- B-101
*S. F. Spangenberg	- B-1225
G. L. Stevens	- A-1230
CRI (1)	- B-1210

MIDLAND

J. S. Kelyman	- 566
*M. V. Koch	- 1897
J. B. Powers	- 1897C
CRI (1)	- 566

PITTSBURG

C. N. Harris	- 463
*J. D. Moseley	- 463

SARNIA

*A. R. McDowell	- 1010
B. A. Prine	- 53

STADE

H. B. Bleichert	- C-5
*E. L. Dreher	- C4-1
H. J. Nau	- A4
F. Schollemann	- G 5-2
J. W. Steinmetzer	- C4-1

*Summary Only